12th International Paleolimnology Symposium
Glasgow SECC 21-24 August, 2012

“advancing the science of palaeolimnology”
Scotland's Round Loch of Glenhead was a key site in the surface water acidification debate and is now one of the flagship sites in the UK’s long term monitoring network of acid waters. Palaeolimnological studies of the loch in the 1980s by Roger Flower, Viv Jones, Rick Battarbee and others showed that the loch had been progressively suffering from the effects of acid rain since the mid 19th century. Following major reductions in the emissions of sulphur and nitrogen gases in the UK over the last 30 years the loch is now slowly recovering.
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Welcome to IPS2012

On behalf of the UK paleolimnological community, welcome to the 12th International Paleolimnology Symposium in Glasgow, UK, organised under the auspices of the International Paleolimnology Association (IPA). This is the second time that the UK has been privileged to play host. The previous occasion was in 1989 when the meeting was held in Ambleside in the English Lake District. The first ever paleolimnology symposium was held in 1967 in Tihany, Hungary, on the shores of Lake Balaton.

Our science has developed very strongly since those early days. The numbers attending our meetings have more than tripled and our community has become a truly global one. At this meeting in Glasgow we are expecting over 320 participants from more than 30 countries.

There are 16 special oral and poster sessions, four plenary presentations and a ceremony to present Outstanding Service and Lifetime Achievement Awards.

Outside the conference venue we have a strong social programme with the Monday night Ice Breaker in the University of Glasgow, the Tuesday night Civic Reception in Glasgow’s City Chambers and half-day excursions on Thursday afternoon to enjoy a Loch Lomond cruise, a visit to Glengoyne Whisky Distillery or a guided walk in the City. We finish off our social events with the Symposium Banquet and Ceilidh on Thursday evening, back in the University.

We would like to take this opportunity to thank all our sponsors, especially Springer for providing the prizes for the best student oral and poster presentations, and to thank you for coming. We hope you have a stimulating time.

UK Local Organising Committee
Andy Henderson, Helen Bennion, Anson Mackay,
Mike Hughes, Simon Patrick and Rick Battarbee
The International Paleolimnology Association

Although the first Paleolimnology Symposium was held in 1967 it was not until the 10th meeting in Duluth in 2006 that the IPA itself was formed. It followed a unanimous decision taken at the 9th meeting in Helsinki in 2003 when the need for an organisation to act as a co-ordinating body for paleolimnology was recognised.

A constitution for the IPA was agreed at the Duluth meeting leading to the creation of an Executive Committee comprising an elected Chair, an elected Young Scientist and ex officio positions for Symposia organisers, the Editor of the Journal of Paleolimnology and the moderator of the Paleolimnology Listserv.

The constitution also required the appointment of an International Advisory Committee (IAC) designed to be representative of all regions of the world and of the different strands in paleolimnological science. The current committee has 10 members. The names of the committee and the IPA Board itself can be found on the IPA website (www.paleolim.org).

Our challenge now is to develop the IPA so it can serve our community in future. We have the support of Springer through their publication of the Journal of Paleolimnology and through their sponsorship of student prizes, and we have been able to use funds from the Duluth and Guadalajara meetings to initiate awards for Lifetime Achievement, first presented in Guadalajara, and for Outstanding Service, to be presented for the first time at this Glasgow meeting.

We now have an additional source of income from the subscription fees levied as part of the registration fee for this meeting. Although our resources are still limited, we are steadily building a strong foundation to underpin the future of our science on the international stage.

At the end of our meeting in Glasgow there will be a plenary meeting to conduct IPA business. You are all members of the IPA, and I invite you to attend the meeting where we will hear reports from the Chair and from the Editor of the Journal of Paleolimnology, we will announce and present the winners of the student prizes, we will elect new officers including a new Chair, a Vice Chair and young scientist and we will, most importantly, decide where the next Symposium will be held.

And finally, as this is my last year as Chairman, I would like to thank friends and colleagues for their help over these formative IPA years, and I wish the IPA and its members every success in the future.

Rick Battarbee
IPA Chairman
IPA Lifetime Achievement Award Citations

During IPS2012 the International Paleolimnology Association will present four lifetime achievement awards and awards for outstanding services to paleolimnology.

Françoise Gasse
Françoise has been a pioneer on many fronts. Her dissertation on Lake Abhé near the Ethiopia-Djibouti border is the first continuous dated African Plio-Pleistocene diatom record. She developed a large database of contemporary diatoms and associated environmental information from African lakes, which was probably the earliest lacustrine transfer function to quantify geochemical variation driven by climate. Françoise worked throughout Africa and western Asia to reconstruct Quaternary climate, and a substantive portion of what we know about African paleoclimate is based on or builds on her work. Her research commonly integrated diatom and isotopic data and is characterized both by its sophisticated understanding of the importance of basin hydrogeomorphology in palaeoclimatic interpretation and the rigour of her taxonomic treatment of the diatoms. Françoise supervised the graduate research of several well-known scientists and has mentored multiple other individuals over the years. The impact and quality of her career are exemplary. She is the first female recipient of the Vega Medal in Gold awarded in 2005 by the Swedish Society for Anthropology and Geography and in 2010 was awarded the Hans Oeschger Medal for her contribution to the reconstruction of climate variability during the Holocene.

John Birks
Prof. H. John B. Birks transformed palaeolimnology in the 1980s by introducing powerful new numerical techniques that allowed us to reconstruct changes in past lake water chemistry from fossil diatom records in a rigorous quantitative way. The techniques he introduced have now become standard in probably every palaeolimnology laboratory in the world. It is hard to fully appreciate John’s legacy in this regard, except to say that his contributions and influence were enormous. Although John must be one of the busiest scientists on the planet, he never hesitates to help colleagues and especially young students as they try and understand numerical methods in palaeolimnology. His work on the editorial board of the *Journal of Paleolimnology*, since its inception, has been exemplary. He is a remarkable leader and role model for younger scientists. In summary, John Birks is an outstanding scientist, colleague, teacher and writer, whose influence on our field has been and is extraordinary.
Peter Appleby

Peter is Professor of Mathematics at Liverpool University. In the late 1970s, together with Frank Oldfield, he revolutionised $^{210}\text{Pb}$ dating by introducing a new approach to age-depth modelling using a constant rate of supply (crs) assumption for the accumulation of $^{210}\text{Pb}$ in lake sediments. He went on to pioneer the non-destructive measurement of $^{210}\text{Pb}$ and other radionuclides from sediments using gamma emission spectroscopy by establishing a purposely designed dating laboratory, the Environmental Radiometric Laboratory, in Liverpool. Over the last 30 years he has analysed and dated hundreds of cores from lakes and other natural archives, carried out seminal research on the fallout, transport and accumulation of $^{210}\text{Pb}$ in lake sediments and forged productive research partnerships with palaeolimnological groups throughout the world. His work has enabled palaeolimnologists to reconstruct the recent environmental history of lakes robustly, with due caution in some cases but with unprecedented accuracy in others, contributing significantly to our science and to its application.

Ingemar Renberg

Ingemar is a highly respected palaeolimnologist who was pivotal in the scientific development of our discipline. He played a central role in the lake acidification debate in which quantitative pH reconstruction established palaeolimnological methodology as a powerful tool in environmental science. Ingemar’s contribution to palaeolimnology is, however, diverse and highly original, covering the introduction of a range of techniques including Near-infrared Spectroscopy (NIR), bacterial spore analysis, and the use of Pb stable isotopes and carbonaceous particles. He also developed methods that improved the collection and subsampling of varves. Designing, building and improving sediment corers (in conjunction with his brother-in-law, Hans Hansson) is close to his heart! As palaeolimnology enters a critical and reflective period in its development, it is pertinent to reflect on Ingemar’s earliest work, published in Early Norrland, where he combined diatom, macrofossil and biogenic silica analyses with sediment geochemistry to show how cultural and natural landscape development can influence lake ontogeny. This prescient study remains an iconic example of what integrated, holistic palaeolimnology can achieve. A careful, analytical scientist, both in the field and the laboratory, Ingemar built up a major palaeolimnological laboratory in Umeå and proved inspirational to the many PhD students and post-docs who benefitted from his friendly and constructive mentoring.
 IPA Outstanding Service Award Citations

These new awards are designed to honour those that have enabled the advancement of palaeolimnology through their dedicated, effective and sustained support for research and for our research community.

 **John Glew**

for dedicated work in developing and improving new corers and samplers used by paleolimnologists worldwide

 **Judith Terpos**

for dedication over many years in helping to make the Journal of Paleolimnology a success

 **Tom Whitmore**

for long-term professional commitment to the running of our listserver

 **Bill Last**

for tireless and enthusiastic work as co-editor-in-chief of the Journal of Paleolimnology for over a decade and serving as co-editor-in-chief of the Developments in Paleoenvironmental Research book series

 **Tamara Welschot**

for promotion of palaeolimnology throughout the world through publishing and for support of students through long-term commitment to the award of book prizes at our symposia

 **Eric Grimm**

for writing and developing the TILIA diagram-plotting software, caring for users and offering them advice and unstinting help for many years
Prof Rick Battarbee  
*Environmental Change Research Centre, UCL*

**PL1 - Palaeolimnology in the UK: Pioneering days**

Palaeolimnology in the UK has a relatively long history, inspired by W.H. Pearsall, one of the founders of the Freshwater Biological Association (FBA). The first sediment core was taken by Clifford Mortimer in 1937 but the real pioneers were Winifred Pennington and John Mackereth. The rest is history!
Dr Marie Elodie Perga  
Alpine Centre for Research on Trophic Networks and Lake Ecosystems (INRA)  

PL2 - Gliding from limnology to paleolimnology to study the ecosystem-wide consequences of human pressures on lake food webs

Studies covering long-term climatic variability have shown that the similar climate change can lead to completely opposite consequences on lake ecological status, depending on its location and morphological characteristics. Our knowledge of climate influences on lake ecology is then considerably hampered by the complexity of the pathways under which climate can act on these ecosystems. Indeed, such a singularity of lake responses to climate results from the fact that the different climate components can affect the lake directly, through modifications of the water column physical, chemical and biological properties, but also indirectly through their impacts on the watershed characteristics and subsequent inputs to the lake (Leavitt et al, 2009). Depending on the lake context, one pathway or the other shall predominate, leading to a lake-specific response to climate change.

Since local anthropogenic pressures exert strong structuring effects on lakes or their watersheds, our assumption in this work is that the impact of climate change on lake ecological and geochemical processes will depend on the intensity of local pressures.

We use, for that purpose, a set of three peri-alpine lakes (Annecy, Bourget, Geneva) exhibiting rather similar morphologies and submitted to the same climatic variability. These lakes have undergone, over the last century, similar local forcings (changes in nutrient inputs and fisheries management practices) but with varying intensities.

The first step of the program has been dedicated to the paleolimnological reconstruction of the lakes ecological and geochemical processes over the last 150 years. To reach a large picture of ecological processes, we implemented the classical paleolimnological approach by several new proxies developed within the program (molecular methods for microbial diversity, stable isotope analysis for food web structure and geochemical indicators of anoxia). We could then achieve a holistic and ecosystem-wide view on how these three lakes changed over the last century.

A second, on-going step consists in hierarchizing the drivers of the ecological changes observed over time. For instance, detected changes in food web structure resulted from the interactions between local and global forcings in all cases. However, using adequate models, we could show that climate impacts on food webs increased with the intensity of local stressors, and especially eutrophication. We could also detect the appearance of lake bottom anoxia, a major symptom of ecosystem degradation, from the 1950’s and its persistence since then, in spite of undertaken remediation measures. The contribution of climate change to the persistence of lake bottom anoxia was shown to be uneven between the three lakes. The role issued to climate versus local stressors increased gradually with the intensity of past eutrophication on these lakes.

The take-home message is then that morphologically comparable ecosystems under similar climate forcing are not evenly sensitive and these differences in vulnerability to climate warming depend on local stressors. Our conclusion fuels the debate about the predictability of the impacts of climate change on ecosystems and emphasises that local forcings should be considered when extrapolating from one site to another.

Professor Tom Johnson  
Large Lakes Observatory, University of Minnesota, Duluth

PL4 - A 1.2 Million Year History of Rainfall and Temperature from Tropical East Africa: Challenges and Rewards from the Lake Malawi Drilling Project

The Lake Malawi Drilling Project obtained cores from the central and north basins of the lake in 2005. Drilling operations at the central basin Site 1, located at 11° S latitude in 600 m water depth, recovered nearly continuous core to a depth of 384 meters below lake floor, representing the past 1.2 million years of environmental history.

Several papers have been published on results from Hole 1C, representing the upper 90 m of sediment, covering the past ~150,000 years. The age model for the deeper portion of the drill site has undergone several iterations over the past few years, and is now settling down, thanks to an Ar/Ar date on a 921 ky tephra that confirmed the identification of subtle, paleomagnetic reversals that are based solely on inclination from this low latitude site. The long records display strong signals of shifting lake level and temperature, which are complex and somewhat disappointing in that they do not mimic iconic records of global climate change exhibited in Chinese speleothems, Antarctic ice cores, or many marine sediment cores.

The hydrological history of the lake is derived from a number of parameters, including the presence or absence of endogenic calcite, abundance of organic matter, ostracod assemblages (when present), and δ13C of long-chain n-alkanes derived from terrigenous plant leaf wax. The paleotemperature record is based on TEX86, an index based on the molecular structure of tetraether compounds derived from prokaryotic Thaumarchaeia that live in the upper water column.

This talk will focus on the TEX86 and δ13C records of past environmental change in the Lake Malawi drill core. The former is noisy, with hints of a 100,000 year cycle in portions of the record, while the carbon isotopic record of “rainfall” displays intervals of precessional forcing with a ~20,000 year period. The TEX86 record is potentially conflicted by the effect of rising and falling lake level, at times by a few hundred meters, which superimposes an adiabatic lapse rate effect on the temperature history.

The lack of clear evidence for Milankovitch forcing of the climate of the Malawi basin is attributed to two factors: the basin’s location near the boundary of a dipole pattern of SE African rainfall, and the opposing effects of SH insolation and Indian Ocean SST patterns on the SE African monsoon.
IPS2012 Plenary Session Abstracts

Professor John Anderson
Department of Geography, Loughborough University

PL5 - Lakes and the terrestrial carbon cycle: palaeolimnological perspectives

Lakes are now considered to be an important part of the terrestrial carbon cycle. They release large amounts of CO$_2$ into the atmosphere as the result of the input of catchment derived C, mainly as DOC, but also bury substantial amounts of organic C in their sediments. From a palaeolimnological perspective, the organic C content of lake sediment (or the organic matter content or their accumulation rates) is a fundamental measurement that is determined at the start of all studies and is primarily interpreted in terms of changing aquatic productivity. This interpretation is, of course, an over-simplification: depending on location, a large fraction of the organic content of lake sediment may be terrestrial in origin while biogeochemists see organic C profiles in sediments primarily as a reflection of mineralization and decomposition processes. In this presentation I will evaluate these contrasting approaches to the abundance of organic matter in lake sediments before assessing regional variability in C-burial rates and their wider significance.

Problems: From a palaeolimnologic perspective there are a number of problems and limitations with evaluating the organic content of lake sediment quantitatively, most notably that of variable preservation, within-lake spatial variability and sediment focussing as well as the key question of how to approach regional upscaling?

Carbon burial rates: it has been estimated that global mean burial rates are in the range 4–15 g C m$^{-2}$ yr$^{-1}$ but palaeolimnological data suggest that burial rates can reach >300 g C m$^{-2}$ yr$^{-1}$, but are there any systematic regional differences and how have these burial rates changed in relation to disturbance regimes? I will examine these questions by illustrating how C burial rates vary geographically, temporally and with lake typology. How do these rates contrast loss rates due to mineralization? Is the relationship between production, sedimentation, burial and decomposition constant over time?

Controls of C-burial rates: are we able to make large scale generalizations about the factors that control carbon accumulation in lakes? I will examine the relationship of OC burial rates to a range of environmental change processes: eutrophication of lowland lakes due to increasing agricultural intensification and phosphorus loading, land-cover change (particularly in the tropics), climate forcing (warming) and stimulation of productivity in remote lakes by reactive nitrogen deposition.

Carbocentric palaeolimnology – aquatic carbon burial at the landscape scale: lake sediments are long-term stores of organic carbon and can effectively remove C from the contemporary C-cycle. It is unclear how this contribution to the terrestrial C-cycle will evolve as land-cover changes due to both natural climate forcing and anthropogenic land-use. Finally, I will illustrate how palaeolimnological studies of carbon burial rates in lakes can have considerable relevance to contemporary carbon budgets.
Session 01 - Isotopes and biogenic silica: understanding lake sediment archives

S01-KN  Advances in the use of Isotopes in Biogenic Silica in palaeolimnology

Leng, M.J.

Department of Geology, University of Leicester, UK and NERC Isotope Geosciences Laboratory, British Geological Survey, UK

The use of oxygen and silicon isotopes in biogenic silica was developed by oceanographers in the 1970s and 80’s following techniques developed forty to fifty years ago. The oxygen (δ^{18}O), silicon (δ^{30}Si), and carbon (δ^{13}C) composition of biogenic silica are being increasingly used as proxies for environmental change. Biogenic silica is structurally a complex mineral especially for δ^{18}O measurement; carbon (δ^{13}C) occurs in very small quantities in organic material hosted within the structure and can be difficult to extract, and while the measurement of δ^{30}Si is relatively simple (in comparison to δ^{18}O, δ^{13}C) there are still uncertainties over the interpretation of the δ^{30}Si signal in palaeolimnology, largely as a result of the paucity of studies. However, the recent renewed effort in using biogenic silica in palaeoenvironmental research has highlighted new ways in dealing with the many issues that accompany its use. Specifically these are: contamination; the hydrous layer and associated maturation of diatom silica; as well as understanding the controls on the δ^{18}O, the potential of δ^{30}Si and occluded δ^{13}C in diatom silica. In particular the presentation will focus on better preparation, analysis, and interpretation of biogenic silica oxygen, carbon and silicon isotopes in diatom silica.

S01-01  Hydrological instability during interglacials in central Asia

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Understanding past environments provides fundamental information on ecosystem functioning during a warmer world. Our knowledge of rapid climate change events during previous interglacials is poor because of the paucity of highly resolved records. The primary aim of this study was to determine climate instability during the last interglacial in central Asia using diatom δ^{18}O (δ^{18}O_{diatom}) analyses of Lake Baikal sediments.

δ^{18}O_{diatom} values gradually declined from the onset of MIS 5e (127.5 kyr BP) to their lowest level of +29.0 ‰ at 119.7 kyr BP. However, superimposed upon this trend were several marked fluctuations in δ^{18}O_{diatom} values, with a pacing between minima of approximately 1.3 ± 0.4 kyr, similar to last interglacial IRD events in the North Atlantic. The minimum between c. 127-126 kyr BP is concurrent with a small but distinct increase in IRD associated with the final stages of Heinrich 11. The minimum in δ^{18}O_{diatom} values between 120.5 and 119.7 kyr BP occurred at the same time as depressed diatom productivity in Lake Baikal. This event has been observed elsewhere in many other records, including European lakes and Chinese loess.

Our data clearly demonstrate that Lake Baikal hydrological variability was significantly more stable during the last interglacial than the Holocene. Evidence of an earlier abrupt event during MIS 11 is also apparent. These events are in close concordance with variation in Atlantic Meridional Ocean Circulation, highlighting that hydrological variability in Lake Baikal is influenced by remote changes in the North Atlantic via teleconnection processes.
A 13,600-year diatom oxygen isotope record from the South Carpathians (Romania): reflection of winter conditions and possible links with North Atlantic circulation changes


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We provide in this study a continuous lateglacial and Holocene record of diatom silica oxygen isotope changes (δ18O<sub>DIAT</sub>) in a subalpine lake sediment sequence obtained from the Retezat Mts (Taul dintre Brazi, 1740 m a.s.l.). This through-flow, shallow, high-altitude lake with a surface area of only 0.4 ha has short water residence time and is predominantly fed by snowmelt and rainwater. We suggest that its δ18O<sub>DIAT</sub> record principally reflects the oxygen isotope composition of the winter and spring precipitation, as diatom blooms occur mainly in the spring and early summer. Hence changes in δ18O<sub>DIAT</sub> are interpreted as seasonal scale changes: in the amount of winter precipitation. We found low oxygen isotope values (27-28.5‰) during the lateglacial until 12,300 cal yr BP, followed by a sharp increase thereafter. In the Holocene δ18O<sub>DIAT</sub> values ranged from 29 to 31‰ until 3200 cal yr BP, followed by generally lower values during the late Holocene (27 to 30‰). Short-term decreases in the isotopic values were found between 10,140-9570, 9000-8500, 7800-7300, 6300-5800, 5500-5000 and at 8015, 4400, 4000 cal yr BP. After 3200 cal yr BP a decreasing trend was visible with the lowest values between 3100-2500 and after 2100 cal yr BP. The general trend in the record suggests that contribution of winter precipitation was generally lower between 11,680 and 3200 cal yr BP, followed by increased contribution during the last millennia.

Our late Holocene decrease in δ18O<sub>DIAT</sub> shows good agreement with the speleothem δ18O, lake level and testate amoebae records from the Carpathian Mountains that also display gradual δ18O decrease and lake level/mire water table level rise after 3200 cal yr BP. Strong positive correlation with North Atlantic circulation and solar activity proxies, such as the Austrian and Hungarian speleothem records, furthermore suggested that short-term increases in the isotopic ratios in the early and mid Holocene are likely connectable to high solar activity phases and high frequency of positive North Atlantic Oscillation indexes that may have resulted in decreased winter precipitation in this region.

Palaeo-seasonality of the last two millennia reconstructed from the oxygen isotope composition of diatom silica and carbonates from Nar Gölü, central Turkey


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Reconstructing climate seasonality using lake sediments requires the analysis of proxies that are sensitive to conditions at different times of the year. In Nar Gölü, a crater lake in central Turkey, diatom growth is weighted towards the early spring and carbonate is precipitated in early summer; both are preserved in the lake sediments. We analysed the oxygen isotope composition of these two hosts from a 1710 year core sequence and use these data to reconstruct δ18O<sub>lakewater</sub> values. At times, there are large (up to 15‰) differences in δ18O<sub>lakewater</sub> values calculated for the times of diatom growth and carbonate precipitation. It is suggested that only an increase in snowmelt, with its associated low δ18O,
forming a freshwater lid on the lake at the time of peak diatom growth, and mixing with the underlying saline waters by the time carbonate precipitated, could account for this. Changes in the abundance of diatom species *Cyclotella meneghiniana* coincide with these periods, confirming there were significant changes in lake state. We show that seasonality was greatest between 301 and 561 AD, with summer droughts and snowy winters. Thus we demonstrate that δ¹⁸O records from hosts that form in lakes at different times of the year can be compared to provide additional information to aid palaeohydroclimate reconstructions.

**S01-04  Shifts in precipitation during the last millennium in northern Scandinavia from lacustrine isotope records**

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We present oxygen isotope data from biogenic silica from two high-latitude lakes located in northern Sweden. One has short residence time and a water isotopic composition that fluctuates due to seasonal variations in precipitation and temperature, and the other has δ¹⁸Olake that is influenced by longer lake water residence times and evaporation. The δ¹⁸O in records reveal common responses to precipitation forcing over the past millennium. Relatively wet summers are inferred from δ¹⁸O between 1000 and 1080 AD, 1300 and 1440 AD, and during the early 19th century, coincided with periods of high cloud cover inferred from tree-ring carbon isotopes, and other data for high Arctic Oscillation index. While relatively dry summers with increasing influence of winter snow is indicated between 1600 and 1750 AD. The co-response between carbon isotopes in trees and oxygen isotopes in diatoms strengthens the relationship between cloud cover and precipitation and the hypothesis that these changes were the result of significant regional shifts in atmospheric circulation.

**S01-05  Environmental controls of freshwater diatom δ¹³C values**

1Webb, W., 1Barker, P., 1Wynn, P., 2Seed, M., 3Heiri, O., 3Van Hardenbroek, M.

1Lancaster Environment Centre, Lancaster University; 3Isoprime; 3Institute of Plant Sciences and Oeschger Centre for Climate Change Research, University of Bern

There are currently few proxies that can be used to quantitatively reconstruct freshwater carbon cycles. Stable isotope analysis of carbon (δ¹³C) provides useful insights, but bulk sediment measurements are dominated by source effects. Here the use of carbon entombed within diatom silica (δ¹³Cdiatom) is evaluated.

During the formation of the silica cell wall (frustule) of diatoms, proteins and long-chain polyamines are trapped within the structure forming organic inclusions. Their incorporation within the frustule provides protection from chemical attack and consumption by heterotrophs, enabling preservation over geological timescales.

Robust cleaning methods have been developed that build on early work by palaeoceanographers. The nature of the organic material has also been confirmed by GC-MS. However, the complexity of freshwater environments requires rigorous evaluation of potential carbon sources, nutrient-productivity relationships, carbon utilisation by diatoms and the effects of analysing samples consisting of frustules from different diatom life-forms (planktonic versus benthic).

Initial results suggest that δ¹³Cdiatom values of
contemporary benthic lacustrine diatoms exhibit a strong correlation to productivity indicators. In comparison we find here that $\delta^{13}C_{\text{diatom}}$ values of diatoms supported by environmental data sampled from streams in Northern England more closely reflect carbon sourcing. We compare these results to new data from a pan-European array of lake surface sediments that will help determine the potential of utilising $\delta^{13}C_{\text{diatom}}$ extracted from lake sediment cores. This contemporary investigation will enable reconstructions using $\delta^{13}C_{\text{diatom}}$ within palaeolimnological work to be more rigorously enumerated.

S01-06 Toward a better understanding of the carbon cycle in freshwaters: $\delta^{13}C$ in diatom silica
Barker, P.
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The carbon cycle of a lake is a balance between supply from the atmosphere and catchment, and the net demand exerted by primary producers, minus losses back to the atmosphere and to sediment storage. Evaluating the sum of these processes and reconstructing them from sediment records of lake history requires a range of methods and a multi-proxy approach. One promising technique is to explore the carbon isotope composition ($\delta^{13}C_{\text{diatom}}$) of organic matter incorporated within the silica frustules of diatom algae. Although, previous work has been undertaken on marine sediments, very little has yet been undertaken in lakes where carbon sources and cycling is complex due to the variable nature of lakes and their intimate relationships with their catchments.

Here we demonstrate that carbon concentrations in contemporary lakes from the English Lake District are related to the productivity of their catchments. Paradoxically, the most productive lakes are also those that emit most carbon to the atmosphere. We use a range of carbon isotope hosts, including epilithic diatoms to demonstrate carbon sources and processing within the lake. Most of the carbon is mineralised in the catchment and transported to the lake via streams and soil water. We will also show that down-core changes in $\delta^{13}C_{\text{diatom}}$ can be detected and interpreted from lake sediments. Ultimately we aim to demonstrate that carbon emissions from lakes has changed through time and has to be captured by climate models.

S01-P-01 Tracking extreme hydroclimatic events in northwest Australia from physical and geochemical sediment patterns of an inland arid wetland
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The semi-arid Pilbara region of northwest Australia is characterized by highly dynamic flooding events brought by frequent low-pressure systems. Current research suggests this region has been experiencing more extreme but less frequent cyclones and overall wetter conditions during the last century. Retrieval of well-preserved sediment archives in this ancient and remote environment is challenging because of the temporary nature of hydrological systems and the complex interactions between surface and ground waters. In addition, paleorecords interpretability is limited by a lack of detailed knowledge of pool and catchment functioning. Here, we use scanning hyperspectral imagery, granulometry and stable isotopes of cores obtained from the largest wetland in the region, the Fortescue Marsh, to track pulse-like events such as tropical cyclones and monsoonal thunderstorms. Over recent decades, severe droughts have been followed by short-lived yet extreme cyclonic rainfall that flush the desiccated stream network and inundate extensive low-lying areas ($>500$ km$^2$). Our preliminary results provide information on sediment mineralogy and evidence of altered redox conditions, flooding intensity and evaporative
sequence of permanent pools through time. Our interpretations are supported by three years of seasonal sampling of surface and groundwater (including measurements taken following tropical Cyclone Heidi, Jan 2012), which show great variation in water chemistry and isotopic content that reflect rainfall patterns.

**S01-P-02 Oxygen isotopes in chironomid head capsules**

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In recent years the remains of chironomid larvae have been investigated as a potential new proxy for inferring past lake water geochemistry. The strongly sclerotized head capsules of chironomid larvae have a high preservation potential under certain limnological conditions and consequentially they are often abundant in lacustrine sediments. Recent seminal studies have illustrated a robust linear relationship between the oxygen isotope composition of chironomid head capsules ($\delta^{18}$O$_{head}$), local precipitation ($\delta^{18}$O$_{precip}$) and mean annual temperature (MAT). Additional complementary studies have focused on developing, methodology (both sample preparation and analysis), theoretical understanding and down-core records. However, many aspects regarding this new proxy remain to be studied. In order for $\delta^{18}$O$_{head}$ to be used effectively in paleo research, it is first necessary to gain a mechanistic understanding of the systematics involved in the incorporation of environmental oxygen isotopes into chironomid head capsules. We identified a number of challenges that remain to be overcome with this proxy. In particular we focused on the effects of sample preparation, temperature and environmental seasonality on $\delta^{18}$O$_{head}$.

**S01-P-03 Do oxygen isotopes of biogenic silica reflect climate? An analysis of lakes across a large climate gradient in Alaska**

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The oxygen isotope analysis of lake sediments offers an effective tool for acquiring palaeoclimatic records, although these isotope records have largely been restricted to carbonate-bearing lacustrine systems. In non-alkaline or dilute oligotrophic lakes where carbonate material is absent or rare, the oxygen isotope composition of diatom silica is now a more widely applied proxy indicator for climatic reconstruction and therefore has the potential to broaden the range of lake environments from which isotope records can be generated. The oxygen isotope composition of diatom silica reflects the temperature at which the diatom frustule forms and the oxygen isotope composition of the lake water. Recently, much research effort has gone into refining the temperature-dependent biotic fractionation of oxygen between water and diatom silica. Current estimates of temperature fractionation are between –0.2 and –0.5 per mille but the relationship between the oxygen isotope composition of diatom silica and lake water remains to be fully tested. Taking a space-for-time approach from 26 sites across Alaska we examined the relationship between the oxygen isotope of diatom silica from surface sediment and the isotope composition of lake water. There is a strong relationship between the oxygen isotope composition of diatoms and lake water, and this is independent of whether the lake is an open system reflecting changes in precipitation or closed system reflecting the precipitation-evaporation balance. While comparisons with lake water temperature are weak it suggests the oxygen isotope composition of lake water is a more important control on diatom silica.
S01-P-04  A reconstruction of climate history at high resolution using C and N isotopes, Northwest Territories, Canada

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The Tibbitt-to-Contwoyto Winter Road (TCWR) is the sole overland route servicing diamond mines north of Yellowknife, Northwest Territories (NWT), Canada. However, as this road is only operational during winter, the length of its season is strongly influenced by climate. This was exemplified in 2006, when an El Niño event caused an unusually short ice road season and resulted in a costly reduction of shipments to the mines. For future use and development of the TCWR, a comprehensive understanding of past regional climate variability is required.

This study is an integral component of a larger-scale study designed to develop a comprehensive database of high-resolution paleoclimate data for the NWT, using a variety of proxies. As part of the larger study, freeze cores were taken from numerous lakes along the TCWR and sliced at 1-mm intervals using a custom-designed sledge microtome. Bulk $^{13}$C and $^{15}$N isotope analysis was completed at preliminary 1-cm intervals through the cores of two lakes on opposite sides of the tree line. Results from this analysis show clear trends with distinct transitions in both cores occurring at around 7,000, 5,000, and 1,000 BP. The closely-matched timing of the transitions in these cores suggests that they are regional-scale climate events.

Additionally, time-series analysis will determine short-term climate cycles on three sections of Danny’s Lake core in which higher-resolution (up to 2 mm) analysis was completed. A transfer function is also under development, which will compare isotopic compositions and environmental properties from numerous lakes in order to quantitatively delineate those properties which affect isotopic variations.

S01-P-05  Silicon isotope records of recent change and anthropogenic pollution from Lake Baikal, Siberia

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Recent years have seen the rapid increase in the use of silicon isotopes in environmental research. The majority of studies, however, have centred on marine, terrestrial and riverine systems. Few to date have investigated the use of this proxy in continental, lacustrine systems. Building on 60 years of extensive research at Lake Baikal, Russia, this project aims to address this gap in scientific knowledge by conducting a detailed study into the systematics of modern day silicon isotope cycling in and around the lake. Silicon isotope measurements in both waters and biological organisms (e.g. diatoms) can be related to changes in nutrient utilisation, which in turn are linked to nutrient availability (e.g. inputs to the lake) and the biological demand for silicic acid (productivity). Research has highlighted the recent changes in nutrient loading into Lake Baikal (e.g. melting permafrost, agricultural, industrial and mining practices) and subsequent lake productivity changes in recent decades. Anthropogenic climate change has also played a role, through decreased lake ice duration and increased water temperatures. To fully understand the degree and impact of such changes and to distinguish between natural and anthropogenic variability in the lake’s ecosystem,
this project will place recent data into an historical context (over the past 100 and 1000 years) through the use of silicon isotopes.

**S01-P-06 Impact of the Younger Dryas (GS-1) on aquatic biogeochemistry in the Cairngorm Mountains, Scotland**

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The aquatic biogeochemistry response to Younger Dryas (YD) climate change was investigated using the biogenic silica abundance (BSi) and δ^{13}C composition of organic matter in lake sediments recovered from an in-filled channel between Loch Garten and Loch Mallachie, Cairngorms, Scotland. The two lakes were previously a single water body that was partitioned by sedimentary infill ~6.5 cal ka BP. The record is constrained by fourteen AMS 14C ages and the Borrobol, Penifiler, Vedde and Katla-type tephras. Using BSi as a proxy for climate-related primary productivity there is an abrupt reduction in aquatic productivity at the onset of the YD, which is concomitant with an similarly abrupt drop in chironomid-inferred July air temperature (C-IT). The tight coupling between BSi and C-IT suggest aquatic productivity is climatically driven at the onset and during the early YD. However, aquatic productivity lags behind increases in C-IT during the mid-YD, and is further attenuated over the YD-Holocene transition. The difference in response between aquatic productivity and temperature is also seen in the loss on ignition profile, although loss on ignition lags further behind BSi at the YD-Holocene transition. The δ^{13}C record does not show the same pattern of change through the YD period, but rather it shows negative values for the early part of the YD followed by enrichment of the dissolved inorganic carbon (DIC) pool during the later stages. We suggest this reflects melting of local remnant glacial ice as air temperatures warmed resulting in muted aquatic productivity during the late YD before the onset of Holocene conditions.

**S01-P-07 Stable oxygen and carbon isotope records of aquatic moss cellulose from Laguna Potrok Aike in southern Patagonia**

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Carbon and oxygen isotope analyses of lake sediment cellulose have shown the potential for obtaining paleohydrologic and paleoclimatic information. An important assumption in the corresponding interpretation is the aquatic origin of the cellulose fraction analyzed which records directly the lake water oxygen isotope composition at the time of cellulose syntheses. Here we report the preliminary results of the stable oxygen and carbon isotope records of submerged aquatic moss from Laguna Potrok Aike, a southern Patagonian maar lake, in the framework of the ICDP-Project PASADO.

We analyzed around 400 samples consisting of available macro aquatic moss remains for the analyse of oxygen and carbon isotope composition of aquatic moss bulk organic matter and extracted cellulose. The samples are from the core sections within the composite depth from 30 to 10 m covering the period between ca. 26,100 – 8,400 cal. years BP including the Last Glacial Maximum (LGM) and the last glacial-interglacial transition.

Preliminary results of aquatic moss bulk organic matter have shown that the samples from late
Glacial and early Holocene have generally higher oxygen isotope values than the samples from the LGM. In addition, a clear negative relation between oxygen and carbon isotope composition is observed in both glacial and late glacial sediments. Combined with the analyses of aquatic moss cellulose which are still ongoing, stable isotope records of aquatic moss allow us to achieve a better understanding of the past changes in lake water balance and its paleoclimatic significance.

S01-P-08 Freshwater mollusc shells. In isotope equilibrium or disequilibrium with lake waters?

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Stable carbon and oxygen isotope composition of lacustrine carbonates is one of the key proxies in palaeolimnological investigations. δ¹³C and δ¹⁸O has been measured in carbonate mud, ostracod carapaces, charophyte encrustations, mollusc shells and fish otholiths.

In the present study a number of mollusc shells and ambient water were analyzed in terms of stable carbon and oxygen isotope composition. The main aim of the study was to find out whether mollusc shells are precipitated in or out of equilibrium with ambient waters. For the study molluscs commonly present in Quaternary lake sediments in Europe were chosen.

Macrophyte samples, mainly charophytes, with alive molluscs attached, were collected in Lake Lednica, western Poland. Four transects were established perpendicular to shoreline of the lake, samples were taken from 0.5, 1, 2, 3, 4, 5, 6 and 7 meters of depth. Along with macrophytes water was collected directly from above the plants. Samples were taken twice, in June and August 2011.

Stable oxygen isotope composition of several mollusc species grown in 2011 indicates a state of equilibrium between the shells and water. However, shells of all the species analyzed isotopically were ¹³C-depleted. In all the samples a repetitive pattern of δ¹³C values was obtained for particular species, i.e. ¹³C depletion increased from ca. 1.5-2‰ in Dreissena polymorpha, through ca. 3.5‰ in Bithynia tentaculata and ca. 5-6‰ in Gyraulus albus and Lymnaea auricularia to ca. 9‰ in Physa fontinalis.

From the study it emerges that stable oxygen isotope composition of mollusc shells may be applied in palaeolimnological studies whereas stable carbon isotope data must be used with caution. Due to species-dependent differences in δ¹³C in shells of particular species samples should be monospecific.

S01-P-09 Are isotope signatures of charophyte carbonates a good tool for palaeoreconstructions?

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Photosynthetic activity of charophytes (Characeae, macroalgae) leads to precipitation of autochthonous carbonates, that may substantially contribute to lacustrine sedimentation. In the sediments charophytes may be preserved as remains of thalli encrustations and calcified female gametangia called gyrogonites. The oldest charophyte fossils are Upper Silurian in age thus these macroalgae are a potential archive of palaeoenvironmental information back to the middle Palaeozoic. Both gyrogonites and encrustations are frequently used in isotope investigations. However, in order to carry out correct, reliable palaeolimnological reconstructions using stable isotope record of the charophyte carbonates it is essential to know the relation between δ¹³C and δ¹⁸O of recent encrustations and gyrogonites and δ¹³C of DIC (dissolved inorganic carbon) and δ¹⁸O of ambient water, respectively.

This issue was undertaken in investigation of five charophyte species derived from four Polish lakes. Samples of charophytes and water from above the plants were collected at permanent study sites.
monthly since the beginning of charophyte growing season up to the time when first signs of decomposition were noted.

Our investigations revealed that Chara carbonates were isotopically heavier than δ13C of DIC and lighter than δ18O of water, both resulting from intense photosynthetic activity of the algae. 13C enrichment is a consequence of 12C utilization by Chara and 18O depletion results from rapid calcification. Despite the differences observed, the results obtained indicate the presence of correlation between δ13C and δ18O of Chara carbonates and δ13C DIC and δ18O of water, respectively, making them a potential tool for palaeo reconstructions.

S01-P-10  δ18O record of Holocene freshwater tufa section from Äntu Sinijärv – an interpretation of palaeoclimate changes

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Lacustrine carbonates are important achieves of climatic and environmental change for stable isotope and palaeoclimatic studies. We investigated ~13,590 cal yr BP old and 3.75-m-long lacustrine sediment record of Lake Äntu Sinijärv, northern Estonia. This lake was chosen for study, because this is the only site in the region where freshwater tufa precipitation is still taking place. The most detailed (219 samples) isotopically studied tufa section in Estonia are supported by AMS 14C dates, palaeobotany and LOI analysis. Based on the age-depth model, tufa precipitation at the site started ca. 11,800 cal yr BP. That is ca. 1000 years later than suggested previously.

Oxygen isotope data from freshwater tufa of Äntu Sinijärv shows small-scale fluctuation between −12.6‰ and −10.2‰; the mean value of the tufa isotope curve is −11.1‰, which correlates well with the average groundwater δ18O composition of Estonia.

Postglacial warming is detectable from isotope composition (rising values from −12.4‰ to −10.6‰ between 12,000 and 10,700 cal yr BP) and it correlates quite well with low water-level and reflects warmer climate conditions in the region. There is a decrease in isotope composition since 10,700 till 9,200 cal yr BP (from −10.6‰ to −11.5‰), which most probably indicates the “9,300 yr” cold event. From 9,200 till 3,500 cal yr BP isotope values remain constant (average −11.1‰). This 5,700-year long, relatively stable period suggests a local HTM, which is followed by an evident cooling trend in δ18O values, which decrease down to −12.7‰ by 900 cal yr BP.
Session 02 - Applied palaeolimnology

S02-KN  The application of palaeolimnology to evidence-based lake conservation and management

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To help meet the requirements of water legislation, palaeolimnology has been widely used to establish "reference conditions" and restoration targets for lakes. However, its potential for assessing the necessity and appropriateness of different lake management activities has been less publicised. With reference to selected case studies derived from UK lakes, we illustrate the key applied role of palaeolimnology when it comes to decisions regarding biomanipulation, the need for nutrient reduction and catchment management, sediment removal and fish management/stocking. Where possible management responses to our recommendations are outlined including any major outcomes. All case studies illustrate the advantages, in terms of lake management and conservation decision-making, of placing current lake ecological conditions in the context of long-term change.

S02-01  The energy-mass (Em) flux framework: An integrative approach to quantify effects of climate, humans and biota on lakes

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The energy-mass (Em) flux framework proposes that climate, humans and other biota regulate lake ecosystems by altering the influx of energy (E) and mass (m) through diverse direct and indirect pathways. In this view, lakes are open ecosystems that retain E and m by production of particles that are deposited as sediments, have limited capability of accessing sequestered materials, and are dependant on a continuous influx of E and m from the ectosystem, the region surrounding the lake. Physical models of the environmental forcing of lakes reveal that neither E nor m pathways are intrinsically paramount, and instead predict that the magnitude of effect of individual inputs depends on the ratio of influx to lake content. This hypothesis was tested by quantifying changes in whole-lake production arising from reciprocal transfer of fish biomass (no net change in influx), introduction of a top predator (pulsed input), and migration of anadromous semelparous salmon (continuous influx). Paleolimnological analyses confirm that ecosystem forcing by fish is a linear function of the importance of E and m subsidies relative to lake content.

S02-02  Paleolimnological evidence of whole-lake processes used to alter management strategies for a large lake, wetland and reservoir in the southeastern USA

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Many aquatic ecosystems in the USA are managed for larger organisms that help or hinder the recreation of the general public. As a result, management decisions are based on a subset of the system’s food web and ignore whole-lake processes. Here, we provide paleolimnological evidence from three aquatic systems where the sediment record was used to alter or expand management practices. In all three accounts, primary producer community structure was inferred from photosynthetic pigment
analysis and compared to allochthonous inputs such as organic matter, nutrients and metals. In Lake Mattamuskeet, North Carolina, USA (162 km², mean depth = 1 m), phosphorus dynamics and cyanobacterial presence were used to alter the construction of a roadway across the lake. In the Florida Everglades wetland system (15520 km², mean depth = 1 m), marl algal mats and sediment phosphorus concentrations provided evidence for predicting the occurrence of unwanted *Typha* sp. throughout the large wetland. In Lake Seminole, Georgia, USA (152 km², mean depth = 3 m), paleolimnological research showed the need to monitor filamentous benthic cyanobacteria in addition to managing for extensive *Hydrilla verticillata* occurrence. In all three systems, paleolimnological evidence uncovered limitations to current management practices as well as a need to focus more on whole-system processes rather than one or two organisms.

**S02-03  Tracking changes in the Laurentian Great Lakes – new diatom-based tools for retrospective analyses**

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Dramatic environmental changes have been taking place for ~200 years in the Laurentian Great Lakes. Monitoring and paleolimnological investigations reveal a complex history of environmental degradation and, sometimes, remediation. The cornerstone of many of these investigations has been the use of diatoms; known powerful indicators of environmental change. These long-term data are needed to distinguish natural from human trends and to reveal the causes and magnitudes of environmental insults. While valuable, contemporary monitoring has not been sufficient to answer Great Lakes management questions regarding climate change, pollution and invasive species. In addition to a new, comprehensive paleolimnological study of the Great Lakes, we have compiled all available historical data from algal monitoring and paleoecological programs to describe the detailed history of pelagic condition in the lakes in the context of diatom indicators. The main goal of this work is to define lake-specific diatom assemblages from several periods (i.e., pre-1850, 1900-1950, 1960s, 1970-1990, 1990s, post-2000 years). As new paleolimnological data are acquired, we will refine our understanding of the lake environmental histories. Further, we are developing a tool that can relate each year’s pelagic diatom collections to these lake-specific baselines in order to track the trajectory of each lake’s condition. For instance, a trajectory of degradation could be if diatom assemblages in Lake Erie are becoming more similar to assemblages observed from the 1960s. These new indicators and paleoecological applications will serve to address the myriad environmental issues that require long-term data in order to make critical remedial decisions.

**S02-04  Assessing degradation and recovery pathways in lakes impacted by eutrophication**

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Efforts to restore enriched lakes have increased yet there remains considerable uncertainty about whether restoration targets can be achieved and over what timescales one might expect to see improvement. Here, palaeoecological techniques are employed to examine the degree of impact and recovery in thirteen European lakes that have been subject to eutrophication and subsequent reduction in nutrient loading. The response of several diatom metrics is explored including percentage plankton, diversity, community composition and diatom-inferred total phosphorus concentrations.

Eleven sites exhibit progressive deviation from the reference sample (core bottom) prior to nutrient reduction. The shifts in diatom composition following reduction in nutrient loading are more equivocal, with a clear reversal towards the reference flora seen only in four of the deep lakes and one of the shallow lakes. The compositional changes are gradual suggesting that ecological recovery may take several years to decades. In the
remaining deep lakes, alternative nutrient sources would seem to explain the lack of apparent recovery. In three of the shallow lakes the diatom assemblages do not track back along the enrichment pathway following remediation but are replaced by a community associated with lower productivity. Hence, ecosystem recovery is not simply a reversal of the degradation process. The present assemblages remain different from those of the pre-enrichment samples in all sites.

By assessing ecological change over a centennial to decadal timescale, the study highlights the important role of paleolimnology in establishing a benchmark against which managers can evaluate the degree to which their restoration efforts are successful.

S02-05 Using local and regional paleolimnological studies to understand biological recovery from acidification in the Adirondacks (NY, USA) in the context of multiple stressors

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The Adirondack Park (NY, USA) contains more protected lakes than any other region in the continental United States. Despite little industrial development in the Park, many Adirondack lakes acidified during the 20th century. Since the implementation of the 1990 Clean Air Act Amendments, some lakes have begun to chemically recover from acidification. However, they continue to be exposed to multiple anthropogenic stressors, the most pervasive being climate warming. Therefore, questions remain as to how to best define targets for biological recovery. This presentation summarizes recent paleolimnological work that i) has identified biological recovery in acid-impacted Adirondack lakes and ii) provides a regional perspective on recent species changes. While modest biological recovery was identified in chemically recovering lakes (i.e. declines in acid-tolerant taxa as pH increased), the chrysophyte species assemblages did not appear to be returning to their pre-acidification state. A regional paleolimnological study was undertaken to contextualize these species changes. 32 lakes that show little exposure to acidification, eutrophication, and salinization were identified as reference lakes from a database of 1400 Adirondack lakes. A ‘top-bottom’ study found that these reference lakes showed pronounced shifts in chrysophyte species assemblages since ~1850, likely due to climate warming. Therefore, it is unlikely that recovering Adirondack lakes will return to their pre-acidification state, even with full chemical recovery. This study illustrates how pairing detailed paleolimnological studies of impacted lakes with broader regional surveys allows researchers to define reasonable recovery targets, a policy imperative as lakes worldwide continue to be increasingly influenced by multiple stressors.

S02-06 Lake response to anthropogenic impact: comparison of multi-proxy sediment record and historical evidence

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Rapid anthropogenic eutrophication in lakes raises concerns about lake ecosystem tolerance capacity and ability to recover. During the last decades, restoration programmes have been initiated to improve lake ecosystems and re-establish their natural conditions. In this study we used 200-year dataset to describe 20th century anthropogenic impact on small, highly trophic Lake Verevi. Series of paleolimnological proxies were used to describe lake natural conditions and lake development also for the time period when monitoring data are missing. Increase in pigments and change in Cladocera composition around 1850s suggested that the lake trophic level raised already before direct
urbanization on the lake shores which started around 1900. Simultaneous increase in erosion suggests that land-use around the lake on-going earlier and had clear effect on lake productivity. Second increase in algal production occurred around 1960s and it was connected with intensified sewage-contamination. Albeit, it didn’t remarkably influence the Cladocera population, pigments showed increase in cyanobacteria and sediment became enriched in authigenic carbonates. In 1980s, extremely high concentrations of sedimentary pigments, particularly those indicating the cyanobacteria blooms, corresponds with monitoring data by which the lake was under hypertrophic conditions. Rise in trophicity was concurrent with change in $\delta^{13}C_{\text{carb}}$ and $\delta^{18}O_{\text{carb}}$ values, what suggest that in highly productive lake also $\delta^{18}O_{\text{carb}}$ values are affected by lake productivity. New community structure of Cladocera and lower proportion of cyanobacteria at the end of 20th century after Lake Verevi underwent restoration management, could be a sign of improvement of the conditions in the lake.

S02-07 Anthropogenic and natural drivers of a long-term dynamics of submerged macrophytes in a shallow lake (Polesie Region, Eastern Poland) inferred from paleolimnological and documentary records

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Drainage of shallow lakes has been applied worldwide, however, the consequences of lowering the water level as a factor determining the entire sequence of further long-term changes occurring in lakes are studied to a very little extent. Due to the above, we analysed alterations that occurred in Kleszczów Lake (E Poland) and its catchment. In order to reconstruct the changes occurring in the lake, we conducted analyses of published data sets, historical maps, and lake sediment (chemical proxies, sedimentary algal pigments, diatoms, green algae, pollen, plant and animal macrofossil, chironomids and cladocerans) that allow for (i) tracking changes both in the terrestrial and water parts of the lake’s catchment and (ii) address the question about pre-disturbance conditions.

At the XVIII/XIX c. the lake sediments originated mostly from autochthonous matter with low C/N ratio. The lake maintained its low trophic status until 1950s. In 1908 the lake basin was incorporated into the network of drainage ditches which resulted in lake drawdown. This enhanced erosion from surrounding mires documented by raising humus content and presence of Sphagnum remains in the sediments. In the first half of the 20th century the phytoplankton generally did not contribute to the increased turbidity as suggested by scarce concentrations of all pigments in the sediment. The lake drawdown allowed charophytes and other submerged macrophytes for colonization almost all the central lake area. Macrophytes cover changed substantially due to both allogenic (natural – dry and wet periods and artificial – lake converted into reservoir, enhanced drainage) and autogenic (succession) reasons.

S02-08 Eutrophication-driven whole ecosystem change in a small calcareous lake, Cunswick Tarn, UK

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Eutrophication is a worldwide phenomenon affecting the ecology of water bodies, yet little is known of the timing, magnitude and characteristics of the resulting change in highly calcareous (marl) lakes. Further, their pre-disturbance condition is poorly defined. To fill this knowledge gap, a multi-proxy palaeolimnological study, combined with a two-year limnological monitoring programme, was undertaken at Cunswick Tarn (UK), a small, fishless eutrophic kettlehole lake. The study aimed to
characterise the centennial-scale eutrophication response of aquatic macrophyte, microalgal and invertebrate communities. Eutrophication-related changes in biological structure were rapid and dramatic. Species succession closely reflects changes in core carbonate concentration: increase over roughly a decade (post-1904) is associated with an increase in charophytes and plant-associated cladocerans. Decrease upcore (post-1920s) is associated with an increase in floating-leaved macrophytes and pelagic cladocerans that continues through to the core top where cyanobacteria and planktonic diatoms become more prevalent. Eutrophication involved a decline in macrophyte species richness (presently 3 submerged species) and a complete loss of charophytes, mirroring established patterns involving macrophyte responses to nutrient availability and light penetration. This pattern is not reproduced by fossil diatoms and cladocerans, with diversity (species number, Shannon index) generally increasing with nutrient enrichment despite qualitative community changes. This may reflect responses to food abundance, as diatoms and cladocerans are notorious for not showing high specificity to the structures of macrophyte communities or sediment. Overall, marl lakes seem particularly sensitive to eutrophication, and near-complete collapse of their characteristic ecology is possible with moderate levels of nutrient enrichment.

S02-09 Contrasting the effects of multiple stressors on Cladocera assemblages from shallow and deep lakes from Ontario (Canada)

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Fossil cladoceran remains preserved in sediment samples from 30 shallow oligotrophic lakes in south-central Ontario were examined and compared to a previously completed study of 41 deeper lakes from the same region to evaluate the nature and magnitude of assemblage changes from both modern and pre-industrial times. Additionally, relationships between present-day assemblages and key environmental variables were investigated using redundancy analysis, which identified that only lake area was a significant (p<0.01) predictor of assemblage composition in the shallow lakes. An ANOSIM was insignificant (p=0.8), indicating that modern assemblages from shallow lakes are not largely different from those of pre-industrial times. Not surprisingly, little change in relative abundances of select species was also detected using 1:1 plots. In summary, shallow lakes maintained relatively stable cladoceran assemblages, in spite of being subjected to multiple stressors, such as acidification, calcium decline, and climate change. Our results show striking differences from those of larger, deeper lakes in the same region, subjected to similar environmental stressors, where marked changes in cladocerans occur in both time and space. The relative stability of these invertebrate assemblages suggests that shallow lakes may be more resistant to ecological change in temperate regions, similar to findings recorded in algal indicators from shallow lakes.

S02-10 3D reconstruction of hypoxia from varve records in three large perialpine Lakes – Bourget, Annecy and Geneva (France – Switzerland) – over the last 100 years

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Spatio-temporal records of biochemical varves were investigated through a set of 80 cores taken from three large subalpine lakes – Lake Bourget, Lake Annecy and Lake Geneva – in French and Swiss Alps. The onsets of biochemical varves, respectively in AD 1933, AD 1950 and AD 1952, were confirmed to result from the exceeding of a threshold in
hypoxic conditions preventing the macro-benthic fauna from mixing sediments. Volumes of hypoxic water were then calculated by integrating the volume between the lake bottom and the depth of the shallowest varve-bearing core for each year since 1900 AD. Validation of the method was performed according to a 50 years monitored series data from Lake Geneva.

Our reconstructions confirmed that the onset of persistent hypoxia in the hypolimnion resulted from eutrophication due to nutrient-rich – especially phosphorus – water input from sewage water and/or diffuse contamination. However, despite massive efforts were initiated by local policies to counter excessive phosphorus inputs from the catchment, today hypoxia re-extends in the three lakes. We showed that cumulative effects derived from global warming could have reinforced the hypolimnetic hypoxic conditions in these lakes. It is hence possible that climatic factors drove fluctuations in hypoxia in a specific context where an equilibrium was initially broken due to a drastic shift in trophic state.

S02-P-01 Can the effects of climate and food web interactions observed in the sedimentary record be disentangled?

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We have initiated a project that studies the impacts of multiple environmental pressures – the effects of fish introductions and changing climate – on the food webs of three lakes located in northeastern subarctic Finland. The aim is to describe the development of food webs of these lakes in the past c. 50 years when, in addition to documented changes in the fish status, the average yearly temperatures have risen.

Our three study lakes are located inside the Värriö Strict Nature reserve. The lakes were naturally fishless, but only one remains fishless today. In 1980, brown trout (Salmo trutta) was introduced into the Lake Kuutsjärvi and Lake Välijärvi, former maintaining over-crowded fish population, while in Lake Välijärvi fish occurred in much lower abundance.

In Lake Kuutsjärvi the change in the abundance of Cladoceran zooplankton was clearly related to the timing of the fish introduction, while in nearby fishless reference lake the abundance of Cladoceran zooplankton remained constant. Also the diatom assemblage of Lake Kuutsjärvi reacted to the fish introduction by distinct decrease of the planktonic species Aulacoseira subarctica and the concomitant increase of Fragilaria pinnata. Although analyses of remains of invertebrates (chaoboridae, chironomidae, gammaridae) are still under way, we can say that the fish have had a strong impact on the food web structure and the native species. These results give us confidence that it could be possible to disentangle the sings of different environmental pressures in the sediment records.

S02-P-02 Varved Sediments in Onondaga Lake (NY, USA): A year by year record throughout the 19th and 20th centuries


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Varves dating back to 1822 were identified in a 1.8m-long sediment core taken from one of the world’s most polluted lakes, Onondaga Lake, Syracuse, NY. Paired dark and light laminae, from 0.3 to 1.0 cm thick, correspond to 137Cs horizons for 1954, 1959, and 1963, and to dated industrial impact events involving phosphorus, PAHs, calcium carbonate, mercury, lead, and other metals. Light laminae are carbonate-rich and contain white sub-laminae formed by calcite crystal precipitation in the lake (whiting events) during summer calcium
carbonate super-saturation. The dark laminae have higher relative abundance of allochthonous clay minerals and represent fall through spring deposition. Changes in varve appearance and shifts in the Sr/Ca ratio can be used to divide the sediment column into ten units, indicative of interplay between heavy in-lake production of calcium carbonate during post-1900 lake hypereutrophy and the more “normal” influence of watershed runoff during the less productive 1800s and 2000s, the latter as the lake has recovered to borderline mesotrophy.

Varve stratigraphy is the basis for a historical water quality analysis of Onondaga Lake. The results of diatom and chironomid inference models for total phosphorus and dissolved oxygen are compared to hindcast predictions from mechanistic water quality models in an ensemble validation approach. The comparison indicates pre-1800 Onondaga Lake experienced summer epilimnetic phosphorus levels from 5.0 to 9.0 µg/l, ranging into low mesotrophy with the natural variability of annual hydrological conditions. At least a few weeks of anoxia occurred at the bottom of the lake each year.

S02-P-03 Large combined datasets for addressing paleoecological questions: Advantages, examples, and importance of archiving data

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Large combined paleoecological datasets are used with increasing frequency to address questions on a regional basis and to develop more refined metrics and study-specific data analysis approaches. Datasets typically include information on diatoms, ostracods, pollen, chemistry, and chronology, among other characteristics. These types of datasets will grow more rapidly because of the advantages of larger datasets and because funding agencies are strengthening requirements that study data be archived and made more widely available. However, the process of archiving data is typically time consuming and confusing for potential database contributors because of lack of commonly accepted data standards, automated procedures, and planning for archiving at the project design stage. As part of the Diatom Paleolimnology Data Cooperative, and now the Neotoma paleoecology database, we and collaborators have developed new approaches, resources and guidelines to make it easier for contributors to archive and use diatom and related paleo data. These include an algae taxa list and the ANSP Algae Image Database (diatom.ansp.org). The taxa list was developed over many years and supported and used by the US Geological Survey National Water-Quality Assessment program and the US Environmental Protection Agency’s National Lake Assessment. The associated sample codes and taxonomic system designations makes it possible to map taxonomic systems to each other and to account for changes over time. Data entry to the Neotoma database will use the Tilia program, commonly used by paleoecologists for a wide variety of paleo data.

S02-P-04 Calibrating the biological record in Nylandssjön (N. Sweden): to what extent do preserved diatoms in the lake sediments reflect seasonal biological processes?

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Within the paleolimnological research community it is often taken for granted that a sediment core collected from the deepest point of a lake adequately reflects the prevailing biota (e.g. diatoms). Very few studies exist that explicitly investigate to which extent the biological assemblage in the water body is reflected by the assemblage preserved in the sediment. The varved sediment record of Lake Nylandssjön allows a comprehensive analysis at annual and even seasonal scale. During the past ten years a monitoring program (bi-weekly plankton survey, sequential sediment trap, sediment freeze-coring) was established to test whether the diatom succession in the water column is reflected
accurately in the sediment trap and the varved sediment.

