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Lagos, Memorias del Territorio

Lakes, Memories of the Landscape

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PLENARY SPEAKERS

Unveiling environmental memories using lacustrine microbialites

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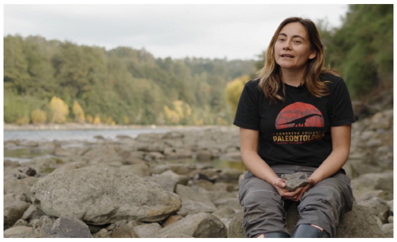
Memory is generally defined as the time within which past events can be or are remembered. It is also the power or process of reproducing or recalling what has been learned and retained especially through associative mechanisms. This last notion is truly important in paleoenvironmental science, implying the development and calibration of proxies that can help us to disentangle those memories. With the improvement of transversal exchange of knowledge between disciplines and the development of new techniques and methods many complex processes start to be understood. One of the milestones in this development has been the use of modern analogues to comprehend processes that have happened in the past. The formation of microbialites – the archives of the oldest known forms of life on Earth – implies complex biogeochemical pathways. Understanding these pathways is critical to reconstruct the past and perhaps forecasting environmental impacts in a changing world. In this talk I will present both experimental results and field data from natural archives focusing in the formation of recent and past microbial mats in various extreme environments in Patagonia. Although still uncompleted, a clearer picture of the processes behind various biomineralization processes is now emerging as a result of the amalgamation of microbiological and mineralogical investigations. The latter can help us to reconstruct the memories of the territory trapped in the sediments of diverse lacustrine basins at different temporal and geographical scales. Likewise, unveiling new aspects of past environments while generating innovative approaches, two critical ingredients for the development of science, lake studies are furthering much of our understanding of the different processes shaping major global events over time. Undoubtedly, a lot more exciting results will come with future lake projects!

Building bridges between disciplines for the conservation of ecosystems



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Ecology, paleoecology and paleobiology have developed over the past century as distinct scientific cultures. Each with its own language, journals, societies, methodologies, and worldviews. Paleoecology has sometimes been loosely linked to ecology, and some ecologists have crossed the boundary by integrating paleoecological studies. Moreover, some paleobiologists have studied the Quaternary and some Quaternary paleoecologists have made incursions into the study of the Neogene or the Mesozoic. In general, the three disciplines remain isolated from each other, encapsulated by their own temporal dimensions and with relatively little communication or cross-fertilization. This lack of communication between disciplines is relatively recent. In fact, they all share a common root in the study of what was called natural history during the 19th century. The works of De Candolle, Darwin, Lyell and so many others included extensive discussions of modern biogeography and ecological processes (competition, dispersal, population growth), climatic changes during the Quaternary and their associated biotic responses, and pre-Quaternary fossil sequences. Lyell and his contemporaries were attempting to develop a unified framework for understanding the short- and long-term processes that determine the composition of the biota. The possibility of sharing a workplace with different disciplines has led me to face the challenge of rethinking conventional explanations and assumptions in my own field and developing methodologies applicable beyond (and over here!) the Quaternary. In general, this experience makes me explore the potential benefits of exchanging ideas across the different time scales at which we can conduct our research; be they tens, hundreds, millennia or millions of years. Such exchanges of ideas are opportunities to reflect on how the Earth's environment and biota behave at different time scales and how we should promote the sustainability of ecosystems. Indeed, our research based on natural history allows us to give identity to research spaces. This information should be part of a country development strategy that considers historical aspects, identity, and memory for the construction of a society that is more aware and at the same time more educated about what we are as human beings in the history of life on Earth. Recognize with humility and amazement the number of organisms and landscapes that have occupied the territories and make them our own to understand our own evolution. Identity, memory, and natural history must be part of the challenge of generating a new policy, more democratic, less unequal and that considers science as an engine of egalitarian development in Latin America. Building bridges for integration between disciplines is never easy. But I believe it is a worthy goal for the ecological and paleontological sciences. Can we achieve an integrated science that understands biotic dynamics under multiple time scales as Lyell and his colleagues aspired to in the 19th century? We might not go all the way, but we will certainly learn a lot if we try.
Acknowledgements: Proyecto Fondecyt 1201528, Fondo del Patrimonio Cultural 37363.

X disciplinarities and other difficult-knowledge dialogues in water-related research

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The presentation focuses on some of the key intricacies, challenges, and opportunities facing the production of knowledge about water-related issues, an area of knowledge and practice of the highest social and Political relevance at global level. The serious problems that humanity faces in relation to the preservation of life in the planet are intimately interwoven with the problems we face to preserve water, in all its forms, and to sustainably manage and democratically govern and share it. The human failures behind the calamitous water-related risks, threats and actual disasters suffered worldwide in recent years, and the expected worsening of this situation in many areas of the world, place a significant challenge for science, and, particularly, for the Politics of Scientific knowledge production, and the Politics of knowledge more generally, which, certainly in relation to water issues, largely exceeds the scientific sphere. A premise of this talk is that the reasons for the current failures and difficult challenges ahead in this field, are NOT due to the lack of quality scientific knowledge about water-related issues and processes but are essentially due to the prevailing disastrous Politics of water worldwide, which includes the Politics of water knowledge and practice. Within this framework, the talk will place emphasis on the challenges we face to develop higher levels of inter and transdisciplinary coordination in the production of water-related knowledge oriented at the preservation of life in the planet and fostering substantive democracy in the Politics and management of water and in social-natural processes more generally.

A multi-scale approach to climate reconstruction from lacustrine deposits: an example of the Neogene in the Ebro Basin, NE Iberia

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This contribution aims to illustrate the potential of lacustrine deposits as archives of environmental information (i.e., depositional, climatic and hydrologic parameters) at different temporal scales, in particular climate variability reflected by carbonate and related deposits.Variations of climate and climate-related parameters (temperature, precipitation, insolation, sediment supply, flora and fauna development, etc.), spanning from the calendar and solar time-frequency to long orbitally-driven cycles, can be recorded by lamination, simple vertical associations of facies or the sequential evolution of genetic stratigraphic units. Some climate parameters, i.e. temperature and precipitation, change both periodically and aperiodically, in particular on the short time scale, making it difficult their distinction in the sedimentary record and hindering the identification of their origin. Periodic processes of any time scale can be correlated over extensive areas, while the characters corresponding to aperiodic processes in the geological record may provide a way to detect sudden changes or events of local to regional extent, depending on each case. Therefore, detecting the climate imprint in the sedimentary record requires using a variety of methods and techniques that include classic stratigraphic and sedimentologic analyses, cyclostratigraphy and geochemistry, all of which are applicable on the aforementioned scales. The Ebro Basin, the youngest southern foreland basin of the Pyrenees (NE of the Iberian Peninsula), comprises -in its central part- a Miocene *ca.* 620-m thick dominantly lacustrine succession. A wide array of sedimentary facies, including sulphate, carbonate and fine siliciclastic sediments represent deposition in saline to freshwater lakes and distal alluvial inputs. Previous studies of the basin have yielded a robust stratigraphic, sedimentologic and palaeogeographic knowledge that has been complemented by mineralogical, geochemical and cyclostratigraphic analyses. Moreover, precise chronology obtained by magnetostratigraphic studies has allowed the characterization of some milestone changes and calculation of deposition rates. Thus, the Ebro Basin includes extraordinary examples of the potential of the lacustrine deposits to record climate variability at different time scales: 1) On the calendar and solar time scale: Textural, $\delta^{13}C$, $\delta^{18}O$ and periodicity analyses of stromatolite lamination have allowed to detect seasonal to pluriannual cyclicity linked to changes in temperature, insolation and precipitation/evaporation ratio, correlatable to QBO, NAO/ENSO-like and sunspot cycles. 2) On the Milankovitch-cycle time scale: Vertical associations of facies, macrosequences and the related sedimentary facies models record those cycles. Coupled facies analysis and $\delta^{13}C$ and $\delta^{18}O$, along with the distribution of lithofacies through time, indicated a closed, shallow, low-slope lacustrine system with water level variations causing freshwater to saline carbonate, sulphate and halite deposition phases. The periodical changes were linked to several ranks of Milankovitch cycles.3) Longer intervals representing up to several million years, including the middle Miocene Climatic Optimum (MMCO). These were characterized by means of sedimentological, mineralogical, ciclostratigraphic and sequential analyses, and $\delta^{13}C$ and $\delta^{18}O$ evolutionary trends. The available chronology allowed the beginning and ending of the MMCO to be constrained and defined in this lacustrine record. Acknowledgements: Grant PID2019-106440GB-C22, funded by MCIN/AEI/ 10.13039/501100011033.

Volcanic eruptions and glacier recession: understanding the effect of particle inputs in planktonic communities of Andean-Patagonian lakes

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Lakes are particularly vulnerable to environmental changes and, in particular, their metabolic pathways and nutrient cycling respond to both natural and human disturbances. Thus, lakes are considered sentinels and integrators of processes that occur in the atmosphere and terrestrial environments. Disentangling the effect of such different forces is a particular challenge for lake ecological studies. Here we will present how biological variables respond to different natural events such as volcanic eruptions (local impact) and glacier recession (global warming) in deep glacial North-Patagonian Andean lakes. These two events have a high preservation potential in the paleolimnological record. Both events involved severe changes in particle input to the aquatic environment, that affect the lake's physical and chemical features and the biota. Volcanic eruptions shape Earth's surface but they also have major impacts on local, regional, and global ecosystems and thus represent "natural experiments". On 4 June 2011, a mega-eruption in the Puyehue volcanic complex (Chile) discharged massive amounts of ash and pumice to the surrounding landscape in Argentina. Using long-term data from several lakes that received differing levels of ash impact, we showed that these inputs resulted in 1.5- to 4-fold increases in light extinction, phosphorus concentrations, and phytoplankton biomass relative to pre-eruption conditions. Furthermore, incubation experiments demonstrated significant impacts of photoinhibition on phytoplankton growth in these lakes at ambient pre-eruption light intensities. Thus, increased phytoplankton biomass following the eruption likely reflects not only nutrient (phosphorus) loading but also attenuation of excessive light intensities, implicating photoinhibition as a key factor affecting phytoplankton dynamics under conditions of high transparency and low nutrients. Climate change affects glaciers all over the world causing glacial recession with the formation of new lakes. A glacial lake outburst flood (GLOF) episode occurred in May 2009 in the Ventisquero Negro glacier and was associated with ongoing glacier retreat and glacier lake formation. Accordingly, the evolution of the Ventisquero Negro proglacial lake showed a continuous increase in its surface. This new lake caused changes in clay input and, consequently, in the transparency gradient of lake Mascardi along the Tronador arm. The decrease of suspended solid from glacial clay produced an increase in light availability and a consequently downward location of the deep chlorophyll maxima. Thus, the deep chlorophyll maxima development resulted in a very sensitive variable to global changes such as increases in temperature, that cause glacier recession. Picocyanobacteria and mixotrophic nanoflagellates are the dominant phytoplankton in lakes in the North Patagonian Andes. In particular, mixotrophic nanoflagellate bacterivory is affected by light; however, glacial clay may also interfere with prey uptake. We modelled this interaction and we successfully predicted the combined effect of light availability and particle interference on the mixotrophic nanoflagellate–bacteria relationship. The model also demonstrated that the effect of light is dampened as clay concentration increases. Finally, we will discuss the stoichiometric constraints due to glacial influence and the biofilm enzymatic activity as an ecological indicator that can be used as a tool for analyzing changes in glacier retreat.

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FOCUS SESSION I

Lake outburst floods (LOFs): characteristics, imprints and risks

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Evidence of a Holocene outburst flood from a landslide-dammed lake, Laguna Blanca, San Juan, Argentina

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Landslide-dammed lakes are common features amongst high mountain environments but, specifically in the Central Andes of Argentina, these events are grossly understated. But, even if there are few historical cases of such events, the hazard associated with an outburst flood from these types of natural impoundments is tremendous. The reason for this underestimation could be the remoteness of the area, the lack of inventories for large landslide-dammed lakes as they can only be detected through remote sensing, or because their outburst floods sometimes are generically named 'aluvión' without further questioning its origin. Laguna Blanca is a landslide-dammed lake formed 12.8 ka ago after a rock avalanche blocked the Laguna Blanca River in a narrow and deep area of the valley. It is still standing and it drains both superficially and through piping, generating a permanent flow. The avalanche came from the southern flank mobilizing Rhyolites, Granites, and moraine deposits both from the outcrop and the valley bottom. Two paleo-lake levels were mapped in the surroundings, one 70 m above the present-day lake and the other one only 2 m above it. The lower and younger paleo-lake was dated through luminescence in 2.5 ka on the bottom and 2.12 ka on the middle sections of the 2 m high sequence. This paleo-lake was estimated to drain catastrophically sometime after 2.12 ka, as stated by an outburst level found on top of a fluvial/alluvial terrace located less than a kilometer downstream. This terrace indicates a permanent flow prior to this outburst event which means that the lake should have been in a relatively stable state. It is considered, then, that an external event caused this partial drainage of the lake, either by excess precipitation or by a rock avalanche that fell into the lake based on fresh scars in the surrounding outcrops.

Risk analysis and reconstruction of the 1934 glacial lake outburst flood event in the Plomo basin (33°S), Central Andes of Argentina

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In the last 230 years, the Plomo River (33°S; 70°W) was dammed at least three times by surges of the Glaciar Grande del Nevado del Plomo (GGNP). The temporary lakes of ca. 60 x 106 m^3 generated six Glacial Lake Outburst Floods (GLOFs) of different magnitudes (from 350 to 3,000 m^3/s). Almost one century after the most catastrophic event happened on the 10th January of 1934, many changes in land use and an increase in human activities along the Mendoza River valley have occurred, exposing new elements to this threat. This research aims to reconstruct the main characteristics of the 1934 and 1985 temporary lakes and the outburst floods generated along the course of the Plomo River, tributary of the Tupungato River, to assess GLOF risk along the Mendoza River valley. Based on historical records, old topographic maps, and remote sensing, we elaborate the hazard and vulnerability thematic maps. The hazard (H) map is developed using data from the 1934 catastrophic event, whereas the vulnerability (V) is evaluated considering the current land use along the historically affected valley. Finally, GLOF risk (R) is assessed by the classical approach of R=HxV and the overlapping of hazard and vulnerability maps. In a second step, general flooding dynamics are being modeled to reconstruct the 1934 major event using the physically-based multi-phase mass flow model r.avaflow. A plausible flood reconstruction will be crucial for a better understanding of the flow dynamics and evolution through material entrainment. In summary, increasing human activity in the valley and new investments aggravate the exposure against this potential hazard. Our results will help to better understand not only GLOFs from the GGNP, but also the possible impact of GLOFs from other glaciers in the region which have experienced extraordinary surges in the last two centuries.

New insights on GLOFs conditioning and triggering mechanisms in the Patagonian Andes

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Following last century's glacial retreat, many glacial lake outburst floods (GLOFs) were reported in the Patagonian Andes. Yet, between 41º-47ºS, glacial lake formation rate may be decreasing at present. We aim i) to examine the evidential basis for forecasting a decline in GLOF frequency/magnitude in this region; and ii) to better establish GLOF drivers in this data-scarce region, where more frequent extreme rainfall events are expected. From ~700 mapped glacial lakes, we produced a GLOF inventory based on available literature, satellite data, inhabitants' quotes, and local reports. An inventory of 70 GLOFs of different magnitudes along the Patagonian Andes was achieved containing 34 recent outburst events, not described previously. A semi-quantitative lake hazard classification was made, considering the main geomorphic features promoting GLOFs (lake/basin areas, ice-contact, type of dam and the topographic potential, i.e., the susceptibility of landslides or rock/icefalls impacting a lake). We found that ~70% of GLOFs occurred in high/very high hazard lakes; including small lakes (<0.05 km2) related to low magnitude GLOFs. On the other hand, a precise date of outburst had been published in 5 cases and was found for 3 of the new GLOFs. For the remaining, date of outburst was constrained to different time windows, mostly from satellite images: 10-15 days (4 events); ~1-3 months (13); < 1 year (11); and >5 years (no relevant) in 34 cases. For the best constrained (11), we processed reanalysis and meteorological station data to understand weather conditions when occurred. Atmospheric river and cut-off low patterns were observed, causing extreme daily rainfall (>98th percentile) and relatively high temperatures. Both factors raise GLOFs susceptibility and are projected to increase with climate change, hence we forecast an increasing GLOF trend in the next years. Therefore, we expect our hazard classification may serve to identify the most dangerous lakes.

Neoglacial increase in high-magnitude Glacial Lake Outburst Flood frequency (Baker River, Chilean Patagonia, 47°S)

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Glacial Lake Outburst Floods (GLOFs) constitute a major hazard in glacierized environments. Despite a recent increase in the size and number of glacial lakes worldwide, there is only limited evidence that climate change is affecting GLOF frequency. In Patagonia, GLOFs are particularly common in the Baker River watershed (47°S), where 23 GLOFs occurred between 2008 and 2020 due to the drainage of Cachet 2 Lake into the Colonia River, a tributary of the Baker River. During these GLOFs, the increased discharge from the Colonia River blocks the regular flow of the Baker River, resulting in the inundation of the Valle Grande floodplain, which is located approximately 4 km upstream of the confluence. To assess the possible long-term relationship between GLOF frequency, glacier behavior, and climate variability, four sediment cores collected in the Valle Grande floodplain were analyzed. Their geophysical and sedimentological properties were examined, and radiocarbon-based age-depth models were constructed. All cores consist of dense, fine-grained, organic-poor material alternating with low-density organic-rich deposits. The percentage of lithogenic particles, which were most likely deposited during high-magnitude GLOFs, was used to reconstruct the flood history of the last 2.75 kyr. Results show increased flood activity between 2.57 and 2.17 cal kyr BP, and between 0.75 and 0 cal kyr BP. These two periods coincide with glacier advances during the Neoglaciation. Our results suggest that GLOFs are not a new phenomenon in the region. Although rapid glacier retreat is likely responsible for high GLOF frequency in the 21st century, high-magnitude GLOFs seem to occur more frequently when glaciers are larger and thicker.

GLOF event in the Turbio river basin in June 2017 (North Patagonian Andean Range, NW Chubut, Argentina): triggers and impacts

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The Turbio river valley can be described as a paraglacial landscape with wide floodplains and glaciers relicts in its headwaters. High-energy events, frequent but not cyclic, have effects on the geomorphological and biological evolution of the basin. Our study focuses on a glacial lake outburst flood (GLOF) that occurred in June 2017 in one of the upper basin tributaries. Based on satellite images and local stakeholder's information, the outburst occurred between June 25th-26th. During those days, a rockslide from the southern slope of the valley reached the lake (42,28°S; 72,13ºW), emptying it completely. The resulting high-energy flow eroded the lateral banks of the Turbio river valley and left a large debris corridor extending more than 7 km. The torrent flood overbanks the lower fluvial plain and reached the fan delta of Puelo lake. Wood debris accumulations (*Fitzroya cupressoides)* were found along the Lake. A rural house was destroyed and trouts (*Onchorynchus mykiss*) were found dead. A few days before the event, a 3-day cumulative rainfall >80 mm was detected, associated with a cut-off low structure developed over the southeastern Pacific. Subsequently, on June 25th, a Mw 4.9 earthquake occurred 12 km from the lake, with a depth <13 km. In this case, the rockslide induced by weather (rainfall) or seismic conditions, or both combined, may have been sufficient to trigger a GLOF. An example is the Valdivia mega-earthquake of May 1960, in which outburst flood and avulsion processes were reported in the same lower basin. We suggest that continuous monitoring of glacial lakes and related hazards in this region is important, despite being sparsely populated. In addition, we recognize that the low anthropization degree of the Turbio river provides an excellent opportunity to study GLOFs and their geomorphic effects in the north Patagonian Andes.

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FOCUS SESSION 2

Lacustrine records of geological and hydrological hazards

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Sediments of Bohemian Forest lakes (Central Europe) show evidence of a high-temperature event at the Allerød-Younger Dryas transition

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Near 12,850 cal. yr. BP, the Younger Dryas stadial (YD) abruptly reversed the warming trend from the last glacial to the present interglacial at high northern latitudes. The main trigger of this ca. 1200-year-long extreme climate event has been attributed to major reconfigurations of the oceanic and atmospheric circulation in the North Atlantic, a large release of meltwater from the area of Laurentide Ice Sheet, volcanic gas aerosols from the cataclysmic Laacher See (LS) eruption (13,006±9 cal. yr. BP; Volcanic Eifel, Germany), or a cosmic body impact/airburst. We retrieved lake sediment cores from three sites located in the Bohemian Forest Mts, a Czechia-Germany-Austria border area. All of them contained characteristic LS (crypto) tephra glass shards that were documented using X-ray fluorescence scanning, magnetic susceptibility measurements, and direct observation using SEM. Chemical characterization and quantification of the glass shards were performed using an electron probe micro-analyzer (EPMA) and a TESCAN Integrated Mineral Analyzer (TIMA). In addition to the cryptotephra, we observed magnetically extracted iron-rich melt grains (microspherules) with signs of high-temperature melting and quenching in all studied sediment cores. Their maxima (3–36 objects per 1 g of dry sediment) were situated 2.2–3.1 cm above peaks in the cryptotephra shard concentrations showing ages that correspond well to the YD onset. Such exotic objects of similar age were reported from numerous sites on several continents, where more impact-related proxies were documented. However, the dating of the previously published records is based only on ^{14}C age-depth models which are always affected by measurement errors and calibration uncertainties. Based on this new evidence with a good age control (LS cryptotephra), we hypothesize that the Allerød-YD transition in Central Europe was likely affected by a high-temperature event, likely related to an impact. The ongoing study is supported by the Czech Grant Foundation (20-08294S – PROGRESS).

A high-resolution seismic investigation of active faulting in lakes of Patagonia

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Subaqueous lacustrine deposits are a valuable tool for the characterization of tectonic deformation since they offer decisive cross-sections with thick and usually well-preserved sedimentary records where to look for markers. This fact plays a key role in places where direct morphological evidence is lacking due to high erosion and/or slow deformation rates or is concealed by dense forests or extensive water bodies, as is the case of Patagonian Andes. This work presents the results of high-resolution seismic research in lacustrine subaquous deposits that led to the identification and characterization of active structures in two lakes encompassed within different tectonic settings. Lago Fagnano, located in the Fuegian Patagonia, runs along the active Magallanes – Fagnano transform fault system. The area is characterized by shallow low-magnitude seismic activity with large historical earthquakes, such as the Mw 7.5 1949. This event generated coseismic ruptures identified onshore, although their full extension remains uncertain. Seismic reflection data in the lake revealed a series of fault ruptures affecting glaciolacustrine and lacustrine deposits, several of which reach the lake-floor suggesting these could represent the offshore continuation of the 1949 rupture. In addition, seismic data shows how deformation is distributed along different fault segments, representing along-strike variations of deformation. On the other hand, Lago Argentino is a large proglacial lake located in the Austral Patagonian Andes foreland. Despite the seismic activity recorded in the area, no studies regarding the neotectonic activity have been carried out so far. We have identified subvertical faults within the post-glacial lacustrine sediments of Rico and Sur arms of the lake that constitute the first evidence of active tectonics in the area. Subaquous faults could be correlated with onshore geomorphic markers that affect basement rocks. The identification and characterization of active potentially seismogenic faults is a key step to a thorough hazard assessment in Patagonia, where these types of studies are yet limited. Not only to evaluate future fault ruptures but also to investigate the occurrence of associated geohazards such as soil liquefaction, landslides and associated tsunami.

A continued long history of earthquakes and Chilean lakes

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In recent years, a wealth of lacustrine paleoseismic studies has emerged around the world, providing often long and highly-sensitive shaking records. Such lacustrine records are particularly powerful for subduction zones, where traditional paleoseismic techniques cannot completely and reliably grasp the manifold of seismic hazards that exist in these settings. In this respect, the south-central Chilean subduction zone has been extensively studied, resulting in the identification of sedimentary shaking imprints in no less than 20 lakes and fjords. Correlation of these records and integration with other coastal paleoseismic and -tsunami archives provided qualitative estimates of the recurrence mode for different types of rupture sources, notably for megathrust earthquakes. Full-segment ruptures, like the M_W 9.5 1960 Valdivia earthquake, occurred repeatedly in the last two millennia. Additionally, numerous partial ruptures and a rupture cascade have been identified alongside a notable seismic quiescence of ~400 years. Long shaking records are however still lacking in a large portion of the along-strike extent of this subduction zone segment, resulting in a knowledge gap of over 600 km long and thus often ambiguous cross-correlations. Also, quantitative estimations of the timing and spatial extent of these events are still lacking due to large uncertainties. These arise from inconsistencies in the applied dating techniques, variable age precision, and the mostly unclear relationship between sedimentary earthquake imprints and rupture characteristics. The new '*QuakeScene Chile*' project aims to push the frontiers of subduction-zone paleoseismology by i) retrieving additional records from several lakes in the Chilean lake district and on Chiloé Island to fill the knowledge gap, ii) developing a new chronological toolbox to improve synchronicity assessment between different sites and archives, and iii) applying ground-motion modelling to establish the missing link between sedimentary shaking evidence and seismological earthquake parameters. We present an overview of past and ongoing work within the framework of this project.

Paleoseismic record from the Rieti Basin; a seismically-active, low-relief area in central Italy

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Small lakes in low relief areas are atypical candidates for paleoseismicity studies, but their sediments can contain seismically induced event layers that are generated through strong ground shaking, sediment transport, hydrological reorganization and changes in groundwater chemistry and flow. Co-seismic movement near low relief lakes can change lake inflow and outflow and in proximal settings can produce seiche waves that can disrupt, resuspend and refocus sediment. Additionally, when lakes receive hydrologic inputs from multiple hydrochemically distinct sources, there is a potential for seismicity to alter the relative contributions of these inputs. Lakes Lungo and Ripasottile are adjacent shallow lakes (<10m deep) located in the Rieti Basin, central Apennines, Italy, where strong normal faulting earthquakes (Mw 6.5 to 7.0) regularly occur. Sedimentological and geochemical analysis from lake cores representing the last ~1000 years reveal four event layers, identified in both lakes, that correspond with >6 magnitude earthquakes having epicenters within 40km of the lakes. These events occurred in 1298, 1349, 1639 and 1703 AD. The common physical structure is a homogenous bed of re-suspended sediment consisting of a denser, high magnetic susceptibility (MS) clastic base, with organic matter concentrated above. Co-seismic to post-seismic chemical signatures are associated with some but not all event layers and may represent abrupt or transient shifts to a groundwater-dominated system with increased inputs from the high sulfate karstic aquifer, or permanent changes in groundwater flow and/ or spring discharge. Excursions in $\delta^{13}C_{org}$ may represent disruptions or changes in carbon source. Not all event layers show the same features, a result attributed to differences in seismic processes as well as the lake attributes and anthropogenic modification. The observations made here may provide a new means of detecting paleoseismicity, add potential for event stratigraphy correlation, and be applied to other low relief lakes in seismically active areas.

Dual-energy CT: a new perspective to reveal the inner structure of sediments according to mineralogical and/or porosity changes in 3D

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Dual-energy CT (DECT) consists in imaging objects using two X-ray incident beams with different energies to discriminate and identify the phases within a sample based on its density (electron density, ρ_e) and elemental composition (effective atomic number, Z_{eff}). Here, a stoichiometric calibration method, originally developed for medical purposes and not requiring the previous knowledge of incident X-ray beam is applied to sediment cores. We explore the potential of this non-destructive technique for studying in 3D the inner changes in sedimentary composition, e.g., mineralogy and porosity. Lacustrine sediment cores from the Canadian Arctic containing pronounced sedimentary variations were tested. Cores were scanned using a medical CT instrument at 70 kV and 140 kV and their properties (ρ_e and Z_{eff}) were calculated by the above-mentioned protocol. Another scanning technique providing elemental composition was implemented: µXRF core scanner analysis were accomplished at the same resolution of CT-measurements. The profiles of these two techniques were compared in different core zones selected in a stochastic way, finding a good correlation between the two properties and some elements. As expected, calculated density values using DECT on fine-grained lacustrine sediment cores were smaller than theoretical ones obtained from large, homogeneous mineral specimens. Yet, standard cores with known porosity were also analyzed and demonstrated that porosity variations can also be inferred using DECT. Eventually, the prediction of sediment core chemical composition was tested, verifying the possibility to make this approach an alternative to current techniques. In conclusion, DECT is a versatile method able not only to visualize non-destructively the inner sediment structure, but also shows promising prospect in identifying mineralogical and/or porosity changes in three dimensions.

Detecting coseismic horizontal slip in lacustrine sediments with implications for the completeness of paleo-seismic records

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Despite the hazard caused by near-surface destructive horizontal displacements during earthquakes, field evidence for coseismic slip along horizontal discontinuities is exceptionally rare, mainly due to the lack of adequate exposure and markers. Within the seismically active Dead Sea Basin, the late Pleistocene lacustrine sediments of the Lisan Formation contain vertical injection clastic dikes and pre-existing steep fault planes that serve as ideal markers for detecting horizontal (bed-parallel) slip. Field observations show that these markers are sheared laterally at maximum depths of 15 m. The displacement profiles and gradients of the sheared clastic dikes provide unique evidence for concurrent displacement along a dozen slip surfaces during a single failure event. We consider the mechanical effect of seismic wave– related transient stress, which, when added to the initial static effective stress, resulted in concurrent horizontal shear failure along weak layers in the Lisan Formation. Surficial and sub-surface deformed intrastratal horizons at different stratigraphic levels also provide evidence for concurrent shear during a single failure event, with seismicity triggering downslope-directed movement of sediments towards the deeper basin. Hence, in lacustrine paleo-seismic records, sub-surface deformation can be significantly younger than the depositional age of beds it affects, thereby weakening age-depth correlations used to estimate the timing of paleoearthquakes. The exceptional quality of exposures and markers in the Lisan Formation enables us to document the details of sub-surface horizontal shearing and indicates that displacement along horizontal bedding planes is a viable mechanism to absorb coseismic deformation in lacustrine sub-surface strata. In lesser-quality exposures of lacustrine sediments that lack adequate markers, horizontal slip may not be documented, weakening the completeness of the paleo-seismic record.

Distinguishing between seismite types using anisotropy of magnetic susceptibility from the Dead Sea sediments

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Seismites are key to understanding the dynamics and spatio-temporal distribution of earthquakes, however, the process of rearranging the deformed volume is not well understood. In order to promote this understanding, we analyzed the anisotropy of magnetic susceptibility (AMS) of various types of lacustrine seismites that were formed during late Pleistocene activity along the Dead Sea Fault (DSF). The magnetic lineation (L) and the shape of the AMS ellipsoid (T) of the seismites are presented in a newly constructed T-L plot. Depending on the type of material (i.e., detritial-rich, aragonite-rich), the seismites are distinguished according to the following characteristics: Injection structures are characterized by a nonlinear correlation curve; damage zones lie on a common linear correlation curve; earthquake-triggered folds also show a linear correlation with those that have undergone major deformation displaying low T and high L values. Breccia layers show a range of T and L values similar to that of primary sedimentary layers, implying that such seismites were formed by sediment that was re-deposited from suspension immediately after an earthquake. Our results also demonstrate that the associated ductile deformation zones are compatible with coseismic dynamic faulting. Most of the AMS fabrics show a conspicuous similarity to that of earthquake fault-plane solutions. This novel application of AMS provides an effective tool for: i) defining the shape and extent of damage zones; ii) determining the principal axes of the local strain field and; iii) resolving the kinematics and dynamics of a wide variety of seismites in soft sediments. We outline a robust procedure to infer the seismite mechanism which is helpful in interpreting paleoseismic records and defining potentially hazardous seismically active regions.

Soft-sediment deformation structures as natural seismographs

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Soft-sediment deformation structures (SSDS) in subaqueous sedimentary sequences are commonly used as paleoseismic indicators. Recent studies suggest that SSDS not only enable resolving earthquake recurrence rates, but can also indicate shaking strength of past events. However, to use SSDS for quantification of seismic shaking strength at different lacustrine settings, a thorough understanding is required of the interplay between i) sedimentological characteristics, ii) seismic sources, iii) slope morphologies, and iv) sedimentation rates. We investigated 25 earthquake-related SSDS within 17 sediment cores (slope angles of 0.2-4.9°) from lake Riñihue, Chile. Background sediments within lake Riñihue are intercalated by clastic deposits (i.e. lahar deposits and tephra), which form the basal layer of SSDS in 72% of the cases. We find that—in first order—individual SSDS thickness is controlled by slope angle, as deformation thickness increases with higher slope angles. In second order, the burial depth of clastic deposits during seismic shaking modulates SSDS thickness as deformation often occurs above the first stratigraphically available clastic deposit. However, at steeper slope angles, clastic deposits that are deeper within the sedimentary sequence serve as basal layer of SSDS. The degree of deformation firstly links to shaking strength, as the megathrust earthquakes that caused strongest shaking also caused highest deformation degrees within the observed SSDS. Secondarily, SSDS thickness modulates deformation degree, as earthquake-induced shear energy is more concentrated within thinner deforming sequences, thus causing stronger deformation. Additionally, we investigate earthquake-related SSDS from nine different lakes with large variation in i) lithologies, ii) seismic sources, and iii) sedimentation rate. We use Principal Component Analysis (PCA) and cluster analyses for a semi-quantitative evaluation of lithological differences. We focus on SSDS related to well-documented historical megathrust, crustal and intraslab earthquakes to evaluate the effect of seismic shaking on deformation. Our study provides the first global overview of earthquake-related lacustrine SSDS found within different lithologies, thereby pushing forward the field of quantitative paleoseismology.

Lahar deposits from Villarrica Volcano in lakes Calafquén and Villarrica (south-central Chile)

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Lahars are among of the deadliest volcanic hazards, but reconstructing comprehensive lahar histories beyond historical records is difficult. This is due to their erosional nature and localized occurrence in valleys. In the right setting, lacustrine sediment sequences may provide useful geological records by means of event deposits. Such a setting is provided by Villarrica Volcano (south-central Chile) and its two neighboring lakes Calafquén and Villarrica, of which the combined catchment covers ~95% of the volcano, and most historical lahars have reached the shore of either or both lakes. Here, we present a detailed sedimentological study of historical lahar deposits from both lakes, including the 2015 lahar in Lake Villarrica. In order to study their distribution, composition, texture and sedimentary structures, we retrieved gravity cores from different water depths and distances from the lahar inflows. In the deep, proximal basins the lahar deposits consist of a basal brown, graded coarse silty to sandy bed, covered by a beige cap of clayey fine silts. The basal bed gradually disappears and becomes finer grained a few tens of meters above the basin floor and we interpret it to be resulting from underflows. Ripples and convolute laminations – revealed by X-ray CT scanning – allow relating the underflows to specific lahar inflows. The beige cap is more widely distributed and also has a very constant grain size across the basin, and we relate them to interflows. Their thickness seems to be related to the size of the lahar. Our study shows the potential of using lake sediments to provide quantitative lahar records over time scales in which both volcanic activity and climate changed, and such records may eventually allow to disentangle these two factors that both influence lahar hazard.

New Mocho-Choshuenco explosive events identified in Laguna Carirriñe sediment cores, Northern Patagonia, Argentina

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Mocho-Choshuenco Volcanic Complex (MCVC) is one of the most active volcanoes of the CSVZ during postglacial times, however its explosive record is poorly studied in Argentina. In order to improve the knowledge of its eruptive history and dispersion patterns east of the Andes, we studied a ~7 m long lake sediment record from Laguna Carirriñe (SW volcán Lanín) spanning 12 ka. We identified several tephras of the E-NE driven plumes derived from the MCVC based on the analysis of tephra layers preserved in Carirriñe lake sediments and their correlation with tephras from Laguna Huaca Mamuil record (NE volcán Lanín) and nearby surface exposures. They are characterized by their glass morphology, geochemistry, mineral association, being the presence of framboidal pyrite a main characteristic that confirms MCVC provenance. We developed a Bayesian age-depth model to estimate the age interval of each described tephra. We identify the presence of 44 direct fallout events sourced from MCVC. The record includes the four largest eruptions previously reported: Neltume (white pumiceous rhyolitic tephra, 12.1-10.8 ka BP, VEI 5.7), Pirehueico (dacitic-rhyolitic glass, 9.2-8.4 ka BP, VEI 5.3) with a scoria layer at its base, Huilo (dacitic-rhyolitic with associated andesitic scoria, 8.4-8.1 ka BP, VEI 5.3), Enco (dacitic-andesitic fine ash, 1.5-1.4 ka BP, VEI 5); three new prominent tephras identified between Neltume and Pirehueico and two events between Pirehueico and Huilo eruptions. Another distinctive bimodal (rhyolitic/basaltic-andesitic) layer (996–931 yr BP), provisionally named Carirriñe Tephra, is identified in both, Carirriñe and Huaca Mamuil records. This layer is geochemically and morphologically characterised, and its NE dispersion is consistent with other prominent events identified within the Lago Carirriñe core. In addition, the ~9.5 cal. ka Chana tephra from Volcán Chaitén and several minor events derived from monogenetic cones sourced from MCVC are also identified in this highresolution record.