Initial analyses show a diatom assemblage dominated by *Asterionella formosa*, *Tabellaria flocculosa* and *Fragilaria* taxa in the sediment trap and the plankton samples, revealing large shifts from season to season, but also from year to year. Compared to the plankton samples, peaks and seasonal shifts of key taxa in the sediment trap are less pronounced and can occur with a time lag. To understand the sedimentation of diatoms, the seasonal dynamics in the water column will be compared to the diatom record in the varved sediments from the last decade. Ultimately, the high resolution diatom record will also be investigated in relation to environmental variables such as weather, water chemistry and catchment processes.

**S02-P-05 Brown trout (*Salmo trutta*) introduction into naturally fishless lake – food web implications using subfossil Cladocera**

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Fish introductions into small, naturally fishless lakes can have profound effects on the food web structure and ecosystem functioning. The impacts of fish introductions have rarely been studied in northern Finland, and very few data exists on these aquatic ecosystems before the fish. Brown trout is one of the most popular game fish in northern Finland, and it has been widely stocked as a common practise for at least centuries. Our project in north-eastern Finnish Lapland studies the responses of northern aquatic ecosystems to trout introduction by combining limnological and paleolimnological methods. In this presentation I compare the subfossil Cladoceran community dynamics of two lakes during the past c. 100 years. The other lake is naturally fishless but has experienced documented trout introduction in 1980, and the other lake, situated close by, has remained naturally fishless. Cladoceran species assemblage and abundance in the fishless lake have not changed during the study period. Cladocera in the stocked lake, on the other hand, show a profound increase in abundance after the fish. Morphology of *Eubosmina* spp. (carapace size, length of mucrones and antennules) indicate differences in the food webs of the lakes. Combined information from all proxies used in the project indicates that the impact of trout on the lake ecosystem has come both via top-down (trout predation on *Gammarus* sp.) and bottom-up (increased nutrients and nutrient recycling rate) mechanisms. Rise in the mean annual temperatures in the area don’t seem to have affected the lake ecosystems.

**S02-P-06 Tracking human-mediated changes in a lake ecosystem with fluorescence and absorption spectroscopies**

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We demonstrate the feasibility of using fluorescence and absorption spectroscopies (FAS) on sediment pore water samples to detect retrospectively organic pollution and changes in a lake’s trophic status. The method was tested on a small (surface area 4.8 ha), deep (mean 6.1 m, maximum 16.9 m) stratified Lake Pappjärv (57°49′00″ N, 27°01′55″ E; Estonia). A 60-cm core was examined. The dating of the sediments by ${}^{210}$Pb, ${}^{137}$Cs and ${}^{241}$Am measurements and by counting annual laminations revealed that this core covers the last 200 years. Lake Pappjärv was influenced by several human activities during the 20th century. In 1950–1960 a bitumen plant, mineral fertilizer storage tanks and a sand and salt mixing site for winter road services were established on the lakeshore. Wastes from these establishments flowed directly into the lake, causing drastic alterations in its ecosystem. Data obtained by FAS corresponded well with age-resolved profiles of chemical (polycyclic aromatic hydrocarbons and oils) and biological (sub-fossil diatom remains) indicators obtained by traditional chemical and palaeolimnological analyses. Thus, FAS can be considered as a useful tool for high-resolution
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screening purposes. The FAS measurements also revealed a qualitative and quantitative shift in the sedimentary organic matter already in the mid-1800s, which was not expressed in other palaeoindicators. Old maps indicate that then large areas around the lake were deforested, which probably caused an increase of terrestrial runoff into the lake.

S02-P-07 Assessing ecosystem integrity through the palaeoecology of lakes in Riding Mountain National Park, Manitoba, Canada

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A principal mission of Parks Canada is preservation of ecosystem integrity in Canadian national parks. Palaeoecological records preserve a rich archive recording the natural, pre-European settlement condition of park ecosystems, and consequently are essential tools for assessing the integrity of such protected areas. Surface samples and sediment cores were extracted from lakes in Riding Mountain National Park and the surrounding region to assess their ecosystem integrity. Fossil diatom and midge assemblages in Clear Lake, and fossil diatoms in Lake Katherine, were assessed in relation to lake trophic status. Multivariate statistical methods confirmed total phosphorus as the environmental variable most closely related to modern diatom distributions in the region; thus, diatom-phosphorus transfer functions were developed and applied to reconstruct historical and pre-historical total phosphorus (TP) and lake trophic state. Paleolimnological assessments of Clear Lake and Lake Katherine revealed a natural borderline oligo-mesotrophic state. Although midge communities remained stable following European settlement and park establishment, diatom assemblages revealed pronounced changes, potentially related to forest clearance, logging and, more recently, expanded recreational activities, cottage and golf course development, and sewage. The reconstructed phosphorus history is somewhat unclear. TP may remain at natural or near natural levels, but diatom communities have not returned to their pre-settlement composition, indicating that biotic conditions have been altered.

S02-P-08 Providing the context for the recent collapse of the Great Lakes food web through retrospective analyses

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The Environmental Protection Agency (EPA) is now in its 27th year of comprehensive monitoring of the Laurentian Great Lakes. Pelagic monitoring includes physical and chemical parameters, phytoplankton, zooplankton, benthic invertebrates and other measurements for contemporary research. Pelagic monitoring in the Great Lakes has revealed significant changes in biological and water quality conditions, particularly within the last decade. Major drivers in these changes appear to be establishment of non-native filter feeders, shifts in chemical parameters such as nutrients and chloride and climate-related changes such as increased water temperature, less ice and longer periods of stratification. Unfortunately, causal mechanisms for recent, dramatic declines in phytoplankton and invertebrates in the upper lakes (Superior, Huron and Michigan) remain uncertain. Also, massive blooms of diatoms and cyanophytes in Lake Erie are not fully understood. Trends in Great Lakes phytoplankton are provided to illustrate the magnitude of these recent changes. Trends in other organisms and chemical parameters are also analyzed to identify relationships among trophic levels. New findings on possible causal factors and remaining unknowns are summarized.

While these trends substantiate the importance of long-term monitoring for phytoplankton, contemporary monitoring alone will not answer the
important questions in the management of environmental conditions. So, a new effort to collect and analyze sediment cores for the Great Lakes has been initiated. Diatom-based algal indicators, which are especially suited to paleolimnology, are anticipated to serve in addressing the issues that require long-term data in order to make critical remedial decisions in the Great Lakes.

S02-P-09 Paleolimnological assessments of reference conditions and biological integrity using benthic animals: a case study from Lake Tiiläänjärvi (Askola, Finland)

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In this study, we aim to demonstrate the value of fossil animal remains in assessments of limnoecological reference conditions. The case study site, clay-turbid Lake Tiiläänjärvi in Askola, southern Finland, suffers from hypereutrophic conditions and late-winter and end-of-summer anoxia. The retrieved sediment record revealed a succession from oligo-mesotrophic to eutrophic community that finally reached hypereutrophic climax community. The reference state was characterized by stable ecological conditions, but the biological integrity was completely lost in the upper part of the sediment profile. The number of taxa markedly decreased following the nutrient enrichment and only one taxon, tolerant of temporary anoxia, remained in the surface sample. Midge-based quantitative reconstruction of autumnal total phosphorus showed an identical trend compared to sediment characteristics, which correspond to increased land-use and other anthropogenic activities in the catchment. The inferred values for the reference state indicated mesotrophic conditions, which are typical for ‘pristine’ clay-turbid lakes in southern Finland, and a subsequent increase to eutrophic conditions, with hypereutrophic state reached at the top of the core. This development corresponds with the instrumentally monitored development since 1978, although the sediment chronology remains to be adequately established. The results support the theory that fossil remains of invertebrates provide a useful tool for assessments of lake reference conditions and biological integrity. Therefore, it can be recommended that the paleolimnological approach and the application of benthic invertebrate remains should be put to better use in local and regional lake management for determining baseline conditions.

S02-P-10 Tracking the effectiveness of lanthanum-saturated bentonite clay as a management strategy for increased nutrients in aquatic systems: an applied paleolimnological approach

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Lake Simcoe, the largest (722 km²) inland lake in southern Ontario, Canada, has been detrimentally affected by increased nutrient inputs resulting from anthropogenic activities. In addition to increases in aquatic plant biomass and algal blooms, decreases in deep-water oxygen have resulted in a loss of coldwater fish habitat, recruitment failures in key species (e.g. lake trout and lake whitefish), and the release of stored phosphorus (P) from sediment sources. In our efforts to reach remediation goals of decreased P loading, the use of lanthanum-saturated, modified bentonite clay (brand name PhoslockTM) to remove P from the water column was investigated at three storm water pond test sites in the Lake Simcoe watershed. While short-term (~14 days) environmental monitoring is required during the testing and application of PhoslockTM, there have been no studies which investigate the long-term (month to year) consequences and efficacy of this product in remediating P-enriched, Canadian temperate-region lakes. Using a paleolimnological approach, this study will enable the assessment of long-term environmental changes in these storm water ponds, account for long-term natural variation, and compare changes in P concentration and algal assemblages before and after PhoslockTM
application. Preliminary results suggest PhoslockTM does reduce P loading in these systems; however, the effects can be short-lived in water bodies with low water residence times.

S02-P-11 Oxygen and carbon isotope record of the Eemian Interglacial (MIS 5e) in Poland based on lake carbonates

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The results of oxygen and carbon stable isotope investigations of eight Eemian (MIS 5e) lacustrine sediments from Poland are presented. The values of $\delta^{18}$O changed from ca. −11 to −1‰, and $\delta^{13}$C values oscillated between −3.5 and +7.0‰. The isotopic record correlated well with pollen, cladoceran, and diatom data that characterized the palaeolake environment, and the evolution of the palaeolakes in Poland was reconstructed. The palaeolakes originated during the final phase of the Wartanian (Late Saalian) Glaciation. The $\delta^{18}$O and $\delta^{13}$C values of that time reflect the input of detrital carbonates into the basins. The boundary between the glaciation and the interglacial period is expressed by a significant decrease in $\delta^{18}$O and $\delta^{13}$C values. During the early Eemian, a positive trend in $\delta^{18}$O values confirms the gradual climatic changes. The Eemian optimum is characterized by constant $\delta^{18}$O and $\delta^{13}$C values. During the Early Vistulian (Weichselian) Glaciation, the palaeolake declined. The varying $\delta^{18}$O values likely reflect frequent changes in water balance between precipitation and evaporation associated with an influence of marine circulation. The fluctuations of the isotopic curves in the upper parts of the successions (the post-optimum) were caused by a shallowing of the basin by infilling with sediments. The observed shifts in the isotopic curves are due to the proximity of the Baltic Sea and earlier strong oceanic influences.

S02-P-12 Reconstruction of the ecological conditions of Lake Garda (Italy) in relation with human impacts over the last two centuries

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Lake Garda is one of the four large Central European lakes included in the EuLakes Project (Reg. Nr. 2CE243P3). The main objectives are to evaluate the lake vulnerability against specific human stressors in a climate change scenario, and to promote sustainable lake management. Lake Garda is the largest lake in Italy. The deep basin (350 m) is little impacted by human activities and is suitable for reconstruction of long-term environmental variability. In contrast, the shallow basin (81 m) is strongly affected by human activities and is for this reason more suitable for studying lake eutrophication. A consistent monitoring program was started in the early 1990s. Before that, only sporadic limnological measurements are available. Lake sediment records provide a complementary source of information to extend the time span of ecological records back into the past, through the reconstruction of secular lake evolution. Radiometric dating, geochemical (water and LOI content) and biological proxies (algal pigments and diatoms) are being analysed in one short core (56 cm) retrieved from the deepest part of the lake.

Initial analyses of the sub-fossil diatom assemblages during the 20th century show two major changes. The first one, recorded around 1960, is an increase in the relative abundance of planktonic Fragilariaceae, whereas centric taxa decrease suggesting a nutrient enrichment. The second change, in mid 1940s, consists of a decrease in benthic taxa, which may be related with the intensive hydroelectrical exploitation of the catchment area. A preliminary diatom-based, quantitative reconstruction of TP concentration over the last 200 years shows good agreement with monitoring data.
S02-P-13 Multi-proxy paleolimnological analyses provide evidence of early Holocene aridity in the Midwestern United States

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This study focuses on developing, well-constrained, high-resolution records of hydroclimatology for the Midwestern U.S. during the mid-Holocene. Although the mid-Holocene is an imperfect analogue of future conditions, improving our understanding of Midwestern U.S. climate conditions during this interval will provide valuable insight to the possible nature of future conditions and the potential feedbacks that may be important in future warm climate scenarios. Multi-proxy paleolimnological analyses of sediment sequences recovered from Brown’s Lake and Smoot Lake, two small lakes in central Ohio, was undertaken to develop new regional records of paleohydrology for this region. The sediment cores were chronologically constrained using AMS 

\(^{14}\)C dating. The cores were analyzed for organic content (estimated using LOI), C:N and sub-fossil midges. Transects of surface samples were also collected at each lake to help with the downcore interpretation of LOI, C:N and midge assemblages. The results of this study identified the existence of notable fluctuations in lake level (effective moisture) through the Holocene in central Ohio. Decreases in LOI, CN and % littoral midge taxa during the early Holocene (9500-7000 yr BP) suggest this interval was characterized by a period of extensive aridity, corresponding to the early Holocene drying identified in the Great Plains and western portion of the Midwestern United States. Increases in LOI, CN and % littoral midge taxa indicate increasing effective moisture characterized this region during the mid-Holocene (7000-4500 yr BP). Fluctuating hydroclimate conditions characterize the late Holocene, with CN de-coupling from LOI and faunal abundance data. These new records of hydroclimate will be used in a preliminarily comparison of proxy-model simulations of Holocene climate for the region.

S02-P-14 Developing a palaeoenvironmental history for Egypt’s largest remaining natural inland lake, Lake Qarun

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Geoarchaeological and palaeolimnological studies of Lake Qarun have shed much light on its development through the Holocene. Lake levels are known to have fluctuated widely in relation to climate and hydrological changes. However, a full chronological record for the Holocene remains elusive and several long sediment cores were recovered (2008/10) to obtain a continuous sediment record.

A 21 m long core (QARU9, 2008) comprised basal sands below finely laminated lake sediment (to 17.3 m depth). Diatom analysis in thin section revealed that this section was varved while the diatom stratigraphy of the whole core indicated rapid filling following a deep lake phase in the early Holocene. Geochemistry reflects the stratigraphy with the sandy basal sediment being rich in feldspar and zircon. Overlying laminated sediment (with planktonic diatom varves) is dominated by clays/micas with low K:Rb. Above c.17 m, the sediment is less calcareous with increasing K:Rb and low volcanic contributions. Geochemistry of most recent sediments indicates more volcanic minerals and a higher energy system with feldspars and zircon spikes and more magnetic minerals.

Dating remains a critical problem for QARU9 but a calibrated radiocarbon date on fibrous material from the beginning of the laminated sediments indicated that the lake rapidly expanded in the early Holocene wet period (c. 10k year BP). The occurrence of varved lake sediments during Lake Qarun’s early Holocene deep-lake phase provides a remarkable palaeo-environmental archive for northeast Africa.
S02-P-15 A paleolimnological record of 200 years of human influence on Onondaga Lake, USA: chironomid inferences of hypolimnetic oxygen

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Onondaga Lake, located in New York State in the northeastern USA, has been described as the nation’s most polluted lake. Onondaga Lake has been settled by Europeans since the colonial era, and substantial human activity was already underway by the 1790s, involving mining of salt brines from natural springs, and the watershed was heavily industrialized by the late 19th century as the City of Syracuse expanded along its shorelines. The coldwater fishery had collapsed by the 1890s, and ice harvesting was banned by 1901. Paleolimnological records of subfossil chironomid assemblages from a 210Pb dated core indicate that Onondaga Lake naturally had periods of anoxia and hypoxia in the 18th century, as assemblages were dominated by Chironomus anthracinus type, however, assemblages also contained oligotrophic taxa such as Micropsectra. Chironomid assemblages suggest that hypolimnetic conditions responded quickly to human disturbance, as oligotrophic taxa had disappeared by the 1820s, and there was a coincident collapse in chironomid head capsule abundances. Chironomid inferences agree with diatom and ostracod inferences of lake response to human activities and lake eutrophication. Steep basin morphometry, with lake conditions that were naturally anoxic/hypoxic, may have made the lake’s benthos particularly vulnerable to increased hypolimnetic oxygen depletion in response to human disturbances.

S02-P-16 Lake transformations within the last millennium recorded in sediments based on subfossil Cladocera (North and Central Europe)

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Cladocera remains were analysed in five lakes: Moczadło, Sierzywk, Charzykowskie (N Poland), Kevojärvi, and Petäijlampi (NE Finland). Main objective of the study presented was to extend the knowledge on the Late Holocene zooplankton in oligo-, meso-, and eutrophic lakes located in Central and Northern Europe. In the Late Holocene the trophic status of many lakes changed. The process depended on the climate and human influence. Particularly in Poland, lakes are under a strong impact of human activity. The lakes of North Finland are more isolated, and mostly influenced by the climate. In spite of that, all of the lakes studied showed distinctive changes in the trophic status. Within the last millennium, the number of Cladocera species increased in all of the lakes, but in Finnish lakes, the number of individuals was much lower than in Polish lakes. In the larger Polish lakes (Charzykowskie and Moczadło), the trophic status changed from oligo- to mesotrophic, and in the small lake (Sierzywk) to highly eutrophic. This was mainly the effect of human activity. In the Finnish lakes, the Cladocera from sediments deposited within the last 30-50 years suggested a recent increase in the trophic status. Higher number of Bosmina longirostris individuals and the presence of Pleroxus uncinatus typical of water with a higher trophy suggest a contemporary increase in the amount of nutrients in the waters. The increase could result from the climate warming leading to faster melting of snow and ice as well as transport of nutrients.
S02-P-17  How to restore the eutrophic and anoxic Lake Muzzano? A first paleo-perspective in a Swiss Lake

1 Larocque-Tobler, I., 2OIKOS 2000 team, 3Rabes, S.P.

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Lake Muzzano (45°59′50″N 8°55′41″E, 337 m a.s.l.) is a shallow (3.2 m), anoxic and eutrophied lake. Its surface is 2.2 km². The lake is surround by three villages: Muzzano (population: 751), Sorengo (1706), Bioggio (2379), Agno (3981) and Collina d’Oro (4217). The lake has three major and four temporary inlets and it drains to Lake Lugano. Lake Muzzano has experienced two major fish-kill episodes in 1967 and 2003, and is regularly covered by cm-think Microcystis blooms in summer. A bypass was installed in 1999 but the problems remain. It was hypothesized that phosphorus is released from the sediment during periods of mixing due to high winds. Removal of the sediment was proposed as a remediation solution. ProNatura, a privately-funded operation for environmental protection, owns the lake and prefers finding the best solution for restoration which would conserve the lake’s unique state and biodiversity. To determine which remediation solution(s) would be the best, neo- and paleo-limnology are being used. Monthly measurements of flow and phosphorus input in affluants, re-suspension of phosphorus from the sediment, physico-chemical parameters in the affluants and in the lake and diatoms, chironomids and LOI in a 44-cm core for the past 300 years to define the baseline conditions are being made. Berilium-7 was measured at three times in the sediment to determine if the sediment in the traps was recent material, or resuspended from the bottom sediment. Results will be presented and input from colleagues would be of high importance for the continuation of this project.
Session 03 - Lurking beneath the surface: decadal to millennial scale records of environmental pollution

S03-KN  Past Environmental Pollution and Vegetation Changes Caused by Ancient Mining Activities in the Eastern Alps
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In the Eastern Alps mining for thousands of years had a formative effect on the cultural landscape and the natural vegetation. Usually such sustainable changes are recorded by pollen analysis, but the pollen signal of mining is a composite signal of both settlement activities and mining. The crucial problem in the evaluation of the pollen record is the segregation of these two components. Here we present a multi-proxy approach by pollen, geochemistry and historical data to separate these two components. Pollen and geochemical analyses reveal the vegetation development in a mining district since the onset of Mediaeval and Early Modern Times, which is validated by historical data on the demography of miners and silver production volumes in the mining district. By these means vegetation changes directly connected to mining are detected. Furthermore, such mining induced vegetation changes are observed also in prehistory and combined with geochemical analyses they disclose past environmental pollution and mining phases in the Eastern Alps.

S03-01  Long term (17,000 years) natural variability of mercury accumulation in Lake Hambre (53 °S) – the role of soil leaching and organic matter accumulation
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Mercury transport from soils into lakes is a crucial process for Hg enrichment in the lake’s food chain, however, little is known about controlling factors and long term variability. We investigated a record of 17,000 years of mercury, organic matter and trace element accumulation in sediments, of a remote lake system in southern Patagonia (53 °S), Chile. In addition, sources of organic matter were examined based on N/C ratios and Rock Eval© analysis (HI- and OI indices.

The sediment record indicates profound environmental and climatic changes throughout the past 17,000 years. On a long term, accumulation of sediment organic matter increased by a factor of ~ 3 reflecting a strong increase of organic matter accumulation in catchment soils. Long term mercury accumulation rates in sediments remained nearly constant (median 29 µg m⁻² yr⁻¹), although short term changes vary in a wide range between 10 to 157 µg m⁻² yr⁻¹. Principal Component Analyses reveal striking covariance of mercury with other organically bound elements in soils such as copper or yttrium, but only a weak relation to total organic matter accumulation. Our data suggests similar long term atmospheric Hg fluxes, but short term changes in soil leaching of organically bound metals attributed to changes in climatic conditions (precipitation). Moreover, changes in organic matter sources as indicated by C/N ratios and Rock Eval© data, reveal that mercury scavenging by algal derived organic matter may enforce mercury accumulation during wetter periods, but is not a controlling factor.

S03-02  Filling the gaps in the history of past mining and metal production by combining archaeology and paleolimnology
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Lake-sediment records preserve a continuous record of environmental changes, which can be a powerful complement in archaeological investigations. A recent archaeological investigation of the copper-cobalt mines at Gladhammar, southeast Sweden,
which first appear in the historical record AD 1525, yielded radiocarbon dates mostly in the historical period from the 16th to 19th centuries, but also provided indication of mining activities already in the 14th century. In collaboration with this work, we analyzed two sediment records; one (Tjursbosjön) from a lake down-slope of the mines and a second (Hyttegöl) from a lake downstream of a blast furnace site from the historical period. Our analyses included multi-element geochemistry (WD-XRF), lead isotopes and pollen. The major impact in the sediment records likewise occurs in the historical period, such as a 500-fold increase in copper, loss of forest cover and an expansion in agriculture. However, the records show a clear impact already in the 12th–13th centuries with a 2–10-fold increase in lead and copper, evidence of erosion in Hyttegöl, downstream of the historical furnace, and increasing charcoal particles. The lead isotope analyses indicate an influence of regional ores as early as the 9th–10th centuries, but the change in composition cannot be linked to other changes in the sediment records. Importantly, this early sediment evidence during the 9th–14th centuries is supported by a few radiocarbon dates, which on their own were considered as vague or improbable outliers by archaeologists.

S03-03  An integrated lake-catchment approach to reconstruct land use changes and pollution history at Aqualate Mere, Central England, UK

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This paper uses a lake-catchment approach to reconstruct land use changes and pollution history at Aqualate Mere in central England. The Mere is a shallow lake (max water depth c. 1m) and is designated a Site of Special Scientific Interest and National Nature Reserve. Formed in a kettle hole since the last glacial period, it holds c. 11 m depth of sediment and regionally provides a unique archive of Holocene environmental change. Radiocarbon, $^{137}$Cs and $^{210}$Pb dating and the distribution of Spheroidal Carbonaceous Particles (SCPs) suggest that the upper 5 metres of sediment accumulated over the past three millennia with an acceleration of sedimentation in the last 200 years. In this paper we use multi-proxy data to reconstruct and investigate the influence of human activities (namely agriculture and metallurgy) on the Mere and its catchment. High resolution pollen and non-pollen palynomorph data provides evidence for woodland clearance and agriculture which intensified during the Roman period, whilst more recent changes match historical documentary evidence of landscaping, tree plantations and industrial pollution. High percentages of Anabaena, a cyanobacteria, and changes in diatom populations suggest that such activities promoted more eutrophic conditions in the Mere; an interpretation supported by the likely increase in bacterial magnetite as reflected in time-synchronous changes in mineral magnetic signatures. Sediment chemistry also provides evidence of regional lead pollution during the Late Bronze Age, the Roman period and the last c. 200 years. Mineral magnetic data and radionuclide signatures of potential catchment sources and Mere sediments proved to be relatively poor discriminators of catchment sources suggesting that, except for the past 200 years, the Mere sediment was autochthonous and perhaps dominated in recent times by a high atmospheric pollution load. The results of our investigation suggest that human impact on the Mere has been considerable since late prehistoric times. A detailed appraisal of both catchment sources and lake sediments is important to understand the interplay of human activities on long term records of environmental change and to fully understand the external and internal processes that can impact on a lake which can then be used to develop effective catchment management strategies.

S03-04  Urban lakes and the sedimentary record of trace metal pollution

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Few studies of metal pollution in lakes have been carried out in urban environments. The sources of
metals to urban lakes are complex and are comprised of atmospheric deposition, direct inputs and runoff from the surrounding catchment. Interpretation of urban lake records is therefore more complicated than for lakes that are remote from industry and transport. Sediment cores were taken from seven lakes across London to evaluate the use of urban sediments in palaeolimnological reconstructions. Concentrations of Ni, Cu, Zn, As, Pb and Hg were determined, and the cores were dated using radiometric methods and SCP analysis. High sediment accumulation rates and interruptions to the sediment record made it difficult to determine chronologies at the sites. Differences in sediment accumulation, metal behaviour and the complex mixture of sources meant that any regional trends in contamination were masked, and the cores primarily reflected local influences. Therefore, the use of a single urban lake as a record of metal pollution may not accurately reflect that of the city as a whole. However, data from contaminated environments is important for other reasons. Across all sites metal concentrations were very high, with concentrations exceeding guideline values both in the past and at present. At various times the concentration of Pb had reached levels that were over 2000% higher than the guideline value. Increasing levels of enrichment and flux towards the surface of the cores also showed that contamination was not declining. Such highly polluted sediments have important implications for ecosystems and toxicity.

S03-05  

_Daphnia_ community responses to historic trace metal pollution and eutrophication

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Humans have dramatically altered the environment over the past century, often with quite unknown consequences for the resident species. Two widespread consequences of human activity include the release and accumulation of persistent contaminants as well as the eutrophication of water bodies. Using historic data, I chose a set of five lakes in Connecticut, USA, which experienced varying extremes in nutrient input over the past 80 years. I reconstructed historic accumulation of trace metal pollution (Pb, Hg, Zn, Cd, Cu, Cr) over the past century in sediments of these lakes. Metals accumulated to differing degrees and during different time periods across the lakes. In some cases, metal peaks far preceded the period of eutrophication, while in others the pollution events coincided temporally. Two lakes that have remained oligotrophic over the past several decades have experienced accumulation of some metals (Hg, Pb, Cd), but have remained relatively uncontaminated by others. I hatched _Daphnia_ from resting egg banks to examine ecological responses to these varying pollution histories. The most resilient species, _Daphnia ambiguа_, occurred in all of the lakes, during time periods experiencing both high and low levels of metal and nutrient pollution. Other species occurred less frequently and more often during more polluted time periods. Future research will examine historic phytoplankton community changes through fossil pigment extraction. I will also measure evolutionary responses of _Daphnia ambiguа_ to metal pollution and cyanobacteria across lakes with varying histories of these stressors.

S03-06  Aquatic ecosystem recovery from extreme acidification and metal contamination in lakes of northern Ontario, Canada

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Mining and its related industries have a long tradition in the province of Ontario (Canada), as do concerns regarding their environmental impacts. Recent discoveries of an extensive chromite deposit in northern Ontario’s “Ring of Fire” region have raised questions regarding how best to evaluate the impacts of proposed industrial developments within the context of a changing climate. Furthermore, there is a renewed interest in understanding biological recovery trajectories from acidification...
Here we examine a series of circumneutral lakes northeast of Wawa, Ontario, that were strongly acidified (pH 3-4) by SO₂ emissions from a nearby iron sintering plant. Following the plant’s closure in 1998, lakewater pH has returned (at a remarkably fast rate) to circumneutral conditions due to the high buffering capacity of the local geology. Paleolimnological analyses of dated sediment cores have detected some biological recovery among algal communities (diatoms and chrysophytes), although not to their pre-impact assemblages. Similarly, recent cladoceran sedimentary assemblages from three impacted lakes remain in an altered state relative to the pre-impact period (e.g. increased relative abundances of *Chydorus brevilabris* and reduced cladoceran density in sediments). Collectively, the multi-proxy paleolimnological analyses of these markedly acidified lakes demonstrate delayed biological recovery from acidification at higher trophic levels, despite the near-elimination of acid deposition a decade prior, which led to a striking recovery in lakewater pH and increased food availability.

**S03-P-01 How lake sediments record air pollution – using mercury as an example**

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Lake sediments as archives have been widely used to reconstruct atmospheric pollution history for many years. This paper demonstrated why lake sediments can be used in this way and how accurate the reconstructed pollution histories are, by looking at Hg contributions from atmospheric direct deposition and catchment inputs into the lake sediments through time in four regions of the world. It shows that fractions of catchment contribution to Hg in lake sediments vary significantly in different regions, and even in different lakes in the same region. However, fractions of atmospheric direct deposition contribution to the Hg in the sediments of a lake can be relatively constant through time, which forms the foundation of using lake sediment to reconstruct the trends of air pollution history. It also discussed some potential factors such as rapid deposition reduction, catchment stability and biomass change within a lake, which could challenge use of lake sediment records to reconstruct air pollution history. Mercury sediment records have been used for estimating atmospheric deposition fluxes in the region by using the Swain model. However, this model may underestimate the real Hg deposition fluxes as it does not put Hg losses through outflow and evasion from lake surface into the account. The paper used measured data to reveal that Hg loss through outflow could considerably reduce the estimated atmospheric deposition flux, while Hg evasion from the water surface should be added to the estimated value.

**S03-P-02 Anthropogenic mercury signals in lake sediments from southernmost Patagonia (Chile)**

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Environmental archive studies from the Northern Hemisphere reveal an increase in atmospheric mercury fluxes by a factor of about 3-5 since the Industrial Revolution. Comparable studies, which investigate the increase in atmospheric Hg fluxes in the Southern Hemisphere, are scarce. In the present study we investigated three remote lakes in southernmost Chile (Patagonia) for past changes in sedimentary mercury accumulation. Mercury accumulation increased during the past 100 years, but varying rates of soil erosion within the past 200 years caused significant variations in the soil-derived mercury flux. Correction for background mercury fluxes derived from atmospheric deposition and soil erosion was carried out using zirconium as a conservative tracer of mineral material. Independent from soil erosion mercury accumulation increased by a factor of 1.2-2.3 compared to pre-1850 AD, which is attributed to an increase in the atmospheric deposition of anthropogenic mercury. These values indicate an increase in atmospheric mercury deposition, which is in the lower range of predictions derived from global mercury models.
Based on the mercury/zirconium ratios absolute values of anthropogenic mercury accumulation in the sediments were calculated. They peaked between 1970 and 1990 AD (2-3 µg m$^{-2}$ yr$^{-1}$) and have been decreasing since then.

**S03-P-03 A Holocene paleolimnological record from a long-term monitoring site in Central Ontario, Canada**

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Anthropogenic disturbances in the 21st century such as climate warming, land use change and air pollution leading to acidification stress aquatic ecosystems. The Turkey Lakes Watershed (TLW), a long-term monitoring site, was established in 1980 in central Ontario to track the effects of these changes on the physical, biological and chemical characteristics of aquatic ecosystems. The goal of our study is to develop a paleolimnological record from the site to provide long-term context for the recent changes. The period of overlap between the monitoring and the paleo-data can be used to help calibrate the indicators. A Holocene lake sediment record spanning 7000 years from Wishart Lake (surface area 19.2 ha; maximum depth 4.5 m) in the TLW includes radiometric dating of surface and Holocene sections, loss-on-ignition, analysis of diatoms assemblages and enumeration of chrysophyte cysts. The average percent organic matter estimated by loss-on-ignition for Wishart Lake sediments was ~40%; inorganic carbon was low (less than 4%). The record is characterized by changing diatom communities. The middle Holocene (7210-6220 cal yrs BP) sediments were dominated by benthic diatoms. *Fragilaria* spp. increased between 5430-1090 cal yrs BP and *Tabellaria flocculosa* increased after 3760 cal yr BP. Increases in planktonic *Cyclotella* spp. occurred in most recent sediments (0-180 cal yrs BP). The record indicates some sensitivity of diatom assemblages to lake ontogeny and recent climate warming. However, possibly due to some buffering capacity in soils of the watershed, significant recent acidification of the lake has not taken place despite nearby industrial air pollution.

**S03-P-04 Paleoenvironmental gradient distribution of subfossil diatoms from a central Chilean wetland**

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*Contribution to POSTDOCTORAL FONDECYT project 3120012; 1Department of Ecology, Pontificia Universidad Católica de Chile, Alameda, 340 2° Of. 206, 6513677; 2Institute of Ecology and Biodiversity (IEB)-Santiago, Chile; 3Laboratorio Internacional de Cambio Global (LINCGLOBAL), PUC-CSIC; 4Instituto Pirenaico de Ecología –CSIC Zaragoza, España; 5Universidad de La Serena, Chile; 6Centro de Estudios Avanzados en Zonas Aridas (CEAZA); 7Universidad Austral de Chile

Central Chile is well known as a biodiversity hotspot yet lacks studies on inland aquatic biota. Ciénagas del Name wetland (35°45.024’S-72° 13.029’W) is part of an altitudinal gradient from the coast to the Andes, 33º-35ºS. This coastal wetland is affected by perturbations in the coupled ocean-atmosphere tropical Pacific system, located along a subsidence zone between the Nazca and South American plates, and surrounded by agriculture and ranching areas: strong modifier agents of coastal ecosystems. We use diatoms as bioproxies to infer past environmental conditions. In 2008, three cores were obtained with a gravity corer: NAME1, 2 and 3 (2.6 and 1 m depth; lengths: 48, 47 and 27 cm), in 2012 we obtained another three with a gravity corer(CN1202SC 1, 2 and 3 at 1.7 m depth, lengths: 60 cm) and two with a Livingstone corer: CN1202AT, BT and CT (1.7 m depth and lengths: 242 cm). Cores were opened, photographed and described sedimentologically. NAME2 and CN1202BT (AMS date of 200±50 $^{14}$C yrs BP) were volumetrically subsampled every 5 cm, aliquots were taken for diatomic analysis, processed according to standard methods for diatoms, permanent slides mounted and observed under an optical microscope. Presence/absence analysis of NAME2 diatoms associations showed for N42cm (base), 28 spp: epiphytic dominant (47.8%), most abundant genus *Navicula* (5sp, 23%) would
indicate high conductivity, moderate pollution and circumneutral to alkaline pH, pristine conditions; N27cm, 6 spp: benthic (60%), Sellaphora (2spp, 38.5%) would indicate moderate pollution and N2cm, 36 species, epiphytic (51.6%), Eunotia (8spp, 15.3%) would indicate acidic to circumneutral pH (current 7.5), stages of human intervention.

S03-P-05 Onondaga Lake (NY, USA) – America’s Dirtiest Lake – past, present and future: a lake’s diatom and ostracode-inferred dramatic journey to recovery


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Multi-proxy paleolimnological techniques were used to investigate historical changes in Onondaga Lake (NY, USA), a Superfund site (http://www.dec.ny.gov/chemical/8668.html) with a long history of industrial pollution. Diatoms were investigated along with chironomids, daphnia ephippia, ostracodes, and sediment geochemistry. The study examined a 1.8-m long sediment core representing the most recent ~ 500 years. Diatom-based transfer functions, developed using a dataset of >1000 lakes sampled during US EPA’s 2007 National Lake Assessment program (www.epa.gov/owow/lakes/lakessurvey/), were used to reconstruct total phosphorus (TP) and conductivity since pre-European settlement. Cyclotella bodanica var. lemanica-dominant diatom assemblages suggest oligotrophic conditions were present prior to human disturbance (mean inferred TP = 9 μgL⁻¹). Post-settlement activities, including canal construction, salt manufacturing and urbanization, transformed Onondaga Lake to a hypereutrophic, saline lake with many marine diatom species becoming prominent. The ostracode record is in general agreement with the diatom record, with a freshwater assemblage in pre-settlement time typical of the Great Lakes and Finger Lakes region, including Cytherissa lacustris, Candona crogmaniana, and Candona caudata. Species richness and abundance decreases above 145 cm (~1822) and include Candona distincta and Physocypria pustulosa, typical of more eutrophic conditions. Above 120 cm (~1875), no ostracode shells are present. During the 20th century, diatom inferred TP and conductivity reached up to 290 μgL⁻¹ and 1595 μScm⁻¹ respectively. Diatom inferences reveal gradual recovery over the last few decades. However, lake TP would need to be lowered ~ 15 μgL⁻¹ to reach nutrient levels close to reference conditions, while modern conductivity is likely within the lake’s natural variation.

S03-P-06 The accumulation and environmental impacts of black carbon (BC) in the European Arctic during the industrial era studied from lake sediments

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During the last century the Arctic has warmed twice as much as the rest of the World. This is thought to be partly caused by light absorbing black carbon (BC), which results from incomplete combustion of biomass and fossil fuels. Due to its black colour BC warms the atmosphere and when deposited on snow or ice it induces their earlier melt. BC may already have caused 50% of the warming and 30% of the melting observed in the Arctic hitherto. The aim of this study is to determine the accumulation of BC and its role in environmental changes in northern Europe during the industrial era from lake sediments. The BC accumulation is calibrated with nearby atmospheric BC measurements for the last decades. In addition to traditional chemical extraction of larger SCP (spheroidal carbonaceous particles) the BC quantification is made by
chemothermal oxidation for finer soot-BC and with a thermal optical method for elemental carbon (EC) commonly measured in aerosols and snow. According to preliminary results the SCP concentrations have decreased in recent decades due to e.g. improvements in particle arrestor technology in Europe. At the same time soot-BC (and probably EC) concentrations may have risen because of increasing emissions in Asia, which according to back-trajectories may reach the European Arctic. In order to evaluate the environmental impact of BC, its fluctuations are compared with measured climate variations and lake ice fenology dynamics in the study area. The source of BC, i.e. biomass vs. fossil fuel, will be determined by radiocarbon dating.

S03-P-07 Spatial variability of Hg in lake sediments – implications for the interpretation of down-core records and bioavailability

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Single sediment profiles are excellent for assessing temporal changes in Hg-loading. However, to allow the calculation of the whole-lake accumulation of Hg, and increase our knowledge regarding the behavior and bioavailability of Hg in lake ecosystems, it is also necessary to determine the extent of spatial variability.

We used 83 evenly distributed surface sediment samples from a single lake to assess the spatial variability in total- and methyl-Hg, and how this relates to the sediment geochemical composition. Total-Hg was controlled by a combination of organic matter (OM) and fine-grained mineral matter (FMM). On a whole-lake basis they were of equal importance, but their relative importance varied between different parts of the lake with higher total-Hg inventories (mass per unit-area) in locations with more FMM (35 and 53 μg m\(^{-2}\) for OM- and FMM-dominated locations, respectively). This implies that a change in total-Hg flux (mass per time unit) in a down-core record not necessarily reflects a change in the Hg-loading, because it might also be a result of a shift in the relative amount of OM vs. FMM. For methyl-Hg the spatial variability was even larger as compared to total-Hg, and deeper locations generally contained more methyl-Hg. However, also shallow locations with coarse-grained minerogenic sediments contained high inventories of methyl-Hg. The later implies that large amounts of methyl-Hg can be present also in the littoral zone, i.e., a zone with high biotic activity.

S03-P-08 Historical trend in metal contamination into a reservoir for public water supply


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Analyses of metals can be used to estimate natural background concentrations as well as to reconstruct past contamination trends. A paleolimnological study was conducted to investigate historical accumulations of heavy metals into a reservoir used for public water supply, in São Paulo, Brazil. A gravity corer was released twice on the limnical area of the reservoir. Each core was sliced every two cm and stored in a sealed plastic bag. One core was used for determination of metals, in accordance with USEPA method 3050B, and dating, using \(^{210}\)Pb technique. The other core was used for determination of organic matter and particle size. The sediment stored represented a period of 83 years. A Principal Component Analysis revealed three main phases: 1) period prior the reservoir construction, represented by the corer base, where the highest levels of sand were found; 2) intermediate period, when the reservoir was being constructed; 3) reservoir operation period, where were found the highest concentrations of Cu, specially on the layers representing the years 1994 to 2010. Except for Cu, metal values were in accordance with sediment quality guidelines, Threshold Effect Level, suggested by Canadian Council of the Ministry of Environment. Geoaccumulation index indicated the status
moderately polluted for Cu. Applications of CuSO₄ as an algaecide, are responsible for the high values of Cu. It is necessary to reduce the inputs of nutrients in reservoir’s tributaries, in order to reduce the algal biomass and, consequently, stop the application of CuSO₄. Otherwise, reservoir’s ‘good quality’ will be at risk.

**S03-P-09  A comparison of lead enrichment records between three raised bogs from the British Isles**

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Ombrotrophic bogs are reliable archives for the reconstruction of past changes in climate and atmospheric metal deposition as their nutrients predominately originate from the atmosphere. Here we present lead enrichment records over the past 3000 years form 3 raised bogs in the Scottish Borders, SW Ireland and N Wales. We compare phases of enrichment and their timing. We can identify similar patterns in enrichment for the Iron Age / Roman period and the Industrial period as well as the decrease of leaded petrol for the Scottish and Irish site. It is likely that these elevated concentrations of lead during the prehistoric and Roman period reflect long-distance pollution sources rather than local activities. However, juxtaposed to this a record from the Welsh site shows a rather ambiguous pattern with elevated lead concentrations recorded from 550 BC and a strong phase of lead pollution occurred during historical times. This may be due to a stronger minerogenic influence at this site as well as continuous metalworking in the area.
Session 04 - Environmental change in the high latitudes

S04-KN  On thin ice: Paleolimnological perspectives on Polar ecosystems in a multiple-stressor world
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High latitude lakes offer tremendous opportunities for paleolimnologists to study long-term environmental changes using lake sediments. For example, paleolimnological studies from many Arctic lakes and ponds have recorded striking and ecologically significant regime shifts especially in diatom assemblages. A large body of evidence, including a growing number of new examples (some presented here), has shown that many of these recent changes are most closely linked to recent climatic change, often through indirect mechanisms (e.g. changing ice cover, enhanced thermal stratification, etc.). Nonetheless, as we have always acknowledged, many environmental variables can influence polar lakes. This presentation will include examples showing how our lab has attempted to disentangled the effects of multiple-stressors on important ecosystem changes, such as the limnological repercussions of permafrost thaw, industrial activities (e.g. the expanding petrochemical industry), eutrophication from both seabirds and humans (archaeological studies and sewage inputs from Arctic hamlets), and the long-range transport of contaminants.

S04-01 Technologies developed for the clean access, measurement and sampling of Antarctic subglacial Lake Ellsworth
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NERC British Antarctic Survey

Antarctic subglacial lakes are thought to be extreme habitats for microbial life and may contain important records of ice sheet history and climate change within their sediments. To test this hypothesis, and to answer the science questions that would follow, direct measurement and sampling of these environments is required. Here, we summarise the scientific protocols and methods that have been developed for the first exploration of Subglacial Lake Ellsworth in West Antarctica, planned for 2012/13. Situated under 3.4 km of ice, the lake is 10 km long, 2-3 km wide and ~100 m deep, with sediments at its base. The exploration will involve accessing the lake using a hot-water drill. This will be the deepest hot water drilling to date. A bespoke communications tether has been designed to operate a series of unique sampling probes and sediment corers to allow sample collection. Sampling challenges include accessing the lake through a small diameter access hole, negative temperatures in the borehole, pressures of 350 bar and sampling in an environmentally responsible manner.

S04-02 Deglaciation & relative sea-level change on the Antarctic Peninsula in the last 10,000 years
1Roberts, S.J., 1Hodgson, D.A., 2Sterken, M., 2Verleyen, E., 2Vyverman, W., 2Sabbe, K., 2Bentley, M.J., 1Watcham, E., 3Whitehouse, P.L., 5Balbo, A., 5Moreton, S.
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The recent disintegration of Antarctic Peninsula ice-shelves and the associated accelerated discharge and retreat of continental glaciers has highlighted the need to provide a longer-term perspective for present ice mass losses from Antarctica and individual ice sheets’ contribution to future sea-level rise. Relatively little terrestrial geological data constraining the geometry, volume and melt history of the former Antarctic Peninsula Ice Sheet from the Last Glacial Maximum-Holocene exists. Holocene-
age sedimentary records with well-defined, and well-dated, marine-terrestrial transitions were extracted from three isolation basins at different altitudes on Beak Island, providing quantified rates of Holocene RSL change for the north-eastern Antarctic Peninsula region. Results show RSL on Beak Island fell from a maximum of c. 15 m above present at c. 8000 cal yr BP, at a rate of 3.91 mm yr\(^{-1}\) declining to c. 2.11 mm yr\(^{-1}\) between c. 6900-2900 cal yr BP, 1.63 mm yr\(^{-1}\) between c. 2900-1800 cal yr BP, and finally to 0.29 mm yr\(^{-1}\) during the last c. 1800 years. The new Beak Island RSL curve implies significant thinning of the former Antarctic Peninsula Ice Sheet by the early-Holocene, and is in broad agreement with some, but not all, glacio-isostatic adjustment models. This and other recently published RSL curves, improve the spatial coverage of RSL data for Antarctica, and provide key field-based data for the glacial-isostatic correction required by satellite-derived gravity measurements of contemporary ice mass loss, which can be used to better assess the future contribution of the continental ice from Antarctica to rising sea-levels.

S04-03 Using geochemistry and chironomids to assess trophic responses of sub-Arctic Alaskan lakes to recent environmental change

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Increases in productivity associated with increased nutrient inputs to Arctic lakes are expected to coincide with increases in temperature, the length of the ice-free season, and permafrost thaw. Here, we utilize a multi-proxy paleolimnological approach in two lakes along the Kougarok River, sub-Arctic Alaska, with different catchment vegetation communities (shrub versus macrophyte-dominated), to characterize the relationship between different sources of nutrient inputs and biological communities in an area undergoing environmental change. Sediment cores were collected during summer 2011, using an Uwitech gravity corer, and processed for chironomids (Diptera:Chironomidae), organic carbon and nitrogen elemental and stable isotope measurements, and cellulose oxygen isotope analyses. Biostratigraphic reconstructions of chironomids from both lakes displayed a reduction of cold-water indicators in recent sediments, suggesting a warming climate in this region. In addition, a shift in chironomid assemblages was observed to coincide with an increase in δ\(^{15}\)N and decline in δ\(^{13}\)C\(_{\text{org}}\), reflecting higher productivity associated with greater nutrient availability in the shrub-dominated catchment. The dominant chironomid taxon was also significantly correlated (r\(^2\) = 0.84) to δ\(^{15}\)N in sediments, suggesting that a major driver of the trophic shift in this system is related to nutrient availability rather than solely temperature. The macrophyte-dominated system showed a similar reduction of cold-water indicators, but no major shift in assemblages possibly due to differences in the source and behaviour of nutrients in the macrophyte-dominated catchment. Thus, coupled stratigraphic analysis of both chironomids and geochemistry readily distinguished between temperature- and nutrient-related factors, providing important information for predicting the future response of Arctic ecosystems to ongoing environmental change.

S04-04 Late Holocene climate change in western Swedish Lapland reconstructed using chironomids and XRF elemental data

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Results from most Holocene temperature reconstructions on a millennial time scale from northern Scandinavia have shown a general cooling trend following the Holocene thermal maximum. However, on a centennial time scale results are inconsistent, probably mainly because of dating uncertainties and the poor temporal resolution of most records. Here we present results from
quantitative temperature analysis using chironomids (non-biting midges) and geochemical analyses on high resolution (centennial time scale) lake sediment cores from Vindelfjällen in western Swedish Lapland covering the last 5000 years.

According to our chironomid temperature reconstruction, July temperatures were c.1°C lower in Vindelfjällen between 4900 and 3100 cal BP compared to the reference period 1961-1990. Higher July temperatures characterised the period between 3100 and 2500 cal BP. Total Organic Carbon (TOC) and geochemical data (XRF) suggest it was also wetter at that time. From 2500 to 1600 cal BP July temperatures were stable and similar to those of the reference period. After 1600 cal BP they were again lower until 1000 cal BP when a rapid warming occurred that lasted until 800 cal BP. After 800 cal BP July temperatures were highly variable. Significance testing have shown that our reconstruction is better (p-value 0.01) at reconstructing July temperature than 999 random reconstructions generated from the same dataset. Moreover we note that the chironomids seem to respond to changes in hydrology and sedimentation. We argue that there is a need for further studies on different environmental factors that potentially cause shifts in chironomid communities and thereby influence temperature inferences.

S04-05 Comparing the relative influences of climate, oxygen and nutrients on chironomid assemblages: eutrophic Arctic ponds as natural laboratories for paleolimnological assessments

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Subfossil chironomids have been used as paleoindicators for climate, nutrients, aquatic production, and hypolimnetic oxygen conditions. However, because high nutrient concentrations and bottom-water hypoxia are often tightly linked, it is difficult to discern whether chironomids are responding to nutrients, oxygen, or some combination of both. In this study, we analyse chironomid assemblages from Arctic ponds possessing rare qualities that allow for a comparative approach to assessing the respective roles of nutrient versus oxygen concentrations in determining chironomid assemblage composition. The study ponds have been eutrophied from nutrient-rich inputs including seabird wastes and human sewage, but are also well-oxygenated due to their shallow nature and 24 hours of continuous daylight. Subfossil chironomid assemblages were assessed from impacted (eutrophic) and non-impacted (oligotrophic) ponds in both locations. Assemblages were dominated by cold stenotherm taxa typical of Arctic environments, with trace abundances of several taxa common to eutrophic temperate lakes. Strong similarities in species assemblages between eutrophic and oligotrophic ponds indicate that nutrient inputs are not directly affecting chironomids. Nutrient inputs increase primary production (i.e., food availability), and subsequently increase chironomid abundance; however, species composition remained largely unchanged between impacted and control sites. These data demonstrate that, in the presence of high concentrations of dissolved oxygen, nutrient enrichment will have little effect on chironomid community composition, whereas oxygen and climate are key explanatory variables.

S04-06 Air temperatures in northern Estonia during the last 13.3 14C cal kyr using the Mutual Ostracod Temperature Range method

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The Mutual Ostracod Temperature Range (MOTR) method is used to reconstruct minimum July and maximum January mean air temperatures during the last 13.3 14C cal kyr in northern Estonia. The modern July mean air temperature is +17.5°C and January mean air temperature is -5.8°C. Freshwater ostracod assemblages from a small lake (Äntu Sinijärv) tufa
sequence showed ecological shifts within the time period. *Metacypris cordata* dominated in the Late-Glacial shallow lake. At the beginning of the Holocene *Pseudocandona compressa* became the main ostracod species as water level increased. During the Mid Holocene *Fabaeformiscandona levanderi* was the dominant ostracod in the shallow lake, giving way to *Pseudocandona rostrata* in the Late Holocene suggesting a coldwater lake fed by bottom springs. Calculating a polynomial trendline, the Late-Glacial July minimum air temperature was +14°C, January maximum temperatures were from +5°C to +7°C. At the beginning of the Holocene, ca 11.7–9.5 ¹⁴C cal kyr, July minimum temperature decreased below +13°C, and January maximum temperature from +5°C to +3°C. During the Mid Holocene, ca 9.5-4.5 ¹⁴C cal kyr, July minimum temperature increased to over +15°C. During the Holocene optimum the January maximum temperature dropped to +1°C to 0°C. The MOTR method indicates winter temperatures were lowest during the Mid-Holocene in northern Estonia, suggesting that winters were cold and dry. In the Late Holocene July minimum temperatures decreased, down to +12°C, however, January maximum air temperature increased during this interval, from +3°C to +7°C, suggesting maritime conditions.

**S04-07 Weather, diagenesis and land-use – lessons learnt from the study of a varved lake sediment**

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Numerous studies have shown that climate affects the geochemical composition of a lake sediment, e.g., runoff influences the transport of material from the catchment and temperature affects in-lake production. However, lake sediments have their limitations as an environmental archive, and knowledge regarding different confounding factors is vital to make the best possible use of sediments as records for past climatic conditions.

We have used a unique series of freeze cores – collected over 30 years and sub-sampled at true annual resolution – from a lake with varved lake sediments to assess; i) diagenetic changes occurring within the sediment, and ii) how well weather data can explain temporal variations in the sediments geochemical composition.

Our results show that: i) several elements (e.g., C, N, P, Br) are affected by diagenesis and the changes are largest during the first 5-10 years, ii) there is a weak but significant link between weather and inorganic fraction of the sediment (R = 0.5), and iii) this link is strengthened if the annual data is smoothed (R = 0.7), indicating that weather controls the long-term trend but that specific years also are influenced by other factors, not least land-use.

This study demonstrates that some caution must be applied in interpreting sediment record, especially if the interpreted changes are small and/or recent. It also shows that even if the climate significantly affects the geochemical composition of the sediment, care should be taken when choosing study sites for climatic studies to reduce the number of confounding factors, e.g., land-use.

**S04-08 Permafrost, larch forests, and epigenetic thaw-lake ion content are a coherent geochemical functional entity in Siberia**


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Siberian larch forests growing on shallow
permafrost soils were, until now, not taken into account as controls of the abiotic and biotic characteristics of the huge number of thaw-lake ecosystems nor were they considered to play a major role in their inorganic carbon cycling.

Here we show that lake-water geochemical composition is highly correlated with vegetation type; in particular higher alkalinity is found to increase with denser forests in the lake’s catchment. We test this relationship with four independent data-sets in space and time: first, for a modern water data-set from 201 lakes covering tundra to typical taiga, and second, for three lake cores from Yakutia where this relationship is proved by applying an alkalinity transfer-function to fossil diatom data. We postulate that in this arid part of Siberia, the higher evapotranspiration in larch forest in comparison to tundra vegetation leads to the local accumulation of salts in soils. These ions are transported to nearby thaw-lakes by rain-events and snow-melt, but are not entirely supplied into rivers due to the lack of a continuous groundwater flow in permafrost soils. This implies that a potentially large shift in aquatic ecosystems to recorded warming is absent because of the slow response of forest systems to climate change.

S04-09 Holocene environmental change in Kamchatka, Far East Russia

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There are relatively few detailed Holocene palaeoenvironmental records or climate reconstructions available from northern Eurasia. The Kamchatka Peninsula, in the far east of Russia, is ideally situated to be responsive to climatic fluctuations and provide information on climatic teleconnections between the North Atlantic and the North Pacific. The modern climate of Kamchatka is sensitive to the intensity of the summer North Pacific High and winter Aleutian Low, which are linked through atmospheric teleconnections to the Southern and Arctic Oscillations. In winter Kamchatka is also influenced by Siberian High and in summer it is influenced by the Asian monsoon. We present a summary of pollen, diatom, chironomid, isotope and sediment chemistry analyses from three Holocene lake sediment sequences in the north and centre of Kamchatka. Our results indicate that the lakes have been influenced by local environmental conditions particularly forest development, resulting in lake chemistry change, deposition of volcanic ash, as well as climate change reflecting local, regional and global influences depending on the situation of each lake, either close to the Pacific or in the central mountain range.

S04-10 Holocene climate change and lake ontogeny in south-western Greenland

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Holocene-scale change in the chemical and biological structure of Arctic lakes is often interpreted primarily as a response to climate variability and yet, lakes change as they age, independent of external drivers in a process termed lake ontogeny. The pace and nature of lake ontogeny are likely to vary within different climatic contexts, but direct comparisons have yet to be attempted. Lakes in south-western Greenland provide an opportunity to investigate ontogeny trends independent of human influence. In the Kangerlussuaq region, there is a marked shift from a warmer continental climate inland to a wetter, cooler maritime climate at the coast, allowing the effect of
climate on Holocene lake ontogeny to be investigated. Therefore, we investigated sediments from two lakes from the coast and two from the inland area to allow direct comparisons over Holocene timescales. Diatoms were used to reconstruct Holocene trends in lake alkalinity and sedimentary pigments as a proxy for whole-lake production. Regardless of lake age, all four lakes demonstrated a pulse in production and alkalinity during the early phases of lake development, followed by oligotrophication after the Holocene Thermal Maximum and during the Neoglacial. The inland lakes displayed an increase in both lake-water alkalinity and production during the last ca. 1500 cal. years BP. These results suggest that low arctic lake ontogeny trends are similar regardless of climatic setting, and are dictated by localised climatic shifts, which can be mediated through catchment processes such as soil and vegetation development.

S04-11 Understanding past environmental responses to cyclic climate phenomena in the Northwest Territories, Canada

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The Tibbitt to Contwoyto Winter Road (TCWR), at 600 km in length, is the world’s longest heavy haul ice road. It is the critical link in the supply chain servicing remote northern mining operations, contributing C$1billion per year to the economy of the Northwest Territories (NT). Unusually mild conditions during the winter of 2006 were associated with an El Niño/Southern Oscillation (ENSO) event. TCWR operations were significantly impacted, resulting in financial losses and the mothballing of one mine. The cyclic ENSO event raised awareness of the need to better understand the range of climate variability in the central NT. Sediment freeze cores along the TCWR, were studied using grain-size analysis (GSA) at millimeter-scale resolution. GSA is a useful proxy of climate-change related catchment erosional dynamics. Time series analysis of this data using well-developed Bayesian age-depth models resulted in the identification of cyclic climate phenomena, such as the ENSO, the Pacific Decadal Oscillation, and Suess cycles, which impact the NT at decadal to centennial scales. Enumeration of arcellacean (testate lobose amoebae) populations from contemporary lakes in the region indicates that their populations are sensitive to climate variability. This is seen through increases of Difflugia globulus and Difflugia glans as being diagnostic of tundra lakes. These results illustrate the range of natural climate variability in the central NT – providing policy makers and climate modelers with essential information needed to project possible future climate impacts on the viability of the TCWR.

S04-12 Recent palaeolimnological change recorded in Lake Xiaolongwan, northeast China: climatic versus anthropogenic forcing

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Lake Xiaolongwan, is a closed maar lake located in the Long Gang Volcanic Field, northeast China. Core XLW2 was collected in 2007 and provides a palaeoecological reconstruction over the past c. 130 years (dated using radiometric methods: $^{210}$Pb). Diatom floristic changes and catchment productivity (stable carbon isotopes) were analysed. Indicators of atmospheric pollution (XRF and SCP inventories) were also conducted. Results showed a marked transition from a dominating benthic assemblage to a
planktonic one (increasing P:B ratios) starting after c. 1940 AD, becoming most prominent after c. 1980 AD (P:B > 1). Most notable floristic changes result from the introduction of the planktonic species of *D. woltereckii* over this time. These changes are concomitant with increased temperature trends from the region and reconstructed temperature anomalies of the NH. However, normalised elemental geochemistry (e.g. Pb/Ti) identifies that after 1970 AD there is a marked increase in ratios, most likely derived from atmospheric deposition in the area, as well as increased SCP concentrations and flux rates. As a result, it is most likely that the shift from benthic to planktonic assemblages result from increased temperature trends, which precede anthropogenic contamination at the site. These temperature trends may be manifested as earlier(later) ice off(on) and/or increased DOC at Lake Xiaolongwan: conditions for which planktonic species have a more competitive advantage. However, it cannot be denied that there is evidence of anthropogenic contamination after 1970 AD, which may also be accountable for the significant species turnover (SD = 1.495) seen during the late 20th century at this site.

**S04-13** Changes in the ecology of West Greenland lakes over recent centuries

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In contrast to much of the Arctic, the area around Kangerlussuaq in West Greenland has not experienced rapid warming in the latter half of the 20th century, but exhibits strong spatial variability in precipitation and temperature from the coast to the ice sheet. Therefore, we studied lake sediment cores from three areas (coast, inland and ice sheet) across a 120km transect to determine whether local or regional factors were most important in driving limnological change. We used sedimentary chlorophylls and carotenoids, diatoms and nitrogen stable isotopes in combination with modern physico-chemical measurements on lake and catchment parameters to test the hypothesis that limnological change would be similar within local areas but vary across the region. Lakes at the coast receiving most precipitation and elevated snowmelt nitrogen loads showed marked changes in diatoms, pigments and nitrogen isotopes after ca.1940 consistent with evidence that atmospheric nitrogen deposition has changed lake autotrophic communities and reduced cyanobacterial abundance. Lakes close to the ice sheet changed over longer timescales (~500 years), mainly in response to the Little Ice Age cooling which suppressed algal production. In contrast, lakes in the warmer and drier inland area displayed relatively little change over recent centuries. Together these patterns provide evidence that nitrogen fertilization may have influenced the ecology of Arctic lakes in areas of substantial precipitation (~500mm/yr). Such effects, however, are combined with those initiated by climate change.

**S04-14** Contrasting the response to climate change of lakes in the Canadian High Arctic along a gradient of elevation and buffering capacity

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Recent climate change has been pronounced in the High Arctic, with paleoecological evidence indicating that high-latitude regions have responded earliest to anthropogenic warming. However, lakes do not respond uniformly to climatic changes. Rather, the response depends upon a number of local and regional factors such as elevation, shading, and
the optima and tolerances of biological communities. Chemical factors, such as buffering capacity, may also modify the biological responses. Several publications suggest that diatom assemblages in poorly buffered lakes show more variability in response to climate-driven pH changes; however, comprehensive comparative studies are lacking. To address this, we examine the diatom response to recent climate change in 6 lakes and ponds from Cape Hershel and Pim Island (Nunavut), which differ in buffering capacities and cover an elevation and climatic gradient. The elevation gradient results in differing lengths of the ice-free season and allows us to examine the interacting effects of ice cover on the diatom response to climate-driven pH changes. The poorly buffered sites were found to have greater diatom diversity in the pre-warming assemblages and showed more variability throughout their record than the well-buffered systems. However, the role of climate-driven pH changes was limited compared to the over-riding influence of ice-cover, and the consequent creation of new habitat, as a driver of compositional change. However, as warming accelerates and ice-cover diminishes in these high-latitude aquatic systems, the role of buffering capacity will likely become a more important variable in structuring the diatom communities and affecting their response to climatic change.

**S04-15** Abrupt changes over the past to decades in subarctic lakes of the Hudson Bay Lowlands: An important test area to demonstrate the over-riding role of climate warming on lake ecosystems

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The Hudson Bay Lowlands (HBL) is a globally and ecologically important region as it stores vast amounts of the world’s carbon in its extensive wetlands and hosts one of the world’s largest polar bear populations. In stark contrast to most of the circum-Arctic, this subpolar region around Hudson Bay has registered minimal warming (or even cooling) due to negative feedback mechanisms linked to the persistence of Hudson Bay sea ice. Consequently, paleoecological profiles from the Hudson Bay region have revealed minimal community change. However, over the past ~15-20 years, this region has crossed a climate tipping point, with increased air temperature, reductions in sea ice, and changes in sea ice phenology that now generate a positive feedback response. The remoteness of this sub-Arctic region together with the rapid transition from a region of cooling to one of amplified warming provides a rare, natural test site to identify the effects of global warming in the absence of confounding, direct anthropogenic influences.

High-resolution sediment cores from four HBL lakes show distinct diatom changes in the past ~two decades that include the onset and increase in planktonic diatoms and community complexity as well as increases in both community compositional turnover and primary production. By comparing the timing and nature of these changes to the wealth of available paleolimnological data, we can exclude atmospheric deposition as a putative cause for these changes. We link these changes to this new climate regime.

**S04-P-01** Multi-proxy analysis of sediment record from small crater lake (Lake Bardarlaug, Snaefellsnes, West Iceland)

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This study contributes to paleolimnological evidence from Icelandic small lakes, a relatively understudied area of research. Short sediment core (55 cm) from small, 4 m deep crater lake was analysed for a series of sedimentary and biological variables. LOI and XRF geochemistry distinguished 2 main sediment phases. Lowermost part is dominated by two tephra layers (depths 45 and 40-38 cm). It is followed by
S04-P-02 What do quaternary sediments in Petuniabukta, Svalbard reveal?

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Study presents the potential of sediments for palaeoecological reconstructions retrieved in Petuniabukta, Billefjorden to track the changes of vegetation due to the changing conditions. Palaeoecological study from the inner fjord of Svalbard archipelago has not been reported yet. It was primarily focused on study of macro- and micro-fossils. Macro-fossils were represented mostly by leafs and buds of Salix species and Dryas octopetala. The former occurrence of hybrid species Salix herbacea x polaris that lasts till nowadays was documented. Special attention was paid to identification of fossil mosses, which built the important part of arctic ecosystems. Pollen grains were present in very low concentrations. Tardigrada remains were found in the sediments in high abundance. Eggs and exuvies of at least six species were identified.

S04-P-04 Diatoms as Indicators of Decadal to Centennial Scale Climate Cyclicity and Winter Ice Cover in the Treeline Region of the Central Northwest Territories, Canada


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The Tibbitt to Contwoyto Winter Road (TCWR), stretching 600kms north from Yellowknife and 88% built over frozen lakes, is an important economic transportation route. The long-term viability of this route is uncertain due to the potential impact of global warming. For this reason, the goal of this research is to provide insight into the nature of natural climate cycles and trends impacting the region through the past ~3500 years, and investigate whether conditions in the 20th and early 21st centuries were unusual. In a typical high latitude lake system, certain benthic Fragilaria diatoms thrive under ice cover while planktonic Aulacoseira diatoms thrive in open water conditions. By studying the ratio of benthic to planktonic diatoms contained in a sediment core, past ice cover can be inferred-data which is of great interest to TCWR policy makers and planners. In March 2010, a freeze core was obtained from Danny’s Lake, located 50 km south of the treeline in the Northwest Territories.
This core was then subsampled at 1mm intervals using a custom-designed sledge microtome. A sampling resolution of on average 6yr/mm was obtained using a Bayesian age-depth model (OxCal) based on 18 radiocarbon dates spanning the past 8000 years. Our paleoclimate reconstruction reveals decadal to centennial-scale cycles in *Aulacoseira* and *Fragilaria* abundance – corresponding to warm and cool cycles over the past 3500 years.

**S05-P-04 Chironomid-inferred Holocene environmental and climate change in Kamchatka**

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The global atmospheric and oceanic teleconnections driving Holocene climate change in the North Pacific, and Kamchatka in particular, are currently poorly known due to a lack of palaeoclimate records. The aim of this study is to provide high-resolution, well-dated, Holocene palaeoclimate sequences from three lakes in Kamchatka. Analysis of the chironomid assemblages indicates a well-preserved and taxonomically diverse temperate fauna. Although the majority of taxa have a Holarctic distribution, a few are morphologically distinct and may be endemic to Kamchatka. During the Holocene the chironomid assemblages appear to respond to multiple environmental and climate drivers including volcanic activity, vegetation changes and climate change. The southern site, Olive-backed Lake, lies in the central Sredinny Range, a mountainous range of active volcanoes. In the early to mid Holocene the fauna was dominated by acid-tolerant taxa. There are numerous tephra layers, suggesting the lake was impacted by a period of intense volcanic activity between 7500 and 5500 cal. yrs BP. Changes in the relative proportions of acid tolerant, profundal and littoral taxa suggest lake water depth was influenced by decreasing monsoonal activity, caused by the southwards migration of the Inter-Tropical Convergence Zone (ITCZ) in response to the orbitally-induced latitudinal shift in summer insolation. In the northern sites, Lifebuoy Lake and Lake Pechora, changes in the chironomid assemblages appear to be influenced by volcanic activity and catchment vegetation. The response to climate appears more muted probably due to the proximity of the Pacific Ocean.

**S04-P-06 Tracking permafrost dynamics by means of visible-near infrared spectroscopy (VNIRS) in lake sediment records from northern Sweden**

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Permafrost dynamics strongly affect the hydrology and vegetation in a lake's catchment, and hence, they also affect the lake itself. In particular, the release of organic matter (OM) from catchment soils can have a strong impact on the lake ecosystem by affecting, e.g., light penetration, internal productivity and the cycling of pollutants.

In this study, we show that visible-near infrared spectroscopy (VNIRS; 400-2500 nm) is a potential method to reconstruct past permafrost dynamics from lacustrine sediments. VNIRS of the sediment reflects the OM quality and can be used to infer lake-water total organic carbon (TOC). Using partial least squares regression, we have established a transfer function between VNIRS of surface sediment samples (0-1 cm) and measured lake-water TOC. Here, the resulting model was applied to three Holocene sediment records from northernmost Sweden, i.e., an area of discontinuous permafrost. All three records show periods of very stable lake-water TOC values, which we suggest correspond to periods when permafrost was present in each of the catchments. The presence of permafrost stabilizes catchment soils and restricts OM degradation as well as water movement trough the active layer, which together lead to a stable export of OM from catchments with permafrost.

Our initial findings indicate that VNIRS is a promising tool for reconstructing temporal and spatial variations in permafrost extent, which would be valuable information when attempting to predict
future changes in permafrost distribution. However, further studies are needed in order to further develop and validate the method.

**S04-P-07  Lake high stands in the Pensacola Mountains and Shackleton Range 4300-2250 cal. yr BP, evidence of a warm climate anomaly in the interior of Antarctica**

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We surveyed and dated the former shorelines of one lake in the Shackleton Range and two lakes in the Pensacola Mountains, situated in the Weddell Sea embayment Antarctica between 80˚ and 85˚ South. These are amongst the highest latitude lakes in the Antarctic and are located in areas where there is little or no Holocene climate and hydrological information. Surveys of the lake shorelines show that water levels have been up to 15.7, 17.7 and 69.5 m higher than present in the three study lakes. AMS radiocarbon dating of lake-derived macrofossils showed that there was a sustained period of higher water levels from approximately 4300 and until sometime after 2250 cal yr BP. This is interpreted as being the result of an increased number of meltwater events and degree-days above freezing, relative to the present. The closest comparable ice cores from the Dominion Range in the Transantarctic Mountains and the Plateau Remote ice core on the continental East Antarctic Ice Sheet also provide evidence of a warmer period beginning at c. 4000-3500 years BP and ending after 2000-1500 years BP, as does a synthesis of oxygen isotope data from 5 Antarctic ice cores. This suggests that the well-documented mid to late Holocene warm period, measured in many lake and marine sediments around the coast of Antarctica, extended into these regions of the continental interior.

**S04-P-08  Aquatic ecosystem responses to permafrost thaw slumping in Canadian Arctic lakes**


Rapid environmental change occurring in high-latitude regions has the potential to result in significant degradation of near-surface permafrost. The impact that this degradation will have on freshwater ecosystems is not well understood. Shoreline retrogressive thaw slumps are a particularly spectacular form of permafrost degradation that have been shown to result in significant changes to contemporary lakewater chemistry; however, to date the long-term impacts have not been assessed. We present the results of a unique paired-lake study design in which lakes with conspicuous retrogressive thaw slumps were compared to paired unimpacted lakes. Using this paired, comparative approach, we examined dated sediment cores from 12 lakes in the Mackenzie Delta uplands (NWT, Canada) to determine how thaw slump development from degrading permafrost affected aquatic ecology, as well as mercury and organic carbon in these systems. We analyzed sedimentary diatom assemblages in order to infer the biological response to thaw slumping, and show that impacted lakes have undergone ecologically significant changes over the last ~200 years. In addition, overall lake primary production was estimated using sedimentary reflectance spectroscopy and a quantitative and qualitative assessment of organic matter was conducted using the Rock-Eval technique. Total mercury and methylmercury concentrations in sediments were also assessed. We conclude that thaw slump development results in diatom community habitat shifts, increases inorganic sedimentation in lakes, while thaw slump development decreases
concentrations of organic carbon and associated Hg and MeHg in sediments. Our results provide the first long-term, comparative, multi-proxy analysis of the impact of permafrost thaw on high-latitude freshwater ecosystems.

**S04-P-09  A diatom-based regional assessment of environmental change in shallow lakes of northern Ontario, Canada prior to large-scale mining operations**

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Northern regions of Ontario have recently become the focus of political, industrial and scientific attention following the discovery of extensive mineral resources (including massive chromite deposits). The extraction of this potential mineral wealth (dubbed the “Ring of Fire”) in remote northern Ontario, which includes the James Bay Lowlands, is complicated as it spans the lands of several First Nations with little existing infrastructure. Approximately 90% of this landscape is covered by extensive peatlands that store vast amounts of the world’s carbon, an important factor to consider given the sensitivity of northern latitudes to recent climate warming. Little is known about the extent of past, present or future ecological changes in this region of Canada, and therefore detailed baseline limnological knowledge is required prior to the onset of mining to better understand and potentially minimize environmental impacts. This study addresses these knowledge gaps by examining changes in diatom assemblage composition from pre-industrial to modern sediments, including significant changes among dominant benthic species, an increase in diatom diversity and planktonic diatoms. The nature of these changes in minimally impacted lakes is consistent to warming-induced alterations in lake water properties and the development and expansion of new aquatic habitats. Applying this paleolimnological technique prior to the onset of regional mining development will help distinguish the ecological impacts related to future mining operations from both natural variation and ongoing responses to recent warming.

**S04-P-10  The Holocene history and ecology of a paleolake in the Darhad Basin, Mongolia, based on diatom records**

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There are small lakes in the Darhad Basin at present, however a huge paleo-lake occupied the basin during the late Pleistocene and Holocene (Krivonogov et al., 2005). Diatom assemblages in the paleo-lake sediments from the Hodon outcrop in the Darhad Basin, Mongolia, were examined in order to understand the Holocene climate change in northern Central Asia. The 13 m high outcrop was investigated by the Darhad Drilling Project team in August 2011. Continuous permafrost is a specific feature of the Hodon sediments. The sediments were deposited between ca. 8 and 2 ka BP based on the 14C and OSL dates. Our obtained detailed diatom record reveals the evolution of the basin during this period. The record is characterized by high diversity of diatoms with the exception of the 5.4-3.2 m layer of sands, which therefore represents conditions unfavorable for diatoms at ca. 5-4.5 ka BP. The dominant diatom taxa were epiphytic and benthic species. Planktonic/benthic diatom ratio shows a slightly deep lake during the middle Holocene, 8-5 ka BP, and a shallow lake during the late Holocene, 4.5-2.5 ka BP. We consider that these changes reflect...
fluctuations of moisture supply and therefore the region was humid in the middle Holocene and arid in the late Holocene. The paleoclimatic record from the Darhad paleo-lake is in agreement with records from other lakes of Central Asia, reported by other investigators (e.g., Travos et al., 2000) and reflects regional and/or global scale climate changes such as the Asian monsoon fluctuations.

S04-P-11 Climate-mediated changes in boreal lakes: A diatom-based reconstruction of changes in lake thermal stratification

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Recent research in a remote, boreal ecosystem in the midwestern United States suggests that lake thermal structure is changing rapidly in response to regional climate change. A diatom-based reconstruction from Siskiwit Lake on Isle Royale, situated in Lake Superior, reveals that the depth of the mixed layer has more than doubled over the 20th century as ambient air temperature and wind strength increased. However, it remains unclear whether these regional changes in heat and wind are: 1) altering lake mixing synchronously across lakes, and 2) affecting biological communities and lake processes. To assess regional variability in lake stratification, diatom-based mixing depth reconstructions were compared across lakes on Isle Royale for the past 200 years. Fossil algal pigments were used to study the effects of lake mixing on primary productivity. In larger (>500 ha), less productive lakes, coherent increases in mixing depth were observed as wind strength increased. This is in contrast to several projections that suggest increasing air temperatures will lead to enhanced stratification and shallower mixing across lake ecosystems. Changes in mixing depth appear to have the greatest effect on algal communities in lakes that experience periodic anoxia in the hypolimnion. In this case, deeper mixing may have led to reduced anoxia and diminished sediment phosphorus release, resulting in decreased algal biomass. Understanding how paleolimnological records of climate-mediated change vary across a landscape and the range of biological response to these changes is key to interpreting long-term trends in lake response to climate.

S04-P-12 Hydroclimate of Northeast Alaska: Oxygen isotope tracers of recent hydrologic change and late Holocene variability

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The Yukon Flats in northeast Alaska is the lowland region surrounding the confluence of the Porcupine, Sheenjek, Christian, Chandalar, and Yukon Rivers encompassing approximately 20,000 lakes. It is a diverse boreal mosaic landscape that provides spring and summer habitat for over 150 bird species. The climate of the area is continental with severe winter temperatures and warm summers with extreme moisture deficits that lead to the unique occurrence of evaporite mineral deposits as well as the highest incidence of naturally occurring wildfires in Alaska. Lake levels and surface area are dynamic on annual and multi-annual time-scales and changes are frequently localized because of bathymetry, river flooding, and local permafrost extent that can determine surface and groundwater flow paths. To better understand the relationships between climate and hydroclimatic change, we are sampling oxygen isotope ratios both spatially and temporally. Here we present lake-water oxygen isotope data between 2007-2011 and GIS-based lake surface area analyses since the mid 1980’s in addition to late Holocene lake sediment oxygen isotope records. Sediment calcite-δ18O trends provide a broader context for evaluating recent changes and have decade-to-century scale temporal resolution back to ~5 ka. Results reinforce that individual lake sensitivity to hydroclimatic change varies considerably in
discontinuous permafrost regions, and that the significance of recent changes are better evaluated within a long-term context of past natural variations provided by paleolimnology reconstruction techniques.

S04-P-13  Ecological regime shifts in Lake Kälksjön, Sweden, in response to abrupt climate change around the 8.2 ka cooling event

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A detailed diatom record from Lake Kälksjön, west-central Sweden, reveals two periods of abrupt ecological change correlative with the 8.2 ka cooling event. Using a combination of abrupt step changes and piece-wise linear regressions, the diatom data were analysed for change points over time, and two sudden and large events that can be described as regime shifts were detected. During the first event at c. 8040 cal. yr BP a large increase in primary productivity can be connected to a major erosion event in the catchment that resulted in an abrupt increase in nutrient supply to the lake. The second event was characterised by a substantial and rapid shift within the planktonic diatom community from taxa indicative of colder conditions to those indicating warm at c. 7850 cal. yr BP. This event was superimposed on a successive change from periphytic to planktonic diatom dominance and a gradual diversification of the periphytic community. Rapid climate warming following the 8.2 ka event likely caused these changes.

This study demonstrates that it is possible to detect, quantify and test for regime shifts in paleoecological data, and highlights the need for high sampling resolution and precise chronological control. High-resolution paleoecological reconstructions of ecological regime shifts in response to climate change can provide useful analogues of future changes in ecosystem structure and functioning with impending climate change.

S04-P-14  Late-glacial environmental and climatic changes in the eastern Baltic area

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The aim of the present study is to evaluate late-glacial environmental and climatic changes in the eastern Baltic area using lake sediment organic matter geochemical parameters and grain size distribution. The sediment core was taken in winter 2009 from Lake Lielais Svētiņu, eastern Latvia (56°45.5 N; 27°08.8 E). Sediment age-depth model is based on 19 dated terrestrial plant macrofossils with complete record of late-glacial environmental history since the Bølling warming 14,500 cal BP. The studied core section spans a period of ca. 4000 years from 14,500-10,700 cal BP. The results of sediment C_{org} and N_{tot} content and the C/N ratio follows paleoclimatic changes of the area. During the Older Dryas and Younger Dryas cooling the C/N ratio in the sediments varies between 6.6–10 suggesting that aquatic algal production was essentially the main source of organic matter. During the Bølling and Allerød warming, the C/N values were slightly higher ranging from 11–14.6. This evidence suggests that during warmer periods the organic matter originates both from aquatic and terrestrial sources and indicates larger terrestrial input from the surrounding land. Biostratigraphical proxies show that the Bølling warming in the eastern Baltic area was a treeless tundra community. At 13,500 cal BP the first birch forests developed. During Allerød maximum warming 13,000-12,700 cal BP, a mixed pine forest with birch and aspen existed. During Younger Dryas cooling period open forest tundra was re-established, yet there is evidence that pine and spruce survived throughout the GS-1 harsh conditions.
S04-P-15  Late-Holocene diatom floristic changes in two lakes from the northern Kamchatka Peninsula

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Two 14C dated sediment cores from the lakes in the Kamchatka Peninsula covering the late Holocene period were analysed for diatoms, tephra and pollen. Diatom assemblages of Lifebuoy Lake, which is located in the north-eastern part of the Kamchatka Peninsula’s Pacific coast, show remarkable variations, implying considerable nutrient enhancement of the lake between 6300 and 4500 year BP, with the abundance of eutrophic planktonic taxa, e.g. *Stephanodiscus medius*, *S. hantzschii* and *Cyclostephanos tholiformis* and *Asterionella formosa* reaching above 40% at some levels. The origin of the nutrient enrichment is not yet fully understood. The diatom assemblages from Olive-backed lake, which is located about 350 km south of Lifebuoy Lake, in the middle of the Kamchatka Peninsula, differ markedly from the Lifebuoy assemblages. Olive-backed lake is dominated by acid-tolerant taxa, typical for coloured, peaty lakes e.g. *Eunotia faba*, *Eunotia incisa*, *Frustulia rhomboides* var *saxonica*, Brachysira vitrea. Reconstructed pH decreased from 6.00 to about 5.00 between 6500 and 5500 year BP and then showed slow recovery to pH of 6 at present. Interestingly, the time of the pH decrease in Olive-backed lake coincides with the period of maximum enrichment at Lifebuoy lake, implying that the changes at both lakes might have been triggered by the same event, possibly a volcanic eruption. Tephra analysis shows presence of tephra layers at both lakes at about 6,300 BP.

S04-P-16  Distribution patterns of chrysophyte stomatocysts in Finland

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Chrysophytes often dominate in the phytoplankton of oligotrophic alpine, arctic and subarctic lakes. Chrysophyte resting stages (stomatocysts, cysts) are considered to be good paleolimnological indicators because they are abundant and diverse in most Northern lakes, they preserve well in the sediment and many taxa have fairly well defined environmental optima and tolerances. The ultimate aim of this project is to create a temperature/length of ice-cover -transfer function for chrysophyte cysts in Finland in order to reconstruct past temperatures and ice cover times. Here, however, we are going to present the first preliminary results of the impact of several measured environmental variables on the distribution of chrysophyte cysts. Surface sediment samples were collected 2007- 2008 from 62 lakes around Finland. These lakes cover different types of catchment areas and span a large temperature gradient with mean July air temperature of 17.1°C in the south to 8.0°C in the north. So far over 13000 SEM images have been taken and 180 taxa identified. However, almost half of the counted ca. 200 cysts/lake are still unidentified so the results of the multivariate analysis are relatively preliminary. Multivariate analysis results indicate that the most important factors affecting chrysophyte cyst assemblages in Finland are pH and altitude/air temperature. Hopefully further analysis will shed new light on how the cysts are linked to seasonal temperatures. As no previous cysts studies in this scale have been conducted in Finland thus far, this study also brings new information about the occurrence of different cyst morphotypes in Finland.
S04-P-17 A multi-proxy palaeoecological investigation of Holocene climate variability, between c. 6,000 and 4,000 cal. years BP, from three lakes in Northern Norway, on the Barents Sea Margin

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The northernmost Peninsulas of Finnmark have been found to be sensitive to North Atlantic climatic changes, caused by oceanic and atmospheric dynamics (Allen et al., 2007; Risebrobakken et al., 2010). To assess the nature of these links, lake sediments from sites across a west-east transect; LitenCap’pesjav’ri Lake, Over Gunnarsfjorden Lake and Over Kobbkrokvatnet Lake, were analysed at high temporal resolution for diatom compositional changes from c. 6,000 to 4,000 cal. yrs BP. Palynological research at these sites shows shifts in regional Pinus sylvestris (Scots pine) and Betula pubescens (Mountain birch) treeline positions linked to climatic changes between c. 6,000 to 4,000 cal. yr BP (Allen and Huntley, unpublished data). Higher abundances of planktonic diatoms (mainly Cyclotella rossii-comensis complex) with large complex periphytic diatoms, were found at Over Gunnarsfjorden Lake between 5,351 to 5,276 cal. yr BP, Over Kobbkrokvatnet Lake between 5,351 to 5,215 cal. yr BP, with subtle community shifts at LitenCap’pesjav’ri Lake between 5,472 to 5,184 cal. yr BP. Redundancy analysis found no significant diatom-treeline relationship, and planktonic:benthic diatom ratios do not correlate with other North Atlantic climatic proxy data, and may therefore indicate more local climatic changes. Overall, diatom taxonomic changes suggest that higher pelagic primary production is associated with reduced lake ice-cover and increased habitat availability, whilst pollen data reflects wider North Atlantic climatology.

S04-P-18 Reconstructing Holocene changes in lake water pH using a 171-lake modern diatom training set from the Canadian Arctic

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A new diatom training set containing 261 taxa and 8 environmental variables from 171 lakes on the Canadian Arctic Islands and adjacent mainland was created by merging published datasets with new data. Taxonomic harmonization involved updating nomenclature and in some cases, merging varieties into species complexes. Rare taxa (appearing at less than 1% and at fewer than 3 sites; numbering 222 out of an original 483 taxa) were not used in the merged dataset. Canonical ordinations indicated that lake water pH explained the greatest amount of variation in the species data. A 2-component weighted-averaging partial least squares (WA-PLS) model fit the pH data best; despite some spatial structure at small scales (less than 20 km), the lake water pH model remains statistically robust. The pH model was then applied to three dated fossil diatom stratigraphies spanning the Holocene from three regions of the Canadian Arctic. At Lake CF3 on Baffin Island, lake water pH showed a long-term decrease through the Holocene. The diatoms at this lake responded to decreasing pH, likely driven by catchment-scale ontogenetic processes, also possibly mediated by millennial-scale climate variability. Reconstructions at two well-buffered, more alkaline sites in the central and western Canadian Arctic (Lakes PW02 and KR02) had poor analogues; the results suggest that perhaps other factors influenced diatom community composition more than pH. The new diatom training set is therefore particularly well suited for reconstructing pH in dilute and poorly-buffered lakes.
**S04-P-19  Preliminary observations on non-pollen palynomorphs in the Eastern Baltic late glacial and holocene sediments**

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The aim of the present study is to determine the impact of the mean winter temperature (Twin) since the Bølling on environmental conditions, vegetation and non-pollen palynomorphs (NPP) in eastern Baltic region. To determine the impact of Twin changes were used data of pollen and NPP. Study site-Lake Lielais Svētiņu (Lake LS) is located in eastern Latvia and is the only site in the eastern Baltic region with whole sediment sequence since the Bølling.

Coring and sampling in the Lake LS done in March 2009. Chronology based on the 8 bulk and 12 AMS radiocarbon dates. NPP analyses were done during the pollen analysis. Pollen-based temperature reconstructions were done using a weighted average partial least squares two-component model, the Finland-Estonia-Sweden-west Russia-Lithuania pollen-climate calibration dataset.

Obtained results may conclude that since the Bølling there were distinct changes of environmental conditions around the Lake LS. Results of pollen and NPP show the trend of soil erosion in colder climatic phases. Lower Twin and wetter climatic conditions cause water level changes thus promote nutrient enrichment in the lake. The high soil erosion is supported by the pattern of charcoal and fungi hyphae accumulation rates.

Within the last 1000 years, the lake has been influenced by human activity resulting from increased nutrient delivery and eutrophication. Landscape of the lake characterized by late human disturbance in which lake sediments has been affected by natural climate and environmental variability; site is reflecting local as well as regional climatic events and conditions.

**S04-P-20  Potentials of pollen and n-alkane biomarker analyses for last glacial vegetation reconstruction in north-eastern Siberia**

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The current study presents quantitative reconstructions of tree cover, annual precipitation and mean July temperature derived from the Lake Billyakh pollen record (65°17′N, 126°47′E, 340 m a.s.l.) spanning the last ca. 50 kyr. The reconstruction of tree cover suggests presence of woody plants through the entire analysed time interval, although trees played only a minor role in the vegetation around Lake Billyakh prior to 14 kyr BP (less than 5%). The reconstructed values of the mean temperature of the warmest month ~8-10°C do not support larch forest or woodland around the lake during the coldest phase of the last glacial between ~32 and ~15 kyr BP. However, modern cases from northern Siberia, ca. 750 km north of Lake Billyakh, demonstrate that individual larch plants can grow within shrub and grass tundra landscape under very low mean July temperatures of about 8°C. This supports our hypothesis that the western and southern Verkhoyans Mountains foreland could provide enough moist and warm microhabitats to allow individual larch specimens to survive climatic extremes of the last glacial. The n-alkane analysis of the Siberian plants presented in this study demonstrates rather complex alkane distribution patterns, which challenge the interpretation of the fossil records. In particular, extremely low n-alkane concentrations in the leaves of local coniferous trees and shrubs suggest that their contribution to the litter and therefore to the fossil lake sediment might be not high enough for tracing the Quaternary history of the needleleaved taxa using the n-alkane biomarker method.
S04-P-21  Reconstruction of the Late Quaternary environmental change of Kamchatka from three lake sediment records

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Holocene vegetational developments in Russia are relatively unknown, and among the least studied areas of the country is the Kamchatka peninsula. Late Quaternary research has focussed on aspects such as volcanology and tephrochronology, glacier fluctuations and prehistoric archaeology. The present study is a multidisciplinary enquiry into the late-Quaternary environmental change of Kamchatka.

The fieldwork needed for this research was undertaken as part of an arctic expedition (Beringia 2005) organised by the Swedish Polar Research Secretariat (Royal Academy of Sciences) and founded by the Swedish Research Council. Three sediment cores from two lakes in the NE and one lake from the centre of Kamchatka were taken. The drill sites are situated in different parts of the peninsula to provide a survey of environmental change in diverse landscapes and to give dated records for these regions. All cores are analysed by pollen and LOI and dated by $^{14}$C. The palynological and sedimentological investigations will be completed by diatom, biogenic silica, isotope ($\delta^{18}$O, $\delta^{13}$C, $\delta^{15}$N), chironomid and tephra analyses.

So far, three pollen diagrams can be presented. The composition of the forests and the way in which they were assembled over time are examined, as well as whether plants survived within the peninsula, or if they spread in from elsewhere in East Asia following the last glaciation. Therefore it is an important tool for drawing conclusions about changing climatic conditions in the research area.

S04-P-23  Environmental changes in the southern Kola Peninsula (NW Russia) during Holocene reconstructed using lake sediments

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Kola Peninsula is very interesting region for paleoenvironmental reconstruction. There are numerous coastal lakes that were the part of the Barents and the White Seas in the past. However, as shown by our studies some lakes in the south of the Kola Peninsula already existed in the Allerød. We obtained new data on the Holocene history of lakes in the River Umba area and Lake Kanozero. Paleoclimate was reconstructed based on the pollen data. The results were correlated with chironomid studies (Ilyashuk et.al, 2005).

The study is supported by the Russian Foundation for Basic Research (№ 10-05-00651-a and № 10-05-00412-a).

S04-P-24  Hydrological and faunal changes in lakes and ponds in Hudson Bay western lowlands (Churchill, Canada) on decadal scale

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Climate variability, invasions, and natural hazards stress the ecosystem and it responds in a short period of time. The individual organism has to react to complete its life cycle and eventually to reproduce successfully. Under extreme conditions the survival of the total population depends thoroughly on the genetic diversity/potential and thus the ability to expand its biogeographical range or to run extinct. The knowledge of the specific plasticity in time is essential to interpret signals of biological proxies in palaeo-records. Hence, we revisited 11 freshwater lakes/ponds in Churchill, Manitobain 2006 to recollect Ostracoda and provide supplementary data such as water-quality and -chemistry and sediment properties, which were already surveyed in 1997. Our findings are discussed in the perspective of the
instrumental climate records accessible from Environment Canada. Here, we present first time data of non-marine ostracods as the published faunal record of Ostracoda is still sparse in this subarctic region. Our results clearly show that the fauna is characterized by adaption of strong variations in water temperature and low ion content of the host waters. However, species with higher temperature preferences recently invaded in the study area, likely related to the general trend of longer ice-free seasons on the lakes/ponds and changes in the water chemistry.

**S04-P-25 A 1000-year record of vegetation change and wildfire from maar lake Erlongwan in northeast China**

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A high-resolution (~ every 20 yrs) pollen and charcoal record from Erlongwan maar lake (EML) documents the vegetation history and fire activity of the Long Gang region (northeast China) over the past millennium. The age-depth model is based on $^{137}$Cs, $^{210}$Pb measurements, and one calibrated $^{14}$C-AMS date at the base of the core. For much of the record, vegetation was dominated by a mixed conifer-hardwood forest. Pollen and charcoal concentrations reveal considerable variability during the past 1000 years. Between 980-1500 AD both pollen and charcoal reached maximum concentrations (~ 1100 AD and 1300 AD respectively). The high pollen concentration was indicative of prevailing moist conditions during the period commonly referred to as the Medieval Climatic Anomaly (MCA). The high concentration of charcoal indicated high frequency and intensity of wildfire during the MCA, probably linked to high biomass productivity and less snow in winter. Between 1500-1850 AD both pollen and charcoal concentrations were low, indicative of colder winters with higher snow fall, relative drier summers and less intensive wildfire, coincidence with the cold period commonly known as the Little Ice Age (LIA). During 1900 to 1950 AD year, the highest relative abundance of *Artemisia* and the lowest abundance of *Pinus* together with high concentration of charcoal indicated strong human activity. Our pollen data are in broad agreement with a previous study from an adjacent lake, indicating regional rather localized human impact.

**S04-P-26 The best duration of settling for diatom suspension**

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Diatom assemblages reflect well the changes of palaeoenvironment, and the key is to get a complete composition of diatom assemblage. The generally used centrifugation method, however, sometimes causes damage to diatoms, particularly fragile ones, causing large error in diatom statistic analysis. An alterative method is settling, but the duration of settling diatom suspension has not yet been reported by far. Here we designed an experiment to find the best duration for all diatoms to settle down. The result shows that if there are less than 5μm diatom in the samples at least 22 hours are needed for all diatoms to settle down.
Session 05 - Advances in development of lake chronologies

S05-KN  Lacustrine Chronologies: Advances and Challenges

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There are many different approaches to developing chronologies for lake sediment sequences. This will always remain the case as each lake has its own characteristics and opportunities for direct dating. The way the chronology is constructed will relate to its purpose. In some cases we may not need very high precision and in these circumstances purely stratigraphic techniques relying on some degree of regional climate synchrony may be appropriate. In other cases, we wish to have highly precise and accurate chronologies, with well-characterised uncertainties which can enable us to study very short term changes in the climate, and their phasing between different locations. Such chronologies provide the greatest challenge for the Paleolimnologist. Dating information can come from a number of different sources: direct scientific dating through methods such as $^{14}$C (on different sample types), $^{210}$Pb, OSL, relative dating information from varves, and indirect methods such as tephrochronology which allow information on remotes events to be imported into the chronology. To build a chronology we must bring all of this information together, while remaining acutely aware of the nature and limitations of the dating information that we have. There are a number of different numerical methods now available for such integrated analysis. They are not without their problems, but the power of these new techniques to answer questions on sub-centennial timescales is something that has the capability to transform the kind of scientific questions we can address.

S05-01  Correlating lake records within a European tephrostratigraphic framework

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http://c14.arch.ox.ac.uk/reset/

Few lake sediment age models have the decadal to centennial precision required to accurately resolve the timing of some of the most rapid climatic transitions within the last glacial to interglacial cycle. This problem, which is particularly acute beyond the limit of $^{14}$C dating (>50 ka BP), precludes precise inter-site comparisons of proxy data. However, volcanic ash (tephra) isochrons can provide stratigraphic tie-lines between independently dated sediment archives, allowing valid comparisons of the proxy records to be made. For example, where two or more tephra layers are co-located in multiple records, rates of change can be compared within a period of equivalent duration, even in the absence of absolute age estimates. Investigations into the presence of visible and non-visible (crypto-) tephra layers within terrestrial and marine palaeoenvironmental records of the last 100 ka BP from across Europe, has contributed to the establishment of a continent wide tephrostratigraphic framework, or lattice. This lattice allows important archives of environmental change to be precisely aligned, whilst maintaining the integrity of each site’s independent chronology. The value of this approach to understanding spatial and temporal changes within lacustrine palaeoenvironmental records will be demonstrated using examples from the RESET project (RESponse of humans to abrupt Environmental Transitions).
S05-02  Non-atmospheric Pb-210 delivery to Lake Pepin: Implications for Pb-210 dating chronologies

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A new method has been developed to quantify the contribution of fallout Pb-210 deposited directly to the water surface of rivers. This technique was developed in the upper Mississippi River system, where large contributions of river sediment (currently 772,000 tons/yr), and associated Pb-210, challenge dating models for Lake Pepin, a natural flow-through lake on the Mississippi River in Minnesota and Wisconsin, USA. There are two sources of unsupported Pb-210 in rivers: (1) Pb-210 that entered the river already adsorbed onto eroded particles, and (2) fallout Pb-210 that is washed out of the atmosphere by precipitation directly to the water surface. When Pb-210 enters the river system by way of eroded sediment particles, Pb-210 and its short-lived granddaughter Po-210 are at equilibrium. However, when direct atmospheric deposition to the water surface occurs, the freshly deposited Pb-210/Po-210 are not at equilibrium. Therefore, the amount of Po-210 ingrowth that appears after sample collection is the portion of unsupported Pb-210 from atmospheric deposition. Results from 24 river samples collected over one year from the Mississippi River near the inflow to Lake Pepin, indicate, on average, that 65% (one sigma = 32%) of total unsupported Pb-210 adsorbed to river sediments was the result of atmospheric deposition to the river surface and did not enter on eroded particles. There is still a significant portion of non-atmospheric unsupported Pb-210, so caution should be used when interpreting dating model results.

S05-03  Stable Pb isotope ratios as mid-1800s chronostratigraphic markers in lake sediments from Eastern Canada

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We determined the vertical distribution of Pb concentrations and stable Pb isotope ratios in 206Pb-dated sediment cores from eight seasonally anoxic headwater lakes located in various regions of southern Québec, Eastern Canada. The only inputs of anthropogenic Pb into these lakes are via atmospheric deposition since their watersheds remained uninhabited and undeveloped. A most interesting feature of the profiles is the presence of sharp peaks of Pb stable isotope ratios below the depth of detectable unsupported 206Pb (i.e., corresponding to mid-1800s) in the sediments of all lakes. Very similar subsurface maxima in Pb isotope ratios have been reported in the sediments of the Pettaquamscutt Estuary, Rhode Island and attributed to the early period of smelting of highly radiogenic Pb ores from the Upper Mississippi Valley. Given that our sampling sites are located more than 2,000 km from this industrial source of Pb emissions, and that back trajectory studies indicate that air masses from the midwest USA reach southern Québec, Ontario and the Canadian Maritime Provinces, we infer that this industrial Pb signal, dated at 1842 by varve counting in the Pettaquamscutt Estuary, should provide a widely distributed and accurate time-stratigraphic marker for various natural archives from Eastern North America.

S05-04  Radiocarbon dating and Bayesian age-depth modelling in the Canadian Subarctic (Tibbitt to Contwyoto Winter Road Project)

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Past climate variability along the strategically important 600 km-long Tibbitt to Contwoyto Winter Road (TCWR) in the central Northwest Territories, Canada is poorly understood. With road traffic projected to increase significantly as new mines open, it is critical that planners and mine developers have reasonable data on the future viability of the
road, as alternate transportation costs (e.g. air transport) are prohibitively high. The research presented here is part of a multidisciplinary paleoclimate study based on analysis of proxy data derived from freeze cores in lakes along the TCWR. For accurate determination of the character, timing and causes of regional climate change, it is critical that age models with exceptional precision and accuracy are derived. Thus far, freeze cores from nine lakes have been analyzed, with 4–17 AMS $^{14}$C dates per core depending on the length (0.5–2m) and quality of the core. As is common at high latitudes, macrofossils were absent, so $^{14}$C chronologies were developed from bulk sediments. Although such dates are not ideal, we corrected for the freshwater reservoir effect on a lake-by-lake basis and removed outliers using the general outlier model in OxCal. Finally, we used deposition sequences based on Bayesian statistics in OxCal and Bacon to incorporate prior information into the age-depth models. Such prior information includes stratigraphic ordering of dates and accumulation variability (k parameter in OxCal, acc.mean in Bacon), which was not previously known so it was estimated as mean sedimentation rates obtained through ‘classical’ age-depth modelling in Clam.

**S05-05 Use of fallout $^{137}$Cs records for correcting $^{210}$Pb dating errors**

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Discrepancies are frequently encountered between $^{210}$Pb dates of lake sediments calculated using either of the standard (CRS or CIC) $^{210}$Pb dating models, and chronostratigraphic dates determined from sediment records of fallout $^{137}$Cs (or other artificial radionuclides with well known fallout records). Such discrepancies can be caused by changes in the rate of supply of $^{210}$Pb to the coring site due e.g. to changes in the lake hydrology, or to singular events such as a sediment slump, turbidity current or major catchment disturbance. This talk will give examples of such discrepancies and discuss methods for determining best chronologies in those cases. Key to these procedures is an assessment of the cause of the discrepancy. Since factors affecting the rate of accumulation of $^{210}$Pb can also affect other environmental records, these causes may need to be taken into consideration when using sediment cores to reconstruct temporal records of environmental change.

**S05-06 Extending the chronology of lacustrine records: recent developments in luminescence dating**

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Lakes can preserve important terrestrial records of palaeoclimate and environmental change, with some sites capable of providing high-resolution records with essentially continuous sediment accumulation over time. In certain settings, very long sediment cores can be retrieved. However, although these thick sedimentary deposits can reveal detailed fluctuations in palaeoenvironmental proxies, these proxy data are of limited value without a reliable chronology. Thus far, lake-floor sediment chronologies have been chiefly reliant on radiocarbon dating, which has typically restricted the ages generated to the last ~40 ka. However, this time range frequently describes only the upper portion of the sediment record, and the deeper portions of the sedimentary record are assigned ages either by extrapolation (thereby assuming a constant accumulation rate, and a continuous sediment record with no hiatus*), or by tuning one of the palaeoenvironmental proxies to orbital insolation. Clearly, a preferable approach is direct numerical dating of the sediments throughout the entire sedimentary sequence.

Luminescence dating provides a numerical chronology, spanning a broader time range (typically of the order of 101 to 105 years) than radiocarbon dating, and the technique also offers the advantage of dating the time of deposition of sediments directly using the commonly occurring minerals, quartz and feldspar. Recent advances in luminescence dating
have brought about a step-change in both the accuracy and precision of the ages generated, making the application of luminescence dating to lake-floor deposits a timely advance. The contribution that these new luminescence techniques can make to lacustrine studies will be discussed, and data will be presented for a 90m sediment core from Lake Tana, Ethiopia, resulting in one of the longest independently dated lacustrine chronologies for East Africa.

S05-P-01 Lateglacial tephrastrostratigraphy of the Swedish Varve Chronology

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Varved records have the potential to allow the assessment of climatic data at annual and potentially sub-annual scales. They are one of very few archives of environmental change which have the ability to provide data at a resolution comparable to Greenland’s ice cores (and the associated GICC05 chronology; Svensson et al., 2008; Rasmussen et al., 2006) and thus are critical for assessing the spatial and temporal differences in environmental responses to changing climates. Throughout Europe, there have been notable successes in generating detailed varved records for the Last Glacial to Interglacial transition (LGIT: 16-8ka BP; Brauer et al., 1999; Brunnberg, 1995; De Geer, 1940; Hang, 2003 Litt et al., 2001; Lotter, 1991; Lundqvist and Wohlfarth, 2001; Ringberg et al., 2003 amongst many others), however, many of these records are not varved to the present day and, even those which are, often have substantial counting uncertainties associated with them, or potential problems of ‘missing years’. These challenges currently limit the potential of this valuable terrestrial archive to contribute to the goals of INTIMATE and require independent age control to unequivocally link them in to continuous chronologies in order that rates, durations and synchronicity of response to climatic change can be more precisely assessed. This paper reports the results of volcanic ash analyses from the Lateglacial section of the ‘continuous’ Swedish Varve Chronology and aims to further develop our understanding of the spatial and temporal links between climatic changes recorded in terrestrial and ice core records.

S05-P-02 Generating high-precision tephra-supported lake chronologies to determine the spatial and temporal pattern of deglaciation in Scotland

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Lakes in previously glaciated regions have the potential to constrain the timing of deglaciation of a landscape via the direct-dating of material associated with the onset of sedimentation. This usually necessitates the dating of organic matter via radiocarbon, which then provides a minimum age for lake formation. By dating several sites within a region, a series of chronostratigraphic ‘pinning points’ can be developed which allow the maximum glacial extent to be reconstructed. This exercise has been attempted numerous times across Scotland over the last c. 50 years and the published results are inconsistent. This most likely reflects the sampling of bulk organic material in the majority of these cases, hence it is possible these dates are affected by mineral carbon, and/or sample selection errors.

In recent years an alternative approach has been applied to address the timing and pattern of deglaciation, namely, cosmogenic nuclide dating of rocks associated with glacial landforms. These studies have frequently suggested a different temporal pattern of deglaciation and subsequent glacial re-advance. However, the chronological uncertainties associated with this technique make direct comparisons between the lake and landform chronologies difficult to achieve. Here we present new chronological data from several sites in Scotland, discuss the application of tephra layers as isochronous marker layers to resolve this problem, and the use of tephras in generating high-precision
lake chronologies.

**S05-P-03** Eight thousand years of varved sediments deposition in Lake Szurpily (NE Poland): varve structure, chronology and turbidite sedimentation

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Annually laminated lake sediments provide a calendar-year age-depth control necessary for high-resolution paleoenvironmental reconstructions. Even though varve counting is regarded as a precise dating tool, it must be validated by independent dating methods. Parallel overlapping sediment cores with total length of 12.38 m were retrieved from Lake Szurpily (NE Poland) in 2007. Due to the massive sand layer at 7.58-9.28 m sediment depth, only the upper undisturbed part of the entire record was used in this study to construct a continuous varve chronology covering the last 8000 years. The annual deposition model (typical varve structure) was established by analyzing thin sections and varve chronology was verified by independent dating (Pb-210, Cs-137 and AMS radiocarbon dating). The varve counting error was determined by three replicate varve counts (Cybis Coordinate Recorder) and compared with an automated counting method (BMPix and PEAK tool). The cumulative manual varve counting error/uncertainty was estimated to be ±1.24% (8165±101 varve years). The age-depth model based on manual varve counting and Pb-210/Cs-137 dating was almost perfectly consistent with obtained radiocarbon dates. Varve thickness ranges from less than 0.1 to 13.7 mm with a mean of 0.83 mm (standard deviation: 0.75 mm). Finely laminated sequence shows slight underestimation (~1%) of automated counts, whereas in sections containing thick and complex varves we found a considerable overestimation (>10%) of automated counts. Grain size analysis was also performed by laser diffraction on selected turbidites. In most of cases the lack of a coarse grained basal layer suggests no or insignificant varve erosion.

**S05-P-04** Characteristics of sedimentary varve chronologies — A review

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We constructed a varve data base (VDB) to study the worldwide distribution of varved sediment records and the fidelity of their varve chronologies. Clusters of lakes with varved sediments exist in central North America, in the Canadian Arctic, and in northern and central Europe. Among the 108 sites included in the VDB, varved records are typically 200-500 cm long and cover a period of 1000-2000 years. Their varve chronologies are often based on counting of annual layers from fresh sediment surfaces and photographs or from epoxy embedded sediment blocks and thin sections. The VDB indicates that chronological errors associated with counting sedimentary varves fall generally between 1 and 3% but only 57% of published records are providing quantitative error estimations for their chronologies. With a careful documentation of varves and by applying radiometric dating methods to surface sediments as well as using historical events as time markers, there is the potential of having centennial-long varved records with a very precise age-depth control. However, it is unrealistic to expect errors significantly below 1% from several millennia long sections. We found no indication that varve chronologies would have been substantially more accurate and precise in some parts of the world than in others or statistically dependent on varve thickness or temporal extension of a varved
sequence. According to the VDB, close to 90% of the published varve chronologies have been cross-checked with some independent dating methods.

**S05-P-05  Environmental evolution of the Xingkai Lake since 200 ka by OSL dating of sand hills**

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Xingkai Lake is the largest freshwater lake in northeast Asia. In addition to the lakeshore, there are four sand hills on the north side of the lake that accumulated during a period of sustainable and stable lacustrine transgression and were preserved after depression. Analysis of well-dated stratigraphic sequences based on 18 OSL ages combined with multiple index analysis of six sites in the sand hills revealed that the north shoreline of Xingkai Lake retreated in a stepwise fashion since the middle Pleistocene, and that at least four transgressions (during 193–183 ka, 136–130 ka, 24–15 ka and since 3ka) and three depressions occurred during this process. The results of this study confirmed that transgressive stages were concurrent with epochs of climate cooling, whereas the period of regression corresponded to the climatic optima. Transgressions and regressions were primarily caused by variations in the intensity of alluvial accumulation in the Ussuri River Valley and fluctuations in regional temperature and humidity that were controlled by climatic change. Moreover, one obvious transgressive process that occurred in MIS3 may have been related to enhanced precipitation that was reportedly widespread in the west of China, while short-term fluctuations in the lake level might well be a direct response to regional precipitation variations on the millennial scale.

**S05-P-06 A new high resolution record of regional volcanic and seismic activity for the past 500 years in South-Central Chile from annually-laminated lake sediments**

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Lake sediments contain unique information about the past recurrence rate and magnitude of volcanic and seismic events within the lake catchment. Here, we present reliably-dated, high-resolution records of natural catastrophes from c. 500 year old annually-laminated lake sediment sequences in three lakes, Villarrica, Calafquén and Ríñihue, in the volcanically and seismically active Chilean Lake District. Using a combination of µXRF scanning, microfacies, grain-size, color and magnetic susceptibility analyses, we characterized four different types of event deposits (lacustrine turbidites; tephra fall-out layers; very fine ash laminae; lahар deposits) and constructed a new eruption record for the Villarrica, Mocho and the Carrán-Los Nevados Volcanic Complexes. Applying time series analysis, we show there were 112 eruptions with a Volcanic Explosivity Index (VEI)>1.
from Villarrica Volcano in last c. 500 years, on average, one eruption every 5.32 years. The Mocho Volcano was significantly less active than the Villarrica Volcano, and less active since 1900 AD. Only three eruptions from Carrán-Los Nevados Volcanic Complex were identified in the last c. 500 years. The last VEI>1 eruption of the Villarrica Volcano dates back to 1991 AD. We estimate the probability of the occurrence of future eruptions from the Villarrica Volcano, and statistically demonstrate that the probability of a 21-year repose period without VEI>1 eruptions is ≤1.8 %. At least one VEI>1 eruption should have taken place between 1991 AD. and 2012 AD. This new perspective on the reoccurrence interval of eruptions and historical lahar activity will improve hazard assessments for this rapidly expanding tourist region.

S05-P-07 Detection of seasonal signals in visually non-laminated sediment of Lake Dudinghausener See, North German Lake District

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Dating sediment layers is of crucial importance for paleolimnological investigation. Ideally, sediment laminae form varves, allowing for seasonal differentiation of minerogenic or biogenic sedimentary events and the establishment of a sound chronology. However, since the uppermost sediment is often homogenized by bioturbation, the ability to differentiate years or even seasons degrades or may be absent. Absolute age dating is usually achieved by radiometric analyses of \(^{210}\text{Pb}/^{137}\text{Cs}\) or \(^{14}\text{C}\), depending on the expected age, which may, in turn, also be influenced by bioturbation. This is unfortunate for paleolimnological reconstruction of the recent past. Therefore, we introduce a novel approach that encompasses homogenous, visually non-laminated sediment cores from dimictic Lake Dudinghausener See (Northern Germany). Based on \(^{210}\text{Pb}/^{137}\text{Cs}\) dating, 45-cm long core represents ~80 yrs, from 2010 to 1929/30, i.e., sedimentation rates are ~5.6 mm/yr. High-resolution (2 \(\mu\)m) XRF analyses indicate variability in the range of the annual band with two seasonal layers. We used the software package BMPix and PEAK (Weber et al., 2010) to “count” these variations. For silica, we were able to distinguish 80 years as curve minima and 80 maxima, as well as 160 seasons, thereby confirming the Pb/Cs dating. Additionally, we count the grey-scale curve derived from visually varved sediment records from Lake Woseriner See.

Our main conclusion is that seasonal-resolution lake chronologies can be established, in combination with methods for absolute age dating, in sediment successions visually free of lamination. We consider this a big step forward because climate signals of bioturbated sediment can now also be studied with seasonal-resolution age control.

S05-P-08 Optical dating of delta sediments at the entrance of the Megalake Jilantai-Hetao by using quartz and k-feldspar: a test on age of the highest lake level during the Late Quaternary, northern China

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A megalake Jilantai-Hetao existed along the bend of the Yellow River in Hetao Plain, northern China, prior to 50-60 ka which was supported by OSL ages from twelve profiles along the highest lake shoreline with altitudes between 1080-1100 m asl. The highest lake level was proved a response of water input from the Yellow River, and an underwater delta was formed simultaneously at the entrance of the lake basin. However radiocarbon age ((41450 ± 470) cal a BP, 7.1 m depth) from the delta contradicts the previous OSL ages of the highest shoreline of the Megalake Jilantai-Hetao. To test validity of the radiocarbon age, OSL ages of three sand samples on multiple coarse quartz grain aliquots were measured by using double SAR protocol in this delta sedimentary profile. OSL ages of quartz are 60.18±6.98, 76.16±7.22 and 70.52±6.73 ka from
three samples at 4m, 6.5m and 7.0 m depth respectively, which are consistent with previously reported OSL ages of the highest shoreline of the Megalake Jilantai-Hetao at other sites. However the radiocarbon age obtained from this profile is 20-36 ka younger than OSL ages, indicating that the radiocarbon age around 40 ka in this delta profile was apparently underestimated. Considering the potential underestimation of OSL ages of quartz older than ~60 ka, the credibility of OSL ages of quartz obtained in this paper were tested through comparison with IRSL dating results from k-feldspar. IRSL ages of k-feldspar from the sample at 6.5m depth in the delta sedimentary profile were obtained as 74.51±3.83 ka and 188.94±9.71 ka by using SAR and post-IR IRSL protocols respectively. For IRSL ages obtained by using SAR protocol, anomalous fading rates (g2d value) were measured as (5.89±0.93) %, (4.33±0.62) % and (7.02±0.70) % from three different aliquots, and the average fading-corrected IRSL age is calculated as 148.53±29.34 ka. Both the fading-corrected IRSL age (148.53±29.34 ka) and the uncorrected post-IR IRSL age (188.94±9.71 ka) from k-feldspar are obviously larger than the OSL ages of quartz (60-76 ka), indicating that OSL ages of quartz obtained from this delta might be underestimated and only provided the minimal age of the highest lake level of Megalake Jilantai-Hetao.
Session 06 - Regional integration of recent lake sediments for management of landscapes, ecosystems and ecosystem services (PAGES Focus 4)

S06-KN Sailing through the perfect storm: wetland condition assessment for wetland management; south-east Australia

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South-eastern Australia is a focus for intensive landscape development for urban settlements as well as for the agricultural activities that support them. It is also a place of great water resource regulation and exploitation across a landscape with labile soils, shallow saline aquifers and erratic climate. As if to further test the laconic nature of the locals, south-east Australia is identified as a global climate hotspot forced to manage the impending collision between social, economic and ecological imperatives, under a diminishing water budget.

The depth of settlement history precludes a clear understanding of the nature of wetlands, or the climates that support them, since European settlement. This has often ensured that the perspectives brought to the management table are short-term, and so misrepresent the full diversity and heritage significance of the sites. This limited view has driven actions that address the derived nature of wetlands. In part, this is exacerbated by management instruments such as Ramsar that identify ecological condition at particular points in time and seemingly commit agencies to manage for stationarity, rather than change and variability.

An emerging synthesis of paleolimnological records across the region contextualise the present climate regime and identify the historical range of variability, and also resilience, of wetlands. Evidence for marked increases in the fluxes of sediments, salts and nutrients since European settlement provides stark contrast with the presumed understanding of ecological condition and more clearly reveals the loss of natural heritage and ecosystem services. The uncomfortable reality of the degraded, but dynamic nature of the wetlands is being brought to the table to encourage accommodation of change rather than management for stasis.

S06-01 Arcellaceans (testate lobose amoebae) as an aquatic ecosystem bio-indicator to gauge the potential environmental impact of oil sands operations, Fort McMurray region, Alberta, Canada

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The Alberta oil sands (AOS) are one of Canada’s most economically important natural resources, which need to be developed in a sustainable manner. Assessing emission pathways and remediating potential detrimental environmental impacts from AOS extraction is therefore strategically important requiring development of new and innovative geoscientific biomonitoring technologies in order to understand potential ecological, temporal and spatial distribution of AOS effects on the environment. To aid in this effort the Geological Survey of Canada’s Coal and Oil Resources Environmental Sustainability Project (CORES) is mandated to assess all potential AOS impacts on water, air and biodiversity. Arcellacea (testate lobose amoebae), a micropaleoecological environmental proxy in lakes has been demonstrated to be a useful proxy in gauging the presence and impact of oil sands derived materials. As part of the CORES initiative, arcellacean assemblages archived in cores and observed in sediment-water interface samples from natural lakes across the region were used to establish baseline background environmental conditions and natural ecological ranges.

A comparison of arcellacean assemblages observed
in core intervals representing pre- and post-oil sands development phases both downwind and downstream of AOS provide no evidence of ecological change related to the environmental impact of AOS developments. In addition, an assessment of the spatial distribution of Hg, previously claimed to be elevated in lakes surrounding the AOS, shows no depositional correlation with prevailing winds or streamflow in the region. Levels of Hg observed in all samples were also found to be within acceptable Health Canada and US EPA levels.

S06-02 Regional analysis of algal community change in lakes of the Windermere catchment, Lake District, UK

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Like many catchments globally, the Windermere drainage basin in the UK Lake District National Park has witnessed a decline in the quality and ecological integrity of its surface water bodies. The Windermere catchment (area 220km², altitudinal range ~900m) comprises five large and fertile lakes in the lowlands and six small unproductive tarns in upland areas which drain into Windermere’s main basins. The aims of this research are to use algal pigments in lake sediment cores spanning the past ~200 years as biomarkers for algal community change and to elucidate the main drivers of change across the catchment. Preliminary results from Blelham Tarn, a small, eutrophic lake in the lowlands indicate that there was a 7-fold increase in the cyanobacterial pigment echinenone and a 22-fold increase in the cyanobacterial pigment aphanizophyll, coincident with the establishment of a sewerage outlet to the tarns main inflow in 1962 and the increase in use of artificial fertilisers in the catchment. Stable carbon and nitrogen isotopes and C:N ratios also indicate an increase in algal production after the same period (ca. 1960). In contrast, pigments from a small upland lake, Stickle Tarn are more likely to be responding to changes in atmospheric contaminants over the past 150 years. This work demonstrates that lakes within a few kilometres of each other respond in diverse ways to localised changes in human pressures including sewage loading and agricultural fertilization as well as regional drivers such as atmospheric deposition and climate change.

S06-03 Lake response to natural and cultural impacts at the landscape scale in western Uganda


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There is an increasing need to integrate a range of long-term records to provide a comprehensive environmental understanding of human-environment and spatial-temporal interactions within a landscape. This approach to understanding modern landscape change in a palaeolimnological framework is especially important when developing management strategies for ecosystems in regions most susceptible to future changes. However, these analyses have rarely been examined at a landscape scale. To address questions of spatial and temporal coherence and the impacts of external and in-lake processes, a multi-lake study, where systems are constrained by similar geology and simple climate gradients, can be used to understand the impacts of recent anthropogenic disturbance. With a high concentration of crater lakes, western Uganda provides a unique landscape in which to tackle and understand questions related to spatial and temporal synchrony of environmental changes in a matrix of sites with differing levels of disturbance.