A look back in the Eye of Quebec: morpho-sedimentary records of natural hazards at Lake Manicouagan (northern Québec)

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Lake Manicouagan is a natural lake lying within the annular depression created by a crater impact in northern Quebec. The landscape of the region has been inherited from the retreat of the Laurentian Ice Sheet and more recently by river damming that highlighted the impact structure, known as 'the Eye of Quebec'. The morpho-sedimentary record of the flooded lake has been investigated combining multibeam swath bathymetry, 4 kHz CHIRP acoustic imagery, and a set of short-cores collected across this 60-km long lake. The swath bathymetry revealed a narrow valley surrounded by a shelf bordering steep slopes, with deep basins characterized by flat (north) and hummocky (south) topography. A narrow channel connects the lake's deep basins in the north, many of which are located at altitudes below sea level. Morphological features of sediment routing (canyons, deltas, alluvial fans) and gravity processes (slide scars) are evidenced in front of river mouths, above the former lake shore, and along the shelf. Gravity processes are supported from the acoustic record showing transparent lenses interpreted as mass-movement deposits intercalated in recent sediments. Core scanning techniques and grain-size analysis show event sedimentation is widely recorded by massive slumped sediments, deformed structures, coarse-based turbidites, sandy layers, and clay caps. The chronological framework suggests the most recent clay cap can be linked to the reservoir flooding during the 1960s. Yet, this event is much thinner than earlier deposits from the past millennium, which suggests other triggers, such as catchment processes (debris flows, floods) or earthquakes, have been involved in the generation and deposition of major sedimentary events. The lacustrine record thereby confirms geological and/or hydrological hazard are recorded at Manicouagan. Ongoing investigations with cross-core correlations and radiocarbon dating are expected to improve hazard identification, spatiotemporal assessment, long-term environmental impacts, and frequency analysis.

Sedimentary record of synchronous crater collapses in Espejo and Reloj lakes (South-Central Chile): evidence for a strong instraslab or crustal earthquake in the 13-14th Century?

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Whereas the sedimentary record of megathrust earthquakes has been extensively studied in south-central Chile, the signature of crustal (e.g. Aysén 2007) and intraslab events (e.g. Chillán 1939) is still poorly understood despite their high damage potential and relevance for seismic hazards. Event deposits in lacustrine sequences can generate insights in their recurrence patterns, which are difficult to obtain using alternative paleoseismic techniques. Lakes Espejo and Reloj are maar lakes located in the Valdivia seismo-tectonic segment. In both lakes, we obtained bathymetric, seismic reflection and sediment core data. The core analysis included macro and microscopic descriptions, loss on ignition, magnetic susceptibility, and X-ray fluorescence scanning. The age-depth model was based on radiocarbon dating of bulk sediment and plant remains. Multiple coeval mass-transport deposits in the upper part of each of the sedimentary successions were interpreted as the effect of synchronous rock slope collapse events. The associated turbidites are caused by the impact of the rock mass on the lacustrine basin floor sediments and date to between the 13th to 14th Century and are thus older than written history. We attribute these two synchronous deposits to a seismic trigger. The absence of seismo-turbidites for large historical megathrust events (e.g. 1960, 1575) in both lakes can be explained by the lack of lacustrine muddy sediments on the steep crater slopes and the fact that rock slope collapses typically require a high PGA and high frequency content of seismic ground motion. Therefore, we propose that the rock slope collapses were triggered by either a local intraslab or local crustal earthquake on a nearby fault. Comparison with emerging lacustrine archives and tectonic geomorphology of the study area will further help constraining the source parameters of this prehistoric earthquake.

FOCUS SESSION 5

Molecular applications and perspectives on modern and Quaternary environmental systems

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Ancient human environmental impacts determined from combining sedaDNA and lipid biomarkers from temperate lakes

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Lakes have been the focus of human settlement and land use in many temperate regions for many millennia. Settlement and most human activities including agriculture and industry influence lake biogeochemical conditions and biology. This can include high intensity impacts close to sites, such as the biogeochemical halo discovered around lake island-settlements but also wider lower intensity effects on the entire lake ecosystem from catchment activity. Such impacts also have to be set against other influencing factors such as climate change and lake ontogeny. In this paper we will show recent research on both high-intensity impacts on lakes in Northern Ireland, UK and lower intensity impacts from lakes in SW Scotland, UK. We have combined sedaDNA with lipid biomarkers (including fecal stanols and bile acids) as well as traditional proxies of human impact (geochemistry, pollen, spores). Some activities may have dual-effects (e.g. habitation, animal slaughter) whilst others may have differential effects (e.g. agriculture). We show how the combination of independent data sets can strengthen inferences, especially in relation to the sources of sedaDNA, but also throw up some inevitable divergencies, which themselves may have evidential value.

Modern plant leaf waxes allow to recognize and reconstruct plant species from a mixed signal in soil and surface lake sediment at South American temperate forest

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Understanding past environments is crucial to improve our knowledge of the future. To achieve this goal, there are several environmental and climate indicators contained in lake sediments like leaf waxes. The latter are relatively easy to measure and used worldwide as a terrigenous biomarker, allowing the discrimination between life traits in soils and lake sediments. Nevertheless, they cannot be directly applied to distinguish different plant species, related to the chemotaxonomic differences reported in modern plants. In this study, we developed two machine learning models (k-nearest neighbors [k-NN] and random forest algorithms) using two leaf wax classes, *n*-alkanoic acids (C_{24}-C_{34}) and *n*-alkanes (C_{25}-C_{35}) from six dominant plant species (75 individuals) of the South American temperate forest. These models based on leaf wax plant data showed good accuracy to reconstruct the six plant species (71.4% - 95.2%). Then, the models were tested using the leaf wax data from soils (7 sites) and surface lake sediments (7 lakes) located in the same forest to estimate the plant species composition in each matrix. The models are able to estimate the plant species in soils and lake samples, especially the random forest one. Using *n*-alkanes alone or the combination of the two leaf wax classes allows estimating the contribution of the six species investigated. In contrast, the model based on *n*-alkanoic acid data alone is not able to detect the presence of the *Araucaria araucana* species that represents at least 10% of the modern vegetation around the investigated lakes. These preliminary results are promising and the models based on leaf waxes could be combined with other proxies like pollen. Such a multiproxy approach would strengthen the past vegetation reconstructions.

Local factors drive deterministic assembly of sediment bacterial and archaeal communities from disconnected mountain lakes

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Complex microbial communities are assembled and maintained through dynamic deterministic and stochastic processes. Yet how the relative importance of each process varies with local and regional factors and secondary structures like depth profiles remains unclear. Alpine lake sediments are a model system to study ecological assembly because they are situated at the bottom of lakes in disconnected mountain ranges with varying dispersal potentials and distinct physicochemical characteristics. Microbes buried in the sediments over time also experience a large shift in abiotic environment from nutrient-rich surface sediments to deep layers low in energy, oxygen, and nutrients. To examine the relative roles of different assembly processes across such environments, we produced 16S rRNA metabarcoding data targeting the diversity of prokaryotic communities in 48 sediment cores from 36 lakes in four mountain ranges of Wyoming, USA. Community composition changed dramatically with sediment depth in a similar way across all cores, but also showed differences between shallow, warm lakes and deep, cool lakes. Differences among assemblages related to burial depth with a high degree of similarity in dominant phyla and families at similar depths across lakes, with little effect of geographic distance. Community similarity distance- and environmental-decay relationships and quantitative ecological process estimates using a null model approach supported our findings. Overall, deterministic processes (selection driven by the environment) accounted for 89.5% of pairwise comparisons, whereas stochastic processes (homogenizing dispersal, dispersal limitation, drift) were responsible for 10.5%. Selection acted to differentiate communities based on local factors including abiotic lake conditions and differences related to depth within the sediment. Despite dispersal barriers, distinct sedimentary environments select for taxa that can persist in extreme conditions. Understanding the spatial variation of microbial diversity and assembly of lake sediments is essential to using sedimentary microbes to understand past and current dynamics of lake ecosystems.

Spring production of alkenones in Lake St Moritz (Switzerland): a first step towards the use of the alkenone paleothermometer in mid-latitude freshwater lakes

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Most traditional paleoclimate proxies are either biased towards summer or assumed to record annual averages. We lack proxies for winter and transitional seasons. As a result, our vision of past climate is incomplete, which limits our understanding of climate mechanisms. A new paleothermometer has recently emerged and shows great potential to reconstruct past spring temperatures in freshwater lakes, the lacustrine alkenone biomarker. Alkenones are temperature-sensitive lipids produced specifically by Isochrysidales algae and have been widely used to reconstruct past sea surface temperatures. Alkenones are also found in lakes and have been linked to lake water temperatures in high latitude freshwater lakes. Monitoring studies in these lakes showed that alkenone production occurred during a short period after the ice melt. Depending on the timing of the ice-out, lacustrine alkenones record spring or summer temperatures. Lacustrine alkenones are increasingly reported in mid-latitude freshwater lakes but the seasonality of their production remained to be constrained. In our study, we monitored for the first time the alkenone production in a mid-latitude lake, Lake St Moritz in Switzerland. We sampled lake water and sediment trap contents during a year to follow the alkenone production in the lake. We also monitored the evolution through time of temperature and physico-chemical parameters of the lake water. We recorded the peak of alkenone production in spring 2022 and calculated the index of every sample containing alkenones to build an in-situ calibration. This calibration should allow us, in the future, to reconstruct spring temperatures in the past from Lake St Moritz sediments. Our goal is also to identify the drivers of the timing of alkenone production to better understand and interpret past variations of alkenone content in sediments. This study lays the foundations for the use of lacustrine alkenones as a spring paleothermometer in mid-latitude freshwater lakes.

Within-lake spatial variation in fish sedimentary DNA concentrations

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Detecting and quantifying fish DNA from lake sediments (sedDNA) offers many opportunities to understand historical lake communities, but often proves more challenging than detecting other aquatic taxa. One possible contributing factor could be that fish sedDNA is less evenly distributed in lakes due to fish habitat associations, that contribute to variable eDNA deposition and degradation. Here, we investigate how fish DNA concentrations vary spatially in lake surface sediments to determine the optimal sampling locations for sedDNA reconstructions of historical anadromous alewife (*Alosa pseudoharengus*) populations. To understand where DNA concentrates when alewives are present, six paired sediment cores and water samples were collected in the summer of 2022 from Walker Pond, Maine, USA, which has had consistent, unimpeded alewife runs for the past 70 years. Water samples were analyzed to confirm alewife DNA shedding in the water column, while DNA from the top centimeter of each sediment core was compared to characterize potential variation in alewife DNA deposition. To clarify the effects of fish phenology and time since deposition, replicate water and sediment samples will be collected in the fall of 2022 and winter of 2023 after alewife have emigrated from the lake. Paired analyses of sediment and water eDNA, and of sediment DNA across seasons, will be used to test whether 1) fish sedDNA is variable across habitats in association with either 2) habitat-specific shedding rates, or 3) habitat-specific degradation rates. Sediment cores yielding the highest surface sedDNA concentrations will be dated and analyzed to determine how far into the past alewives can be detected. Understanding of spatiotemporal variation in fish sedDNA is expected to help reduce potential false negatives and quantification bias in sedDNA of lake communities and improve reconstructions of historical anadromous fish ecology.

Calibration and application of the branched glycerol dialkyl glycerol tetraether proxy for temperature in tropical South America

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Decades of research have established a coherent temperature history for the high latitudes and the world's oceans, yet we continue to lack proxies to quantify the temperature history of the tropical continents. Branched glycerol dialkyl glycerol tetraethers (brGDGTs) are an emerging molecular tool that can solve this challenge. brGDGTs have been widely applied to lake sediments in tropical Africa where they have documented the timing and amplitude of deglacial warming and the Holocene thermal maximum at various elevations through the lower troposphere; however, brGDGTs have only been sporadically applied in other parts of the tropics. We examined brGDGTs in lake sediments from throughout the tropics, including 57 new sites in tropical South America extending from the Amazon basin into the eastern Andes. We produced a new pan-tropical calibration of lacustrine brGDGT abundances to air temperature that improves the error statistics of previous tropical African and global calibrations. Furthermore, tests of this calibration against global lacustrine brGDGT calibrations reveals biases that point to effects of seasonal brGDGT production on existing calibrations in the mid- to high latitudes. We tested the applicability of this new calibration to a sediment core spanning the last ~16 kyr from Laguna Llaviucu, located at ~3000 m elevation in Ecuador. The record indicates ~4 ºC warming from 16 ka to the Holocene, comparable to changes in mountain lakes in the African tropics. This is followed by relatively stable temperatures during the Holocene, in contrast to early- to mid-Holocene warming observed across tropical Africa. These patterns suggest similar responses of tropical temperature to rising atmospheric CO_2 concentrations during the last deglaciation, but regional differences during the Holocene, when forcings were weaker, driven by climate- and land-surface feedbacks.

Evaluation of eukarya metabarcoding of four meters of sediments from Lago maar Rincon de Parangueo

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DNA preserved in lake sediments is a potential proxy for understanding the geological and biological dynamics of ecosystems. Especially in extreme environments, metabarcoding analysis for the 18S rRNA gene generates clues about biodiversity and community interactions. The Eukarya domain plays a key role in global ecosystems, but little information is known on high-pH and high-salinity maar lakes ecosystems such as Rincon de Parangueo. Here we used Illumina high-throughput DNA sequencing metabarcoding to characterize the eukarya communities by the 18S rRNA genes, from four microecosystems collected in this maar lake located in the Valle de Santiago region (Central Mexico). Thirteen samples, collected from microbialites, sediment, water and mats inside the maar were analyzed using DADA2 from R. The input data were above 250,000 sequences while the results obtained after removing chimeras and quality filtration are close to 170,000. The highest ASVs abundance were found in water and microbialite micro-ecosystems. Among the most represent Order were Cholorophyta with the genus *Ctenocladus_circinnatus* and *Coccomyxa*, both part of the microbiota of the microbialites, adapted to live in high salinity anda alcality environments. Interestingly we identified reads for *Gallus gallus*, *mammalia* and some ferns traped in the sediment which could represent part of the past and present biodiversity in the area. We could detect *Picosystis* one of the most important microalgie of the primary diet of microcrustaceans in the high salinity and alkaliny lakes, also we observed high abundance of *Flosculariaceae* an invasor microcrustaceans, which could compited with the natural microcrustaceans. Our results supporting a highly impact on the ecosystem, which suffered from hydric exploitation since at least 40 years ago and human invasion since prehispanic times.

Late Quaternary paleoenvironmental evolution of the geoarchaeological site TaguaTagua 3 in central Chile (~34ºS)

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The ancient Tagua Tagua Lake (ATTL) is one of the few sites in South America where evidence of early megafaunal hunting converges with a lacustrine sedimentary record that allow us to evaluate distinct hypotheses about events that occurred during the Pleistocene-Holocene transition (PHT). In this work, we show biogeochemical evidence obtained from the archaeological site Taguatagua 3 (TT-3) that indicates more arid conditions during the Pleistocene than previously described. The sedimentary sequence (TT19-3A; 2.8 m depth) was sampled for bulk geochemical indicators (TOC, TIC, C/N, TS, $\delta^{18}O$ and $\delta^{13}C$), grainsize, phytoliths, diatoms and lipid biomarkers (*n-alkanes, n-alkanols, sterols and fatty acids*). The record spans the last ~20 ka cal BP (14 AMS 14C dates). The record suggests that ATTL evolved from a shallow lake with cold environmental conditions between ~20 and ~17/17.5 ka cal BP to a slightly larger aquatic system with warm temperatures between ~17.5 and ~12.5 ka cal BP, coeval with the first records of human occupations at TT-3. Major shifts occurred at ~12.5-12, ~11.5-11, and ~10.5-10 ka cal BP characterized by the onset of wetter conditions (increasing tychoplanktonic diatom species at the expense of littoral species tolerant to high conductivity, less negative $\delta^{18}O/\delta^{13}C$ values, and greater arboreal development). Additionally, we detected a statistically significant cold pulse between ~11.7 and 10.5 ka cal BP. Deeper lake conditions with a higher abundance of shrub phytoliths ensued between ~10 and 5 ka cal BP at the time of the second human occupation at TT-3, and overprinted by large-magnitude temperature fluctuations between ~6.5 and 5.0 ka cal BP. Late Quaternary paleoclimate dynamics in ATTL suggest important changes in the strength of the South Pacific anticyclone, synchronous, with large-scale atmospheric changes such as the Southern Westerly Wind drift and other global climate drivers. Fondecyt #11220930; #11170919; Universidad de O'Higgins; I. Municipalidad de San Vicente de Tagua Tagua; Fundación Añañuca; NITT; NCN19_153.

Evaluation of prokaryotic communities along a sediment vertical profile in two saline-alkaline crater maars using 16S rRNA metagenomic approach

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Hoya La Alberca and Hoya Rincón de Parangueo are small volcanic maars of phreatomagmatic origin, located in the central part of the Trans Mexican Volcanic Belt, that hosted saline-alkaline crater lakes during most of their Quaternary history. Nowadays both lakes are nearly desiccated, and can be considered extreme environments for life, with Na^+, Cl^-, and CO_3^{2-} as predominant ions, pH ranging from 9.7 to 10.2 and high conductivities (165000-124600 μS/cm^{-1}). Metagenomic DNA from the archaeal and bacterial community was extracted directly from sediments, each sample represents 20 cm in 4 meters deep stratigraphic logs drilled at the center of each crater. 16S rRNA sequencing method was employed to characterize the vertical distribution of the microbial community in both locations. The influence of environmental factors (physical and chemical properties) on the microbial communities that live within the sediment environment was examined. The bacterial phyla present in both sites included members of Firmicutes, Proteobacteria, Actinobacteria, Bacteroidota and, Chloroflexi, while Archaea was mainly dominated by Halobacterota. However, significant differences were found in microbial communities from the two lakes. Cyanobacteria, Acetothermia, Hadarchaeota and Thermoplasmatota were identified only in the Rincón de Parangueo samples. Instead, Gemmatimonadota, Acidobacteriota Halanaerobiaeota and Crenarchaeota were only present in La Alberca samples. We discuss that environmental variables are significant contributors to the total variation, and conductivity and pH are the most important factors due to significant correlation with the distribution of the microbial communities.

Sediment DNA and pigments show increasing abundance and toxicity of cyanoHABs during the Anthropocene

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Harmful cyanobacteria blooms (cyanoHABs) are assumed to be increasing in abundance and toxicity since the start of the Anthropocene, but comprehensive analysis of changes in cyanobacterial assemblages are limited, in part because some key taxa (e.g., *Microcystis*) leave ambiguous evidence of historical abundance and toxicity. In principle, sedimentary ancient DNA (*seda*DNA) can allow for the reconstruction of the cyanobacteria community composition, as well as the frequency of genes specific to cyanotoxin production over centuries. Here we present gene frequency and cyanobacteria community data from *seda*DNA as well as fossil pigment concentrations in nine Minnesota (USA) lakes, spanning over 100 years, along a gradient of lake size, depth, and trophic state. The abundance of genes associated with microcystin toxin-producing potential (*mcyE*), total cyanobacteria, and the genus *Microcystis* (MICR) were quantified via droplet digital polymerase chain reaction (ddPCR) and these data were combined with high-throughput sequencing (HTS) on a subset of three lakes to investigate how the occurrence of toxin-producing gene changes with cyanobacteria community dynamics. Our results showed a significant correlation between the MICR and *mcyE* gene frequency and cyanobacterial taxa with known toxin-production potential. The frequency of both genes likewise increased concomitantly through time. Time constrained analyses of HTS data showed significant change in cyanobacterial communities commencing ca. 1990, wherein the *Dolichospermum* and *Microcystis* genera underwent a pronounced increase. Cyanobacteria pigment data reflected these changes only in deeper lakes, possibly suggesting issues related to benthic production or biomarker preservation in shallower systems. This study provides evidence for historical development of increasingly toxic cyanoHABs across a diverse set of lakes and illustrates how *seda*DNA may help link changes in the cyanobacteria community to the expression of potentially toxic genes.

Multiple trophic level recovery from a large-scale natural pulse disturbance detected using paleo-molecular markers

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Past recovery of lake biological communities from natural pulse disturbances (such as fires, volcanic eruptions and earthquakes) can be highly informative for assessing current and future lake responses to extreme climatic events. This study used a combination of metabarcoding (16S rRNA and 18S rRNA) and geochemical proxies (clastic sediment, organic carbon and isotopic ratios) to characterise the impact and subsequent recovery of multiple trophic levels in Lake Paringa (New Zealand) following the most recent Alpine fault earthquake (Mw > 7) in 1717 CE. In general, aquatic primary producers (cyanobacteria, phytoplankton and macrophytes), consumers (protists and arthropods) and decomposers (bacteria and fungi) responded similarly to the large influx of terrestrial sediment. Abrupt shifts in composition lasted ~20 years for phytoplankton and ~50 years for all other communities, including the disappearance of macrophytes and cyanobacteria, until sediment inputs decreased around ~1760 CE. The results showed that the initial trophic responses were driven by abiotic (physico-chemical), bottom-up nutrient dynamics, while long-term community composition was mediated by biotic (mutualistic or parasitic) interactions. Although the lake community regained relative stability for ~100 years after the postseismic phase ended (1760-1860 CE), a shift to more variable compositions and lake productivity indicators, in the absence of increased sediment inputs, suggested this stability had been eroded. Long-term shifts in phytoplankton composition coincided with a changes in the dominant fungal taxa followed by more variable algal productivity. Dominance of parasitic fungal lineages suggest an important role for host-parasite interactions, which may have had cascading effects on macrophyte and arthropod communities. This study demonstrates that multiple trophic levels can recover following natural pulse disturbances and highlights the strength of paleo-molecular approaches to identify high-level, whole lake community changes.

Redox state impacts the preservation and interpretation of lipid biomarker and ancient DNA proxies in high latitude lake sediments: A case study from northeast Iceland

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Recent scientific advances have enabled increasingly more detailed interpretations of past environmental change based on molecular proxies such as lipid biomarkers and sedimentary ancient DNA (*seda*DNA). However, the degree to which the proxy records an environmental variable of interest, such as temperature or plant community, remains less clear. For example, lipid-based temperature indices can be confounded by changing biological sources and *seda*DNA's preservation can be biased in certain environmental settings. In this study, we provide a Holocene case study from two coastal lakes in northeast Iceland that aims to shed light on the impact of different lake types on the preservation and interpretation of these two environmental proxies. The two lakes are separated by only 0.6 km, sit at the same elevation, and are therefore influenced by the same local climate. However, due to their different surface areas (2.51 vs 0.21 km^2) and depths (48 vs 2.5 m), the lakes exhibit variations in their seasonal stratification and water chemistry today. In Holocene sediment cores from both lakes, we reconstructed temperature and vascular plant community based on bacterial branched glycerol dialkyl glycerol tetraethers (brGDGTs) and *seda*DNA metabarcoding, respectively. Using local brGDGT-temperature calibrations, the large lake produces a summer temperature record consistent with many qualitative proxies from Iceland, reflected by peak warmth in the Early-Middle Holocene followed by coolest conditions in the Late Holocene. However, the small lake produces a relatively flat temperature record. Additional GDGT-based indices indicate that this is likely the result of long-term anoxia for most of the Holocene, which can contribute brGDGTs from additional pools such as anaerobic bacteria. In terms of local plant history, *seda*DNA records for both lakes are largely the same, except for two key differences. The first is that our small, shallow lake has relatively larger contributions of aquatic and emergent plants. Second, the earliest portion of the small lake's record did not have any amplifiable DNA. Based on GDGT indices, this period corresponds with an oxic environment, which is less conducive for DNA preservation, before the long-term switch to low oxygen conditions that prevailed for the rest of the Holocene. Therefore, for the small lake, both brGDGT-based temperatures and DNA preservation seem to be impacted by the redox state of the water column and/or sediment-water interface. However, brGDGT and *seda*DNA proxies from the larger lake, which did not seem to experience the same degree of oxygen depletion, appear immune to redox state.

The hunt for brGDGT-producing bacteria: insights from genomic and lipid biomarker analyses in modern and ancient Icelandic lacustrine environments

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Lipid biomarkers preserved in lake sediment archives are valuable tools in the study of Earth's paleoclimate. Of these, a class of bacterial membrane-spanning lipids called branched glycerol dialkyl glycerol tetraethers (brGDGTs) have become popular as a proxy for environmental temperature and pH. However, gaps remain in our knowledge of brGDGTs that complicate their application at this time. One key knowledge gap is an incomplete identification of their microbial producers. Though these lipids are nearly ubiquitous in lacustrine, marine, and terrestrial environments across the globe, only two species of brGDGT-producing soil bacteria have been successfully cultured in a laboratory setting. This barrier limits our ability to refine brGDGT-based proxies through controlled laboratory experimentation. It also obscures our understanding of which ecological and biogeochemical niches brGDGT-producing organisms inhabit, information that can be pertinent for interpreting a brGDGT proxy record in lacustrine environments. Here, we aim to identify potential brGDGT-producing taxa by measuring brGDGTs and microbial community composition in tandem from lake surface sediments and soils across Iceland. We used statistical tools such as ordination analyses to examine correlations between microbial taxa and brGDGT fractional abundances and discuss the utility of this approach for identifying brGDGT-producing taxa and/or biogeochemical niches. We additionally analyzed the lipid distributions and microbial community compositions of downcore sediment records from two lakes in Iceland. Genomic analyses identified microbial communities that are unusual for lacustrine environments, distinct from both surface sediments and soils, and variable throughout the sedimentary record. We compare these genomic data with brGDGTs measured in the same samples and discuss the ways in which such comparisons can inform our interpretation of lipid biomarker proxy records.

IAL IPA 2022

FOCUS SESSION 6

Varves records: from tracking natural and anthropogenically induced changes of the environment and climate to improving chronologies of past events

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Influence of climatic trends and cycles on the annual varve deposition in Crawford Lake, Ontario, Canada

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The proposed Anthropocene Epoch, defined as the interval where marked changes to Earth's systems driven by human impacts, has left a permanent geological record. Research is underway to select an Anthropocene Global Boundary Stratotype Section and Point (GSSP) with one candidate being the sedimentary sequence preserved in Crawford Lake, Milton, Ontario, Canada. Exceptionally well-preserved annually deposited varves accumulate below the chemocline in this deep karstic basin, and are comprised of productivity influenced dark-colored organic matter laminations, alternating with light-colored calcite precipitated laminations. These laminations archive a record of both natural and anthropogenic change at sub-annual resolution, particularly from the late 19th century onward. A novel high-resolution imaging protocol was used to photograph freeze core CRW19-2FT-B2, collected in February 2019. Individual images were stitched into one cohesive image that was subsequently used to: 1) characterize and identify the chronology of varve couplets deposited between AD 1870 and 2000; 2) document distinctive varves preserved in the core record, including the Holocene-Anthropocene boundary, present throughout the entire lake basin, permitting correlation between existing and future core records; 3) measure the thickness of varves including their distinct dark and light colored laminations; and 4) carry out wavelet and spectral time series analysis based on varve thickness data to identify depositional patterns that can be correlated to trends and cycles in climate and lake productivity. Time series analysis resulted in identification of cycles with statistically significant periodicities that correlate with the Quasi-biennial Oscillation (2.3 years), El Nino Southern Oscillation (2-7 years), the 11-year Schwabe sunspot cycle and Pacific Decadal Oscillation (50-70 years). This research not only provides baseline chronostratigraphic data that definitively archives to the seasonal level the Holocene-Anthropocene Epoch transition preserved in Crawford Lake, but also documents the dynamics of the natural drivers that have influenced deposition in the lake since 1870.

Annual-scale assessment of mid-20th century impacts on the algal ecology in Crawford Lake, Ontario, Canada

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The meromictic Crawford Lake, located in SW Ontario, Canada is characterized by varved sediments, allowing for high-resolution paleoecological studies. Freeze cores, the only coring method available that reliably preserves the fragile laminations representative of summer and winter deposition in the lake, were used to document the siliceous record of diatom and chrysophyte communities at an annual resolution from 1930-1990CE. Stratigraphically constrained cluster analysis showed major assemblage changes that are believed to have been caused by local, regional, and global anthropogenic impacts. The assemblage changes within the siliceous algae are attributed to increased industrial emissions and related effects of acid deposition on the lake's catchment associated with the Great Acceleration – the massive economic, industrial, and demographic expansion beginning in the mid-20th century which is also coincident with observed increases in other anthropogenic markers found within the lake sediment. The findings reflect major changes in earth systems that the Anthropocene Working Group proposes to use to establish a mid-20th base for the Anthropocene Epoch, providing support for the laminated sedimentary sequence from Crawford Lake as a potential Anthropocene GSSP.

Seasonality of calcite precipitation and biological productivity in a marl lake to understand potential drivers and limiting factors of varve formation

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Palaeoenvironmental and palaeoclimate research based on varved lacustrine records have been increasing over the last decade. But proxies from varves require careful interpretation as the lake itself acts as a filter between external environmental variables (e.g. climate) and the sedimentary record. In lakes where varves are preserved at present, it is possible to compare modern varves with observational data of the modern limnology and sediment trapping allowing a deeper understanding of the complex interaction between the physical, chemical and biological processes controlling the sediment flux. Diss Mere is the only lake in the UK that presents a continuous varved record through most of the Holocene (2.1 – 10.3 ka BP). As with many mid-latitudes, alkaline, eutrophic lakes, Diss Mere presents biogenic-calcite varves. We have conducted a 3.5-year lake monitoring survey to test modern varve formation, validate the palaeo-varve model, and refine skilful environmental and climate proxies, such as diatoms and lake chemistry. Main finding reveals that varvse are still forming but not preserving due to a shallowing of the lake in the last two millennia. Primary productivity is higher in autumn and winter in response to nutrient recirculation and input into the photic zone. Calcite precipitate through the whole years but a precipitation peak occurs in the warmest months of the year followed by a secondary peak in the traps that could be indicating either resuspension, biological-induced precipitation or both. Modern analogue can be applied to ancient varves revealing potential for summer temperature reconstruction, winter wind conditions and interannual climate variability over the Holocene.

A varve and radiocarbon-based age estimate for the deglaciation of the British and Irish Ice Sheet in South Wales

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Chronologies for the deglaciation of the British Irish Ice Sheet after the LGM have been constructed using radiocarbon, OSL dating and cosmogenic radionuclide dates and retreat rates inferred from Bayesian age models. The potential of annually-resolved glaciolacustrine records have yet to be fully exploited in the UK. Currently, three varve chronologies from the late Dimlington Stadial are available and these short, floating records provide decadal-scale resolution for transient changes in the ice margin position. However, the spatial extent of UK varve archives requires improvement and the floating chronologies linked to absolute timescales. This paper presents the first multi-millennial varve chronology for the LGIT in the British Isles from Llangorse Lake, south Wales, that provides a new age estimate for the deglaciation of the southern part of the BIIS. The varve data suggests that, during deglaciation at Llangorse, an ice-dammed glacial lake formed that transitioned into a cold climate lake system when the ice dam was breached due to northward retreat of the ice margin. Microfacies work has produced two varve chronologies from cores extracted from the extant lake and were merged to create a master varve chronology, which has a total duration of 3505 years +/-143 years. This chronology is anchored to an absolute age using radiocarbon dates from higher in the sequence and extrapolating the Bayesian age model to date the end of varve formation. An age of 19.16 cal ka BP for the formation of the glacial lake is calculated this lake level fell to form a cold climate lake at 19.08 cal ka years and persisted for ~3400 years until 15.66 cal ka BP.

Lake varves record the causes and effects of the Plague of Justinian, the world's first pandemic.

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Annually laminated sediment archives can offer unique insights into past environmental events. One such relates to the Justinianic Plague (JP) that struck the Byzantine Empire in 541–542 CE, subsequently recurring until ~750 CE. The initial plague outbreak occurred following an exceptionally cold decade, while contemporary historians describe a dimming of the sun for over a year. Did climatic disturbance therefore trigger or amplify the spread of plague? There is also uncertainty and disagreement concerning its impact on human mortality. It has been widely believed that the JP led to the death of 25% or more of the population, but Mordechai et al. (*PNAS*, 2019) offer an alternative, minimalist view. One of their lines of evidence comes from pollen, which does not show a detectable decline in agricultural crops during the 6th century CE. However, most of the pollen records they used have imprecise chronologies and only centennial sampling resolution. Nar lake in central Anatolia has a continuously varved sediment record more than 2600 years long. Initial analysis of cores included stable isotopes (5 varve-year (VY) sampling for the JP), pollen and diatoms (both 20 VY-sample resolution). $\delta^{18}O$ data indicated a major dry-to-wet climate shift during the 6th century, while the pollen record did not show any clear decline in cultivation of cereals and tree crops. We report new, higher resolution, multi-proxy analytical results based on parallel cores with an independent varve chronology spanning the JP. They include replicate stable isotope and pollen analyses (3 VY-sample resolution), elemental chemistry from ITRAX core scanning and thin-section analysis (both sub-annual resolution). These allow us to test the role of changes in climate as a causal agent and land cover as a proxy for impact on rural economy and demography, close to the centre of the world's first historically recorded pandemic.

Millennial-scale lead (Pb) pollution in the southern Baltic lowlands from stable Pb isotopes in the Lake Tiefer See record

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Lead (Pb) pollution is a global issue and has occurred in the Northern Hemisphere concomitantly with economic development since antiquity. In northern Europe, much of the knowledge about the history of anthropogenic Pb emissions during the past four millennia derives from Pb contents and excursions of the $^{206}Pb/^{207}Pb$ isotope ratio in sediments of peats and lakes in the northwest Baltic area, and the pollution history of the southern Baltic area remains fragmented. Herein, we investigate a well-dated record of partly varved Holocene sediments from Lake Tiefer See (northeastern Germany), formed by subglacial processes at the end of the last glaciation, by assessing the stable Pb isotopes ^{208}Pb, ^{207}Pb, ^{206}Pb, and ^{204}Pb at sub-decadal resolution. During the last four millennia, the stable Pb isotope excursions fluctuate together with the Pb enrichment in the sediments, outlining well known periods of Pb pollution in North Europe, such as during the Pax Romana (27 BCE – 180 CE), part of the Middle Ages (750 – 1500 CE), and later from the Industrial Revolution (~1800 CE) to modern times. At selected time intervals, we have quantified the contribution of atmospheric Pb from different sources of early metallurgic activity using a bayesian mixing model. Especially the history of the Harz mining district, located xx km to the Southwest in the prevailing wind direction, is very welloutlined in the sediments of Lake Tiefer See. A first expansion in the Harz mining activities after 850 CE as reported in several archaeological sites is shown to have peaked at 930 CE, and has been underestimated in north Europe so far.

Decade-long observations of relationships between meteorological conditions and varve formation processes in Lake Żabińskie (Poland)

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Knowledge about how seasonal meteorological conditions influence sedimentation, varve formation processes and varve composition in lakes is still limited. Here, we investigated Lake Żabińskie in northeast Poland to explore how changing meteorological conditions affect deposition of biochemical (calcite) varves in this lake. We applied the combination of ultra-high-resolution µXRF and hyperspectral imaging (HSI) techniques to detect sub-seasonal variability of biogeochemical composition in the topmost sediments and compared this dataset with meteorological data, water column characteristics, and modern sedimentation data as recorded in sediment traps. We observed that mass accumulation rates and sediment composition in sediment trap samples were well reproduced in the sediment record, i.e. in varve thickness and structure. The influence of air temperature is particularly seen in multiple calcite laminae deposited within one year. The grain size of the first (spring) calcite laminae is influenced by lake mixing intensity resulting from wind activity. Additional calcite laminae are deposited after colder and windier periods during summer stratification. We also show that distinct manganese (Mn) peaks in sediments correspond with periods of hypolimnetic oxygenation and are indicative of holomixis events which tend to occur during relatively long and cold springs or in fall/early winter due to the late formation of ice-cover on the lake. Our findings confirm that comprehensive observations of limnological parameters combined with sediment trapping and high-resolution analyses of sediment cores enable tracking the influence of meteorological conditions on varve formation and climate signal preservation in sediments.

A preliminary perspective on the last millennium in the High Caucasus: an example of Lake Kelitsadi (Georgia)

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Paleolimnological investigations at remote sites with the complicated geopolitical situation are still rare. The High Caucasus is an important example of such an area, with a sparse network of sites in Georgia being researched to this day. High-altitude lakes provide an opportunity to study past environmental change, especially climate with little or no human imprint, providing an accurate baseline for natural climate variability. Because of that, we selected Lake Kelitsadi, located in the Georgian part of the High Caucasus (elevation 3080 m a.s.l., surface area 0.24 km^2, 10 m max water depth) for preliminary investigations. We collected a 128 cm-long gravity core, which showed a clear lamination pattern interrupted by massive layers. Preliminary chronology based on ^{210}Pb/^{137}Cs dating, and tentative laminae counting suggest that the record could span over the last millennium. We combined high-resolution µXRF scanning, magnetic susceptibility readings, and elemental (TOC. TIC, TN, TS) data to provide the first insights into the lake and catchment evolution in the past. Changes in organic matter content, proxy-based grain-size, as well as carbonate content, suggest climate-driven changes in the primary production and changing weathering rates in the catchment. Occasional massive layers can possibly be linked to increased rheology and thaw in the catchment. At least three main lake ontology phases can be recognized at this point, suggesting significant transformations of this remote site. Therefore, Lake Kelitsadi promises first-of-a-kind, high-resolution paleoenvironmental reconstruction from the High Caucasus.

Preliminary geochemical investigation of proximal sediment cores in a high latitude fjord lake in Labrador, Northeast Canada

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Fjord-basins provide an ideal environment for the uninterrupted accumulation of sediments due to their depths and usually long retention-times. Grand Lake is a 60-km long fjord-lake located in the Boreal Forest in central Labrador, that contains a high-resolution varved archive. The quality of the sediments and the thickness of the deposit open the possibility that Grand Lake contains a continuous climatic/environmental record with annual resolution for the last 8,000 years, which would make it one of the longest varved records in eastern North America. As Labrador is influenced by major climate systems such as the North Atlantic Oscillation and the Atlantic Multidecadal Oscillation, the study of Grand Lake sediments will improve the understanding of Northeast Canada's environmental responses to large-scale atmospheric and oceanic mode variability, which are important climate factors controlling abrupt changes at the global scale.This study reports the preliminary bulk geochemical and new imaging techniques (Itrax, hyperspectral) results from the proximal cores GL17-04 and GL17-05, located in the Naskaupi River delta. The main objective of this study is to understand changes in both lake productivity and mixis using photosynthetic pigments and carbon isotope analyses. This study will shed light on the complex interactions between organic matter transportation, its trophic state, and water column structure at an unprecedented temporal resolution. To support bulk organic matter analyses, analysis of isotopes in *n*-alkanes as biomarkers in Grand Lake will help to establish causal relationships between the isotopic proxies and specific environmental factors as well as sediment preservation conditions. Furthermore, we will also explore hydrodynamic variations using hydrogen isotopes, linking these variations to climate modes to better understand natural conditions with both local and regional perspectives in Northeastern Canada.