Nine lake sediment cores across an anthropogenic
disturbance gradient in western Uganda were analysed for physical properties and diatoms. All sites, regardless of contemporary anthropogenic impact, demonstrate unprecedented levels of sediment influx occurring over the last 50-75 years. This increase in sediment flux is coincident with diatom habitat changes (from predominantly planktonic to benthic systems). In areas such as western Uganda, where lakes are heavily relied upon as a source of potable water, understanding the complexities of change and the sensitivity and resilience of these systems to future change are paramount to preserving both the ecological and social functioning of these vulnerable ecosystems.

S06-04  Impact of forestry on net ecosystem production in upland lakes of north-west Ireland


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Many lake upland catchments in North-West Ireland have been subjected to afforestation, which involves initial ploughing and planting, subsequent fertilisation and then clear-felling and replanting. This study links records of forestry management activities with changes in lake ecosystem production to examine the role of managed coniferous forestry in driving allochthonous and autochthonous lake carbon flux since the 1960s. We hypothesized that nutrients from fertiliser application would lead to elevated autochthonous production, whereas ploughing and clear-felling of forest would increase the input of allochthonous dissolved and particulate carbon (and therefore water colour), reducing light penetration and potentially limiting production. We tested this hypothesis using chlorophyll and carotenoid pigment analysis of six 210Pb dated sediment cores from upland lakes to infer lake net-ecosystem production across a range of past forestry regimes. Past water clarity in four lakes was inferred using UV-screening compounds. In one site (Crockacleaven) algal production increased markedly in response to forestry likely due to fertilization. However, at five other lakes (Annary, Carrownabanny, Afurmagh, Fadd and Lough Lettercraffroe) the major changes in algal pigments pre-date forestry management. Here, algal pigment variations are more strongly associated with catchment drivers including agricultural activity, atmospheric deposition and fluctuations in water colour (from clear-felling and planting). This study suggests that in the majority of lakes studied net ecosystem production was driven predominantly by wider catchment drivers, rather than non-native coniferous forestry.

S06-05  A typology of wetland response to catchment and climate change based on a regional synthesis of palaeoecological records

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Over the past two decades, numerous sediment records from billabongs throughout the Murray-Darling Basin have been subject to palaeoecological analysis. The picture that emerges from these studies is of ecosystems that have undergone substantial ecological change in response to recent (past 200 years) human activities. A common ecosystem response observed in these records is a switch in state from macrophyte to phytoplankton-dominance around the time of European settlement. It has been postulated that this switch occurred when increased turbidity associated with anthropogenic soil erosion resulted in a reduction in photic depth beyond a critical threshold. However, not all billabong records display this pattern. Some billabongs remain in a macrophyte-dominated state; some appear to switch between macrophyte and phytoplankton-dominance later in the post-European period, or even independent of human activities; others do not show...
stability in either a macrophyte or phytoplankton-dominated state. This variation in response may be due to spatial variation in the nature and intensity of stressors affecting individual billabongs or to underlying differences in the resilience of the billabongs themselves with respect to these stressors. We use a regional synthesis of billabong records to investigate patterns in system resilience. On the basis of this investigation we postulate a typology of response models whereby system resilience can be predicted by underlying hydrology and geomorphology. This understanding will aid the management and conservation of these important habitats in the context of intense, competing demand for water and future climate change.

**S06-06 Defining regional boundaries for human activities through analysis of past records**

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For the earth system, the planetary boundaries concept (Rockström et al., 2009) provides a powerful framework for exploring thresholds in key global processes. But without parallel understanding at regional scales it is difficult to advise national and local stakeholders about ‘confining’ their actions (ICSU 2010). Here we explore the use of past records of ecosystem services from lake sediments and monitoring data to help define boundaries for human activities – the safe operating spaces within regions. Our approach follows Rockström et al. (2009) in defining boundaries on the basis of system dynamical properties. We have begun to identify regional boundaries between safe and dangerous states by reference to the direction of trajectory and variability in past records of change. So far we have identified four types of ‘boundary’. One regional case-study, the 2000 km² Erhai lake-catchment, Yunnan, China, has a long history of unsustainable pressures on ecosystem services, particularly regulating and supporting (Dearing et al., 2007; Dearing 2008). Modern environmental impacts include deforestation, soil erosion and eutrophication of the lake and rivers. Using analyses of recent lake sediments and environmental records we have made initial maps of the trajectories over the last 40-50 years for water purification, terrestrial biodiversity and water availability. The results show that water purification services exceeded a critical transition in the late 1990s largely as a result of accelerated agricultural effluent loadings pushing the agriculture-fertilizer-animal waste-effluent-lake system into a dangerous – critically unsustainable – space. Terrestrial biodiversity has also moved into the dangerous operating space while water availability has begun to recover since the 1990s. Overall our findings show that multi-decadal palaeoecological records provide a basis for defining modern socio-ecological systems in terms of dynamical behaviour. This basis provides an opportunity to assess current ecological conditions and establish regional boundaries and safe operating spaces for human activities at regional scales worldwide.

**S06-P-01 A neo- and palaeolimnological approach to understanding landscape functioning of a peatland undergoing windfarm development**

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Scotland’s peat landscapes are desirable locations for wind-based renewables due to high wind resources in these areas. The environmental impact of siting wind-based renewables on peats however, is unknown. As peatlands are natural carbon sinks, it is imperative to assess if the impact of construction activities of this type of renewable development contribute to any degradation of peatlands, so they subsequently become carbon sources. For instance,
predicting the time for renewables to ‘payback’ the carbon lost as a result of construction of these projects has not been fully characterised and this research will provide data that can supplement current ‘carbon payback calculator’ models for wind farms that aim to reinforce their ‘green’ credentials.

The Gordonbush Estate, Brora, Scotland is a peatland that is currently undergoing development in order to host a 35-turbine wind farm. The wind farm catchment drains in to Loch Brora and therefore increases the likelihood that the total amount of particulates and carbon will be deposited in the lake. Sediments recovered from Loch Brora record carbon dynamics and sediment export characteristics of the peatlands pre-wind farm construction. This palaeolimnological approach couples monitoring particulate and dissolved organic carbon in river input, with sediment traps collecting the overall sediment delivery to Loch Brora. Initial $^{210}$Pb results indicate the top ~30 cm of Loch Brora sediments have accumulated over the last 150 years. Additional results will further highlight how lake sediments can be used as a tool to track modern carbon fluxes and sediment characteristics from peatland landscapes.

S06-P-02 Expanded spatial extent of the Medieval Climate Anomaly revealed in lake-sediment records across the boreal region in northwest Ontario


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Multi-decadal to centennial-scale shifts in effective moisture over the past two millennia are inferred from sedimentary records from six lakes spanning a ~250 km region in northwest Ontario. This is the first regional application of a technique developed to reconstruct drought from drainage lakes (open lakes with surface outlets). This regional network of proxy drought records is based on individual within-lake calibration models developed using diatom assemblages collected from surface sediments across a water-depth gradient. Analysis of diatom assemblages from sediment cores collected close to the near-shore ecological boundary between benthic and planktonic diatom taxa indicated this boundary shifted over time in all lakes. These shifts are largely dependent on climate-driven influences, and can provide a sensitive record of past drought. Our lake-sediment records indicate two periods of synchronous signals, suggesting a common large-scale climate forcing. The first is a period of prolonged aridity during the Medieval Climate Anomaly (MCA, c. 900-1400 CE). Documentation of aridity across this region expands the known spatial extent of the MCA megadrought into a region that historically has not experienced extreme droughts such as those in central and western north America. The second synchronous period is the recent signal of the past ~100 years, which indicates a change to higher effective moisture that may be related to anthropogenic forcing on climate. This approach has the potential to fill regional gaps, where many previous paleo-lake depth methods (based on deeper centrally located cores) were relatively insensitive. By filling regional gaps, a better understanding of past spatial patterns in drought can be used to assess the sensitivity and realism of climate model projections of future climate change. This type of data is especially important for validating high spatial resolution, regional climate models.

S06-P-03 Tracing the source of the signal – exploring the potential for watershed monitoring to explain variation in sedimentary records

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Three lakes in Iceland’s Westfjords contain records of mineral deposits with an apparent 80-110 yrs cyclicity (Doner, 2003). In 2011, a team of sedimentologists, geochemists and hydrologists began a 4-year monitoring project to identify the cause of these mineralogic cycles by examining river, soil and lake reservoirs and fluxes under varying meteorology conditions. Here we present monitoring results of riverine, soil pore water and soil chemistry of the Vatnsdalsvatn catchment (65°36′N, 23°05′W; 102 km2). Analyses of isotopic and geochemical tracers from the feeder streams to the Vatnsdalur R show snowmelt is a major control on source water and that significant temporal chemical fluxes occurred in the river water. Despite high discharge, particulate load was minimal except during rain events. Runoff dominates solute fluxes of Na, Si, and K, but V and Rb are controlled by snowmelt and subsequent pore water mobility. Dissolved Al, Ti, Pb, Zn, Mo and Mn, weathering products of basalt, mobilize in rain events. XRF analyses of contiguous soil profile samples show generalized depletion of K, Mn, Y and Cl below the surface horizon and accumulation of Si, Al, Ti, Ca, Sr, V, Fe and P. These results suggest that surface erosion of soil may be a source of some of the lake deposits, but that deeper erosion is needed to explain most of the lake sediment mineralogy. During wetter intervals, dissolved mineral yields are significantly higher than in drier intervals. Dissolved vanadium (at least) is stored by the lake, presumably in sediments.

S06-P-04  Groundwater variability and extreme rainfall events in Mediterranean areas: the Holocene record of Lake Banyoles (Catalonia, NE Spain)

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Banyoles (42°08’N, 2°45’E) is the largest and deepest (46.4 m) lake of karstic-tectonic origin in the Iberian Peninsula. The lake basin comprises eleven sub-circularly shaped depressions fed by subaqueous springs. The intensification of groundwater inflow in the deepest depressions leads to the fluidification of the sediments deposited in these areas and their subsequent transport by turbidity currents flowing over the southern sector of the lake. These fluidification events occur during periods of higher groundwater discharge caused by intense precipitation in the recharge area of the aquifer and are likely responsible of the deposition of thick and homogeneous mud layers identified in the recent sedimentary sequence.

The combination of high-resolution seismic stratigraphy (3.5 Khz pinger and multi-frequency Chirp surveys) and the multi-proxy analysis of a 13 m long piston-core, including sedimentology, physical properties, high-resolution elemental geochemistry, organic and inorganic carbon, and grain size analyses, allows the reconstruction of the main hydrological changes in the lake during the Holocene.

The age model based on 137Cs/210Pb and AMS 14C indicates that the recovered Banyoles sedimentary record spans the last 7020±52 cal yrs BP. Shallow, carbonate-producing lake conditions were reconstructed for Mid to Late Holocene times. A deeper lake system was established during the last millennia, and frequent homogeneous layers were deposited as a result of a recent increase in groundwater input. We investigate the number, thickness and age of these layers as a proxy of frequency and intensity of heavy rainfall events during the late Holocene in the Western Mediterranean region.
**S06-P-05 Eutrophication process in Erhai lake, Yunnan province, China, based on fossil diatoms**

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Eutrophication in Erhai Lake, Yunnan province, China is understood with one sediment core for the deepest part of the lake. Fossil diatoms as well as chemical elements and TOC/TN is analysed to explore the lake’s eutrophication process. The results suggest that the lake’s eutrophication is caused by the nutrients enrichment from the catchment. The evidence can be found from the rising of the organic matter (TOC), sediment phosphorus (P) and fossil diatom communities’ change from 1960s. The diatoms show that the biotic conditions changed at the early of 1960s, and the variance of the change increased after 1980s. All sediment proxies indicate an abrupt change after 2001, which was correspondence to the lake’s continuous algal blooming records. The bloom of species such as *Fragilaria crotonensis* indicate the lake’s phosphorus recycling from the sediment in spring, therefore, the diatoms records can reveal the appearance of a positive feedback between anoxia conditions and phosphorus recycling from the sediment. The regime shift of Erhai lake should be due to the appearance of this new positive feedbacks.

**S06-P-06 OPALaeolimnology: sediment histories for the people**

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The OPAL Water Centre at UCL has been using palaeolimnology to provide historical context to a England-wide lake monitoring project. OPAL (Open Air Laboratories) is funded by the Big Lottery Fund’s ‘Changing Spaces’ programme. The objectives of OPAL are to generate greater awareness and understanding of nature through participation in environmental monitoring and providing new approaches to learning. The OPAL Water Centre ran a national survey in 2010 to assess water quality in ponds and lakes. More than 4000 surveys have been submitted.

Quarterly water sampling took place between 2008 and 2012 at 9 lakes chosen by community groups across England. Measurements of lake water chemistry, trace metals, Hg and persistent organic pollutants were collected to provide contemporary environmental data on the status of the lakes and provide information for future management decisions.

Dated sediment cores from the lakes exhibit a range of environmental histories related to the characteristics of the lakes and the extent of human interference. Sediment geochemical, biological and pollutant measurements were used to extend the timescale of environmental monitoring. Significant sediment contaminant levels are observed in all the nine lakes from catchment and atmospheric inputs.

We have found palaeolimnology to provide an exceptional perspective and generator of ‘real-world’ interest to community groups and individuals who are often unaware of basic concepts of limnology and environmental change. The novelty that global/national/local scale environmental processes are recorded in sediments of small, disturbed (classically ignored) lakes should not be overlooked by scientists engaging with the public.

**S06-P-07 Are recent lake sediment records enough? The complexity of anthropogenic and natural forcing in a semi-arid climate zone: preliminary results from a Holocene study of Balkan Lake Dojran, Republic of Macedonia**


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The southern Balkan region is a hotspot of biodiversity, with high levels of endemism in ancient lakes. In a semi-arid climate zone, these lakes are key hydrological resources for humans. In a
European context, they are also in one of the regions thought to be most vulnerable to the effects of future climate change. Lake Dojran (Rep. of Macedonia/Greece), is currently hypereutrophic and shallow. As part of the ICDP Deep Drilling project on Lakes Ohrid, Prespa and Dojran (Wagner et al.), a 720 cm-long, ca. 10-12 ka Holocene lake sediment core was collected from Dojran in summer, 2011. The study is part of a multi-proxy, multi-site investigation of the interactions between climate change, tectonics, human impact and shifts in biodiversity in the southern Balkans. Here, we present preliminary palaeolimnological interpretation of diatom and sedimentological data in the context of understanding the particular challenges faced in defining and understanding baselines for lake restoration in arid regions. The results indicate that the lake has undergone unprecedented eutrophication in the recent past, suggesting that a simple nutrient baseline can be defined for restoration. There is longer-term evidence for complex palaeolimnological shifts, however, which suggests that accelerated nutrient input is only one of a complexity of interacting factors affecting lake status. These include climate change, water abstraction and soil erosion, both from deforestation and the influence of earthquake activity on sediment input. There is a clear need to model longer-term ecosystem dynamics and external inputs to understand current lake status.
Session 07 - Tibetan Plateau: disentangling the Asian monsoon system

S07-KN  Records of past climate from the Lake Qinghai Drilling Project and implications for paleoenvironments on the Tibetan Plateau

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The Lake Qinghai Drilling Project has obtained drill and piston cores that provide a detailed record of climate change in the Qinghai Basin over the last 32,000 years. Many different kinds of sedimentary analyses provide proxies of past climate, which are dated by abundant radiocarbon ages. Although detailed interpretations of the climate proxies and age models are complex, the results indicate that the climate on the eastern Tibetan Plateau is controlled by two systems: relatively cold, dry Westerly winds, similar to modern winter conditions, and relatively warm, moist circulation, similar to the modern Asian summer monsoon. These two systems clearly are anti-phased in their strength. Cool, Westerlies-dominated climate persisted through late marine isotope stage 3, the last glacial maximum, and the late glacial. Wet conditions dominated in the early Holocene, gradually waning through the rest of the Holocene. Our core-based reconstructions are somewhat at odds with recent dating of shoreline deposits above present lake level.

Isotope stage 3, a time of intermediate climate on long timescales, remains an enigma, apparently an arid extreme in the Qinghai basin, in contrast to suggestions of extreme high lake levels in other parts of the Plateau. Monsoon indicators in the Lake Qinghai record correlate quite well with those in lowland China speleothems. However, in details such as relative variability and abruptness of changes, the Qinghai monsoon record exhibits threshold behavior in the system, in which a major threshold was crossed about 11.5 ka, at the transition from the Younger Dryas to the Holocene.

S07-01  Orbital- and sub-orbital-scale climatic changes of Qaidam Basin in NW China over the past 50,000 years

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Minerals and visible reflectance of a 48-m long sediment core in the central Qaidam Basin were used to reconstruct climatic changes from 52 to 8.8 cal kyr BP. It was a relatively humid climate characterized by detrital siliciclastics and gypsum between 52 and 33 cal kyr BP. Halite began to precipitate at 33 cal kyr BP, indicating the climate became dry. The lacustrine deposition terminated at 8.8 cal ka BP suggests the climate was extremely dry during the last 8800 years. On orbital timescales, increases in summer temperatures and evaporation triggered by peak summer insolation levels may have led to the formation of halite at 33 cal kyr BP and lacustrine deposition termination at 8.8 cal kyr BP. On sub-orbital timescales, it is shown that Qaidam Basin was relatively wet indicated by high redness values during the occurrence of the North Atlantic region Younger Dryas (Heinrich event H0), and Heinrich H1-H5 events. Dry periods characterized by low redness values in Qaidam Basin appear to have occurred at nearly the same time as warm periods in the North Atlantic region. Our data support the hypothesis that the polar jet stream as a principal component of the atmospheric teleconnection that linked climate change across the upper part of the Northern Hemisphere.
S07-02  Multi-proxy analyses of sequential sediments from Genggahai Lake in northeastern Qinghai-Tibetan Plateau: implications for changes in atmospheric circulation

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The northeastern Qinghai-Tibetan Plateau is affected by complex atmospheric circulation, e.g., the westerlies, the Asian summer monsoon and the cold air mass from high latitudes, and therefore is sensitively in response to climatic changes. Lake sediments from this region can be used to reconstruct changes in atmospheric circulation to further understand potential forcing mechanisms for climatic changes. In January 2008, core sediments in a length of 7.82 m were recovered from Genggahai Lake at the central Gonghe Basin. The chronology was established by using 12 AMS $^{14}$C ages with a correction of ‘reservoir effect’ (= 1010 years). Multi-proxy analyses, including grain size, biotic macrofossil, TOC/TN and $\delta^{13}$C of organic matter and oxygen isotopic composition of authigenic carbonate ($\delta^{18}$O c), were performed on the sediment samples. Macrofossil assemblages indicate that the water level of Genggahai Lake was generally low during the last Deglaciation and the late Holocene (6.3 ka to present) (1 ka = 1000 cal. yr B.P.), while it was high during the early Holocene, despite a low level spell from 9.2 to 7.4 ka. Changes in aeolian activity (dust storms) exhibited a similar pattern to the history of lake-level fluctuations, reflecting that regional moisture balance may have played an important role on dust deflation, through affecting changes in vegetation covers in this area. However, dust storm events extraordinarily occurred on centennial to millennial scales during the late Holocene, most likely indicating that near surface winds episodically became stronger when vegetation cover was generally declined. The $\delta^{18}$O profiles also were characterized by several negative shifts during the last Deglaciation and the late Holocene. The $^{18}$O depletions were interpreted as a result of vapour from remote sources (or from high latitudes) and/or low air temperature. These lines of independent evidence suggested that during the early Holocene the Asian summer monsoon dominated the area, resulting in high lake level and less dust emission, but the monsoon circulation weakened during the last Deglaciation and the late Holocene. The changes in dust storms and $\delta^{18}$O strongly suggest that the northeastern Qinghai-Tibetan Plateau have been greatly influenced by cold air mass from high latitudes and/or the westerlies since 6.3 ka. Our results suggest that atmospheric circulation may have been readjusted during the mid-Holocene transition from a warm and humid climate to a dry and windy one.

S07-03  Last glacial maximum to post glacial climatic transition from a lake core evidence in the central Tibetan Plateau


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The mechanism of climate changes and some abrupt events on the Tibetan Plateau since LGM exists many uncertainties. Further understanding is possibly provided by a continue lake core records in the Nam Co (4718 asl, 2015 km$^2$) on the central Tibetan Plateau. The 11m long core collected in 90m deep water area has a well age-depth distribution according to $^{24}$C dating data. 24-19 ka BP, higher Pediastrum suggested a shallow water condition. 19-16.5 ka BP, decreased Pediastrum and Cyperaceae suggested water depth increasing and wetland reducing. Pinus, Picea and Abies were over than 30% during 24-16.5 kaBP, implying a different climate condition than it at present. 16.5-14.2 ka BP, humidity was enhanced according to Cyperaceae, Gramineae, Artemisia and
Chenopodiaceae. *Pinus, Picea* and *Abies* were less than 10%, suggesting climate shifted in lake area. 14.2-13.2 ka BP, Fe/Mn, Ca and Sr/Ba indicated water depth increase while total pollen concentration (TPC) and TOC (endogenesis source) reflected temperature rising. 13.2-11.5 ka BP, cold-dry climate was reflected by lake volume changing based upon Fe/Mn, Ca, Sr/Ba and *Pediastrum*, and the decreasing of TOC and TPC. 11.5-8.5 ka BP, a good water and heat condition was indicated by pollen assemblages and geochemistry, and the best period was within 10.2-9.3 ka BP. 8.5-5.8 ka BP, the best water-heat condition gradually weakened according to decreased TPC but stable TOC. After 5.8 ka BP, climate tended to be dry. In general, there were not only existed several climatic change events in the Nam Co lake area, but also occurred climatic type shifting since LGM.

**S07-04 Late glacial high-resolution palaeohydrological changes over southern Tibet: multi-proxy evidence for Indian monsoon variability**

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The Tibetan Plateau including the Himalayas is the most topographically imposing feature on Earth and is inextricably linked to Asian climatic, hydrological and ecological systems. Perturbations in the environment of the Tibetan Plateau have a profound effect on global climate as the plateau acts as an atmospheric nexus between the tropics and higher latitudes. Long-term lake sediment records show significant variability over the Tibetan Plateau during the late glacial period. We present high-resolution multi-proxy evidence from Peiku Co, a topographically closed lake basin in southern Tibet, for large variations in the Indian monsoon since ~15,000 years ago. Sedimentary facies with high siliclastic content indicates increased runoff and sediment delivery from the catchment during wetter periods, whereas carbonate precipitation is dominant during arid phases as a result of increased evaporation and thus, water ionic concentration. Furthermore, changes in the relative abundance of different phases of carbonates (aragonite, low-Mg calcite and high-Mg calcite) reveal abrupt fluctuations in lake water chemistry in response to changes in hydrological balance. The broad trend in sedimentology, oxygen isotopes and trace element composition of ostracods is similar to orbitally forced speleothem records of Oman and central and southern China. Superimposed on this trend, high-resolution oxygen isotope data show a striking coherence with decadal- to centennial-scale changes in precipitation changes across the monsoon domain. The oxygen isotope record is currently one of the highest resolution late glacial-Holocene lake sediment records available from the Tibetan Plateau and highlights the sensitivity of Tibetan Plateau lakes to high-frequency monsoon fluctuations.
mineralogical and micropaleontological (diatoms, ostracodes, pollen) data and climate modeling will lead to an improved understanding of the physical mechanisms controlling monsoon dynamics. In autumn 2011 several sediment cores were collected in two Kyrgyz lakes: Son Kol and Kara Kol. A long core from Lake Chatyr Kol will be retrieved in summer 2012.

Here we present preliminary results from diatom and ostracode assemblages from Lake Son Kol sediments that provide information about lake system dynamics during the past approximately 7,000 years. Ostracode abundances are highly variable throughout the record. At ca. 4,000 cal. yr BP, the diatom assemblage changed from benthos- to plankton-dominated. Bivalve shells appeared after 3,300 cal. yr BP. Diversity of both ostracodes and diatoms increases in the upper 10 cm of the core. This suggests high lake level variability during the Holocene resulting from frequent changes in monsoonal and westerly moisture availability.

S07-P-02  Carbonate isotope evidence for melt water and dry events during the past 26 kyr on the southern Tibetan Plateau

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A 26 kyr carbonate stable oxygen and carbon isotope record with decadal (15 to 50 years) resolution from the 10.4 m long sediment core NC 08/01 collected from Lake Nam Co, Southern Tibetan Plateau, shows large ranges of up to 5 per mil for δ¹³C and up to 10 per mil for δ¹⁸O values. The δ¹³C record is characterized by a stepwise evolution on millennial scale, and the δ¹⁸O record shows a higher degree of centennial variability and long-term trends. For the past 16 kyr the record is supplemented by stable isotope data from shells of benthic ostracodes.

Most prominent features are three negative spikes in both δ¹⁸O and δ¹³C from 14.2 – 13.2, 12.0 – 11.4, and 10.2 – 9.3 kyr BP. Spikes are distinct and not reflected by ostracode data and thus suggest that input of turbid melt water into epilimnion decreased photosynthetic productivity. δ¹⁸O data suggest that the Late Glacial is characterized by drought maxima contemporary to the Heinrich 1 event and the Younger Dryas. The trend to more positive δ¹⁸O values for both carbonate and ostracode valves during the Holocene confirms the general weakening of monsoonal precipitation and a decrease in temperature. Brief dry periods occurred at around 8.2 and 4.2 kyr BP. After 2 kyr BP, P-E (δ¹⁸O) and productivity (δ¹³C) in the lake increased.

Overall, results suggest a strong linkage of monsoon dynamics and Northern Hemisphere climate with cold events in the North Atlantic causing weakening of monsoonal precipitation over the Tibetan Plateau.

S07-P-03  Modern sedimentation processes on lake Nam Co, Tibetan Plateau, China – Project presentation and first results.

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The Tibetan Plateau is often referred to as the third pole of the earth due to its outstanding position and its relevance for global climate. Numerous lakes on the plateau can serve as geological archives for past climate evolution and human impact on this region. An increasing number of studies prove their big potential for these aspects.

Studies on modern processes within these high elevated lakes and their surroundings that can help to understand the palaeoenvironmental records are almost lacking. In order to fill this gap CADY, a project within the framework of CAME (funded by the German BMBF) was launched at the end of 2011 in order to study modern sedimentation processes on
Lake Nam Co, Tibet. Therefore moorings with sediment traps, thermistors and multiprobes were installed in the lake. Beside these installations a frequent multiprobe profiling as well as water and sediment sampling program will be carried out during the ice free season. In addition sampling for living ostracods will be performed to get data on their ecology as well as their vital effects on the isotopic and geochemical composition of their shells. We expect that this study of modern processes in lake sediment formation on Lake Nam Co can help to improve the interpretation of lake sediment records for palaeoenvironmental studies on the Tibetan Plateau.

**S07-P-04 Hydrodynamic process of Tibetan Plateau lake revealed by grain size: Case study of Lake Pumayum Co**

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Under the background of global warming, some lakes on the Tibetan Plateau (TP) are potentially sensitive to temperature change. With a case study of Pumayum Co, where glacier meltwater is important to supply (we call this a glacier-fed lake hereafter), we analyze the sensitivity of lake sediment grain size to temperature change. This is done by resolving the modern hydrodynamic process, coupled with comparison of paleoclimatic proxies. According to the spatial distributions of parameters, percentage of grain size and the grain size frequency distribution curve, hydrodynamic processes are analyzed. Five clastic sedimentation types are thereby discriminated. In the open lake area, suspended load transport is the main transport agent. Grain Size Trend Analysis (GSTA), a sediment dynamics model, reveals a trend toward eastward transport. This indicates that the largest and glacier-fed river, the Jiaqu River, influences the entire lake (not just the subsurface alluvial fan), and that lake sediment grain size may serve as a temperature indicator. Time series comparison between grain size of a short core from the central lake and meteorological data confirms this temperature indication, which in turn shows reliability of the method discriminating the hydrodynamic process. This case study will improve the ability of paleoclimatic reconstruction using lake sediment in glacier-fed lakes on the Tibetan Plateau.

**S07-P-05 First and preliminary investigations on bathymetry, water quality and modern sedimentation rate of Mapam Yumco and La’ang Co in southern Tibet**


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As a well-known holy lake in religion all over the word, Mapam Yumco, together with La’ang Co, is situated in Southern Tibet. In the recent years, both lakes as well as their basin also attracted people on scientific concerns, such as but not limited lake and glacier area changes, hydrological cycles and processes, environmental changes, and so on. Here, we present the first and preliminary results on these two lakes on bathymetry, water quality and modern sedimentation based on our investigations in September, 2009 and July, 2010, respectively. The maximum depths of both lakes are recorded as 72.60m and 49.03m, respectively. More than 100 years ago, Sven Hedin, a famous Swedish explorer, measured water depth of Mapam Yumco by ropes; he got the maximum depth of 81.8m or 77.0m (two versions in recordation). If we assumed that both surveys arrived at the real deepest areas, the present water depth decreased 9.2m or 4.4m compared with that of a century ago, indicating a very humid period in 1910’s in this area.

On line monitoring of water quality conducted by a Hach Hydrolab DS5 multi-probe in both lakes indicated that Mapam Yumco is a fresh water lake and La’ang Co is a rather salty lake, with the conductivity almost three times that of Mapam Yumco. In Mapam Yumco, there was a distinct
thermocline layer developed in depth of 25-35m, and the water temperature was 7.2°C in bottom (ca. 60m depth); pH ranged 9.6-7.2 from top to bottom layers. While temperature profile in La’ang Co showed another pattern which decreased from 10.5°C in the very top to 8.2°C in the bottom (ca. 40m depth), no obvious stratification appeared, and pH ranged 8.9-6.0 in the profile. Two short cores were retrieved by a gravity corer in deepest areas in both lakes; $^{210}$Pb and $^{137}$Cs measurements were conducted to determine the modern sedimentation rate (MSR) in Mapam Yumco and La’ang Co. The results indicated that the MSR of both lakes were 0.31mm/a and 0.65mm/a, respectively, based on the CIC model from $^{210}$Pb data. Both results showed rather good agreement with that of $^{137}$Cs fallout maximum time marker.

**S07-P-06 Trace elements of ostracod shells from Southern Tibetan Plateau lakes as paleoenvironmental proxy – a methodological intercomparison**

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Trace element analyses of ostracod shells are a vital tool for paleoenvironmental reconstructions. However, there are some limitations associated with aragonite overgrowth and diagenetic alteration. Based on a comparative methodological study the most appropriate analytical technique for trace element determination in ostracod shells will be assessed. Therefore, three different techniques will be evaluated: conventional batch dissolution, laser-ablation measurement (LA-ICP-MS) and flow-through based dissolution. The integration of results from these methods allows for the development of new approaches to assess ostracod shell chemistry.

The LA-ICP-MS method provides the advantage that the heterogeneity of individual shells can be resolved. Low detection limits (in ng/g range) with high spatial resolution (10-100µm), allow to investigate single ostracod shells providing a distribution pattern for all trace elements of interest. The flow-through analysis technique allows to chemically separate mineral phases of different solubility such as, in particular, original shell calcite from overgrowth calcite, and thus correct the measurements for the biogenic signal. This is necessary because variations in trace element contents have been identified to be in the order of a magnitude range, likely associated with original and altered shell calcite.

Analyses will be carried out on ostracods from Tangra YumCo and Tar Co sediments (Southern Tibetan Plateau). In conjunction with the ion composition of the host waters, further hydrological reconstructions will be derived, including Mg/Ca paleothermometry and Sr/Ca paleosalinity. In addition, we want to test the environmental significance Manganese, Iron and Uranium that may serve as indicators for oxygenation cycles as well as Barium as indicator for changes in productivity.

**S07-P-07 Ostracod-based water depth estimation for Holocene lake sediments of the Tibetan Plateau – a critical review**

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Among the most searched parameters in lacustrine geoscience research are lake levels of the past. They reflect the water balance of closed basins and are therefore valuable environmental and climatic
indicators. Lake level estimations based on micropalaeontological proxies are frequently used. The most important microfossil group from the mainly saline lakes on the Tibetan Plateau is Ostracoda. Ostracods show water-depth related distributions, indicating their potential for the use of transfer functions for reconstructing past water depths. We present examples for their depth distribution from the lakes Nam Co, Npen Co, Puma Yumco, and Donggi Cona on the southern and north-eastern plateau. A test of regional ostracod-based water depth transfer functions shows their applicability within the same lake under very similar environmental conditions. The transfer function for Nam Co, successfully used for reconstructing a lake level drop during the Little Ice Age, fails to estimate reasonable water depths for older sediments as comparisons with other proxies demonstrate. We explain this failing by the fact that water depth itself is not a driving ecological factor but other environmental parameters bound to water depth, i.e. ion composition and concentration, habitat structure (including substrate type), water turbulence, variability and range of water temperature and oxygen availability, as well as type and amount of food available. We conclude, that ostracod-based water depth transfer functions can be used in general for close to present day lake system conditions only, with great care, and using cross-checking with other proxies.

S07-P-08 Quaternary stromatolites at Tangra Yumco, central Tibetan Plateau

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In 2009, a large microbialite field with tufa towers and stromatolites of probably Holocene age was discovered during palaeolimnological field work at the northern shore of Tangqun Co, a highly saline lake (c. 100 ‰). The altitude of this occurrence is about 4500 m a.s.l. The tufa towers reach up to about 3.5 m over the ground. They have no internal layering except their base and arise gradually from underlying fine calcareous lake sediments originating from a highstand phase during the early Holocene. The tufa towers seem to be arranged along faults suggesting extruding groundwater stimulating the built up of these microbialites. Abundant stromatolites are grouped hill-down around the occurrence areas of these tufa towers, either in knoll-like bioherms or wall-like covers of slopes of small gullies in gravels and coarse sands. No recent microbialites were found so far. We assume a middle or late Holocene origin of the microbialites, when Ca\(^{2+}\)-delivering groundwaters entered a less saline but highly alkaline lake from subaquatic springs of the submerged alluvial fans. In addition, groundwater circulation might have been enhanced by hydrothermal activity at that time. Stromatolites may have formed during subsequent evaporative draw-down of the lake-level, with Ca\(^{2+}\) supply from waters seeping from the exposed tufa tower areas to the shoreline. In future, a dating of the stromatolites and geochemical investigations will provide insights into the lake evolution, and a detailed analysis of ostracod associations from the surrounding lake sediments will allow a reconstruction of this remarkable ecosystem in extraordinary altitude.

S07-P-09 The present lake reservoir effect of high-altitude lakes in Central Asia

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Radiocarbon dating is the standard chronological method for the establishment of late glacial and Holocene palaeoclimate records from high-altitude lakes in Central Asia. Due to the common scarcity or lack of terrestrial organic matter in the lake sediments from high altitudes, the total organic carbon (TOC) is mainly used for radiocarbon dating of lake sediment cores. Different approaches are applied to determine the present or past lake reservoir effect commonly used for the correction of downcore radiocarbon data. These approaches
include the radiocarbon age determination of living macrophytes, macro-algae or animals from the core site or its vicinity, the age determination of TOC, the alkali soluble ‘humic’ fraction or the alkali insoluble ‘humin’ fraction from a surface sediment or core-top sample, the age determination of the dissolved inorganic or organic carbon of the lake water, and the extrapolation of radiocarbon ages from a number of downcore sediment samples to the core top. The determined reservoir age data for 25 lakes on the Tibetan Plateau and in the adjacent mountains range from 140 to 5790 $^{14}$C years BP. However, the low reservoir age of 140 $^{14}$C years BP represents an exception since the other 39 published and unpublished dates are higher than 600 $^{14}$C years BP and thus, not negligible in high-resolution palaeoclimate studies of late glacial and especially Holocene time scales.

Reservoir ages of open-basin freshwater lakes and closed-basin brackish to saline lakes cover more or less the same range with 140 to 5790 $^{14}$C years BP for open-basin lakes and 640 to 5700 $^{14}$C years BP for closed lakes. Reservoir ages tend to increase with stronger aridity, possibly as a result of a larger contribution of groundwater in comparison to surface runoff and a more efficient rock-groundwater interaction. Higher groundwater contribution and more efficient rock-water interaction is probably also the reason that larger catchments in comparison to lake areas are typically related to larger reservoir ages.

The variability of the reservoir ages for different sites and analysed materials from individual lakes ranges from only 70 $^{14}$C years BP for Ahung Co (n=3) to 2500 $^{14}$C years BP for Bangong Co (n=2). Ahung Co is a freshwater lake with small size (3.6 km$^2$) whilst Bangong Co is a larger lake (604 km$^2$) which has a strong salinity gradient increasing from East to West. Reservoir ages between 640 and 1100 and between 1655 and 2290 $^{14}$C years BP were determined for different materials and different sites in the lakes Qinghai (n=5) and Donggi Cona (n=5). Given the importance to decipher leads and lags in the environmental and climate histories of the sensitive high-altitude regions in Central Asia and the required significant efforts to recover continuous lake records and perform high-resolution multi-proxy analyses, more emphasis should be placed on the determination and assessment of the lake reservoir effects.

S07-P-10 Quantification of lake nutrient changes using elemental (C, N, S) and isotopic ($\delta^{13}$C and $\delta^{15}$N) composition of submerged plant macrofossils

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We highlight the potential of using elemental and stable isotope analyses of aquatic macrophytes in palaeolimnological studies. Potamogeton pectinatus material was collected from modern plants and from two late glacial to Holocene sedimentary records on the northeastern Tibetan Plateau. It was analyzed for $\delta^{13}$C$_{\text{Potamogeton}}$ (modern: $-23$ to $0\%_o$, fossil: $-19$ to $-4\%_o$) and $\delta^{15}$N$_{\text{Potamogeton}}$ (modern: $-11.0$ to $+13.8\%_o$, fossil: $-9.5$ to $+6.7\%_o$) in addition to elemental carbon and nitrogen (modern C/N$_{\text{Potamogeton}}$: $7$ to $29$; fossil: $13$ to $68$) and sulfur (fossil: $188-899$ μmol/g dry weight). Fossil data were interpreted in terms of palaeo-nutrient availability and palaeo-productivity based on the modern relationships between various proxies and certain environmental data. Productivity of Potamogeton pectinatus mats as indicated by palaeo-$\varepsilon_{\text{Potamogeton-TIC}}$ (i.e. the enrichment of $\delta^{13}$C$_{\text{Potamogeton}}$ relative to the $\delta^{13}$C$_{\text{TIC}}$) was reduced during periods of high conductivity. At certain times a strong increase in productivity lead to a strong decrease in the water HCO$_3^-$ concentration as inferred from the application of a $\varepsilon_{\text{Potamogeton-TIC}}$-lnHCO$_3^-$ transfer function. A comparison of
reconstructed productivity changes with further environmental proxies suggest that primary productivity changes are probably a function of internal lake dynamics and were only indirectly triggered by climate change (Herzschuh et al., 2010 QSR; Herzschuh et al., 2010 JoPL).

S07-P-11  A fluctuating humid climate during the early to middle Holocene in central Asia as indicated by sedimentary and geochemical multi-proxies from Son Kul, Kyrgyzstan

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We investigated a 148-cm composite core from a Kyrgyz lake (Son Kul) in order to understand hydrological changes during the Holocene and the associated climatic controls in central Asia. A reliable age-depth model was established using the means of AMS 14C dating and the Sequence model. Geochemical multi-proxies, such as total nitrogen (TN), total organic carbon (TOC), organic carbon and nitrogen isotopes as well as oxygen and carbon isotopes of bulk carbonates, were determined at the interval of 1 cm, equivalent to ca. 40 years. Mineralogical compositions and lamination of the sediments were examined with the methods of X-ray diffraction (XRD) and scanning electron microscope (SEM).

The geochemical proxies and sedimentary features suggest that organic matter contents and carbonate isotopes as well as lamination in the sediments are good indicators of hydrological change, especially for the stratification of lake water. As results, we reconstructed the history of the lake level changes based on the interpretations. The reconstruction show that there were rapid fluctuations of lake level during the early to middle Holocene (from 8.3 – 5.3 ka) whereas the lake level during the late Holocene (from 5.3 – 1.9 ka) was generally low and relatively stable. The hydrological changes of Son Kul suggest the climate in central Asia changed frequently but was generally humid during the early-mid Holocene, and it has become relatively dry since 5.3 ka. The hydrological changes of Son Kul were related to variations of summer insolation in the North Hemisphere, which led to the regional climatic system evolved from one influenced both by the middle latitude westerlies and Asian summer monsoons before 5.3 ka to one predominantly controlled by the westerlies during the late Holocene.

S07-P-12  Quantitative reassessment of Holocene vegetation change on the upper Tibetan Plateau using the pollen-based REVEALS model

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Fossil pollen records on the Tibetan Plateau have been widely used to infer the past climate changes, which however, demands better understandings in the vegetation changes. Previous studies based on fossil pollen data have reported significant changes in vegetation on the alpine Tibetan Plateau during the Holocene. However, since the relative proportions of fossil pollen taxa are largely influenced by individual pollen productivities and the dispersal characteristics, such inferences on vegetation have the potential to be considerably biased.

We therefore reexamined the modern pollen-vegetation relationships for four common pollen species on the Tibetan Plateau, using Extended R-
value (ERV) models. Using Poaceae as the reference taxa, high PPEs were deduced for *Artemisia* and Chenopodiaceae, and Low PPE for the Cyperaceae. Applying these PPEs to four fossil pollen sequences since the Late Glacial, the plant abundances on the central and north-eastern Tibetan Plateau were quantified using the “REVEALS” model. The proportions of *Artemisia* and Chenopodiaceae were greatly reduced compared to their original pollen percentages in the reconstructed vegetation, while Cyperaceae showed a relative increase in the vegetation reconstruction. The reconstructed vegetation assemblages always yielded smaller compositional species turnovers than suggested by the pollen spectra, as revealed by Detrended Canonical Correspondence Analyses (DCCA) of the Holocene sections, which indicates that the strength of the previously reported vegetation changes may therefore have been overestimated (Wang, Y.B. and Herzschuh, U., 2011).
Session 08 - Environmental records of climate change and human impacts in mountain regions

S08-KN  Land of the Unexpected: palaeoecological exploration in the mountains of New Guinea

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The island of New Guinea remains one of the most enigmatic, challenging and exciting places on Earth to conduct field-based research. This is in no small measure related to the remarkable diversity of landscape and ecology inhabited by 8 million people speaking over 1000 languages. New palaeoenvironmental data utilising high-resolution approaches show that rapid transformation of past plant communities can occur in the face of environmental change. For example, the extensive destruction of rain forest by fires across the highlands of New Guinea during recent El Niño events clearly demonstrated the susceptibility of large areas to burning under conditions of extreme drought and proximity to ever increasing human population densities. In this presentation I will take you through some of the key findings from recent palaeoecological research on lakes and swamps in the highlands of New Guinea that reveal the tempo and direction of environmental change under the influence of variable frequency of short-term disturbance events and the changing nature of human influence through the Holocene.

S08-01  Mid- to Late Holocene lacustrine response to millennial-scale climate forcing in the southern tropical Andes of Peru


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Although the climatic state of the North Atlantic region is not currently a major factor in forcing modern South American climate variability, evidence from numerous Quaternary records and model outputs has demonstrated a more influential role in the past. On millennial timescales, for example, periodic so-called ‘Bond’ episodes of Holocene cooling in the southern North Atlantic resulted in enhanced precipitation levels across the southern South American tropics and drier conditions in the northern tropics. However, as the generally poor spatial extent of high-resolution palaeoclimatic records across the continent improves, a more complex picture than this is beginning to emerge.

Here we present a new 5000-year multi-proxy record from Huacarpay, a lake situated at an altitude of 3100m in the southern Peruvian Andes. Decadal analysis of a 4.3m-long cored sedimentary sequence from the lake reveals periods of aridity (marked by catchment dust deposition and lower lake-levels inferred from isotopic evidence) that coincide with the timing of Bond Events in the North Atlantic. This pattern is in apparent anti-phase with many other records across the southern South American tropics, highlighting not only the complexity of Andean climate response on millennial timescales, but also the potential for better understanding biological and cultural evolution in the region. For example, the first appearance of maize agriculture in the highlands (around 2.7–2.5ka) was an important driver for subsequent cultural growth and development. Properly characterising the climatic framework underpinning this event is crucial if we are to understand how societies expanded across these highland environments.
Over the period of instrumental records, precipitation maximum in the headwaters of the Rocky Mountains has been dominated by winter snow, with a substantial degree of interannual variability linked to Pacific ocean-atmosphere dynamics. High-elevation snowpack is important water storage that is carefully observed in order to meet increasing water demands in the greater semi-arid region. The purpose here is to consider water trends during the Holocene, a time when known changes in earth’s energy balance were caused by precession-driven insolation variability. The seasonal precipitation balance between rain and snow at upper elevations during these time periods is investigated here using oxygen isotope ratios ($\delta^{18}O$) of lakes from continuous sediment-calcite records. A sediment record of endogenic calcite-$\delta^{18}O$ from Bison Lake, an overflowing headwater of the Upper Colorado River, documents seasonal precipitation balance. Insight into past summer climatology is provided by a record of calcite-$\delta^{18}O$ from nearby, evaporation sensitive Yellow Lake and the isotopic difference between Bison and Yellow calcite-$\delta^{18}O$ ($\Delta\delta$Yel-Bis). Results indicate a regime shift from a summer monsoon affected mid Holocene to a winter storm affected late Holocene coincident with evidence for the development of ENSO/PDO dynamics. Snowfall amounts reached a maxima after ~3.5 ka and during the Little Ice Age, whereas the Medieval period was one of extreme seasonal precipitation variations. The Holocene perspective indicates a far broader range of variability than that of the past century and highlights the non-stationary character of hydroclimate in the U.S. west.
**S08-04 Human impact on the hydroenvironment of the Zagros, SW Iran, through the late Holocene**

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There are multiple drivers of environmental change in mountain regions such as the Zagros, including climate, tectonics, and people. Teasing apart the dominant drivers of change in any lake catchment through time therefore requires a multi-proxy approach. We present new data from the Fars province of southwest Iran. The study site, Lake Parishan, has almost completely desiccated over the last 5 years, at least in part due to the 3000 wells in the surrounding administrative region.

A 250cm core spanning the last 4000 years shows significant changes in multiple proxies around 2,500 cal BP, the beginning of the Persian Empire. Changes in stable isotopes, carbonate mineralogy, ostracod and diatom fauna within the lake are compared to changes in vegetation and burning regimes, from pollen and charcoal data, within the catchment. The data suggest that human activity, through agriculture (cereal and tree cultivation) and forest clearance, had a significant impact on lake hydrology. The major changes in lake chemistry, which lag changes in catchment vegetation, are marked in particular by a change from calcite to aragonite precipitation and in the dominant ostracod fauna, which suggests a change in the alk/Ca ratio from 1. We suggest this is due to reduced recharge by Ca bearing groundwaters as water is extracted for agriculture. Minor changes in human activity, marked by increases in burning in the first half of the 2nd millennia BC are also followed by similar shifts in ostracod fauna.

**S08-05 Prokoško Jezero – an environmental record from a subalpine lake in Bosnia-Herzegovina**

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In the frame of an archaeological investigation about the Neolithic in Bosnia-Herzegovina (Hofmann et al., 2006) a core was taken from a kar lake in the subalpine region of the Vranica Massiv being a part of the Dinaric Alps. Prokoško Jezeron is located 22 km west of the town of Fojnica. The lake has a size of 4,8 ha and is located at 1670 m a.s.l. This is close to the modern tree limit that lies about 1800 m above sealevel. As the tree limit is dependant not only on climate but also on the exposure and grazing pressure it is difficult to define a strict border for this vegetation zone. The area is still used for transhumance and the lake is surrounded by huts of shepherds.

The core is 11.44 m long and was taken at a water depth of 12 m. It covers the complete Holocene and goes back into the Weichselian/Devensian glaciation. The pollen record shows a nice development of the vegetation during the late glacial and the spreading of thermophile trees in the early Holocene. Just small disturbances during the Neolithic indicate human presence but no deforestation as effect of intensive grazing is expressed. Thus the area was visited and used by Neolithic people but indicators for open habitats do not increase before 4000 BC. Nevertheless a natural succession and the establishment of a beech dominated forest continues until medieval times. Around 500 AD the increase of herbs and grasses show the opening of the woodland and probably a continuous lowering of the tree limit by grazing activities. Thus the pollen record documents a long lasting usage of the area. Deforestation reached highest values in the last 500 years.
Medieval Climate Anomaly (MCA) and Little Ice Age (LIA) signatures in high altitude Central Pyrenean lakes (NE Spain): Marboré (2500 m altitude) and Basa de la Mora (1900 m asl) records

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The multi-proxy study of sediment cores recovered in Marboré (2500 m asl) and Basa de la Mora (1900 m asl) lakes, in Central Pyrenees has shown large hydrological, vegetation and anthropogenic changes during the last 2 millennia in these alpine environments. Hydrological and vegetation responses are similar in both lakes. Fluctuating but generally lower lake levels occurred between 200 BC-1250 AD. The MCA (900-1300 AD) is characterized by the lowest lake levels and the largest Artemisia expansion over the last two millennia. On the contrary, increased run-off and sediment delivery, higher bioproductivity and decreased Artemisia pollen occurred during the LIA (1300-1850 AD). This depositional and hydrological evolution is coherent with other Iberian marine and lacustrine records and underlines the sensibility of high altitude Pyrenean environments to rapid changes. Human impact in the watershed is more evident in Basa de la Mora lake, located at lower altitude. However, the onset of agricultural practices in Medieval times is recorded in both lakes by an Olea increase after 1300 AD. The occurrence of distinct Pb peaks in Marboré associated to mining activities highlights the global reach of human activities even in pristine alpine settings.

Cold-season temperatures in the Swiss Alps during the past millennium: from a stable Medieval Climate Anomaly to a highly variable Little Ice Age

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High-Alpine Lake Silvaplana (1791 m a.s.l.) provides an ideal setting for high-resolution studies of past environmental changes, since it has annually layered sediments covering the past 3000 years, recent human impact changes are well-known and documented, and homogenized meteorological timeseries are available from a meteostation situated within 3 km from the shoreline. Here we present a reconstruction of cold-season (mean October to May) air temperatures based on Chrysophyte stomatocysts (siliceous resting stages of the golden-brown algae). Cold-season air temperatures were reconstructed quantitatively, at a high resolution (5 year) and with high chronological precision. The reconstruction covers the period from AD 1060-2002. The record provides detailed climatic information for a region (high-alpine) and season (cold-season) for which currently very few data are available.

Cold-season temperatures were characterized by a relatively stable Medieval Climate Anomaly (MCA) and a highly variable Little Ice Age (LIA). Interestingly, comparison to the North Atlantic Oscillation shows that the relative stability during the MCA coincided with a prolonged, predominantly positive NAO phase, whereas the change to highly variable temperatures occurred when NAO variability also increased. The classic summer pattern of a warm MCA, cool LIA and recent warming (as seen in summer temperature reconstructions from the same sediment cores) was not present in the cold-season record. At decadal to multi-decadal timescales, summer and cold-season temperatures also differed strongly throughout the last 1000 years, except for the rapid warming recorded in both reconstructions after AD 1980. This recent cold-season warmth is highly unusual, but not unprecedented in the context of the last 1000 years. The data also indicate that there is a strong need for additional cold-season reconstructions from high-alpine sites, since the temperature variability in our reconstruction greatly exceeds that of other cold-season records based on lowland data.
S08-P-01  Quaternary environments of the Tequixquiac Basin, northern Basin of Mexico

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Tequixquiac’s Late Pleistocene megafauna deposits are frequently mentioned in literature discussing the evolution and extinction of these animals across Mesoamerica. However, despite this Quaternary megafaunal history, the Tequixquiac sediment sequence is poorly understood with very little research done until now. The Tequixquiac sediment sequence spans the Early Pleistocene through to the Late Holocene and suggests that there has been hydrological change. Lake deposits at the base of the sequence have been dated (tephra: Ar – Ar) to 550ka (upper contact). In places these deposits are overlain by spring carbonate deposits (tephra Ar – Ar) dated to 404ka. Between the Late Pleistocene and Late Holocene (constrained by nine $^{14}$C AMS dates) sedimentation was predominantly alluvial and fluvial, occurring in localised areas relative to watershed drainage patterns. Reconnaissance geochemical data is discussed with field observations, in view of defining the modern hydrologic and hydrogeologic characteristics of the Tequixquiac region of the Basin of Mexico. The aim of this reconnaissance study is to determine hydrological changes, drainage basin evolution and their influence on humans and associated fauna in the northern Basin of Mexico. This will also be used to discuss the usefulness of using $^{18}$O & $^2$H modern analogue data in this area of the Basin of Mexico when interpreting $\delta^{18}$O & $\delta^{13}$C values from the Tequixquiac and spring carbonate and lacustrine sequences.

S08-P-02  Holocene fire records from small subalpine lakes in southeast British Columbia, Canada

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Understanding climate-fire-vegetation interactions at local and regional scales is crucial for sustainable forest management and conservation in boreal regions. Fire poses an immediate threat to life, health, infrastructure, accessibility, and economic activity of many communities at the wildland-urban interface in the Columbia Mountains of British Columbia (BC), Canada. In order to better understand current and future forest fire regimes, long-term records of natural fire histories need to be investigated. Holocene histories of fire events are developed through the analysis of macroscopic charcoal (>150 µm diameter), which is transported to a lake following a local fire within the watershed.

Here, we present the results of macroscopic charcoal analyses from 3 lakes with similar vegetation assemblages, at different elevations within the Columbia Mountains, near Nelson, BC. An analysis of the past 5000 years, that includes previously published sites, shows that fire events have been synchronous at centennial to millennial scales between sites with similar aspect. Fire events are also more frequent on south-facing slopes than north-facing slopes. Fire return interval distributions are similar between sites with similar aspect. A composite fire history from the region indicates that fire frequency was highest between 2750-4250 yrs BP, and lowest from 750 yrs BP to present. These results suggest regional-scale climate is a strong control of fire regimes in this region by modulating meteorological and fuel conditions at broad scales and interactions between climate and local controls are important for influencing fire activity and stand development at a landscape scale.
S08-P-03 Changes in cladoceran and diatom community and its relationship with NAO index and temperature during the last 150 years

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We explore whether changes in cladoceran and diatom community can be linked to changes in mean temperature and in the NAO index. A high NAO index is associated to drier conditions over southern Europe and yields dust transport from Sahara desert over the western Mediterranean basin during summer. *Daphnia pulicaria* relative abundance shows an important increase in the lake during the last decades, mainly from 1970, whereas *Alona quadrangularis* increase occurs from late 80s simultaneously with the decrease of *Chydorus sphaericus*. *Daphnia* relative abundance through the core is positively correlated to the NAO index but no with temperature values. The opposite is found for *A. quadrangularis* and *C. sphaericus*. The most abundant diatom species and the factor 1 of the principal component analysis performed on diatom assemblage are correlated to temperature values and do not show any relationship with NAO index. A positive correlation between *Daphnia* and the NAO index is also found for 10 years of *Daphnia* sampling in Río Seco Lake (1996-98 and 2005-2011).

We hypothesized that *D. pulicaria* is probably benefited by Saharan dust calcium, because this species is likely limited by Ca in Río Seco Lake and Saharan dust is rich in Ca, whereas other cladoceran and the diatom species are more affected by temperature changes in the lake region.

S08-P-04 Holocene vegetation and climate variation in westerly dominated areas in Central Asia inferred from Sayram lake in northern Xinjiang, China

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Pollen-assemblage and charcoal data from a 300-cm-long sediment core from Sayram Lake in northern Xinjiang constructed from 11 AMS radiocarbon dates on the bulk organic matter describe the changes in the vegetation and climate of the Westerly dominated areas in Central Asia during the Holocene. Desert vegetation dominated the lake basin before ca. 9.6 cal kyr BP inferred from *Artemisia* / Chenopodiaceae ratio and principal component analysis results, suggesting a warm and dry climate in early Holocene. Desert steppe / steppe expanded 9.6 to 5.5 cal kyr BP, implying a remarkable increase both in the precipitation and temperature in mid-Holocene. Desert vegetation dominated the interval from 6.5 to 5.5 cal kyr BP, marking extremely warmer and drier condition. Steppe / meadow steppe recovered and temperature decreased from 5.5 cal kyr BP in late Holocene as indicated by increased *Artemisia* and the development of meadow. Low temperature decreased evaporation and increased effective moisture and vice versa. Variation in temperature is to some extent affects changes in humidity. These changes in vegetation and the climatic evolution of Sayram Lake are similar to those of adjacent areas. Sayram Lake sediments responded to regional environmental change, global abrupt climate events and followed the westerly dominated climate model. Changes in the temperature on millennial to centennial scales related to the tropical Pacific and the subpolar Atlantic suggests that solar insolation is the primary force driving regional climate change. Dry conditions in early Holocene might arise from strong evaporation caused by high temperature.

S08-P-05 Complex Winter and Summer Temperature Variations documented by Lake sediment in Central China during the last
Deglaciation and Holocene

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Global warming since AD 1850 is unequivocal and evident from a various range of observational data. However, there is still intense debate about the relative contribution of natural and anthropogenic forcing to this warm period. It is thus crucial to acquire a profound understanding about how the winter and summer temperature changes during times warmer than today under natural conditions, to constrain the potential factors controlling temperature variability. In this study, using pollen preserved in lacustrine sediments from an Alpine lake - Gonghai Lake in north central China, temperature variation history during the last 14400 years was quantitatively reconstructed at a high resolution (4~70a) for the first time. It is found that vegetation experienced significant changes since the last Deglaciation in the study area with several replacements between forest and steppe. Quantitative reconstruction suggests that, as regard to the warmest month, highest temperature occurred at 11000~9500 cal yr BP in the early Holocene and stable warm period extended from 7000 to 2700 cal yr BP with a 1.0~1.5 °C higher temperature than present. For both the coldest month and the whole year, highest temperature occurred at 7100~2700 cal yr BP, with a 4.0~5.0 °C and 3.5~4.5 °C higher temperature than present, respectively. There are clear signals for the Medieval Warm Period (MWP), Little Ice Age (LIA) and Current Warm Period (CWC) in this record. Relatively high resolution (~5a) made it possible for the temperature time-series to reflect the secondary cold interval within the MWP. Annual and coldest month temperature during MWP is generally 2 °C and 3 °C higher than present, respectively. Bølling/Allerød temperature was similar with that at present in this record. In addition, a series of abrupt climatic change including 8.2 ka event are evident in our reconstruction. It seems that broad temperature trend in the warmest and coldest month in this region was generally controlled by North Hemisphere summer and winter insolation respectively, and modulated by sea temperature and terrestrial vegetation cover as well. During the Last Deglaciation and early Holocene, temperature change was substantially influenced by high latitude climate. On the centennial-millennial time scales, solar activity and internal variability within the climatic system both played their roles in forcing temperature variations in northern China. It is concluded from this study that there exist several periods featuring much higher temperature than today, and the temperature change is determined by both external and internal forcing factors.

Late Holocene environmental Change in Lac Ba Be, Viet Nam

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A diatom assemblage reconstructed from a sediment core from Ba Be, a karst lake in the northern mountains of Viet Nam, was analyzed to assess environmental change over the last 500 years. The most striking feature of the core is an assemblage change in the uppermost four cm (late 1970s/early 1980s). Prior to this interval, the planktic diatoms were dominated by heavily-silicified Aulacoseira species. There is a step-wise change to the modern flora, which is characterized by more lightly-silicified planktics, such as Cyclotella delicatula, C. ocellata and Discostella species. This flora also has a higher planktic to benthic ratio and lower nutrient requirements than the previous one. The change in flora is interpreted as a possible response to declining nutrient availability due to decreased precipitation over the last 40-50 years. A persistent drought has diminished the monsoon rains that would normally bring nutrients from soil runoff and rivers. Furthermore, during a normal flooding season, the singular outflow of the lake via the Nang River reverses and the Nang flows into the lake, providing nutrients and increasing the residence time. In a drought, the Nang would not flow in, delivering nutrients and stopping nutrients from leaving the lake. A concomitant reduction in wind-induced mixing from the bottom waters likely
exacerbates this situation. There is as yet no evidence that land use changes or modifications in lake management are the cause for the change.