Human-induced vegetation fires derived from Lake Lubińskie sedimentary record

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Well before the appearance of humans on the Earth, fire played a key role in the origins of plant adaptations as well as in the distribution of ecosystems and thus it is considered a natural component of many environments. However, since the rise of humans, people have heavily influenced fire regimes, often in ways that affected the sustainability of some ecosystems. In recent years more studies have shown that fire was also an integral part of the vegetation transitions in European Lowland because of frequent droughts, increasing human impact, and development of societies. Here, we present the past fire activity in western Poland, define the fire causes, and assess the fire influence on the landscape. The study is based on the varved sediment record of Lake Lubińskie located in the region, which experienced several economic turnovers. Using geochemical, palynological and paleofire proxies, we demonstrate conditions before and after human-derived changes in the catchment, the role of fire in shaping the ecosystem, and the sedimentological consequences of anthropogenic activity in the region. The preliminary results show that fire was observed in the region over the last 3000 years perhaps suggesting a climatic influence on the fire behavior before the permanent human settlement. However, the majority of fires were related to human activity starting from Lusatian culture (until ~500 BCE), Western Slavs (800-950 CE), through the citizens of emerged Polish State (ca. ~1000 CE) and the arrival of the Knights of the Order of St. John (Joannites) in 1350 CE to the area incorporation into the Duchy of Prussia (later into Germany) in 1871 CE and its transfer to Poland after 1945 CE. Therefore, our data show that the fire frequency goes in line with the human density growth indicating fewer fires during the Migration Period or turbulent times of famine and wars.

IAL IPA 2022

FOCUS SESSION 7

Beyond just research data: The value of outreach, education, equality, diversity and inclusion around lakes

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A Deeper Look at Lakes (Tiefer Sehen): Investigating lacustrine sedimentary archives with local school children

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Earthquakes, floods, climate changes and human impact: There is more to lakes than meets the eye. During the course of a year, we introduced about 200 children, ages 4 to 14, to the concepts of limnogeology to understand the sedimentary archive of their local lake. Together with one kindergarten, primary and secondary school class for each lake, we investigated five alpine lakes in Tyrol, Austria, and showed that each lake has its own unique story. The project kick-off were excursions to each lake for each of the fifteen classes to show how we scientists look at lakes and investigate them. We developed new didactical hands-on methods to explain sedimentation, radiocarbon dating and bathymetric maps. Next, we undertook a one-day fieldwork at each of the five lakes and acquired our own sediment cores. Highlight of the day was the live splitting of the core and first impressions of the sedimentary archive. We showed the kids traces of local earthquakes, floods and even of a seiche deposit linked to the remote 1755 CE Lisbon earthquake. Moreover, special attention was given to different types of human impact, such as lake eutrophication and hydropower engineering. The grand finale of this project was a one-day conference for which children from all over the province gathered at the University of Innsbruck. In talks and a poster session, they presented and discussed their own scientific or artistic work themed around their local lake. Here, we will look back on the Tiefer Sehen project (in collaboration with nature association Natopia and funded by the Austrian Science Fund) and present the outline, newly developed methods and future perspectives of this project.

Three years communicating geosciences in social networks: Divulgación Terróloga

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Social networks have become important communication bridges between the scientific community and society. For this reason, on June 11, 2019, “Divulgación Terróloga” was created by Mexican early career researchers. The main goal of this initiative was to create a Spanish Facebook and Instagram website to accurately and clearly disclose the different processes that intervene in the dynamics of our planet. In this initiative, periodic publications are made about the different terrestrial spheres including aquatic systems. In addition, we promote the research work of undergraduate and postgraduate geoscientists in the “Young Researchers Wednesday” section. Likewise, in the “Geoscientists in Action” section, we disseminate the work activities of geoscientists from outside academy. On Facebook, as of May 31, 2022, about 360 posts have been made. Total followers are 5200, and, the average number of people reached per post is 2200. The most viewed post reached nearly 60 thousand views. The 49% of our followers are women and 51% are men. The followers of the page reside in Latin America, the United States and Europe. Our publications have been translated into English, French and German. The results obtained during this time highlight the importance of science communication in Earth Sciences.

Donde nacen las aguas (DNLA): building new local collective practices for the defense of a common good

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The community of El Chaltén (Santa Cruz, Patagonia Argentina) is located within a water landscape and surrounded by Los Glaciares National Park (LGNP), which constitute the third world freshwater reserve and a UNESCO World Heritage site. The town´s main economic activity is tourism. In recent years, the exponential growth of these activities without planification or reinvestment, is leading to negative environmental impacts such as: degradation of water supplies and generation of a greater volume of wastewater. In this context, several stakeholders joined efforts to defend their hydro-social territory by implementing participatory strategies. "Donde Nacen Las Aguas" is a collaborative research project for monitoring surface waters in the North Zone of the Los Glaciares National Park. It is entirely led by women belonging to different organizations and institutions. The participatory process allowed getting financial support, fieldwork assistance, and laboratory analysis cooperation. DNLA´s objectives are: (a) the creation of the first environmental baseline of surface waters, (b) the definition of a participatory methodology for monitoring water quality and (c) an analysis of the current governance from a gender perspective. During the spring summer of 2021-2022, DNLA mobilized more than 30 people who sampled 80 sites over an area of approximately 850 km^2. This study included the evaluation of physicochemical, microbiological, biological and isotopic parameters in different aquatic ecosystems. The systematization of the participatory approach through the project promotes the creation of inclusive and equitable citizen research practices. In this process, the diversity of knowledge about aquatic ecosystems is legitimized, valuing personal skills to strengthen collective action. In addition, informal support and solidarity networks were created to carry out the project's objectives.

Learning & Service (L+S), a methodology to promote social awareness and a tool to generate basic environmental information about lake ecosystems

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The present work exposes the development of a pedagogical experience in the undergraduate course "Fundamentals of Limnology and Oceanography" using Aprendizaje y Servicio (Learning and Service, A+S). In this methodology, an intentional design of disciplinary formation converges, which is achieved through the development of a community service and that allows the satisfaction of a felt need, promoting a positive impact on those involved in the learning and service experience. The educational journey began by talking to a neighborhood group dedicated to the protection, conservation and restoration of Laguna Junquillar in the San Pedro de la Paz community district and the induction of L+S methodology by the Centro de Innovación y Desarrollo Docente de la Universidad Católica de la Santísima Concepción, Chile. A formal commitment was made with the group to conduct water and sediment sampling of El Junquillar lagoon, where the students are the ones who prepare, plan and carry out the sampling with coaching of the neighborhood group and teachers (practicals and lectures) as guide-consultant. Finally, water and sediment were sampled on El Junquillar lagoon and La Posada Lake, where the access was coordinated with a private company that controls the site location together with the Environmental Departments of two municipalities (San Pedro de la Paz and Coronel, respectively). During several weeks, the students analyzed nutrients, chlorophyll-a and total organic matter, in laboratory sessions in which members of the neighborhood group were invited to participate. Details and results of the educational experience are presented, where L+S responds to the need to make effective the commitment of Chilean Higher Education Institutions, managing to articulate human development, social awareness, and disciplinary training.

The lake Retba geomorphosite (Senegal): Evaluation and Promotion for Sustainable Human and Socio-Economic Development

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Lake Retba, known as tourist name "Pink Lake", has a high landscape and aesthetic value and is within the most important coastal ecosystems of Senegal. Located 30 km at the Northeast of Dakar, it is characterized by oversalted (120 to 340 g / l salt), pink colored waters. It contains an aerobic mesophile flora composed by the halophile green algae *Dunaliella salina* associated with archaea such as *Halobacterium sp.*, responsible for pigmentation. In addition to its endemic flora, the lake works as resting area for many bird species. Its borders are occupied by a lumachel of marine shells. It extends between two hydrogeological, archaeological, and biodiverse dune systems. The value of lake Retba and its surroundings has motivated the evaluation of this site to promote geotourism aiming sustainable development. To achieve this goal, scientific, didactic, and supplementary methods have been used to assign scores. The evaluation of the geomorphosite revealed a high scientific importance, but its global worth is negatively impacted as its integrity is threatened with disappearance. The visit conditions are generally good. In addition, a significant number of economic activities are developed including tourism, salt exploitation, gardening market or shell extractions and artisanship, making it a socio-economic zone of interest for Senegal. However, the intense and anarchic exploitation of water resources and shellfish clusters have several harmful effects on the lake environment. Its area has gone from 15km^{2}to about 3km^2 nowadays. The identification of lake Retba as Geomorphosite by this work will help complete the list of potentially exceptional sites at national level. This will also enable to protect the lake for its importance in multidisciplinary points of view, and to reinforce development policies and preservation planning.

Towards an inclusive and community-driven Iberoamerican geo-limnology science: the tropical South American diatom database

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In the current era of open data and synthetic large-scale environmental change questions, it is key to acknowledge contributions from historically marginalized regions through inclusive and democratic data sharing practices. This is the case of South America where a comprehensive assessment of rates of limnological change is hindered by the lack of geographically wide biological databases. In this contribution, we will present the tropical South American diatom database (TSADB) and its structure and functionality. The TSADB include diatom taxa from 437 samples from 326 sites distributed across Andean and adjacent Amazon lowland regions (0 to 5,070 m a.s.l, and between 8°N–35°S; 58–90°W). Access to database, usage, and future additions is through publicly available repositories, reproducible R workflows, and a guide to contributors, respectively. The TSABD is also currently part of Neotoma–a global community-curated database by regional experts for multiple types of pal eoecological data–from which the TSADB can contribute to by providing modern analogues for paleolimnological reconstructions in the Neotropics. Steamed by the lessons learned with the TSADB, we will finally introduce the international Spanish diatom researchers' network which aims at increasing the visibility of diatom studies and researchers from Iberoamerican countries as well as fostering new multidisciplinary collaborations. The final goal of the TSADB is to provide a collaborative network where academics, stakeholders, and professionals share diatom data following not only FAIR (findable, accessible, interoperable, and reusable scientific data) principles but also embrace the values of inclusivity, diversity, and equity.

Women, science and development in Latin America: the case of limnologists and paleolimnologists in the Organization of Women in Science for the Developing World - OWSD

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A significant gender gap persists at all levels of science, technology, engineering and mathematics (STEM) disciplines around the world. Even though women in Earth sciences are making significant progress towards increasing their participation in higher education, they are still under-represented in the field. Specifically, the situation of women in Limnology and Paleolimnology shows evidence of gender bias. Even though the history of Limnology and Paleolimnology registers substantial contributions of women to the advancement of these disciplines, their excellence and leadership capacity have not yet received full recognition. In the world, in 2021, only nine women chair Limnology associations out of a total of 31. However, this data is not disaggregated for the area of Paleolimnology and much more information is needed regarding representation of women as senior scientists, access to funding and career progression. Therefore, it is necessary to have teams that work together with limnology and paleolimnology associations around the world to collect this data and identify the key points regarding systemic disparities. Moreover, women scientists in the developing world face further challenges rooted in their specific geographic and cultural contexts, that is why in 1987 the Organization for Women in Science for the Developing World (OWSD) was founded to (1) inspire and engage women and girls from the Global South in science, and (2) support them in their professional careers. It is a UNESCO program unit and the first international forum to unite eminent women scientists from the developing and developed worlds with the objective of promoting their representation in scientific and technological leadership. The OWSD network operates in four regions and is structured in national sections or chapters: 1. Africa, 2. the Arab Countries, 3. Asia-Pacific, and 4. Latin America and the Caribbean (LAC). In total, 51 National Chapters are active, of which 15 are from the LAC region. Nearly 9,000 women scientists are part of the OWSD global community, while 1,900 belong to the LAC region. In the OWSD LAC network, preliminary data indicates that less than 400 women work on topics related with water, of which an estimated 20 are limnologists and/or paleolimnologists. For this group of women, OWSD has been a platform where they have received research training, career development and networking opportunities at different stages in their careers. In this research we delve into their trajectories and career paths; by applying a methodology for identification, mapping and characterizing, we explore their profiles, major challenges and achievements as women scientists from the developing world.

Current situation in the positions and hierarchical spaces in an Earth Sciences Research Center (CICTERRA, Argentina): A gender perspective approach

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The Argentinian Earth Sciences Research Center (CICTERRA) is a CONICET and UNC institute (since 2007) focused on geosciences research. In 2020 it already had more than one hundred members including researchers, technicians of the upport Personnel Career, university professors, doctoral and postdoctoral students and administrative staff. Women represent 54% of the total population. However, when the members are broken down into the different scientific positions (5 categories), a clear imbalance can be seen between the lowest research categories (mostly dominated by women) and the highest ones (dominated by men). Regarding hierarchical positions, the direction has always been represented by men, whereas only 1 woman was co-director. Analyzing the evolution from 2017 to 2020, women changed from the first and second categories to the third one. However, in the fourth category the number of women remained constant, while the men doubled. The highest category never had female representatives. Regarding doctoral students, the proportion remained constant (55% of female members). In relation to the technical staff, more than 60% is represented by women. During the last decades, the participation of women in science in Argentina has increased, equaling that of men. However, hierarchical positions are still dominated by men and it is clear that the invisible barriers as the “glass ceiling” still influence significantly in the academic evolution of women. Furthermore, the phenomenon “frozen middle” describes the slowed down women’s progress, if not halting, in the ranks of middle categories. This affects female professionals, as well as women in a variety of fields including science. The gender inequality in the scientific system in Argentina is still pronounced. More research about this subject deepening about the lower proportion of women in hierarchical positions in the scientific system, would make it possible to better distinguish the obstacles to occupy those spaces.

Challenges faced by bi-cultural, dual-career academics and suggestions for how to address them

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We are both scientists, one of whom specializes in paleolimnology and the other in geophysics. We have a 5-year-old son and 10-year-old daughter. We are originally from Guatemala (Perez) and Germany (Bücker), and our children were born in Mexico, where we worked for seven years before moving to Germany. The academic system rewards scientists who have demonstrated high mobility by completing their PhDs and postdocs abroad. Nevertheless, changing your country of residency is challenging, especially if it involves moving into a new cultural setting that is very different from that of your home country, as was the case for us. This culture shock is amplified if one has small children who require special care and support, e.g., with school activities, and is especially challenging if both parents are full-time researchers. We experienced serious culture shock when we moved from Latin America to Germany. It quickly became apparent that it would be difficult for us, as a couple, to live equitably at home and at work, and achieve a good balance between family life and work responsibilities. We learned to be resilient and managed through the pandemic, whereas other researchers did not, with negative consequences generally affecting women. We are lucky in that one of us (Bücker) was recently awarded a tenure-track junior professorship, for which we are tremendously grateful, as many researchers in Germany do not have permanent positions. Academic options for trailing spouses, however, are typically very limited, as few universities have programs for dual-career couples with children. This is the biggest obstacle we face now, as it has become common, at least in Germany, for dual-career academic families to live apart, if both are to be gainfully employed. Trailing spouses who come from developing countries are faced with even greater challenges when seeking employment in German academic institutions. We take this opportunity to share with you, especially those of you who are younger scientists both with and without children, some of the professional challenges we have encountered. We also want to let you know how we coped with and overcome those challenges faced by families in which both adults are academic researchers. It is our hope that you will be able to use our experiences to chart a professional path for yourselves, perhaps with fewer obstacles.

Gender and parenthood effects in career advancement, evidence from the Argentinean National Council of Science (CONICET)

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As a woman in limnology from South America, and a mother, I have faced several barriers along my scientific journey. In this presentation I intend to address the question if gender and parenthood affect career advancement among Argentinean scientists. For this, I gathered up to date information from the Argentinean Science National Council (CONICET, August 2022), which employs 12044 permanent researchers. Within the researchers, women are also a majority and represent more than half of the population, considering all five categories (53%). Women are majority in the three lowest categories within CONICET (Asistente, Adjunto, Independiente), yet the trend reverses in the two highest CONICET categories (Principal, Superior), where men prevail. Indeed, about 4 men per woman reach the highest CONICET category. This data suggests a gender effect in career advancement (crystal roof) for women. Regarding motherhood, most researchers in CONICET are mothers (60%), but mothers prevail only in the lower categories (average 61% mothers) whereas in the higher two categories most women do not have kids (average 37.5% are mothers). Remarkably, within the women who reach the highest CONICET category only half of them are mothers. These data suggest a maternity effect/cost (maternity wall) in science advancement. Indeed, mothers in science face all the gender related issues that women face, plus the extra challenges due to caring and raising children. Men who are parents, evidenced a similar trend as mothers (in the lowest categories 50% are fathers, whereas in the highest categories only 40% are fathers), also suggesting that fatherhood has an impact on scientific advancement. Gathering these data is the first step towards visualizing and addressing barriers that can hinder career development for women and parents, and in implementing equality in opportunities.

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Limnogeology in Patagonia: Reconstructing the challenges of the living and non-living worlds throughout the Quaternary

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Palynological evidence of Holocene climate variability and Southern Hemisphere Westerly Wind dynamics in the sub-Antarctic

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The Southern Hemisphere Westerly Winds play a major role in the global climate. By driving the vigorous Antarctic Circumpolar Current, the Westerlies affect the upwelling of carbon-rich deep water and thereby impact the oceans' ability to take up atmospheric CO_2. In the sub-Antarctic, the Westerlies strongly influence large scale temperature gradients and precipitation patterns, acting as a first order control on local environmental conditions. Long-term natural variability of the Westerlies strength and latitudinal position have been inferred but remain unconstrained. Due to the lack of landmass in the Southern Hemisphere, terrestrial records from sub-Antarctic islands are key for a wider spatial covering and deeper understanding of the natural behavior of the Westerlies. We use lake sedimentological and palynological records from the islands of South Georgia and Kerguelen to reconstruct both Holocene vegetation and surface (wind) climate. Long distance transport of pollen from southern South America and Africa is used as a unique proxy to infer past strength and position of the Westerlies. Local climate is reconstructed using the so-called 'upland-lowland principle', where native species inhabiting respectively upland or lowland sites indicate relatively colder or warmer climate conditions. On South Georgia we find an increase in pollen influx of South American taxa like *Nothofagus*, *Ephedra* and Asteraceae towards the Late Holocene, a trend also seen in neighboring records of long-distance pollen transport. This is most likely linked to changes in the strength of the Southern Hemisphere Westerly Winds. Peak influx occurs during periods with locally relatively cold climate conditions. On Kerguelen we mainly see an influx from *Podocarpus* and Asteraceae. Due to the position of Kerguelen in relation to southern Africa we expect that the influx of long-distance transported pollen grains mainly reflects changes in latitudinal position of the Westerlies.

Searching for the Little Ice Age in the last ~900 yrs record of the shallow lake Laguna Polo, Patagonia, Argentina

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The records of the Little Ice Age (LIA) in lacustrine sediments from southern south America (SSA) are still rare. Indeed, most of the evidence of this period in SSA comes from tree rings records. Our main goal was identifying the signal of the LIA at Laguna Polo (49° 15' 59.4" S, 72° 53' 38.4" W), in Santa Cruz, southern part of Patagonia. For this multiproxy reconstruction, we analyzed a 54-cm long sediment core and conducted paleoecological analysis on testate amoebae and chironomids in combination with grain-size distribution and geochemical composition (TOC, TIC, TN, biogenic silica (BiSi), $\delta^{15}N$, $\delta^{13}C$ and C/N). The age model, based on radiocarbon dates and tephrochronology, indicated a basal age of ca. AD 1300. Based on the biological proxies, we divided our record into 4 zones. In zone 3 an important ecological change in both bioproxies was detected for the period AD 1420 to 1780. On the one hand, testate amoebae show an increase in abundance but a decrease in diversity. Difflugids were highly abundant and were dominated by *Difflugia glans*. Chironomid assemblages, on the other hand, reveal a decrease in abundance of head capsules but an increase in diversity with the appearance of *Cricotopus* and *Dicrotendipes*. The taxa of both taxonomic groups found during this period have been reported as indicators of cold environments. Grain-size analyses indicate a concurrent proportional increase in silts and clays, whereas geochemical analyses record a decrease in TN, TOC, TIC, BiSi, $\delta^{13}C$ and the C/N ratio, but an increase of $\delta^{15}N$ which may be indicative of a cooler and wetter period, as has been previously described during the LIA period in Patagonia.

A diatom perspective on the evolution of the Southern Westerly Winds over southwestern Patagonia since ~14 ka

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The Southern Westerly Winds (SWW) govern the climate of the Southern Hemisphere mid-latitudes. Climate change related to SWW variability during the Holocene has seldom been documented through lacustrine fossil diatom records. Here we present a new fossil diatom record from Lago Cipreses (51°S), a closed bed-rock basin of glacial origin located in the forested Andean foothills of southwestern Patagonia (SWP; 49°-55°S), spanning the last ~14,000 years. In this sector, modern temperature and precipitation anomalies are exclusively related to SWW intensity, whose variability can be reconstructed through past assemblage-level responses in the fossil diatom record that likely reflect climate-driven limnological changes. Throughout the record we observe centennial to multimillennial alternations between three main assemblages, namely, (i) small fragilarioids, (ii) *Aulacoseira spp.*¸ and (iii) a mixed planktonics-benthics assemblage. We posit that these assemblages alternate their dominance during extended lake freezing seasons, ice-free turbulent conditions, and ice-free thermally stratified conditions, respectively. We observe near complete dominance of small fragilarioids between ~14-12 ka, indicative of stormy and colder-than-present conditions brought upon by strengthened SWW. A sudden shift to *Aulacoseira spp.* ensued, suggesting warm to temperate conditions that lasted until ~3.1 ka. From this point onward, small fragilarioids accompanied by epiphytic species resurged as the dominant assemblage, which we interpret as cooler climate brought upon by strengthened SWW. The interval between ~9.1-7.4 ka stands outs as a warm/dry climatic extreme based on the maxima of the planktonics-epiphytics abundance that punctuate a wider period (~11.5-3.1 ka) dominated by *Aulacoseira spp.*, tentatively construed as a Holocene SWW minimum in SWP. This diatom-based paleoclimatic insight constrains the chronology and direction of SWW evolution in SWP during the Holocene, and allows testing competing hypotheses of SWW evolution in the region.

Fires and rates of change in the temperate rainforests of northwestern Patagonia since ~18 ka

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We examine the temporal and spatial structure of wildfires and rates of vegetation change over the last 18,000 years based on 15 sites from the Pacific sector of northwestern Patagonia (40°-44°S). Macroscopic Charcoal Accumulation Rates (CHAR), a proxy of past local fires, shows a geographic variation that mirrors the modern north-to-south and low-to high elevation increase in annual precipitation and decrease in precipitation seasonality. Andean and Western Upwind Environments (WUE) share a common structure of fire activity since ~18 ka, overprinted by millennial and centennial-scale divergences. These divergences underscore the role of explosive volcanism as a trigger or modulator of fire activity in the vicinity of active eruptive centers. We posit that fire activity in WUE was driven primarily by changes in the intensity of the Southern Westerly Winds. Compilations of CHAR and the Rates of Change (ROC) parameter, a measure of the magnitude and rapidity of changes in the pollen records, show very strong positive correlation at the onset of recurring fires at ~13 ka and moderate positive over the last ~4000 years, suggesting that fires induced or catalyzed abrupt vegetation changes during specific intervals since the last glaciation. Strong correlations between CHAR, ROC, and the summed probability density of radiocarbon-dated archeological sites since ~4 ka suggest that humans facilitated or enhanced natural fire occurrence and abrupt vegetation changes at regional scale. The ubiquitous fire maximum over the last four centuries relates to large-scale disturbances by sedentary Chilean/European settlers.

Comparative analysis of extant and Holocene ostracod assemblages from Northern Patagonia, Argentina

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Lake sediments archive and integrate the physical, chemical, and biological responses to climate change. Therefore, their study allows the reconstruction of past environmental and climatic conditions, and their evolution. These processes can be decoded using a selection of bioindicators, organisms that overcome taphonomic barriers and can be preserved in lacustrine sediments. Ostracods are one of the most used bioindicators, due their adequate preservation, high population densities and strong sensitivity to environmental variations. In this context, the increasing knowledge about the taxonomy and autecology of many living species, allowed defining “modern analogues” of fossil assemblages in sedimentary cores, where the palaeoenvironmental signals can be interpreted in terms of climatic changes. In this study, we compare the composition of the ostracod assemblages of extant and Holocene lake samples (El Toro [40°19´S, 70°25’W] and Cari-Laufquen Chica [41°35´S, 69°25’W]) from Northern Patagonia Argentina, to establish analogs. Our results reveal a high similarity between the composition of extant and Holocene samples, supporting the relevance of this taxonomic group as bioindicator. Additionally, it is confirmed that oligomesohaline to mesohaline conditions prevailed during the Holocene. Furthermore, much of the species sampled in actual limnetic environments have not been until now recorded in sedimentary sequences. This opens up significant research questions: the lack of fossil and sub-fossil records of these species is a consequence of a lack of sampling in the region and not a real absence of the species, or is due to a recent colonization. More comprehensive surveys on both extant and Holocene environments are needed to clarify this matter.

Vegetation and climate evolution in Central Isla Grande de Chiloé (42°S) during the last glacial maximum and the last glacial termination

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Northwestern Patagonia (40°-44°S) has been the focus of numerous paleoenvironmental investigations on the glacial, vegetation, and climate history during the Last Glacial Maximum (LGM) and the Last Glacial Termination (LGT) since the mid-20th century. Few studies, however, have examined in detail the transition through the LGM, LGT, and the current interglacial along a time continuum using lake sediment cores. Lago Auquilda (42°22' S, 73°49' W, 150 m.a.s.l.) is a small closed-basin lake located in central Isla Grande de Chiloé, ideal for examining the paleovegetation, natural disturbance regimes (paleofires and eruptive volcanic activity), and climate evolution during and since the LGM. In this study, we present a multidecadally resolved pollen record that spans the ~19000 - 9000 cal yr BP interval and shows the continuous presence of closed-canopy temperate forests initially dominated by *Nothofagus*, followed by diversified Myrtaceae-dominated forests, mixed forests with the conifer *Podocarpus nubigena*, and a sudden irruption of *Weinmannia trichosperma* together with an increase in macroscopic charcoal. The early Holocene shows a forest dominated by *Nothofagus* and *Weinmannia trichosperma*, lacking cold-tolerant hygrophilous conifers. Unlike the majority of records in the region, our results show persistence of dense *Nothofagus*-dominated forests with low variability during the final portion of LGM and the initial phase of the LGT. This was followed by abrupt millennial-scale changes of the paleovegetation, natural disturbance regimes (paleofires and explosive volcanism), and hydroclimate trough LGT into the early Holocene. We will discuss details on the composition, timing, rates, and direction of changes in the paleovegetation and fire history at local scale, and their implications at regional and hemispheric scale.

A paleoenvironmental analysis of natural and anthropic events in the Caviahue area (Neuquén Province; Northern Patagonia) inferred from chironomids and other sediment proxies

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Lacustrine sediments represent natural archives allowing the development of continuous records integrating local, regional, and global environmental signals by preserving diverse paleoenvironmental indicators. Our aim was to identify the occurrence and impact of natural (climatic fluctuations, volcanic eruptions) and/or anthropogenic (species introduction, fire activity, transhumance, urbanization) events in an area affected by the Copahue Volcanic Complex (CVC). We present the results from Lake Portezuelo (central western Neuquén, Copahue-Caviahue region), a small and shallow environment with abundant emergent and submerged macrophytes and absence of fish (apparently since 2012, caused by a CVC eruption). This study was mainly based on chironomid remains observed along a sedimentary sequence extracted in 2014, dated with ^{137}Cs technique (sedimentation rate: 0.307 cm yr^{-1}) and comprising approximately the 200 last years. Chironomid community was composed of 22 taxa belonging to subfamilies Orthocladiinae, Tanypodinae, Podonominae, and Chironominae. A major change in assemblages occurred at ~1990, characterized by a decrease of *Parapsectrocladius* sp., *Cricotopus* sp., and some Tanypodinae members; and an increase of *Parachironomus* sp. This was coincident with temperature increases and precipitation decreases recorded in Patagonia for recent decades. Previous decreases in chironomid abundance could reflect both lower temperatures (available from models) and effects of anthropogenic fires during late 19th and early 20th centuries. Despite most volcanic deposits (previously identified) caused immediate decreases in chironomid abundance and richness, the greatest changes in midge assemblages were associated with decadal periods. To disentangle past environmental impacts, the analysis of the chironomid community was complemented with sedimentary, mineralogical and geochemical indicators (density, organic matter, major/trace elements). By contrasting chironomid variations with temperature and precipitation data from available meteorological models (CRU TS 4.01) for the last century, inferences to past periods are expected to be possible, enabling the development of precise paleoclimatic and paleoenvironmental interpretations that will allow future projections in the Patagonian region.

Limnogeology by the end of the last ice age in Isla Grande de Chiloé, northwestern Patagonia

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The transition from the Last Glacial Maximum (~35- 18 ka) to the last glacial termination (~18-12 ka) involved vast landscape changes in northwestern Patagonia, triggering major modifications in the depositional dynamics of lakes located within the Chilotan Archipelago. The sedimentary record from Lago Auquilda (42ºS; 74ºW, 150 m a.s.l.), located at the eastern foothills of the Coastal Range in Isla Grande de Chiloé, offers the opportunity to study the depositional changes that occurred in close association with the western limit of the Golfo Corcovado glacier lobe during the transition from full glacial to interglacial times. We could identify three main different units in the sediment cores that represent major multimillennial changes in the lake dynamics through the analysis of medical computed tomography, laser diffraction grain size variation, magnetic susceptibility changes and geochemical X-ray fluorescence data. Radiocarbon accelerator mass spectrometry chronology starting prior to 30 ka (ka= 1000 calibrated years before 1950), facies characterization, and dedicated core correlations support and time-frame the depositional history of this lake. Results suggest non-continuous stepwise changes ranging from ice-proximal glaciolacustrine (rhythmically laminated facies) to distal (banded clastic-rich sediments) and non-glacial closed-lake conditions (organic matter-rich banded to massive sediments), including evidence of multi-decadal periodical clastic supply variations within the units, and significant event deposits along the record. This work is a part of an ongoing interdisciplinary study on the landscape evolution of Isla Grande de Chiloé in an effort to decipher and synchronize the glacier, climatic, and terrestrial ecosystem history of northwestern Patagonia and the evolution of south westerly winds since ~30 ka.

Middle to Late Holocene environmental changes in the Fuegian steppe (northern Tierra del Fuego, Argentina) based on multiproxy analyses from Laguna Amalia

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Laguna Amalia (53°35´09.4´´S; 68°26´34.3´´W) is one of the most prominent semi-permanent water bodies in the northern Tierra del Fuego. It is an ephemeral, shallow lake located in the semiarid steppe. We studied a 103 cm long sedimentary core to reconstruct the environmental conditions during the last ca. 7100 cal yr BP. The mutiproxy analyses (pollen/spores, fungal remains, freshwater algae, grain size, and sediment composition) together with the geomorphological features of the landscape allowed us to interpret changes in the lake level. The sediments are dominated by medium to fine silt, with variable percentages of clay, fine and very fine sand. Between 78 and 8 cm depth, there are abundant sandy-silt and silty-sand laminae that could be related to eolian activity around the lake. Organic matter content increased from about 6000 cal yr BP, while carbonate content displayed a decreasing tendency. The pollen assemblages throughout the entire profile revealed a landscape dominated by grasslands (Poaceae) along with open shrub vegetation of Asteraceae subf. Asteroideae, dwarf shrubs of *Empetrum rubrum* and forbs (Caryophyllaceae, *Acaena*, *Gunnera*, Euphorbiaceae, *Valeriana*, *Caltha*). The halophyte communities (Chenopodiaceae) developed in the surroundings of this shallow lake accompanied by low proportions of sedges (Cyperaceae), and hygrophilous taxa (Iridaceae, Juncaginaceae, *Myriophyllum*). The Andean forest communities were represented by the record of long-distance *Nothofagus* pollen. In general, wet periods were characterized by retraction of halophytes, proliferation of *Pediastrum*, presence of *Diploneis* spp., and massive silty sediments. Conversely, the dry intervals showed the spread of halophytic vegetation around the lake, increased amounts of *Botryococcus* and *Spirogyra*, and records of *Surirella tuberosa*. Diatom assemblages were dominated by *Diploneis elliptica*, *Diploneis* sp. and *S. tuberosa,* although valve counts were generally low. These environmental changes would be related to variations in the strength and/or latitudinal position of westerly winds during the middle to late Holocene.

Comparison of historical volcaniclastic records in sequences from Lakes La Zeta and Brychan (43° S), Patagonia Argentina, affected by the Austral Southern Volcanic Zone.

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Eastern Andes lacustrine ecosystems in Northern Patagonia have key paleoenvironmental interest because of their unique position along a strong climatic gradient while being under the effect of ashfall from the Austral Southern Volcanic Zone (ASVZ), all related to prevailing westerlies at these latitudes. Ashfalls, particularly, are capable of generating chronostratigraphic markers. However, its preservation, comparison and correlation can be complex due to individual volcanic plume dispersion and depositional dynamics of each lake. We examined sedimentary records from short cores extracted in lakes La Zeta (ZE, 65.5 cm length; 42.89°S-71.35°W, 8.2 m depth) and Brychan (BRY, 82 cm length; 43.06°S-71.49°W, 8 m depth), separated by 20 km, with the aim to identify volcaniclastic deposits from the ASVZ, spanning the last centuries. In the laboratory, cores were split in two sections, described, and macroscopic tephras were identified. Magnetic Susceptibility (MS) profiles were obtained allowing the identification of potential microtephra layers. Then, cores were subsampled every 1 cm or following natural boundaries, and lyophilized. Sequence dating by ^{210}Pb, ^{137}Cs, and ^{14}C techniques will be complemented with tephrochronology. Visual inspection with a magnifying glass confirmed the existence of tephra layers. Morphological, mineralogical, and first chemical analyses of the volcanic components were obtained by Scanning Electron Microscope coupled with Energy Dispersive Spectroscopy; major and trace element composition from separate samples was obtained by Instrumental Neutron Activation Analysis. According to the component´s characterization, density and MS profiles, and the inspection of the sediment showed, until now, four volcanic levels in ZE and two in BRY, preliminarily correspond to four volcanic sources. Geochemical correlations with volcanoes from the ASVZ besides comparison with tephrochronological records from the area will provide i) information about the eruptive sources improving the knowledge of regional historical eruptions and dispersion, and ii) chronological frameworks for future paleoenvironmental studies in these sequences.

Vegetation response to fire and volcanic disturbances since the Late Pleistocene in the Southern Patagonian Andes (49°S)

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High-Andean fossil records from the southeast Patagonian Andes (49°S) bring a unique perspective for analyzing past vegetation disturbances such as fires or tephra deposition after volcanic eruptions occurred since the Last Glacial Termination (T1) at the eastern margin of the South Patagonian Icefield. Pollen, charcoal and tephra records from two sedimentary sequences from high-Andean lakes were analyzed in order of evaluating potential changes in the vegetation as response to fire activity and tephra deposition from NAVZ (North Austral Volcanic Zone). Pollen data reveal Late Pleistocene to Holocene vegetation dynamics at Laguna Gemelas Este (LGE, 883 m.a.s.l., 49°23'06" S, 72°53'50" W), with high Andean taxa dominating the area before 15,200 cal yrs BP. Then, between 15,200 and 4,600 cal yrs BP, the record shows the onset of *Nothofagus* forest establishment followed by the development of subantarctic forest as we know today. Laguna Chiquita (LCH, 987 m.a.s.l.; 49°22'22" S, 72°58'28" W) pollen suggest a closed *Nothofagus* forest with no major changes of vegetation during the last 500 cal yrs BP. Charcoal data reveal high fire activity peaks before 15,200, 4500 and around 500 cal yrs BP at LGE and before 500 cal yrs BP and in modern times at LCH. LGE oldest and higher fire episodes are likely to be related to non-arboreal burned material due to scarcity of local *Nothofagus* forest presence in the area, while LCH fire peaks are probably linked to forest wood burning. Tephra deposition produced slightly lower concentrations of pollen in the sedimentary sequences, but no major changes in vegetation occurred during/after these events, showing a high resilience of subantarctic forests to such disturbances.

First approach to the description of phytoplankton and periphytic communities in freshwater bodies of South Patagonia (49°S), Argentina

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The limnological and ecological information of water bodies located on the eastern slope of South Patagonian Andes (49°S) is scarce. Particularly, understanding the phytoplankton and periphyton algae components will enrich the interpretation and discussion of the evolution of these water bodies from the Late Holocene to the present. The algae remains presented in the fossil record as well as in lake sediment samples are known as non-pollen palynomorphs (NPPs), and their identification constitutes an important paleoenvironmental contribution to environmental reconstructions. Thus, the aim of this work is to characterize the phytoplankton and periphyton community present in water bodies and the NPPs in surface sedimentary samples, with emphasis on the diversity of cyanobacteria and chlorophyta algae. Three freshwater bodies (Laguna Gemela Este, Laguna Gemela Oeste and Laguna Chiquita) located between 400 and 1100 m.a.s.l. at Los Glaciares National Park, were sampled during the 2020 and 2022 summer fieldwork. At each lake, phytoplankton samples were obtained with plankton net whereas periphyton was removed by scraping off the predominant littoral vegetation. Both samples were observed under an optical microscope. The water-sediment interface samples were taken with a gravity corer and received a conventional palynological treatment. The limnological measurements were registered *in situ*: water temperature, pH, electrical conductivity, maximum depth and transparency. Phytoplankton and periphyton communities presented similar taxonomic composition and despite the low counts, the diversity of chlorophyta algae was significant. Dominant taxa were different among water bodies and communities sampled, including Desmidiaceae genera (*Cosmarium* and *Closterium*) and volvocine chlorophytes in phytoplankton; filamentous chlorophytes and cyanobacteria in periphyton; and *Pediastrum* and zygospores of Desmidiaceae and Zygnematales in water-sediment samples. These data constitute the first approach to the description of phytoplankton and periphyton communities in water bodies of the region.

Fire and vegetation dynamics in the Nahuelbuta mountain range during the Holocene

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Fire activity during the Holocene has been mainly controlled by climate, fuel availability and anthropogenic influence. The integration of information provided by diverse records at regional (central Chilean Patagonia) and extra-regional (Chilean Patagonia) scales indicates that the changes recorded from the early Holocene to the mid-Holocene were mostly related to latitudinal shifts and variations in intensity of Westerlies, or to the complex relationships between vegetation, fire, volcanism and human occupations during this time. In contrast, it has been proposed that for forests associated with *Araucaria araucana*, fire is the main disturbance factor in the South American Andean region. To further test this relationship and complete a picture of regional dynamics in altitudinal gradient, it is necessary to incorporate the record from the Nahuelbuta Range (37º 40'S and 37º 50'S) to those already available for the Andean area (Tolhuaca National Park and Laguna Portezuelo) and the intermediate depression (El Valle bog). This research aims to evaluate whether fire is a modelling component of the vegetation assemblages that have inhabited the Nahuelbuta mountain range during the Holocene, and its possible relationship with the human occupations of the territory. Preliminary results show an important fire activity in the early Holocene (10.3 kyr cal BP) and a moderate activity at the end of the late Holocene (0.4 kyr cal BP). This record is consistent with records from the region, so that fire appears to be a component of ecological dynamics and is poorly related to human activity prior to European colonization.
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Environmental reconstruction in the Nahuelbuta mountain range during the Holocene, Chile

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The Araucanía region currently presents a highly diverse vegetational scenario due to the interaction between the Mediterranean climate of central Chile and the humid temperate climate of southern Chile, which together with the regional geomorphology give way to precipitation and temperature gradients that shape the structure and dynamics of the forests. In this sense, carrying out an environmental reconstruction of the Aguas Calientes site corresponding to a peat bog in the Nahuelbuta mountain range (37°47'S - 73°01'W) allows understanding the dynamics of the forests, showing the relationship between climate variability at regional scale and the establishment of the different taxa identified. A 160 cm deep sediment core was obtained with a basal dating of 8935±44 ^{14}C years BP, which was processed for pollen analysis that will allow modeling the values of precipitation and temperature during the Holocene from a current pollen calibration set that includes 52 sites. Additionally, charcoal analysis was performed to evaluate the relationship between environmental variables and fire dynamics in the area. Preliminary results show five fire peaks, three of them during the early Holocene, while the other two occurred during the last 600 years, probably related to the colonization of the territory. As for the palynological results, it is evident that the resinous *Araucaria araucana* forests were maintained throughout the Holocene, however, suggesting a change in relative abundance related to changes in temperature and precipitation. Acknowledgments: FONDECYT #1201528.

IAL IPA 2022

FOCUS SESSION 10

The challenge of public communication of science in Limnology & Paleolimnology

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Lake Nahuel Huapi, what lies beneath art, science and the creative process

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“Tres a la deriva” (Three adrift), and “Cinco en tránsito” (Five in transit) are two artist collectives that are connected by interests and members. One of the ideas we explore comes from Guy Debord’s philosophy. He called psychogeography the ways in which humans wander the urban environments using the word “dérive”. Hence our names and some of our interests. Bariloche grew inside a National Park and by Lake Nahuel Huapi. How does the lake and its surroundings shape each other, and how is the memory of its existence recorded? How does this affect the way we feel and interact with the city and with nature? As artists we question the relationship we have with our environment, sometimes imagining how our discarded trash becomes a part of it and others, asking scientists that study it, what captivates and motivates them, this in turn, inspires us. Rapoport and Rubio’s discovery of aquatic arthropods, led us to name one of our soft sculptures ”Nahuelensis sp.”, and later, the “Críptides Nahuelensikes” piece draws on the shape of these animals and the lake’s. Mónica Díaz’s passion for algae triggered our series of “Algae Blooms”. Always trying to expand and deepen our knowledge of the area, we are now also starting to investigate how people of different origins dialogue with nature in the past and present. These ideas then become new ways of communicating our interactions with our surroundings, through different techniques and materials, ranging from printmaking and textile art to concrete and recycled elements, mainly as installation pieces, and sculptures. “Tres a la deriva” has also created fanzines. It is important to us how the public views, interacts and thinks about art and the ideas we work with. The artists in “Tres a la deriva” are Soledad Escudero, Patricia Piñero and Ingrid Roddick. “Cinco en tránsito” also includes Carlos Iriarte and Moma Mozetich.

PAGES Horizons: an outreach magazine about paleosciences

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Past Global Changes (PAGES) recently established *PAGES Horizons*, a new publication for teenagers, young adults, and general public interested in Earth's history. *PAGES Horizons* highlights how understanding the science of the past can help in critical environmental issues such as the modern climate crisis, and more generally the current global change. The magazine strives to communicate sound scientific facts using an uncomplicated language, diverse graphic outputs, and an attractive visual format. The first two issues of *Horizons* (2021, 2022) have provided scientific information from the scientists themselves to strengthen links and communication between the academic and non-academic worlds. The aim is to provide scientific knowledge in order to make readers aware that lessons from the past can help us to understand the current global change and what can be done to aim a sustainable future. *PAGES Horizons* includes articles about different environments and regions around the globe, and about the interactions of climate, ecosystems and humans. Here, we would like to invite paleocientists to share their ideas and comments on the first two issues, to encourage discussions to create new opportunities, to invite colleagues across the paleosciences to join this project and contribute with articles, and to develop our network of collaborators and the dissemination of this science outreach project. *Horizons* is a great adventure, not only because we have the opportunity to address the wide public, but also because it challenges us, paleoscientists, to communicate our research to a different audience!

The scientific communication journal from Nahuel Huapi National Park

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This magazine brought up twelve years ago, from the idea of Juan Salguero, the main head of the Nahuel Huapi National Park (PNNH) then. By that time, the country's political and social context was favorable to the development of these ideas leading the appearance of this magazine. Simultaneously, the applied studies and conservation program (CENAC) involving scientific researchers and students working in the line of the national park conservation issues was encouraged. The magazine aims of publicizing and disseminating studies, research and conservation projects carried out in the PNNH. The first edition was published in 2010, coordinated by the Environmental Conservation and Education Department. Since then, the CENAC researchers team participate in the editorial committee. Along these years, all of us who actively participate are motivated in displaying the wide variety of scientific and technical research that are performed in the one of the principal protected area in northern Patagonia, among them limnology studies. Some examples can be read in the numbers 1, 4, 5 of our magazine. Actually, we are developing the 11ed edition and permanently focused in improving the graphical design, thinking in our readers. We can assure that this magazine plays a very important role displaying a wide range of scientific issues performed both by leading researchers and by early career researchers, bringing them the opportunity to make it work accessible to all the public.

Rethinking Palaeolimnology for Society: co-production strategies for an effective science-policy interface

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There is a recognised gap between data generated by environmental and climate scientists (limno- and palaeolimnologists) and evidence needed by policy makers; for example, in relation to the future impacts of climate change on regional climate. This is in part because influencing policy through research is complex and requires skills that might not be valued or common in research systems. Palaeolimnologists do not often have impact beyond academia because research questions are theoretically driven instead of responding to societal needs. The current situation of our Earth's system, together with the social movements for climate justice, urge a step change in how policy and scientists approach climate change. Funded by UK Research and Innovation and supported by both Ministerial Departments and stakeholders, we (palaelimnologists) are developing a co-production model of research where scientists and stakeholders work in a synergy to develop research questions, produce research, and communicate effectively, to contribute to the policymaking system. Evidence-based insights and improvements in how to better communicate uncertainties to both policy and media are key areas to develop. Regarding pathways to engage with policy makers and, more important, how to get them to be engaged with us, we recommend informal regular meetings, as simple as a coffee or lunch, to stablish closer relationship, hence reputation and trust.

The rhythm of lakes: dancing the climate of the past

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Lake sedimentary records are excellent archives of the variability in the climate system. Changes in the climate along Earth history, particularly during the last 2.5 million years, have been modeled by a variety of drivers interacting over different time scales. These forcings include Milankovitch cycles, atmospheric interactions, ecosystem variations, and even human activity. We aim to share the principles of paleolimnology through the arts, specifically using the versatility of oriental dances. We will create a video to illustrate which are the climatic drivers that have modified the climate during glacial and interglacial periods, as well as the importance of their role during the lacustrine sediment's deposition. Communicating this knowledge with the non-scientific community is relevant because our society has played an important role in the modeling of ecosystems in the last decades. Using easy and attractive media such as the arts may promote a better comprehension about our labor as paleo-scientists and may be key in future climate decisions.

Climate change in the Los Lagos region, Chile: 'Laguna Verde' as a platform for outreach, education and inclusion

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Aquatic ecosystems are important natural laboratories because they record in their sediments the effects of local and regional environmental change, whether of natural or anthropogenic origin. The climate change in Laguna Verde, located near Ensenada in the Los Lagos Region, Chile, is studied using chironomid insects as paleoindicators. Laguna Verde is located in Vicente Pérez Rosales National Park and belongs National Forestry Corporation (CONAF). Information to the visitors includes the installation of sediment core, a bathymetric map of laguna Verde, an edition of booklets about chironomids, and media positioning through the web, Twitter, and talks to schools and public organisations. Some key subjects are the protection of water bodies, the ecosystem importance of chironomids and the relevance of environmental reconstructions. The collaboration of CONAF Park Rangers during the fieldwork and the partial funding of DI-ULagos (RTI-22) is appreciated.

Science and Paleolimnology in Social Media

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Modern society is characterized by a wide us of social media, mostly amongst the younger sections of our population. However most of the information that circulates in social media has no validation from scientists or scientific institutions and therefore frequently lacks validity and accuracy. At times the information that circulates involves false statements that could eventually even put people's integrity in danger. To improve this situation scientist and scientific institutions (universities, science museums, etc.) need to be more actively involved in social media, be ready to rapidly provide validation (or not) of the information and be active in preparing outreach material in an "easy to digest", social-media friendly format. However, to have a true impact in society, scientific institutions need to become more active in social media and work together with communication specialists, facilitating the collaboration between social media experts, scientists, technicians and students. The fields of Earth Sciences, limnology and paleolimnology, are of particular relevance in scientific outreach as they are closely related with controversial issues regarding for example human impact on the environment, pollution, etc. We will share experiences that come from two different kinds of outreach efforts from scientific intuitions in Mexico, on the one hand the social media from a small, institutional science museum ("Museo de Geofísica") and on the other hand the social media run by scientists in a research laboratory ("Laboratorio de Paleolimnología").

How to communicate on social media

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I´ve been working on advertising since 2015, in all these years i´ve noticed that all the good ideas have a great development on how they are communicated. That's why I propose this meeting to show you the best way you can use social media to communicate your innovation ideas and make sure that it will be shown to the right target. We are going to have a trip through Linkedin, Web and Instagram: what type of content, the different tools and the different objectives you find in each social media. At the end of the meeting, we will discuss all the questions that this information brings you to explore those tools in science communication. Enjoy the ride!!

IAL IPA 2022

FOCUS SESSION 12

Lake biodiversity changes through time and space

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Informing freshwater management through paleoecological assessment: The case of Sable Island National Park Reserve, Canada

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Traditional aquatic monitoring programs often rely on decades of baseline data to support conclusions of impairment or establish conservation goals. Using paleolimnology to complement biomonitoring can fill long-term gaps of frequently missing data through the analyses of biological indicators preserved in sediment profiles. This is demonstrated in the freshwater ponds of Sable Island National Park Reserve, a small isle of sand on the edge of the continental shelf in the Atlantic Ocean. Here, small freshwater ponds are crucial for maintaining rich biodiversity, including more than 500 feral horses; yet the longevity of the ponds is not well understood. We established a biomonitoring approach using benthic macroinvertebrate indicators to understand external influences on water quality parameters. The comparison has demonstrated a high correlation between dissolved organic carbon, sulfate, and the diversity of macroinvertebrates, while conductivity, ammonia, and calcium correlated with species richness. While this establishes a baseline for continued monitoring, reference for historical ecosystem changes is missing. Thus, we conducted a stratigraphic analysis of subfossil chironomids (Insecta: Diptera: Chironomidae) in four ponds to expand the knowledge of past environmental conditions. Community shifts throughout the cores indicated changes in habitat conditions in two ponds; both reflected large changes in catchment vegetation from recession of surrounding heath, and increased productivity from nutrient enrichment, inferred from the decrease in Microtendipes and increase in Cricotopus, respectively. Presence of Glyptotendipes and Paratanytarsus in one pond suggests impacts of erosion and increased submerged vegetation, while a large inflow of sand in the other pond reset the community composition to reflect the sandier conditions. Findings suggest that the primary causes for ecological stress are unmanaged wildlife populations and major morphological change associated with storm-surge activity. The case of Sable Island demonstrates that paleolimnological analysis can inform continued monitoring and contextualize ecosystem management.

Towards disentangling the effects of salinity and eutrophication in shallow lakes

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Using palaeolimnological data to disentangle multiple drivers of biodiversity shifts in shallow lakes is often hampered by circular reasoning, predominantly from a lack of independent variables and long-term monitoring data. In dynamic coastal lakes, co-varying increases in nutrient enrichment and salinity can be particularly problematic to disentangle as feedback mechanisms (e.g. the mobilisation of phosphate bound in sediments and the salt-induced aggregation of suspended matter) result in non-linear shifts and the relative contribution of the various controls is often poorly understood. Here, we use a case study of Hickling Broad, located in the Broads National Park (UK), where previous studies have shown complex responses of macrophytes to long-term changes in salinity and eutrophication. Previously, a lack of robust palaeosalinity and palaeoproductivity reconstructions has hindered full understanding, but now we present a comprehensive multi-proxy palaeolimnological dataset of biota (diatom, ostracod and macrophyte assemblages), ostracod shell chemistry (which allows independent reconstructions of water composition), diatom transfer functions and sedimentary geochemical properties. Alongside long-term (123 years) archival records of salinity and macrophyte presence-absence, ostracod Sr/Ca, the presence of saline tolerant macrophytes, and archival records of salinity suggest periodic increases in salinity associated with storm surges. Using Generalized Additive Models, we test the unique and joint contribution of salinity (e.g. ostracod Sr/Ca and $\delta^{18}O$) and productivity (e.g. ostracod $\delta^{13}C$) gradients to individual species and community composition. More diatom species responded to salinity derived from ostracod $\delta^{18}O$ than Sr/Ca, whereas ostracod species showed little response to either, likely due to the euryhaline fauna. The interaction between $\delta^{18}O$ and $\delta^{13}C$ yields a significant contribution of $\delta^{18}O$ on the diatom community only. These preliminary results suggest diatoms may hold potential for tracking independent salinity changes over time in Hickling Broad.

Combining palaeo- and contemporary ecology to assess biodiversity in aquatic environments

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Biodiversity changes over the last 200 years in lowland agricultural settings are primarily influenced by human activities, particularly farming practices involving fertilisers and land use changes. These changes occur on both long (decades-centuries) and short (years) timescales, and the intensity of these changes due to stressors varies over time and space. The River Glaven catchment, north Norfolk, UK, offers an opportunity to examine biodiversity changes in the freshwater landscape using both palaeo- and contemporary ecological techniques. At two lakes in the catchment, Selbrigg and Bayfield, palaeolimnological studies, principally macrofossils and diatoms, have been carried out on radiometrically-dated sediment cores. Additionally, both sites have been fully and casually surveyed for aquatic macrophytes for the last 20 years. Selbrigg is situated near the headwaters of the river system and is therefore likely to be a comparatively clean site with less overall nutrient input, whereas Bayfield is an onstream site near the mouth of the river and as such can be considered a good catchment integrator, representing change and inputs from the entire catchment. Combining palaeoecological data with detailed, consistent contemporary surveys and casual observations allows for analysis of both long-term and more rapid changes in biodiversity and can be used to answer questions such as how, when, and where biodiversity changes occur in a catchment in response to stressors. It also allows for a more robust analysis of biodiversity loss, as the large spatial coverage provides crucial information on the location, in the wider landscape, of species that have been lost from specific sites.

Connecting changes in cyanobacteria biodiversity with warming winters in Maine, USA, using photosynthetic pigments and sedDNA

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To better understand the factors that promote cyanobacteria harmful algal blooms (cyanoHABs), prior work calls for taxon-specific studies of algal responses to specific climate metrics over longer temporal scales. The state of Maine, USA, is experiencing some of the most significant winter warming in the country. *Gloeotrichia*, a toxin-producing, bloom-forming taxon, has already been identified in many low-nutrient Maine lakes, including drinking water sources and recreational areas. *Gloeotrichia*'s meroplanktonic life history makes it especially sensitive to changes in winter temperatures and is thus of distinct concern in Maine. A multi-proxy paleolimnological approach using established (e.g., photosynthetic pigments) and newer (e.g., sedimentary DNA [sedDNA]) proxies can provide a deeper understanding of ecological changes driven by climate and/or anthropogenic activities. Here, biodiversity changes in cyanobacterial communities were reconstructed via photosynthetic pigments and sedDNA metabarcoding in low-nutrient lakes in Maine. Sediment cores were collected and sectioned from Maine lakes at 0.25-centimeter increments for a minimum of decadal resolution. Photosynthetic pigments and sedDNA metabarcoding analyses were performed from each sediment section and compared to temperature records over the past 150 years. Results are expected to show synergistic, detailed reconstructions of cyanobacterial community abundance and composition changes over the past 150 years, with special attention given to *Gloeotrichia*. These sediment profiles fit into larger project goals that aim to assess the interactive effects of how trophic state and climate change have altered overall cyanobacteria abundance in 12 Maine lakes, and to investigate how decades of warmer winters have specifically affected *Gloeotrichia* populations in Maine lakes over the past 150 years.

Littoral zone Chironomidae (Diptera) in sediments of karst lakes from the Lacandón Forest, Chiapas, Mexico

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The limnological and climate heterogeneity makes the northern Neotropics a suitable area to investigate the distribution patterns and ecological preferences of freshwater communities. Therefore, the chironomid larvae assemblages of 38 littoral zone surface sediment samples from 11 karst lakes located in the mountains of the Lacandón Forest, Mexico, were analysed. In total, 3029 head capsules were found and 71 taxa belonging to 43 genera, eight tribes and three subfamilies were identified, while 16 taxa were rare species (<2 % in all samples). The species accumulation curve suggests that a more exhaustive sampling could reveal a higher number of chironomid taxa. Our study reports for the first time the presence of unknown *Tanytarsus* and *Pagastiella* morphotypes. Multivariate analyses (DCA, CCA) indicated elevation and carbonate content in lake water to be the most influential factors for chironomid distribution. *Goeldichironomus holoprasinus*-type and *Tanytarsus* spp. displayed higher abundances with increasing elevation, whereas *Polypedilum nubeculosum*-type showed higher abundances with increasing carbonate content. A decrease in biodiversity with increasing elevation was observed. This study is the first contribution to the taxonomy and ecology of chironomids of lakes from the Lacandón Forest.

Large Lake biodiversity changes through Holocene time according novel palaeolimnological records

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Recently we have been actively studying the natural and anthropogenic impact on Lake Ladoga and its catchment area as well as impact dynamics in the Holocene period. To do this Lake sediment sequences were studied using the same methods include lithology, grain-size, pollen, diatom, metals, phosphorus and radiocarbon AMS dating. The results are compared with similar data on small lakes that were part of Ladoga during the Holocene, as well as with similar results from studies of archaeological sites located on the watershed of the Lake Ladoga. At present, we have received new results from studying the sequence of sediments in the Lake Ladoga. We present analyses of a ca. 12,000-year pollen and diatom record, as well as lithology geochemistry and grain-size data. For the first time for Lake Ladoga, changes in phosphorus during the Holocene dated by the radiocarbon method were obtained. An increase in phosphorus, LOI and the Fe/Mn ratio was recorded during the climatic optimum of the Holocene. At the same time pollen data showed the spread of broad-leaved forests. The upper peak of phosphorus is smaller, than in the climatic optimum. This may indicate that climatic factors affect the large lakes ecosystems a more significantly than anthropogenic ones. New dates for the first appearance of cultivated cereals on the coast of the Lake Ladoga were obtained at about 4500 cal. years ago. The study is being performed within the framework theme № 0154-2019-0001(Institute of Limnology RAS).

Macrophyte pollen in the lakes history studies

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One of the main methods of studying lake sediments is pollen analysis. There are excellent conditions for pollen preservation in lake basins that makes them a valuable database of paleogeographic information. Terrestrial vegetation pollen is commonly used for reconstructions. The role of aquatic vegetation pollen is often underestimated due to their low occurrence and poor preservation. However, the macrophytes dynamic might indicate many processes in the aquatic environment. Therefor palynological chronicle of water basins created by macrophyte pollen makes them an important source for studying the lakes history. Lake Vitalievskoye located on the Valaam Island (Lake Ladoga) is used as an example to consider the role of macrophyte pollen for studying the lakes development. The lake had been part of Lake Ladoga, but isolated during the Ladoga regression in the Late Holocene. Based on the results of pollen analysis of the Lake Vitalievskoye sediments sequence we have obtained data on changes in the species diversity of macrophyte pollen and have selected the stages of the lake development. At the first stage (Late Atlantic – Early Subboreal) Lake Vitalievskoye was part of Lake Ladoga with poor aquatic vegetation. At the second stage (end of the Subboreal) it was isolated that is highlighted by the disappearance of macrophyte pollen. At the third stage (Subatlantic) the lake was gradually populated with its own aquatic vegetation. The dynamic of macrophyte pollen at the different stages makes it easier to understand the Lake Vitalievskoye development. Further researches will expand the importance of macrophyte pollen for studying the lakes history. The study was carried out within the framework of the State Research Program of the Institute of Limnology RAS – SPC RAS No. 0154-2019-0001.

Late-Holocene dynamics of interdunal fresh water environments at the southern coast of Buenos Aires Province, Argentina

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Late-Holocene environmental conditions are investigated at the south coast of Buenos Aires Province, Argentina. Laguna Olvidada and Laguna Grande sediment sequences, temporary fresh water bodies located between the dunes, are analysed for ostracods and plant macro fossil remains. Supplementary information is provided by sedimentological analysis. The microfauna recovered consist of abundant ostracods although with low diversity. Charophytes, mostly *Chara* spp. and *Nitella hyalina*, *Daphnia* resting eggs and abundant seeds of *Ruppia* cf. *maritima*, an aquatic submerged macrophyte, were also found. Distinct assemblages of ostracod species characterize the sediment sequences. *Heterocypris* cf. *incongruens*, *Sarcypridopsis aculeata* and *Cypridopsis vidua* are the dominant species in the Laguna Olvidada sediment record, while *Potamocypris villosa*, *Limnocythere* spp. and *Sarcypridopsis aculeata* dominate the ostracod assemblage of the Laguna Grande core. The microfossil assemblages suggest water level fluctuations and salinity changes throughout the sequences, which may have been caused by fluctuations in precipitation. This study evaluates how and to which extent different types and intensity of disturbances have shaped the coastal aquatic systems through time in particular changes on their biodiversity.

Multi-proxy temperature reconstruction and paleoenvironmental conditions during the late glacial and early holocene in the Černé Lake, Central Europe

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Multi-proxy climate reconstructions can provide better insights into the past environmental conditions. This research aims to test paleoclimatic reconstructions obtained from different proxies to discern the climatic signal from other environmental factors. For that purpose, we analyzed the climatic signal from chironomids, isoprenoid GDGTs and pollen during the Late Glacial and Early Holocene (13,500-7,690 cal yr BP) at Černé lake, in Central Europe. Other proxies, such as pollen and geochemistry estimated past environmental conditions such as the vegetation dynamics, the variability of erosion (Rb), and the sources of organic matter (C/N ratio and d13C). Temperature reconstructions showed similarities during the main cooling and warming transitions, but different responses were found in other climatic events. Isoprenoid GDGTs appeared to react to changes in organic carbon sources, producing a shift in the bacterial community and increased methanogenic activity, which likely altered the climatic signal. Those anoxic episodes in the lake might be caused by an increasing input of nutrients from the catchment, related to the development of the vegetation at the beginning of the Holocene. This increment of nutrients to the lake also affected the chironomid community, causing maybe the greatest environmental shift in the life of this temperate mountain lake. Our study helps to better understand the climate-vegetation-environmental feedbacks during the Late Glacial and Early Holocene in the montane forest zone in Bohemian-Bavarian Forest, Central Europe.

Fossil pigments and environmental conditions in the oligotrophic Laja Lake in the Chilean Andes

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Interactions among climate change, ozone depletion, and ultraviolet radiation affect aquatic ecosystems. Meteorological and biological monitoring is often too brief, however, to record the magnitudes of past changes in ultraviolet fluxes and their effects. This study presents an analysis of fossil pigments and environmental conditions in the oligotrophic Laja Lake in the Chilean Andes over a 60-year period. The age of the sediment core was determined using high-efficiency gamma spectrometry and dated with lead-210 (210Pb). Analysis of the total and specific fossil pigments from a sediment core utilized a combination of analytical methods, spectrophotometry, and high-performance liquid chromatography. Environmental variables, such as stratospheric ozone concentration, temperature, precipitation, and ultraviolet radiation explained changes in the fossil pigment scytonemin. Results showed that low cloud cover over the high mountain lake predominated, with high ultraviolet radiation and temperature values during summer months. The most abundant group was Bacillariophyceae (diatoms). The highest concentrations of the pigments (canthaxanthin echinenone, myxoxanthophyll, aphanizophyll zeaxanthin and scytonemin) that represent the cyanobacteria groups were found in the upper part of the core (cm 0–15). The trend analysis further suggested that the influence of environmental features enabled generation of ultraviolet radiation-shielding pigment in the algae communities in the high mountain lake.This study advances understanding of the interactive effects of climate change, ozone depletion, and ultraviolet radiation on aquatic ecosystems. Fossil pigments proved to be good indicators of lake-ecosystem response to climate/environmental changes, which are necessary for predicting possible effects of future climate change. Center for Water Resources for Agriculture and Mining (CRHIAM) ANID/FONDAP/15130015.

Wetter early Bølling–Allerød and early Holocene in central Mesoamerica of southwest Mexico: comparison of proxies and possible forcings

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Most of the proxy-based hydroclimate records from the Mesoamerica are restricted to the Holocene when several urban centers flourished and declined. The information about late last glacial and subsequent deglaciation is scarce due to lack of longer lacustrine archives and growth interruption in stalagmites. A recently collected sediment core from Lake Coatetelco in southwest Mexico (~19 °N), with a volcaniclastic watershed and limestone basement, provided an opportunity to extend the paleoclimatic information from the western part of central Mesoamerica up to the latest glacial. Stratigraphic changes in Ti, $CaCO_3$, $\delta^{18}O_{carb}$ and $\delta^{13}C_{carb}$ in inorganic fractions and TOC, $\delta^{13}C_{org}$ and C/N in the organic fractions suggested wetter conditions during the warmer early Bølling–Allerød (B/A) interstadial and early Holocene (~10.2-9.5 cal ka BP) with above-average runoff, less evaporation of water column and preservation of more organic matter. However, the productivity was both autochthonous and allochthonous (aquatic and C_3 plants) during B/A and mostly allochthonous with more contribution from C_4 plants during the early Holocene. ITCZ remained at northern latitudes and Atlantic Meridional Overturning Circulation (AMOC) was stronger during both these wetter intervals. The possible depositional hiatus/low depositional rate with below-average runoff represented the arid conditions during the Heinrich Stadial 1 (HS 1) and Younger Dryas (YD). Although the evaporation remained low during the both the cooler intervals, the dissolved inorganic carbon was sourced dominantly from dissolution of basement limestone as ITCZ shifted to the southerly latitudes and AMOC remained weaker. Comparison with the speleothem record from Juxtlahuaca Cave (Mexico) and lacustrine archive from Petén Itzá (Guatemala) suggested synchronous hydroclimate changes across the central Mesoamerica and possible role of the zonal flow of the Caribbean low-level-jet.

Stable oxygen and carbon geochemistry for the first Caspian Sea stack

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Caspian Sea (CS) is the world-largest isolated water basin. Stable oxygen and carbon isotopes in lacustrine carbonates are significant (however, not widely adopted) tools for studying its level and configuration changes, reflecting both regional and global climatic events. Continuous sediment record and methodological research are required for an accurate data interpretation. Here we introduce the first attempt to create ostracod $\delta^{18}O$ stack composed of more than 10 records from the Central and Southern CS for 25 ka, and use its signal for paleoclimate reconstruction along with preceded methodological aspects. The carapace mineral composition reflects the host water chemistry. The smallest measurement discrepancies were obtained for *Candonidae*, it confirms taxa dependence of vital effects on oxygen isotope fractionation. The ostracods vital offset influence on $\delta^{13}C$ is higher and seems to create systematic variations, but still not completely understood. We established the topmost factors influencing isotope composition in CS are depth, salinity, and temperature. Measured modern ostracods are 2.28‰ richer in heavy oxygen than host water, the smallest shift is peculiar to the mixed taxa samples (+2.07‰). The difference between measurements within the same species in cores turned out to be much smaller than in sea-bottom samples: 0.19‰ for oxygen, 1.2‰ for carbon. Covariant trend at the end of Khvalynian era along the sea-level fall reflects fundamental changes in the basin regime – there was a hydrologically open system. Hereafter the Mangyshlak regression appears with limited, intermittent connection between different parts of the CS. Shift to a warmer, more humid climate led to CS level rise, resulted in the Newcaspian transgression with maximum level recorded at the beginning. Low-amplitude oscillations did not affect the deep-water core structure; therefore, a lowering sea level trend to the current position is observed during the end of the Holocene. The research was funded by RSF no. 21-44-04401.

Using biological multiproxies to infer biodiversity changes in del Monte shallow lake, Argentina

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The Salado river basin is the most important riverine system in the North-East area of the pampean region, one of the major zones of food production in Argentina. Del Monte shallow lake is a wetland into the Salado basin. The lake is placed nearby the locality of San Miguel del Monte. Here, a European fort was established in the XVIII century, as a borderline with the indigenous people. Earlier limnological and paleolimnological studies have been carried out in the area, focussing in the geomorphological origin of the lake and its current ecological status. Information about long-term changes of the lake biodiversity is scarce. The aim of this study is to evaluate the use of biological remains as a tool of environmental reconstructions. A sedimentary core of 74 cm long was taken from the deepest part of the lake. Sediment samples of 0.5 cm^3 were analysed at continuous intervals for loss on ignition to estimate the content of organic matter and carbonates. Subsamples of 5 to 15 cm^3 of sediment were taken at 2 cm intervals along the core for biotic macroremains analysis. These samples were sieved through 250, 125 and 63 µm mesh. A diverse of plant and invertebrate remains have been identified. Assemblages consisted of seeds of angiosperms, megaspores of ferns and oospores of charophytes with changes in their abundance and diversity throughout the core. Also, reproductive structures like cladocera resting eggs, bryozoan statoblasts, sponge gemmules, and platyhelminth cocoons have been recovered, as well as, chitinous remains of diptera, cladocera and calcareous remains of ostracods and molluscs. The biological proxies recovered in del Monte lake lead us to establish the environmental evolution of the lake based on changes in the composition and abundance of its biotic communities during the last centuries.

Tracking long-term environmental change and anthropogenic stressors: using lake sediment records to investigate human impact since the Mesolithic-Neolithic transition

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Lake ecosystems in Europe have experienced major biological, chemical, and ecological changes caused by accelerated and intensified human activities at several times since the mid-Holocene (and the introduction of agriculture), of which the current Anthropocene (here, 1950s-present) is perhaps the most rapid and extensive. Far less is known of many such earlier episodes, however, and their interactions with natural environmental change (such as climate). Understanding the extent of lake system environmental change across a multicentennial/millennial scale and how different stressors interact is essential to enhance our knowledge of the long-term dynamics and complexity of historical human and climate disturbances. While studies on waterbodies have collected ample evidence of change during the Anthropocene, long-term Holocene records in UK waterbodies are rare, particularly studies covering the beginning of the Mesolithic-Neolithic transition (≈6000 years BP). Obtaining continuous sediment records since the Neolithic period and applying a multivariate, multiproxy approach to UK lakes would offer an exciting opportunity to elucidate the interactions between cultural changes, the environment and human demography potentially from the introduction of agriculture up until the modern era. The integration of multi-proxy paleolimnological techniques (e.g., diatoms, stable isotopes, geochemistry, pigments, lipid biomarkers and sedimentary DNA (sedaDNA)) offers the most robust assessment of environmental change across a decadal, centennial to multi-millennial scale, and allows a deeper understanding of different drivers of the local aquatic and regional terrestrial systems. This research aims to provide a picture of cultural and natural disturbances over key time periods and the lessons that may be learned to guide the future sustainability of the UK landscape. Consequently, understanding how lakes were affected by past natural climatic and environmental change and anthropogenic stressors will help improve catchment planning, mitigation, and adaptation strategies under projected climate change scenarios for the UK.

Diatom and ostracod community changes in Nam Co, Tibet shown by sedimentary ancient DNA

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Sedimentary ancient DNA (sedaDNA) metabarcoding has revolutionised the field of tracking biodiversity of target organisms from sediment cores, such as from lakes, spanning thousands of years. Traditionally, past aquatic communities are studied using morphological identification of the microfossil remains. However, sedaDNA sequencing data has an incredible potential e.g., in cases where no fossil remains were preserved. Several studies already compared the morphologically and genetically retrieved species communities, showing that both methods give similar results. Ostracods, as well as diatoms are sensitive to environmental factors, such as e.g., temperature, pH, salinity, conductivity and water depth, and are therefore, used as bioindicators and for reconstructions of past environments. In this study we analysed a 107 cm long lake sediment core at 27 m water depth from the Eastern part of lake Nam Co on the Tibetan Plateau in order to investigate community assemblage changes of diatoms and ostracods. Due to possible intermixing of sediment layers, only the upper 70 cm could be included in the age-depth-model and were dated to 230 BCE. Previous studies on this core material investigated the compatibility of morphological and genetic diatom diversity and primer sequences for non-marine ostracods were evaluated on surface sediment material from Nam Co. Here we focus on the sedaDNA metabarcoding data which showed that the most dominant ostracod species throughout the core were *Leucocytherella sinensis* and *Limnocythere sp*. SN005, which occurred interchangeably, and the most dominant diatom taxa were *Amphora* and *Pseudostaurosira*. Interestingly, *Fabaeformiscandona gyirongensis* was found in intermediate abundance throughout the morphological ostracod dataset, however, the DNA of this species was found only in eight samples, mostly at 38 cm to 45 cm depth. Detailed cluster analysis of the datasets are the next step to understand assemblage shifts and identify differing zones across the lake sediment core.

Postglacial vegetation dynamics and environmental conditions of southwest Patagonia Argentina (49º S; 72º W). Pollen and plant macrofossils analysis

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Towards the end of the Last Glacial Maximum, southern Patagonia glaciers began their retreat, allowing the lakes and bogs formation and plant colonization in Andean Patagonia. The main purpose of this work was to reconstruct the dynamics of the subantarctic forest community during the deglaciation and their relation with the climatic variations from a wetland sediment core in southwest Patagonia Argentina (49ºS; 72ºW). The wetland is currently dominated by *Pilgerodendron uviferum*, Cyperaceae and Sphagnum. The pollen and plant macrofossils content was analyzed for the period between ca. 18,500 and ca. 11,000 cal years BP. Between 18,000 and 14,500 cal years BP, the pollen data suggest a sub-shrub steppe dominated by *Ephedra*, *Empetrum*, *Azorella* and shrubs such as Asteraceae subf. Asteroideae. At a local scale, a lacustrine-type deposit with moisture-indicating vegetation such as Caryophyllaceae, Gentianaceae, Urticaceae and *Myriophyllum* was inferred. Then, up to 10,000 cal years BP a shift towards a Poaceae steppe and the beginning of an open *Nothofagus* forest was suggested. *Nothofagus* remains indicated the local presence and expansion of the forest in the area. Identification of leaf fragments indicates the dominance of *Nothofagus* pumilio in the forest. At a local scale, a development of a mire deposit dominated by Cyperaceae and Bryophytes is inferred. The results obtained in this work coincide with global temperature models, the gradual increase in temperature recorded regionally is evidenced by the change from a sub-shrub steppe to a grass-*Nothofagus* forest ecotonal environment. The integration of plant macrofossil analysis with pollen analysis gives a more detailed picture of the composition of the local vegetation and, therefore, a more accurate environmental and climatic reconstruction.

How do sediment surface diatom, cladoceran and chironomid taphocoenoses of mountain lakes reflect environmental variability?

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Biotic remains from the sediments of 40 lakes were studied in three mountain regions (Fagaras Mts, Pareng Mts and Retezat Mts) of the Southern Carpathians (SC) to (1) investigate how taphocoenoses of diatoms, cladocerans and chironomids reflect the variability of mountain environment and (2) to improve training sets for quantitative environmental reconstruction. Diverse diatom flora and poor chironomid and Cladocera taphocoenoses were found in SC. Diatoms explained the differences between the three mountains. Cladoceran and chironomid communities of the Fagaras Mts differed significantly from Retezat Mts, while only slight differences were found compared to Parang Mts; they presented high similarity between the Parang and Retezat Mts. The replacement component of beta-diversity of diatoms was high (60%) suggesting that the mountain environment does not filter them. In contrast, the similarity component of cladocerans was high (47%) and a very poor Cladocera fauna was found. Chironomids occurred in modest diversity, but their beta-diversities were determined by the replacement component (46%). The high percentages of richness difference of cladocerans (30%) and chironomids (27%) show the effect of rare species that appeared in a few lakes and were responsible for the modest beta-diversity. A complex network was drawn for diatoms, while the network was very simple or atomic for chironomids and for cladocerans. We infer that the use of those taxa which suffer from strong environmental filtering is limited for paleoenvironmental reconstruction.