S08-P-07 The impact of climate on metal loads and aquatic organisms in alpine lakes

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Climate warming strongly influences mountain regions with effects on water quality and quantity, and productivity. In contrast, the current increase in metal concentrations in water bodies in the Alps attributed to the melting of permafrost was unexpected (Thies et al., 2007). Although the melting of permafrost is enhanced by the recent warming, the processes causing this metal increase remains enigmatic. If permafrost melting is the main driver for metal increase, we should observe similar peaks during particularly warm periods that followed a longer lasting cold period in the past. At the same time it is well known that changes in organic matter may affect the metal load of lakes (Wolfe et al., 1997). With a multi-proxy approach including organic and inorganic analyses, and organisms sensitive to metal loads, we aim to disentangle the major drivers, and to separate natural from anthropogenic influences on the metal increase. We compare short and long sediment cores that cover both the recent centuries and the Holocene from lakes with permafrost and without permafrost in the catchment. In lakes with permafrost influence, water monitoring since the mid 1980s shows a strong increase in the ion concentration. Metal concentrations are currently far above the drinking water limit, and modern chironomids depict deformations. Still, nickel and sulfur concentrations are highest in the sediment layers of the early Holocene, apparently deposited after rapid warming events following cold periods. Thus the contemporary metal increase is not unprecedented, but still causes an unexpected additional climate driven threat for several Alpine water bodies.

S08-P-08 Rapid climatic changes (RCCs) as reflected by siliceous algal records in the South Carpathian Mountains (Romania)

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Siliceous algal assemblages of Lake Brazi (1740 a.s.l.), a small, shallow lake in the Retezat Mountains, were studied for detecting the climatic changes after the deglaciation (ca 16 kyr). High resolution diatom analyses were carried out together with loss-on-ignition and biogenic silica measurements. Total epilimnetic phosphorus (TP) concentrations and pH were reconstructed quantitatively. Ten statistically significant zones were distinguished, six of which appeared in the lateglacial and Early Holocene suggesting the instability of diatom assemblages after deglaciation. The uppermost zone covered six thousand years, which suggests that diatom assemblages remained quite stable during the second half of the Holocene. The lateglacial and Holocene diatom species composition are considerably different. We paid special attention to the Holocene climatic variability. Rapid climate change (RCC) occurs when the climate system is forced to transition to a new state at a rate that is determined by the climate system itself, and which is more rapid than the rate of the change of external forcing. There have been several attempts to quantify these RCC events; studies so far suggest that they depend chiefly on geographical location. Three RCCs could be clearly traced in the Lake Brazi palaeo-record; namely RCC 9000-8000, 6000-5000, and 3500-2500 cal yr BP. Successive meltwater pulses and a sudden decrease in solar activity are deemed to be the main climate-forcing factors in the 9000-8000 period, whereas changes between 6000-5000 and 3500-2500 cal yr BP may be attributable to shifts in insolation and solar activity.
S08-P-09  Reconstructing environmental and landscape change in the Cairngorms, Scotland

Cunningham, L., Twiddle, C., Edwards, K., Wilson, R.

A multiproxy palaeolimnological study was undertaken in the Scottish Highlands in order to reconstruct environmental changes during the Holocene. A 2.5 m sediment core recovered from Loch an Eileen forms the basis of the results and is augmented by sub-fossil pine material (trunks and branches) recovered from this and an adjacent lake. The lower section of the Loch an Eileen core spans the transition into the Holocene period, with minerogenic sediments and the diatom species Fragilaria and Aulacosira initially dominant. By ~8,700 cal yr BP Cyclotella had become the dominant species, potentially indicating a warming climate. The pollen record also shows a marked transition from an early Betula-dominated community to a Pinus-dominated one, further reflecting inferred warming. Additionally, sub-fossil pine material clearly shows extensive mature Pinus woodland by ~7850 cal. yr BP at several sites within the Cairngorms.

From ~6100 cal yr BP there is a transition to mixed pine-birch woodland with a decline in Pinus, while the diatom communities reveal compositional shifts potentially linked to changes in stratification and mixing regimes. The pollen record indicates a continued pine decrease until ~2500 cal. yr BP, which is consistent with a lack of sub-fossil material dating from ~5900-3200 cal. yr BP.

This record provides a long-term context against which more recent changes can be compared and highlights the value of multiproxy reconstructions.

S08-P-10  Palaeoenvironmental reconstruction of the Cuatro Ciénegas Basin, NE Mexico from the Late Pleistocene to the present

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With over 200 pools, lakes and rivers supporting over 70 species of endemic flora and fauna the Cuatro Ciénegas Basin, Coahuila, NE Mexico is an extremely important and extensively studied area in terms of its conservation. The palaeoenvironment, however, is relatively understudied with only two reconstructions to date – Meyer’s 1973 study indicating environmental stability and Mickley and Jackson’s 2008 study indicating environmental instability over the past 20,000 years. Here, $^{18}$O/$^{16}$O and $^{13}$C/$^{12}$C isotope data is presented from a 15 m sediment core taken from Poza Tierra Blanca in the Cuatro Ciénegas Basin. The data suggest the Cuatro Ciénegas Basin has undergone large environmental shifts since c. 85,000 cal yr BP to the present – units 1, 3, 5 and 7 have $\delta^{18}$O values ranging between -15‰ and 0‰, suggesting that environmental conditions within these units were unstable and subject to rapid change when compared to the relative stability of units 2, 4 and 6, which display $\delta^{18}$O values between -8‰ and -6‰, typical of modern day meteoric water values in the basin. Low $\delta^{18}$O values (-14‰) are interpreted as extreme dry conditions and are associated with organic rich peat sediments, suggesting natural eutrophication associated with drying climatic conditions. A drying event observed in unit 6 is interpreted as being associated with the Bølling-Allerød event (c. 12,500 cal yr BP). $\delta^{18}$O and $\delta^{13}$C isotope values in the Cuatro Ciénegas Basin suggest that the basin has undergone large climatic shifts from c. 85,000 cal yr BP to the present.

S08-P-11  Human induced soil erosion in small, central Italian (Apennine Mountains) river catchments

Hoelzmann, P., Borrelli, P., Domdey, C., Knitter, D.

With over 200 pools, lakes and rivers supporting over 70 species of endemic flora and fauna the Cuatro Ciénegas Basin, Coahuila, NE Mexico is an extremely important and extensively studied area in terms of its conservation. The palaeoenvironment, however, is relatively understudied with only two reconstructions to date – Meyer’s 1973 study indicating environmental stability and Mickley and Jackson’s 2008 study indicating environmental instability over the past 20,000 years. Here, $^{18}$O/$^{16}$O and $^{13}$C/$^{12}$C isotope data is presented from a 15 m sediment core taken from Poza Tierra Blanca in the Cuatro Ciénegas Basin. The data suggest the Cuatro Ciénegas Basin has undergone large environmental shifts since c. 85,000 cal yr BP to the present – units 1, 3, 5 and 7 have $\delta^{18}$O values ranging between -15‰ and 0‰, suggesting that environmental conditions within these units were unstable and subject to rapid change when compared to the relative stability of units 2, 4 and 6, which display $\delta^{18}$O values between -8‰ and -6‰, typical of modern day meteoric water values in the basin. Low $\delta^{18}$O values (-14‰) are interpreted as extreme dry conditions and are associated with organic rich peat sediments, suggesting natural eutrophication associated with drying climatic conditions. A drying event observed in unit 6 is interpreted as being associated with the Bølling-Allerød event (c. 12,500 cal yr BP). $\delta^{18}$O and $\delta^{13}$C isotope values in the Cuatro Ciénegas Basin suggest that the basin has undergone large climatic shifts from c. 85,000 cal yr BP to the present.
Within a geoarchaeological research project, geomorphological and sedimentological investigations of the late-Holocene landscape evolution revealed in several subcatchments of the upper Turano River (Lazio, Italy) up to 10 m thick alluvial valley fills that were sampled continuously with a closed drilling system. The aim of our study is to investigate and quantify the effect of early human interaction with the landscape in the central Apennine region. Here human occupation took place since the early Iron Age and lasted throughout the Classical, Medieval and Modern periods. Based on $^{14}$C dating, sediment formation occurred mainly during the last ca. 4200 years. The sediments, mostly resulting from the mobilization of Cambisol covering middle Miocene pelitic-arenaceous siliciclastic turbidites consist of carbonate-free, intercalated, badly-sorted fine sands to coarse silt with clay contents of < 7 %. The distribution of the cumulative probability of the radiocarbon ages of charcoal of the valley-fills shows distinct peaks that represent periods of enhanced sediment formation and thus increased supply of colluvial soil that was redeposited in the isobaths. As several peaks are related to historical periods when social changes occurred the valley-fills reflect the geomorphic response to a shift from natural to anthropogenic causes.

**S08-P-12 Reconstructing climate-driven changes in lake thermal structure in alpine regions**

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Very few palaeoecological tools are available to reconstruct temperature-driven changes in alpine ecosystems. Here we demonstrate the potential for using planktic diatom indices and mixing depth calibration techniques as a metric for reconstructing past temperature-driven changes in lake thermal structure in alpine regions. We developed a diatom-based inference model for lake mixing depths using a combination of experiments and comparative lake sampling. The model was tested on a short core spanning the last few centuries from a lake in the northern Rocky Mountains of the U.S. Consistent with tree-ring temperature inferences for the region, diatom-inferred mixing depths were deeper during the cooler period from 1750 AD to 1850 AD, and became shallower during the 20th century as air temperatures increased and treeline advanced. We applied the model to sediment cores spanning the last 5,000 years from three additional lakes varying in lake size, basement geology, and elevation across the region. Changes in fossil diatom assemblages varied across the three lakes, but mixing depth inferences indicated regionally-coherent changes in lake mixing across the lakes, with a shift to deeper mixing in all three lakes with neoglacial cooling (3400 years before present) and a shift to shallower mixing during recent centuries. The diatom-based inference model used here provides a new tool to reconstruct changing thermal structure in oligotrophic, alpine lakes over the Holocene.

**S08-P-13 Multisite reconstructions of Holocene climate, fire and vegetation interactions at tree line in the Northwestern Swiss Alps**

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Tree line ecosystems are highly sensitive to environmental change, because trees grow at their lower limit of thermal tolerance. Climatic changes or disturbance by human land use can change the elevation and composition of the tree line. Sediment series from high-elevation lakes provide valuable records of the interactions among climate, humans, and vegetation. The combination of different proxies and dynamic vegetation models can help to disentangle the effects of climate and human impact on the vegetation at tree line.
We present new pollen and macrofossil-inferred reconstructions of Holocene vegetation from a series of lakes at, above and below present tree line in the Northwestern Swiss Alps, which span the entire Holocene.

Analysis of pollen and plant macrofossils shows that the tree line was below 1400m during the Late-Glacial and Younger Dryas and reached its maximum elevation of around 2200 m in the early- to mid-Holocene. The tree line was in equilibrium with climate until humans started to use the alpine meadows as pasture at the beginning of the Neolithic. During the Bronze Age, timberline forests were repeatedly cleared to expand pastures and finally lowered to their present position in the Middle Ages. Cross-correlation analysis shows that the expansion of Picea abies and the demise of Abies alba was strongly supported by human fires and animal grazing since the Neolithic.

Our results help to develop sustainable management practices and to identify threats to alpine biodiversity under future Climate Change.

S08-P-14 Phytoplankton lake sediment records from remote lakes: A whole ecosystem response to global change.

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Understanding of ecosystem response to present global change is essential to improve biological forecasting by anticipating critical transitions that would adversely affect humanity on a global scale. Remote lakes have already provided signals that reflect the influence of global factors such as climate warming or the atmospheric deposition of pollutants. Furthermore, as they integrate a whole ecosystem response these signals are reproducing also changes in their catchments. Furthermore, the scarcity of long-term records made lake sediments a valuable source of information to understand and predict earth-system response to global forcing factors. Here we show that global change is the main latent factor driving recent (last two centuries) phytoplankton variability in three remote lakes with contrasting lake, catchment features and amounts of atmospheric pollutants. Furthermore, they are situated in two distant geographical areas with different climate settings. Phytoplankton variability assessed by principal component analysis of chrysophyte cyst records was explained by fluctuations in Northern Hemisphere mean temperature, here used as a surrogate for global forcing. Locally, these global latent factors, show up as distinct combinations of climatic variables (e.g. air temperature monthly means) and pollutants, which differ between sites. However, variables indicating global forcing (e.g. NH-temperature, solar irradiance, CO₂ levels) have more explicative power than any local variable by itself. Our results indicate that lake phytoplankton response to global change in remote sites may be synchronized globally, although the specific features (i.e. species responding, local climatic links) may locally vary, global forcing emerge as the main driver of phytoplankton inter-annual variability.

S08-P-15 Diatom and vegetation responses to late-glacial and early-Holocene environmental changes at Lake Estanya (Pyrenees, NE Spain)

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We investigate the ecological responses of diatom communities and vegetation cover to abrupt climate changes between 20-9 ka yr BP in lake Estanya, NE Spain, in order to understand biotic consequences to rapid events and to evaluate possible future scenarios for global warming.

Preliminary results show an early lake stage (~20.6-20.4 cal kyr BP) characterized by Diploneis ovalis
probably indicative of fluctuating humid/dry conditions during glacial times, later substituted by dominant Cyclotella ocellata populations (~20.4-13.5 cal kyr BP) indicating permanent water bodies but punctuated by five episodes of strong Cyclotella decrease. Low pollen preservation between 20-17.5 cal kyr BP and dominance of Artemisia, other steppe herbs and Poaceae with Pinus and Juniperus as the main arboreal components suggest arid conditions during deglaciation. Betula developed since 18 ka yr BP, probably associated to refuge areas. Since 14.5 cal kyr BP steppe taxa progressively decrease and the forest develops with fluctuations. Between 13.5 and 12.8 cal kyr BP C. ocellata gives way to scant populations of Hantzschia amphioxus, Mastogloia spp. and Luticula mutica, suggesting brackish conditions. From ~12.8 to 10.6 cal kyr BP diatoms are nearly absent. These biotic responses take place in the frame of a complex, highly variable climate during MIS 2 with two main periods, the “Mystery Interval” and the Younger Dryas, characterized as cold and dry intervals. The Holocene transition is characterized by the presence of Fragilaria brevistriata reflecting a return to a brackish lake, and by the development of conifers and later mesic elements.

S08-P-16 Vegetation history and dynamics in the middle reach of the Yangtze River during the last 1500 years revealed by sedimentary record from Taibai Lake

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Pollen and charcoal records of a 150-cm-long lake sediment core from Taibai Lake in the middle reach of the Yangtze River reveal seven major changes in regional vegetation over the last 1500 years. During the period c. AD 480-710, evergreen broadleaved forest occurred in the Taibai Lake catchment. From c. AD 710 to 1050, the vegetation shifted to a mixed conifer and broadleaved forest. Between c. AD 1050 and 1320, evergreen broadleaved forest reoccupied the studied area. From c. AD 1320 to 1650, the area of primary forest decreased markedly with synchronous reduction in broadleaved trees and Pinus. Between c. AD 1650 and 1740, the biomass declined rapidly. During c. AD 1740-1950, forest extent increased slightly comparing to the previous stage. After c. AD 1950, the biomass in the surrounding area was very low, with vegetation type similar to that at present. The pollen assemblage, charcoal record, and magnetic susceptibility, as well as detrended correspondence analysis (DCA) with 125 pollen samples and 34 main pollen species, are combined to further discuss the main forcing factors inducing these vegetation changes. The vegetation changes were mainly controlled by the climatic changes, with the weak impacts of human activities before c. AD 1320. Since then, the intensity of human influences on vegetation increased gradually, entering a transitional period of main controlling factors of vegetation changes from nature to human activities. After c. AD 1740, the vegetation changes were chiefly controlled by human activities, and the climatic signal was weak.

S08-P-17 High resolution climate change in mid-late Holocene on Tianchi Lake, Liupan Mountain in the Loess Plateau in central China and its significance

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Asian monsoon variations during the Holocene have been well-documented by precisely dated cave deposits. The general climate change trend follows changes in summer insolation at low latitudes of north hemisphere. Holocene climate patterns in arid central Asia, controlled mostly by westerly circulation, show an out-of-phase relationship with Asian monsoon history, which may mainly controlled by North Atlantic sea-surface temperatures (SSTs), high-latitude air temperatures that affect the availability, amount and transport of water vapor and also, topography of the Tibetan Plateau and adjacent Asian highlands. The Tianchi Lake, located in the transition area of the East Asia monsoon region and northwest arid region, is an
ideal region for study on the Holocene climatic changes, considering its ecological fragility and sensitive environmental responses. Sediments from the Tianchi Lake afford very good high-resolution mid-late Holocene climate change achieve for the Loess Plateau. The preliminary result shows that the basic climate background was in agreement with the records from cave records in monsoon region in eastern China. Besides, it shows more detail record in abrupt climate change. This high resolution record provides background of climate change for the Neolithic culture evolution in the western Loess Plateau, such as Dadiwan culture. Further research will focus on the lamination of Tianchi Lake sediment. Reliable annual chronology will be taken from well preserved organic-detritus laminations. Hopefully we could obtain nice records on ENSO events, flood, winter monsoon researches as well as temperature record during mid-Holocene. The records would also discover the relation between human revolutions, human activities and climatic, environmental changes in the western Loess Plateau, China.

**S08-P-18  Recent ecological change of a remote alpine lake in Southeast margin of Tibet**

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There are widespread paleoecological evidences have revealed the recent quick change of alpine lake ecosystems, most of them are attributed to climate warming since 1850s or the nitrogen deposition. However, the responses of alpine lakes to recent environment change are among a wide range. In this study, we report ecological change of a small, remote, oligotrophic alpine lake (Shade Co) in Southeast margin of Tibet. The lake is located above local tree line, and surrounded by alpine shrub. In order to track the dominant factors of recent change, multi-proxies (diatom, pigment, geochemical indicators, stable isotope, and magnetic susceptibility) were analyzed on a 210Pb-dated sediment core, together with the collected reconstructed summer temperature in southeast Tibet. In last two centuries, the climate have the most significant influences on lake during the cold period between ~1820s and ~1860s, the change of indicators might reflect the prolonged ice-cover, aquatic macrophytes grew in the shallow open water moat around the periphery in growing season. After this cold episode, the lake experienced a stable recovery process. From around 1930s, the lake productivity (inferred from organic matter, total nitrogen and pigment concentration) increased consistently but there was regional cooling between 1970s and 1980s. So we speculate the possible drivers of the increased productivity may associate with nutrient enrichment by catchment process, nitrogen deposition, and cultural eutrophication. The results indicate the nutrient loading is exerting considerable influence on lake ecology in recent decades.
Session 09 - Thirty years of quantitative palaeoenvironmental reconstructions: lessons from the past and future challenges

S09-KN  Quantitative environmental reconstructions in palaeolimnology – progress, current status, and future needs
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In the 40+ years since Imbrie and Kipp’s (1971) and Webb and Bryson’s (1972) pioneering publications that introduced calibration (=transfer) functions into Quaternary science and the 30 years since Renberg and Hellberg’s (1982) pioneering quantitative pH reconstructions from diatom assemblages using index B, considerable progress has been made within palaeolimnology in developing ecologically realistic and numerically robust procedures based around the simple idea of two-way weighted averaging (ter Braak and van Dam 1989) and its numerical relatives such as WA-PLS (ter Braak and Juggins 1993). I outline this progress and review the current status of quantitative palaeolimnological reconstructions in terms of basic assumptions, methodology, model evaluation, assessment, and validation, uncertainty estimation, and ecological and numerical interpretation. I discuss future needs, in particular variable selection for reconstruction, selection of calibration data-sets and numerical method, cross-validation procedures, model selection, and reconstruction robustness, all of which involve a close interaction between ecological realism, numerical simplicity, and computational feasibility.

S09-01  Power analysis of tests of statistical significance of quantitative reconstructions
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Tests of the statistical significance of quantitative reconstructions inferred from biotic assemblages have the potential to have a large impact on palaeoecology. If the statistical tests are powerful, they will help palaeoecology become a more robust, hypothesis-driven science, but, if the tests are not powerful, they risk making our ability to reconstruct past environments appear unduly limited.

This presentation explores the tendency of several proposed reconstruction significance tests to generate Type I errors (false positives) and Type II errors (false negatives), and the circumstances that elevate the risk of these errors, by testing the significance of reconstructions from “pseudocores” of observations selected from calibration sets.

Some proposed methods have elevated Type I error rates, and should probably be avoided. The Type II error varies strongly between methods and data sets and is often high. The weighted correlation of the weighted-average optima and the axis one scores of an ordination of the fossil data constrained by the reconstruction was typically the most powerful method, except where species diversity was low. Statistically significant reconstructions from pseudocores have a higher correlation between the predicted and measured environmental variable which indicates that the significance tests are useful for distinguishing between good and less good reconstructions. Factors that increase the Type II error rate include: short environmental gradients in the fossil data, poor analogues for the fossil data in the modern data, low effective number of species, and long nuisance gradients.

The results suggest that tests of the statistical significance of reconstructions are useful, but caution should be used when rejecting borderline non-significant reconstructions.

S09-02  The influence of continentality on chironomid-based temperature reconstructions and the importance of training set selection

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Chironomids are recognized as a powerful proxy for inferring past climatic changes and fossil chironomid remains encountered in lake sediments have been widely used to infer quantitative mean July air temperatures. In this study, we present three chironomid records from Sokli (Finland) that were deposited during (1) the Holocene, (2) MIS-3 and (3) MIS-5cd. These time-intervals are characterized by different insolation values, which might have had an effect on the continentality (e.g. shorter but warmer summer season) at the site. Continentality is thought to have an effect on the ability of chironomids to complete (part of) their life cycle in a single summer season.

In this presentation we study three independent chironomid-climate training sets: from Norway, Finland and Russia. We show that the relationship between individual chironomid taxa and temperature differs for each training set. Chironomid taxa from Russia consistently show higher optima than their Norwegian counterparts, which is probably an effect of the different climate conditions (in terms of season length) between the different regions. The temperature-optima in the Finnish training set are also higher when compared to the Norwegian-based estimates, but this is probably the result of the short temperature-gradient in the Finnish model.

We apply the three different chironomid-temperature inference models to the fossil chironomid data. A comparison of the temperature inferences derived from the different training sets shows that there can be an offset of 1-4 °C between the reconstructions. Our results illustrate that the selection of the training set used as a modern analogue is of key-importance in any palaeoenvironmental study.

S09-03 Chironomids = Temperature: a validation for the past 1000 years

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Determining if temperatures of the last century exceed natural variability necessitates the use of high resolution paleo-reconstructions extending beyond the instrumental data (i.e. >150 years). Although syntheses using tree-ring, stalagmite, and borehole based reconstructions are available, biological proxies preserved in lake sediments have been neglected as a source of high-resolution information on climate change, as there is still doubt on their accuracy. In a recent publication (Velle et al., 2010), it was suggested that chironomids could not reconstruct climate at regional scale as local environmental factors had a greater impact on their temporal changes than temperature. Here, we present a decadal-scale mean July air temperature reconstruction covering the past millennium from varved Seebergsee, Switzerland and compare it to instrumental data at local, regional and European scales, to another high-resolution chironomid-inferred temperature reconstruction from Lake Silvaplana (Switzerland), to a composite of paleo-climate reconstructions from the Greater Alpine Region and to various millennial scale climate reconstructions from the northern hemisphere. Significant relationships between the Seebergsee record and other records were obtained at all scales (local, regional, central European and even northern hemisphere). These results illustrate that chironomids can indeed provide accurate temperature reconstructions, even when the calibration used was not constrained only to temperature, a critique provided by Velle et al. (2010).
S09-04 Lake selection and design of a training set to develop climate transfer functions for biological proxies in Polish lakes

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Transfer Functions based on modern training sets are well established and powerful tools in quantitative paleolimnology and environmental/climate reconstructions. However it is increasingly recognized that the selection of lakes and the design of the Transfer Function is most critical and may bias the results.

Here we show how we selected lakes out of a database with physical and chemical parameters of lakes in northern Poland to develop a Training Set for quantitative environment/proxy relationships and, ultimately to reconstruct quantitative seasonally resolved temperatures and precipitation from Chrysophyte stomatocysts, chironomids, diatoms and stable C and O isotopes in Lake Żabińskie (lowland NE Poland) for the past 1000 years (Project CLIMPOL: ‘Climate of northern Poland during the last 1000 years: Constraining the future with the past’). In this context, Poland has been recognized as one of the best places to study European temperature variability since explains up to 86% of the variance of winter temperatures. Lakes included in the training set were chosen among 2913 lakes from NE Poland. Using univariate and multivariate outlier detection techniques, we removed lakes without available water chemistry data, with extreme values (morphology, physical and chemical parameters), and/or lakes close to big cities and the coast. From the remaining 1247 lakes we selected 50 lakes for the final training set using stratified balanced sampling with ten equidistant blocks along longitude (in Poland a proxy for the temperature gradient) and other environmental variables. Lakes are below 250 m.a.s.l., deeper than 6 m, and slightly basic (pH ranging 6.5-9). The lakes are located along a W-E mean annual temperature gradient of 6-8.5°C and N-S precipitation gradient between 650-550 mm year⁻¹. For Training Set development, sediment traps and thermistors were deployed in these lakes.

S09-05 The limits and limitations of datasets for palaeoclimatic reconstruction: nonmarine ostracod problems and solutions

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The calibration of ostracod species as palaeoclimate proxies utilises living ostracod distributional datasets in combination with modern climate datasets. Small regional datasets of geographical distribution collected during relatively short time intervals may be internally consistent in terms of sampling methods, taxonomy and positional accuracy, but often fall short of capturing the full climatic ranges of taxa. Geographically more extensive, literature-based datasets are more likely to encompass species’ distributions in climate space but, since they represent collections by many people over many years, are prone to taxonomic inconsistency as well as poor locational precision and accuracy, and may even represent distributions blurred by shifts in response to contemporary climate change. Regional climatic datasets, too, span different time intervals. The inability to match climate data exactly to the interval during which distributional data were collected weakens an underlying assumption of palaeoclimate proxy methods: that species’ distributions are in something approximating to equilibrium with climate. We explore some implications of these issues with reference to large regional nonmarine ostracod databases for Europe and North America. We suggest that the accuracy of ostracod proxy methods for palaeotemperature reconstruction may be improved by utilising (1) OMEGA (Ostracod Metadatabase of Environmental and Geographical Attributes), a global metadatabase under development that will facilitate the capture of the full climatic ranges of species, and (2) the
WorldClim global interpolated climate dataset as a standard for species calibrations. Realising the potential of such a global dataset will require the harmonisation of the taxonomic schemes of the component regional databases.

**S09-06** Assessing midges (Chironomidae and Ceratopogonidae) as paleosalinity and paleotemperature indicators: in-vitro temperature and salinity experiments

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Chironomidae and Ceratopogonidae, were tested in-vitro for their responses to salinity and temperature. Three independent studies tested the effect of experimental temperatures (4, 14, and 24°C) on emergence of midge faunas collected from littoral zones of three separate lakes; from profundal zones of three other lakes; and the littoral, sub-littoral and profundal zones of one lake. Results from these experiments indicate: that some species may achieve optimal development at cooler temperatures; cold temperatures inhibit emergence of some species; exposure to temperatures too warm may result in developmental stress and sometimes death of some species; and chironomid emergence events appeared more or less synchronistic. In summation, some chironomid taxa may have relatively narrow optimal temperatures at which development and emergence can occur. In-vitro experiments were also conducted to assess larval midge salinity thresholds. Midges collected from ponds were subjected to diverse salinities (specific conductance levels varying from & <1000 to 45000 µS/ cm) and their survival rates observed. In this experiment Ceratopogonidae, Cricotopus/ Orthocladius, and Cladotanytarsus mancus appeared to have the highest tolerances to salinity while Chironomus anthracinus and the subtribe Tanytarsina displayed low tolerances. Results from these experiments indicate that temperature and salinity directly impact midges by regulating emergence (in response to temperature), and survival (in response to temperature and osmotic stress). Responses are similar to those predicted in palaeoenvironmental inference modeling studies, and support the continued use of midges as both paleosalinity and paleotemperature indicators.

**S09-P-01** Sub-fossil Cladocera as indicator of salinity based on surface sediment of 32 Turkish shallow lakes

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Sub-fossil Cladocera species were identified from the surface (0-1.5 cm) sediments of 31 shallow (mean depth = 4.25 m) lakes spanning over five latitudes from the semi-arid north (41°52´N, 27°58´E) to the arid south (37°06´N, 29°36´E) of Turkey. Sub-fossil cladocerans and environmental variables were used together to generate a calibration data set using ordination techniques, namely Detrended Correspondence Analysis (DCA) and Canonical Correspondance Analysis (CCA) for investigating the key environmental factor that is related with climate change structuring cladoceran community composition. CCA showed that the distribution of the cladocera in surface sediments was explained (62.4 % of the total variation) by lake water salinity (p=0.001). Based on this strong relationship salinity inference models were developed, using weighted averaging (WA) techniques. WAtol inverse deshrinking model based on 25 lakes produced the lowest root mean square error (RMSE; 0.03 log(x+1) salinity) and root mean square error of prediction (RMSEP; 0.05 log(x+1) salinity). The improved transfer function was applied to cladocera
assemblages from a dated sediment core from Lake Göllhisar, located in southwest Turkey, covering 80 years. Cladoceran-inferred log(x+1) salinity data shows some variation between 0.05 and 0.11 ‰ from 1932 to 2007 and can be characterized by three zones along with relative abundance data.

**S09-P-02** Diatom-based reconstruction of the pelagic environment of Burg Lake (Pyrenees) during Late Glacial and Early Holocene: does it make sense to use a single proxy for reconstructing several environmental variables?

Rivera Rondón, C., Catalan, J.

Transfer functions for several environmental variables were developed based on a survey of 82 mountain lakes of the Pyrenees. The environmental gradients surveyed included the main bedrock types, altitudinal range and lake morphologies. The variables selected for potential reconstructions were those explaining relatively independent variability of the diatom distribution among lakes and comprised major chemical conditions, water transparency and nutrients.

The transfer functions were applied to a diatom record from Burg Lake (42°30′N, 1°19′W, 1820 m.a.s.l.). The record was thirteen meters long and was sliced every centimetre. The bottom of the sequence was dated at 16,700 yr cal BP and, as the lake becomes a wetland with high peat accumulation at about 5,000 yr cal BP, the diatom record was analysed between these two dates.

Finally, the reliability of the reconstructions was evaluated from two complementary perspectives. Statistically, they were compared with the principal components of diatom community variability, with environmental randomly generated variables and using cross-correlations at different time windows. Functionally, the reconstructions were evaluated in the light of their coherence with known biogeochemical processes occurring in mountain lakes under ontogenic and climatic changes.

**S09-P-03** Sedimentary Pigments in Turkish shallow lakes: assessing the relation to environmental variables and inferring the change in past phytoplankton communities


Fossil pigments that are produced by algae, phototrophic bacteria and aquatic plants can be used in studying ecosystem changes, like eutrophication and acidification, in aquatic environments. Therefore, the primary aim of the study was to determine the environmental variables potentially influencing phytoplankton composition using sedimentary pigments. High pressure liquid chromatography (HPLC) analyses of phytoplankton pigments were conducted in the surface sediment samples (~0-1.5 cm) of thirty shallow lakes spanning over a latitudinal gradient from the North (42° 0′N, 34°55′E) to the South (36°41′N, 28°50′E) of Turkey. Redundancy analysis (RDA) captured 62.1% of total variation along the first two axes and suggested that total nitrogen (TN) was the most important variable (p = 0.001) determining main phytoplankton species composition. Being coherent with the RDA results, TN was responsible for the first split in multivariate regression tree (MRT) analysis. Furthermore, a model application was performed for the dated cores (~75 and 104 cm respectively) gathered from the two shallow, large lakes (Marmara and Uluabat) that had varying productivity through time. The results from both of the cores showed an increase in cyanobacteria indicator pigment concentrations
towards the surface layers, possibly indicating a recent eutrophication.

**S09-P-04 Ostracods, beetles and midges: inter-proxy testing of quantitative methods for Quaternary palaeotemperature reconstruction**

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The application of quantitative methods to Quaternary palaeoclimatic reconstructions invariably yields plausible results which should not be accepted uncritically but need to be tested and validated. We employ a multi-proxy approach to explore agreements and, perhaps more interestingly, disagreements between palaeotemperature estimates furnished by different biological proxy groups and methods, including the Mutual Ostracod Temperature Range, Coleopteran Mutual Climatic Range and Chironomid Transfer Function methods. New as well as previously-published multi-proxy palaeotemperature estimates from European Pleistocene and Holocene deposits are compared and discussed. We find some encouraging examples, from both warm- and cold-stage deposits, of good matches or overlaps of palaeotemperature ranges obtained independently from different proxy methods. Some (but not all) mismatches can be attributed to issues of sample resolution and equivalence. We consider whether a "mutual mutual range" method combining two or more proxies is justifiable and useful.

**S09-P-05 Diatom assemblages as quantitative indicators of past environmental conditions in Turkish shallow lakes**

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Palaeolimnological approaches, especially surface-sediment calibration sets, are commonly used to reconstruct past environmental conditions in freshwater ecosystems. Diatoms are widely used biological proxies due to their sensitivity to water quality and have been employed to reconstruct pH, nutrient and salinity changes at numerous lakes worldwide. There are a few studies to reconstruct past lake ecosystems in Turkey that focus on diatom-salinity and diatom, ostracod-conductivity training sets. The aim of this study is to find traces of salinization and eutrophication for Turkish shallow lakes using diatom assemblages.

This study includes twenty-seven shallow lakes along a latitudinal gradient ranging from the North (41°52´N, 27°58´E) to the South (37°06´N, 29°36´E) of Turkey. A kajak corer was employed to collect surface sediment and short core samples. Diatom assemblages in the surface (0-1 cm) sediments and environmental variables were used to generate a calibration data set which was explored using Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA). As the DCA gradient length of the species dataset was > 4, CCA with Monte Carlo permutation tests was employed to explore the species-environment relationships. The 15 environmental variables captured 65% of the total variation in the species composition of diatom assemblages while conductivity and NH₄ had the highest explanatory power (p < 0.05) for Axis 1 with the eigenvalues of 0.87 and 0.30, respectively. The dataset will be used for developing diatom based transfer functions to infer past conductivity and NH₄ concentrations and will be applied to selected short cores from Turkish shallow lakes.

**S09-P-06 Goldilocks and the three transfer functions**

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Gaussian logistic regression (GLR) and calibration is a formal statistical approach to regression and calibration. The relative computational complexity and comparable error performance compared to weighted averaging methods have resulted in the limited use of GLR for palaeoenvironmental
reconstructions. Recently, statistical machine learning methods such as boosted regression trees and random forests have been applied to calibration problems (e.g. Simpson & Birks, 2012). These machine learning methods derive response relationships with the predictand from the data themselves without the user having to specify the functional form of those relationships. However, the resulting relationships can often be highly complex having partial-responses with the predictand that are hard to justify on ecological principals. We might reasonably ask whether these models are over fitted to the training data? Generalised additive models (GAMs) can be seen as falling somewhere between GLR and boosted regression trees. GAMs also allow for response relationships to be derived from the data rather than be specified a priori by the user, yet retain the formal statistical model of the GLR. Using recent theoretical and computational advances, GAMs can be constrained to largely avoid overly-complex response relationships thus helping to avoid over fitting. I discuss the above issues and compare a GAM-based calibration model with equivalent models fitted using GLR and boosted regression trees, highlighting the relative properties and advantages each approach using several well-studied training sets, including the SWAP and EDDI data sets.

S09-P-07 Can chironomids and chrysophytes be used to quantitatively reconstruct temperature in Polish lakes?

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The aim of the recently established project CLIMPOL (Climate of northern Poland during the last 1000 years: Constraining the future with the past) is a quantitative reconstruction of climate change from varved lakes in northern Poland during the last 1000 years. This reconstruction will be obtained using biological (chironomid head capsules, chrysophyte stomatocysts, diatoms, pollen), stable C- and O-isotopic, sedimentological and geochemical proxies. Here, we present the first high-resolution chironomid and chrysophyte-inferred temperature reconstructions in a Polish lake. The first 64 varves of Lake Żabińskie (54°07’54.5”N; 21°59’01.1”E) were analysed for chironomids, and a transfer function from eastern Canada (Larocque, 2008) was applied to quantitatively reconstruct mean August temperature. For the chrysophytes, an Austrian transfer function was used. However, in both cases, Polish transfer functions will be developed to reconstruct climate on longer time scales. Lake Żabińskie is located in the Masurian Lakeland. It is relatively small (40.1 ha) and deep (43.5 m). The lake has one major and several minor inflowing streams and one outflow connecting to the much larger Lake Goldopiwo. The first measurements of physical and chemical properties of the lake water indicated a eutrophic, thermally stratified, hardwater lake with seasonal anoxia in the hypolimnion. The core ZAB-11/3 was collected in September 2011 from the central part of the deep basin using a UWITEC gravity corer. Each varve was subsampled and analysed for chironomids and chrysophytes. Preliminary results are presented.

S09-P-08 The relationship between chironomids and lake depth in Bosten Lake, Xinjiang, NW China

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A significant relationship between the distribution and abundance of chironomids and water depth has long been recognized. However, few studies have been done on this topic in arid regions where the chironomid community is usually controlled by water salinity. Thus Bosten Lake, the largest inland freshwater lake in China and located in the
northwest of the country, provides a unique opportunity to investigate this relationship in an arid region. A total of 37 surface sediment samples, from water depths of 4 m to 17 m and 12 chironomid taxa were used in the analysis. The first PCA axis explained 76.8% of the variance in the chironomid assemblage and there was a significant correlation between PCA axis 1 scores and water depth. The chironomid assemblages significantly changed at 8.0 m and 11.3 m. The change at 8.0 m water depth corresponded to an abrupt change in the underwater slopes and the spatial pattern of aquatic vascular plants, but an interpretation for the change at 11.3 m requires further ecological and physiological research. RDA showed that the abundance of Chironomus sp-1, Microchironomus and Crypochironomus was positively correlated with water depth, whereas the abundance of Tanytarsus, Polypedilum nubifer-type, Cricotopus and Psectrocladius sordidellus-type was negatively correlated with water depth. These ecological relationships have previously been reported in the literature. We also compared qualitative chironomid-inferred changes in lake level to qualitative diatom-inferred changes in salinity from the same sediment core and obtained close agreement in trends of these two variables.

**S09-P-09 A model for linking grain-size component to lake level status of a modern clastic lake**

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Grain-size distributions of fluvial, eolian and marine sediments were explicated decades ago. For lake sediments, however, there is still great uncertainty in explaining the genesis of grain-size components due to the inherent complexity of their polymodal distributions. In this study, the grain-size components of the surface sediments of Hulun Lake, Inner Mongolia, were partitioned using a lognormal distribution function and the relationship between the identity of each component and the specific sedimentary environment was investigated. The data indicate that the modern clastic sediments of Hulun Lake contain five distinct unimodal grain-size distributions representing five grain-size components. Each of the components retains its identity including modal size, manner of transportation and environment of deposition although the relative percentage varies with the hydraulic condition throughout the lake. These components are specified from fine to coarse modes as long-term suspension clay, offshore-suspension fine silt and medium-to-coarse silt, and nearshore-suspension fine sand and saltation medium sand. The percentage of the components interpreted as an indication of nearshore environments displays a negative correlation with water depth across the modern lakebed, suggesting a model for linking the nearshore components in sediment cores to the lake level status in the geological past. The model was applied to a sediment core from the lake where high percentages of the nearshore components in the core sediments were correlated with low regional precipitations reconstructed on the pollen profile of the same core, revealing the potential of the grain-size component–lake level status model for lake’s paleohydrological reconstruction.

**S09-P-10 Regional climate dynamics during the last 2000 years – the PAGES 2k Network**

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Past climates are rich resources to learn about the dynamics of the climate system on interannual to multicentennial timescales and to provide Earth System Models (ESMs) with benchmarks different from the present. Matching the increasing resolution of ESMs and serving the need for regional climate change information requires improving the quality of sub-continental climate reconstructions. Extending the record of climate change back in time beyond the instrumental period relies on well-dated
and highly resolved proxy-based records derived from climate archives such as documentary evidence, lake and marine sediments, tree rings, speleothems and ice cores. The Past Global Changes project (PAGES) has developed the Regional 2k Network with the aim to obtain detailed climate reconstructions over the last two millennia with worldwide coverage. For nine continental regions (including the polar areas and the oceans), regional working groups compile and analyze the best proxy time series and produce spatial reconstructions of state variables of the climate system (e.g. temperature or precipitation).

The poster will present results from the first phase of the 2k project with a focus on regional interannual to multidecadal variability of temperature. Temperature curves and field reconstructions are presented and compared in the scope of natural and anthropogenic forcings.

S09-P-11 The Neotoma Paleoecology Database: A multi-proxy data source

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The Neotoma Paleoecology Database (www.neotomadb.org) is a multiproxy relational database that includes fossil data for the past 5 million years and modern surface-sample calibration datasets. The Neotoma project is an international collaborative effort among individuals from more than 20 institutions worldwide, including scientists representing a spectrum of fossil data types, as well as experts in information technology. Neotoma is an open-access community database that provides the underlying cyberinfrastructure for a variety of disciplinary database projects.

A key design concept of Neotoma is that “stewards” for various data types will be able to remotely upload data to Neotoma and manage data already in Neotoma. The steward interface uses web services that provide access to the database. Cooperatives for different kinds of paleo data or from different regions appoint their own stewards. Paleo data include pollen, diatom, ostracode, vertebrate fauna and packrat midden datasets from stratigraphic records worldwide.

A major challenge to organismal databases is changing taxonomic concepts. For example, this challenge has become particularly acute with the many recent changes in diatom taxonomy. Diatom names in Neotoma have been revised to be in accordance with the latest advances in taxonomy, but special effort has been made to preserve taxonomic circumscription in legacy data. All datasets stored in the Diatom Paleolimnology Data Cooperative (DPDC) are being migrated to Neotoma.

An example of how a research database can maintain its independence and also be migrated to Neotoma is that of NANODe, the North American Nonmarine Ostracode Database, which was recently uploaded to Neotoma. NANODe combines modern species occurrence data with hydrochemical and climatic data for lakes, streams, springs and wetlands in the United States. NANODe continues to exist as a maintained website (www.kent.edu/NANODe) with species images, but the data are now accessible through Neotoma, and can be searched along with a range of multiproxy data.

S09-P-12 Why Transfer Functions Don’t Work

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The first palaeolimnological transfer functions built on a long history of observed organism response to pH and salinity. Since then predictive models have been constructed for a wide range of environmental variables including nutrients, anion and cation concentrations, DOC, $p$CO$_2$, methane emissions, heavy metals, water depth, marsh elevation, flooding period, lake water and air temperature, and duration of lake ice and snow cover. This presentation will take a critical look at the ecological and statistical basis for these models. Using examples of real and
simulated data I will demonstrate that many are based on weak, non-causal species-environment relationships that are confounded by the effects of often strong “nuisance” or secondary environmental gradients. As such, they lack statistical validity, have little predictive power, and produce reconstructions that are problematic and unreliable. I argue that to make progress palaeolimnologists must take a more critical approach as to which variables can be reconstructed and to validate models across multiple datasets and regions.

S09-P-13 Early Holocene environmental change in northeastern Fennoscandia
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The Holocene thermal maximum (HTM), a warming which is most pronounced in the Northern Hemisphere (NH) and with summer temperatures 1-2°C higher than today, is traditionally placed between 4000 and 7000 cal. yrs. BP while cooler climates are generally considered to have dominated the early Holocene. The high spatial variability of the HTM timing and magnitude is well acknowledged, however, high resolution multi-proxy studies with emphasis on this phenomenon are scarce in northeastern Fennoscandia. In this study, we focus on the early Holocene with the aim to quantify July temperatures and reconstruct environmental conditions such as trophic status and vegetation development directly after the deglaciation. An exceptionally long lake sediment core retrieved from Lake Loitsana, northeastern Finland, allows for the reconstruction to be conducted with a decadal resolution. The methods include biogeochemical data obtained through LOI, C/N and XRF (ITRAX core-scanner) measurements, plant macrofossil, diatom and chironomid analyses, lithological characteristics and AMS 14C dating. A radiocarbon date performed on seeds of tree Betula indicates that the area was deglaciated before 10 700 cal. yrs. BP. Preliminary plant macrofossil and chironomid results suggest a peak in summer temperature during the early Holocene, a time when the NH summer insolation was at its highest. Aquatic macrofossil taxa, i.e. Glyceria lithuanica, indicate a mean July temperature of at least 15°C at 10 700 cal. yrs. BP, 3°C higher than present. The vegetation immediately after deglaciation appears to have responded rapidly to the summer insolation peak after the influence of the ice-sheet was diminished.

S09-P-14 Climate of northern Poland during the last 1000 years: Quantitative multi-proxy reconstructions with annual resolution based on varved lake sediments from Lake Żabińskie
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The recently established project CLIMPOL (Climate of northern Poland during the last 1000 years: Constraining the future with the past) aims at a quantitative reconstruction of climate change based on varved sediments from Lake Żabińskie in northeastern Poland. The project has been funded by the Polish-Swiss Research Program and is scheduled for the years 2011-2015. After establishing a precise chronology (varve counting, C-14, Pb-210, Cs-137), analyses will cover biological (chironomid head capsules, chrysophyte stomatocysts, diatoms,
pollen), stable C- and O-isotopic, sedimentological and geochemical proxies. Results will be calibrated with a modern training set of lakes (transfer function) and a calibration-in-time approach using long instrumental data series validated with early instrumental and documentary data.

Field investigations show that sediments of Lake Żabińskie fulfill two criteria which are crucial for an annually resolved reconstruction: (1) sediments from the deepest basin are continuously varved, and (2) high sedimentation rates allow subsampling procedures that provide sample material for all proxy parameters with annual resolution. The sediment record shows a varved structure of biogenic–calcareous gyttja along the entire length. This is confirmed by first results of high-resolution XRF scanning which shows excellent agreement of calcium peaks with the position of pale layers. Varve thickness varies along the core in the range of 2-18 mm with the last 1000 years being represented in the uppermost ca. 4 m of the retrieved sediment core.

At the current stage, samples covering the last 120 years are analyzed and compared with instrumental data series available.

**S09-P-15 Pollen based quantitative climate reconstruction on the Tibetan Plateau: Challenges for large lakes**


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The past climate on the Tibetan Plateau (TP) is of great importance for understanding of global climate processes and for predicting the future climate, leading to various climate reconstructions over the last decades. However, inferring quantitative climate information from large lakes is still challenging because of the influences by different pollen source areas. Here we present a fossil pollen record since the LGM from Lake Donggi Cona (northeastern TP). A new modern pollen data-set consisting of over 50 large lakes (with minimal lake radius of 750 m) from the arid/semi-arid regions in central Asia is also presented herein. The pollen source area of each modern lake was estimated according to Sugita’s theoretical model. The modern climate data for each sampling sites were estimated by inverse distance weighting the grid climate data within individual pollen source areas, and then used for quantitatively reconstructing the past climate change.

The climate inferences from pollen records generally follow the assumption that past vegetation changes are primarily driven by climate changes, which needs further confirmation. Here, in order to identify the potential drivers of vegetation change on the TP, a high resolution (10–15 yr) late Holocene pollen record from Lake Kusai was analyzed. A moving-window Redundancy Analysis (RDA) based on parallel analyzed pollen and sedimentary proxies reveals multiple drivers for vegetation change, among which climate was not always the dominant factor. Additional Procrustes and ProTest analyses indicate that the human activities have possibly influenced the vegetation changes during the last centuries.

**S09-P-16 Rare Diatom Taxa – setting a sense**

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Several recent bio indicator programs in different European countries are using rare benthic diatom taxa (e.g., German’s PHYLIB module: Quotient of Reference Species (RAQ)). The abundance of diatom data are calculated mostly based on the count
of 400-500 diatom frustels within a preparation of a sample. Simulation studies were used to analyse the effect of rare taxa (rel. abundance < 1%) to infer environmental parameters as to calculate the RAQ. The results showed that the finding of rare taxa was highly influenced by chance and that no ecological conclusion should be drawn of finding them. As the RAQ bases on present-absence information of the single taxa, rare taxa have the same weight as abundant taxa and influence the RAQ strongly. It was shown, that just by chance different scientist will come to strongly different results when calculating the RAQ based on their counts within the same diatom sample. Additionally, significant different results appears when comparing the calculated RAQ for diatom associations found on different substrates.

In conclusion it is highly recommend to control, whether rare taxa should be included in bio indication using diatoms.
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Session 10 - Understanding low-latitude climate change: recent developments from palaeolimnology

S10-KN  Lacustrine records of tropical paleoclimate: new tools, new records, new directions

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Paleoclimate records from tropical lakes have played a critical role in our understanding of the Earth’s climate evolution for nearly a century. Pioneering work used fossil pollen and lake level histories allowed the qualitative reconstruction of orbital-scale features of late Pleistocene hydrology, leading to the first integrations of paleoclimate data with quasi-equilibrium climate modeling experiments in the 1970s and 1980’s. Over the three decades hence, the number of proxies available to palaeolimnologists has exploded, as has the spatial and temporal resolution of proxy records. Coupled with the rise of climate model simulations run in transient mode, we are now poised to unravel new aspects of low-latitude climate dynamics, from the thermal history of the tropics to numerous aspects of the low-latitude coupled ocean-atmosphere circulation.

For decades low latitude climate reconstructions focused almost exclusively on tropical hydrology, due primarily to a lack of temperature proxies. Yet surface temperatures control the buoyancy and circulation of the lower troposphere, including many aspects of tropical convection. New proxies have begun to rectify this problem. The development of temperature proxies based on glycerol dialkyl glycerol tetraethers (GDGTs), the so-called TEX$_{86}$ and MBT-CBT proxies, and their application to lake sediments are providing new insight into the long-term controls on tropical continental temperature. For instance, application of TEX$_{86}$ to sediment cores from large tropical lakes indicates glacial-interglacial warming of ~4°C, higher than warming simulated by state-of-the-art climate models. Moreover, warming began early in the deglaciation in tropical Africa and peaked during the mid-Holocene, highlighting important feedbacks between high-latitude processes, low-latitude hydroclimate, and tropical temperatures. While TEX$_{86}$ reconstructions have been largely restricted to only the largest tropical lakes, temperature calibrations based upon branched GDGTs have now been successfully applied to small tropical lakes. The coming decade could witness a dramatic surge in the availability of tropical temperature reconstructions, changing our view of tropical paleoclimate in the same way that lake level studies did thirty years ago.

The past decade has also witnessed a dramatic rise in the number of high-resolution reconstructions of equatorial and southern hemisphere climate. Isotopic records from speleothems have highlighted the importance of north-south migration of the Intertropical Convergence Zone (ITCZ) in controlling orbital- to millennial-scale patterns of low-latitude atmospheric circulation. Yet paleolimnological records indicate a far more complex picture of tropical rainfall and hydrology, including equatorial and southern hemisphere aridity during times when the ITCZ shifted southward. These ‘mismatches’ suggest changes in the strength of convection within the ITCZ, and/or zonal reorganizations of the tropical atmospheric circulation are at least as important, if not more important to tropical hydrology as migration of the ITCZ. Indeed, the integration of climate model simulations with new paleolimnological records from Indonesia suggest substantial changes in the walker circulation during the late Pleistocene. During the next decade improved synthesis of lacustrine records and their integration with transient model simulations will greatly improve our understanding of the sensitivity of tropical hydrology and atmospheric circulation to orbital, glacial, and greenhouse gas forcing.
“A tale of two lakes”: comparing laminated records for the last 17 ka BP from Cappadocia, Turkey

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Varved lake sediments offer a chronological precision comparable to the best natural archives of climatic change. However, in the absence of replication between records, it may not be easy to separate local, lake-specific factors, such as basin infilling and catchment erosion, from those of wider regional significance (e.g., climatic change). In this study, we compare two volcanic lake sediment records from Central Turkey between Glacial times and the present-day. The sediments of Eski Acıgöl are laminated between the LGM and ~6.5 ka BP, but non-laminated after this, and they offer a highly-resolved record of environmental change during the late Pleistocene-early Holocene climatic transition (Roberts et al., Holocene 2001). The palaeoclimatic signature at Eski Acıgöl has been superimposed on a long-term trend towards basin infilling, and it may not always be straightforward to separate these two processes.

Nearby Nar lake has varves forming at the present-day, and which we have monitored since 1998 (Jones et al., JoPL 2005, Woodbridge and Roberts, JoPL 2010). Stable isotopes, pollen and diatoms provide a detailed palaeolimnological analysis of the last 1,720 years (Jones et al., Geology 2006; England et al., Holocene 2008; Woodbridge and Roberts, QSR 2011). In 2010, we obtained a 21.69 m core sequence from Nar lake, >80% being laminated, which spans the last ~17 ka. Because of its greater age and larger volume, basin infilling has not interfered significantly with the lake sedimentary record. On the other hand, part of the Nar lake catchment is actively eroding, which has led to the creation of a fan-delta on its southern edge and to the deposition of turbidite layers on the lake bed.

Comparison of the sediment records shows significant differences in the history of varve formation between the two lake basins, largely related to sedimentary infilling of Eski Acıgöl crater which ultimately led to lake shallowing and holomixis in this basin. On the hand, there are also important periods of convergence between the two records which suggest a common, climatic causation, especially when they are supported by other proxy data. They include:

- shallow water conditions in both lakes, during the Younger Dryas and again ~4.2 to ~2.5 ka BP
- deepwater conditions and varve formation between 11.6 and 7 ka BP in both lakes, reflecting a Neolithic climate wetter than at present.

Investigating drivers of hydrological variability in the North American Monsoon region during the last glacial cycle

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The North American Monsoon (NAM) is a key feature of the large scale atmospheric circulation over the North American continent. During the last glacial cycle, insolation, the extent of the Laurentide Ice Sheet and changes in the North Atlantic Meridional Overturning Circulation (AMOC) are all considered to have had an impact on the NAM, but their relative importance remains poorly understood.

We present results from a 34 m sediment core from the Sayula Basin in western Mexico, close to the core of the NAM. The Sayula basin (1350 m a.s.l.), presently an ephemeral playa system, lies in a graben at the northern end of the Colima Rift,
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extending c. 60 km N-S and 20 km E-W. Mean annual precipitation is 800 mm (mainly June to September) associated with the onset of the NAM. The core covers the last c. 70 kyr BP (6 radiocarbon dates, 1 U-series date on diatom silica and an Ar-Ar date on tephra). The multi-proxy record is based on Itrax XRF core scanning, bulk organic geochemistry and isotopic composition of calcite, along with a preliminary assessment of diatom assemblages.

Five periods of relatively wet conditions are identified: 68 – 64 kyr BP, 55 – 52 kyr BP, 38 – 34 kyr BP, 16.6 – 13.6 kyr BP and 11 – 7.5 kyr BP. Whilst there is some correspondence with insolation forcing, a strong imprint of North Atlantic variability is observed during MIS-3. The Laurentide Ice Sheet was a significant driver between the LGM and early Holocene through its effect on mid-latitude westerly circulation.

S10-03 Varved sediments of Lake You (Ounianga Kebir, Chad) reveal progressive drying of the Sahara during the last 6100 years


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The sedimentological and geochemical properties of a 7.47 m long laminated sequence from hypersaline Lake You in northern Chad has been investigated, representing a unique continuous 6100 year long continental record of climate and environmental change in the eastern Central Sahara. These data were used to reconstruct the Mid to Late-Holocene history of this currently hyper-arid region in order to address the question of whether the Mid-Holocene environmental transition from a humid to a dry Sahara was progressive or abrupt. This study involved a suite of analyses, including petrographic and scanning electron microscope examination of thin sections, X-ray diffraction, X-radiography, granulometry, loss-on-ignition and magnetic susceptibility. The potential of micro-X-Ray fluorescence core scanning was tested at very high resolution (100 µm). Detailed microscopic investigation revealed the sedimentary processes responsible for the formation of the fine laminations, identified the season during which they were formed, and confirmed their annual nature. Geochemistry and mineralogy revealed that, due to decreasing monsoon rainfall combined with continuous and strong evaporation, the hydrologically open and fresh Mid-Holocene lake Youa slowly evolved into the present-day hypersaline brine. During the oldest part of the investigated period, Lake Youa probably contained a permanently stratified lower water column that was nevertheless disrupted by relatively frequent events of deep mixing. Subsequently, deepwater anoxia became progressively more stable because of the gradual increase of salinity-driven density stratification. In parallel, the sediment grain size proxies record a progressive increase of aeolian input in the course of the last 6100 years. Altogether, all geochemical and sedimentological indicators point to a progressive drying of the eastern Central Sahara.

S10-04 Holocene transitions between meromictic and holomictic mixing regimes in a mid-altitude tropical lake in western Mexico

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La Alberca de Tacambaro (19°12'40”N, 101°27'30”W, 1,460 m asl) is a deep lake (30 m) with a small area (0.08 km²) at the ecotone between tropical (tropical deciduous forests) and temperate
(pine-oak forests) climates; it was selected for paleoclimatic studies, retrieving an 8.5 m core. Chronology is given by 12 AMS \(^{14}\)C dates. Cladocera, diatom and palynological data give evidence of increasingly eutrophic conditions (9000BP – 5000BP), with *Bosmina longirostris*, *Gloeotrichia equinulata* and *Aulacoseira* spp. indicative of effective mixing. Chironomids were dominated by tanypods (predators) and *Cladopelma*.

By ca. 5000PB a sharp transition is recorded with low abundance of palynomorphes, diatoms and cladocera which suggest nutrient limitation; diatoms shift to a *Synedra delicatissima* assemblage, a species with lighter valves that require less turbulence. Chironomidae shift to a *Goeldichironomus* assemblage suggesting shallower, low oxygen conditions. High abundance of Chaoboridae indicates anoxia and ineffective mixing (meromixis) with limited nutrient recirculation. Meromixis is possible in nutrient rich deep tropical lakes with small surface areas and protected basins such as La Alberca de Tacambaro. Pollen suggests warmer than present conditions coeval with this change (tropical taxa: *Bursera*, *Lonchocarpus*). After AD1100, cladocera and diatom abundance recovered, with *Discostella stelligera*, indicative of the modern eutrophic, tropical monomictic lake. This transition corresponds to the end of the “Maya Drought”. Pollen data indicates deforestation and human impact by ca. 1300 (Tarascan empire) but the strongest erosion rates are at ca. 1550, when the Spaniards settled in the area.

**S10-05  Holocene carbon isotope inferred variations in precipitation in the subtropical Pacific**

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Holocene records of subtropical precipitation are rare, particularly in the Southern Hemisphere. Yet such information is vital for a comprehensive understanding of global climate system dynamics. We present precipitation-inferred records based on the \(^{13}\)C composition of *Melaleuca quinquenervia* leaves in the Holocene sediments of Swallow Lagoon, North Stradbroke Island, in the subtropics of Australia. The precipitation record from Swallow Lagoon shows centennial and millennial scale variability, with some evidence for periods of increased aridity possibly associated with the mid- to late Holocene establishment of modern El Niño Southern Oscillation conditions. However, the most notable feature of the record is quasi- millennial scale variability in precipitation. Notably, the record shows a strong correspondence with a recent synthesis of Holocene cooling and drying events, which is heavily biased towards records from the Northern Hemisphere. Inferring precipitation maxima correspond with cold phases identified in the synthesis, particularly those centred on 6.3, 2.7 and 1.6 ka BP. This talk will explore the possible linkages that result in a correspondence between precipitation in the low latitudes of the Southern Hemisphere and Northern Hemisphere cooling events.

**S10-06  Intensification of the Australasian Monsoon over Java, Indonesia, during the past millennium**

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Precipitation in Indonesia is strongly correlated to variations in the Asian/Australasian monsoons, the Walker circulation, and migrations of the Intertropical Convergence Zone (ITCZ). However,
limited continental proxy data spanning the past millennium in this region make it difficult to assess the influence of these phenomena on multi-decadal to millennial variations in Indonesian rainfall. We present a new, high-resolution precipitation proxy reconstruction from Lake Lading (8.5°S, 113°E), Java, from 850 C.E. to present. This reconstruction is based on the δD of terrestrial plant wax compounds preserved in the lake’s sediments, which records the δD of precipitation and reflects regional convective processes. We also present the δ13C of wax compounds, which illuminates the effects of climate and other changes on local vegetation. Our results indicate that Australasian monsoon rainfall has steadily intensified in Java over the past millennium. This increase persists into the 20th century, despite evidence from other tropical proxy records for a northward movement of the ITCZ since the end of the Little Ice Age (~1750 C.E.), which should introduce drier conditions to Java. Our findings indicate that while variations in the strength and position of the ITCZ and the tropical rain belt may be important on multi-decadal to centennial timescales, the overall evolution of precipitation in western Indonesia over the past millennium was more influenced by changes in the Asian/Australasian monsoons and by zonal circulation in the Indo-Pacific.

S10-P-01 CHAPHOLO: Paleolimnological evaluation of Lake Chapala, western Mexico, during the last 10,000 years

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CHAPHOLO (CHAP: Chapala; HOLO: Holocene) is a scientific drilling project whose goal is to evaluate paleoenvironmental variations recorded in the sediment of neotectonic Lake Chapala (LCH), western Mexico. The lake lies at 20°15.129’N, 103°02.996’W, about 1524 m asl. CHAPHOLO is supported by funds from the Mexican government (CONACYT Grant CB2011-168685). LCH is the largest lake in Mexico (1,100 km2), but is shallow (zmax = 10.5 m). It is located in a basin belonging to the Citala Rift, the east-west branch of three continental rifts that join to form the so-called Jalisco triple junction. We consider LCH to be a paleoenvironmental and geolimnological reference site in western Mexico. The working hypothesis is that recent (Holocene) paleolimnological changes in LCH were caused by major climate variations and by minor regional/local processes (e.g. volcanism). We will drill a 40-m-long core from the lake depocenter, with the objective of recovering a full Holocene record, and likely more, assuming a mean sedimentation rate of 2 mm yr-1. Core chronology will be established using AMS 14C and 210Pb techniques and climate inferences will be made using geochemical, geophysical and micropaleontological proxies. The working group is multidisciplinary (Geochemistry, Micropaleontology, Paleolimnology, Geophysics) and involves multiple institutions (Guadalajara University, Mexican National University-UNAM, University of Florida, University of Nebraska-Lincoln,). The theme of CHAPHOLO is consistent with global environmental programs such as PAGES and CLIVAR. This project will be developed in stages over three years.

S10-P-02 The environmental record of Lake Stymphalia (NE-Peloponessse, Greece) and its linkage to the local/regional cultural development

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How climate affected the development of cultures has long been a subject of research, especially in the Eastern Mediterranean region with its rich (pre-)historical record. But for some archaeologically well investigated areas such as the Peloponnesian, terrestrial environmental archives are still sparse. The sedimentary sequence of Lake Stymphalia (37°50′58″N, 22°27′38″E; 600 m a.s.l.) for the first time sheds light on the palaeoclimate development of the Peloponnesian peninsula from at least Neolithic to modern times.

We present new geochemical data, together with a Bayesian AMS $^{14}$C age-depth model, based on high-resolution X-ray fluorescence scanning which provides in-situ, and continuous analysis of predefined element suites on split-core surfaces. Variations of elements over time were assessed constructing correlation matrices based on the calculation of Pearson correlation coefficients. The element suite includes Al, Si, K, Ca, Ti, Mn, Fe, Zn, Rb, Sr, and Zr. A major result includes that changes in element behaviour are related to hydrological changes in the catchment (precipitation), lake level status, and evaporation (insolation), and are ultimately driven by climate. Major trends-shifts in elemental ratios correspond to the climate development in the Eastern Mediterranean region.

Based on our excellent correlation of Rb/Sr, reflecting cold/warm climates, with the stable oxygen-isotope record of Soreq Cave (Israel), periods of rapid climate change, e.g. the 8.2 ka BP cooling event, and the Little Ice Age were identified. A special focus lies on the period of rapid climate change between ca. 3500-2500 yrs BP which is coincident with the Late Bronze age collapse/demise of the Mycenaean culture around 1200 BC and the following dark ages, the transition from Bronze to Early Iron age, on mainland Greece.

Volcanic ash (tephra) from explosive eruptions can be preserved as discrete layers within lake sediments. Tephra layers can be characterised using the chemical composition of the glass shards and correlated either to proximal tephra outcrops (which can be radiometrically dated) and/or to other distal occurrences of the same layer. Many studies have now shown that tephra can be detected in records 1000 km’s from their source, often as microscopic or “cryptic” layers. These layers are isochrons, deposited instantaneously and rapidly buried within accumulating lake sediments. During the Late Quaternary there have been many explosive eruptions from volcanoes along the East African Rift and these have produced many widespread tephra layers. The East African Rift is also home to some of the longest continental lake sediment records in the world, which are providing important insight into past environmental and climatic conditions. Research is underway to detect (crypto-) tephra layers within Late Quaternary sediments from a number of lake records in East Africa, including Lake Malawi and Lake Tanganyika. This project aims to build a regional tephrostratigraphic framework which will: (i) Enable more robust correlation of palaeoclimate archives from across tropical Africa, by providing stratigraphic tie-lines between archives; (ii) provide age constraints for individual core chronologies, in particular beyond the limits of radiocarbon dating; and (iii) increase our knowledge of Late Quaternary explosive volcanism in East Africa.
S10-P-04 Recent environmental change recorded in Lake Malawi (East Africa) varved sediments
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Varved lake sediments from the North Basin of Lake Malawi contain records of environmental change. To evaluate changes that have occurred over the past 50 to 100 years we recovered a set of multicore in early 2012. Using a combination of optical images, x-radiographs and XRF scanning elemental analyses we developed a varve counting chronology that is consistent with previous work (Barry et al., 2002) on cores recovered in a previous coring effort in 1998. Our results indicate significant shifts in sediment characteristics in material occurring during the intervening 14 years between coring expeditions. Notably there are greater inputs of silicate minerals. This may be linked to changing land use in the basin leading to increased delivery of riverine material to the lake.

S10-P-05 Exploring site specific responses to regional climatic drying during the ‘Maya collapse’: A late Holocene vegetation history from Lamanai, Northern Belize
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A 3m core from the New River Lagoon, adjacent to the Maya city of Lamanai, Northern Belize, contains a continuous record of vegetation change between ca. 1500 BC – AD 1500. Inferred changes in forest abundance and plant community assemblage builds on previous palaeolimnological analysis of the same core reported by Metcalfe et al. (2009). A near-complete, abundant record of Zea mays grains provides a detailed account of field-based agriculture local to Lamanai, in the context of a regional record obtained from a large lake (13.5km²) with a substantial catchment. Three periods (ca. 170 BC – AD 150, ca. AD 600 -980 and ca. AD 1500) of extraction of Pinus from pine savannas adjacent to the east of the New River Lagoon, can be distinguished from clearance of seasonal broadleaf forest for agriculture. This record shows that during the late Classic period the Maya actively managed the vegetation resources using a combination of field-based agriculture, arboreal resources and palm cultivation. There is no evidence from the vegetation history of drying during the late Classic coincident with the Maya ‘collapse’ and this is consistent with the palaeolimnological and archaeological records of continuous occupation of the Maya at Lamanai. This record further emphasises the need to incorporate a site specific approach within a regional context to better understand system responses to climatic drying and human disturbance.

S10-P-06 The East Asian winter monsoon over the last 15,000 years: its links to high-latitudes and tropical climate systems and complex correlation to the summer monsoon
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The East Asian winter monsoon (EAWM) not only plays an important role within the Asian climate system, but also acts as a link between the polar and tropical climate systems. However, past changes of the EAWM have not been clearly established so far due to the lack of suitable proxy records. Here, we at first establish an index of the EAWM by comparing the results of a sediment trap experiment and 100-year sedimentary record from Huguang Maar Lake (HML) with modern records of the EAWM, Siberian High (SH) and Arctic Oscillation (AO). Secondly, we present a continuous record of the strength of the EAWM for the past 14,500 years in HML. The link with the EAWM intensity is through high wind speeds inducing turbulent mixing, which stimulates the productivity of the meroplanktonic species Aulacoseira granulata. The diatom record of the past 15 000 years shows that the EAWM shifted from strong to weak from the early to late Holocene. This linked to both changes in winter temperature at high-latitudes and in E Niño conditions in the tropics. Our record shows that the EAWM and East Asian summer monsoon (EASM) were in-phase.
instead of anti-correlated on orbital time scales during the Holocene. On a millennial time scales, the relationship between the EAWM and EASM show spatial and temporal variability, and is dependent on the strength of the EAWM. Finally, the EAWM was probably one of the most important factors in influencing the changes in the ASM during the early Holocene.

S10-P-07 Lake Chalco, a tropical high altitude site in Central Mexico, as a potential deep continental drilling site.
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Lake Chalco, part of the former lakes in the Basin of Mexico, has more than 300 m of continuous sedimentation that potentially records climatic and environmental changes on a high altitude tropical location during the last ca. 500,000 yr. Previous research (paleomagnetism, diatoms, pollen) on a 26 m core (ca. 45,000 yr BP) identified maximum lake levels by ca. 35 ka, a trend to shallower, saline conditions until ca. 22.5 ka and a drastic environmental change to freshwater environments; during the early Holocene shallower, saline conditions return. Recently a 122.5 m sequence was retrieved; radiocarbon dates, tephra layers and paleomagnetism allow assuming it covers the last 200,000 yr. Ar-Ar dates are being determined to refine this chronology.

This sequence is being studied by a collaborative team from the National University of Mexico and the University of Minnesota. Analyses currently being performed include elemental analysis (XRF scanner), magnetic mineralogy, TIC, TOC, C/N, geochemical biomarkers, charcoal particles, pollen.

Preliminary results are in agreement with previous research and extend the Chalco record further into the Pleistocene. Iron is related with tephra deposition and indicates an increase in the frequency of volcanic events in the upper half of the core. Calcium records changes on the hydrologic balance, with increasing Ca during wetter periods. Pollen results indicate changes in plant communities and charcoal particles along with TIC data identify drought events. These preliminary results show that Chalco preserves a good palaeoenvironment record of the Late Pleistocene and that it is a valuable target for deep continental drilling.

S10-P-08 Lake Isotope – Climate Model comparisons: an iterative approach to improved palaeoclimate understanding?
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Lake oxygen isotope records provide an important window into variability in hydroclimate on timescales longer than those available to us via instrumental records. Here we describe an approach for lake isotope data – climate model comparison, which could ultimately result in an iterative approach to a better understanding of both. With climate models increasingly becoming isotope enabled, understanding isotope palaeoarchive systematics is vital for fulfilling the potential for data model comparisons.

An initial case study from Nar Golu, Turkey will be presented. Long term (>5 year) monitoring of lake systems allows the development of robust lake isotope models that explain the measured variability. These models can be used to model lake isotope variability in 2 temporal directions and allow comparison with isotope records from sedimentary archives and climate model output. Forward modelling of the Nar isotope system driven by climate model output, in this case from the CSIRO Mk3L climate system model (Phipps et al., 2011 Geoscientific Model Development 4, 483-509), can be compared to the lake isotope record (Jones et al., 2006 Geology 34, 361-364) over the last 1500 years. Inverse modeling using the lake isotope system model and the sedimentary isotope record can be used to compare with climate model output. These
exercises will highlight the differences between the isotope data interpretation and the climate model output which can be investigated and iteratively reduced, improving performance of the model and our interpretation of lake isotope records.

**S10-P-09 Holocene climatic and environmental variation identified from ITRAX core scanning of sediment sequences from Nar Lake, Turkey, and interactions with the human past**

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The ITRAX core scanning technique is non-destructive and records copious amounts of continuous data for a range of selected chemical elements. Calibration against other proxy data allows elements to be attributed to different climatic/environmental processes. Geochemical data obtained using ITRAX on laminated lake sediments from Nar Lake, Central Anatolia portray in fine detail a record of climatic and environmental variability for the Holocene. The annually deposited Nar laminations were analysed at 0.2mm resolution and show significant changes related to lithostratigraphic units.

ITRAX scans document a shift from a predominately stable system (high authigenic Ca & Sr) to one exhibiting much higher annual variability, including clastic in-wash events, characterised by peaks in Fe, Ti, Si, K and Rb. These high detrital components indicate strong erosion input into the lake which is related, in part, to the impact of increasing human occupation and catchment use. Increased catchment sediment supply is particularly prevalent between 8800-7840 varve years (vy) B.P. and 2600-0 vy B.P. Both periods coincide with the growth of Neolithic populations and the development of obsidian ‘factories’ on near-by Nenezi Dağ, and the establishment of Phrygian, Persian, Hellenistic-Roman, and Byzantine rule respectively. The former may also have been influenced by volcanic activity. Less variable conditions and reduced detrital input between 7840 and ~6200 vy B.P. occurred during times when archaeological survey data suggests less intensive human occupation of Central Anatolia. The Nar lake geochemical record thus records both natural (e.g. climatic) and human-induced processes, with the balance between them changing over time.

**S10-P-10 Linking Spatial Distributions of Sediment Diatom Assemblages with Hydrological Depth Profiles in a Plateau Deep-Water Lake System of Subtropical China**

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The seasonal variation of diatom community in the water column, sediment traps as well as surface sediments from Lugu Lake were studied. The seasonal distribution of diatom assemblages from the sediment trap and water column indicated the response of seasonal variations of planktonic and benthic diatom to seasonal changes of limnological physical parameters (thermal stratification and mixing). The rising temperature was a key factor impacting diatom assemblage composition of this deep lake. The increase of temperature enhanced the primary productivity of planktonic algae and prolonged the duration of the growing season in planktonic algae. The seasonal diatom dynamics in temperate lakes may provide important information for the refinement of paleolimnological interpretations. In addition, the spatial distributions of approximately 160 diatom taxa from surface sediments of the plateau deep-water Lake were investigated. The results exhibited a change in the sediment diatom composition with increasing water depth. The main patterns of variation, derived from a principal component analysis (PCA) and detrended correspondence analysis (DCA), showed that diatom community composition was divided into three depth gradients (near-shore zone; mid-depth zone; profundal deep zone). With increasing depth, the pattern of predominantly periphytic taxa in the shallow waters changed to planktonic assemblages dominated by *Cyclotella ocellata*, *Asterionella*
formosa and Cyclostephanos dubius. These distinct spatial patterns in diatom distribution are clear markers of current water levels within Lake Lugu and represent a benchmark for evaluating paleolimnological changes in water levels, which can be an indirect proxy of regional climate in this monsoon region of southern Asia.
Session 11 - Recent biomarker advances and applications in paleolimnology

S11-KN   Biomarkers In Paleolimnology: Progress and Problems

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The questions driving research in paleolimnology are important not only for our understanding of how the Earth System has changed in the past, but also because this time period represents the closest analog for what we will be seeing in the near future. Changes in temperature and hydrology can have a significant impact on both terrestrial and aquatic biota, which can in turn lead to feedbacks to the climate system if the response of biota is great enough, as is predicted for (catastrophic) drying of the Amazon, for example. Research efforts over the past decade have highlighted the potential for new, molecular and isotopic proxies to be applied in paleolimnology. As a result, biomarkers can now be used to reconstruct temperature quantitatively using proxies such as the developing TEX$_{86}$ and MBT/CBT, along with molecular isotopic tools such as δ$^{13}$C and δD of plant leaf waxes to reconstruct relative aridity and the response of vegetation (terrestrial and aquatic) to climate and environmental change. However, while many of these proxies show promise, there are a number of complicating factors that can make rigorous application difficult in lacustrine systems. Here, I will discuss some of these recent advances in biomarker paleolimnology, with a focus on both progress and problems in biomarker paleolimnology.

S11-01   Calibration and application of the branched GDGT proxy on East African lake sediments


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Branched glycerol dialkyl glycerol tetraethers (GDGTs) are derived from the membranes of an unknown bacteria and are found in a variety of sediments, including lake sediments. The relative distribution of these compounds has been shown to relate to temperature, and several studies have used lake surface sediment samples to explore the best way to model this relationship, including use of the methylation (MBT) and cyclization (CBT) indices of branched GDGTs, the relative abundances of the major, non-cyclized branched GDGTs, and best subsets regression using relative abundances of all branched GDGTs. However, none of these studies has yet applied to a lake sediment core to test the validity of using these compounds as a paleotemperature proxy.

Here we present an expanded East African branched GDGT surface sediment dataset based on 111 lakes. We create three new temperature calibrations from these data, including an MBT/CBT calibration, a major GDGTs calibration, and a new significant subsets regression (SSR) calibration that uses the relative abundances of the four branched GDGTs that explain the most variance in temperature in our dataset. We apply these and the five previously published lacustrine calibrations to our surface sediment dataset and a core from Sacred Lake, Mt. Kenya dating back 48 ka. We find that our new SSR calibration has the lowest root mean square error (RMSE) when applied to our surface sediment data and reconstructs the most reasonable temperatures from our Sacred Lake core based on other paleotemperature estimates from the region.
S11-02 Amplification of the response of Western European continental environments to Younger Dryas cooling through the hydrological cycle – evidence from a biomarker hydrogen isotope record from Lake Meerfelder Maar

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The Younger Dryas (YD) cold episode (ca. 12.68 – 11.59 ka BP) is a prominent example of rapid cooling of 4-6°C in Western Europe. However, the impact of cooling on the regional hydrological cycle and the timing of such changes is largely unknown, due to the lack of continental high-resolution archives and direct hydrological proxy records.

Here we present a paleohydrological record of decadal resolution from a sediment core from lake Meerfelder Maar (MFM) in Western Germany based on the hydrogen isotopic composition (δD values) of aquatic (nC23) and terrestrial (nC29) n-alkanes.

Our data show that both biomarker δD values begin to decrease already at 12.88 ka, likely due to cooling at MFM, synchronous to the onset of Greenland Stadial 1 in the NGRIP ice-core. 200 years later, at 12.68 ka BP, we detect another decrease in biomarker δD values along with a strong increase in terrestrial evapotranspiration and major changes in sedimentation rate and pollen composition. This was the consequence of changes in the pathway of atmospheric moisture delivery to Western Europe, as stronger, more zonal westerly winds brought cold and dry air from the seasonally frozen N-Atlantic to MFM. Our paleohydrological record emphasizes that the YD in Western Europe was characterized by rapid changes in moisture pathway to MFM. These hydrological changes significantly amplified the response of terrestrial ecosystems to YD cooling. We also show the potential of lipid biomarker δD values as a tool to decipher changes in the regional hydrological cycle in unprecedented detail.

S11-03 Long term dynamics and diversity of freshwater picocyanobacteria: Coupling between molecular tool and paleolimnological approach

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We applied a molecular paleolimnological approach on sediment records from a deep peri-alpine lake that has experienced dramatic changes in environmental conditions during the last century (eutrophication, re-oligotrophication, large-scale climate changes). We investigated more particularly the long term (100 years) diversity and dynamics of the picocyanobacteria using preserved DNA from laminated sediments.

The application of qPCR methods allowed the reconstruction of picocyanobacteria (i.e. Synechococcus) and total cyanobacteria dynamics in Lake Bourget. The results suggest that picocyanobacteria benefited the high availability of nutrient resource during eutrophication, exhibiting a unimodal relationship with phosphorous concentrations (maximum abundances at moderate P concentration). Interestingly, we detected also a significant effect of temperature on the proportion of Synechococcus (relative abundance to total cyanobacteria).

The diversity of Synechococcus spp in Lake Bourget and the evolution of its genetic structure were studied from the phylogenetic analyses on the 16S rRNA gene and internal transcribed spacer (ITS). Up to 23 different Operational Taxonomic Units OTUs were identified over the past 100 years in this lake. These OTUs fall into various cosmopolitan or endemic groups/clusters. The study of the ITS increased the phylogenetic resolution, revealing a high diversity within 16S based OTUs. Overall, the
sequencing results showed that environmental changes (here, temperature and phosphorus concentration) impacted picocyanobacteria community structure, translating into changes in genotypes composition and rearrangements of diversity patterns.

This study illustrates the promising approach offered by the coupling between molecular tools and paleolimnology for the reconstruction of lake biodiversity history.

**S11-04 Biomarkers and compound-specific isotopes reveal climate mechanisms forcing alpine vegetation change from Laguna de Río Seco, Sierra Nevada, southern Spain**

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The Sierra Nevada of southern Spain are located in a region sensitive to changes in North Atlantic climate dynamics, namely the North Atlantic Oscillation (NAO) and the Atlantic Meridional Overturning Circulation (AMOC). The well-dated, high-resolution pollen record (previously published) shows major changes in the vegetation assemblage, largely influenced by changes in moisture throughout the Holocene. Here we analyze biomarkers and compound-specific stable isotopes from the same intervals that confirm the inferences from the pollen analysis. Furthermore, the biomarker data reveal abrupt hydrological changes coinciding with the onset of longer-term changes in the vegetation assemblages. In particular, notable shifts, up to 30 permil, in the H-isotopic composition of aquatic macrophyte biomarkers (C\textsubscript{23} alkanes) without a corresponding change in terrestrial, higher plant leaf wax biomarker (C\textsubscript{29} alkanes) H-isotopes suggest that a major change in precipitation source occurred during the Younger Dryas and 8.2 event. We hypothesize that these two periods are associated with the slow down of the AMOC, causing a shift to a more southerly source of precipitation.

**S11-05 Compound-specific carbon and hydrogen isotopes (δ\textsuperscript{13}C, δD) in sediments of Lake Ohrid (Albania, Macedonia) – proxies for carbon fluxes and moisture source**

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Lake Ohrid (Albania, Macedonia) is Europe’s oldest lake, dating back 3-5 million years. The ecosystem of the Ohrid Basin has experienced climate changes that significantly affected its hydrological cycle. Precipitation-controlled changes in the vegetation cover altered terrestrial organic carbon export (biomass production, soil erosion) and nutrient fluxes that control lake productivity. Our investigation of Lake Ohrid sediments uses composition and compound-specific isotopic analysis (CSIA) of lipid biomarkers (δ\textsuperscript{13}C, δD) to reconstruct changes in organic matter fluxes from aquatic and terrestrial sources and to test the hypothesis that the inflow of Mediterranean air masses during cold climates compensated for reduced moisture supply from Central Europe. The key observations from our initial sample set across Termination II (MIS 6-5) are:

1. No significant difference in δD of terrigenous lipid biomarkers between warm and cold climates suggesting that the main atmospheric moisture supply for terrestrial vegetation always came from the North.

2. A 3-4 ‰ offset in δ\textsuperscript{13}C between \textit{n}-alkanoic acids and \textit{n}-alkanols during MIS 6 gradually disappearing before the onset of Termination II which we interpret as gradually reduced input of soil organic matter depleted in \textit{n}-alkanoic acids and carrying a C\textsubscript{4} plant signature (e.g. from pioneering C\textsubscript{4} grass \textit{Hyparrhenia hirta}).
3. Mid-chain length compounds (C_{22}) are significantly depleted in $^{13}$C suggesting a distinct source.

4. A lack of correlation between CSIA and bulk organic matter $\delta^{13}$C records.

Our findings illustrate the potential of CSIA for paleolimnology but also highlight the requirement of a much extended end-member database for individual compound sources.

S11-06  Multiproxy biomarker, isotopic and pollen palaeoclimate reconstructions for the last 6200 yr from lake Tianchi, the Loess Plateau, central China

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The Asian monsoon is a key component of the Earth’s climate system that directly affects the livelihoods of billions of people. At the far edge of monsoonal influence, lies the loess plateau of China, home to 50 million people in a region particularly vulnerable to future changes in temperature and aridity. Therefore, palaeoclimatic information on the natural sensitivity of the region to changes in monsoon driven aridity are crucial. Reconstructions from this region, have been limited by the low resolution of loess deposits and the scarcity of other palaeoclimate archives (e.g. natural lakes, speleothems). Here we present multiple proxy records from Lake Tianchi, one of the few natural lakes on the loess plateau and central China. Evidence from pollen and macrofossil data show deciduous trees decreased from 6200 cal yr BP and then more rapidly from 1000 yr BP. The $n$-Alkane Paq index suggests increasing relative abundance of macrophytes over this time, which we interpret (based on lake morphology) as decreasing lake-level. Our GDGT based temperatures closely correlate on millennial to centennial timescales with the independent $\delta$D measurements on C_{28} fatty acid methyl esters (C_{28} FAMEs), whose signal is assumed to derive primarily from terrestrial plant waxes and the $\delta$D values to reflect local changes in relative humidity. Comparisons with stalagmite $\delta^{18}$O records from the monsoon region and summer insolation suggests strongly that our record reflects regional changes in monsoon strength. Superimposed on the longer-term northern hemisphere insolation driven monsoonal changes are centennial scale variations.

S11-P-01  Effects of different geological dynamics on lake biomarker records: Comparison of the last 2000 years recorded in sedimentary archives from Lake Marmara (western Turkey) and Lake Van (eastern Turkey)

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In order to understand the mechanisms by which different environmental dynamics affect lake sedimentology and biomarker records, we have studied two fundamentally different lake systems in western and eastern Turkey, namely Lake Marmara and Lake Van. Both lakes are located at the same latitude, but in different geological settings considering tectonic and volcanic activity. We examined, whether the biomarker records of these lakes are sensitive to the associated differences in geological processes. Lake Van is located on the east Anatolian Plateau (lake level: 1647 m above sea level) and surrounded by recently active volcanoes in the west and east. The ecosystem of Lake Van is of special importance as it is the largest soda lake and fourth largest terminal lake on Earth (area: 3522 km², maximum
water depth 451m; water volume: 576 km$^3$). It exhibits high alkalinity (152 meq L$^{-1}$) and salinity (22‰) (Kempe, 1991), both properties resulting from the weathering of volcanic rocks and evaporation in a closed lake. On the other hand, Lake Marmara in Western Turkey is one of the few lakes that have survived through the Holocene until present, and offers Holocene palaeoecological records of an Aegean region with E-W extending graben and valley developments. This lake is located on the northern boundary of the tectonically active Gediz Graben. We studied these two unique ecosystems, using a multidisciplinary approach that combines bulk/molecular organic and inorganic geochemical methods, including total organic carbon (TOC), GC-MS of biomarkers, bulk and compound specific stable carbon isotopes and high resolution (500 µm) XRF core scanner analysis.

Lake Van sediments contain 1.1% – 2.3% TOC of algal to terrestrial origin according to intermediate to high Hydrogen Index (HI) values (254 – 632 mg HC/g TOC). The carbon isotopic signature of organic matter (OM) in Lake Van sediments varies only slightly between -22.9‰ and -23.7‰ VPDB. Younger sediments (recent to 1650 varve years BP) are characterized by an n-alkane distribution, which has its maximum at n-C$_{17}$, typical for aquatic producers. In contrast, the main sources of OM in the older sediments probably are terrestrial plants, as indicated by the dominance of the n-C$_{29}$ and n-C$_{31}$ alkanes. In the sedimentary record from Lake Marmara, the last 1000 years are characterized by an n-alkane distribution which has its maximum at n-C$_{25}$, typical for aquatic macrophytes. However, during the period of 2000 to 1000 years BP the sediments contain higher amounts of the C$_{29}$ n-alkane, which is typical for terrestrial OM transported into the lake from the catchment area. A short time interval from 2000 to 1800 years BP exhibits a bimodal n-alkane distribution with maxima at n-C$_{23}$ and n-C$_{29}$, indicating two different OM sources. In general, the n-alkane distributions (n-C$_{29}$ and n-C$_{31}$) predominance and high amounts of n-C$_{23}$ and n-C$_{25}$) reflect dominantly plant derived OM from trees, herbs/grasses and macrophytes. Sharp changes in the biomarker composition, together with corresponding changes in inorganic elemental composition were detected in both lakes. We propose that detrital supply is the main controlling factor for the observed changes of the biomarker distribution in Lake Marmara. This relationship is especially clear for the period 2000 – 1800 cal yr BP. On the other hand, in Lake Van the main reason for the biomarker variations is volcanic activity in Lake Van environment. After each period of volcanic activity, the dominant n-alkane is found to be n-C$_{17}$, which indicates strongly increased primary bio-productivity. However, during the other periods the biomarker distributions indicate a high OM contribution from terrestrial plants. Therefore, volcanic activity is the main control on nutrient type and availability and on the intensity of primary productivity in Lake Van.

**S11-P-02 Biomarker evidence for increasing aridity in Central India over the Holocene**

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The Indian monsoon is an important component of the climate system that has a direct effect on the lives of more than one billion people on the Indian subcontinent. A better understanding of past variations in monsoonal rainfall is essential in order to predict future changes in rainfall patterns due to climate change. Using lipid biomarkers and their stable isotope ratios we reconstructed centennial to millennial scale hydrological variability of monsoonal rainfall from Holocene sediments of Lonar Lake from the ‘core monsoon zone’ of Central India.

During the early to mid Holocene (10.2–6.5 ka BP) leaf-wax n-alkane composition (low ACL index) and negative δ$^{13}$C values (-30‰) indicate the dominance of woody C$_3$ vegetation in the catchment. Between 6.5 and 4 ka BP, we identified rapid fluctuations in
the abundance of both terrestrial and aquatic biomarkers, including the appearance of tetrahymanol indicating the onset of salinity in the lake. Rapid and pronounced shifts to higher ACL values and more positive δ¹³C values (-22‰) of leaf-wax n-alkanes over this period indicate that vegetation transitioned to C₄ grasses. Along with a 40‰ increase in leaf wax n-alkane δD values we interpret this period as transition from wet to drier conditions in Central India with increasing aridity until ca. 2.5 ka BP when conditions likely similar to today became established. Our record suggests substantial weakening of the monsoon over continental Central India during the Holocene, placing the onset of aridification at 6.5 ka BP, earlier than observed in marine records throughout the Indian Ocean.

S11-P-03 Subdecadal rainfall variability during the last two millennia from the Eastern tropical Pacific (Lake Isabel, Mexico) based on lipid biomarker distributions

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Isabel is a hypersaline lake on a volcanic island, off the Pacific coast in central Mexico. In the region, the highly seasonal rainfall pattern is dominated by the annual northward migration of the Intertropical Convergence Zone (ITCZ). The modern planktonic community in this highly productive lake, is controlled by salinity fluctuations as a consequence of rainfall seasonality: after freshening of the upper water layer due to the summer rainfall green algae thrive, whereas the bacterivorous ciliate populations become dominant during the dry season, when lake water becomes hypersaline. These two planktonic populations can be traced through specific lipid biomarkers, n-alkyl diols and tetrahymanol, respectively and consequently concentration changes of these compounds in the sediment record rainfall variability. Moreover, the concentration ratio between both specific biomarkers in the uppermost 16 cm of the lake sediment was significantly correlated with the wet seasonal rainfall anomaly (r=0.68, p below 0.01) from instrumental data over the last 65 years. Applying this novel biomarker index on a 2000-year annually laminated sedimentary sequence we reconstructed subdecadal rainfall variability. First results show substantial changes of seasonal rainfall in accordance with other lacustrine records in central Mexico: dry periods were observed in the second half of the 4th century, AD 860-915, and at the beginning of the 20th century. This high resolution record allows a detailed evaluation of regional rainfall variability during key periods, such as, the Medieval Climate Anomaly and therefore, contributes to the understanding of climatic variability in the Eastern Tropical Pacific.

S11-P-04 A lacustrine GDGT-temperature calibration from the Scandinavian Arctic to Antarctic: Renewed potential for the application of GDGT-paleothermometry in lakes


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Recent advances in molecular geochemistry have led to the construction of temperature calibrations and indices for use in marine environments (TEX₈₆) and soils (MBT/CBT) using glycerol dialkyl glycerol tetraethers (GDGTs), a group of temperature-sensitive membrane lipids found in Archaea and bacteria. Here we examine GDGT-temperature
relationships and assess the potential for constructing a GDGT-based palaeo-thermometer for lakes. We examine GDGT-temperature relationships using core top sediments from 90 lakes across a north-south transect from the Scandinavian Arctic to Antarctica including sites from Finland, Sweden, Siberia, the UK, Austria, Turkey, Ethiopia, Uganda, Chile, South Georgia and the Antarctic Peninsula. We examine a suite of 15 GDGTs, including those used in the TEX$_{86}$ and MBT/CBT indices, reflecting the broad range of GDGTs in lakes.

The TEX$_{86}$ index is not applicable to our sites due to large relative proportions of soil derived and methanogenic components. The MBT/CBT index is also not applicable and predicts temperatures considerably lower than those measured. We examine relationships between individual GDGT compounds and temperature, pH, conductivity and water depth. Temperature accounts for a large and statistically independent fraction of variation in branched GDGT composition. We propose a GDGT-temperature regression model with high accuracy and precision ($R^2=0.88$; RMSE=2.0°C; RMSEP=2.1°C) for use in lakes based on best subsets regression of branched GDGT compounds and highlight the potential of this new method for reconstructing past temperatures using lake sediments.

S11-P-05 Deciphering timings and rates of abrupt climate changes over the Lateglacial-Holocene period: The Lake Suigetsu biomarker record

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Past climate reconstructions are fundamental to understand long-term trends in climate variability and to test climate models used to predict future climate change. Detailed reconstruction of lead-lag relationships in different regions provides important information about causal links between regions in the context of global climate change.

Lake Suigetsu is a small lake in central Japan under strong influence from both summer and winter monsoonal systems. In 2006 a ~73m continuous sediment record was collected from the lake, spanning the last ~150ka, and with annually laminated (varved) sediments back to ~70ka. The site was named a parastratotype of the Holocene onset (Walker et al., 2009) following pollen-derived evidence of abrupt warming at the start of the Holocene (Nakagawa et al., 2003).

Here we examine high resolution organic geochemical evidence for climate change across the Lateglacial and Holocene onset. Biomarker analysis enables examination of both autochthonous and catchment responses to climate change and compound specific isotopes ($\delta^1$D) are used as a proxy for hydrological variations. Changes in sedimentary total organic content (TOC) is determined via a novel site specific TOC calibration created using near-infrared spectroscopy (NIRS). We investigate potential leads/lags between proxies which will be of importance when trying to understand the nature of responses of different proxies to climate change as well as the nature and timing of abrupt climate changes.

S11-P-06 Relative effects of wave-induced mixing, irradiance regime, and thermocline depth on the distribution of phytoplankton across a depth gradient

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Pelagic and benthic phytoplankton are anticipated to vary in their response to future climate warming, ozone depletion, and hydrologic change, necessitating improved understanding of the mechanisms that control interactions between these
two distinct communities. In general, the ecotone between benthic (B) and planktonic (P) habitats is assumed to be regulated by physical factors, including turbulence, irradiance, and thermal stratification. To identify the hierarchical relationship among mechanisms controlling this boundary, we utilized multiple biomarkers including sedimentary pigments from algae and bacteria and sub-fossil diatoms along a depth transect in a shallow headwater lake in northwestern Ontario. Analysis by high performance liquid chromatography (HPLC) and light microscopy at 1-m depth intervals revealed synchronous changes in sedimentary pigment assemblages and sub-fossil diatom species composition, with the most significant transition occurring at ~6 m. Between ~3.2 and 5.5 m, concentrations of pigments from diatoms (diatoxanthin, diadinoxanthin, fucoxanthin) and chlorophytes (Chl b, pheophytin b) increased 2- to 5-fold and a rise in tychoplanktonic or benthic (including small Aulacoseira and Fragilaria) diatoms. Interestingly, these changes did not correspond to but were bracketed by the depth of wave-induced turbulence (3.1 m) and the base of the metalimnion (6 m). In addition, cluster analysis identified a secondary transition in phytoplankton pigment assemblages at ~2.5-m depth, above which deposition of light-sensitive diatoms declined ~50%. Taken together, these findings suggest that in this lake, algal composition is regulated by a unique combination of diatom life-history traits turbulent mixing, and light penetration.

**S11-P-07** Constraining growing season drought during the Holocene in the Northern Great Plains, U.S.: a rainfall reconstruction using H-isotopes of terrestrial leaf waxes


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Existing records of drought from Northern Great Plains (NGP) are based on pollen or on lake-water ion concentration (salinity) reconstructions from fossil assemblages (diatom-inferred salinity) and trace-elements (ostracode Mg/Ca) that reflect lake response to hydrological variability (precipitation minus evaporation, P-E). In this study, we show that H-isotopes of terrestrial leaf waxes (n-acids) are a proxy for growing season precipitation in the region. The precipitation proxy is validated against the instrumental record for the past 100-yrs. Low precipitation occurs during the early Holocene beginning at 9.1 ka, with peak drought at 8.4 ka. After this peak, precipitation was highly variable (8.2 ka to 3.5 ka) with alternating wet-dry periods. This variability is not evident in prior lake studies, which had lower temporal resolution in the mid-Holocene, but provides support for summer moisture variability suitable for supporting Ambrosia-type vegetation. The H-isotopes suggest that the 1930’s Dust Bowl Drought is one of only several drought events throughout the past 9.4 ka to reach that severity. Within the past 1.8 ka, the low rainfall events generally coincide with phases inferred to be dry in regional lakes by in-lake proxies (Rice Lake, ND, Coldwater Lake, ND, Moon Lake, ND, and Elk Lake, MN), although the decreased rainfall events are abrupt and less prolonged than the inferred lake response to P-E. Comparing this record with other regional reconstructions, we begin to separate the effects of growing season rainfall from winter rainfall and increased temperatures with associated evaporation.

**S11-P-08** 14C as a tool to trace terrestrial carbon in a complex lake system: implications for food-web structure and carbon cycling

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Carbon and nitrogen stable isotope analysis (SIA) has identified the terrestrial subsidy of freshwater food-webs but relies on different 13C fractionation in aquatic and terrestrial primary producers. However dissolved inorganic carbon (DIC) is partly comprised of 13C depleted respiration of terrestrial C
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and ‘old’ C derived from weathering of catchment geology. SIA thus fails to differentiate between the contribution of old and recently fixed terrestrial C.

DIC in alkaline lakes is partially derived from weathering of 14C-free carbonaceous bedrock. This yields an artificial age offset leading samples to appear significantly older than their actual age. As such, 14C can be used as a biomarker to identify the proportion of autochthonous C in the food-web. With terrestrial C inputs likely to increase, the origin and utilisation of ‘old’ or ‘recent’ allochthonous C in the food-web can also be determined.

Stable isotopes and 14C were measured for biota, particulate organic matter (POM), DIC and dissolved organic carbon (DOC) from Lough Erne, Northern Ireland, a humic but alkaline lake. High winter δ15N values in calanoid zooplankton (δ15N = 24‰) relative to phytoplankton and POM (δ15N = 6‰ and 12‰ respectively) may reflect several microbial trophic levels between terrestrial C and calanoids. Furthermore winter calanoid 14C ages are consistent with DOC from inflowing rivers (87 and 75 years BP respectively) but not phytoplankton (355 years BP). Summer calanoid δ13C and δ15N (312 years BP) indicate greater reliance on phytoplankton. There is also temporal and spatial variation in DIC, DOC and POM C isotopes.

S11-P-09 Calibration of lipid biomarker proxies in Southern Patagonia

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The PASADO (“Potrok Aike Maar Lake Sediment Archive Drilling Project”) Lipids project aims at providing new insights into the climate history of southern South America by using organic-geochemical proxies based on lipid biomarkers from terrestrial and aquatic organisms and their compound-specific isotope composition (δD, δ13C) as well as from microbial membrane (glycerol dialkyl glycerol tetraethers, GDGTs) distributions.

To investigate the hydrogen isotope signal in wax lipids derived from higher terrestrial plants in terms of moisture sources and fractionation effects during evaporation and transpiration we analysed 16 top-soil samples along a W-E transect in southern Patagonia. Long-chain n-alkanes (n-C29 & n-C31) in the topsoils have similar compound-specific δD and δ13C compositions as the same compounds from previously investigated sediment samples of Laguna Potrok Aike (51°58’S, 70°23’W). The δD values of the n-C31 alkane vary from -225‰ to -195‰ and show an increase from W to E which might indicate the higher relative influence of the Atlantic-derived (isotopically enriched) moisture over south-east Patagonia. The compound-specific δ13C values of the n-C31 alkane (range: -34.9‰ to -32.7‰) also show an increase from W to E which is interpreted as higher water-use-efficiency of the C3 plants in the east due to higher aridity, i.e., lower mean annual precipitation amounts. The positive correlation of 13C and 18O signals suggests that fractionation effects due to higher evapo-transpiration rates in the east partly cause the observed trend in long-chain n-alkane δD values.

GDGT distributions in the top-soil samples as well as a series of lake surface samples were analysed in order to examine their relationship with modern soil temperature and soil pH. Preliminary results confirm a correlation between GDGT index parameters (TEX86 and MBT/CBT indices) and soil temperature and pH in the study area. The predicted temperatures based on the published global calibration are lower than measured temperatures. For this reason a new calibration is essential for the reliable use of GDGT-based proxies in southern Patagonia.

S11-P-10 Reconstructing Holocene Climate across the Polar Frontal Zone (PFZ)

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Reconstructing past climate variability is imperative for predicting future responses to climatic change.
Studying the impact of natural warming on climatically sensitive areas, such as Antarctic and sub-Antarctic regions, will help us better understand the impact that climate warming may have in the future. This study focuses on reconstructing past climate change across the PFZ which forms the key climatic barrier between Antarctica and the mid-latitudes. Analyses of various proxies in lake sediments will be used to reconstruct climate changes during the Holocene.

Past research has indicated several significant environmental changes in the Antarctic Peninsula and sub-Antarctic regions, including changes in ice thickness and extent, collapses and re-advances of ice shelves and changes in relative sea level. Lake sediment records have also documented changes in proxies responding to temperature. Nevertheless more records are required to provide a detailed history of Antarctic climate as past temperature reconstructions currently rely heavily on ice core records (Hall et al., 2010).

This project focuses on the use of novel sedimentary biomarkers, primarily glycerol dialkyl glycerol tetraethers (GDGTs). GDGTs have been used to construct temperature indices for use in oceans (Schouten et al., 2002) and soils (Weijers et al., 2007), but their examination in lake sediments is relatively new (Blaga et al., 2010; Powers et al., 2010; Pearson et al., 2011). Geochemical, sedimentological and isotopic analysis will also be used in a multi-proxy approach to reconstruct past changes in temperature, precipitation and nutrient flux. Preliminary GDGT data from modern lake samples will be presented.

S11-P-11 Habitat and food preference of chironomids influence climate and food web inferences

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A major challenge for modern ecology and paleolimnology is to merge fundamental knowledge of principal ecological mechanisms into traditional paleolimnological work. It is generally agreed that there is not a simple direct relationship between climate and lake functioning. Quantitative climate reconstructions suffer from confounding effects associated with ecological mechanisms that control the abundance of species that are used in the paleolimnological reconstructions. In the present study, integrated analyses of stable carbon and nitrogen isotopes of individual chironomid genera and sediment pigment analyses of contemporary communities from South West Greenland were conducted to increase understanding of the mechanisms controlling the chironomid composition and abundance. Individual habitats from both freshwater, oligosaline and silty lakes were analyzed covering the major lake types in the area. Detailed information on trophic position of individual chironomids revealed that they cover several trophic levels while the chironomid community showed distinct differences between hard (stones and macrophytes) and soft (sediment) habitats. This new genera specific knowledge of chironomids are believed to greatly improve the interpretation of paleolimnological studies and thereby generate a stronger tool for estimating current and future changes in lake ecosystems.

S11-P-12 Biomass burning recorded in lake sediments – using levoglucosan as a specific marker of fire events in lake sediment cores

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The primary objective of this project is to study temporal and regional evolution of biomass burning during the Holocene in Central and North America to determine anthropogenic fire impacts on the climate system with the advent of agriculture and in a warming climate. This requires high-resolution biomass burning proxy records combined with Holocene climate records at the respective locations. The approach is based on analyses of levoglucosan (1,6-anhydro-β-D-glucopyranose), on Central and North American lake sediment cores as well as on the Greenland NEEM deep ice core and their interpretation in context with climate records.

Lake sediment core studies of past fires primarily use charcoal counts as a paleofire indicator and are supplemented by studies investigating lignin burning products, polycyclic aromatic hydrocarbons (PAH), and monosaccharide anhydrides (MA). Among MA, levoglucosan is considered an excellent proxy for past biomass burning because it is emitted in large quantities and is source specific. It is unambiguously a degradation product from cellulose formed at temperatures higher than 300°C. The University of Venice has pioneered a technique for the direct determination of levoglucosan concentration in ice. Current development has expanded the novel technique to the determination of levoglucosan concentration in sediment cores which allows to access another paleoclimate archive close to early human activity where no ice cores exist. Levoglucosan is ultrasonic extracted from the sediment with an aqueous methanol solution in a class 100 clean room. The subsequent chromatographic analysis is performed using ion chromatography–electrospray ionization tandem mass spectrometry.
Session 12 - Land, sea and society: palaeoenvironmental perspectives on coastal, brackish and saline systems

S12-KN  Palaeoenvironmental perspectives on coastal, brackish and saline lakes

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Saline lakes exist in a number of different settings. In coastal areas, salinity is controlled by the mixing of marine and meteoric water. In continental regions, salinity is generally determined by evaporative concentration of water in hydrologically-closed basins with long residence times. Salinity may also arise in continental settings in the absence of significant evaporative concentration, where salts are supplied by dissolution of catchment evaporites. The source of salts will determine not only the salinity of the lake water, but also its ionic composition. Continental saline lakes in particular can have very diverse ion chemistry, dependent on water-rock interaction and evaporative enrichment, which in turn is controlled by climate. Palaeolimnological reconstructions from saline lake systems can yield a variety of information depending on setting, from changes in sea-level and continental hydrology in coastal regions through to variations in effective moisture in continental areas. Palaeosalinity and palaeosolute composition can be reconstructed using different types of biological, geochemical and isotopic evidence. In this presentation, I use three examples of salinity and solute reconstruction from lake sediments. The first is from a shallow coastal lake in East Anglia, where salinity change over the past few centuries is reconstructed from microfossils and geochemistry validated using documentary records. The second comes from the Holocene of continental China and illustrates the pitfalls of using geochemical indicators of salinity in the absence of supporting information about the lake and its sediments. Thirdly I discuss microfossil and geochemical evidence for marine saline intrusion into continental waters in the British middle Pleistocene.

S12-01  Comparing investigation to human impact on the landscape in North –West Germany: the palaeolimnological history reflected back to the last ice age in the sediments of the lake Large Sager Meer

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From the beginning of the neolithic revolution man started to change the landscape appearance (Dörfler 1992) and intensified this process during the late roman iron-age. On the other hand man and landscape were influenced by inconstant climate conditions (Barth 2001; Kirilova et al., 2009). So climate depression, beginning in the end of the Iron Age (Dreßler et al., 2006) is assumed to be the cause for the Migration period starting ca. AD 300 in northern Germany. Until now there exist several investigations concerning the interaction between man, environment and climate in the North European region based on holocene lake sediments (Glaser 2001; Baier et al., 2004; Bradshaw et al., 2005; Dreßler et al., 2006; Hübener et al., 2009; Dreßler et al., submitted; Kirilova et al., 2010), but with a lack in the area of North – West Germany. This study reconstructs the environmental changes of Lake Großes Sager Meer, NW Germany and its catchment area based on diatom analyses as a part of multidisciplinary studies (pollen analyses, geochemistry and archaeological investigations of the landscape encircling the lake) back to 11500 BP. The sediment core of 16,24 m length was taken in 2006.

Out of 85 samples 179 diatom taxa were identified in total. By means of the species composition four diatom zones (DAZ) could be differentiated. After a continuous decrease of planktonic fraction from 7321 – 1036 cal BP the planktonic species escalates up to nearly 90 % between 916 – 903 cal BP. This phase was dominated by the oligo- to mesotraphent Aulacoseira subarctica. During DAZ III (892 – 669 cal BP) the relative abundance of plankton decreased to a minimum, concurrent with a relative high trophic level in 845 cal BP. The second maximum
rose up to nearly 70% between 549 – 482 cal BP and was dominated first by the eutraphent Asterionella formosa and then by the meso- to eutraphent Aulacoseira ambiguа. The conspicuous increase of the relative abundance of plankton could be caused by longer circulation periods of the lake (Dreßler et al., 2011) or it occurred due to lake level rising. Until ca. 900 cal BP the Lake Großes Sager Meer could be classified as oligotrophic (according to OECD 1982) and until ca. 340 cal BP as mesotrophic. Ever since the trophic level has changed to eutrophic values. The higher Di-TP values could be explained as a consequence of longer mixing periods with longer time span for release of nutrients from the sediment. Nutrients could also be released from the catchment area of the lake as a result of human impact. From other districts is known that with the end of the migration period Slavonic tribes from the east of Europe started to settle down in the area of northern Germany (Müller wille 1991). Shorter winters also could explain the second event of rising trophic level and higher plankton abundance in the end of the Middle Ages. From then on to the beginning of the industrial revolution and the intensified agricultural farming and depletion of peat, starting in the middle of the 19th century, the trophic level was more or less stable. So there could be pursued a rise in the trophic level not only during the last two centuries but already from the Middle Ages.

S12-02 Low coherence among diatom-inferred salinity records across the Great Plains (USA): the role of climate-induced changes in planktic versus benthic habitat

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Sedimentary diatom profiles from saline lakes are frequently used to reconstruct lakewater salinity as an indicator of drought. However, diatom-inferred salinity (DIS) reconstructions from geographically-close sites in the Great Plains (USA) have yielded disparate results. Here, we explore how physical changes in lake habitat caused by drought may affect the accuracy of salinity reconstructions. We examined how relationships differed among drought, lake level change, and diatom community structure over the last century for three saline lakes of the Great Plains with mismatched DIS records. At each site, we examined instrumental drought records and three-dimensional models of planktic:benthic habitat (P:B) relationships with lake level change, and compared these data with fossil diatom assemblages to understand how drought conditions were reflected in both DIS and P:B ratios of diatom species in sediment records.

The accuracy of drought reconstructions were affected by site-specific physical characteristics that altered relationships between lake level change and P:B habitat zonation within the lakes. Moon Lake showed the best correlation between drought and DIS, though this relationship broke down during wetter time periods due to a larger influence of benthic diatoms during highstands. The P:B habitat within Coldwater Lake, a complex dual-basin system, varied widely depending on lake level. At Lake Cochrane, the simplest of the three basins, the P:B of fossil diatoms was a better proxy for drought than DIS. The integration of additional ecological characteristics into interpretations of paleoclimate records, for biologically-based reconstructions, is important to improve our understanding of site-specific responses to regional environmental changes.

S12-03 Diatom evidence for coastal lake response to Holocene sea level maxima in the terminal lakes of the River Murray, South Australia

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Global mean sea level rise of between 0.2 and more than 1.0 m is predicted by the year 2100. This is likely to negatively impact the freshwater coastal lakes Alexandrina and Albert, at the terminus of Australia’s largest river system, the Murray-Darling. These lakes are nationally important wetlands and recognised internationally by the Ramsar Convention. We investigated the response of this system to past higher sea levels using two sediment records from Lake Alexandrina. The records are of mid-Holocene age (6.9 and 7.6 ka BP) and benthic fossil diatoms indicative of a brackish/marginal marine environment dominate in their basal sediments. In both cores, this suite of diatoms is replaced by an assemblage dominated by freshwater planktonic *Aulacoseira* diatoms during a putative +2 m sea level maximum 6-6.5 ka BP. Occasional peaks in brackish species occur sporadically in both records, but an absence of true marine species during these times suggests lower lake level and heightened salinity in response to evaporation and reduced river discharges, rather than episodes of marine incursion. This indicates that the effectiveness of river discharges was greater than tidal pressure and/or that developing coastal barriers played a role in hindering the passage of marine water into the basin during the highstand. These results are against expectations, and should inform management decisions as to the fate of the water quality in the lakes under pressure from climate change. However, due to upstream water abstraction, maintenance of freshwater conditions in the face of sea level rise is unlikely without substantial environmental water provisions.

S12-04   Environmental changes in the central Mediterranean area during the last millennia: the annually-resolved record of Lake Butrint (SW Albania)


Lake Butrint (39º47’ N; 20º02’ E) is the southernmost and largest lagoon of the Ionian Sea coast of Albania. Lake waters are permanently stratified with an anoxic bottom layer caused by the strong temperature and salinity gradients, leading to the deposition and preservation of annually-layered (varved) sediments.

These laminated sediments are composed of triplets of organic matter, carbonates and clayey laminae deposited during spring/fall and winter seasons reflecting water chemistry, and precipitation/runoff, respectively. This robust annual chronology was also validated by $^{137}$Cs dating and the correlation of a series of well-defined homogeneous layers that are interpreted as earthquake-induced mass wasting events, corresponding to historically reported earthquakes in the region. Previous studies (Ariztegui et al., 2010) have shown a cyclicity in the thickness of the detrital clayey laminae during the last 300 years. The frequency of these changes is mostly controlled by NAO variability that modulate precipitation patterns in the Mediterranean region.

Fluctuations in the thickness of the different types of lamina of the most recent sediments indicate variations in water salinity, organic productivity and runoff in the lake’s catchment. These changes in sedimentation are mostly controlled by climatic variability in the Central Mediterranean region and modulated by episodic neotectonic activity and variable anthropogenic impact from the nearby ancient city of Butrint, occupied since Ancient Greek times. The multi-proxy analysis (microfacies, high-resolution elemental geochemistry, biological proxies) of a newly retrieved 12 m long piston core has allowed the extension of this annually-resolved record throughout the Holocene, showing the transition from open-marine estuarine to modern restricted lake conditions. It also offers the unique opportunity to reconstruct both the climatic history and neotectonic activity in this key area of the
S12-05 The Late Pleistocene – Holocene sedimentary evolution of Zevulun Plain, northern Israel- focusing on the wetlands

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The existence of Holocene wetland sediments in the subsurface of Zevulun Plain (ZP) of Israel has long been known, yet their spatial and temporal distributions remained indefinite. The current research presents a reconstruction of the wetlands time span, conditions and the sedimentary setting leading to their formation.

A terrestrial and marine sedimentary sequence of three cores was recovered from ZP, and analyzed by sedimentological and paleontological methods and dated by 14C and luminescence. The results revealed two separate wetland regions occurring during the Early-Holocene, yet not synchronously as the south wetland originated (6490-5430 cal. BP) while the northern wetland terminated (7520-6230 cal. BP). Fresh water conditions were indicated by faunal assemblages and floral remains which were dominated fresh water algae (Chara sp.) and water plant (Cladium mariscus). However, some of the faunal assemblages: the benthic foraminifera Trichohyalus aguayoi and the bivalve Cerastoderma glaucum, indicated on slightly brackish conditions at specific depths. Overall, the sedimentary sequence of ZP displays Late Pleistocene–Early Holocene terrestrial sediments (alluvial or fluvial) covered by Early-Middle Holocene wetlands. The wetlands terminated as the sea level rose covering the wetlands with marine sands later on reclaimed by aeolian sand dunes.

The environmental changes which occurred in ZP through the Holocene emphasize the transient processes taking place along the coast. These changes are coupled with the pattern of the Bronze Age urban settlements as in Tel Zibda and Tel Afek. Moreover, the major modern rivers flowing through ZP are adjacent to the geographical occurrence of the wetlands.

S12-06 To Bloom or not to bloom? Investigating cyanobacteria abundance in the Baltic Sea during the Holocene era

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Cyanobacteria blooms are a regular occurrence in the late summer months in the Baltic Sea, which has intensified significantly in the past 20 years. One of the major causes of these blooms is due to eutrophication, yet it is still not certain whether these blooms have occurred in the past and what may have triggered cyanobacteria blooms to form. The goal of this study is to determine if hypoxia influences cyanobacteria abundance throughout the Holocene era. Cores collected in the Baltic Sea were used to obtain historical records. Physical examination of the cores for the presence or absence of laminations and mineral magnetics were used to examine for periods of hypoxia. Molybdenum:aluminum was used as an indicator of euxinia. Pigment concentrations and δ15N isotopic signatures were measured through out the sediment cores to determine the influence of cyanobacteria. Our results suggest that cyanobacteria blooms are in fact correlated with hypoxic events. These hypoxic events occurred during 3 periods: 1) 4,0000- 7,0000 years B.P. following the transition from Ancylus Lake into the Littorina Sea, 2) during the Medieval Warm period and 3) from ca 100 years to present. During hypoxic events the biogeochemical cycling of nutrients changes, specifically increases in phosphorus concentrations into the water column, which creates favorable conditions for cyanobacteria to thrive. Without these conditions, where today’s hypoxia is due to human induced eutrophication, it is unlikely that cyanobacteria blooms would form and
be present in the Baltic Sea.

**S12-07 Holocene vegetation history and sea level changes in the SE corner of the Caspian Sea**

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The palynological investigation of core TM (27.7 m long) reveals Holocene vegetation history at the NE foothill of the Alborz Mountains and water level changes of the Caspian Sea. The delay in woodland expansion at the beginning of the Holocene, which is typical of eastern Turkey, the Iranian plateau and recorded in the CS south basin, is only weakly felt in the region as it is close to glacial refugia of trees. The succession of the main trees out of their refugia has been established as deciduous *Quercus*, *Carpinus betulus*, *Parrotia persica*, and *Fagus orientalis-Pterocarya fraxinifolia*, presenting therefore close affinities to south European interglacials of the Early Pleistocene.

A *Pterocarya* decline is observed after AD 315. The studied region is close to the tree easternmost distribution; this could explain why it has been affected earlier than elsewhere in the northern Alborz and the Caucasus. In addition human activities during the Sasanian Empire and the subsequent drying of the climate may have contributed to weaken the spread of this tree.

A maximum sea level occurs in the first part of the Holocene at 10.6-7 ka. It is suggested that the CS levels were significantly influenced by the monsoon precipitations over the western Himalayas. This is followed by low levels at 7-3.5 ka.

Finally it is recommended that the Neocaspian should be considered a biozone rather than a chronozone as the environmental conditions reconstructed from dinocyst assemblages are different in shallow shelf waters than in the deep basins of the Caspian Sea.

**S12-P-01 Late Holocene environmental change at the Wilderness coast, southern Cape, South Africa**

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The southern Cape coast between George and Knysna provides a unique combination of climatic and geomorphic properties. Year-round rainfall supports afromontane forests with intermediate fynbos patches. The coastal plain is made up of sub parallel dune cordons with intercalated depressions holding wetlands and lakes. Within the framework of a bilateral German-South African research project a sediment reconnaissance survey was conducted during which short gravity cores (< 1 m) were recovered from Eilandvlei and Swartvlei. In the laboratory, sedimentological and geochemical properties as well as variations in the diatom assemblage were investigated.

Radiography and grain size distribution which were analysed in 1-cm-intervals show distinct variations in both records. These are most likely caused by variable runoff and sediment fluxes from the catchments. Despite considerable differences of the studied ecosystems the sedimentary records exhibit some similarities. In the upper 0.4 m, cores from Eiland- and Swartvlei show a clear decrease in mean grain size. It is hypothesized that this is attributable to increased sediment yield from the catchment following changes of vegetation patterns pre-dating the arrival of European settlers. Strengthened fining in the upper 0.2 m and rising concentrations of Al indicate an intensified minerogenic sediment yield to the lakes during the last century. Increasing diversity of diatom species indicating rising water conductivity suggests simultaneous ecological changes in both lakes. These recent changes were most likely caused by land use induced soil erosion,
water abstraction from tributaries and water level manipulation among other anthropogenic impacts rising in the 20th century. Further investigations, e.g., pollen analysis, are necessary to scrutinize these preliminary interpretations.

**S12-P-02 Palynology: A tool to identify abrupt events? An example from Chabahar Bay, southern Iran**


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The ability to distinguish between tsunami, storm and flood deposits is still a matter of considerable debate. Traditionally, palynological study has been used to reconstruct both terrestrial and oceanic palaeoenvironments. Here we use both pollen and dinocyst analysis to aid in understanding depositional mechanisms. We have dated and examined an 88 cm long sediment core from the tectonically active and cyclone prone Chabahar Bay area (southern Iran) where we tested the traditional methods for identifying abrupt events (grain-size & geochemistry), which we supplemented with the novel palynological approach. Both sedimentological and palynological approaches suggested a large event which we dated just prior to AD 1808, whereas geochemical approaches failed to identify the presence of any abrupt event. Although sedimentology identified the event, it was unable to inform on the depositional mechanism. The pollen and dinocyst assemblages over the event provide evidence for a large previously undocumented flood just prior to AD 1808 on the southern Iranian coastline. Our study demonstrates the utility of the palynological approach in identifying and understanding the causes of abrupt marine events over more traditional sedimentological and geochemical approaches.