Use of diatoms for disentangling of climate and tectonic forcing in the development of the last volcanic lake of Carpathians during the Last Glacial Maximum and deglaciation (Lake St. Anne, Romania)

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High-resolution diatom analysis (156±87 yrs) was carried out to assess the limnological and climatic changes in Lake St Anne volcanic lake between ~27.7±1.4–6.2 ka cal BP. The lake development can be described as an overall trend from a slightly alkalic/ circumneutral lake (pH=7–7.4), to a shallow, oligotrophic peatbog with large hollows (pH=6–5) during the studied period. Diatom assemblages were dominated by small benthic fragilarioid taxa of *Staurosira* and *Staurosirella* with large celled *Gyrosigma acumintum* and *Navicula radiosa* for the Last Glacial Maximum and deglaciation period of the record. An abrupt change with the disappearance of several taxa and decreasing diatom diversity was detected at ca. 16.7 ka. At the same time, the diatom-inferred lake water chemistry also showed abrupt change. These results together with the pollen and chironomid inferred climate changes suggest that the diatom assemblages in Lake Saint Anne primarily reflect macro-climate variability in the studied period. However, microtectonical changes via modifications of the CO_2 degassing processes could have also trigger the reorganization of siliceous assemblages around 16.7ka. The YD cooling can be well detected in the sediment, by the dominance of acidophil *Encyonema neogracile* and *Staurophorma exiguiformis*. These inferences are also corroborated by the paleoclimate proxies of the Black Sea sediment records, even though the palaeoclimate reconstructions are affected by dating uncertainties increasing with age.

Stable isotope geochemistry for the modern ostracods in the Caspian Sea

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The main role in the present study is played by paleoecological studies – "the study of the relationship between the world of organisms of the geological past and their habitat" (Gofman, 1962), and oxygen isotope studies of the modern benthic microfauna of ostracods, without which further detailed paleogeographic and paleoclimatological constructions are impossible. To compare the measurements obtained as a result of implementing different approaches to sample preparation, we used the species *T. amnicola donetziensis*, which is the most common in surface samples. Sample points are located in the western part of the South Caspian to the north of the confluence of the Kura, not far from each other. From the surface samples at these points, 5 samples were taken for the implementation of 5 cleaning techniques. The difference between the oxygen isotopic compositions of ostracod shells bears a species-index imprint, but shows small discrepancies, which are lower on average than for any other marine carbonates used in the analysis of stable isotopes, which makes ostracods a universal and reliable object of both paleofaunal and geochemical studies. The influence of metabolic effects on the fractionation of oxygen isotopes depends on the genus, the smallest discrepancies are typical for species of the genus *Candonidae*. The difference between the carbon isotopic composition of shells is not only species-specific, but also variable for each individual species. For the analysis of stable oxygen isotopes, it is permissible to use different species of ostracods, preferably closely related ones. Averaging of the measured values does not lead to a false interpretation of the isotope record and is not capable of distorting the paleogeographic picture; on the contrary, it gives a smoother result, excluding the manifestation of random factors and rebounds.

FOCUS SESSION 13

Linking the past and the present of Pampean shallow lakes to infer the future

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Quantitative analysis of pollen and vegetation richness relationship at the southeastern Buenos Aires coastal dune system

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This project aims to evaluate the relationship between plant and pollen richness of the Coastal Dune System (CDS) of the southeastern Buenos Aires, Argentina, associated to taxonomic and taphonomic constraints on pollen production, preservation and dispersion at local and landscape scales. Pollen analysis is a widely used tool in paleoecology to reconstruct both vegetation history and to analyze temporal changes in plant diversity. However, pollen abundance cannot be directly translated into plant abundance in the vegetation when interpreting past pollen assemblages. To overcome this issue, it is necessary to improve past plant diversity reconstructions by calibrating modern pollen-vegetation diversity relationships, by studying pollen surface samples to understand fossil pollen assemblages and their ecological significance. We took 21 pollen surface samples from interdune lagoons to analyze their pollen content and its relationship with the surrounding vegetation cover at different radii (5, 10, 20, 1000, 2000 m). Sediment samples were treated according to standard techniques to obtain pollen grains. Vegetation cover was calculated by field measurements at 5, 10 and 20 m. We took local vegetation information to generate vegetation maps at 1000 and 2000 m radii from the pollen surface samples point. Plant richness and pollen surface samples were analyzed through linear regression models and multivariate analysis. We find positive and close correlation between plant richness and their pollen equivalents (adjusted r^2= 0.5116). Also, we find a positive and significant correlation between pollen surface sample richness and plant richness at 20, 1000 and 2000 m. Multivariate analysis relates high pollen surface sample richness with sites partially covered by *Pinus* and other alien tree and herbs communities, within to 2 km radii. These preliminary results shows quantitatively that there is a positive relationship between plant and pollen richness at local (20 m), extra-local (landscape) and regional scales in the CDS. However, the Adjusted R-squared is smaller at 2 km distance with respect to 20 m. This patter suggest that these models fit better assuming smaller Relevant Pollen Source Area.

Changes in the turbidity of shallow Pampean lakes during the last 30 years using remote sensing data

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The Pampean Plain host thousands of eutrophic and hypertrophic shallow lakes. In last decades it has been incrementing the proportion of land dedicated to agriculture activities in the region, which impacted the water quality of these lakes. However, there is a lack of long-term monitor programs of Pampean shallow lakes that study the impact of these activities. Remote sensing allows enlarging the time and spatial scale coverage resulting in a very useful tool to analyze possible changes in some water characteristics, like turbidity. We analyzed the changes in turbidity of 6 Pampean shallow lakes (Chascomús, La Limpia, Salada Monasterio, El Burro, La Segunda and El Triunfo) from 1986 to 2021. We used Landsat 5-TM, Landsat 7-ETM+ and Landsat 8-OLI images processed using the ACOLITE software and applied a general turbidity algorithm developed for turbid waters. We validated the satellite-derived values with field turbidity data. The temporal series were analyzed to separate the general trend from the seasonal variability. Chascomús exhibited oscillations, but always around high turbidity values (95.5 - 593.8 FNU). La Limpia shows an increment of turbidity reach a maximum in 2009 (846 FNU) and then diminishing. Salada Monasterio also tended to oscillate, with a minimum of 52.5 FNU and a maximum of 400.2 FNU. In El Burro we detected an increasing trend throughout the analyzed period, with values ranging from 41.8 FNU to 388.5 FNU. Finally, La Segunda and El Triunfo exhibited lower turbidity values respect to the other lakes (mean: 3.2 FNU in La Segunda and 51.5 FNU in El Triunfo). However, due to the presence of macrophytes that interfered in the turbidity algorithm, the temporal series obtained were much more limited. We monitoring oscillations and changes in the water turbidity of Pampean shallow lakes by mean of remote sensing along with field data.

Environmental evolution of the lakes in the arid-semiarid Pampas of Argentina over the last millennium

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Many shallow lakes in Argentina's Pampean region provide essential ecosystem services, encouraging conservation and protection efforts and research regarding their fate in the face of climate change and human impact. We created a paleolimnological and paleoecological reconstruction based on litho-stratigraphy, diatoms, phytoliths, and geochemistry of four Pampean shallow lakes (La Salada, Sauce Grande, Los Chilenos, and Puan). The lakes are strategically placed along a climate gradient from arid to semiarid conditions. We aimed to determine the primary causes and mechanisms of long-term ecological change in Pampean lakes. According to our findings, lakes changed from being temporary with clean waters to becoming permanent with turbid waters. We argue that an increase in net precipitation causes this shift by raising lake levels and lake extension, which favored sediment resuspension and primary productivity. The climatic improvement happened first in the current dry region, at 910 and 593 cal. yr. BP in La Salada and Sauce Grande, respectively, then in the semiarid zone, at 463 cal. yr. BP in Los Chilenos, and lastly in Puan at 20 cal. yr. BP (1930 AD). Secondary drivers of ecological change were salinity (in Puan and La Salada) and nutrients (in Los Chilenos and Sauce Grande). Human-induced eutrophication affected the lakes only in recent times. This study demonstrates the significant effect that climate change has on ecosystem shift on shallow lakes and alert us about new shifts resulting from the dual impact of climate change and anthropogenic activities.

Paleoenvironmental history of Siete Lomas shallow lake (Southeast Pampa plain, Argentina) during the last 1000 years

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A multi-indicator analysis, including pollen, non-pollen palynomorphs, paleopigments, total phosphorus -TP, organic matter, plant macrofossils and associated fauna, was performed to reconstruct the paleoenvironmental history of Siete Lomas lake (37º08'S, 57º38'W) during the last *ca*. 1000 years. During the early period of the lake history, changes in dominant communities were mainly controlled by climate, and later, changes probably resulted from a combination of both climate and human impacts that generated an accelerated eutrophication. Three scenarios in lake's evolution were recognized. Since *ca*. 1050 AD a clear and ephemeral/small shallow lake with a low primary productivity and low nutrients was indicated by low TP concentrations, the dominance of submerged macrophytes (angiosperms and charophytes) and low abundance of phytoplankton, probably associated with a dry period. At *ca*. 1880 AD a transition towards a turbid, eutrophic perennial lake with higher primary productivity, increased nutrients (*i.e.*, TP levels) and water level and a diverse community composed by plants, algae and zooplankton was denoted, likely related to the onset of a wet period. During this time the aquatic community was dominated by the phytoplanktonic algae (e.g., *Pediastrum* and *Gloeotrichia*), which was confirmed by fossil pigments indicators of chlorophyte, cyanobacteria and diatom algae. On the other hand, the local community of macrophytes (*Myriophyllum*; *Ceratophyllum*.; *Potamogeton*; *Chara* and *Tolypella*) was poorly represented. During the last scenario, since *ca.* 1975 AD, a hypereutrophic, turbid and enlarged lake was denoted by an exponential increase in TP, the dominance of *Gloeotrichia*; *Pediastrum* and *Scenedesmus*, and also of diatoms, as indicated by fucoxanthin increase. The abundance of cladocera (*Daphnia* sp., *Ceriodaphnia* sp., *Simocephalus* sp. and *Moina* sp.) and bryozoans (*Plumatella* sp.) also indicated the lake eutrophication. During the last century, the main drivers of changes in the lake history were those related to eutrophication: the agriculture and the cattle breeding implemented in this landscape as well as the foundation and settlement of cities.

Identifying the influence of environmental drivers throughout the 20th - 21st centuries in the paleolimnological record of a Pampean lake (Argentina)

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Laguna del Plata (LP; 30°55′ S, 62°51′ W) is a saline lake located in central Argentina linked to the SW margin of Laguna Mar Chiquita (LMC). LMC is the largest saline-lake of South America and an important regional climatic sensor. The environmental variability of LP occurred in the last *ca.* 80 years was reconstructed through a multi-proxy approach in a sedimentary core with the aim of identifying the influence of both natural and anthropic drivers on the lake functioning. The analysis of instrumental and demographic data along with physicochemical proxies (i.e., MS, carbonates, TOC, CD, TC, TN, TP) allow us to identify two main environmental stages. Stage I (1934–1976 CE) is characterized by low values of nutrients (TN, TP) and primary production proxies (TOC, CD, TC) in agreement with low-water levels and high-water salinities while the stage II (1976–2017 CE) is the record of high-water levels and lowwater salinities. Along stage II three sub-stages related to changes in nutrient load were recognized. Sub-stage II A (1976–1983 CE) is characterized by an increase in primary production proxies and TN mainly related to a humid context and reduced water salinities. During sub-stage II B (1983–2010 CE) the synchronous increase between nutrients and primary production proxies matches urban population growth and agriculture expansion after the 1980s. The record of sub-stage II C (2010–2017 CE) shows an increase in all the proxies because of anthropic influence, despite water lake level variability. Results show that regional hydroclimatic variability acts synergistically with anthropic influence ruling the nutrient fluxes to LP and therefore influencing the eutrophication in the lake. Our results provide tools for developing watershed management policies and adaptation measures to current global change under the increasing anthropic pressure and large and rapid hydrological variability in Southeastern South America.

Chironomids (Diptera) checklist from Pampean shallow lakes, Argentina

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Pampa plain is extended between *ca.* 33° to 39°S and 57° to 66°W and shallow lakes are the dominant aquatic ecosystem of the region. These water bodies are mainly influenced by inter-annual variations in rainfall, and constitute great biodiversity reservoirs. The Chironomidae (Diptera) have so far received limited attention in terms of their ecologically and taxonomically knowledge, in contrast to other regions of Argentina where they are been widely studied as bioproxy or complementary indicators in paleoenvironmental reconstructions, and in environmental quality studies. In this opportunity, we present the first checklist of the Chironomidae from the Pampa plain. The cataloged fauna contains 19 genera and 3 subfamilies for modern fauna and 16 morphotypes in 13 genera and 3 subfamilies for subfossil Chironomidae, based on non- intensive samplings of Chironomidae larvae and adults, from 22 shallow lakes and the surrounding habitats in the central-south area of Pampa Plain.

The sedimentary and palynological record of the Monte Lake, Buenos Aires, Argentina

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The endorheic system of Lagunas Encadenadas del Oeste is located SW of the Pampa plain (36º 30'- 38º 05' S; 61º 40' - 63º 23' W). It is conformed by five interconnected lakes aligned on a regional depression. Here, we analyze the last 500 years of environmental evolution of the del Monte lake from a sedimentological and palynological perspective. Four pollen and non-pollen palynomorph (NPP) assemblage zones were determined by cluster analysis. The record spanning form AD 1418 to 1750, is characterized by low values of Chenopodiaceae, high values of Bryophyta spores and NPPs such as Botryococcus and Zygnema. It is characterized by laminated structure and medium silts. The total organic carbon contents (TOC) is the lowest of the all the record. All these characteristics indicate a clear state of the lake. The record dated between AD 1750 and 1908 shows a decrease of Bryophyta spores and an increase in Chenopodiaceae *and Asteraceae /* Asteroideae. It shows massive to laminated structure and medium silts, and an increase in TOC values. Toward the top, between AD 1908 to 1959, a replacement of Poaceae by Chenopodiaceae is evident and the presence of taxa associated to disturbance. It corresponds to a laminated to massive structure from base to top and coarsening upward medium to very fine sandy silts. Finally, the period from AD 1959 to 2015 is defined by the appearance of introduced taxa, *Pinus* spp. and *Eucalyptus* spp., and a considerable increase of *Pediastrum*. This unit presents coarse to very fine sandy silts with massive structure and highest TOC values, indicating a turbid state. These results allow inferring an environmental evolution, from clear to turbid stages. At the same time, the record shows changes in the vegetation which can be attributed to anthropogenic impact since the last 100 years.

FOCUS SESSION 15

Subaqueous mass wasting in natural and artificial lakes: triggers, development and impacts

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In-situ geotechnical analysis of translational landslides in Lake Villarrica and Lake Lucerne: new insights in slope stability and frontal emplacement style

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Translational landslides commonly occur in lacustrine settings due to a pronounced stratification in subaqueous slope sedimentary sequences. The resulting mass-transport deposits (MTDs) and turbidites can be mapped using seismic-reflection profiles and sediment cores, and are often used to identify and date prehistoric earthquakes. This follows the premise that strong seismic shaking can trigger multiple synchronous failures of slopes that are stable under static conditions. Many questions remain regarding i) the subaqueous stability of muddy hemipelagic slopes and the nature of potential sliding surfaces ("weak layers"), and ii) how the sliding mass affects the basin plain sediments. Results from geotechnical lab tests on sediment cores from landslide features are often not representative for the natural conditions in the sediments and therefore in-situ measurement techniques are needed. We here present in-situ geotechnical data obtained by free-fall piezocone penetrometer tests (CPTu) in stable slopes, failed slopes and MTDs, and complement these data by standard soil mechanic index properties and advanced tests (oedometer, dynamic triaxial test) on selected sediment cores. Our study targets several earthquake-triggered landslides from Lake Villarrica (South-Central Chile) and Lake Lucerne (central Switzerland). Our data show an important role of i) sandy tephra layers above which sliding can initiate, ii) soft fine-grained glacio-lacustrine deposits as "weak layers", iii) in-situ overpressure and focused fluid flow that locally decrease slope stability, and iv) shear strength and geometry of basin plain sediments controlling whether the sliding material will emerge from its stratigraphic position and propagate over the lake floor or whether it remains in a confined position and progressively deforms the basin-plain sediments. Despite the wealth of information that can be obtained in a cost-effective manner, such process-orientated subaqueous landslide research in lakes is rare when compared to the marine realm.

Lacustrine records of seismo-volcanic events in Andean Patagonia

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The Andean Patagonia is characterized by its highly active geodynamic setting associated to the Pacific convective margin. Intense seismicity originated in the Liquiñe-Ofqui Fault System and the Andean Transverse Faults and volcanic activity from the Southern Volcanic Zone are typical in the North Patagonian Andes. Atmospheric circulation at this latitude is dominated by westerly winds and controls the dispersion of explosive plumes, driving them predominantly to the East. Consequently, the lakes located east of the Andes are a valuable resource for reconstructing the volcanic and seismic history of the region. In the last two decades several works have provided abundant paleoseismological and tephrochronological information for the region. An interesting association of seismic and volcanic signals was identified for several postglacial episodes that have been referred to as seismovolcanic events, the most recent of which was the 1960 Valdivia earthquake, followed within hours by the concomitant Cordon Caulle eruption. An association of seismic, tsunamigenic mass wasting and volcanic events occurred in several localities in Chile and Argentina. This paradigmatic episode had devastating effects in Bariloche where a major subaqueous slide and consequent tsunami destroyed the Puerto San Carlos pier, killing two people and sinking several ships. Forty hours later, Bariloche was impacted by the Cordon Caulle tephra fall event. Lago Frias record also shows conspicuous seismic deposits associated with the 1960 Cordón Caulle tephra. Two other important seismovolcanic events have been clearly identified in lacustrine records from the region: one of them associated to the Nahuel Huapi Tephra (Playas Blancas Negra), an important regional tephrochronological marker dated at 2,05 cal. ka BP and a previous event dated 12,4-12.1 cal. ka BP in Lago Trébol cores that is correlated with a basaltic andesitic tephra from Osorno volcano interbedded with roof collapse deposits in two different archaeological sites.

Disturbance events recorded in the sedimentary infill of Lago Guillelmo, Parque Nacional Nahuel Huapi, Argentina

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Lago Guillelmo is a lake of glacial origin located at the eastern side of the Andean mountain range (Northern Patagonia). This zone is frequently affected by pyroclastic falls due to the proximity to South Andean volcanoes and also by hydrogeomorphic processes within catchments related to heavy rains. In order to look for evidence of these natural disturbances in the lacustrine sedimentary record, we analyze lacustrine cores and Ground Penetrating Radar (GPR) profiles, taken in the distal deltaic environment. We also analyze satellite and historical images of the nearby catchment. The analysis of the cores (Gui-220419-1, 2 and 3) allowed us to identify different units (1) poorly laminated brownish sandy silts , with autochthonous organic matter associated to charophytes, corresponding to the normal lacustrine sedimentation (2) tephra layers attributed to Cordón Caulle, Calbuco and Osorno Volcanoes according to pyroclast petrography and fragment morphology, and (3) sediments with terrigenous sediments and organic matter, interpreted as hyperpycnites. Especially at the bottom of Gui-220419-1 core we observed a ~9 cm thick (46 to 38 cm depth) fining upward sequence, grading from medium sand to very fine sand, with presence of leaves, roots and charcoal. From the GPR profiling we obtained a radargram with 1 major reflector which corresponds to a tephra layer observed at Gui220419-2 at 50-51 cm. We also observed another reflector corresponding to lobe-shaped morphologies that could be related to the hyperpycnites identified in Gui220419-1. These morphologies and its deposits are located in front of the mouth of an abandoned river course, observed in satellite and historic images. These results show the interruption of the normal lacustrine sedimentation by these disturbances and confirm the utility of this type of analysis. This work will be extended to other zones of Northern Patagonia, linking land surface and subaqueous environments analyses.

Coastal instability associated to gravitational processes in large Patagonian lakes: a study of recent events

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Subaqueous mass-wasting involving coastal areas of large Patagonian lakes is a little-known and almost unexplored phenomenon. However, its impacts over people and coastal infrastructure are increasingly reported. We study the characteristics, conditioning factors and probable triggers of a series of recent events that occurred at lakes Nahuel Huapi (2005), Huechulafquen (2010), Lacar (2015) and Espejo (2021), affecting coastal properties and public recreational beaches. Available information was collected through interviews with witnesses, municipal government officials, national parks staff, landowners and concessionaires of lacustrine coasts. Geophysical equipment (GPR, side scan sonar, phase-measuring bathymetric sounder, sub-bottom profiler and dual-frequency echosounder) were used to survey the lake floor. Drone and satellite imagery were visually interpreted. A coastal sublacustrine slope located immediately below the wave-base depth (locally called "veril") is a typical feature of Patagonian lakes, due to their glacially-carved basins and the reworking of coastal deposits by waves. These results show the occurrence of rotational slumps (with headscarps of up to 15 m height and 500 m length) that initiate at the coastal subaqueous slopes (18° - 32°) and may affect the shore either by subsidence or erosion by the original failure or headscarp retreat. The slumps subsequently evolve into translational slides or channelized flows that mobilize the sediment masses hundreds of meters into the lake basins. From sedimentological and morphological analysis we conclude that coastal areas with high sedimentation rates (e.g. lacustrine deltas or windward-facing beaches where thick remobilizedtephra deposits were accumulated) show the highest susceptibility, especially with recent anthropic intervention on the subaqueous slopes. A clear link between the occurrence of these events and concomitant regional or local seismic events were found. In order to reduce the exposure of vulnerable coasts, coastal gravitational processes should be considered in territorial management, especially when addressing secondary hazards derived from seismic and volcanic events in Patagonia.

A first landslide-induced tsunami generation mapping tool in the Argentinean North Patagonian lakes

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Sub-lacustrine landsliding is a geologic hazard of the Argentinean North Patagonian Andes. The main consequences are the impact on submerged or semi-submerged infrastructure, the loss of recreative beach areas, and even the generation of proximal tsunamis that represent a risk for nearby coasts, among others. Currently the assessment of the latter in this region is mostly qualitative (i.e., descriptive) and allows basic inferences, thus it is necessary the implementation of analysis that enable a quantitative assessment of the hazard that a landslide-induced tsunami can produce and suitable for producing hazard maps. In order to develop a low-cost assessment methodology, easy to transfer to local pertinent institutions (e.g., city government), an empirical quantitative approach which works with few data input and applies verified analytic solutions in two dimensions, under a freesoftware environment and low-computational costs was chosen. These analytic solutions involve the hybridization of different methodologies and comprehend the description of hypothetic mass movements, the consequent waves in the surface and the Run-Up over the proximal coasts. Due to similar physiographic conditions on slope and beach along the delta, a simple *actualist* approach was used to translate 2D Run-Up values. In Ñirihuau Delta test area (41°4'48.19"S-71°10'42.39"W), in which ca. 70 events were morphometrically characterized, preliminary results show that in most cases, the Run-Up constitutes a hazard mainly for the coastal area. The main susceptibility was found on the river outlet. Nearby coastal streets were affected only under the worst-case scenario prediction (i.e., maximum Run-Up and maximum seasonal lacustrine level). Although hybridization methodology outputs seem reasonable so far, scarce tsunami event records in the region added to the absence of deterministic models for contrasting purposes, constitutes issues to be resolved in order to apply this first, low-cost approximation in the future.

Analysis of a short sediment core from Lago Frías, North Patagonia, Argentina

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The Andean North-Patagonia includes the central-SVZ and the Valdivia and Concepción seismotectonic segments. It is under the influence of frequent explosive eruptions, megathrust earthquakes and the Liquiñe-Ofqui-Fault-Zone activity. In order to expand the knowledge of events that affected the backarc-area, one approach is to study the lacustrine sediment record. In this case, we present preliminary results about Lago Frías sedimentary record (41°3’39.10752’’S; 71°47’56.10048’’W; 790 masl). This 80 m deep proglacial lake is distal-fed by the Frias Glacier. A 98 cm gravity core was collected at the center of the basin. Sediment characterization was performed by X-radiography, magnetic susceptibility logging, water and organic contents determination by weight-losson-ignition, and macro and microscopic components description. The core consists of a background rhythmic deposit of olive-black silt and olive-gray clay, regarded as varves based on the bibliography, and four event-deposits (base to top): (1) a 32.6 cm thick masstransport-deposit at the base (olive-gray massive mud bed with fine-pebbles, sand and disperse plant remains, poorly-laminated at the top, with a brownish-black discontinuous pyroclastic-rich sand lamina intercalated in the deposit), preliminary associated with the 1960 Valdivia earthquake (Mw=9.5); (2) a 27.3 cm massive turbidite deposit (sharp-base, fining-upward from a brownish-black pyroclastic-rich sand to light-olive-gray clay, with plant remains), dated post-1960 main shock according to the presence of white pumiceous and yellowish-brown obsidian vitroclasts associated to the 1960 Cordón-Caulle eruption; (3) a 0.8 cm turbidite bed (grayish-black fining-upward sand with plant remains) which is preliminary attributed to the 2010 Maule earthquake (Mw=8.8); (4) a 0.1 cm direct fall grayish-black ash layer assigned to 2015 Calbuco eruption. The chronology relies on the identification of this tephra layer, supported by varve counts and data from previous cores. These results contribute to the palaeoseismological knowledge of the region, further research is under development.

Event stratigraphy along Las Piedritas watershed, northern Patagonian Andes, Argentina

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Northern Patagonia is frequently affected by abundant pyroclastic fallout as a consequence of the explosive activity from the Southern Volcanic Zone. The remobilisation of this unconsolidated material throughout watersheds may lead to secondary lahars. Since lake sediments usually record the processes affecting the catchment, the information preserved in them can be useful for the long-term analysis of these phenomena. Thus, in order to assess the spatial and temporal distribution of such events, this study attempts to trace remobilised tephra deposits along Las Piedritas watershed through riverside outcrop survey and prodelta core sampling. A 46 cm-long core was taken at the mouth of Arroyo Las Piedritas into Bahía Craft (Lago Nahuel Huapi), spanning the last ~300 years. Although distinct flow deposits composed of volcaniclastic material are found at exposures along the creek, no tephra layer of secondary (reworked) origin is recognised in the core. Instead, eight tephra inter beds of primary (airfall) origin are identified and characterised. As a result, according to their petrographic features (colour, glass shard morphology and mineral association), these deposits are correlated to different eruptive centres and, based on the estimated sedimentation rate, matched to reported historical eruptions when possible. The oldest tephra, identified at the base of the core, is tentatively associated with the eruptive activity from Volcán Osorno. Several ashfall layers are attributed to eruptions of the Cordón Caulle, including the 1960 and 2011 eruptions. Also, three Calbuco sourced tephras are correlated to the 1917, 1929 and 2015 eruptive events. The lack of reworked volcaniclastic deposits in the core may be explained by the presence of a wet meadow in the delta plain, which would be working as a sediment sink. Work is underway to retrieve cores from this wet meadow and other prodelta environments for reconstructing the magnitude and recurrence patterns of secondary lahars affecting the region.

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Sensitive high-altitude aquatic ecosystems on mountains and plateaux

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The REPLIM Network: monitoring and paleolimnology to assess past global changes in the Pyrenees

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The REPLIM network was established in 2017 to monitor lakes and peatlands in the Pyrenean Mountains and to serve as an observatory of the impacts of climate change and human activities on high mountain ecosystems (http://www.ipe.csic.es/proyecto-replim). In selected lakes, annual sediment and water surveys are conducted and temperature is measured hourly at several depths and the depositional evolution is reconstructed with multiproxy paleolimnological analyses. The information is summarized in the Pyrenean Observatory of Climate Change (OPCC) geoportal (https://opcc-ctp.org/es/geoportal). The annual thermal regimes from the southern central Pyrenees sites showed higher surface water temperatures, greater in summer and especially in autumn, and shorter ice-covered periods. The paleolimnological studies identified rapid and abrupt changes, particularly an increase in Total Organic Carbon and lithogenic fluxes at the end of the Little Ice Age (LIA) (ca. 1850 CE) and since the mid to late 20th century, correlating with the warming post LIA and the onset of the recent temperature increase (0.2^{o}C/decade since 1950). Higher TOC_{flux} and geochemical (lower $\delta^{13}C_{bulk}$ and C/N) and biological (diatom assemblages) signatures since 1950 CE suggest an increase in algal productivity, likely favored by warmer temperatures and higher global nutrient deposition. Recent lithogenic fluxes increase after the Great Acceleration (1950 CE) could be related to higher erodibility by rainfall and run-off during the longer snow-free season in the Pyrenees. The recent, unprecedented changes in the lakes identified by paleolimnological analyses demonstrates the regional impact of the Great Acceleration not only in the ecological dynamics of alpine lakes but also in the hydrological cycle in high altitude mountain watersheds. The REPLIM network approach may serve as an example for larger networks such as the PALEOLINGLOBAL, including lakes from different regions and biomes to better understand changes at a global scale.

How climate changes affect Daphnia population in a dystrophic mountain lake – a stable isotope record

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Stable isotope records of organic carbon and nitrogen give us an opportunity to look at how water organisms react to environmental stress and help to identify stressing factors. Here we present data on $\delta^{13}C$ and $\delta^{15}N$ in ephippia of *Daphnia* picked-up from 50 cm long sediment core of a dystrophic lake located in the Tatra Mountains (Carpathians, Central Europe). *Daphnia* ephippia had an average $\delta^{13}C$ and $\delta^{15}N$ values of -34.4‰ (s.d. ± 1.7‰) and 0.96‰ (s.d. ± 0.84‰), which are significantly different from values for bulk sediment (-28.16 ± 1.19‰ and -0.04 ± 0.76‰, respectively). The carbon isotopic record in *Daphnia* ephippia followed climate changes over the last 1000 yrs. The highest values of $\delta^{13}C$ were recorded during the Little Ice Age (LIA) period, while there was a continuous drift to lower $\delta^{13}C$ values during the 20th century. Similar trend was observed for bulk sediment $\delta^{13}C$. The nitrogen isotopic record of *Daphnia* also, in general, followed that for bulk sediment, but was not so clearly related to climatic events. The $\delta^{15}N$ was ~0‰ with some excursion to higher values (~3‰) during the Medieval Warm Period and LIA until the 1960s. Then, a decreasing trend in $\delta^{15}N$ has been started, but still some fluctuations from this general pattern to higher values were observed. These excursions to higher $\delta^{15}N$ values, especially if correlated with increases in $\delta^{13}C$ (e.g. in 1960 and in the middle of the 19th century), represents presumably short-lasting shifts in *Daphnia* diet from detritus-dominated to algae-dominated. On the other hand, the recent decline in $\delta^{15}N$ might indicate a higher proportion of nitrogen-fixing bacteria in *Daphnia* diet.

Lacustrine infill indicate heterochronous deglaciation of the Tatra Mts. Lakes (Slovakia)

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The deglaciation of the Tatra Mts. led to the development of lakes in glacial cirques, trough over-deepening, and various morainic and inter-morainic depressions. Generally, two different limnic litho-stratigraphic sections with discrete boundary were recognized, but a paleolimnological investigation of eleven lakes on the Slovak side of the Tatra Mts. explored the high facial and age variability of the infill attaining the thickness from 0.75 m up to more than 11 m. Glacigene deposits of unknown thickness and occasionally rocky bedrock formed the lake bottom on which fine laminated varves reflecting annual glacier melting were deposited. The age of the oldest varves reached ~17,700 cal yr BP and the youngest varves were dated from 14,700 cal yr BP to ~9,800 cal yr BP. Gyttja with dispersed clayey to sandy grains lays on glacigene deposits and varves or occurs as single lake infill deposited on the bedrock. Oldest gyttja were dated back to ~13,800 cal yr BP, but the beginning of organic deposition varies among the lakes and reflect more the local sedimentary conditions. As a termination of varve deposition is heterochronous among the lakes, we suppose the deglaciation was a heterochronous process in the Tatras.Acknowledgement: This work was financially supported by the project APVV-15-0292 and VEGA2/0163/21.

Heterocypris schwalbi n. sp. a high altitude asexual microcrustacean ostracod from Nam Co, Tibetan Plateau

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The Tibetan Plateau has the highest altitudes on the planet (> 4500 m a.s.l.). Its extreme temperature (-16 °C in January) and precipitation conditions (100 mm/year) caused the aquatic animals that inhabit this area to specialize and form resistance strategies to survive. Ostracods are microcrustaceans and an important part of the biodiversity of the aquatic ecosystems of the Tibetan Plateau. In recent decades, the number of identified species has increased from 30 to 89. Its large area (~2.5 million km^2), which includes several thousand aquatic systems such as ephemeral pools, springs, rivers and lakes, has probably not been fully documented in terms of ostracod diversity. In September 2019, a surface sediment sample was collected from a temporary pond near Nam Co, in the center of the Tibetan Plateau. A new species was identified: *Heterocypris schwalbi* n. sp. The complete ontogeny was recorded, eight juvenile stages and one adult. Furthermore, our study includes a morphological comparison with congeneric species, *Heterocypris incongruens* and *H. salina* (from Germany) which were also recorded in previous studies on the Tibetan Plateau. Regarding the sizes, *H. schwalbi* presented intermediate measures of length (1146 µm) and height (638 µm) of the carapace, contrasting *H. salina* (l= 1044 µm; h= 641 µm) and *H. incongruens* (l= 1355 µm, h= 769 µm). Considering the soft parts, such as the female genital lobes, it was possible to differentiate *H. schwalbi* from *H. incongruens* and *H. salina*. Likewise, *H. schwalbi* was recognized to reproduce asexually, similar to congeneric species, and we observed that the eggs have three embryonic layers that probably protect ostracods under stress conditions such as drought and low temperatures. These findings highlight 1) the importance of using the female lobes as a characteristical feature to differentiate those morphologically-close and asexual species, and 2) the role of eggs as resistance structures in extreme environments.

Chironomid (Insecta: Chironomidae) responses to hydrological changes during the Current Warm Period in Nam Co, Tibetan Plateau

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The recent rise in air temperatures detected at high-altitudes of the Tibetan Plateau accelerates glacier melt and retreat. Moreover, monsoonal precipitation has increased runoff and transport of allochthonous material to the lakes. Consequently, water levels are rising, modifying the spatial distribution and composition of local aquatic biota. In order to infer these environmental and biological changes during the last ~ 160 years, a 30-cm long sediment core from an endorheic lake in Tibet, Nam Co, was recovered and analyzed for subfossil chironomid assemblages and sediment geochemistry. In total, 25 chironomid morphotypes were identified. Nineteen were considered as non-rare taxa (abundances > 2 %) and six as rare taxa (abundances < 2 %). Around 1960 CE, higher chironomid richness (n = 19) and Shannon index diversity (H = 1.6) are evident compared to the previous period from 1861 to 1960 CE (n = 15, H = 1.2). Since 1960 CE, the simultaneous decrease of profundal *Micropsectra radialis*-type abundances and increase of *Chironomus* and *Procladius*, both taxa adapted to more eurytopic and slightly warmer water bodies, indicate increasing temperatures and intensified primary productivity. The dominance of littoral chironomid assemblages recorded at the same time, reflects increasing lake water level, flooded shorelines and expansion of littoral areas as a result of high precipitation and/or glacial melting as a result of the increase of temperature. This is confirmed by the increases in total nitrogen and Zr/Rb ratio, indicating high trophic state and coarser grain size due to increased fluvial activity. The progressive increase in lake water levels has caused the expansion of littoral habitats where the increase of nutrients in the lake are associated to the time of high runoff from the Niya Qu River. These hydrological changes result in a positive water balance that can be linked to changes in the atmospheric circulation (i.e. Asian Summer Monsoon) and glacier dynamics which, in turn, are reflecting increasing temperatures and precipitation since the beginning of the 20th century.

Changes in moisture availability and weathering intensity recorded in Tibetan Plateau lakes by rare earth elements in ostracod shells

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Long-term variations in strength and extent of the Asian monsoon system are reconstructed using a novel set of ostracod shell chemistry proxies from two lakes on the southern Tibetan Plateau, Nam Co and Tangra Yumco. The sediment records covering the past 18 cal. ka BP demonstrate the suitability of rare earth elements (REE) as indicators of weathering intensity and thus changes in hydrology and moisture sources. In Nam Co, high concentrations of heavy REEs during the late glacial are indicative of groundwater inflow, while very low concentrations in light REEs show that hardly any weathered material was entering the lake, indicating ice coverage and frozen ground. High concentrations of light REEs between 14 and 13 cal. ka BP suggest an increased drainage from the glaciated mountains south of the lake, pointing to meltwater input. Other trace elements, such as Mg/Ca, Sr/Ca and Ba/Ca ratios, reflect salinity and changes in effective moisture, but are also controlled by changes in carbonate mineral precipitation. Synchronous or asynchronous behavior in Mg/Ca, Sr/Ca and Ba/Ca allow, for example, identification of low-Mg/Ca warm-wet conditions (calcite precipitation), or high-Mg/Ca cold-dry conditions (monohydrocalcite precipitation). Furthermore, Fe/Ca, Mn/Ca and U/Ca ratios in ostracods reflect changes in oxygen saturation in lake bottom waters controlled by water level and microbial activity. Both paleoclimate records show similarities during most of the late Quaternary. Two major dry periods were identified, coinciding with the Heinrich 1 and the Younger Dryas stadials, followed by increasing Indian summer monsoon (ISM) precipitation. A moisture maximum occurred during the early Holocene, suggesting abundant water supply by the ISM. A shift to dry conditions and decreasing lake levels occurred at 2.6 cal. ka BP at Tangra Yumco, and 600 years later at Nam Co, resulting from a weakened ISM intensity due to a southeastward migration of the ISM-Westerly boundary.

Physical and chemical variability as a structuring factor of the diversity in plankton and benthos of Salares of the Andean Altiplano

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The Ascotán and Carcote salt flats correspond to two close evaporitic basins located at 3700 m.a.s.l. in Southern Andean Altiplano. Are fragile environments with a great importance for biological conservation. These salt flats have shown differences in their recent histories, especially associated with the extraction of borates for a long time in the Salar de Ascotán. Being able to determine differences between both salt flats, in the taxonomic composition and in diversity indices, is essential to know the current state considering anthropic threats typical of mining activity and climate change. A field work was conducted in which water physical and chemical parameters were measured in situ and samples were obtained for quantifying the elemental composition, in addition to a biological sampling of phytoplankton, zooplankton, benthic macroinvertebrates (MIB) and zoobenthos. With the taxonomic information, diversity indices were estimated, and the relation of between measured environmental variables. The results obtained show a difference in the physico-chemical composition between both salt flats, Carcote has a greater salinity and concentration of dissolved ions. Phytoplankton was the biological component that showed the greatest differentiation between both salt flats, and Carcote reaches a greater diversity values than Ascotán. The MIB presented differences between both salt flats in the community composition. In the Andean salt flats, the large amount of minerals in these environments makes it impossible to identify a single variable as structuring the communities. From the results obtained we can state that there is a positive association between diversity and salinity for some groups. Nevertheless, the ecological aquatic communities are strongly structured by the interaction of multifactorial composition, sensitive attributes to water availability and water-scape changes.

Plankton communities under water level fluctuations in two lakes of the arid Patagonia

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This study focused on the analysis of the limnological changes associated to water level fluctuations in two shallow lakes (Cervecero and Chapu) of the Buenos Aires plateau, and the effects on their planktonic communities. In 2015, both lakes were in a clearvegetated state, being more suitable for waterbird nesting. In 2016, the water level dropped by half (approx. 1m), in 2017 lakes dried completed, and next year, lakes were filled again due to winter snowfall. Environmental and plankton samples were collected in three summer campaigns (2015, 2016 and 2018) to answer, "how lakes change their abiotic characteristics and their planktonic communities with interannual hydrological variations". Phyto- and zooplankton were analyzed by microscopy, while picoplankton assemblages were studied by flow cytometry and high-throughput sequencing. Principal component analysis ordinated samples of 2016 towards higher values of dissolved organic carbon, total nutrients, and conductivity, compared to samples of 2015 and 2018. In 2015 and 2016, both lakes showed similar patterns of bacteria, the most abundant phyla were Proteobacteria and Bacteroidota. However, both lakes showed higher bacteria concentrations in 2016 than 2015. In 2018, Chapu presented 96% of Proteobacteria, while Cervecero showed 52% of Verrucomicrobiota. Photosynthetic picoplankton showed the highest concentration in 2018 dominating phycocyanin-rich picocyanobacterial in both lakes. Regarding phytoplankton, both lakes showed high diversity groups in 2015. In 2016, diatoms and chlorophytes dominated in Chapu and chlorophytes dominated in Cervecero. In 2018, chlorophytes dominated in Chapu and the cyanobacteria *Dolichospermum flos-aque* developed a bloom in Cervecero. Zooplankton also showed interannual variations in both lakes; particularly in 2018, *Keratella kostei* dominated in Cervecero, while in Chapu the groups were even. This study revealed a differential response of the planktonic communities of the lakes to an abrupt interannual hydrological shift, that may have implications for conservation of these ecosystems.

Geochemistry of a high-altitude hypersaline Andean lake and associated carbonate deposits (Laguna del Peinado, Southern Puna Plateau, NW Argentina)

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The Puna Plateau hosts numerous lakes that are very sensitive to fluctuations in water balance. Laguna del Peinado is a hypersaline lacustrine system located at 3760 m a.s.l. in the Southern Puna of Argentina where wide scale carbonates precipitation occurs. These carbonates comprise a variety of facies including the largest microbialite system in this region and provide promising sensors for studying recent and past environmental and hydrological changes. However, a better understanding of the geochemistry of the contemporary lacustrine system as well as the carbonate formation within is imperative for further application of geochemical proxies and robust reconstructions. To resolve this, we investigated the coupled brine-carbonate chemistry using petrographic (SEM, XRD) and geochemical tools (δ^2H, $\delta^{18}O$, $\delta^{13}C$, $\delta^{11}B$, major and minor ion composition), as well as aqueous chemistry modelling (PHREEQC). We found that the main source of water to Laguna del Peinado are hydrothermal springs linked to old meteoric water, which in combination with strong evaporation create distinctive hydro-chemical sub-environments where microbialites (travertines, microbial mounds, microbial mats) and fine-grained calcite mineral precipitates form. In the hot springs, $CaCO_3$ precipitation is triggered by a shift in carbonate equilibrium by hydrothermal CO_2 degassing and microbially-driven elevation of local pH at crystallisation. In the Laguna del Peinado lake, $CaCO_3$ precipitation is induced by evaporative supersaturation, CO_2 degassing and microbiological processes under apparent equilibrium conditions with the carbonates largely recording the evaporitic enrichment of the parent water. This study provides a detailed account of the hydro-chemistry and functioning of the Laguna del Peinado system, illuminates the intricate processes that drive carbonate formation in a volcanic basin, and contributes to the discussion of fractionation and partitioning of key isotopes and elements in a well-constrained natural brine-carbonate laboratory, with implications for paleoenvironmental and paleoclimatic studies.

Neoentomology of the temporal and permanent lagoon systems of the Sierra Nevada del Cocuy, Cordillera Oriental, northern Andes, Colombia

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The northern Andes has a complex evolution history associated mainly to the lifting of the mountain range system itself, as well as to climate conditions at the global, regional and local levels. The Sierra Nevada del Cocuy (SNC) is located in the eastern Cordillera of Colombia with peaks ca. 5500 masl. Elucidating the paleoclimatic and paleoenvironmental history of this system is a key to understanding the current cycles associated with global climate and environmental change. To do this it is not enough a single proxy line, e.g., geomorphology, isotope geology, palynology, paleoglaciology, and related sciences. The current insects and those preserved in the sediments from ancient lagoon systems, indeed offers an interesting opportunity to generate paleoenvironmental data. In this research is shown the taxonomic composition and altitudinal distribution of macroinvertebrates, and of the aquatic and surrounding vegetation of the lagoon systems. It was sampled with a benthos net, 21 lakes located between 3830 and 5490 masl. It was settled down and discriminated shallow-temporary water bodies from superpáramo zone recently formed at the Little Ice Age (LIA) limit, semi-permanent water bodies with a high sedimentation degree, and the permanent ones in the low zones. The taxonomic composition of macroinvertebrates is represented by six phyla, ten orders and twenty five families. According to the seriation of the organisms, it is proposed a gradient of climatic altitude, being Eremaidae, Chydoridae and Chironomidae from superpáramo lakes, Elmidae, Ceratopogonidae and Tanypodinae from the páramo lagoons, and Odonata from the subpáramo zone. In the physionomy and composition of the aquatic vegetation, dominate the families Poaceae, Cyperaceae, Juncaceae, Caryophyllaceae, Bryophytes, Pteridophytes, and Asteraceae in the earthen places. The neoentomology of lagoon systems of the SNC, correspond to the paleoentomological groups found in the peat bogs of the old lagoon complexes of the páramo del Sol in Urrao, Antioquia from the Late Glacial 18 000 yr BP.

Volcanism drives fire regimes in a high Andean lake during the last 1400 years (Laguna Nieblas 36ºS).

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Fire regimes in central Chile are strongly influenced by both climatic and cultural factors. However, few case studies assess these factors which further integrate socio-ecological systems from a long-term perspective. In this context, lacustrine sedimentary records allow fire regimes based on macrocharcoal are also remarkably scarce, adding to our lack of understanding of past fire dynamics for different areas of central Chile. In this study, we reconstruct the fire dynamics and examine their possible climatic and cultural associations using a short sedimentary core from a high Andean lake of the Maule region (Laguna Nieblas; 36ºS). For this, we obtained a macrocharcoal and biomarker (fecal sterols) as proxy for past human population size. Four large peaks in macrocharcoal occur right after the deposition of tephra layers at c. 1000, 850, 700 and 21 cal yrs BP. The earliest of these corresponds to the largest peak in the sequence (c. 1000 cal yrs BP), whereas the second largest event, which occurred right after the well-known Quizapú eruption (1932 CE), one of the largest eruptions recorded in Chile. The remaining two macrocharcoal peaks were much lower in magnitude. Fecal sterols remain very low throughout the entire record, implying that this ecosystem had scarce human influence during the prehistoric and Colonial-Republican periods. Archaeological sites in the area have been linked mostly with seasonal usage and quarries and none of these provide evidence for long-term stays or cultural activities involving large population pressures on this ecosystem. An increase in epicosprostanol/coprostanol since the beginning of the 20th century is probably associated with an intensification of summer grazing activities in the area. The frequency of fires rises sharply from this time to the present, providing a contrasting and differing view of low frequency of fires at pre-Hispanic times.

Spatiotemporal evolution of High Andean waterbodies in the innertropics explained by morphological parameters

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Paramo high elevation ecosystems harbor abundant and diverse water bodies, including lakes and different wetlands types. Those lentic ecosystems provide various ecosystem services, including water supply, hydrological regulation, carbon storage, and conservation of livelihoods and biodiversity. Determine the spatiotemporal evolution of the water system is essential to understand the hydrological dynamics and connections between water bodies within a mountain basin. The aim of the study is to study the monthly fluctuation of the flooded area and analyze spatially wetland location, floodable behavior and relate this to morphological parameters. Based on Sentinel-1 SAR imagery we reconstruct the evolution of flooded areas using Otsu classification method for 2016-2021 period. Thus, we find that the flooded area does not show marked seasonal behavior or decreasing trend. However, the study area experiments weak flood pulses that match with higher precipitation months. These results match with the hydrological behavior of this ecosystem due to its pedological capacity to maintain a constant subsurface flow that feeds wetlands even in precipitation absence. On their side, spatial analysis of the study finds that the mean frequency of flooding time of wetlands in each basin varies between 30.49% and 88.32% during the study period. Likewise, the basin covered by floodable lands varies from 0.6 to 42.6% of the total basin area. A principal component analysis shows relationships between wetlands indicators (flooding frequency and wetland area) with morphological variables (mean slope, area, perimeter, circularity ratio, altitude, and flow accumulation). The result shows how wetlands with higher hydroperiods, bigger areas, and spatially homogenized are positively correlated with altitude and flow accumulation; and are negatively correlated with slope. The interpretation of the results is related to hydrological phenomena such as orographic precipitation and the role of slope on water flow to explain the importance of altitude and slope in wetland formation.

Modeling complexity and chaos in the high andean mountain: GIS, Big Data and AI applied to climate variability

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Due to the complexity and many variables that influence climate variability in high andean mountain landscapes, many unanswered questions and methodological proposals currently arise which attempt to offer new explanatory alternatives to this modern important challenge: ¿How could factors such as the geography, geomorphology, climatology and astronomy, among others, be considered and integrated into this important scientific discussion?, ¿how different are climate cycles in different regions and latitudes worldwide?, ¿how many climate cycles were there and what was their intensity?, ¿were the traces left by the different glaciations or glacial events erased or superimposed?, ¿how long will the remaining glaciers last in the tropical andean countries?. There are many of these kinds of questions waiting to be answered. Precisely to advance in this need for studying and modeling climate change in tropical glaciers in the northern andean, it is proposed a integration of geographic information systems (GIS), Big Data, artificial intelligence (AI), wavelets, and some of the latest generation tools which have being applied here in order to advance in this direction. PaleoELAs were found by three different methods, for eight glaciers in the study area, and two glacial events, which allows us to better understand and quantify the magnitude; likewise, another methodology is proposed to build a spatial database that allows inventorying, storing, monitoring and analyzing glaciological and environmental data associated with Climate Change; and finally, pattern recognition, mapping, and characterization of tropical glaciers are analyzed. These results are an initial contribution to fill the gap about andean tropical glaciers research.

Paleoclimatic and paleoenvironmental changes in the Lagunas de Vilama lake System (Argentinean Altiplano-Puna Plateau, 22°S): The Medieval Climatic Anomaly and the Little Ice Age in the high Andes

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The Lagunas de Vilama System (4500 m a.s.l; Central Andes) hosts several shallow lakes, which are very sensitive to climate change. The aim of this research is to analyze the climatic and environmental conditions during the last millennium for this region. To address this, we performed sedimentological, geochemical and palynological analyses of the lacustrine record of Lake Pululos. The geochronological framework was defined by combining ^{14}C and ^{210}Pb ages through a Bayesian analysis, obtaining a high-resolution age-depth model for the last 1300 years. The results indicate a period with extreme droughts (AD 720-895) before the Medieval Climatic Anomaly (MCA), characterized by a saline-hypersaline lake and the development of halophytic plant communities (Amaranthaceae-Chenopodiaceae). During the MCA (AD 895-1110), the record suggests slightly wetter conditions with a saline lake and marsh vegetation. In AD 1110, an abrupt shift to wetter conditions occurred that continued with significant fluctuations until AD 1880. From this period, a wet MCA-Little Ice Age (LIA) transition-stage stands out between AD 1110 and 1270, characterized by high lake-levels with freshwater vegetation and macrophytes (*Zanichellia, Potamogeton, Myriophyllum*). Afterwards, the LIA was established with a dry-phase (AD 1270-1500) marked by a decrease in lake-levels and the presence freshwater vegetation. This was followed by the establishment of a wet-phase of the LIA between AD 1500 and 1880, characterized by an oligotrophic to eutrophic lake. Between AD 1880 and -2017, the record reflects high lake-levels corresponding to the Current Warm Period. However, from 2009 onwards the record shows a change in climatological and environmental conditions towards a decrease in lake-levels, which would reflect the current negative trend of precipitation in the region. These results provide novel data for the Altiplano-Puna Plateau and highlight the potential of Andean lakes to unravel the mechanisms of past changes in the atmospheric circulation of the Central Andes.

High-Andean paleoenvironmental dynamics in the Central Andes of Argentina (35°S) during the last 2700 yrs

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The last IPCC climatic report points out the Central Andes of Argentina (32°-35°S) as one of those areas that have been experimenting a strong trend towards more arid conditions. A significant decrease of winter precipitation on the Andes, source of water for socioeconomic activities of central-western Argentina, is the most evident effect. At present, whether this scenario is part of the natural climatic variability is difficult to determine given the lack of proper local paleo-records. The present study aims to reconstruct the paleoenvironmental dynamics of the Central Andes of Argentina (35°S) at centennial/sub-centennial scale by analyzing the pollen record of Laguna Corazón (LCO), a high-Andean close lake, encompassing the last 2700 yrs BP. Naked-eye description, RX radiographs, Loss on Ignition, and pollen analysis were performed on the 1.8-meter long sediment core of LCO. The sedimentary record is mostly composed of dark-brown laminated silts and presents a volcanic ash layer at 21-24cm depth that according to the chronological control could be attributed to the 1932 Quizapu eruption. The pollen record is dominated of Poaceae associated with pollen types of shrubs like *Senecio*, *Baccharis*, *Ephedra*, Euphorbiaceae, *Leucheria/Nassauvia* and dwarf shrubs such as *Acaena*, *Mulinum* and *Oreopolus* type. Thus, the record reflects the development of a grass steppe with three major changes at ca. 1800, 1100 and 300 yrs BP associated with changes in the accompanying shrubs and dwarf shrubs. Exotic pollen as well as *Spormiella* spores are present in the last 100 yrs pointing out the colonization of the area and its seasonal use for cattle breeding. These changes imply more humid conditions than present between 2700-1100 cal yrs BP followed by a decrease in moisture up to 300 cal yrs BP when similar than present conditions established but under a high environmental variability. FONDECYT #1180413; SIIP 2019- 06/A711; PICT 2019-3426.

Mid-Holocene environmental dynamics of the subtropical Andes (33°S)

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The subtropical Andes (32°-35°S) are one of those areas in the world that has been experimenting a strong trend to more arid conditions as the result of increased temperatures and a reduction in (winter) precipitation due to the ongoing climate change. The scarce long-term records in the Andes located southwards and in the western lowlands point out that this region experimented widespread and extreme arid conditions during the Middle Holocene. Hence, studying the high Andean environment response to such conditions in the past would provide some clues to face the future scenarios in this region. Thus, this paper aims to reconstruct the environmental dynamics of the subtropical Andes at centennial time scale based on the pollen record of Laguna Chepical (LCH; 3100 masl, 33°S). Naked-eye description, RX radiographs, Loss on Ignition and pollen analysis were performed on the 130cm long sediment core of LCH. The sedimentary record presents gray clays at the base (260-240cm) followed by inorganic gytjja (240-190cm) and organic gytjja (190-130cm). The LCH pollen record reflects that a periglacial environment with Sub-Andean and Low Andean vegetation occurred between 7800-7400 cal yrs BP followed by a dominance of Low Andean vegetation dominance in a post-periglacial environment with variable lake levels until 6200 cal yrs BP. A drastic decrease of pollen types of Low Andean vegetation along with a drop of azonal pollen types point out the driest period between 6200-4800 cal yrs BP followed by a gradual rise of moisture reflected by the increase (decrease) of Low (Sub-) Andean pollen types until 3200 cal yrs BP. As a result, the LCH record indicate that drier-than-present conditions occurred in the subtropical Andes (33°S) during the Middle Holocene and that zonal and azonal vegetation effectively responded to such centennial scale changes.
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Extreme climates, extreme habitats: a paleoecological study in Lake EL Sello (-46.9234º, -71.3374º), the volcanic Buenos Aires Plateau, southern Patagonia

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The Buenos Aires Plateau (Santa Cruz, Argentina) is a bed of alkaline basalt formed during tectonic episodes in the Miocene-Pliocene periods. It covers an area of 3650 km^2 holding more than 150 endorheic shallow lakes, highly exposed to the westerlies winds. During the last years, several lakes have suffered substantial water level reduction with negative consequences on the aquatic communities. Example of this is the shallow lake El Sello (-46.9234º, -71.3374º, 1466 m asl), the largest lake of this plateau. In the last 38 years, it was observed a reduction of the area lake by 52%, associated with the decrease in rainfall. We present preliminary data obtained from analyzing a 50 cm sediment core of El Sello lake aimed to make the first inferences on the recent past environmental conditions in the area. From the core analysis we detected 5 tephra levels (1, 8, 23-27, 43 cm) along the core. At the moment, the remains bioproxies recovered were ephippias, cladocerans (*Chydorus*), testate amoebas (*Diffulgia oblonga*), chironomids (*Cricotopus*) and oogoniums (*Chara*). This is a first attempt to develop a palaeoecological study in these basaltic patagonian plateaux. We expect to find changes in the biota assemblage related to the extreme climate conditions of the area which let integrate with environment and climatic events in Patagonia.

Paleoecological development at centennial-scale inferred from bio-proxy records in the biosphere reserve of Yungas (NW, Argentina)

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In order to contribute evidence about the paleoecological development of the biosphere reserve of the Yungas in the Eastern Cordillera of NW Argentina, we have conducted a bioproxy analysis from a 5 m long sediment core retrieved in Laguna Comedero (24°06'54.7" S - 65°29'7.2" W, 2,035 m asl). We present the first results from the pollen, spores and diatom dataset spanning the last *ca*. 1300 yrs. The preliminary chronological framework (^{14}C) and the zonation of fossil sequences allow us to distinguish different seral stages. Before 670 cal AD, a very low concentration of palynomorphs and the absence of diatom remains suggest low humidity conditions with sparse vegetation and reduced water level. Between *ca.* 810 and 1350 cal AD, an ecesis process probably occurred with the establishment of xerosere communities (e.g. montane grassland) in more humid conditions. These changes are based on a noticeable increase of the pollen richness. Poaceae pollen dominated in association with saxicolous plants and fern spores of semiarid environments. Also, pollen of macrophytes appears and a group of small epiphytic araphid diatoms dominate the diatom assemblages. From *ca*. 1470 to 1760 cal AD human activity might have caused structural changes in the landscape. Poaceae pollen decreased whereas pollen from shrub and grazing indicator plants increased. In the lake, benthic diatoms from well-developed littoral environments suggest that the water level remained high. From *ca*. 1850 cal AD to the present, the grassland was replaced by a woodland habitat accompanied by the progressive eutrophication of the lake. Pollen concentration of the current tree species increased. This reconstruction provides valuable information on natural and anthropogenic changes at centennial scales and can be useful to the management of this protected area.

Late Quaternary paleoclimatic implications of subtropical Andean lake pollen records (30-34°S)

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Subtropical regions are characterized by being relatively arid environments compared to other zones, such as tropical or temperate zones, so the availability of lakes to take proper sedimentary records is comparatively scarce. The subtropical region of Chile is no an exception and moreover, it is a highly sensitive region to current and past climate changes since it is located on the northern edge of the southern Westerly Winds Belt. In order to establish the past environmental changes in the subtropical zone of Chile, we have analyzed more than 10 pollen records from lakes in the subtropical Andes (30-34°S), many of them with basal ages around 4000-5000 cal. years BP and other spanning the last 15,000 cal. years BP. The analyzed records covering the entire Holocene show two distinct pollen patterns with a latitudinal trend. Thus, the sites located northwards (30-32°S) show the most arid phase of the Holocene around 8000-6000 cal. years BP and the most humid phase starting at 2000 years BP. On the other hand, those records located to the south (33°-35°S) show the most arid phase of the Holocene between 10,000-7000 years BP and the beginning of the most humid phase around 3000 years BP, even beginning at 4000 years BP, in the southernmost part. We hypothesized that the different latitudinal patterns could be due to a greater influence of exclusively winter rains in the northern part, compared to the records from the south, which could have the influence of rainfall year long. Otherwise, the temperature could be playing a more determining role than expected controlling the altitudinal changes of the vegetation belts in some of the records. Acknowledgements: FONDECYT 1180413; 1220203; ANID – Programa Iniciativa Científica Milenio – NCN19_153; Concurso de Fortalecimiento al Desarrollo Científico de Centros Regionales 2020-R20F0008-CEAZA

Holocene paleohydrological reconstruction in a high-altitude periglacial basin (Central Andes): a joint paleolimnological-geomorphological view

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High-altitude wetlands and rock glaciers correspond to exceptional climate-sensitive archives occupying the current periglacial areas from the Central Andes. In this study, we analyze the sedimentary record of the Laguna Leoneajo wetland (22°S/65°W at 4526 m a.s.l), which is located in a small-periglacial basin at the Santa Victoria range of Northwestern Argentina. The Laguna Leoneajo wetland is situated in a glacial valley, downstream of an active and relict rock glacier. Robust radiocarbon dating, geochemical and physical data from a composite sedimentary core, reaching the lake basement, comprise the record of the lake-environmental history since the last deglaciation, and document the hydrological changes occurred during the last 15,000 years. Complementary geomorphological analysis and the monitoring of the rock glacier activity located upstream of the Laguna Leoneajo wetland, are combined with the paleolimnological data in order to reconstruct the evolution of this periglacial basin. The beginning of the lake record, the time of formation of the present-day relict rock glacier and its collapse, and their connection with major climate changes occurred in the Central Andes, as well as the equilibrium (or not) of the periglacial landforms with the current climate conditions are the main topics discussed along this work. Outcomes of this research provide essential hydrological and environmental knowledge to a region which is largely fresh-water-restricted and thus, fragile under a climate warming scenario.

Monitoring lakes and wetlands in the Colombian High Andes

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The Institute of Hydrology, Meteorology and Environmental Studies - IDEAM is an entity of the Colombian State, dedicated to the scientific and technical support to the environment sector that carries out technical-scientific research on natural resources and ecosystems, including the high Andean ones. Considering that 3.6% of the continental territory of Colombia is high mountains and the large population that benefits from these ecosystem services, IDEAM has prioritized conducting research and implementing monitoring processes in these areas. Since 1996, IDEAM has led the monitoring of main glaciers in Colombia, and found that two (Tolima and Santa Isabel) of the six glaciers present in the country are at high risk of disappearing due to the effects of climate change. Additionally, since 2007, hydrometeorological and carbon cycle monitoring have been carried out in high mountain ecosystems, with emphasis on carbon flows and stocks in vegetation and soils of the moors and high Andean forests, as well as measuring greenhouse gasses mainly CO_2 and methane in high mountain wetlands. This monitoring has been carried out uninterruptedly in two protected areas in the country, and the data show that the ecosystems that are part of the PNN Chingaza retain more carbon than those found in the PNN Los Nevados, a site where CO2 and methane emissions in the peatlands are also lower. Another site of particularly importance for the country is the Lake Tota Basin, where future dry and humid scenarios for 2030 show a decrease in the lake volume and the surface area and new monitoring protocols have been implemented, including citizens and institutions.

IAL IPA 2022

FOCUS SESSION 17

Linking Land and Water: Paleolimnological Reconstructions connecting Land Use with Limnological Change

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Pre-Colonial and Colonial landscape disturbance recorded in Laguna Sausacocha, Peru

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In the Andes, the nature and magnitude of pre-Colonial landscape disturbance is often ill-defined, making it difficult to place historic disturbances into an appropriate context. Here we present a record from Laguna Sausacocha in the Cordillera Occidental of Peru. The lake is an important freshwater resource but is located in a region of intense mineral resource exploitation. Archaeological evidence suggests that people have been living around the lake for millennia, but the impact of their settlement on the landscape is unknown. Using magnetic susceptibility, losson-ignition, elemental composition, and direct mercury analysis, we aim to reconstruct lake conditions prior to disturbance as well as periods of land use and attendant lake impacts. We find that the sediment is characterized by three major depositional units: an early one dominated by terrigenous sediments; a middle one dominated by organic-rich sediments; and a terminal one dominated again by terrigenous sediments. Pending the development of an age model, we provisionally interpret these as the early establishment of the lake in a glacial/neoglacial setting, a long period of relative lake level stability, and a subsequent period marked by anthropogenic erosion in the area around the lake. We hypothesize that different land use regimes during various historical periods are tailored to the environmental conditions of the region, resulting in different degrees of disturbance.

Holocene lake phosphorus species and primary producers reflect catchment processes in a small, temperate lake

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In this paleolimnological study we investigated how natural processes and anthropogenic land-use changes affected sediment phosphorus (P) forms and primary producers in small, temperate Lake Fuglsø (Denmark) throughout the Holocene. Our multi-proxy approach used pollen, X-ray fluorescence scanning, carbon (C) and nitrogen concentrations and stable isotopes, sequential P extraction, pigments, diatoms, and plant macrofossils from a ^{14}C-dated sediment record. We found three periods of human impact: (1) low disturbance from domestic grazing during the early/mid Neolithic (~3600 to ~2600 BC), (2) higher disturbance because of animal husbandry and some grain cultivation during the Late Bronze and Pre-Roman Iron Age (~800 BC to AD ~100), and (3) strong disturbance caused by domestic grazing, intensified crop cultivation and, in particular, by retting of fiber plants during the Middle Ages and Renaissance (AD ~1000 to ~1700). Cultural eutrophication during the latter phase caused unprecedented changes in the lake, including altered species composition, high production, and strongly accelerated sediment accumulation rates. Generally, catchment deforestation was related to elevated proportions of metal (iron, aluminum, calcium)-bound P forms in the sediment, whereas high tree cover correlated with elevated proportions of P forms associated with organic material ("organic" P, humic-bound P, refractory organic P) and loosely bound P. During phases with forest in the catchment, silicon (Si) inputs to the lake were insufficient and diatom frustules were mostly absent in the sediments. In contrast, diatoms thrived in the lake when the landscape was open and erosional Si influx was high. This study is a good example of the tight links between catchment processes and lake status. Furthermore, our data show that human activities have shaped landscapes and impacted aquatic systems substantially for millennia, i.e., long before the Great Acceleration of the 20th century.

A first critical evaluation of two independent methods for reconstructing past lake water TP concentrations: 170 years of agreement at Crose Mere, UK

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Effective management of lakes and their catchments is key to reducing excess nutrient inputs and reversing the global deterioration in water quality and overall ecosystem health. The success of these management schemes relies on knowledge of their status prior to significant human impact, however scarcity of long-term monitoring data means predisturbance reference values must be predicted. Diatom inference methods (DI-TP) have made a valuable contribution to defining these reference values for total phosphorus (TP) concentrations. However, we know that for some lake types DI-TP values may not reflect true baseline conditions and under certain circumstances the technique is not applicable. A newly developed sediment-inferred TP model (SI-TP) applies a simple mass-balance to sediment geochemical records. It offers a complementary approach to DI-TP, but is not yet sufficiently validated. Here we present the first critical comparison of the two wholly independent methods using a sediment record from Crose Mere, a lake in lowland England. We find similar magnitudes, trends, and intervals of change in both records. The agreement between these two records greatly increases confidence in the reliability of the historical TP reconstruction. Applying the SI-TP model to the Holocene sediment record from Crose Mere shows P enrichment from ca. 9000 BP, with firm evidence human impact on lake water TP concentrations from at least ca. 6600 BP. The reconstructions suggest the lake may have become eutrophic as early as the Iron Age, reaching TP concentrations comparable to modern levels following a significant shift in vegetation cover, the introduction of cattle, and increased erosion in the catchment. The clear link between human activity and the increase TP demonstrates that the widely held view that Crose Mere is naturally eutrophic can be rejected. This also highlights the need for a millennial scale perspective to truly capture predisturbance lake conditions.

Sediment-inferred lakewater total phosphorus inference (SI-TP): where it works and why

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Reliable evaluation of historic drivers of landscape phosphorus exports depends on accurate palaeoecological inference of past lakewater TP. A novel sediment geochemical approach to inferring past long-term average lakewater TP offers a new opportunity to validate existing inference methods. Sediment Inferred lakewater TP (SI-TP) has been successfully tested against a lake data set for recent sediments, and shows very good agreement with diatom-inferred TP at a lowland lake site in the UK ("A first critical evaluation of two independent methods for reconstructing past lake water TP concentrations: 170 years of agreement at Crose Mere, UK", FS17). However, there is uncertainty about whether the method is applicable at lakes with substantial sediment P diagenesis and high internal P load. We tested the SI-TP method at Lake Søbygaard in Denmark, a shallow lake with exceptionally high internal P loading and visible diagenetic impacts. Applied to six cores taken between 1985 and 2004, the model results show that despite partial degradation of the sediment P record, SI-TP usefully reconstructs monitored TP values, capturing the magnitude of peak TP enrichment. Here we explain why SI-TP works at Lake Søbygaard despite sediment P diagenesis, and present new developments in estimation of lake P retention that further enlarges the set of suitable sites. Implications for evaluation of recent and prehistoric landscape P dynamics are also addressed.

Impacts of asbestos mining activities on lake ecosystems: insights from a multi-proxy paleolimnological investigation

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The impacts of asbestos mining activities and wastes on aquatic ecosystems are generally assumed to be minimal, yet have been poorly studied. To evaluate their importance, we analyzed several sediment cores collected in the Bécancour River Basin, notably in 4 fluvial lakes located downstream from Thetford Mines (Quebec, Canada): Stater Pond, Trout Lake, Lake William, and Lake Joseph. This region has been the center of more than a century of asbestos mining activities (1877–2011 CE), which resulted in the accumulation of huge piles of wastes (tailings and waste rock) on riverbanks. Age-depth models, primarily derived from radiometric dating (^{137}Cs, ^{210}Pb, ^{14}C), revealed extreme increases in sediment accumulation rates in Stater Pond and lakes Trout and William, corresponding with the 1955–1959 CE drainage and excavation of an upstream lake for mining purposes. This event also corresponded with their strong eutrophication, as revealed by sudden changes in diatom assemblage composition (e.g., proliferation of *Cyclostephanos invisitatus*/*makarovae*, *Cyclotella meneghiniana*). ICP-MS/ICP-AES analyses revealed that post-1960 sediments at Stater Pond and lakes Trout and William, which maintained very high accumulation rates, were distinctively enriched in magnesium, chromium, and nickel. This provided evidence that they are contaminated by asbestos mining wastes, hence that the piles on the riverbanks are exposed to heavy erosion. Analyses by transmission electron microscopy demonstrated that post-1960 sediments contain important asbestos fiber concentrations (up to 6.9 wt%). Evidence of asbestos mining contamination has also been found in Lake Joseph, which showed that it spreads over ≥ 25 km in the Bécancour River system. We conclude that asbestos mining activities and wastes are susceptible to cause high sediment loads, as well as metal and fiber contamination in aquatic ecosystems (among other undesirable effects). Therefore, more efforts should be invested in the restoration of such mining sites and in controlling pollution they cause.

Complex ecological legacies of past gold mining activities in lakes of Atlantic Canada

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The discovery of gold deposits around the mid-19th century led to the establishment of more than 60 gold mining districts throughout the province of Nova Scotia, Canada between 1860 and 1940. Mercury amalgamation was used predominantly to extract gold from arsenic-rich ores and tailings were disposed into local landscapes, which continue to be an environmental concern today. Specifically, the transport of mine tailings from land to local freshwaters via surface waters and wind has been identified as key to the movements of historical contaminants. We used geochemical proxies to track the transport of mine tailings from land to lakes and examined biological responses by analysing subfossil remains of benthic invertebrates and zooplankton. Specifically, we examined dated sedimentary records from four lakes from the most productive mining districts (Montague, Waverley, and Goldenville). Sedimentary metal(loid) concentrations increased during the mining era and exceeded the Canadian guidelines for probable effects levels by several folds. Especially, mercury levels exceed the guidelines by 6 to 65 times at the peak of mining operations. Despite the cessation of mining activities for more than eight decades, the contaminant levels in modern sediments continue to be higher than pre-mining levels. Benthic invertebrate and zooplankton assemblages have responded to the cumulative effects of mining contaminants and land-use changes related to urbanization. While paleolimnological records from the four sites shared several similarities in geochemical trends and biological responses, site specific characteristics are influencing long-term aquatic responses to these stressors. This work contributes to the growing body of knowledge on the cumulative effects of multiple environmental stressors and emerging challenges to geochemical and ecological recovery from historical mining activities.

Disentangling the geologic, human and climate drivers influencing sediment deposition in volcanic lakes on the Azores Archipelago

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The Azores Archipelago Western (AAWG) and Central (AACG) groups possess a high diversity of tectono-volcanic settings, and therefore, a wide range of lake-watershed-system morphometries. This archipelago has suffered from anthropic impacts, mainly abrupt land-use changes, since medieval times (between 700 and 850 CE), and increasingly after the Portuguese arrival in the 15th century. In this complex geologic and human context, we used a multiproxy approach in sediment records from Lakes Caldeirão (Corvo Island), Funda (Flores Island), and Caveiro (Pico Island) to demonstrate complex interactions among several environmental drivers over the last few millennia. Paleoenvironmental changes were defined by a multivariate analysis of sedimentary facies, biogeochemical and mineralogical data. This analysis highlights that the most prominent sedimentary process in the AAWG lakes (Caldeirao and Funda) is hydrological grain size sorting, driven by runoff. Additionally, smooth catchment slopes of low-gradient Lake Caldeirão modulated this process by favouring rock grain size diminution through weathering, whereas the steep topographic-bathymetric profile of high-gradient Lake Funda did so through water-level fluctuations. The frequent volcanic activity of the AACG and the small size of the Caveiro lake catchment favoured the deposit of pyroclastic tephra through direct fallout on the lake, over the catchment-sourced inputs, reworked by climate and tectonic activity. The biogeochemical and mineral composition of the sediment records present extreme change rates at 1288^{+28}_{-22}-1388^{+41}_{-32} CE, corresponding to the age of the most intense landscape transformation. Therefore, to obtain robust climate reconstructions from these Azorean lacustrine records, we present a detailed statistical approach to isolate the climate signal from volcano-tectonic,

morphometric, and anthropic drivers.

Assessing the long-term impacts of the mink fur industry on lakes on Nova Scotia, Canada

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Residents and environmental managers in Nova Scotia (NS), Canada, have attributed mink fur farms as a possible source of nutrient pollution that is causing algal blooms in regional lakes. However, water quality monitoring was only initiated in 2008, decades after the advent (ca. 1930s) and expansion (ca. 1970s) of the NS fur industry. Further, multiple anthropogenic stressors, including climate change, acidification, brownification, and other land-use changes are likely contributing to ecosystem change. We used diverse proxies to document the impacts of multiple stressors on regional lakes, and to better understand the environmental impacts of fur farming in NS. Our analyses included a detailed water chemistry survey, bioindicator analyses (diatoms, chironomids, and Cladocera), stable isotopes, and spectroscopic inferences of whole-lake primary production and organic carbon. Our data clearly implicate fur farms as a source of nutrient pollution. The most severe eutrophication impacts occurred in lakes where farms were closest to the shoreline. Some lakes were more resilient to eutrophication due to high colour and trace metal concentrations. This information can be used to inform management efforts.

Stable isotopes, biogenic calcite crystal composition and biotic remains were used to infer Holocene paleoenvironmental conditions in Lake Balaton, the largest shallow waterbody in Central Europe

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Increasingly, frequent periods of drought fundamentally change the sediment-water balance in continental waters (rivers, lakes), and consequently, water quality. This is especially true for large, shallow lakes like Lake Balaton where biogenic calcite precipitation contributes to >80% of the total sediment accumulation. We analysed one full Holocene and one short (last 500 years) sediment core from the central part of the lake. TOC, TN, micro-XRF, TEM, XRD, ICP and chlorophyll content measurements were done, together with chironomid, diatoms and pollen analyses. For dating, 210Pb/137Cs analyses were run in conjunction with AMS 14C measurements on pollen extracts and plant macrofossils. Regional plant cover estimates were made using the REVEALS model.Biogenic carbonate precipitation in Lake Balaton produces calcite and Mg-calcite. Using this relationship for the past, and corroborating it with δ18O and δ13O measurements and TEM-derived crystal structure, we found two periods of Mg-calcite increase in the Holocene, at 5200-5000 and 3300-3000 cal yr BC, which likely indicate drier climate conditions connected to well-known rapid climate-change events. Pollen data showed that the watershed was characterised by increased forest fires during these intervals. Our data furthermore show that the lake was characterised by deeper, mesotrophic conditions with strong biogenic carbonate precipitation from 2800 cal yr BC until AD 1700, which was followed by a sudden increase in organic productivity between AD 1700 and 1750, simultaneous with a decrease in water depth. The chironomid fauna demonstrated that because of fish stocking in the 1960s, the invertebrate fauna was left impoverished. Procladius became dominant, replacing a formerly diverse fauna. Sediment accumulation rate (0.15-0.43 mm yr-1) and sediment P concentration (0.32-0.5 mg g-1) was fairly stable in the Holocene, and did not increase during dry or wet periods in the central Szemes Sub-basin, suggesting that dredging may not be the best solution.