**S12-P-03 Environmental change and the decline of oysters at the Danish Mesolithic-Neolithic transition**

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Establishing what caused the widespread decline in Ostrea edulis (European flat oyster) in Danish shell middens in the Early Neolithic is paramount to a full understanding of the Mesolithic-Neolithic transition (at 3,900 cal. BC) in Denmark. Several hypotheses (invoking environmental, demographic and cultural causes) have been proposed to explain this oyster decline, but to date none offer a completely satisfactory explanation, nor is there or currently sufficient evidence to test these rigorously. For example, a decrease in salinity is often cited as a result of declining sea levels reducing the input of saline nutrient-rich water from the North Sea. This ‘salinity’ hypothesis, however, remains speculative to date, lacking any high-resolution and quantitative salinity data covering the Mesolithic-Neolithic transition. In this study particular attention is placed on critically testing the environmental hypotheses by reconstructing changes in key environmental parameters (i.e. salinity, productivity and sedimentary regime) over the Mesolithic-Neolithic transition.

Here, results are presented from a multiproxy study (including sedimentary techniques, diatoms, molluscs, foraminifera, sedimentary pigments, isotopes, pollen and plant macrofossils) assessing environmental change over the Mesolithic-Neolithic transition from five Danish coastal sedimentary sequences (collected from Kilen, Norsminde Fjord,
Korup Sø, Tempelkrog and Horsens Fjord). A diatom-based salinity transfer-function based on a trans-Baltic training set is employed for quantification of temporal changes in salinity at each site, in order to test the salinity hypothesis (outlined above). Alternative environmental theories (e.g. increased sedimentary accumulation rates) for the oyster decline are also explored.

**S12-P-04 The annually laminated sediments of Grand Lake, Labrador, Canada**

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The ARCHIVES has for objective to reconstruct past hydro-climate variability of the Boreal region of Québec-Labrador over the past millennia using dendrochronology and varved lake sediment. Within this project, the sediments of Grand Lake, a deep (>300 m), 60 km long brackish lake were cored and analyzed. Clastic varves or fluvial origin are found in several cores located near the two main inflows at depth greater than 130m. These varves consist of two main units: a fine sand and silt rich layer (high energy / slow melt) and clay rich unit (low energy). The coarse unit can be graded of not, simple or finely laminated and the clay cap can be sometimes interrupted by silts layers. Instrumental discharge records over the period 1979-2010 are showing that the duration of the peak discharge (slow melt) controls in part thickness of the total coarse layer. Similarly we can relate the interrupted clay caps with late fall high discharge events. The depth of the lake, the presence of a chemocline and the very turbid inflows contribute to the exceptional preservation the sediments of Grand Lake. The direct relationship between these clastic varves properties and local and regional river discharge to develop an hydroclimatic reconstructions over the past 500 years.

**S12-P-05 Microfossil assemblages response to anthropogenic influence over the last 2000 years in coastal Baltic Sea – initial results**

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Baltic Sea is one of the largest brackish seas in the world and has been in the spotlight due to its wide range of environmental problems, such as human-induced eutrophication and anoxic bottom waters. Considerable scientific efforts have been made to understand its geological and environmental history, however, the coastal zone has received less attention and the potential to use coastal sediments as a high resolution environmental archive has not been explored. In our project we aim to reconstruct nutrient, salinity and oxygen status in several coastal areas along the Swedish Baltic coast, covering the last two millennia. Here we present data from two stations, one close to Karlskrona, Blekinge Archipelago, S Sweden and one close to Västervik, Småland, SE Sweden. We have sampled long (~520 cm) cores at both sites and are employing XRF scanning and a range of biological proxy variables, such as dinoflagellate cysts, testate amoebas, benthic foraminifera, and tintinnids. First XRF results indicate high proportion of Bromine in laminated intervals that may be related to marine organic matter. The micropaleontological analyses indicate a poor benthic foraminifer fauna with very few agglutinated species such Miliammina fusca, no calcite adult species but a few unidentified juvenile forms. Preliminary analyses also reveal a large abundance of tintinnids, which can be related to environmental settings with large amount of organic matter.

**S12-P-06 Diatom evidence and paleocoastline changes in North Estonia over the last 4000 years**

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Diatom, loss-on-ignition, magnetic susceptibility analyses and radiocarbon dates of sediment cores from two North Estonian lakes have been examined in purpose to detect the age of isolation from the
Baltic Sea as well to reconstruct the temporal 3D palaeogeographical maps for different time periods. The basins are situated in the coast of the Gulf of Finland between altitudes 5.5 and 3.9 m above sea level. The isolation contact was determined using lithological and diatom data and dated by $^{14}$C accelerator mass spectrometry method. Lake Lohja isolated from the sea ca. 2300 cal yr BP and Lake Käsmu ca. 1800 cal yr BP as a result of glacio-isostatic rebound. Constructed shore displacement curve shows that during the last 2300 years the total land upheaval rate was 2.6 mm yr$^{-1}$. The research revises the knowledge about the shoreline displacement in the region.

S12-P-07 Coastal sediment records from Galway Bay, Ireland spanning the Holocene – A look at stratigraphy and diatom records to date

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A palaeoecological study spanning the Holocene and utilising the sediment record of a coastal ecosystem is being carried out in Galway Bay, Ireland. Coastal sediment records can be used to track Holocene environmental change; including climate change, sea level rise, freshwater discharge and recent anthropogenic changes. A transect of the inner bay silt/clay depositional areas <1.8km from the coast was targeted for the extraction of four vibrocores. These sediments are being examined for their physical, chemical and biological properties and their response to bay dynamics, the range of natural variability and responses to unusual events. Coastal sediment records can portray amalgamated profiles of the extent of land-based activities, along with sedimentation rates, time marker horizons, geochemical signatures and biological responses represented in fossil assemblages. These assemblages provide an ecological track for further assessment of contemporary and future impacts. Diatom presence and identification is currently being carried out. This poster displays the diatom record for vibrocore VC001, as well as, a sample of work completed on all four vibrocores to date, including: sedimentology, lithology, stratigraphy and the AMS $^{14}$C dates established. On-going investigations of this PhD project will comprise further fossil assemblages (including foraminifera), biochemical properties, salinity levels and sea-level variation. Based on these investigations, past climatic conditions and environmental change during the Holocene in Galway Bay will be assessed.

S12-P-08 Paleoenvironmental evolution of the Santo André lagoon (SW Portugal): Palaeobotanical contribution

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Depositional systems such as lagoons and estuaries are natural archives of information on environmental changes that occurred in the recent past and on coastline evolution. For the Portuguese coastal fringe, based on geological and paleoecological data from the Santo André lagoon (SW Portuguese coast, 80 km south of Lisbon), an evolutionary model has been proposed which comprises a transgressive phase until the middle Holocene, followed by a forced regression, despite the continuous positive eustatic signal. However, so far no palaeobotanical proxies were included in the evolutionary models. To improve the knowledge of the present models, a 4.96m-long core (LSA4) has been collected from the permanently lagoonal flooded domain. The sedimentological analysis and $^{14}$C dating of cored material, allowed us to identify four major lithostratigraphical units, accumulated after 6.3 ka cal BP. Presently the palynological analysis focused
on the lower units, before 5000 BP, namely LSA4 Unit I (bioclastic muddy peats) and LSA, base of Unit IIA (muds).

The presence of Mediterranean trees (evergreen *Quercus*) and shrubs (*Olea, Pistacia*), in the Santo André basin during the first half of the Holocene, reflects the development of a local *Quercus* forest with Mediterranean shrubland. The vegetation reflects the development of a freshwater pond (*Botryococcus, Pediastrum, Nymphaea, Myriophyllum*) as a consequence of the formation of a coastal barrier, but with some sea water influence as reflected by the presence of dinoflagellate cysts of *Spiniferites* and occurrence of *Cymatosphaera*. The presented results represent a contribution, from palynological science, to the evolutionary models already proposed in the literature (and based on other proxies) in what concerns palaeoclimatological and human-induced contributions to modulate coastal responses.

**S12-P-09  Industrial Past, Urban Future: the Barwon Estuary, Victoria, Australia**

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As focal points for human occupation, estuaries provide a sedimentary archive of civilisation and its impact on the natural environment. The Barwon Estuary in southeastern Australia has witnessed the full gamut of anthropogenic influence since the arrival of Europeans in the early 1800’s, including river regulation, land clearing, gold mining, polluting industries, intensive agriculture and water abstraction. This site is also immediately adjacent to a major residential development which will see the current pastoral land converted to medium –density housing for 60,000 people within the next 10 years.

The Connewarre Complex is a series of Ramsar-listed wetlands found within the estuary and includes the tidal Lake Connewarre and freshwater Reedy Lake as well as ephemeral swamps and lagoons. Analysis of diatom assemblages, biogeochemistry ($\delta^{13}C$, $\delta^{15}N$, C/N) and heavy metals from core sediments can pinpoint each of the major anthropogenic influences over the last 170 years and the biotic response. We use this study to test the resilience of the system to rapid change, in view of the increased urbanisation forecast for the very near future.

**S12-P-10  Dead Sea laminae and its implication to understand hydro-climatic events**

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Sediments may serve as archives of the past, with different proxies providing environmental information that can produce palaeoclimate records. In this research project we use Dead Sea Basin (DSB) laminated sediments as archive, and abiotic and biotic indicators as environmental proxies. A detailed daily precipitation record from the watershed starting in 1895 may provide the basis for a comparison between limnological and meteorological data.

The lacustrine DSB record consists of mm-scale alternating dark-detrital and white-chemical laminae. Previous studies assumed a seasonal origin of the couplets, summer chemical vs. winter detrital precipitation. Our alternative hypothesis is that the laminae represent inter- and intra-annual flash-floods events delivering suspended fine sediments into the lake followed by chemical deposition. We are analyzing millimetre-thick laminae sequences dated to the Hellenistic and the late 19th-early 20th centuries high-stands using abiotic (grain size and mineralogy) and biotic proxies (pollen and spores), which are independent indicators to determining seasonality. The air-borne pollen permits to establish the seasonal character of the laminae by comparing to flowering periods (provided by Tel-Aviv University) with the palynological record in both detrital and chemical laminae, as well as current flash-floods sediments.
The second part of the project is related to daily climatic records from Jerusalem starting in 1895 that was recently obtained from the British Meteorological Office archive. We will analyses the precipitation record in light of the flashflood proxies and establish a cross correlation that could serve as a modern analogue for the relation between the sedimentary and climatic records. This can later be extrapolated to the entire sedimentary Holocene sequence to trace the paleo-hydrology of the DSB system.

S12-P-11 Climate dynamics in an Arctic fjord environment: evidence from geochemical analysis of marine sediments

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The archipelago of Svalbard lies on a key boundary between the Norwegian Sea, the Barents Sea and the Arctic Ocean, and is thus highly sensitive to climatic changes. The western Svalbard margin is affected by both Atlantic and Polar surface Water, and therefore is a particularly important location for determining the relationship between glacial activity and climate variability. Even small geographical displacements in ocean fronts along the west Svalbard coast can produce large shifts in climate and glacial processes in the region.

Utilising fjordic sediment archives to reconstruct the western Svalbard environmental conditions of the last 2000 years, it is possible to constrain the variability of glacial activity and recent changes in climate for the region. However, there are significant gaps in our knowledge of climate over the last two millennia in this crucial high latitude region, where the knowledge of glacial history is mostly based on fragmentary onshore moraine records, exposed sediments in section, relatively restricted marine sediment records, ice cores and lake sediments archives.

Despite the limitations associated with some of these records, they indicate the presence of high-amplitude climate variations even within the last millennium from Svalbard, and highlight the potential for generating high-resolution climate records. The aim of this project is to generate the first sub-decadal resolution late Holocene climatic record, to determine the nature and timing of environmental changes across transient climate events at an unprecedented temporal scale for this region. XRF analyses provides the high-resolution data series, which has been integrated with sedimentological data to better define the environmental processes; thus providing the basis for the reconstruction of climate change in the glaciated fjordic environment.

S12-P-12 Holocene sea-water level fluctuations in the White Sea, the Baltic Sea and the Black Sea inferred from lake sediments

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The results of the palaeolimnological investigations in the White Sea, the Baltic Sea and the Black Sea areas are presented with the accent on the large palaeobasins level changes in the regions. The area of Solovki Isl. located above 30 m a.s.l. became isolated before 10000 cal. BP while the lowlands at 3 m a.s.l. remained under the sea till 1300 cal. BP. The water connection between Lake Ladoga and the Baltic in the northern lowland of the Karelian Isthmus has been originated after the ice retreating ca 14000-12000 cal BP. Until the catastrophic dropping of the Baltic Ice Lake (BIL) water-level happened ca 11500 cal BP, Lake Ladoga was a deep easternmost bay of the BIL. After 11500 cal BP a straight/river existed in the northern part of the Karelian Isthmus during ca 7000 years. Around 4000-3000 cal BP a new outflow – the River Neva, was formed due to the influx of fresh water from the Saima water-system and isostatic uplift caused a rise of the water level of the Ladoga Lake known as “Ladoga transgression”, which afterwards
completely reshaped the waterways of the entire area. In the studied Crimean lake sediments the transition from the open sea environment conditions to the lagoon and the closed mineralized lakes is dated ca 5600-5350 calendar yr BP. The ensuing glacio-eustatic New Black Sea transgression resulted in a gradual rise of sea level, which reached its maximum of 2.0-2.5 m at 5800-5600 BP. Grant RFBR10-05-00651a.

S12-P-13 The Caspian Sea, a Laboratory for Investigating Impacts of Changes in the Variations of the Sea Levels

Suzanne, L., Klaus, A.

The sea level of the Caspian Sea has varied considerably during historic times, by 3 m during the last century and perhaps by 10 m during the last millennium according to direct observations, traveller accounts and sedimentary archives (Leroy et al., 2011). Such large and rapid changes cause problems to society, e.g. petroleum industry, harbour accessibly and fishery (caviar). The Caspian Sea is a closed sea without any connections to the ocean. This makes its level dependent on a delicate balance of water budget, which is mostly a balance between the Volga River discharge and the evaporation over the Caspian Sea itself. Recent investigations found a connection between global changes and the El Niño – Southern Oscillation (Arpe et al., 2000), further the impacts of global warming has been estimated (Arpe and Leroy, 2007) and finally the more short-term prediction of the Caspian Sea level has been started (Arpe et al., 2011). The latter showed that meteorological events as the drought over European Russia in 2010 can have a profound impact on the Caspian Sea level and in fact a drop of the Caspian Sea Level of 50 cm during 2010-2011 has been observed which can be explained with presently available meteorological data, provided by the European Centre for Medium-Range Weather Forecasts. As the latter provides as well seasonal forecasts, there seems to be a scope for providing forecasts of the Caspian Sea Level 6 months ahead which might help the mitigation of the impacts of such sea level changes.

S12-P-14 Midges, salinity & sea level change in the Hudson Bay Lowlands

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A survey of midge (Chironomidae, Chaoboridae, and Ceratopogonidae) remains preserved in the surficial sediments of 69 water bodies located in the Hudson Bay Lowlands was conducted to assess the feasibility of reconstructing paleosalinities to infer a sea-level history for the region. The training set comprised 69 water bodies, 8 environmental variables, and 53 midge taxa. Canonical correspondence analysis revealed that log conductivity contributed most significantly to explaining midge distributions. Weighted averaging partial least squares (WA-PLS) was used to estimate midge salinity optima and tolerance ranges. These results constitute the basis for a midge-salinity inference model and for reconstructions of paleosalinity and sea level change in the Hudson Bay Lowlands. Parallel in-vitro experiments were conducted to independently assess the WA-PLS estimates of species’ salinity tolerances which validate the inference model techniques but suggest caution must be exercised during analysis.
Polycyclic aromatic hydrocarbon (PAH), pesticide, and metal contamination in estuarine sediments often result from residential and commercial runoff from urban areas adjacent to coasts. Sediment profiles in estuaries near urban areas often are disturbed by high-energy water movements associated with stormwater inflows, as well as tidal action and riverine inputs. Portions of small estuaries thus affected are likely to vary among depositional, transitional, and erosional phases over time. Disturbed sediment profiles make it difficult to meaningfully interpret historical patterns of sediment and contaminant deposition, and are likely to demonstrate undatable $^{210}$Pb profiles. This study examines factors that influenced historical patterns of contaminant deposition in sediments of Clam Bayou, St. Petersburg, Florida, a small, spatially complex estuary that receives stormwater inflow from an urban area approximately 15 times its size. Contaminant concentrations in a surface-sediment survey showed that contaminants were bound preferentially by organic-rich deposits associated with mangroves. We used historical aerial photographs to select 3 mangrove sites for sediment core retrieval, and examined contaminant and organic matter content, radioisotopic activities for dating, and mangrove macrofossil evidence in the cores. All 3 cores showed distinct contaminant deposition profiles. Only the site that supported the longest mangrove presence contained a complete $^{210}$Pb profile, and timing of the appearance of metals and pesticides generally was consistent with dates estimated for the core. Violations of assumptions for dating models are likely to occur in such complex environments, so dates and accumulation rates must be interpreted cautiously.
Session 13 - Past climates of the Southern Hemisphere

S13-KN  A 36000 year long lacustrine record in the central South Atlantic exhibiting large-scale climate shifts during the last glacial

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From Nightingale I (37°S) in the central South Atlantic we present a 36 ka long record from 1st Pond (1P). The sediments between 36-12.5 ka BP consist of more or less organic-rich lake sediments, overlain by peat; the chronology was established by 37\(^{14}\)C dates. We analyzed the sediments with respect to TOC, BioSi, N, magnetic susceptibility, XRF, C/N ratios; diatom, pollen and isotope analyses are under way. These proxies reflect the combination of air temperatures, SSTs, precipitation and wind strength.

An obvious topic for such a site is to link it to polar ice cores, and to detect any bipolar seesaw effects in these fairly northern latitudes of the Southern Hemisphere. The EDML ice-core interstadials between 36-27 ka BP correspond to periods of increased aquatic productivity in 1P. Also, the long and complex LGM in EDML, 27-17.5 ka BP, corresponds to variable but low productivity 26.5-18 ka BP in 1P, implying harsher conditions. For example, the previously dominating diatom species *Staurosira venter* disappears, but returns again to be dominating, and together with the absence of *Phylica arborea* pollen (native tree/bush), we argue for significantly lower temperatures, possibly triggered by northward shifts of the Antarctic-Subantarctic fronts and sea ice limit. Did winter conditions reach down to the freezing point and where were the SHW situated? Finally, our deglacial warming was contemporaneous with the onset of Antarctic warming, and bipolar seesaw effects are displayed during the Last Termination. Our data suggest presence of SHW, but with varying wind strength and precipitation, during parts of MIS3 and during parts of the Last Termination, implying large latitudinal shifts of this globally important circulation system.

S13-01  The Last termination in the South Atlantic region reconstructed from terrestrial and lacustrine archives from Nightingale Island

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The last glacial period exhibited synchronous climate shifts of opposing signature in the North and South Atlantic regions, called the bipolar see-saw. The pattern is particularly strong in Greenland and Antarctic ice cores, and has also been inferred from marine sediment cores. The antiphase climate behaviour has been explained in terms of variations in heat transport between the hemispheres through the meridional overturning circulation. The last deglaciation was characterised by rapid warming and strong climate fluctuations in the North Hemisphere and a more gradual warming in the Southern Hemisphere, as inferred from ice cores. Here we present results from two overgrown small lakes on Nightingale Island in the central South Atlantic (37°S) covering the last deglaciation. We have analysed the sediment cores with respect to their carbon, nitrogen and biogenic silica content, mineral magnetic properties, x-ray florescences and diatom assemblages. The results show a rapid increase in lake productivity starting at about 17.5 ka. The pattern is in general agreement with the deglacial warming inferred from Antarctic ice cores. This shows that this northern site in the South Atlantic was in phase with the general southern hemisphere climate evolution during the deglaciation. Short fluctuations in our records between 13 and 15 ka are contemporaneous with the Antarctic Cold Reversal and are potentially associated with shifts in the oceanic and atmospheric fronts in the South Atlantic.
S13-02 Precipitation variability in the winter rainfall zone of South Africa during the last 1400 years linked to the austral westerlies


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The austral westerlies strongly influence climates and marine circulation in the southern temperate zone, with potentially important consequences for cultures and ecosystems. Many climate models anticipate poleward retreat of the austral westerlies with future greenhouse warming, but most of the available paleoclimate records that might test these models have been limited to South America and New Zealand, and are often not fully consistent with each other. Here we present high-resolution lacustrine sediment and microfossil records from Verlorenvlei, a coastal lake in the winter rainfall region of South Africa, representing precipitation associated with the northern margin of the austral westerlies during the last 1400 years. Rainfall was relatively high ~1400-1200 cal yr BP, decreased until ~950 cal yr BP, and rose again through the Little Ice Age with decadal-scale peaks ~600, 530, 470, 330, 200, 90, and 20 cal yr BP. Synchronous changes in ice chemistry at Siple Dome suggest that these fluctuations were linked to changes in the westerlies. Equatorward drift of the wind belt during the humid periods may have influenced Atlantic meridional overturning circulation by interfering with ocean current flow around the tip of Africa. Inconsistencies among records from South America, New Zealand, and South Africa warn against the simplistic application of single records to the southern hemisphere as a whole. Nonetheless, these findings appear to support projections of increasing aridity in the austral winter rainfall zones with future global warming.

S13-03 Holocene westerly wind and ecosystem changes on sub-Antarctic Macquarie Island

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The mid- to high-latitudes of the Southern Hemisphere are dominated by the westerly winds. These are important because changes in their strength determine precipitation and temperature regimes. However, little is known about their past strength, or spatial and temporal variability. Sub-Antarctic islands are the only landmasses between Antarctica, South America, Africa and Australia where terrestrial climate and ecosystem records are available, making them crucial locations for linking southern mid- and high-latitude regions. However, few long-term climate and ecosystem records exist. This project aims to address these gaps by utilising lake sediment cores from Macquarie Island (54°30’S, 159°57’E) to reconstruct changes in wind strength and identify ecosystem shifts over time. A marked west-east gradient in salinity exists across the island as saline ions are delivered by wind-derived sea spray. A diatom-salinity model was established and applied to a sediment core dated using 210Pb and 14C. This was used to infer past lake water salinity and wind strength (i.e. higher salinity implies stronger winds). Windier conditions prevailed during the early-mid Holocene (7000-5500 years BP), followed by a period of reduced wind strength. After c. 4700 years BP conditions became windier. An abrupt change in sedimentation rate occurred c. 4000 years BP, following a peak in wind strength. A period of slow sedimentation occurred from 4000 years BP, possibly due to drier
conditions. Comparisons to other studies in the sub-Antarctic region and mid- and high-latitudes of the Southern Hemisphere were made to investigate broader-scale changes in wind strength and ecological responses to changing climatic conditions.

S13-04 Climates variability in southeastern Australia over the past 1500 years inferred from the high-resolution fossil diatom records of two crater lakes

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The climate of Australia displays high spatio-temporal variability. Multi-year droughts, often followed by extreme rainfall events, are a common feature of the instrumental climate record (~110 years). However, very little is known of climatic variability beyond this period as written records only exist since European settlement (AD 1787) and even then are very sparse. Highly-resolved palaeoclimate records are therefore required in order to evaluate the long-term context of recent climatic events, trends and variability. However, to date, only one high-resolution record has been published that encompasses the last millennium: a tree-ring based warm season temperature reconstruction from western Tasmania (Cook et al., 2000. Climate Dynamics, 16:79-91).

We present the results of a study from western Victoria, in the southeast of mainland Australia, in which the fossil diatom records from two crater lakes were examined at sub-decadal resolution. Results were applied to a diatom-conductivity transfer function in order to infer past variation in lake-water conductivity, a proxy for effective moisture, over the past 1500 years. Coherence between the lake records indicates that both sites are responding to a regional-scale climate forcing.

The results provide evidence of an extreme drought and a lengthy period of high-amplitude variability, neither of which have an analogue in the historical period. The 1500-1850 period, commonly associated with the ‘Little Ice Age’, is marked by reduced interdecadal variability and high effective moisture. These are the first millennial-length high-resolution records from mainland Australia and provide new insight into both short and long-term patterns of regional climate variability.

S13-05 Late Quaternary Environmental change at Lake McKenzie: evidence from geochemical and biological proxies

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Climate change and anthropogenic activities are potentially threatening the quality and volume of surface water worldwide. In Australia, surface water resources are scarce due to the dry and variable nature of the climate. For this reason, the maintenance and conservation of freshwater resources is a priority. Yet there is a lack of information regarding the environmental history of Australian lakes and their response to continuing climate variations. This study applies palaeolimnological techniques to the unique deflation lake, Lake MacKenzie on Fraser Island to investigate water quality and effective precipitation changes in the late Quaternary period. Sediment cores were retrieved using gravity corers in late 2010. Geochemical, biomarker and diatom analysis has been conducted in combination with high resolution 210Pb and AMS 14C dating. A basal date suggests an age of ca. 37,000 cal yr BP. A hiatus at 25 cm depth is apparent in the geochemical records and relates to ca. 18,230–13,990 cal yr BP. The diatom record indicates fairly consistent biodiversity and a dominance of benthic species. However, the abundance of planktonic species varies and may be related to changes in effective precipitation. This site at Fraser Island has the potential to provide a deeper understanding of aquatic ecosystem response to
climate change and aid management of surface water resources in the future.

S13-06 A new humification record for northeastern Australia: dating millennial and centennial scale climate variability

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Peat humification analysis is presented as the primary palaeoclimatic proxy in this study of Late Holocene peat sequences from the humid tropics of northeastern Australia. To determine the presence of regional climatic signals in the peat record (as distinct from local changes in basin hydrology or ecology), two sediment sequences from two basins are examined.

Our results indicate that while the hydroseral successions for Bromfield Swamp and Quincan Crater are quite distinct over the duration of the mid to late Holocene, wetter and drier phases are evident in the humification records of both sites. Three wetter phases are seen in the humification record for Bromfield between 3500-2100 cal. yr BP (at about 3390 cal. yr BP, 2900 cal. yr BP and 2280 cal. yr BP), followed by further wetter phases between 1200-600 cal. yr BP. The humification record for the peat sequence in Quincan Crater shows a very similar pattern of wet and dry phases over the last 4,000 years. Data collected from a suite of other palaeohydrological proxies (pollen, δ13C, grain size analysis, magnetic susceptibility and charcoal) are presented, showing support for the conclusions reached.

S13-P-01 A 28,000 year multi-proxy record of environmental change from the sub-tropics of Australia


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The south-west Pacific is an important region in Southern Hemisphere climates because of the presence of major processes (such as ENSO, the west-Pacific warm pool and the East Australian Current) that exert substantial influence over climates of the region and beyond. In order to understand the past behaviour of these processes, there is a need for a wide suite of studies that cover key periods of climatic change, such as the last glacial maximum (LGM) and the last glacial-interglacial transition (LG-IT). Australia is ideally located to contribute to these discussions, however continuous records of the LGM and LG-IT are relatively uncommon and the sites that do exist are primarily concentrated in the northern tropics and the temperate south-east.

We present the results of a multi-proxy investigation of a 450 cm sediment core from Welsby Lagoon, a perched lake on sub-tropical North Stradbroke Island. A combination of pollen, stable isotopes, macrocharcoal and sediment analysis provide detailed insights into climatic change over the past 28,000 years. The results provide evidence of substantial variability during the LGM and LG-IT chronozones, highlighting the complex nature of the late glacial transition in the Southern Hemisphere. With the exception of macrocharcoal, the Holocene is marked by a general stability in the proxy records, with little indication of a mid-Holocene intensification of ENSO. This contradicts the
findings of numerous studies and therefore is most likely indicative of the persistence and stability of the site, highlighting its importance as a potential freshwater refuge during periods of drier climates.

**S13-P-02 Evidence for pre-European drought in south-eastern Australia: a historical context for the ‘Big Dry’?**

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Droughts, though not unusual in Australia, have serious and detrimental effects not only in terms of the environment, but also on the society and economy of the affected region. Whilst it has been well documented that previous droughts, documented during European settlement, have been of a similar duration (e.g. 1936-1945 drought) to the recent ‘Big Dry’, this has been of a greater intensity and has been linked to rising temperatures over recent decades.

Western Victoria has a large number of climatically sensitive lakes from which records of past environmental change are being extracted. The high-resolution nature of these records has allowed the ‘Big Dry’ to be placed into a context that extends beyond European historical records and offers a longer-term perspective of natural climate variability. The results from one such site, Lake Colac, are presented here.

The analysis of diatoms, terrestrial and aquatic pollen, macrofossils and sedimentary pigments provides the first evidence for a period of prolonged drought prior to European settlement. This drought, centred on c. AD 1500, is characterised not only by increases in saline diatom taxa, but also a state switch from a macrophyte-dominated to an algal-dominated system (as indicated by pollen, macrofossils and pigment data). Statistical analyses suggest that the ‘Big Dry’ has contributed to the production of unprecedented conditions in the lake sediment record, forcing the lake to function outside of its historical range of variability and most likely reducing the resilience of the system to future perturbations.

**S13-P-03 Late Holocene paleolimnological reconstructions in the Pampa plain, south of South America: regional paleoclimatic inferences from multiple shallow lake records**

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To reconstruct the late Holocene environmental history of the southeastern Pampa plain of Argentina (37°–38°S; 57°–58°W), in the context of regional Holocene paleoclimatic changes, a multi-proxy analysis was performed. Diatoms, charcoal, plant macro-remains and associated fauna, mollusks, ostracods, pollen and non pollen palynomorphs (NPPs) were analyzed from four shallow lakes. Similar patterns of variation of the proxies in the analyzed lake-records indicate the presence of a climatic control at a regional scale. Three phases in the evolution of the lakes were recognized. Between ca. 4500 and ca. 700 cal yr. BP, a clear macrophyte-dominated phase, with charophytes and brackish-freshwater diatoms, ostracods and NPPs (dinocysts and crustacean eggs), can be described in a context of regional arid conditions indicated by high percentages of Chenopodiaceae in the pollen record. After ca. 700 cal yr. BP the lakes changed gradually towards turbid phytoplankton-dominated conditions,
with chlorococcales and freshwater diatoms and a pollen record dominated by emergent macrophytes in a regional more humid context. Modern even more turbid conditions have recently established due to re-suspended sediments and a regimen of periodic droughts. The shift between lake phases may be attributed to a climatic change occurred at ca. 700 cal yr. BP towards wetter conditions after the Medieval Climate Anomaly. Even though each record is primarily representing local conditions, the joint analysis of a network of lakes has shown great potential in deciphering regional climatic and hydrological changes.

S13-P-04 Paleolimnological reconstruction of Holocene changes in the wind-driven mixing regime and human impacts in Lake Villarrica, South Central Chile

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Temperate regions in the Southern Hemisphere are highly influenced by climate fluctuations such as ENSO and changes in the Southern Westerlies. These processes can alter physical properties in lakes such as water-column mixing which, in turn, is an important driver for phytoplankton community dynamics. Here we present a Holocene diatom stratigraphy of a 14 m long sediment core from Lago Villarrica (39°15’S, 72°02’W), which was combined with sedimentological proxies. The reconstruction of changes in wind-driven mixing regime was aided by a newly developed diatom training set based on standing populations and surface sediment data from 27 Chilean lakes (38°-43°S). Differences in planktonic diatom community structure were mainly related to gradients in the light climate and mixing regime.

Between 9369 and 5900 cal yr BP, overall high diatom productivity and high relative abundances of Discostella stelligera, D. cf. mascarenica and Urosolenia eriensis point to the occurrence of thermally stable water conditions, which is likely related to the Early Holocene warm period. During the Mid- and Late-Holocene, enhanced seasonality with longer and more stable lake water stratification during summer, and more intense winter mixing, could be inferred based upon the notable co-occurrence and high abundances of Aulacoseira granulata, A. granulata var. angustissima and U. eriensis. Changes in the abundance pattern of U. eriensis and the occurrence pattern of lahar laminae during the last 3000 years are likely related to ENSO activity. The marked increase of Asterionella formosa and Fragilaria crotonensis during the most recent period can be linked to increased anthropogenic impact.

S13-P-05 Lacustrine and terrestrial responses to glacial climate shifts on Nightingale island

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Nightingale Island is part of the Tristan da Cunha island group situated in the central South Atlantic (37ºS). We have recovered sediment cores from an overgrown small lake going back to 36000 yrs cal BP. Here we present diatom and pollen data, together with x-ray florescence and bulk geochemistry (C and N content) covering the 36000-12000 yrs BP. Before the last glacial maximum (LGM), 36000 to 27000 cal yrs BP, the diatom flora was dominated by small benthic (Fragilaroid spp.) species. During the LGM (27000-17000 years BP) these decreased substantially and planktonic (Aulacoseira spp.) species appeared. This probably reflects the response to harsh climate conditions during the LGM. The fraction of tree pollen and fern spores in the sediment is low during during the LGM period, which indicates a decline in forest covered areas on the island. Probably there was little, or no, species turnover during the peak of the last glacial period since all major pollen and spore types are present also in the bottom of the sequence. The diatom assemblages and chemical proxies display several shorter shifts, which may be associated with
temperature and/or precipitation events caused by changes in the position of fronts over the South Atlantic.

S13-P-06  A 950 year temperature reconstruction from Duckhole Lake, southeast Tasmania, Australia

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A lack of quantitative high resolution paleoclimate data from the Southern Hemisphere limits the ability to examine current trends within the context of long term natural climate variability. This study presents a temperature reconstruction for southeast Tasmania by analyzing lake sediment proxies from Duckhole Lake (43°21’S, 146°52’E). The relationship between scanning reflectance spectroscopy measurements in the visible spectrum (380-730 nm) and the instrumental temperature record (1911-2000) was used to develop a calibration-in-time reflectance spectroscopy-based temperature model. Results showed that a trough in reflectance from 650-700 nm, which represents chlorophyll and its derivatives, was significantly correlated to annual mean temperature. A calibration model was developed (R=0.56, p<0.05, RMSEP=0.21°C, 5 year filtered data, calibration period 1911-2000) and applied to reconstruct annual mean temperatures in southeast Tasmania over the last c. 950 years. This showed that conditions have fluctuated between relatively warm (c. AD 1100-1210, 1320-1390, 1760-1900s) and cool (c. 1210-1320, 1390-1430, 1630-1760), before a cool first half of the 20th century, followed by warming since AD 1960. Comparisons with high resolution temperature records from western Tasmania, New Zealand and Patagonia reveal some similarities (in particular a cool period in AD 1700s and early 1900s in most records), but also highlighted the differences in temperature variability across the mid-latitudes of the Southern Hemisphere. These are likely due to a combination of factors including spatial variability between and within regions, and differences between seasonal (i.e., warm season/late summer) and annual temperature variability. This highlights the need for further records from the mid-latitudes of the Southern Hemisphere in order to understand natural spatial and seasonal/annual temperature variability in the region, and identify and attribute changes due to natural variability and anthropogenic changes.

S13-P-07  Diatom evidence for a MIS 5 mega lake highstand in the Kalahari (Botswana)

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The geomorphological features of the northern and middle Kalahari provides evidence for a palaeolacustrine system spanning ~70,000 km² that has been termed Lake Palaeo-Makgadikgadi. Dating of palaeo-shorelines at 936-945 m a.s.l. indicates several lake high stands during the last ~300 ka. The limnology of this large palaeolake, however, remains unknown. During one of these lake high stands a 30-cm diatom-rich sediment bed was deposited at c. 935 m a.s.l. along the Gidikwe Ridge, a palaeo-shoreline system bounding the Makgadikgadi Basin to the west. OSL dates from this sequence suggest the diatom bed was deposited between 105 and 75 ka. We examined the diatom assemblages within this stratigraphic zone and there is low diatom species diversity throughout, with a total of fifty different species identified. There are four dominant taxa throughout the diatom bed Pseudostaurosira brevistriata, Rhopalodia gibberula, Cyclotella meneghiniana and Mastogloia elliptica, with a high abundance (64 – 88%), although P. brevistriata and R. gibberula are the most dominant. These data suggest that the diatom bed was deposited in a low saline, alkaline and shallow water environment. The evidence for a relatively fresh water system is being tested with the oxygen isotope composition of these diatoms and analysis is ongoing.
S13-P-08 Paleoecological study of Raraku Lake (Easter Island) during the last 34000 cal yr BP

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Easter Island is an isolated island in the South Pacific Ocean. Although previous paleoenvironmental studies based on lake sediments have shed some light on island’s environmental past, its climatic and ecological history is still debated. We present the preliminary results of an ongoing paleoecological study of last 34 cal kyr BP from Lake Raraku, mainly based on the palynological and macrofossil record. Four main vegetation shifts are observed. Since 34 to 31.5 cal kyr BP, the pollen record indicates the presence of an open palm forest with well developed shrub stratum and abundant grasses, suggesting a relatively humid and possibly cool conditions. A similar forest but slightly more open, without Coprosma and higher abundance of grasses and ferns, is inferred between 31.5 to 16.4 al ky BP. This has been interpreted as a cooler and likely wetter period. Since 16.4 to 11.3 cal kyr BP palm pollen become more abundant together with Triumfeta. Grasses and Sophora decline, and other taxa almost disappear from the record, suggesting warmer conditions. Since 11.3 kyr BP onwards the pollen record is composed almost exclusively by palms. Lithostratigraphic features point the transformation of the lake into a swamp around that time, and drier conditions are inferred. Raraku sedimentary sequence is interrupted by a hiatus from 4.5 to 0.8 cal ky BP, interpreted as a result of a drought phase.

S13-P-09 Using sedimentary pigments to reconstruct primary production and phototrophic community structure in south-eastern Australian lakes and estuaries

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In recent decades, sedimentary pigment records have received attention from many palaeoecologists who have attempted to gain a more complete picture of past ecosystem conditions through the reconstruction of past productivity, phototrophic structure or phytoplankton composition. By assembling this information, palaeoecologists expect to understand changes in aquatic ecosystem function arising from climate and catchment changes. Although the analysis of sedimentary pigments is widespread across the northern hemisphere, it has rarely been applied to Australian lake and estuarine systems.

This research aims to understand how Australian lake and estuarine ecosystems respond to climate and catchment changes in terms of primary production and phototrophic community structure by: (1) adapting and refining the technique of sedimentary pigment analysis using High-Performance Liquid Chromatography (HPLC) to contribute to multiproxy palaeoecological studies in key Australian sites; (2) reconstructing past primary production and phototrophic community structures in lake and estuarine ecosystems using fossil pigments and (3) comparing sedimentary pigment data to other proxies (diatoms, aquatic pollen) in order to provide an holistic understanding of aquatic ecosystem response to climate change and variability.

Results from four sites (three lakes, one estuary) in south-eastern Australia highlight the potential of applying sedimentary pigment analyses to southern hemispheric sites. There is good fossil pigment recovery, allowing profiles to be reconstructed back to 6000 years; changes in pigments show good correlation with diatoms and aquatic pollen stratigraphy (lake sites), and recent algal bloom events can be tracked using the sedimentary pigment
profile of the estuarine site with unprecedented increase in cyanobacteria pigment concentrations.

S13-P-10  Lake sediments in the Chilean Andes – towards seasonally resolved temperature reconstructions

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Climate in the central Chilean Andes is characterized by strong seasonal and interannual variability. In summer, dry conditions dominate, related to a strong South Pacific Anticyclone. In winter, however, weakening of the anticyclone allows for the northward progression of the westerly wind belt, controlling temperature, wind and precipitation patterns between ca. 32-65°S. Therefore, seasonally resolved proxy records are required to reconstruct past climate variability and mechanisms in this region.

A sediment core from Laguna Chepical, a high-alpine lake in the central Chilean Andes (32.16°S, 70.30°W, 3050 m. a.s.l.) was analysed using scanning reflectance spectroscopy (VIS-RS 380-730 nm). C/N, total biogenic silica and total organic carbon from AD 1900 to present were measured at 2 mm resolution. The calibration-in-time approach showed that the minerogenic content of the sediment (derived from VIS-RS scanning) yielded a high, significant correlation to summer temperatures (R = -0.77, padj = 0.018). The VIS-RS based reconstruction back to AD 1800 shows strong similarities to the independent summer temperature reconstruction from lowland Laguna Aculeo, central Chile.

To reconstruct past cold-season temperatures in this region, a spatial training set for chrysophyte stomatocysts (silicious remains of the golden-brown algae) is under development. Previous studies in the Alps and Pyrenees have demonstrated the potential of chrysophyte stomatocysts as a cold-season temperature proxy. In summer 2010/2011, thirty Chilean lakes (between 37-39°S, altitude 340 – 2020 m asl) were equipped with thermistors and sediment traps. Samples and temperature data will be collected after 1 and 2 years.

Results obtained so far indicate that several methods can be used to generate quantitative, season-specific climatic reconstructions from non-varved lake sediments. This is important in a region for which currently few – in particular cold-season temperature – reconstructions are available.

S13-P-11  A 12,000 year record from the Barff Peninsula, South Georgia, sub-Antarctic: linking terrestrial climate, sea ice variability and insolation

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South Georgia (55°S, 36-38°W), lying south of the Antarctic Polar Front (APF) and north of the present limit of Antarctic winter sea ice, is ideally positioned to record major climatic shifts following deglaciation. Lacustrine archives provide an important link between Antarctic ice core and Southern Ocean palaeoclimate records.

Here, we present the sediment record from an unnamed lake on the largely ice-free Barff Peninsula, Cumberland Bay. The 185cm sequence reveals that deglaciation occurred c. 12 kyr BP. Eleven AMS radiocarbon dates provide a robust chronology for the Holocene sequence. High-resolution XRF core scanning and bulk organic geochemistry indicate three principal phases of lake development (12 – 7 kyr, 7-4 kyr, 4 kyr – present). Diatom preservation is poor prior to 4 kyr BP with
only minor assemblage changes through the Late Holocene.

Minerogenic inputs are high at the base of the core, declining between 12 kyr and 10.5 kyr BP following initial deglaciation. Laminated sediments preserved between 12 kyr and c. 7 kyr BP suggest a continued glacial influence in the catchment, probably maintained by increased precipitation accompanying a southward shift in the southern hemisphere westerlies. Between 7 and 4 kyr BP, maximum productivity and summer warming occurred, a time when marine records suggest declining sea surface temperatures and increasing sea ice extent. A downturn in productivity occurred during the last 4 kyr BP. Major changes in the Barff Peninsula record during the Holocene are best explained by local insolation seasonality.

S13-P-12 Reconstructing a past environmental & relative sea level change on the South Shetland Islands, Antarctica, from lake sediment and terrestrial records

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The western Antarctic Peninsula (WAP) is located in one of the fastest-warming regions on Earth, and is a key area for studying the impact of changing climate on glacier dynamics, sea level, and terrestrial and marine ecosystems. Since 2005, as part of BAS-core research programs and ongoing collaborative AWI (Alfred Wegener Institute)-IAA-BAS-ICBM IMCOAST associated projects, we have been investigating relative sea level change and biogeochemical sedimentation processes and rates of change on Fildes Peninsula and Potter Peninsula, South Shetland Islands. Using lake sediment records from Fildes Peninsula, and recently collected lake, and terrestrial samples from Potter Peninsula, our aims are to: (i) improve existing, and produce new, relative sea level curves for the South Shetland Islands; (ii) study present and past geochemical characteristics of terrestrial sediments on Fildes and Potter Peninsulas; (iii) examine rates of deglaciation, and deglaciation-related changes on Fildes and Potter Peninsulas, and the erosion of terrestrial deposits into Potter Cove and Maxwell Bay; (iv) develop new biomarker-based temperature and biogeochemical proxies to quantitatively constrain past changes in temperature and precipitation; (v) examine 5-0k bio-geochemical changes at high resolution to separate hemispherically and regionally driven changes from local change. In this poster, we summarise some key findings to date, including a new relative sea level (RSL) curve for the South Shetland Islands, and inorganic geochemical data linking elevated ‘bio’-elements (commonly found in penguin guano) in some lake sediments to changes in penguin population dynamics and climate change during the Holocene.

S13-P-13 A Palaeolimnological Reconstruction of Mid and Late Holocene Climate Change in South Georgia

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South Georgia is a key location for studying the main drivers of past and present-day climate variability in the South Atlantic. We undertook multi-proxy analyses in a 5.83 m long, ca. 7800 cal. yr. B.P. old, sediment core from Fan Lake, Annenkov Island, South Georgia (54°29’0”S, 37°5’0”W) to infer past climate changes and
patterns in local catchment stability and glacier activity.

Deglaciation of the Fan Lake site occurred ca. 7800 cal. yr. B.P. A low productivity environment could be inferred until ca. 3600 cal. yr. B.P., which was followed by a short period of elevated biological productivity between 3600 and 3380 cal. yr. B.P. Anomalous radiocarbon ages of terrestrial mosses between 3380 to 2735 cal. yr. B.P. most likely reflect enhanced inputs of older terrestrial moss from the inflow streams that pass over moss banks in the catchment area. The most recent phase of lake development (2735-0 cal. yr. B.P.) was characterized by high and variable concentration of the primary production proxies. Diatom community composition was dominated by a single species (*Cyclotella stelligera*), but some pronounced fluctuations in the abundance of other diatom species occurred in the upper part of the core. For example, a peak of the diatom *Fragilaria capucina* could be tentatively linked to increased catchment disturbance ca. 1100 cal. yr. B.P., which is possibly related to local deglaciation following a cold spell ca. 1770-1335 cal. yr. B.P. Other brief cold spells could be tentatively inferred at 2364 and between 720-495 cal. yr. B.P.
Session 14 - Palaeoecological reflections of biodiversity: challenges and new advances

S14-KN Community structure dynamics and biodiversity across a continuum of past, present and future

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Lacustrine sedimentary records archive a time continuum through which species and communities flow as they evolve and undergo ecologic transformations. Although both ecologists and paleoecologists share a common goal of gaining a fuller understanding of biosphere processes, the sedimentary record presents challenges as it provides only a meager sample of past life. These samples are not random but are highly taphonomically biased by a variety of biologic, chemical and sedimentological processes. Any paleolimnologic study must therefore be based on a clear understanding of what can and cannot be achieved with proxy data. With these limitations in mind, there have been recent major advances in paleolimnological research that have improved the ability of paleoecologists to provide a more accurate determination of community structure and biodiversity changes over time. These include: 1) statistical approaches (e.g. improved training sets, transfer functions, better variable selection); 2) improved age modeling (e.g. advanced Bayesian techniques); 3) an increase in multi-proxy studies (e.g. greater paleoenvironmental insight); and 4) higher resolution core analysis (e.g. resulting in improved assessment of community response to environmental cycles, trends and stressors). These advances are discussed in the context of research initiatives where detailed information on paleolimnological trends are required by policy makers and planners to determine the future impact of climate change and success of ongoing remediation efforts, including: 1) climate variability on the long-term viability of the Tibbett to Contwoyto Winter Road, Northwest Territories; 2) oil sands extraction in Alberta; and 3) road salt contamination and phosphorus loading within the rapidly urbanizing Greater Toronto Area.

S14-01 The use of aquatic macroinvertebrate sub-fossil remains to help identify ‘reference conditions’ for the restoration of the River Wensum, Norfolk

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The impact of anthropogenic activities on riverine environments has been extensive throughout documented history, with the last 200 years bringing about unprecedented transformations. Given the need to achieve ‘Good Ecological Status’ (GES) for the EU Water Framework Directive (WFD) and to define ‘reference conditions’, there is an urgent need to examine how palaeo-ecological techniques can inform river management and restoration activities. Palaeochannels represent sedimentary archives that provide detailed records of channel evolution. Examination of sedimentary records and the sub-fossil remains of aquatic macroinvertebrates (e.g., Trichoptera, Coleoptera and Gastropoda) can be used to determine historic instream hydraulic and habitat characteristics. This paper examines how palaeo-ecological information can help inform contemporary river management using the River Wensum in Norfolk to illustrate the approach. The River Wensum is designated as a Site of Special Scientific Interest (SSSI) as well as a European Special Area of Conservation (SAC). However, the condition assessment undertaken in 2002 concluded that the river was in an unfavourable condition due to poor water quality, siltation and physical modifications. The results of this study were obtained from examination of the sedimentary sequences and sub-fossil invertebrate remains from a palaeo-channel, formed in the 1940’s as a result of channel straightening, and the contemporary riverine fauna. Direct comparison of the palaeo and
contemporary Trichoptera, Coleoptera and Gastropoda communities enabled the identification of changes between the 1940’s (baseline / reference condition) and the contemporary channel. The potential wider application and value of the approach in underpinning the restoration of lowland rivers is explored.

**S14-02 European Mountain lake Biodiversity: Contemporary patterns and change since the pre-industrial era**

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Although mountain lakes are generally perceived to be in pristine condition they are threatened by acid deposition from sulphur and nitrogen compounds, atmospheric deposition of persistent organic pollutants, and trace metals and they are also vulnerable to the effects of climate change. Climate change is one of a number of threats to aquatic biodiversity in mountain regions. Temperature, in particular plays a key role in life-cycles and the general distribution of biota. Under a warming regime cold-adapted taxa may have no opportunity for migration, with the possibility of local and regional extinctions occurring. Given the degree of endemic species in some mountains, local extinction may result in a worldwide species extinction. In addition, although suitable habitats may not disappear completely for most species, the altitudinal upward displacement of low temperature isotherms will result, for many species, in a shrinking of niche space. Further, milder weather will facilitate expansion of low altitude species upwards and alien invasion of hitherto unsuitable habitats.

Here we present results from a statistical analyses of data from over 350 mountain lakes across Europe examining;

i. current biodiversity patterns in European Mountain lakes using contemporary and surface sediment samples,

ii. how biodiversity has changed in European Mountain Lakes by comparing the surface sediment record with samples representing pre-industrial conditions, and

iii. the impacts of multiple stressors on mountain lake biodiversity

**S14-03 Relationships between chironomid diversity and temperature in lakes from Europe and North America**

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Investigations into the relationship between biodiversity and climate, and changes in biodiversity in relation to climate change, have mainly been based on short-term ecological studies or in experimental settings, and relatively few have focussed on invertebrates or freshwater systems. Palaeoecological data offer the possibility of studying changes on long time-scales, and determining how known cold and warm periods in the past have influenced changes in diversity. Here, we look at the relationship between the diversity of chironomids and temperature in a range of modern datasets from Europe and North America, as well as changes in chironomid diversity during the Lateglacial, Holocene and the last millennium. In modern datasets from Iceland, Sweden, Norway, Russia, Switzerland and eastern Canada, a relationship between the Hill’s diversity index and the measured mean July temperature was studied. Our analyses suggest that chironomid diversity increases as summer temperature increases to reach a peak at around 20°C. Diversity then declines before increasing once more above 25°C. Our analyses suggest that summer temperature is more influential in driving chironomid diversity than other variables (e.g. TP, water depth, LOI). Through the
late-glacial and Holocene a decrease of in chironomid diversity is apparent during the Younger Dryas, the 8.2 ka BP event and “Little Ice Age” cold episodes. Chironomid diversity increased during warmer periods including the Holocene Thermal Maximum and the “Medieval Climate Anomaly”.

S14-04 Can taxonomic and functional classifications provide similar insight into the diversity-productivity relationship for lake communities? A paleolimnological perspective

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Nutrient enrichment has long been found to drive the community structure and diversity patterns of lake organisms. In particular, species richness and community dissimilarity are sensitive indices in response to the changes in lake productivity. Taxonomic differences mainly reflect the evolutionary history of taxa, however, their impacts on ecosystem functioning through the phylogenetic and functional features remain largely unknown for aquatic organisms. This talk will present an application of taxonomy and trait-based approaches to explore the patterns of diatom and cladoceran community responses recovered from surface sediments of 31 Irish lakes along an eutrophication gradient. Cell size and volume, cell shape, coloniality and motility are the main traits for diatoms; cladoceran functional traits include body size, habitat preference, trophic level and feeding type. Taxonomy-based patterns will be compared with trait-based indices to test whether trait-based methods could provide additional information on community responses for diatoms and cladocerans, which are at different trophic levels. Trait-based community structure patterns for both organisms will then be compared to examine the impact of nutrient and energy link along food webs (i.e. bottom-up effect), as well as the predation control exerted by planktivores (i.e. top-down effect). Trait-based community and diversity patterns can help understand the mechanisms that structure the community and help predict how communities reorganize with lake eutrophication. Therefore, approaches based on both trait and taxonomic groups have the potential to be used to detect specific impacts under different environmental stressor scenarios.

S14-05 Long-term changes in diversity linked with eutrophication and dispersal in shallow lake metacommunities

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The Upper Lough Erne system in Northern Ireland comprises a dynamic, hydrologically-connected and eutrophic shallow lake landscape. Evidence from contemporary comparative analyses of macrophytes and macroinvertebrates indicate that dispersal is a major force in community structure in the system. Dispersal facilitates local biological compositional responses to eutrophication by compensating for local extinctions though immigration processes. By using a multi-proxy, multi-lake palaeoecological approach this study investigates the long-term simultaneously responses of selected taxa to nutrient enrichment and dispersal. Our data revealed changes in community composition and in the relative abundances of species along three major temporal phases (c. pre-1900 oligo-mesotrophic assemblages to c. 1950-1900 mesotrophic assemblages and to c. present-day-1950 meso-eutrophic assemblages). Temporal assembly dynamics suggests a change in dominance over time that occurred more rapidly than changes in species composition. This trend is consistent with transitions that would be expected under a joint interaction of dispersal and eutrophication. This change was accompanied by an increase in temporal (within-lake) and regional (between-lakes) β-diversity. Our data indicates that dispersal has helped to buffer the effects of eutrophication by maintaining poor competitor
species over time. The significant increase in dominance, suggest however that if continuing, eutrophication may eventually overcome dispersal. Our study provides novel insights on the application of palaeolimnology for studying the effects of eutrophication and other processes that occur on a regional scale (e.g. dispersal) in structuring shallow lake communities.

**S14-06 Subfossil Bosmina size structure as an effective tool to track changes in food web structure**

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Paleolimnological techniques continue to be embraced by lake managers globally as an effective method for assessing the impacts of environmental perturbations on lakes. However, many challenges still exist regarding the usefulness of palaeolimnology for tracking changes in predation regimes. Subfossil Cladocera are often used as indicators of fish predation, especially the proportion of Daphnia, a preferred prey item for planktivorous fish. However, Daphnia are also highly influenced by abiotic factors, which can limit their utility in tracking food web shifts. Within the Cladocera, Bosmina morphology may change in response to fish and invertebrate predation. Because their remains are well preserved and often highly abundant in lake sediments, the potential exists to use measurements of subfossil Bosmina morphological features to indicate shifts in predation regimes. Using examples from lakes in the eastern Maritime province of Nova Scotia, Canada, we will demonstrate the effectiveness of subfossil Bosmina morphology for detecting food web shifts resulting from biomanipulations like the introduction of smallmouth bass, stocking of brook trout, and, in an extreme case, the elimination of the native fish community of a lake via copper sulphate poisoning. Collectively, these examples demonstrate that Bosmina morphology may provide a better indication of changing predation regimes than cladoceran species assemblage structure in multiple stressor systems. Moreover, the relative ease of size measurements make Bosmina size structure well suited for complementing the more traditional cladoceran assemblage techniques. Collectively, these datasets can provide a more holistic picture of long-term changes occurring in aquatic food webs in response to anthropogenic stressors.

**S14-07 Cryptic genetic diversity in Staurosira construens from arctic lake sediments**

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This study provides insights into the morphological and genetic diversity of diatoms in Siberian lake sediments. In addition to morphological analyses of diatom assemblages, we designed a genetic survey technique specific for diatoms utilizing a short region (73-76 bp) and a large region (577 bp) of the ribulose-1,5-bisphosphate carboxylase/oxygenase large subunit (rbcL) gene as genetic marker. Our analyses (i) validated the use of the short rbcL fragment as a barcoding marker for diatoms, applied to arctic sediment samples and (ii) showed similar results obtained by morphological and molecular data, as both recent data sets were dominated by fragilaroid species/haplotypes. Contrastingly, core samples showed higher diatom diversity mirrored by both approaches. Within the groups of fragilaroid types (iii) results of the large rbcL fragment indicated spatial genetic variation in Staurosira construens resulting in distinct genetic lineages (supported by significant pairwise FST values) occurring in different lakes. This genetic diversity, hidden behind same morphotypes, is probably correlated to ecological differences in the lakes.
investigated.

Given the promising results from single core sediment samples in this study, future studies on continuous sediment cores started, and preliminary investigations indicated the presence of intra-specific genetic variation over time. With this data we will be able to track changes in diatom turnover on a finer scale that might be correlated to environmental changes in the Arctic over the last 2000 years.

S14-P-01 Reconstruction of paleovegetation changes during the development of Lake Mazais Ungurs according to the plant macrofossil analysis data

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The study of plant macroremains from the sediments of Lake Mazais Ungurs (Eastern Latvia, 57°20'06"N 25°04'12"E) was carried out with special attention to very rare aquatic plant species Isoëtes lacustris occurrence. Plant macrofossil composition and sediment chemical analysis to determine total nitrogen concentration (g kg\(^{-1}\)), phosphorus pentoxide (g kg\(^{-1}\)) concentrations and sediment pHKCl value were carried out in study.

Five plant macroremain zones (PMA) have been subdivided in studied sediment section reflecting changes in vegetation composition during the lake development.

Changes in the aquatic plant macrofossil composition in Lake Mazais Ungurs sediments is caused by Ungurs Mire impact on the lake water pH: seeds found in the deeper parts of the sediment (Nuphar lutea, Potamogeton natans, Characeae) indicates towards basic lake water pH, but the upper parts of sediment (Isoëtes lacustris, Typha) suggest acidic water pH value.

The chemical analysis data indicate the higher concentrations of the total nitrogen (g kg\(^{-1}\)), phosphorus pentoxide (g kg\(^{-1}\)) and total carbon (%) content in comparison with sites were Isoëtes lacustris are not growing. The sediment pHKCl value was higher in the places where the plant is not growing.

Changes in the aquatic (Nuphar lutea, Isoëtes lacustris, Potamogeton natans, Scirpus lacustris, Typha sp.) and wet meadow plant (Carex, Lycopus europaeus, Comarum palustres) composition indicate the water level fluctuations. The development of the Isoëtes lacustris in Lake Mazais Ungurs coincides with the appearance of wood coal appearance in sediments, which may be a reflection of the human impact on the development of Isoëtes lacustris.

S14-P-02 Changes of Lake Engure sedimentation conditions reflected by paleovegetation records

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Study of lagoonal origin Lake Engure sediment composition has been done with aim to get valuable information about lake development character and thus can be used to study long-term, natural, human and climate impacts on lake and it basin, which provoked eutrophication and lake-level changes. The results of plant macroremains, pollen and sediment biological composition analysis applied in this study clearly indicate changing sedimentation environment since the Littorina Sea transgression and intensification of lake eutrophication and overgrowing processes after the Mersrags Canal building.

Pollen data from the different parts of the lake reflect various evidences of paleovegetation, which, probably, can be explained by erosion or redeposition of sediments. Strong proof of the human presence and activities has been recorded by weed and ruderal plant pollen in the sediments conditionally attributed to regression time of the Littorina Sea (approximately before 5000-4500 years) and last century.

Presence of plant macroremains of Fennel Pondweed (Potamogeton pectinatus) and Horned
Pondweed (*Zannichellia palustris*) point on seawater inflow in the lake. Appearance of these plant remains and presence of brackish diatoms (*Mastogloia elliptica, M. smithii, Diploneis didyma* etc.) is more frequent from the depth of 20 cm, which is dated by $^{210}$Pb method and is in good correlation with the Mersrags Canal excavation date. The results of this study indicate that the human impact on Lake Engure ecosystem, building of the Mersrags Canal is reflected in lake sediments. Both results of sediment composition and paleobotanical analysis indicate significant changes during superficial sediment accumulation.

S14-P-03 Spatial distribution of sub-fossil Chironomidae in surface sediments of a large, shallow and hypertrophic lake (Taihu, SE China)

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Spatial heterogeneity of benthic communities has clear implications for estimating lake production, biodiversity as well as identifying representative sites for palaeolimnological studies. This study investigates chironomid variability and the controlling factors (environmental and spatial variables) in surface sediments from Taihu Lake (2338 km$^2$), a hypertrophic lake in the Yangtze delta in eastern China. The spatial distribution of chironomids shows distinct heterogeneity. *Microchironomus tabarni*-type and *Tanypus* dominate midge communities around the estuaries, while *Cricotopus sylvestris*-type and *Polypedilum nubifer*-type are the predominant taxa in the East Bays and the East Taihu Lake. Redundancy analysis revealed that four variables were identified as significant factors that influence chironomid community structures. High nutrient concentrations around the estuarial areas favor the development of nutrient-tolerant taxa. Water depth-related oxygen depletion in the open lake during algae blooms prohibits the survival of many organisms, except for a few hypoxic-resistant species. High transparency in the East Bays and the East Taihu Lake indirectly creates a favourite microhabitat for macrophyte-associated chironomid species through aquatic plants. Space per se is a significant forcing factor for organism community and distribution at scales of >1000 km$^2$. It might be important to consider spatial variables more explicitly in future studies of chironomids in large lakes where multiple stressors make the interactions within the ecosystem more complicated. This study aims to illustrate the ecological characteristics of specific chironomid taxa related to a ‘micro-ecosystem’ which is contributed by multiple environmental gradients within a large lake, and to provide empirical support for interpretation of palaeo-chironomid data.

S14-P-04 Multi-proxy research of the exploited former lake, Lake Komorany, Czech Republic

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The lack of natural lakes is typical for the Czech Republic. Several limnic sediments originated in the Late Glacial were discovered beneath the surface. The only larger lake which persisted until the 19th century was the Komorany Lake (the Most Basin, Northern Bohemia). However, its sediments were totally removed due to the coal mining. Presented multi-proxy study comprises the last several archived sediment profiles. Development of aquatic environment was tracked using diatoms, plant macrofossils, coccol green algae, sedimentology, geochemistry, stable isotopes and chironomids. The surrounding vegetation cover was reconstructed by
the means of pollen analysis. Potential human impact was reflected by the settlement density data. Radiocarbon dating placed the formation of the lake into the Bølling period. Further expansions of the water body deduced from the developing of littoral profiles occurred in the Preboreal period. Then, the character of the aquatic environment was very steady without major disturbance up to the abrupt eutrophication in ~2200 yrs BC. Its connection with the decrease of water level suggests rather natural causality, although synchronicity with the start of the Bronze Age prevents exclusion of the human impact. The most recent and probably the largest expansion of water body was indicated by the formation of the littoral profile in the interval of ~800 yrs BC – 500 yrs AD. Following lacustrine development is not clear since the upper sediment layers were removed during exploratory works foregoing the mining.

S14-P-05 Paleoecological study of the littoral profile from the former lake, Lake Komořany, Czech Republic

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Lake Komořany represented the largest Holocene natural water body in the Czech Republic. Its area was approximately 25 km² and depth reached estimated maximum of 10 m. The water basin was completely artificially drained in the 19th Century. Limnic sediments totally disappeared owing to surface mining of tertiary brown coal deposits on the site in 20th Century. However, several lacustrine profiles were recovered before the complete sediment removal. The profile PK-1-CH recorded the middle Holocene (~7200 – 2100 yrs BC) development in the southern littoral part of the basin. Within the interval, no major changes in the aquatic environment deduced from diatom analysis and diatom inferred transfer functions were revealed. Similarly, geochemical data along with macrofossil record suggest rather gradual moving of the lake shores towards the profile location until the abrupt transformation to the fen in ~2200 yrs BC. In contrast, archaeological settlement density in the lake vicinity changed considerably with the maximum in the Neolithic. It indicates minor influence of the Neolithic and Eneolithic (Late Neolithic) activities on the lacustrine environment, although changes in the pollen spectra documented human impact on the plant cover. The invariable development of the lake environment is also in conflict with proposed climate alteration during the studied period (Boreal – Atlantic- Epiatlantic). It raises the discussion of the central European Holocene division.

S14-P-06 Lake sediment DNA barcoding: a new tool to reconstruct past human activities and plant cover?

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Here we propose to use a new proxy, DNA barcoding, to reconstruct human activities and plant cover evolution, in order to better characterise human-climate-environment interactions from lake sediments. Extra-cellular DNA from mammals and plants is preserved in lake sediments, bind to clays, sands, humic substance and organomineral complexes. The method consists in four steps: (i) extra-cellular DNA extraction from the sediment, (ii) amplification with appropriate primer pairs (different for mammals and plants) of short-enough regions to allow the amplification of degraded DNA, (iii) DNA sequencing on next generation sequencers and (iv) comparison of the sequenced DNA barcodes to a reference database. This last step permits to establish the relative abundance of a list of taxa,
with identification up to family level and sometimes to genus or species level.

The Holocene sediment core of Lake Anterne (2063 m asl, NW French Alps) was chosen for the study because soil and erosion histories were already known. Moreover, palynological and archaeological data are available for the catchment and around. This well-known context thus constitutes a favourable situation to evaluate the potential and the validity of DNA barcoding as a proxy of grazing activity and plant cover successions. Twelve samples corresponding to periods of major environmental changes (from -25 to 10160 years cal. BP) were taken for a preliminary test.

Collected data suggest an expansion of plant cover during the first half of the Holocene, leading to the soil development that was previously underlined through organic geochemical measurements and erosion records. In detail, the first taxa having place in the catchment are Salicaceae for trees and Saxifragaceae for herbaceous. They are followed by Pinus genus with Apiaceae and Asteraceae. These species start to decrease around 3400 cal. BP and characterise a landscape opening, also marked by the appearance of Alnus genus. At the same time, Plantago genus appears, suggesting an opening accompanying grazing activity. First occurrences of sheep and cow DNA are found during the Iron Age (2340 cal. BP) and Antiquity (2000 cal. BP). During, the Little Ice Age a grazing activity with only cow is also recorded. During these periods, enclosure concentrating flocks and thus the faeces may have existed in the catchment. This assumption seems supported by archaeological data, as a summer pastoral dwelling, occupied at least from the Late Iron Age to the Early Antiquity, was discovered on Lake Anterne shore.

Ancient lakes with sediment records spanning more than one glacial-interglacial cycle are rare. They are renowned for their high biodiversity value and offer unique potential for long-term continental palaeoenvironmental reconstruction. In the context of understanding ecosystem and biodiversity response to anthropogenic impact during the Holocene, it is often difficult to disentangle the relative impacts of climate change and human activities, and the influence of natural lake ontogeny is often assumed to be negligible. This poster presents summary results of diatom analysis of the last glacial-interglacial cycle in the ancient graben, Lake Ohrid (Albania/Macedonia; Ohrid ICDP project; B. Wagner et al.; core Co1201; 135 ka) and of the last three glacial-interglacial transitions in tectonic lake Ioannina (NW Greece; NERC C507210; core I-284; &gt;200 ka). The primary aim was to test response to past climate change, but the results have important implications for understanding natural shifts in biodiversity, whole-ecosystem status and proxy response, upon which the imprints of human activity are superimposed. Firstly, the assumption that taxa exhibit a linear response to a single environmental parameter can be false; in the case of these two lakes, which share some dominant taxa, the response is driven variously by changes in lake level, nutrient status and ice cover. In Ioannina, response thresholds (to climate) vary over time even within a single lake basin. We have identified impacts on biodiversity due to anthropogenic activities – both positive and negative – and tentative regional evidence for evolution at an intra-specific level.

S14-P-07 Palaeoecological reflections on biodiversity, whole-ecosystem shifts and proxy response: ancient lakes of the circum-Mediterranean

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S14-P-08 Examining benthic community response to road salt contamination in lakes: insights from a modern Arcellacea (testate lobose amoebae) dataset from southern Ontario, Canada

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Arcellacea, also known as thecamoebians or testate lobose amoebae, are unicellular protozoans that occur in fresh and brackish water environments. They are useful for palaeoenvironmental reconstruction because they are sensitive to a wide variety of environmental variables and because their tests are generally resistant to dissolution. In lakes, faunal assemblages are sensitive to many parameters, including substrate changes, nutrient loading, temperature change, salinity, pH and metal contamination. Few studies have, however, attempted to quantify the relationships which this predominantly benthic group of organisms have with specific environmental controls, or studied intra-lake variations in assemblage composition. We examined modern lake arcellacean faunas from lakes with a significant history of winter de-icing salt contamination in the Greater Toronto Area, together with lakes with reduced or no de-icing salt inputs from more rural settings, to i) examine spatial responses to salt contamination; and ii) develop an arcellacean-derived ‘Salt Contamination Index’ for assessing lake community response to salt loading over several seasons. Key road-salt related water property (e.g. conductivity, Na, Mg and Cl ions) and sediment-based geochemical variables were measured. Detrended Correspondence Analysis (DCA) and Q-R-mode cluster analysis of the assemblages from 70 stations in 15 lakes resulted in recognition of four community groupings. The findings show that the group have considerable potential for elucidating the timing, scale and impacts of salt contamination in lakes and for delimiting pre-disturbance conditions, which are integral for remedial efforts.

S14-P-09 Assessing the changing status of slender naiad (Najas flexilis) in Scottish mesotrophic lochs using the sediment record: implications for conservation

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Najas flexilis is considered a threatened species, and is protected under domestic and international legislation. Based on 19th and 20th century botanical records, the distribution of Najas flexilis in the UK is currently thought to be in decline (Wingfield et al., 2004). Knowledge of the conditions in which the plant thrives suggests that this may be linked to: (i) eutrophication; and/or (ii) competition from invasive species (Wingfield et al., 2004; 2006). The plant is highly suited to the use of paleolimnological techniques due to the good preservation of macrofossils – particularly seeds – in the sediment. Despite this, the decline has never been investigated in this way. This new PhD project is embarking upon a comparison between historic botanical records and the occurrence of Najas flexilis seeds in new sediment cores in order to assess the representation of the rare species through time. It is hoped that, with this knowledge, information gleaned from macrofossil reconstructions will run alongside multi-proxy investigations into the environmental changes since 1850, and that the decline of one specific species of scientific interest – Najas flexilis – may be determined.

S14-P-10 Climate variability of the last 1,500 years in the NW Pacific: High-resolution, multi-biomarker records from lake sediments

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A key question in climate science is: to what degree
are current climatic changes unusual in their rate and magnitude? To answer this question on a global scale, geographically widespread records of climate change are required. While, instrumental measurements only record the last ca. 150 years of climate change, ‘proxy’ records from tree-rings, lake and ocean sediments and other paleo-climate archives extend these records back much earlier. Many such proxy records now exist for northern Europe and the N.E. USA. Despite the vulnerability of the highly populated regions of Japan, Korea and N.E. China to future climate change, the North West Pacific region is an under-represented region. With a focus on Hokkaido, Japan, this study aims to reconstruct past changes in temperature over the past 1,500 years. Following pilot studies, Lake Toyoni was identified as a promising site due the presence of alkenones which have not been reported from any other lake sites in Japan.

Alkenones are produced by haptophyte algae within the water column. They have been widely used as a paleo-temperature proxy in the marine environment for decades however their use in lakes is novel. In the marine environment, the haptophyte algae producing alkenones are well-known. In comparison, the identity of lacustrine alkenone producer(s) may be different at different lake sites (and therefore require different temperature calibrations). As a result, it is important to identify the alkenone producer(s) within lakes. This study presents genetic DNA fingerprinting data to identify the alkenone-producer(s) in Lake Toyoni.

S14-P-11 Functional diversity of Cladocera attributes to lake deterioration – A paleolimnological perspective

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In paleolimnology, biodiversity has traditionally equaled to species diversity, although for ecosystem functioning taxonomic identity may not always be relevant because community and ecosystem processes are dependent on functional characteristics of species. Thus, functional diversity (FD), which is a biodiversity measure based on functional traits of species, may enable assessing ecosystem functioning and stability more comprehensively. The objective of the current study was to evaluate the usability of FD in paleolimnology by examining the centennial succession of Cladocera FD from a severely eutrophicated lake. Ecological characters (body size, feeding type, habitat affinities) relevant to ecosystem functioning were chosen to separate functional traits. The functional dendrogram revealed that taxonomic identity does not fully correspond to functional differences but taxonomically close species exhibit separation in their functions, especially within Chydoridae. The FD index used for the core assemblages was based on the dendrogram of the cladoceran community with weights of species abundances and it was compared to taxonomic diversity indices and to an independent proxy-based inference curve of total phosphorus. The results showed that FD had a similar trend with taxonomic diversity decreasing along with eutrophication and a strong negative relationship with trophic status. The results suggest that long-term succession of functional diversity in aquatic communities may be indicative of environmental perturbations (eutrophication) and ecosystem functions (productivity, resilience).

S14-P-12 Exploring fossil assemblages from modern woodland ponds; implications for catchment processes and biodiversity

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As part of research investigating Holocene and interglacial vegetation open-ness, we have examined the relationship between selected proxies (Coleoptera and pollen) and their catchment within shallow woodland ponds in England (Smith et al.,
We have sampled modern surface-sediments from 25 ponds from a diverse range of ancient woodland environments with differing levels of openness, grazing regimes and management. Here, we compare the catchment area of fossil insects and pollen rain from the different sites as well as intra- and extra-pond variability of the recent fossil assemblages.

These data reveal important insights into the formation and catchment of the fossil record and the relationships between the fossil archive, proxies, and the spatial representation of the wider landscape. Additionally, the Coleopteran assemblages also reveal major differences in terms of community dynamics and biodiversity compared with earlier Holocene palaeoecological records as well as critical insights into the aquatic ecosystem being sampled.

The former Komorany Lake (the Most Basin, Northern Bohemia) was a large open natural aquatic area, without any adequate analogy within the area of the Czech Republic. Thus, it is a site whose elaborate investigation poses a particular challenge. Since the basin of the former lake has been completely destroyed by coal mining, recently rediscovered well preserved sediment profiles possess the last complete record of past environmental changes.

In order to obtain the complete palaeo-information, we have contributed to the detailed knowledge of this site with a multi-proxy analysis. Results indicate that formation of the profile PK-1-C corresponds with the expansion of the lake water level at the beginning of Holocene. Following distinctive fluctuations in pollen and diatoms concentrations and spectra could be assigned to the water level fluctuation and local desiccation supposedly during Preboreal oscillations. Pollen analysis revealed the discrepancy in pollen record captured in different parts of the lake. Further results originating from the data of the PK-1-C profile proved, that no direct human impact on aquatic environment was detected using diatom inferred total phosphorus and pH along with concentration of tracked element during ~9200–2200 BC. However, eutrophication connected with the infilling process was documented during Subboreal (~2200–1200 cal BC) by loss on ignition, macrofossil and diatom analysis. Pollen and microcharcoal analysis indicate distinct human impact during the Bronze Age at the site.

Palaeolimnological techniques are increasingly recognized as important tools for interpreting changes in biodiversity in lake ecosystems. Diatoms are particularly suitable for studying the sedimentary records of past changes in biodiversity because their remains are diagnostic at the species level and the number of original individuals coincides with the number of preserved fossils.

Lake Sihailongwan, a maar lake in northeastern China, is an ideal site for studying long-term variations in past diatom biodiversity. The varved sediments of this lake are precisely dated, provide a continuous record covering up to 80,000 years and diatom remains are generally abundant and well preserved.
In this study, changes in diatom biodiversity over the past 20,000 years were assessed using species richness standardized by rarefaction analysis, as well as other measures of diversity such as species evenness (estimated using Hill’s N2) and dominance (Simpson’s D). To address the issue of changes in sedimentation rate, contiguous sediment intervals at the top of the core were pooled so that they represent the same time windows as samples taken deeper down-core. Differences between planktonic and benthic components of the fossil assemblages were also assessed.

The interval around 13 kyrs BP, which corresponds to the Allerød period in the European biostratigraphy, is characterized by particularly low diversity as the assemblages are dominated by *Stephanodiscus minutulus*, an indicator of eutrophic conditions.

**S14-P-15 Assessing microbial diversity using recent lake sediments and estimations of spatiotemporal diversity**

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A central theme in ecology is to understand the factors that control species diversity and distribution in natural ecosystems. Lakes have been of scientific interest to ecologists since the 19th century. They are species diverse and highly responsive to environmental change. Evidence for such change is often preserved in lake sediments. These palaeoenvironmental records allow past communities to be reconstructed and so can extend the temporal scale of contemporary ecological studies. Furthermore, lake surficial palaeolimnological samples potentially hold a large amount of empirical data that are readily available for developing and testing ecological theory. Recent papers have used large palaeolimnological datasets to reveal biodiversity patterns of aquatic microorganisms. However, scant attention has been paid to the influence of time on these patterns. Where lake surficial sediment samples are used as integrals of diversity, the time interval of each sample varies according to differences in sediment accumulation rates. Here we show that increasing the time interval represented by a surficial sediment sample did not affect the diversity results. Diversity estimation was only altered in lakes experiencing high community turnover due to strong environmental change. The use of surface lake sediments is suitable for estimating the average site diversity of free-living microorganisms. Diversity is integrated in a single sample and species assemblage composition is derived from microbial communities living in distinct lake micro-habitats. Species remains, accumulated in a single sample over several years of environmental variability, represent a diversity integral that captures a spatiotemporal component equivalent to gamma diversity measure.

**S14-P-16 Mid-Late Holocene environmental changes based on multiproxy records from lake sediments of Laguna Encantada, in the Neotropical Gran Sabana (Venezuelan Guayana)**

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The Gran Sabana (GS) region (SE Venezuela) lies on the north-eastern sector of the Precambrian Guayana Shield. The GS is characterized by treeless savannas intermingled with forests patches. Diatom-based paleolimnological studies are scarce in the GS and in Venezuela, in general. This work is part of a high resolution study with emphasis on biological responses within the aquatic environment. In this study, we analyze the environmental changes occurred during the last 6900 cal yr BP using diatoms, sponge spicules and pollen analyses on lake sediment cores from Laguna Encantada. The
information from these biological proxies is interpreted in combination with physico-chemical proxies, in a multiproxy approach. The record was subdivided into three zones. The first two zones (6880-3500 cal yr BP and 3500-1750 cal yr BP) represent two different types of forest succession apparently related with fire dynamics. The silicobiolith results together with the physico-chemical properties of lake sediments indicate relatively dry mid and early-late Holocene climates and lake level variations. The last zone (1750 cal yr BP to present) represents a significant vegetation change, likely as a consequence of increased local fire incidence. C/N values indicate higher aquatic productivity, and the diatom increase points to a slight wetter climate and higher lake levels. Local fires have been related with the increased human presence and the corresponding landscape transformation. This study contributes to clarify the role of both climate and humans on the shaping of present-day GS landscapes and the response of water bodies and the ecosystems they contain.

Lake Iznik is located 20 km to the east of the Marmara Sea (Western Turkey), in the expected key area of transcontinental dispersal of modern humans from the Near East to the Balkans. Recently discussed to serve as a potential (temporary) waterway connecting the Black Sea and the Mediterranean during the Quaternary. We retrieved a continuous sediment record from Lake Iznik covering the past ~36 ka cal BP. A multiproxy approach enabled us to reconstruct the environmental history. We included diatoms, cladocerans and ostracods as biological proxies, but also physical and geochemical proxies were analysed.

Here we present the ostracod record, which changed dramatically in the Pleistocene from a low diversity fauna (Candona, Ilyocypris, Leptocythere, Limnocythere) to a monospecific assemblage (Limnocythere inopinata) lasting the entire Holocene. An substantial alteration in the hydrology of the lake which led to a sudden increase in alkalinity is proposed to have caused the whole ecosystem to change. This is also supported by geochemical sediment proxies (i.e., element analysis), diatoms and ostracod shell chemistry. In addition, we demonstrate that morphological changes of Limnocythere shells can be used to infer lake water quality based on modern regional training sets. Finally, we are confident to stress that Lake Iznik was not connected directly to a marine realm during the time covered by our study.
Session 15 Abstracts – Terrestrial Matter Cycles and Impact on Lake Functioning

Session 15 - Holocene lake sediment records of changing terrestrial matter cycles and their impact on lake productivity and functioning

S15-KN  Paleo-productivity, the Elusive Grail – Integrating the effects of nutrient and DOC loading on lakes over millennial timescales

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One of the enduring themes in paleolimnology is the long-term trophic development of lakes – as a consequence of natural or anthropogenic changes in material export from the terrestrial catchment. While we’ve become reasonably proficient at reconstructing material fluxes (nutrients, major ions, sediment) associated with human disturbance, progress on the effects of natural forcing (climate, fire, vegetation and soil development) is more limited largely because of the comparative subtlety of the signals and the complexity of the catchment processes involved. And trophic reconstruction itself has been a particularly elusive grail, owing to the fact that we have no reliable proxy for total ecosystem productivity and because heterotrophic and autotrophic production cannot at present be de-convolved in the sediment record. This presentation will review concepts of lake productivity from a paleo- and neo-limnological perspective and efforts to reconstruct trophic change and its linkages to the transfer of both organic carbon and nutrients from the terrestrial system. Nutrient export, particularly that associated with human activities, has received the greatest attention in our discipline, owing to its obvious effects on autotrophic productivity. However, organic carbon subsidies, which reflect long-term-catchment vegetation succession and soil process, have equally profound effects on biological structure and trophic interactions in aquatic systems. This talk will thus consider the contrasting trajectories and drivers of heterotrophic and autotrophic production in the context of postglacial landscape development, land-use disturbance, and climate change.

S15-01  Long-term dynamics of phosphorus in deglaciated landscapes: combining Holocene lake sediment records with process modelling

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Our current understanding of long-term (Holocene) phosphorus dynamics in terrestrial ecosystem derives mainly from studies of soil chronosequences, with the consequence that most effort has been devoted to quantifying solid phase transformations. Here we present an alternative source of information, provided by lake sediment phosphorus records, that emphasises instead the leakage of phosphorus from soils. We show that these two contrasting data types complement each other, and together reveal a pattern of early soil development characterised by rapidly depleting primary soil apatite paralleled by rapid leakage of P from the soil. This pattern is entirely consistent with the soil chronosequence data and analysis of Walker and Syers (1976) and Crews et al. (1995), but conflicts with more recent quantitative interpretations of global soil P dynamics, the latter characterised by far slower soil P export rates.

We present evidence that the high soil P leakage rates found at our lake sites and published soil chronosequences are representative of the global situation, such that geological dominance of P on newly formed soils lasts in the order of 104 years, not 106 as previously suggested. This being so, then three important changes must be made to the current conceptualisation of terrestrial P dynamics. First, the initial geological dose, long regarded as the major source of P for terrestrial ecosystems, is globally much less important than atmospheric supply. Thus, Walker and Syers “terminal steady state” is the norm not the exception, and would better be termed the “atmospheric phase”. Second, in the face of far weaker soil P retention than previously thought, the role of bioregulation in governing soil P availability needs re-evaluation. Third, given high rates of P
leakage, rapid apatite dissolution and consequent depletion from soils on deglaciated land leads to any early pulse in P supply to surface waters, with important implications for our understanding of early Holocene aquatic ecosystems.

S15-02 Farming, mining and extreme flows: impacts of accelerated sediment flux to Bassenthwaite Lake


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Lakes in the NW England, as part of a wider regional signal, have experienced substantial changes in both water quality and the fluxes of inorganic and organic materials from their catchments. These changes have to greater extent been attributed to impacts on landscape and water courses by human activity. Bennion et al. (2000), for the deeper abyssal waters at Bassenthwaite Lake (NW Lake District), identified increases in nutrient fluxes in the last 250 years and a trend with the sediment becoming more organic, reflecting eutrophic conditions and accumulating more rapidly in the last 100 years. Bassenthwaite Lake has protected status (NNR, SSSI), attracting attention for the probable demise of Coregonus albula L. (Vendace), the rarest and most threatened freshwater fish in Britain. Recent work sampling sediment records from shallower waters near the main River Derwent and Newlands Beck inflows to the lake reveal a complicated history of varying sediment flux during the last 500 years driven by catchment agriculture, industrial activity (mineral ore extraction) and flood events. The geochemistry of the lake sediments faithfully mirrors mining production data for the catchment contributing a well resolved chronology. Rates of sediment accumulation are rapid across the southern third of the lake with >2.5m in 4-500 years, the burial of gravel bed spawning grounds probably a key contributor to the demise of the vendace. There is also a strong regulation of mineral matter flux to the lake by extreme flows with the delta proximal sediments displaying a clear flood stratigraphy.

S15-03 Can sedimentary pigments be used to track ecosystem response to climate change and anthropogenic impacts in Australian lakes? A case study from Tower Hill, Victoria, Australia

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Tracking the response of lakes to past climate change and anthropogenic impacts through changes in aquatic community structure provides a baseline from which we can understand how aquatic ecosystems may respond to future pressures. South-eastern Australia has recently experienced a severe drought, lasting for more than a decade. This drought caused considerable change to the ecology of many lakes; in western Victoria many lakes dried completely, whilst others had a significant decline in water level, which was unprecedented since European settlement.

This research aimed to investigate changes in lake ecosystem function using sedimentary pigment biomarkers. Tower Hill, western Victoria, presents an opportunity to compare new results from sedimentary pigment analyses over the last 6000 years to other biological proxies, as well as a number of other studies undertaken at the site over the last 30 years, allowing an integrated understanding of ecosystem function through time.

The reconstruction of phototrophic community structure indicates major changes in primary production and algal composition across five major periods at Tower Hill. Productivity was high 5550 years BP but declined until 2000 years BP. The lake appeared to be at its most productive c. AD 1500, after which productivity declined once more. In the
last 100 years lake productivity once again increased. Prior to European settlement, productivity tracks periods of climate variation as demonstrated by other studies from the region (e.g. Lake Keilambete). However, the most recent productivity increase is likely a net result of catchment disturbance, increased nutrient delivery and a drying climate.

S15-04 Carbon burial by shallow lakes on the Yangtze floodplain and its relevance to regional carbon sequestration


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Floodplain lakes may play an important role in the cycling of organic matter at the landscape scale. For those lakes (over 600 lakes >1 km²) on the middle and lower reaches of the Yangtze (MLY) floodplain which are subjected to intense anthropogenic disturbance, carbon burial rates should, theoretically, be substantial due to the high nutrient input and high sediment accumulation rates. 210Pb-dated cores were combined with total organic carbon (TOC) analyses to determine annual C accumulation rates (CAR) and the total C-stock (since ~1850). The sediment TOC content is relatively low, with an average <2% in most lakes. CAR ranged from ~5 to 373 g C m⁻² yr⁻¹, resulting in C standing stocks of 0.60–15.3 kg C m⁻² (mean: ~5 kg C m⁻²) since ~1850. A multi-core study of Chaohu Lake indicated that spatial variability of C burial was not a significant problem for regional upscaling. The possible effect of changes in lake size and catchment land-use on C burial was examined at Taibai Lake and indicated that lake shrinkage and declining arable agriculture had limited effects on CAR. The organic C standing stock in individual lakes is, however, significantly dependent on lake size, allowing a simple linear scaling for all the MLY lakes. Total regional C sequestration was ~80 Tg C since ~1850, equivalent to ~11% of C sequestration by soils but in ~3% of the land area. Shallow lakes from MLY are a substantial regional C sink.

S15-P-01 Paleolimnological perspective on the lake response to anthropogenic impact: multi-proxy analysis of sediment from Lake Lohja, North Estonia

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A lead-210 dated sediment core from small soft water lake was analysed for changes in geochemical composition, fossil pigments and Cladocera remains. The aim was to analyse lake response to land-use changes during the 20th century. In 1965, carp population was poisoned as a fish-management attempt. In the same year, as a measure to increase alkalinity, oil-shale ash was distributed over the lake. There has been a consensus that as a consequence of these measures, the lake quality deteriorated during 1970s. Our paleolimnological data did not confirm a clear-cut change of lake conditions linked to these management measures. Instead, we observed gradual increase in minerogenic matter from late 1930s until present, with a steep increase in 1960s and late 1990s. A similar pattern was detected in fossil pigments. High algal productivity and increase in cyanobacteria were confirmed during the 1980s. However, this culmination was a result of a successive increase from late 1930s, followed by a second peak in late 1990s. Main changes in the Cladocera record reflect rise in algal productivity and do not show clear link with the alteration of fish community. The changes in the geochemical composition of sediments, the rise in lake productivity and the change in the Cladocera community closely follow the history of construction of melioration channels, as they were observed from archival maps. Our paleolimnological approach suggests that the long-term, low-intensive impact on the lake catchment has had a more
significant effect on the lake ecosystem, as compared to direct, high-intensive, but short-term, impact.

S15-P-02 Local environmental response of climate change in the Trzechowskie paleolake in northern Poland, during the late glacial and early Holocene

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This study focuses on the palaeoecological reconstructions of climate and lake environment changes in late glacial and early Holocene. The sediments of paleolake Trzechowskie were analysed with the use of several methods which are based on subfossil remains of plants and animals (pollen, plant and animal macrofossils, Cladocera, Diatom, Oribatidae mite), chemical component of the sediments (13C and 18O stable isotope, LOI, carbonate content – CaCO3). The paleolake is located in the eastern part of the Pomeranian Lakeland northern Poland (Tuchola Pinewoods). Its genesis is associated with the melting of a buried ice block. Trzechowskie paleolake is about 1.5 km long and the average width is 450 m (area 28 ha). In our research we focused on the bottom sediments and multiproxy high resolution analysis were carried out. The chronology was based on palynological analysis, but also on the age-depth model, developed from five radiocarbon dates AMS 14C. The results of palynology and also radiocarbon dates clearly shows that the biogenic accumulation in the Trzechowskie paleolake started during Bølling-Allerød warmer period (12040 ± 70 BP 14C). The rapid cooling at the beginning of the Younger Dryas caused great changes in lake ecosystem, influenced on accumulation rate. At that time lake sediment changed from a varved to massive gyttja. At the decline of Younger Dryas all proxy (bioindicators) indicated distinct warming. This study presents the records of the large and rapid changes that occurred in aquatic ecosystem of Trzechowskie paleolake during the transition from Younger Dryas to Holocene. This results are very valuable and complements the existing knowledge about the influence of rapid climate changes on the lake ecosystem.

S15-P-03 Holocene climate changes in central Asia reflected by multi-proxy records from Sayram Lake, northern Xinjiang, China

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Multi-proxy data are presented to assist in the determination of Holocene paleoclimatic and paleoenvironmental changes from a 300-cm-long sediment core from Sayram Lake, located in northern Xinjiang, China. The chronology was established from 11 AMS radiocarbon dates on bulk organic matter. Analyses of pollen, TOC, TN, δ13C of organic matter, grain-size and chlorophyll-a suggest the following Holocene climate patterns: (1) temperate and dry (~12.3–8.7 cal. ka BP), (2) warm and wet (8.7–3.2 cal. ka BP), and (3) cool and wet (3.2 cal. ka BP – present). The climatic evolution
records of Sayram Lake have undergone two climate shifts at 8.7 and 4.6 cal. ka BP respectively and responded to regional environmental change and global abrupt climate events. Changes in solar insolation is the primary force driving climate change and unmelted ice at high latitudes during early Holocene might have exerted a strong influence on environmental systems over this region. Climate change in westerly dominated areas of central Asia was roughly synchronous with that of areas affected by the monsoon Asia from early to mid-Holocene. The different effect in precipitation and evaporation caused by temperature variation can explain discrepancy in moisture evolution between arid central Asia and humid monsoon areas during late Holocene.

S15-P-04  Lake environment changes as a response to variable climate condition in Preboreal period

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This work present the results of the research conducted on the sediments of the shallow lakes located in Poland in various distance from the reach of the last glaciation. One of the lake, Trzechowskie, is located in northern Poland and is under the influence of transitional climate. The other, Lake Lukie, lies in eastern part of the country where climate has more continental features. Lake Trzechowskie genesis is connected with the melting of buried ice blocks while Lake Lukie genesis is thermokarstic. Preboreal period is known for its variable climate. After the distinct warming which finished the Younger Dryas there were again cooling known as PBO. This fluctuations marked visibly in Greenland icecores and several terrestrial sites. In order to study the reaction of the lake’s ecosystem on the Preboreal climate variations, multiproxy analysis were carried out. Here are presented selected results of the palinology, Cladocera, plant macrofossils analysis and also stable isotopes $^{13}$C, $^{18}$O and the chemistry of the sediments. They clearly show that Preboreal climate changes influenced the ecosystems of both lakes, however this changes are much clearly recorded in Lake Lukie sediments. Differences are due to the impact of air masses and lake distance from the range of the last glaciation.

S15-P-05  Mineral magnetic study of lacustrine sediments from Gonghai Lake, North China, and its paleoenvironmental significance since the last deglaciation

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A preliminary magnetic study was conducted on Core GH09B (9.42 m long), drilled in Gonghai Lake, North China. The results demonstrate that main magnetic minerals in the sediments are magnetite in PSD state and mainly originate from detrital input, while the post depositional effects on the magnetic properties of detrital minerals are very weak. Although the variations in concentration of detrital magnetic mineral input and their grain size in all core reflect both soil erosional and dust input, it is proved that the climate/environment meaning of magnetic parameters of lake sediment changes with
time. At top 2.4 m of the core (the last 1046 years), the detrital magnetic minerals mainly originated from soil erosion in the lake drainage when the vegetation cover was sparse and depositional rate was the highest. The variations of magnetic parameters (e.g. \( \chi \)) in lake sediments in its highest values reflect the degree of pedogenesis in the lake catchment and then the paleaomonsoon history. At main part of the core at the depth of 7.7–2.4 m (12024-988 cal yr BP), the detrital magnetic minerals mainly originated from dust input when the lake catchment was covered by forest and soil erosion and lake depositional rate was minimum in the core. The variations of magnetic parameters in its lowest value mainly reflect the highest soil stabilization and the variable dust input, and then strongest summer monsoon during Holocene. At low part of the core at the depth of 9.42-7.7 m (14685-12024 cal yr BP), the detrital magnetic minerals mainly originated from both base rock erosion, soil erosion and dust input when climate mended after cold and dusty last glacial maximum. The increasing \( \chi \) background in this part may indicate mixture among developments of lake environment, soil stabilization and the decreasing ratio of dust input. Finally, the magnetic parameters of the core sediment can sensitively indicate the main environmental changes, showing three stages of monsoon evolution history since the 14685 cal yr BP with boundary at ca~11500 cal yr BP and 2900 cal yr BP, respectively.

**S15-P-06 Structuring role of floating islands in floating mat development and shoreline changes in peatland lakes (Tuchola Forest, Poland)**

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Multitemporal aerial photography and topographic maps were applied to investigate shoreline and lake area changes induced by floating islands in three small (area < 1 ha) peatland lakes in Tuchola Forest. The observation period spans the last 60 year (1951-2011). Shoreline of peatland lakes are stable unless parts of them disconnect from the floating mat and became free floating islands. These can be moving only sporadically in the past and currently they are rooted permanently to the mat (Dury I and Dury V Lakes) or floating loose all the time (Kozie Lake). In the observation period moving of the islands and closing of lake bays due to overgrowing were the main reasons of shoreline changes. At the boundary of dense floating mat, mainly formed by Sphagnum mosses, coastal vegetation zone develops. It is dominated by *Rhynchospora alba* and *Carex limosa*. The largest clusters develop in bays and in shoreline segments with zigzagging and meandering waterline.

There is a distinct difference in thickness, form and plant components of the floating mat edge between lakes with permanently rooted and floating islands. In case of rooted island a curtain of plant remains (mainly *Rhynchospora*) developed at the edge of the mat reaching the thickness of 100-150 cm. On the lake with floating islands the thickness of the edge reaches 40-60 cm on average because the island prevents the development of *Rhynchospora-Carex* community when hitting the edge.

**S15-P-07 Spatial-temporal dynamics of overgrowing of peatland lakes influenced by natural and anthropogenic factors**

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Aim of the project was the research of accumulation rate of lake and peatland sediments during the Holocene and their differentiation within the basin: on peatland, floating mat and the lake in oligotrophic sites of Tuchola Forest. Analysis of human impact, especially forestry and agriculture on the overgrowing of the lake was the additional aim of the research.

Geological research of peatland, floating mat and limnic sediments, high-resolution pollen analysis, plant macrofossil for lake Dury were done. Chronology was prepared for three cores of sediments, from the peatland, floating mat and the lake by AMS datings. Geochemical analyses were
done for limnic sediments. The highest accumulation rate (ca 10 mm/year) was found in floating mat, sedimentation rate on the peatland was estimated at 2.1 – 2.2 mm/year. Accumulation rate of limnic sediments was the lowest, with an average of 0.48 mm/year, a little growing in the upper layers. In nearby lying Lake Kozie this rate was even lower – 0.17 mm/year.

Such results show that accumulation rates vary to high extent in different parts of all the basin what is conditioned by autogenic factors mainly. Alogenic factors like climate and human impact are much less important. However little stronger human activity was suggested in the younger part of the cores by pollen grains of Secale, Rumex, Plantago lanceolata and some weeds and gradual decrease of TOC/N ratio probably as a result of fall in mineralisation of organic compounds due to worse oxygenation of the water.

S15-P-08 The early-Holocene history of Lilla Öresjön

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Lilla Öresjön in south-west Sweden is a typical kettle lake suitable for the study of environmental changes in the Holocene. This research shows natural changes in the lake evolution, in the early stage of the lake. The combination of biology and geochemistry allows the demonstration of a strong correlation between the productivity in the lake and the loss of phosphate apatite in the catchment in the late-glacial and early-Holocene.

The lowest 1.5 meter sediment core from Lilla Öresjön was 14C dated and analysed for geochemistry (XRF) by John Boyle (University of Liverpool) and diatoms by Samanta Skulmowska (UCL). Diatoms were coded to correspond to the Surface Water Acidification Project (SWAP) codes and the transfer function was applied to inferred past pH. The initially unproductive ecosystem has mainly benthic taxa in Bølling/Allerød and Younger Dryas, zone 1 and 2. The inferred pH is above 6.5 and there is depletion in elements such as Al, Si and Ca that are being used by algae. In zone 3, from 10,206 ± 43 BP the lake becomes more productive and more diverse where benthic species are replaced by planktonic ones, dominated by Cyclotella comensis along with Achnanthidium minutissimum, Achnanthes pusilla and Aulacoseira distans. There is a significant increase in P and Fe being released in the ecosystem and evidence for soil stabilisation. These considerable changes in the lake and in the catchment are due to major climate changes in the early-Holocene. Finally, in zone 5, around about 8,000 years ago diatom assemblages indicate natural acidification of the lake and less productivity.

Lille Öresjön naturally acidified in the early-Holocene which along with the loss of apatite and cations in the catchment, demonstrate the correlation between the catchment geochemistry and hydrology of the lake and changes in lake biology.

S15-P-09 Sedimentological and geochemical study of the lacustrine deposits of the former Komořany Lake

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Komořany Lake was the most extensive (25 km2) and the longest existing (until 1834) Late Glacial lake in the Czech Republic (former Czechoslovakia). The lake was located in the northwestern part of the Czech Republic (Central Europe) at the foot of the Ore Mountains in the alluvial plain of the river Bilina. This shallow water body arised due to erosion processes on impermeable clay subsoils at the Pleistocene / Holocene border. The reconstruction of sedimentary basin evolution and development of water level oscillations was based on sedimentological, geochemical (TOC / TN) and stable isotope (δ13C), research. A small water body existed in the central part of the basin during Late
Glacial. The basin became a large floodplain of the river Bilina in the older Holocene. A large lake formed at the end of the older Holocene and persisted up to the end of the middle Holocene. The water level increase was probably caused by the more humid climate, the existence of a landslide of rocks and impermeable bedrock. Lake area started to change on a large swamp at the end of the middle Holocene.
Session 16 - What have we learned from drilling large lakes?

S16-KN  Key findings and unanswered questions from the Lake Peten Itza Scientific Drilling Project


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In 2006, sediment cores were drilled at seven sites in Lake Peten-Itza, northern Guatemala, with support from the ICDP, US-NSF and Swiss NSF. Pioneering work on Peten lakes by Ed Deevey and colleagues had demonstrated previously that glacial-age deposits consisted of interbedded gypsum and clay with pollen assemblages dominated by temperate xeric thorn scrub, suggesting a much colder and drier glacial climate than today. We have thus far focused our efforts on site PI-6, consisting of a ~71-m long section spanning the last 85-ka. The chronology is well constrained by 44 AMS-14C dates on terrestrial organic matter and 4 ash layers. We speculate the lake dried out completely during the precession maximum (boreal summer insolation minimum) centered at ~95 ka and filled at the next precession minimum (~85 ka) associated with Marine Isotope Stage (MIS) 5a. With the onset of Heinrich events in the North Atlantic ca. 60 ka, there is a transition from cool, moist conditions to much drier climate. Gypsum precipitation ensued at 48 ka BP and climate alternated between cold, arid periods during Heinrich stadials and relatively cool, moist periods during interstadials and the entirety of the Last Glacial maximum. Plant associations during the Heinrich stadials were without modern analogs and pollen-derived temperature estimate suggests a cooling of at least 5.5 to 7.5 °C relative to modern. Contrary to previous suggestions, the Last Glacial Maximum was relatively moist and the time of greatest aridity and lowest lake stage occurred during Heinrich Stadial 1 (~18.5 ka), when a pervasive tropical megadrought has been postulated (Stager et al., 2011). New tandem measurements of δ18O in gypsum hydration water and ostracod shells suggest temperature at the beginning of Heinrich Stadial 1 was 6-10 °C lower than present. The derived temperatures support previous findings of much greater tropical cooling on land in Central America during the Late Glacial than indicated by nearby marine records, underscoring a long-known yet unresolved problem in paleoclimatology. Pollen data indicate near-complete absence of tropical forest taxa until the onset of the Holocene, ca. 10.4 ka BP, raising questions about the location of Ice-Age biotic refugia.

S16-01  500,000 years of vegetation change in western tropical Africa

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Over the last 500 kyr marine and icccore records reveal that the Earth has undergone four full glacial-interglacial cycles which resulted in many terrestrial ecosystems experiencing significant changes. The fossil record offers the opportunity to explore the response of vegetation to past climatic change. Cores from Lake Bosumtwi (Ghana) drilled as part
IPS2012 International Paleolimnology Symposium

of the ICDP Lake Bosumtwi Drilling Project in 2004 provide a continental record of West African climate over the last 500 kyr, capturing multiple glacial-interglacial cycles. Here we present the new 500 kyr pollen and δ\(^{15}\)N isotope record from Lake Bosumtwi. Fossil pollen assemblages reveal dynamic vegetation change through the last 500 kyr, which can be broadly characterized as indicative of biome shifts between savannah and woodland. Savannah formations are heavily dominated by grass (Poaceae) pollen (> 40%) typically associated with Cyperaceae and δ\(^{15}\)N values greater than 10‰. Woodland formations are complex but fall into two main types those associated with and without charcoal (fire). The woodlands with high charcoal abundances are typically comprised of Celtis, Moraceae/Urticaceae and Melastomataceae/Combretaceae; while those devoid of charcoal contain similar taxa but are generally more palynologically diverse. Comparison with records and models of global climate change reveal that fluctuations between savannah and woodland systems for the period c. 500-200 and 28-0 kyr follow global glacial-interglacial cycles. Vegetation change between 200-28 kyr shows periods of prolonged stability (savannah 113-76 kyr) and extreme aridity (76-64 kyr). The changing pattern of biome shifts could be a result of a variation in the seasonal distribution of rainfall.

S16-02  A 250,000-year record of climatic change from Lake Tana, source of the Blue Nile


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Seismic and core data from the deep sedimentary infill of Lake Tana, the source of the Blue Nile, provide the first long (~250 ka), near-continuous, independently dated palaeoenvironmental record from continental NE Africa. Chronological constraints on the 92 m core are from polynminerol fine grain [post-IR] IRSL dating combined with radiocarbon analyses of the younger sediments. Geochemical data from high-resolution XRF scanning, combined with very high-resolution seismic data, show high terrigenous input to the lake during MIS 6. Input was low input during MIS 5e and 5c, interpreted as evidence for a stable, vegetation-covered catchment in a moist climatic regime. Marked changes in moisture regime occurred during MIS 5d, 5b and especially in later MIS 5a, when sedimentary wedges formed in a shallow lake. The data also provide evidence for drought intervals contemporaneous with North Atlantic Heinrich events.

Overall, interpreted wet and dry intervals in Lake Tana show strong coupling with East Equatorial Atlantic sea-surface temperature and salinity, and correspond to run-off and dry episodes reported for the Nile Delta. The correlations with global proxies suggest that NE African climate change over the last 150 ka is primarily linked to millennial-scale high-latitude northern hemisphere changes. The most prominent environmental change appears to be at ca. 60 ka, marking the end of wedge progradation and the start of a major drought episode. Environmental pressure over this sustained dry period may have influenced the size and distribution of early modern human populations.

S16-03  Super Interglacials and Arctic Climate Evolution over the Past 3.6 Myr: Lake El’gygytgyn, Western Beringia, a new polar lens focused on high latitude environmental change


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International Continental Deep drilling (ICDP) at Lake El’gygytgyn (67°30’ N, 172°05’ E; or “Lake E”) recovered lacustrine sediments dating back to 3.58 Ma that now provides the first time-continuous Pliocene-Pleistocene paleoclimate record of different interglacials from the terrestrial Arctic. The Pliocene portion of the lake record (~3.58-3.0 Ma; a time when atmospheric CO$_2$ levels may have been in the range of 400 ppm) has more than twice the sedimentation rate as later Quaternary intervals. Spores and pollen from this portion of the core show the area was once dominated by trees, providing the pace of variability in Pliocene Arctic forests, which included species of pine, larch, spruce, fir, alder, and hemlock. Modeling suggests sustained forests at Lake E in both cold and warm orbits during this interval and restricted ice over Greenland. Extreme warmth in the Mid Pliocene Arctic occurs at the same time ANDRILL results suggest the WAIS was non-existent. Younger warm interglacials investigated so far are those correlative with MIS 1, 5e, 9, 11 and 31 that differ in character, due to orbital forcing and feedbacks. Multi-proxy evidence shows that interglacials MIS 11c and 31 were remarkably warmer than MIS 5e; other super interglacials include MIS 49, 55, 77, 87, 91, 93, G1, G3 and G7. In MIS 31, peak warm austral summers precede peak warm boreal summers by ~10,500 years; The record from Lake E, especially the history of super interglacials, provides a fresh means of testing what controls polar amplification over time including times when pCO$_2$ was not the likely culprit.

**S16-04 The Towuti Drilling Project: Quaternary Paleoclimate, Ecosystem Evolution, and Geomicrobiology of a large Indonesian Lake**

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Lacustrine scientific drilling in South American and African lakes has highlighted the critical role that migration of the Intertropical Convergence Zone plays in regulating continental moisture balance. Whereas we once thought African moisture balanced marched to the beat of global ice volume, for instance, megadroughts during Marine Isotope Stages 4, 5, and 6 document large, coupled changes in the monsoons, the Intertropical Convergence Zone, and the Hadley circulation forced directly by orbital precession. While these studies have significantly advanced our understanding of meridional variations in tropical paleoclimate, we are still far from understanding long-term changes in zonal climate gradients associated with the Walker Circulation. This is because we do not have long paleohydrologic records from the largest zone of deep atmospheric convection on Earth, the Indo-Pacific Warm Pool.

Over the course of four field seasons we have acquired over a thousand kilometers of seismic reflection data and 150 m of piston core from Lake Towuti (2.75° S, 121.5° E, 561 km$^2$, 203 m max depth), one of the largest lakes in Indonesia. Located in central Sulawesi, in the heart of the Indo-Pacific region, Towuti contains up to 150 m of stratified lacustrine sediment that chronicles mid- to late Pleistocene variations in Indo-Pacific convection, rainfall, and associated changes in the Walker Circulation, the ITCZ, and the Austral-Asian monsoons. Lake Towuti also has high rates of biological endemism and is hosted in the East Sulawesi ophiolite, one of the three largest ophiolites on Earth. Drilling Towuti’s sediments will elucidate the evolutionary and geomicrobiological processes operating in this unique basin. We are developing a
new lake drilling program for Towuti, spearheaded by a collaborative US, Indonesian, German, Australian, and Canadian team.

Lithologic, stable isotopic, and geochemical analyses of existing sediment cores spanning the last 60 kyr BP underscore Towuti’s unique scientific potential. Our data indicate large changes in rainfall and convection during the Last Glacial Maximum (LGM) and most Heinrich events, and suggest that the LGM was the wettest period of the last ca. 100 kyr, in contrast with sites to the north and west. Based upon climate model experiments, we interpret this feature to reflect the influence of ice sheet topography on equatorial winds, as well as the intensification of the glacial Walker circulation due to low atmospheric CO$_2$ concentrations. These results highlight the potential for Lake Towuti to constrain long-term changes in Indo-Pacific convection and hypotheses to be tested over multiple glacial-interglacial cycles by lake drilling.

S16-05 High-resolution paleomagnetic secular variations and relative paleointensity from Southern Patagonia since the Late Pleistocene


Paleomagnetic secular variations (inclination, declination) and relative paleointensity were reconstructed from the sediments of Laguna Potrok Aike (Southern Patagonia, Argentina) in the framework of the International Continental scientific Drilling Program (ICDP) as part of the Potrok Aike maar lake Sediment Archive Drilling Project (PASADO). Here we present the u-channel-based full vector paleomagnetic field reconstruction since 51.2 ka cal BP. The new record is compared with other lacustrine and marine records, as well as paleomagnetic stacks from the mid- to high-latitudes of the Southern Hemisphere, revealing consistent millennial-scale variability, the identification of the Laschamp and possibly the Mono Lake geomagnetic excursions. These comparisons, along with the ones made with other high-resolution records located on the opposite side of the Earth in the Northern Hemisphere and with various dipole field reconstructions, demonstrate the global nature of the Laschamp and probably the Mono Lake geomagnetic excursions, but also document distinct paleomagnetic secular variations in southern South America at ca. 20 and 46 ka cal BP. In particular, the directional swing and sharp minimum in intensity recorded at 46 ka cal BP seem to be mainly observed in the Southern Hemisphere and could likely be used as a new regional chronostratigraphic marker. Finally, these new paleomagnetic results reveal magnetostratigraphy as a promising tool to better constrain the PASADO chronology at least at the millennial-scale in specific intervals where geomagnetic changes are either global or regional and where radiocarbon dating is currently challenging (i.e., from ca. 30 ka to the base of the record).

S16-06 What have we learned from drilling Lake Titicaca (Bolivia/Peru)?


Drill cores from tropical high-altitude Lake Titicaca, Bolivia-Peru (~15°S) extend continuously over the last 370,000 years. The record indicates that periods of regional glacial advance and retreat were concordant respectively with global glacial and interglacial stages. Intervals of regional ice advance were periods of positive water balance in the lake, as evidenced by deep and fresh water, whereas, reduced glaciation occurred during periods of negative water
The coincidence of positive water balance of Lake Titicaca and glacial growth in the adjacent Andes with Northern Hemisphere ice-sheet expansion implies that regional water balance and glacial mass balance are strongly influenced by global-scale temperature changes, as well as by precessional forcing of the South American summer monsoon (SASM). Between ~60 and 20 ka BP, the drill core record shows millennial-scale climate variation, and the wet periods apparently were correlated with cold events in the North Atlantic region. This suggests that SASM intensity was influenced by sea-surface temperature gradients in the tropical Atlantic and as a part of near-global scale climate excursions. The drill core record also suggests the long-term evolution of the lake basin and its biota. Secular shifts in the nature of the diatom assemblages suggest that the modern deep lake may result from a progressive subsidence and deepening of the basin over time. In addition, morphological evolution in one of the major lineages of planktic diatoms indicates substantial change in the limnological environment that affected species morphology and may have driven speciation.

**S16-P-01** Late Pliocene/Early Pleistocene environments of the north-eastern Siberia inferred from Lake El'gygytgyn pollen record


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The German-Russian-America “El’gygytgyn Drilling Project” of ICDP drilled the Lake El’gygytgyn (67°30’N, 172°05’E) penetrate about 318 m lacustrine sediments and about 200 m impact rocks below. The meteorite crater was created nearly 3.6 Myr ago. The impact formed an 18 km wide hole that then filled with water. The scientific drilling offers unique research opportunities for time-continuous reconstruction of the climatic and environmental history. Pollen studies show that lake sediments are an excellent archive of vegetation and climate changes. Pollen assemblages from the lower 200 m lacustrine sediments reflecting Late Pliocene and Early Pleistocene paleoenvironmental changes can be subdivided into 40 pollen zones. Spruce-fir-larch forests dominated the vegetation in nowadays treeless tundra area about 3.5-3.35 Myr BP. Temperatures were at least 15°C higher than modern. After ca 3.4 Myr BP dark coniferous taxa gradually disappeared from vegetation. The very pronounced environmental changes are revealed about ca 3.35-3.275 Myr BP when treeless tundra and steppe like habitats appeared. Climate conditions were similar to those during the Late Pleistocene. Numerous coprophilous fungi spores point to presence of grazing animals around the lake. It is noticeable that it occurred at the Mammoth subchron (MIS M2). Larch-stone pine forests with some spruce changed again to treeless and shrubby environments at the beginning of the Pleistocene, ca 2.6 Myr BP. Early Pleistocene pollen assemblages reflect alternation of treeless intervals with cold and dry climate and warmer intervals. High amounts of *Botryococcus* point to a shallow water conditions ca 2.55, 2.45, and ca 2.175 Myr BP.

**S16-P-02** The Peten-Itza Scientific Drilling Project: Insights into Pleistocene and Holocene Climate and Environmental Change in the Lowland Neotropics


1 Department of Geological Sciences, and Land Use and Environmental Change Institute (LUECI), University of Florida, Gainesville, FL 32611, USA; 2 Godwin Laboratory for Palaeoclimate Research, Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK; 3 Eawag, Überlandstrasse 133, Postfach 611, 8600 Dübendorf, Switzerland; 4 Section of Earth Sciences, University of
In 2006, sediment cores were drilled at seven sites in Lake Peten-Itza (A=100 km², zmax=165 m, 110 masl), northern Guatemala, with support from the ICDP, US-NSF and Swiss NSF. Multiple cores were collected at each location, enabling study of continuous composite sections. A long (~71-m) core from site PI-6 was collected in ~71 m of water and contains an approximately 85-ka, high-resolution record of climate and environmental change in the lowland Neotropics. Paleoenvironmental conditions were inferred from stratigraphic changes in lithology, aquatic bio-indicators (ostracods), isotope geochemistry ($\delta^{18}$O and $\delta^{13}$C) of carbonate shells, $\delta^{13}$C of bulk organic matter and long-chain n-alkanes, and pollen counts. Beginning about 48 ka BP, climate varied between wetter (interstadial) and drier (stadial) periods, the latter associated with more southerly location of the ITCZ. Following the relatively moist LGM in the region, the deglacial was characterized by episodes of very dry climate, during which gypsum precipitated on the lake bottom, oxygen isotope values of ostracod shell were greater and dry-adapted plant taxa expanded. New tandem measurements of $\delta^{18}$O in gypsum hydration water and ostracod shells suggest temperature at the beginning of Heinrich Stadal 1 (18.5 ka) was 6-10 °C lower than present. Pollen data indicate near-complete absence of tropical forest taxa until the onset of the Holocene, ca. 10.4 ka BP, raising questions about the location of Ice-Age biotic refugia. Climate fluctuations inferred from this continental Central American site coincide temporally with climate shifts documented from study of tropical marine records (e.g. Cariaco) and high-latitude ice cores.
S16-P-04  A model for linking grain-size component to lake level status of a modern clastic lake

Xiao, J., Fan, J., Zhou, L., Zhai, D., Wen, R., Qin, X.
Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

Grain-size distributions of fluvial, eolian and marine sediments were explicated decades ago. For lake sediments, however, there is still great uncertainty in explaining the genesis of grain-size components due to the inherent complexity of their polymodal distributions. In this study, the grain-size components of the surface sediments of Hulun Lake, Inner Mongolia, were partitioned using a lognormal distribution function and the relationship between the identity of each component and the specific sedimentary environment was investigated. The data indicate that the modern clastic sediments of Hulun Lake contain five distinct unimodal grain-size distributions representing five grain-size components. Each of the components retains its identity including modal size, manner of transportation and environment of deposition although the relative percentage varies with the hydraulic condition throughout the lake. These components are specified from fine to coarse modes as long-term suspension clay, offshore-suspension fine silt and medium-to-coarse silt, and nearshore-suspension fine sand and saltation medium sand. The percentage of the components interpreted as an indication of nearshore environments displays a negative correlation with water depth across the modern lakebed, suggesting a model for linking the nearshore components in sediment cores to the lake level status in the geological past. The model was applied to a sediment core from the lake where high percentages of the nearshore components in the core sediments were correlated with low regional precipitations reconstructed on the pollen profile of the same core, revealing the potential of the grain-size component–lake level status model for lake’s paleohydrological reconstruction.

S16-P-05  Sub-annual variability in Lake Malawi sediments over the last 800 years examined by scanning XRF

Petrick, B.F., Brown, E.T.
1Department of Geography, Newcastle University; 2Large Lakes Observatory and Department of Geological Sciences, University of Minnesota Duluth

Varved sediments of Lake Malawi (southern East Africa) provide a sub-annual history of climate change from a region where observational climate records are sparse. Two cores from the north basin of Lake Malawi were examined using scanning x-ray fluorescence to evaluate regional environmental change. The XRF results were also used in conjunction with high-resolution optical images and x-radiographs to develop a varve counting chronology that appears robust for the past 800 years. Four major chemical elements or ratios of chemical element were used to represent the major components in the sediments of the core: Fe for silicate minerals and clays, Si/Ti for biogenic silica (BSi), inc/coh scattering ratio for total organic carbon (TOC), and K/Ti for fresh volcanic sediments. Comparison of Fe to recent records of lake level fall and rise suggests increased clay input in response to in wetter years with greater fluvial input. Coral records Indian Ocean SSTs suggest linkages to lake level fluctuation over periods of 5-10 years. Comparison of the inc/coh scattering ratio with a 150 year Indian Ocean Dipole (IOD) record suggests that lake productivity responds to shifting regional atmospheric circulation dynamics. Over this time period, the Si:Ti record suggests that the proportion of diatoms in the planktonic community is highly variable during times with greater IOD variability. The longer record suggests dry periods from the base of the varved section to around 1250 AD and from 1550 to 1650 AD, with an interceding wetter period from 1250 to 1550 AD. The record from 1650 AD to the present shows minor fluctuations in an overall steady record. This is broadly consistent with records from other East African lakes.
S16-P-06  Model of sedimentation in the Darhad paleolake: a contribution to the Darhad Drilling Project 2010

Krinvonogov, S.K., Yi, S., Kim, J.C., Oyunchimeg, Ts., Narantsetseg, Ts.

Korea Institute of Geoscience and Mineral Resources, Korea; Institute of Geology and Mineralogy SB RAS, Russia; Institute of Geology and Mineral Resources MAN, Mongolia

We reviewed previously published and present new data on the Darhad Basin in northern Mongolia. The previously published data include those obtained in the 20th century by Soviet geological surveys and researches of the Darhad Basin, which are, as a rule, not accessible for an international reader, and those obtained by several international teams during the last decade. The new results include geomorphologic, sedimentological and geochronological data obtained prior to and within the International Darhad Drilling Project (DDP-2010). These data show that the Darhad sedimentary sequence has been formed since the Pliocene and represents a detailed archive of environmental changes due to a high content of lacustrine beds. Lakes formed several times in the Darhad Basin by basaltic, glacial and sedimentary dams, which blocked the water outlet of the basin. Of special importance are the late Pleistocene damming events, which are well-documented in the sediments and landforms. There have been two stages of deep lake. The first lake was dammed by glacier during late MIS 5 or, alternatively, during early MIS 3. The second damming, glacial or sedimentary, formed another deep lake during MIS 4 or MIS 2. The level of the lake was greatly variable up to its complete disappearance. Our new data on the DDP10-3 and DN-1 boreholes and the Hodon outcrop extend the development of the paleolake to the Holocene, which was dammed by the sediments at that time. We propose a first sedimentation model for the Holocene part of the lacustrine sedimentary sequence. The lake was absent at ca. 12-8.5 and after 4 ka BP, relatively deep at 8.5-6.1 and 5.6-4.0 ka BP and shallow at 6.1-5.6 ka BP
**Delegate List**

This list shows people who have registered as delegates for IPS2012.

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