Paleolimnology of meromictic Teapot Lake, Ontario, inferred using palynological and geochemical variables

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Teapot Lake is an environmentally sensitive meromictic lake located in the Heart Lake Conservation Area, Brampton, Ontario, Canada. Although there is a long history of indigenous peoples in the area, large-scale clearance of the area surrounding Teapot Lake for agriculture only began in the early 19th century with the arrival of European settlers. The entire region is now highly urbanized, with major highways, industrial areas, aggregate quarries, and housing. A paleoenvironmental record is necessary to analyze the impact of historic and ongoing anthropogenic change to the lake. As there is a paucity of instrumental records prior to the 19th century, proxy indicators such as pollen and sediment geochemistry were used to infer paleoenvironmental changes at Teapot Lake over the Holocene. Four stratigraphically constrained palynological zones (TPZ-1 – 4) were delineated in core TPL C-2, which was collected at the center of Teapot Lake. Based on changes in the relative abundance of pollen genera such as *Tsuga*, *Picea*, and *Fagus*, the region surrounding Teapot Lake experienced warm-dry (TPZ-1, ~8000 – 6000 yr BP), warm-moist (TPZ-2, ~6000 – 3500 yr BP), and then cool-moist conditions (TPZ-3 – 4, ~3500 yr BP – present). Trace element analysis of the core showed intervals of high Fe, P, and Mn, with iron phosphate mineralization in Zone TPL-2 during the Holocene Climate Optimum (HCO) [~7000 – 3000 yr BP]. These higher concentrations of Fe and Mn suggest enhanced interaction between groundwater, the primary recharge source of Teapot Lake, and till, whereas P enrichment suggests longer residence times of migratory birds during the warmer conditions of the HCO. The onset of cool-moist conditions may have limited subsurface water flux and prevented Teapot Lake from receiving dissolved ions from groundwater. This multi-proxy paleoecological approach enabled us to: 1) infer the past vegetation and climate history of the basin, ands 2) reconstruct past hydrological and nutrient conditions in the lake.

Farming, fire and phosphorus led to Late Holocene cyanobacteria blooms in tropical and subtropical lakes

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Land-use alterations in subtropical and tropical areas have been shown to increase material transport into aquatic environments. These materials can drive ecological change, leading to increases in trophic state and harmful algal blooms (HABs) in lakes. Whereas modern HABs are currently being studied, examination of historical records of HABs could benefit models and future projections of HAB occurrences. We applied paleolimnological methods to sediment cores from three tropical and subtropical lakes to document the development and persistence of dense cyanobacteria communities from the Middle Holocene to the present (last ~5000 years) in response to a variety of land-use changes. The objectives of the study were to: 1) compare modern limnological conditions and land use to pre-human-disturbance periods, and 2) determine if the drivers of modern cyanobacteria communities differ from those that drove prehistoric communities. We utilized paleolimnological techniques to infer past allochthonous inputs (nutrients, organic matter, metals) and autochthonous responses (photosynthetic pigments, cyanotoxins) in Lakes Harris (Florida, USA), Ditch (Alabama, USA), and Amatitlán (Guatemala). Results suggest that historic HABs and cyanobacteria development were linked with increased nutrient inputs from land use changes, coupled with limnological modifications. Lake Harris showed hydrological modifications as the primary driver of cyanobacteria dominance during historic periods, whereas Lake Ditch developed hypereutrophic conditions in response to major alterations to the riparian forested landscape. Lake Amatitlán showed historic hypereutrophic conditions in response to ancient Maya settlement in the watershed, with nutrient inputs related to increased rural farming populations. These results suggest that historic HAB occurrences were linked to different past land uses.

The use of paleolimnology to inform freshwater management of urban lakes: Halifax Regional Municipality, Nova Scotia, Canada

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Watershed-scale stress from urbanization can negatively impact ecosystem services communities rely on; yet, a lack of historical context for individual-lake conditions impedes management planning that promotes evidence-based restoration/remediation targets and the efficient allocation of resources. Halifax Regional Municipality, Nova Scotia, Canada, has hundreds of lakes that are increasingly influenced by residential development, and most lakes in the urban/suburban core are developed to some degree. Here, we compare water quality parameters in a local water quality monitoring program to subfossil chironomid assemblages (Diptera: Chironomidae) from 51 lakes to understand the broader context of urban influence, and to provide a better understanding of how local environmental stressors may influence diversity. Through the additional biostratigraphic analysis of three lakes, we apply paleolimnology to fill the gap in long-term monitoring data and to infer the influence of watershed development on urban lakes; Chocolate Lake and Settle Lake lie in residentially developed watersheds, and Spider Lake is in an undeveloped watershed. We found that urban development has influenced species diversity in urbanized lakes and that shifts in chironomid assemblages over time reflect patterns of human disturbance. In contrast, lakes in undeveloped watersheds were found to have regional level influences, such as climate warming. Our results will facilitate informed decisions related to restoration/remediation targets and assist in the planning and management of freshwater resources.

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FOCUS SESSION 18

Integrating process models into paleolimnological methods : toward hindcast-forecast approaches to assess evolution of lake-watershed systems

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Integration of lake modeling, paleolimnological records and in situ measurements towards the reconstruction of dissolved oxygen concentrations in perialpine lakes over 250 years (1850–2100)

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Numerical process-based lake models are powerful tools to simulate the dynamic of aquatic ecosystems and to investigate the past and future of lakes. In this regard, onedimensional models have been widely implemented over the last couple of years, but most of these models are calibrated and validated against short limnological records, potentially limiting the robustness of long-term reconstructions. The present study performs long-term simulations from 1850 to 2100 to investigate the temporal evolution of dissolved oxygen concentrations along the water column in perialpine lakes. The one-dimensional General Lake Model is coupled to the Aquatic EcoDynamics library (GLM-AED2). Pluri-decadal series of limnological data monthly collected by the French Observatoire des LAcs (OLA) are used to calibrate and validate the model. In addition, model outputs are further validated with published paleolimnological records of hypoxia from sedimentary varves for the past 170 years. Preliminary results of the calibration procedure show that the GLM-AED2 model accurately predicts the magnitude and seasonal dynamics of dissolved oxygen along the water column with goodnessof-fit metrics under the literature range. The integration of a one-dimensional lake model, paleolimnological records and in situ measurements supports a deeper understanding of the temporal evolution of hypoxia events by providing more robust long-term hindcast/forecast simulations to elucidate the impacts of climate change and anthropogenic pressures affecting lakes.

Multiproxy paleolimnological modelling of the non-stationary dynamics of catchment inflows and sediment yield, and sedimentation for three New Zealand lakes

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With rapid environmental change, there has been an increasing interest to predict future changes in water quantity and quality. For this purpose, observational data over an instrumental period has been used to validate hydrological models. However, numerical modelling of catchment hydrology and lake water quality based entirely on instrumental period datasets provides limited perspective on long-term climatic variation and changes in catchment hydrological behaviour. Numerical modelling of catchments and receiving waters on paleolimnological time scales has not been attempted before, partly because it has not generally been computationally possible or there is difficulty in input data reconstruction. To fill this gap, we extended predictions beyond the instrumented hydrological record using lake sediment core data from three mutually independent lake catchments in New Zealand. The aims of the study were to 1) estimate streamflow and sediment delivery daily to the lakes over 2000 years, 2) determine whether hydrological models are suitable tools to reproduce paleolimnological records preserved in the sediment core, 3) predict sedimentation rates over long time periods in a changing climate. Our overarching objective was to predict future lake sedimentation and water quality given likely changes in land use, climate, and management scenarios. We tested a hypothesis of non-stationarity of streamflow and nutrient loads associated with climate and anthropogenic catchment disturbance (e.g., forest clearance) using 50 years (1972-2022) of observed climate and 22 years (2001-2021) of streamflow and water quality data pre and post land use change. Our simulations improve predictions for the hydrological impacts of climate change based on variability from 2000-years of sedimentation dynamics and paleoclimate data across New Zealand, and using models to connect climate, catchment and lake dynamics.

Quantifying soil erosion during the Holocene by coupling land surface modeling and paleoenvironmental approaches

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Anthropogenic land use changes and hydroclimate fluctuations are generally described as the main control factors of soil erosion on centennial to millennial time scales, but their relative contribution on erosion trends is barely quantified yet. While past erosion dynamics can be inferred from lake sediment records, improvements in land surface models now allows the quantification of soil erosion on a variety of spatial scales ranging from plot to regional or even global scales. However, application of model approaches to long timescales is still at its dawn, limiting quantification of past soil erosion, investigation of scenarios, interpolation of data spatially and temporally, or testing hypothesis. Here we show how coupling paleo-environmental data and spatially distributed models of erosion constrained by land cover data might help to assess past soil erosion dynamics and to quantify soil loss exports. The methodology has been tested on six alpine lake catchments that cover large altitudinal gradients (from 420 to 2494 asl) over the Holocene period. Our results show that erosion dynamics in the Alps seems to be characterized by two main regimes: 1) a long-term (i.e. pluri-millennial) slow increase in soil erosion that we attribute to progressive land use change, and 2) 'short' term (i.e. decennial to centennial) erosion crisis associated with faster land uses changes. Our results suggest that reconstructing past soil erosion requires accurate land cover change reconstructions. Our results further suggest that deforestation and land opening may have amplified the effect of precipitations on soil erosion. Coupling model and paleolimnological approaches should hence open new avenues to assess in a more integrative way mass fluxes and stocks within lake catchments systems over long-term periods.

Hindcast/forecast of thermal regime and oxygen solubility in four perialpine lakes using 1D model and OLA observatory data

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Climate change modifies globally the thermal regime and solubility of oxygen in lakes, resulting in the alteration of lake habitats. The use of 1D lake models has become the standard in lake researches to evaluate the effects of climate change. However, the required global scale forcing parameters have several limitations, such as the need of downscaling. In this study, several 1D lake models' robustness were tested for long-term variations based on 50±13 years of limnological data collected by the French Observatory of LAkes (OLA). We evaluate the possibility to force mechanistic models by following the long-term evolution of shortwave radiations and air temperatures while providing realistic seasonal trend for the other parameters for which local scale downscaling often lacks accuracy. Then, the effects of climate change on the thermal regime and oxygen solubility were analyzed in the four-largest French peri-Alpine lakes. Our results show that 1D lake models forced by air temperatures and shortwave radiations accurately predict variations in lake thermal regime over the last four to six decades, with RMSE <1.95 °C. During the last three decades, water temperatures have increased by 0.46 °C decade^{-1} (±0.02 °C) in the epilimnion and 0.33 °C decade^{-1} (±0.06 °C) in the hypolimnion. Concomitantly and due to thermal change, O_2 solubility has decreased by -0.104 mg L^{-1} decade^{-1} (±0.005 mg L^{-1}) and -0.096 mg L^{-1} decade^{-1} (±0.011 mg L^{-1}) in the epilimnion and hypolimnion, respectively. Based on the ssp370 socio-economic pathway of the IPCC, perialpine lakes could face an increase of 3.80 °C (±0.20 °C) in the next 70 years, accompanied by a decline of 1.0 mg L^{-1} (±0.1 mg L^{-1}) of O_2 solubility. These results suggest important degradation in lake thermal and oxygen conditions and a loss of habitats for endemic species.

The paradox of increasing long-term carbon sequestration in lake ecosystems despite reoligotrophication: addressing the case of four deep French perialpine lakes with paleo-environmental data and modelling approach

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A growing number of studies have shown that lakes play a critical role in the global carbon (C) cycle, mediating C transfer from land to the atmosphere, and burying organic C in their sediments. Published paleolimnological records show an increasing trend in C sequestration in lakes all over the world over the last 200 years. In this study, we address the case of four large French perialpine lakes (Annecy, Bourget, Aiguebelette and Geneva) to investigate C trends and drivers from monthly to centennial timescales using both paleolimnological records and mechanistic 1D lake model approaches. In the four perialpine lakes, sediment records confirm the increasing trend in carbon sequestration during the last 300 years. Counterintuitively, abatement of phosphorus (P) concentration in the four lakes since the 1970s following restoration measures have not reduced the carbon accumulation in sediment records. The present study addresses this paradox by reconstructing trends in carbon sequestration from 1966 using a modelling approach, and then by confronting model results to paleolimnological records. Calibration and validation of the 1D model were carried out over 50±13 years of limnological data collected by the French Observatory of LAkes (OLA). Our results show that the increase in carbon accumulation rates over the last decades is mainly due to nutrient inputs and low oxygen conditions, and that low oxygen condition is the main cause of the non-return of low C accumulation in a P reduction context. Our study further suggests that perialpine lakes will continue in the coming decades to accumulate higher C stocks in their sediments due to climate change that will maintain low oxygen conditions, hence favoring C preservation.

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FOCUS SESSION 19

Degradation and restoration of deltas, wetlands, and floodplain lakes and ponds in the Anthropocene

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Shifts, baselines and nonlinearities in a Mediterranean delta: quantifying ecological resilience using a combined limnological-paleolimnological approach

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Although borrowed to illustrate the impacts of overfishing, the term shifting baselines, or the extent to which each human generation accepts a degradation of the environment and perceives it to be “natural”, can also be applied to other pressing disturbances, such as eutrophication, salinization, and hydrological alteration. This is the case of Mediterranean deltas, where major transformation through agricultural expansion and catchment modification took place during the pre-instrumental era, and hence a long-term vision is needed. In this contribution we will present preliminary results of a combined limnological-paleolimnological approach to characterize multiple shifting baselines in the Ebro Delta (NW Mediterranean). We use a 9800 cal yr BP record to identify feedbacks between proxies for natural disturbances in the delta (pulse events such as lobe switching and climate or fluvial regimes), and ecosystem responses, using XRF techniques and foraminifera community time-series data, respectively. We also compared fossil foraminifera trajectories to a regional data set characterizing the full range of modern communities from marine to deltaic plain habitats, to validate drivers of community change, using a space-for-time substitution approach. Preliminary paleolimnological-scale analyses suggest that following the post-glacial sea level rise, significant peatland-type habitats developed. Thereafter the delta has gone through three ecological states (submerged-vegetated habitats) by crossing two tipping points that marked synchronous changes in both XRF and foraminifera changes. Hierarchical Generalized Additive Models were used to model rate of change and variance which preceded deltaic ecosystem shifts, hence validating their use as resilience loss indicators. Millennial-scale analyses combined with contemporary data provided a robust quantitative framework of habitat regime shifts. The novelty of our paleolimnological-scale resilience analysis is that we should be able to make contributions towards ranking past habitat states in terms of, for instance, sensitivity to variables or combination of variables (sea-level rise, sediment type, salinity) for assessing different lines of evidence for multiple reference baselines at local and regional scales against which to define management and restoration efforts in the Ebro Delta.

Can flood histories be reconstructed in tropical mega-delta lakes?

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Tropical mega-deltas in South and Southeast Asia are dynamic places where aquatic ecosystems face impacts from changing hydrology, seasonal monsoons, and the effects of climate change. Flooding from seasonal rains or extreme weather events has occurred throughout history in the region bringing numerous ecological and societal disruptions, yet the economies of this region are tied to the annual occurrence of the monsoon. With South and Southeast Asia projected to face some of the more disruptive effects of climate change such as mega-droughts or increased occurrences of extreme weather events, the frequency and severity of floods in the region may be impacted leading to uncertainty in how to account for these hazards. Previous palaeolimnological research has shown that flooding histories can be reconstructed in lakes. However, the largest issue facing lakes in tropical delta systems are the impacts due to human activities such as fishing, industry, and altering of hydrological flow, as well as seasonal fluctuations in water levels, thus presenting a range of problems in detecting flood histories in the sediment record. In this study, we recovered sediment cores from two ox bow lakes in southwestern Bangladesh. A chronology was established using ^{210}Pb radiometric dating and multi-proxy analysis including grain-size, pigment, and scanning XRF was conducted to detect flooding and any changes to severity or frequency. Anthropogenic impacts to the aquatic ecology of each lake were also reconstructed. We present our flood history results from these two lakes to understand potential future impacts to these vital social-ecological systems from climatic and human-driven changes.

Why is tufa not depositing anymore at lowland alkaline fen in Central Europe? Insights from monitoring and paleoecological data

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Tufa depositing alkaline fens, formerly abundant, have been decreasing in numbers since the mid-Holocene, first due to natural causes and recently due to human impact. Actions undertaken to protect and restore those ecosystems include restoring conditions favouring tufa deposition, which assures a proper substrate and allows to retain low fertility of the fen by nutrient bonding during $CaCO_3$ precipitation. In the present study, we aim to: i) reveal the limiting factors for tufa accumulation at the alkaline fen in Suwalski Landscape Park, NE Poland, holding the history of heavy $CaCO_3$ precipitation during the early and mid-Holocene; ii) evaluate the potential for reestablishing carbonate deposition. To complete our aim, we investigated the current fen ecosystem, which included botanical and malacological inventory and yearly monitoring of the physicochemical properties of the groundwater emerging at the fen and testing whether $CaCO_3$ precipitates there. Also, we studied the long-term responses of biotic and abiotic components of the fen ecosystem to environmental changes since the tufa deposition ceased ca. 5400 cal yr BP. The decreased temperatures at the fen surface resulting from climate cooling and entering of trees at the fen were likely responsible for the ceasing of tufa deposition in the mid-Holocene. At present, despite the unfavourable conditions for $CaCO_3$ precipitation, i.e., negative or neutral calcite saturation index, calcite crystals were observed in the spring and summer. This indicates the importance of the autotrophs, which absorb CO_2, locally increase pH and provide sites for $CaCO_3$ nucleation. The combined effect of global warming and cutting down the birch stands are likely to increase the temperatures at the fen surface, reactivate tufa deposition, and help restore the proper alkaline fen ecosystem. Currently, the calcium-rich substrate is indicated exclusively by *Carex paniculata* and two gastropod species, *Vertigo geyeri* and *Vertigo angustior.* Source of funding: Project NCN 2018/29/B/ST10/00120

Environmental reconstruction changes in Soldier Meadows (Great Basin, USA) during the last 500 years through a multi-proxy approach

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Located in the Black Rock-High Rock National Conservation Area, northwestern Nevada (USA), Soldier Meadows is characterized by the presence of small endemic populations of thermophilic fish (desert dace, *Eremicthys acros*) and springsnails (genus *Pyrgulopsis*). These populations have been threatened by human activities including ranching, especially in the last century. The entire area has also been used for recreational purposes in numerous hot springs that provide the unique environment for endemic species. To better protect the endangered species and restore the natural conditions of the wetlands, a paleoecological study was conducted using sediments recovered from the wetland, to understand the human impact of ranching and grazing on the aquatic ecosystem. One short 40-cm sediment core was dated using a combination of radiocarbon and lead-210 methods, yielding a basal age of ~600 CE but with most of the core dating to the last 500 years. Pollen and non-pollen palynomorphs (NPP) analysis was conducted. While the pollen diagrams show a broad consistency in the vegetation components (shrubs and trees), the most interesting variations in the aquatic environment were showed by the NPP, around 1570 CE, when a dramatic change in the aquatic local condition occurred. The cyanobacteria *Rivularia* sp. increased abruptly along with the aquatic vegetation (Cyperaceae, *Typha* sp. and *Triglochin* sp.) suggesting a rising in water level and salinity possibly due to dissolution of alkali minerals from the surrounding playa, favoring the alkaline tolerant *Rivularia* sp. blooming. This change in water level may have been a result of the Little Ice Age (LIA). Ranching in Soldier Meadows area started around 1860-1880s. While shrubs remain consistent during this period through the 20th century, oscillations of aquatic plants and microorganisms can be attributed to human activities such as water diversion and livestock grazing. This study underlines the importance of multi-proxy approach in paleoecological reconstructions and how they can support informed restoration projects in sensitive wetlands.

Holocene development, functioning and decline of a Central European alkaline fen ecosystem

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$CaCO_3$ depositing alkaline fens host many endangered species of plants and animals and act as an important carbon sink. These unique peat-tufa accumulating ecosystems become rare due to natural environmental changes and human impacts. Proper protection and restoration measures of alkaline fens require their functioning in long temporal scales to be thoroughly understood. In the present study we investigate the development, functioning and decline of the formerly $CaCO_3$ depositing cupola alkaline fen in Makowlany (north-eastern Poland). We aim to recognize the major drivers of the fen ecosystem evolution. Two sediment cores collected from the top and slope of the fen cupola were radiocarbon dated and analysed for geochemistry (loss on ignition in 550 and 950°C, macro- and microelements, $\delta^{13}C$ and $\delta^{18}O$) as well as plant macrofossil and mollusc compositions. Peat deposition at the fen started ca. 11200 cal yr BP; however, tufa deposition did not begin until ca. 10700 cal yr BP when permafrost thawing in the area enabled circulation of deep groundwater that provided the ecosystem with elements necessary for calcite precipitation. Change in the chemistry of the fen surface favoured plants and molluscs typical of alkaline fens, including mosses, e.g. *Tomentypnum nitens* and gastropod *Galba truncatula*. The most optimal conditions for calcium carbonate precipitation, and therefore the development of the alkaline fen ecosystem with *Cladium mariscus* stands persisted between 8800 and 5800 cal yr BP, which was an effect of high temperatures and humidity associated with the Holocene Thermal Maximum. The gradual decline of sedimentary $CaCO_3$ since ca. 5600 cal yr BP likely records the temperature drop in central Europe. The increasing thickness of the sediments accumulated at the cupola could have also disabled the artesian waters from reaching the fen surface. Since then, brown mosses were replaced with vascular plants. Source of funding: Project NCN 2018/29/B/ST10/00120

Assessing the potential of neodymium isotopes in the research on environmental disturbances in wetlands

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Like other types of wetlands worldwide, peatlands are experiencing numerous disturbances linked to climate change and anthropogenic activities. Drainage, peat extraction, deforestation, or increased fire activity, are damaging peat carbon stocks. One of the critical challenges is to recognize how past disturbances impacted peatlands in order to predict their future development trajectories in a warmer world. Several proxies are commonly used in palaeoecological studies to reconstruct past disturbances. Testate amoeba assemblages give insight into hydrological changes in the peatland, highlighting periods with water table fluctuations or droughts. Sedimentary charcoal is used to reconstruct past fire activity, while certain pollen types (for example *Secale cereale, Centaurea cyanus* or *Fagopyrum*) can indicate human presence in the study area. Among various geochemical proxies, X-ray Fluorescence Spectroscopy is most commonly used. However, other geochemical proxies, including neodymium isotopes ($^{143}Nd/^{144}Nd$, typically expressed as εNd), have the potential to record environmental changes. To date, Nd isotopes have rarely been applied in peat-based palaeoenvironmental reconstructions. Until now, Nd isotopes have been used in peat to identify atmospheric dust deposition from distant sources, such as volcanic dust or desert particles, often covering continental-scale atmospheric dust fluxes. This study aimed to investigate Nd isotope composition of peat profiles in high-resolution, similar to other proxies, for example pollen, plant macrofossils, charcoal, and testate amoebae. We hypothesized that local environmental changes that caused an increased mineral input into the peatland will be correlated with a change in Nd isotope composition in the peat archive. This approach has a potential to enlarge the set of proxies used for disturbance identification from peat.

Limnological change and interactive threats in a floodplain lake landscape in the Magdalena River, Colombia

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The Magdalena River in Colombia (South America) is one of the world's largest (discharge = 7,100 m^3/s) tropical rivers, containing > 300,000 Ha of floodplains and lakes, and hosting > 170 aquatic vertebrate species. Several anthropogenic activities resulting in large-scale damming, water pollution, invasive alien species introduction, deforestation and erosion, and climate change pose, unfortunately, unprecedented ecological and environmental challenges for the future of the river's floodplain unique biodiversity; problems that, in most cases, occur without fully understanding the natural dynamics of these valuable ecosystems. We combined modern surveys with multiproxy (diatoms, pigments, and sediment geochemistry) paleoecological data, and historical maps and climatic records from a set of interconnected lowland floodplain lakes to document lacking information on the links between long-term (decades-centuries) natural limnological dynamics, carbon cycling, and anthropogenic activities impacting the Magdalena River. Preliminary results indicate a dynamic transition between river-governed systems, wetland conditions, and lake systems. River conditions are interpreted from dominance in planktonic diatom species, low concentration of organic matter (OM), and high detrital inputs and grain size, while wetland conditions through prevalence of aerophile diatoms and high (OM). Lake conditions are inferred from a dominance of benthic/ tychoplanktonic diatoms, increases in autochthonous productivity, declines in detrital inputs and grain size, higher sedimentation, and water column oxygenation. Increases (> two folds) in sedimentation across the lakes since the late 1990s, concurs with an escalation in the river catchment deforestation. Lake hydrological connectivity to the Magdalena River is also suggested, as a central factor controlling long-term limnological responses, where highly connected lakes respond more acutely to ENSO events, while isolated lakes are more sensitive to local land-use changes. Our results yield a robust picture of variability over recent centuries and the main factors that destabilize and jeopardize the health of the community in the Magdalena River and its tributaries.

Environmental variability of urban endangered wetlands of western central Argentina (Mendoza, 33°S) during the last 2200 yrs

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Wetlands located in arid and semi-arid regions are hot spots of biodiversity and play a key role for migrating species. In eastern Mendoza (western central Argentina) exists a series of wetlands which according to historical documents were key not just for plants and animals but for native human groups as a source of resources for survival. However, in the last 100 yrs, changes in these wetlands watersheds summed to the development of extensive and intensive agriculture as well as urbanization have seriously affected their dynamics up to dry them seasonally. Therefore, this paper aims to disentangle the environmental variability of one of the Arroyo Tulumaya wetlands, the laguna El Viborón (LVI, 32° 53’ 36.49” S - 68° 36’ 40.76” W), during the last 2200 yrs in order to provide a long term picture of its dynamics to be applied on their proper management and conservation. The pollen record of a 0.7m-long core retrieved from a coastal area of LVI was analyzed. It is dominated by azonal pollen types such as Poaceae, Cyperaceae, Juncaceae, Amaranthaceae and Asteraceae subf. Asteroideae and reflects four main phases. Phase I, starting at 2200 cal yrs BP, reveals slightly wetter than present conditions followed by desiccation of the coastal area of the LVI under modern levels of the lagoon during Phase II. Phase III was the wettest phase during the last 2200 cal yrs BP which turned into the driest part of the whole record at the beginning of Phase IV. Since then, a gradual increase in moisture and plant diversity occurred also showing the appearance of exotic pollen types around 1929 AD. Phase IV changes, however, would be related to human activities as the establishment of a private fishing club for tourism and sport activities by this age. Acknowledgements: PICT 2019-3426; ANLAC; Proyecto PIO.

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FOCUS SESSION 21

Lakes as archives of the Anthropocene

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Great Acceleration record preserved in the annually laminated sediment succession of Crawford Lake, Ontario, Canada as a candidate locality for the Anthropocene Global Boundary Stratotype Section and Point (GSSP)

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The varved sedimentary succession preserved in Crawford Lake, Ontario, Canada is proposed as the Global boundary Stratotype Section and Point (GSSP) for the Anthropocene Series/ Epoch, with a proposed base in the mid 20th century. The sedimentary sequence is comprised of seasonally deposited laminations of organic matter capped by calcite that is precipitated each summer in alkaline surface waters. The record includes diverse proxies that reflect environmental change at global to local scales that have been documented to characterize the beginning of the Anthropocene. The spheroidal carbonaceous particles and bulk sediment nitrogen isotope sequence records a significant increase in fossil fuel combustion in the early 1950s. Ratios of ^{239}Pu:^{240}Pu and ^{14}C:^{12}C both peak in the 1960s, coincident with an increase in radioactive fallout from thermonuclear testing; the latter more than compensating for the effects of old carbon in the dolomitic basin of Crawford Lake. The rapid industrial expansion in the North American Great Lakes region that occurred during, and particularly after, WWII, associated with what has come to be known as the Great Acceleration, led to enhanced leaching of terrigenous elements by acid precipitation. A reduction in calcite precipitation and low primary productivity produced thin calcite laminations coeval with the proposed GSSP. The absence of fossil pigments from obligately anaerobic purple sulfur bacteria indicates the presence of an oxygenated monimolimnion with elevated bottom-water salinities being responsible for the preservation of varves. This inference is confirmed by water property data collected through the modern lake water column in all seasons. Such an aerobic depositional environment is unusual for a meromictic lake and serendipitously prevented the mobilization of 239Pu in the lake sediments, the proposed primary stratigraphic marker for the Anthropocene.

Intertwining sedimentary and historic archives from medieval to early modern times: the story of Bad Waldsee (southern Germany)

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Lakes close to European historic urban settlements were exposed to human activities much earlier than the often-assumed reference conditions before 1800. The direct impact and exact mechanisms, however, often remain speculative due to the interplay of natural climatic and anthropogenic signals as well as a lack of historical evidence. Lake Stadtsee, located in the medieval city of Bad Waldsee, offers a continuous record of mostly seasonally laminated sediments. Precise correlation of sedimentary signals with numerous local historic documents allows for a detailed evaluation of human-environment interaction. An interdisciplinary research team, combining both natural scientists and historians, was established to assess the environmental impact of socio-economic development for the preindustrial phase of Bad Waldsee from 1200 to 1800 and to determine the effects of climatic changes on the population. Diatoms were analyzed in the sediment record together with other biological (Bryozoa, Cladocera) and geochemical (element composition, stable isotope ratios) proxies to infer past limnological changes. Overall high abundances of eu- to hypereutraphentic diatom taxa already 800 years ago proof the significant impact of the population on Lake Stadtsee. The transitional period between the Medieval Warm Period and the Little Ice Age (LIA) as well as the beginning of the LIA are characterized by increased abundances of turbulence and turbidity indicating diatom taxa, possibly related to decreasing temperatures and extreme weather events. Around 1400, high numbers of bryozoan statoblasts and cladoceran ephippia suggest disturbance of the aquatic system. In the historical records, decreased numbers of baptismal entries as well as a description of the fourth plundering of Waldsee by Swedish troops in 1632 suggest a population decline during the Thirty Years' War. Concurrently, the lake ecosystem showed a temporary recovery by reduced diatom concentrations together with decreasing abundances of the hypereutraphentic *Stephanodiscus hantzschii* and a subsequent peak in the meso-eutraphentic *Pantocsekiella ocellata*.

Biotic responses of shallow subarctic ponds to a warming climate in the Anthropocene: A perspective from the Hudson Bay Lowlands, Canada

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Ecotones are dynamic ecosystems where ecological communities are compressed across a spatial transition, and as such can be very susceptible to environmental change. Here, we examine the paleohistory of two lakes in the ecotonal Hudson Bay Lowlands, Canada, to understand how their biological communities have responded in an increasingly climate-stressed Anthropocene. Increased evaporative stress during drier summers combined with lower snowmelt runoff can cause widespread desiccation in these kinds of lakes. Using a multi-proxy paleolimnological analysis, we reconstruct past environmental conditions through the examination of subfossil chironomids (Diptera: Chironomidae) and compare these records to prior palaeohydrological analysis of *cellulose-inferred lake water d*^{18}*O* records. Despite their close proximity, the two lakes had vastly different responses to climate change. Larch Lake, which was once a small shallow pond, has became connected to other ponds due to the formation of permafrost degradation channels. This connection increased water levels, created new aquatic habitats, and lead to a biodiversity shift from an environment that was once dominated by *Limnophyes* and *Psectrocladius* to one dominated by various species of *Tanytarsini*. In contrast, Left Lake was once a deeper isolated basin, but is now experiencing increased evaporative pressure that has significantly decreased its surface water volume. A shift in chironomids to a community dominated by *Dicrotendipes* and *Procladius* suggests that this system has increasingly transitioned from an isolated deeper system to one which has a larger, much shallower, littoral environment. Despite their different hydrological histories, both ponds had significant shifts in their chironomid assemblages that reflect modern climate warming ~1990. This signal is only expected to get stronger as the effects of climate change become more severe. Understanding how dynamic environments such as those in the Hudson Bay Lowlands have been responded to past warming is crucial for understanding how these environments will respond in the future.

Effects of land-use change on watershed erosion and nitrogen cycling in the northeastern United States

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Land-use changes can result in a multitude of direct and indirect consequences to surface processes and downstream waterbodies. This study examines sedimentary archives from a network of 17 lakes across the northeastern United States. The watersheds of these lakes span a range of topographic and surficial geologic characteristics, and have land-use histories with differing types, timing, intensity, and duration of anthropogenic disturbance. Sediment cores from all lakes were analyzed to identify distinct event deposits and changes in clastic sediment input indicative of landscape disturbances. Watershed sensitivity to erosional disturbances was greatest in higher relief, mountainous watersheds with abundant glacial-age sediment. A subset of 3 lakes representing different patterns of land use disturbance and erosional responses were further analyzed for geochemical indicators (C and N, $\delta^{13}C$; $\delta^{15}N$) of changes in nutrient cycling and aquatic productivity. The three watersheds associated with these lakes are distinguished by differing land use histories described as 1) limited anthropogenic impact until the onset of lumbering ~1900 CE and ongoing timber harvest, 2) early land clearance and conversion to agriculture in the 18-19th centuries followed by some reforestation and rural development, and 3) a period of timber harvest in 19th century and ending early in the 20th century, followed by strict conservation and complete reforestation. In the watershed subject to ongoing timber harvest, sediment yield increased markedly while $\delta^{15}N$ remains near pre-disturbance levels. Only in the watershed with strict conservation does lake sediment $\delta^{15}N$ show depletion consistent with global trends in atmospheric in N deposition. Where forested land was converted for agriculture use and rural residential development, terrestrial sediment yield and $\delta^{15}N$ have increased and remained enriched.

Reconciling global lake oxygen observations by coupling model, limnological and paleolimnological approaches

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Long-term and short-term observations from sediment records and limnological data show that a decline in dissolved oxygen is widespread in deep-water lake habitats. Despite congruent observations on the oxygen decline, the interpretations of the drivers of that decline yet differ between long and short timescales' approaches. On the one hand, limnological synthesis from 393 temperate lakes indicates that the decline in deep waters is associated with stronger thermal stratification and loss of water clarity over the last 40 years. On the other hand, paleolimnological synthesis from 365 lakes suggests that the increase of human activities and nutrient release is leading to hypoxia onset over the last 300 years, but not the climate. To reconcile these apparent contradictions, our study investigates changes in bottom oxygen conditions in four perialpine lakes over the last 300 years, on a daily resolution, by coupling numerical 1D process-based models and paleolimnological records. The GLM-AED2 model has been calibrated and validated against 37 to 63 years of limnological data collected twice a month by the French Observatory of LAkes (OLA) since 1957. In addition, model outputs have been further validated with paleolimnological reconstructions of oxygen conditions based on varve records for the four lakes for the past 200 years. Our results show that the GLM-AED2 model accurately predicts the magnitude and seasonal dynamics of oxygen conditions along the water column. The integration of paleorecords and lake model shows that a historical shift in oxygen conditions was controlled by nutrient supplies at the turn of the 1950s. After that shift, in a low oxygen context, second amplitude variations in oxygen conditions were essentially driven by climatic factors, such as air summer and winter temperatures and winds. In addition to environmental forcings, the mechanistic model also allows us to suggest what processes were involved in oxygen conditions changes.

Mercury deposition and mass balance in tropical and temperate freshwater lakes of Australia

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Lake sediments have been used as natural archives to infer spatial patterns and temporal trends in past mercury (Hg) cycling and deposition. They integrate Hg deposited directly on the lake itself and on the lake's watershed. Environmental factors such as soil Hg concentrations, catchment vegetation and lake productivity, play an important role on controlling the accumulation of Hg in lakes, though the influence of these environmental factors on the Hg mass balance deposition in lakes is poorly understood. This is particularly the case for lakes in the Southern Hemisphere. In this multi-lake study, we assess the effects of catchment vegetation, soil Hg content, and trophic state on Hg sediment from tropical and temperate lakes in Australia. Ten sediment cores were analysed, five from lakes north of 30º S (Lake Barrine, Girraween, Euramoo, Horse Swamp and Boggy Swamp) and five from lakes south of 30º S (Blue Lake, Club Lake, Hidden Lake, White Bull Lagoon and Owen Tarn). We investigated Hg concentrations in soils and sediment of these lakes and compared them to vegetation. Background sediment from tropical lakes north of 30º S showed 2-fold higher Hg concentrations than temperate lakes. Closed forest lakes had higher Hg concentration (85 ng/g) than lakes surrounded by woodland (35 ng/g), but more lakes are needed to confirm this correlation. The Hg mass deposition fluxes revealed that the northern most lakes with higher productivity are significantly larger sedimentary Hg sinks than temperate lakes in Australia, while high altitude temperate lakes showed more abrupt changes in Hg deposition as a response to climate change.

Assessing the effect of mining pollution in a lacustrine system from the arid region of the Atacama Desert, Chile

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The Atacama Desert (AD) (Northern Chile) has large reserves of salts and minerals, and as a result of these deposits, mining is one of the largest industrial economic activities in the area and the country. The impact of pollution through the deposition of heavy metals generated by industrial exploitation on the evolution of water bodies in arid sites has been little studied. In this study, we evaluate the impact generated by the mining industry on the water bodies of the AD, taking the Inka Coya lake, Antofagasta Region, as a model. An analysis carried out on a sedimentary core from this lake showed geochemical and also ecological changes in current sediments with respect to the old sediment. In the recent period, an increase in the concentration of Al, Cu, Fe, Mn, Ni, and Zn and higher densities of diapause egg banks of zooplanktonic organisms are observed, in addition to a change in their community composition. Specifically, in the most recent period, the egg bank is dominated by structures of the genus Brachionus, a rotifer sensitive to metal contamination. These preliminary results show the ecological impacts of the historical exposure of water bodies to metals and their evolutionary importance for the aquatic communities of the AD.

Human occupation and climate as influences for the ecological change of a high-altitude lake in the Sierra Nevada, California

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High elevation lakes in the Sierra Nevada, California, have been subject to a number of stressors ranging from climate change to water diversion and eutrophication. High-resolution paleoenvironmental records are a powerful tool for understanding the natural variability of aquatic ecosystems and how they respond to changes in their surroundings. With the aim of understanding the impact that human activities have had in lakes in the Sierra Nevada, we collected a series of sediment cores from Gull Lake, located at the western edge of the Great Basin in eastern California. Through the use of diatoms as a biological indicator and charcoal as a fire proxy, we aim to identify changes in water quality in relation to human occupation of the basin. The sediment record spans the last 200 years and can be characterized by three distinct zones of ecological change. Zone 1 (*c* 1756 - 1908 CE) is defined by the abundance of *Stephanodiscus coruscus* and *Asterionella formosa*. Zone 2 (*c* 1913-1961 CE) shows a shift towards the dominance of *Stephanodiscus minutulus* and *Fragilaria crotonensis*. Zone 3 (*c* 1964-2021 CE) is defined by an increase in diatom diversity, with an increase in abundance of *Aulacoseira granulata var. angustissima* accompanied by an increase in the tychoplancton. These shifts are related to increases in nitrogen in the lake, suggesting an overall effect of human arrival in the area. The diatom reconstruction also suggests changes in the thermal stratification of the lake as a result of increasing temperatures, resulting in disrupted nutrient cycling. These results suggest that these remote and sensitive ecosystems should be studied in high resolution in a long-term scale in order to understand their natural variability and response to environmental stressors, allowing us to generate appropriate management strategies.

Stable isotope signals followed the changes in lake productivity in two alpine lakes

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Długi Staw lake (DLU) and Kurtkowiec lake (KUR) are located in the Hala Gąsienicowa Valley in the Tatra Mountains (Carpathians, Poland). The lakes are similar in many ways: both are located at similar altitude and climatic zone, both are oligotrophic and have similar lake area. However, some of their characteristics differ, and most important are depth, dominant vegetation in the catchment (meadow/rock vs. dwarf pine zone), catchment area and morphology of shores determined by lakes' origin. These features were enough to make the geochemical and palaeobiological records in these two lakes very different. Relatively high values of the $\delta^{13}C$, comparing to sedimentary OM of other lakes in the region, noted especially in KUR, point to inlake primary production as a major source of sedimentary OM in both lakes. Stable values of the C/N ratio (~9-12 in DLU and ~15 in KUR) suggest stable proportion of organic matter coming from inlake primary production and transported from the lakes' catchment. However, the amount of organic carbon and nitrogen and, most of all, changes in stable isotope composition of C and N, indicate changes in the lake environment. In KUR changes in $\delta^{13}C$ followed changes in C content, which additionally confirms stable source of OM deposited into sediments. In DLU this relationship was not so obvious and in lower portion of the core (depth >25 cm) $\delta^{13}C$ increased while C content was stable. In younger sediments (depth <20 cm) $\delta^{13}C$ started to follow C content. The switch coincided with change in diatom assemblage, namely decrease in the abundance of *Aulacoseira* spp. and *Pseudostaurosira elliptica* and an increase of *Sellaphora seminulum*, suggesting increase of lake's productivity.

Paleolimnological studies on the East European Plain: PaleoLake Database

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We have established a PaleoLake database where we summarized and analysed the available information on litho-, bio- and chronostratigraphy of bottom sediments of the different types of lakes located in the East European Plain and adjacent territories. PaleoLake combines results of more than 70 years of paleolimnological investigations and contains information on 287 studied lakes. The original data have been published mainly in Russian in more than 145 monographs, articles, dissertations, abstracts, scientific reports and other scientific sources and were hard to access for a broad international community. The PaleoLake database includes morphometric parameters of the studied lakes (area, mean and maximum depths), information on lake origin, information on studied sediment core(s) (core length, covered time interval, and age), results of laboratory analyses (lithology, geochemistry, etc.), micropaleontological data (pollen, diatoms, macrofossil, etc.), applied dating methods (type, material, methods etc.) and references. Complete sediment cores were investigated from 191 lakes. The most often studied time interval is the transition from the late Pleistocene to the beginning of the Holocene (from 12 000 to 9 000 years ago). Information on this period is available for 94 lakes. The database reflects the spatial distribution of the lakes and availability of suitable research objects. Synthesis of paleolimnological studies into PaleoLake will help to plan or optimize further investigations. The database will be supplemented with new information upon availability. The study supported by project No FSZN-2020-0016.

Past, present and future of megadroughts in high Andean lakes of northern and central Chile

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Chilean Andes lakes (18ºS - 38ºS) are important freshwater reservoirs critical to human wellbeing, and at the same time are highly vulnerable systems to human activities and climate change. The current mega-drought affecting the country is characterized by an uninterrupted sequence of dry years that has put water resource availability at risk. Moreover, human activities (e.g., mining, agriculture) strongly affect water quality and availability. In this context, the study of the lacustrine dynamics (i.e., volume, trophic state) and their relationships with climate variability are key to assess present and future changes in water availability. Despite their overall importance, very few studies address the temporal changes of basic data such as water volume, quality, and sediment input. Furthermore, improving the knowledge regarding how water reservoirs are impacted by ongoing hydric stress is crucial for water management decisions as well as mitigation measures. Here, we present the first results of a recently awarded project that aims to understand the climate and ecological impacts of the present and past droughts on high Andean lakes. We use a multiproxy approach that includes satellite images (lake-surface reconstruction), organic geochemistry analyses for both, lake (water column-sediment) and its watershed (soil-vegetation) and stable isotope analyses to monitor water quality and nutrient cycling. Our results will be available to scientific and non-scientific community and are expected to improve our understanding of future water availability across the region.

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FOCUS SESSION 23

2Kyr Lacustrine proxies of southern South America: understanding climate and anthropogenic impacts

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Reconstruction of the southern westerly winds core intensity during the Late Holocene based on aeolian particles of lacustrine sediments of Southern Patagonia (~51°S)

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The Southern Westerly Winds (SWW) play a fundamental role on the exchange of carbon dioxide between the ocean and atmosphere. Variations in the SWW position and intensity cause changes in precipitation and temperature affecting vegetation, fires and glacier extension. In the southern hemisphere, SWW extend between 30-60°S and its core is currently located at ~51°S. In this study, we present a qualitative wind intensity reconstruction for the last 2000 years based on aeolian particles found in the lacustrine record of the closed-basin Lago Dorotea, southern Patagonia (~51°S). Several analyses were conducted, including loss on ignition, radiocarbon dating, laser granulometry, X-ray fluorescence and provenance analysis using Sr-Nd isotopes. The isotopic results indicate a distal western source of sediments from the Southern Patagonian Batholith, discarding other sources nearby the lake. The record shows cyclic grain size variations for which we decided to use D90 as a proxy for wind intensity since it is the granulometric parameter that better reflects differences in grain size and, hence, the wind's capacity to transport large- or fine-sized particles. Radiocarbon dating allowed the temporal reconstruction of the SWW strength according to the D90 parameter. The results indicate an interdecadal-centennial alternance of SWW strengthening/weakening periods during the last 2000 years, characterized by a progressive strengthening during the last ~100 years. This is consistent with previous studies in the region and it's coherent with a positive SAM phase. This investigation validates grain size as a direct wind intensity proxy, contributing to the understanding of the SWW variability in Southern Patagonia.

Climatic and tectonic control on lacustrine sedimentary supplies over the last millennia in Chilean Patagonia (Lake Esponja 45°S)

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The environmental variability of Northern Chilean Patagonia during the last millennia is evaluated using a multi-proxy analysis of sediment cores from Lake Esponja (45°S - 72°W), a lake located in a glacio-tectonic valley. The sediments were analysed for grain size, magnetic susceptibility, organic matter, diatom assemblage, mineralogy, organic and inorganic geochemistry (C and N analyses by IRMS, XRF core-scanner at 1 mm). The age model is derived from ^{210}Pb, ^{137}Cs, ^{14}C data and tephrochonology. Lake Esponja sediments record ≤ 4 kyr of allochthonous detrital and volcanic supplies combined to variable autochthonous contribution in relation with diatom productivity in the water column. The sedimentation is interrupted by mm to cm tephra layers related to explosive eruptions of nearby volcanoes Macá, Melimoyu and Hudson. In the upper core, the diatom assemblages dominated by *Frustulia* and *Eunotia* indicate a closed and more acid basin. The closure of the basin is related to a rejuvenation of the local Mañihuales fault, in relation with regional earthquake recorded by a massive deposit described in the literature in Aysen fjord *ca.* 100 AD. The identification of both regional and local volcanic and tectonic-related perturbations in the LEs record is a prerequisite for further paleoclimate reconstruction.

Lacustrine record of last millenia precipitation from Lake Esponja and Lake Bertrand of Northern Chilean Patagonia (72°W)

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The aim of this study is to reconstruct climatic variability and its impact on the environment in Northern Chilean Patagonia during the last millennium, using a multi-proxy analysis of a sediment core from Lake Bertrand (46°55'S 72°50'W). The lake is located in the Aysen del General Carlos Ibanez del Campo region of north-western Patagonia. Core LBb11A (161 cm) was collected in a sub-basin of Lake Bertrand in 2011 at a depth of 21 m. XRF core scanner geochemistry and SCOPIX X-radiography were conducted at 1 mm sampling resolution. The lake sediments are mainly composed of clayey silts with some organic-rich layers. The XRF core scanner geochemistry indicates dominant detrital supplies (> 80%) into the lake. The organic matter mainly comes from the watershed. Correlations between sedimentological and geochemical parameters as well as instrumental data allowed the identification of precipitation proxies. A multivariate analysis was used to reconstruct the precipitation for the last 2200 years through the sedimentary sequences of the lake. The same approach was then applied on another lake (i.e., Lake Esponja 45°09'S, 72°08'W) on core LEs14 (150 cm) collected in 2014 at a depth of 40 m from the Aysén area. Both reconstructions and regional paleoclimatic information derived from lake sediments and other archives were compared as a validation of the approach. Events such as the Little Ice Age and the European Medieval Warming are common features in both sedimentary records. The application of similar methodology to other Patagonian lake sequences would bring a more global vision of the evolution of the climate in Patagonia over the last millennia.

A Common Era climate reconstruction at Lago Frío (Northern Patagonia, Chile): testing novel geochemical proxies

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The southern westerly wind belt (SWW) controls the hydroclimate of southern South America and is closely tied to upwelling and carbon cycling in the Southern Ocean. Recent work indicates that the position and long-term migrations of the SWW are directly tied to temperature anomalies in the Pacific Ocean but the timing and duration of the changes in the average position of the SWW are not well established. In this study, we investigate the relationships between regional climate and the long-term trends in the position of the SWW through a paleoclimate reconstruction using lake sediment derived biomarkers from a 2,000-year sediment record in Lago Frío, a small freshwater lake in southern Chile that lies in a highly seasonal area that depends on the SWW for winter-time moisture delivery. We closely examine specific intervals of interest that capture global climate phenomena, including the Medieval Climate Anomaly (MCA, a warm period from approximately 950-1250 AD) and the Little Ice Age (LIA, a cool period from approximately 1300-1800 AD). Studies have implied that there is a teleconnection between the Southern and Northern Hemisphere climate systems, and during these paleoclimatic events, temperature and precipitation fluctuations in the SH coincided with changes of a similar nature and on the same climatic variables but in the NH. Our results indicate that during the MCA, conditions were warm and dry in southern Chile, and while during the LIA, conditions were cool and wet, suggesting latitudinal and spatial variations in the SWW. Clarifying the timing and magnitude of global climate phenomena can enable us to predict future scenarios using models with greater fidelity. Our results also highlight the usefulness in biogeochemical proxies to study short term and low magnitude climate events from the last millennium.

Leaf waxes from lake surface sediments in southern South America: Testing a hydroclimate/vegetation proxy along a strong climate gradient

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The abundant precipitation of westerly origin controls the climate on the western side of the Andes Mountains with non-seasonal rainfall (i.e., year-round) from 55° to 42°S and seasonal rainfall pattern from 42°S to 30°S, associated with a seasonal drought at latitudes <42°S. As a result, the vegetation change (ca. 42°S) from Temperate and Valdivian Rain Forest to North Patagonian Evergreen Forest, a vegetation change characterized by a gradual decrease in diversity attributed to lower temperatures as well as changes in precipitation. Evaluating climatological changes along South-Central Chile is difficult because meteorological stations are scarce, and have low temporal and spatial resolution. Proxies and paleoclimate records are useful to gather data on climate variability in such remote areas with scarce instrumental records and compare to climate models evaluating their performance and improve future climate projections. Sedimentary leaf waxes derived from alkanes (>C25) and alkanoic acids (>C23) are among the most long-lived and widely utilized proxies of terrestrial organic matter. The abundance and distribution (i.e., Carbon Preference Index and Average Chain Length) of sedimentary plant waxes had been intensively used in environmental, modern and paleoclimate studies. Here we show the abundance and distribution of leaf-wax n-alkanes and alkanoic acids from a suite of lake surface sediment (core-top) samples spanning the transition from a Mediterranean climate with a patchwork of cultivated vegetation, pastureland, and conifers in central Chile to a rainy temperate climate dominated by broadleaf deciduous and evergreen forest further south. Data are correlated against latitudinal and orographic climatic trends and mean annual precipitation and temperature from reanalysis products of the Climate Forecast System Reanalysis - CFSR). We applied this dual leaf wax proxy approach to a paleolimnological reconstruction from Lago San Pedro, a small closed-basin lake located at ~38.5 °S, within the present-day region of Nothofagus-Araucaria forest in the Andean region. Acknowledgement: Fondecyt projects 1201277 and 1190398.

Environmental changes during the past millennium in northwestern Patagonia (41°S) inferred from a high-resolution diatom record

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The Pacific sector of northwestern Patagonia (NWP; 40°- 44°S) is a key region for deciphering the impacts of climate variability on terrestrial and aquatic ecosystems in the southern mid-latitudes. Modern climate analyses have detected a strong positive correlation between Southern Westerly Wind (SWW) intensity and precipitation in this sector, enabling the reconstruction of SWW variability through precipitation-sensitive sensors preserved in stratigraphic records. The most recent relationship between climate and environmental change, however, is compounded by land use changes since the arrival of Chilean/European settlers. How did ecosystems in NWP respond to the sequence and juxtaposition of climate change and anthropogenic disturbance has not been addressed with sufficient detail in the literature from this region. Here we present a new high-resolution fossil diatom record from Lago Pichilaguna (41°S), a closed-basin and shallow lake located atop moraines deposited during the Last Glacial Maximum. The diatom record reveals centennial-scale changes we interpret as alternations between warm/dry and cold/wet intervals. We attribute high abundance of small *Aulacoseira spp.* between ~1000-900 cal yr BP and ~600-300 cal yr BP to warm/dry conditions related to diminished SWW influence. This condition contrasts with increments of small fragilarioids and small raphid diatoms between ~900-600 cal yr BP and ~300-200 cal yr BP, likely favored by cold/wet conditions driven by enhanced SWW influence. A conspicuous shift in diatom assemblages started at ~200 cal yr BP marked by an abrupt transition in dominance from periphytic to planktonic diatoms, which suggests the onset of the driest phase during the last millennium. This shift overlaps with the onset of large-scale disturbance by Chilean/European settlers through the use of fire, native forest exploitation, and the establishment of pasturelands during the 19th century in this region.

A multiproxy sediment record of the last 200 years in Lake Llanquihue (Southern Chile): looking for productivity proxies and its usefulness in normative tools

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As part of a worldwide trend, Chilean lakes are undergoing a deterioration of its water quality which has generated national normative tools in order to stop the increasing trend in trophic-related parameters. Lake Llanquihue in southern Chile has implemented such tools based on the measurement of key parameters of water quality but not considering the information stored in bottom sediments. The aim of this research was to determine if total nutrients, total chlorophyll, and diatoms in a sediment core, allow to track recent trophic changes in the littoral zone of Lake Llanquihue and evaluate if such data can be useful for normative tools. A 30 cm long sedimentary core was obtained using a Uwitec gravity corer, at 20 m deep in the littoral area of Frutillar Bay, lake Llanquihue. Sediment sequence was dated using 210Pb and 137Cs and analyzed for total phosphorous, total nitrogen, chlorophyll and diatoms. Results show a clear increase in organic matter and carbonates from the 4 cm until the core top, a similar trend is evident in chlorophyll, increasing clearly around 1985 CE. Total nitrogen and total phosphorous show a noticeable increase after 1967 CE. Our findings indicate, i) an increasing pattern to the core top and coherency in the fluctuations of different proxies, in response to changes that occurred during the second half of the 20th century, ii) when comparing these trends with past water quality data, the latter one does not allow to infer any trend, indicating probably a higher sensitivity of the sedimentary record to trophic forcings. Hence these results highlight the importance to consider a paleolimnology approach in lake monitoring. This research was supported by Fondecyt projects 1201277, 11201231 and 1190398.

Diatoms, sedimentology and geochemistry study from a high altitude lake in the Fuegian Andes

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In order to analyze environmental and climatic changes during the late Holocene, a lacustrine sediment core was obtained from Laguna Ceniza (54˚ 40' 38" S; 68˚ 13' 13" O) located in a hanging valley in the Fuegian Andes (Argentina). The lake is fed by a stream originating from a small cirque glacier located in the valley head. The core (75 cm) was taken close to a delta of the stream and covers the last 2775 cal years BP. Here, we present the preliminary results based on sedimentological, geochemical and diatom data from the upper part of the core (last 1500 cal years BP). The sedimentological analysis shows the presence of six lithofacies: grey silty-sand, reddle silty-sand, laminated sandy-silt, laminated silt, grey clay-silt and white clay-silt. These lithofacies are likely associated to variations in the relative importance of glacier dynamics and mass movement processes from the valley slopes. The geochemical data (ITRAX core scanner) show a general decrease in the Al-Ti towards the top, and throughout the core there are several distinct peaks in Ca-Sr (possibly indicating input from the glacier). The diatom assemblages show a variety of species mainly dominated by *Pinnularia microstauron* (60 %) and *P. interrupta, P. viridiformis, Aulacoseira alpigena, Brachysira huitatorum, Encyonema difficilis, Frustulia aff fuegiana, F. rhomboides* and *Veigaludwigia urbana* in lower frequency (20%). In general, these taxa indicate a freshwater basin with oligotrophic conditions. At 16-17 cm of the core (900 cal years BP), *Achnanthidium minutisimum* reaches a frequency of 40%, together with an increase of *Psammothidium incognitum* (28%) and *P. confusum* (9%). The clear rise in the mentioned diatoms is associated to the reddle silty sand lithofacie, suggesting the occurrence of a high-energy flow event into the lake.

Diatoms and sedimentological parameters to study recent environmental changes in a small lake of Chilean Patagonia

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A multiproxy approach was used to reconstruct the limnological variations in Lake Maldonado (Chilean Patagonia), during the last 1300 years, in order to evaluate changes in the watershed and in the lake. For this purpose, a 50 cm sedimentary profile dated with ^{210}Pb and ^{14}C, was analyzed for the relative abundances of diatoms and sedimentological parameters. The diatom community was composed by 10 genera in total, being the most abundant *Punctastriata, Pseudostaurosira, Staurosira,* all of them characteristic of lakes situated in cold and dry climates. The proxies used here allowed us to identify changes in the lake that were linked to anthropogenic fires recorded in the 20th century as a result of the settlement process. In addition, the assemblage composition changed in the periods coincident with the Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA) chronozones. Our results contribute to the understanding of diatom diversity and its ecology in northern Patagonia, while providing insight into past environmental conditions like regional climate changes and recent anthropogenic impacts. Funding for this research was provided by Fondecyt projects 1201277 and 11201231.

Effects of human-driven impacts on the freshwater communities in Lanalhue lake, south-central Chile

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Climate change, contamination, and land-use (cover) changes are the main threats to Chile's continental water bodies, including the coastal lake Lanalhue (37.9°S - 72.3°W, 3 m a.s.l.). Soil loss has become the main environmental problem in this basin due to the intense activity of the forestry industry in recent decades. Although changes in the landscape are evident, the effects of soil loss on aquatic communities are poorly understood. In this work, we analyze the temporal changes of the chironomid and diatom assemblages for the past 1600 years to determine the main drivers that influence their compositional turnover downcore. The results show that between 400 and 1500 CE, the diatom community was characterized by the oligotrophic-adapted taxa *Staurosirella pinnata* and littoral chironomid *Ablabesmyia*, Tanytarsini 1D, and *Parapsectrocladius*. These assemblages reflect the pre-industrial baseline indicating good quality water in Lanalhue where small-scale prehispanic horticulture practices have been recorded (e.g., *Zea mays*). Around 1500-1600 CE, the decline in the diatom and chironomid remains at almost zero co-occurs with high values of inorganic matter that may evidence changes in the sedimentation rates. This is coincident with the Spaniard's arrival which led to a rapid decline of native forests and the intensification of large-scale farming practices from European colonization. After 1650 CE, both communities recovered the previous composition exhibiting high resilience after short to middle-term disturbances. With the beginning of the exotic-tree plantations in the basin after 1980 CE, the most significant compositional turnover occurs with the rise of taxa that tolerate high nutrient loadings and/or low oxygen concentrations: the diatom *Aulacoseira ambigua* and the chironomids *Parachironomus* and *Nanocladius.* The soil mobilization toward the lake and the contamination not only have impacted the diatoms and chironomids but also lead to the loss of ecosystem services in Lanalhue. Acknowledgments: FONDECYT #3220525 and #1201528, FNDR-PRELA 608897-63-LP18.

Characterization of tephras in two Chilean lakes and its implications on the geochronology for the last millennia

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Paleolimnological approaches require an accurate chronology, especially in a short time framework. Tephras are good palaeomarkers in lake sediments when they are well recognized, however in volcanic zones is hard to identify their source and age, then its interpretation is required to consider the deposition process, where morphological and granulometry features can be useful. The aim of our study is to characterize the morphology and grain size distribution in different tephra layers found in lake sediment cores of two small lakes located in the Southern Volcanic Zone (SVZ) to evaluate its use in age models during the last millennium. Two sediment cores of 135 and 131 cm were retrieved from Pichilaguna and Tepual, respectively. The age models based on ^{210}Pb and ^{14}C data established that both sediment cores cover the last two millennia. Visual inspection, X-ray, magnetic susceptibility, LOI550, and LOI950 permitted to recognition of six tephra layers in Pichilaguna and three in Tepual. Samples were cleaned with peroxide and acid treatment and all volcanic glasses were extracted and classified morphologically. Grain size distribution was performed in tephra layers and the upper and lower following sections. All tephra in both lakes were composed of angular and subrounded glasses, observing that the main difference was found in the proportion of each morphotype and grain size. The predominance of angular glasses (>80%) in tephra layers evidenced a primary volcanic deposition, while a high proportion of subrounded glasses (>60%) indicates a post-depositional volcanic event. High mean grain size and magnetic susceptibility values were associated with primary volcanic deposits, but their ranges changed for each lake, which could be related to distance from the volcanic source. We recognized three tephra in Pichilaguna and one in Tepual as primary volcanic deposits, that could support or improve the age models. Finally, chemical analysis can help us to confirm the source. This research is financed by the ANID/Fondecyt projects N°11201231, N°1201277 and CRHIAM/Fondap 15130015.

Paleoenvironmental reconstruction and paleoclimatic implications of Laguna de las Nutrias sedimentary record, SE-Uruguay (1500 CE to the present)

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Laguna de las Nutrias (LN) holds a relatively high-resolution sedimentary record for inferring the environmental response of the lake to the climatic variability, as it is a small shallow lake located within a protected area. We aimed to infer the environmental changes for the last 500 years and to determine their association with the climatic modes of variability (CMV). We performed µXRF (every 2 mm) scanning analyses from a sediment core retrieved from LN, which was dated combining both ^{14}C and ^{210}Pb techniques, and utilized Ti/Al, Ti/K, Ti/Ca, Fe/Mn, S/Ti, Br/Ti and Si/Ti as proxies for continental runoff, grain size, lake level changes, redox conditions, organic matter, storms, and productivity, respectively. The lowest sedimentation rates, runoff values and highest trophic state were recorded between 1500-1700 CE, assigned to the Little Ice Age-LIA, characterized by lower humidity conditions related to the inactivation of the South American Low-Level Jet (SALLJ). Subsequently, the highest and most variable/lowest and least-variable values of runoff/trophic state proxies were recorded up to the present, together with the highest sedimentation rates. This was related to the onset of the Current Warm Period-CWP, which was characterized by higher humidity conditions. Within such period, the highest sedimentation rates and the maximum runoff values were observed after 1980 CE, consequence of the notable increase in local rainfall during the climate shift that occurred since the 1970s. In addition, all proxies displayed multidecadal, decadal and inter-annual cyclicity, attributable to the CMV. In this sense, a high significant positive/negative correlation between runoff/trophic state proxies and the El Niño Southern Oscillation-ENSO reconstruction of Mann et al. (2009) was observed. ENSO modulates the frequency of SALLJ, thus generating an increase in rainfall and associated runoff into LN which lead to a decreased trophic state due to dilution processes.

Branched GDGTs from lake surface sediments: Testing global and local paleotemperature proxy calibrations

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Branched glycerol dialkyl glycerol tetraethers (brGDGTs) have shown great promise in lacustrine temperature reconstructions across different continents. While brGDGTs have been reported from many different regions and global brGDGT-temperature calibrations have been developed with various methods, many areas of the globe remain blank with little available data. Here, we discuss data from key understudied regions, Mexico/Central America (~100 samples) and southern South America (Chile, ~50 samples). These regions are critical to understanding major climate systems, yet modern climatological data remain sparse making paleolimnological studies valuable to understand changing climate – but only if the proxies applied are rigorously tested and validated. We investigated the relationships between the distribution of brGDGTs and temperature, developing regional calibrations for Mean Annual Temperature using multiple different approaches. To assess the fidelity with which these calibrations can be applied to different regions, we compare them with both existing and newly developed global calibrations, including novel machine learning methods such as Hierarchical Clustering, Ridge Regression and Random Forest. Within a region, different calibration approaches yield similar results, with similar error ranges. The existing global brGDGT-temperature calibrations tend to have a "cold-bias" in some areas, producing anomalously low temperature reconstructions at temperatures below 15ºC, likely due to a large proportion of arctic samples that spent significant portions of the year below freezing. Application of machine-learning techniques such as those discussed here facilitate the identification of bias in temperature proxy calibrations.

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FOCUS SESSION 24

Paleolimnology of high-latitude lakes: sensitive archives of past environmental change

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Diatom responses to Late Quaternary climate changes and feedbacks to organic carbon accumulation in Arctic lakes

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On Arctic expeditions in the last decades, we have retrieved long sediment cores from high-latitude lakes and performed multiproxy-based environmental reconstructions of boreal ecosystems. Based on our own and other published paleolimnological data from Late Pleistocene and Holocene lake sediment archives, we assemble standardized time-series of diatoms, organic matter, and geochemistry for data-science systems. Preserved diatom valves represent a major part of lake primary producers that can be described through alpha diversity, rate of species change, or valve concentrations. We compare diatom indices with accumulation of organic carbon, main element ratios, and heavy metal mercury load. Species assemblages reflect not only glacial-interglacial and secondary climate changes, such as Younger Dryas and Holocene Thermal Maximum, but also lake ontogenic trajectories. We investigate how catchment vegetation and lake algae production can cause lakes to become carbon sinks. In some lakes we find a lead-lag relationship between diatom diversity and carbon accumulation while at the same time diversity developments and valve accumulations appear to be driven by climate shifts. We observe millennial-scale carbon accumulation to be strongly correlated with mercury concentrations. However, northern remote and pristine lakes show mercury contamination caused by anthropogenic industrialization since 1850 CE. Based on our multiproxy evidence, we discuss potential mitigation effects of long-term environmental change through diversity-productivity-geochemistry interactions deduced from paleolimnological time series. If lakes act as natural long-term buffers to external stressors such as warming, land-use intensification, and industrial contaminants, we anticipate a substantial threat to potential self-regulation and deposal mechanisms of natural high-latitude lake ecosystem over ongoing anthropogenic impact.

Holocene methane emissions from high latitude Alaskan lakes

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Temperatures are increasing at an unprecedented rate, with northern high latitude regions warming almost twice as fast as the global average. These landscapes have a large proportion of the world's freshwater lakes and ponds, which are highly vulnerable to climate change and a large natural source of methane, an important greenhouse gas. As temperatures increase, methane emissions from these lakes are expected to increase; however, the magnitude and timing of this increase remains uncertain. Proxy-based estimates of lake-methane production during warmer periods, such as the early Holocene (8,000-11,000 cal BP) can help validate model simulations of how much methane can be produced and released in lake systems under warmer climates. These proxies include the stable-carbon isotope values ($\delta^{13}C$) of bacterial hopanoids and remains of aquatic invertebrates. The $\delta^{13}C$ values measured on sedimentary remains of these proxies are lower when methane-derived carbon is an important part of the lake carbon cycle. Our proxy-based estimates of methane production from lakes across Alaska during the Holocene suggest that methane availability could have been 2-5 times higher during the warmer early Holocene than at present. These results can help validate modelling studies which also predict increasing high-latitude lake methane emissions under future warming scenarios.

Holocene hydroclimate and its influence on carbon cycling of a northern boreal lake

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The present rate of climate warming above the Arctic Circle intensifies the water cycle and is likely to increase precipitation in the form of rain. The changing hydroclimate will have a marked influence on terrestrial hydrology, catchments, and lakes, a predominant landscape feature at high latitudes. Hydroclimate changes have the potential to modify lake thermal structure and water levels, and catchment inputs of water, sediment and organic matter (OM). Consequently, lakes are likely to face ecological alterations in their internal structure and processes. However, we have little knowledge of hydroclimate impacts on lake OM source and carbon (C) cycling over pre-anthropogenic time scales. In this study, we probe the influence of varying Holocene hydroclimate on the OM cycle of a northern boreal lake (Lake Kuutsjärvi, eastern Finnish Lapland, 67˚44'49'' N, 29˚36'35'' E) in terms of quantity (accumulation) and quality (sources). We will present the reconstruction of the lake hydrology using $\delta^{18}O$ from head capsules of fossil Chironomidae and the parallel changes in lake OM cycle based on elemental (C, N) and stable isotopic ($\delta^{13}C$, $\delta^{15}N$) composition of sediment OM. To reinforce the past biogeochemistry, we also studied the present-day ecosystem. We will characterize the lake hydrological proxies using yearlong monitoring data of water isotopic composition in precipitation and lake water and Chironomidae head capsules from surface sediment. In addition, we implemented an end-member mixing model based on $\delta^{13}C$ and C:N of modern POM, algae, and plants from the catchment and lake as sources and the lake sediment signatures as mixtures. Our results show shifting trends in the sources and accumulation of OM. There is a high accumulation of OM from the catchment at the onset of the Holocene, decreasing and changing to a predominant autochthonous production throughout the epoch. We will present these interpretations alongside the hydroclimate reconstruction.

Disentangling ecologies of key diatom taxa in West Greenland lakes using paleo- and neo-limnological approaches

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Arctic lakes are experiencing major ecosystem shifts in response to rapidly increasing air temperatures and earlier timing of ice-out. In many Arctic lakes, small centric diatoms have recently increased in abundance which has been interpreted as a response to reduced ice cover, longer open-water periods, and enhanced stratification. However, contrasting shifts in diatom community reorganization have been observed across the Arctic despite the widespread trend towards higher air temperatures and earlier ice-out. For example, diatom communities in West Greenland lakes have become increasingly dominated by benthic taxa while many planktonic species have declined within the past three decades. Explaining these opposing trends will require a better understanding of how key diatom taxa respond to changing environmental conditions; however, the lack of relevant limnological data has hampered attempts to better define their ecologies. Here, we combine paleo- and neo-limnological approaches to further explore environmental relationships of individual diatom species to better understand their ecological preferences and hence their utility in interpreting responses to recent climate change in paleolimnological records. Using two sets of surface sediments collected pre- (1996) and post- (2013) climate shift from 21 lakes in West Greenland, we identify species with strong responses during this time frame. Focusing on key diatom taxa (*Lindavia* and *Fragilaria* species), we link changes in species abundance to physical responses of lakes to climate change, leveraging a comprehensive limnological dataset (2010-2022) and climate-based modeling for inference of past lake conditions. Combining long-term limnological data and modeling provides a unique opportunity to gain insight into how diatoms respond to climate-driven environmental shifts.

Isotope-based southern westerly winds reconstruction from South Georgia reveals stable Holocene until Common Era intensification

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The Southern Hemisphere westerly winds sustain the Southern Ocean`s role as one of Earth`s main carbon sinks, and have helped sequester nearly half of all anthropogenic CO_2 stored in the ocean since the industrial revolution. Observations reveal shifts in the vigor of this global climate regulator, but climate models don`t agree how future changes may impact carbon storage due to a scarcity of baseline data. Here, we use the hydrogen isotope ratios of sedimentary leaf waxes from a lake in sub-antarctic South Georgia to resolve Holocene changes in Southern Hemisphere westerly wind strength. Our reconstruction suggests that stable conditions prevailed until the Common Era ~2000 years ago, when waxes from aquatic plants became progressively enriched. We attribute this isotope excursion to Southern Hemisphere westerly wind-driven evaporation of lake water. Regional paleoclimate evidence shows this trend coincides with the onset of a negative phasing of the Southern Annular Mode – the Southern Ocean`s main mode of atmospheric variability. Because this shift is unmatched during the ~7000-year period covered by our record, our findings suggest that the millennium-long Southern Annular Mode indices that are used to benchmark future change may not capture the full range of natural variability.

A Holocene-length multi-proxy record of climate change and volcanic activity on Kerguelen Islands

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Climate dynamics around the Antarctic count within the pacemakers of global climate changes. However, the long-term climatic evolution of Southern mid-latitude remains greatly unknown over most part of these remote areas due the absence of adequate natural archives. In this paper, we present the first Holocene-long high frequency record of volcanic activity and climate changes based on a lake sediment record from Kerguelen Archipelago in the Subantarctic Indian Ocean. Lake Armor is a 4 km-long fjord-type lake located in the central area of Kerguelen mainland. It is made of 3 sediment basins, among which 2 have been cored over the whole Holocene period. The sediment was dated using ^{14}C macroremains. The presence of 8 major local volcanic deposits was identified using visual description and geochemical logging. Major element geochemistry of glasses led to characterise each of them with the aim of establishing the basis for a further Kerguelen tephrostratigraphy. We also established the first high resolution magnetic secular variation curve in the region. Climate dynamics was approached by combining the study of organic matter molecular and isotopic compositions, GDGTs and leaf wax δD. We also documented the input of marine and long-distance aerosols using metal (Br, Hg, Se) and PAHs concentrations, respectively. The integration of the whole dataset is ongoing and will permit a better understanding of the climate dynamics in the area.

Microbial communities as sedimentary indicators of anthropogenic impact on Fildes Peninsula (King George Island, Maritime Antarctica)

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Fildes Peninsula has been the site of year-round human presence since the construction of Bellingshausen Station in 1968, is among the Antarctic regions with the highest intensity of human activity, and is situated in a region that is greatly influenced by global warming. Consequently, alterations to the environment have been noted, for example due to transportation and oil pollution. However, the degree of environmental impact is still poorly understood and monitoring programs in general have only been in place since the agreement of the Protocol on Environmental Protection in 1998. There is thus a lack of data concerning the region's natural state before the increased human presence. Lakes are a pervasive feature of Fildes Peninsula landscapes, some of which are used as water sources, with a large number in close proximity to the permanent stations. In order to establish changes over the past century in the microbial community composition of four lakes in the Fildes Peninsula, sediment cores were taken to examine biological indicators including fossil pigments (by HPLC) and ancient microbial DNA (subjected to next generation sequencing). Biological indicators were combined with analysis of organic and inorganic sediment geochemistry. We observed that bacterial communities in lakes closer to stations underwent major changes since ~ 1970 as well as certain bacteria groups (e.g., Desulfobacterota and *Anaerolineae*) that became more abundant in recent times. Increases in primary production, together with anoxic conditions and metals that are common in gasoline (e.g., Cu and Zn), may be related with the increased anthropogenic activities, particularly in the lakes closer to the airport. We also observed changes in bacterial communities in the lake furthest from the research stations, indicating that other factors such as the pronounced climate warming observed in the region could also help explain community structure shifts in Fildes Peninsula lakes.

Arctic terrestrial ecosystem change over the last 54,000 years revealed by sedimentary ancient DNA on a lake sediment core from Far East Russia

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Arctic environments are threatened by recent warming and have experienced climate transitions in the past. Important environmental archives in poorly studied Siberian regions are lake sediment cores. We recovered a 10 m long sediment core from Lake Ilirney, located in a continuous permafrost zone in Eastern Chukotka (Russian Arctic), that covers the last 54,000 years including warmer (at about 30-36 ka and from 16 ka-towards today) and cooler periods (at about 54-36 ka and 30-16 ka). We used sedimentary ancient DNA (sedaDNA) shotgun sequencing to discover past biodiversity changes of the terrestrial catchment community under different climate periods. Our data reveal that the catchment vegetation around lake Ilirney changed from herb, with herbivorous mammals occurring during cooler times, to shrub dominated plants since 16 ka. Along with an increase in woody vegetation in warmer periods associated biota responsible for plant organic matter degradation, like saprotrophic fungi and lignin degrading bacteria, increased accordingly. Beside the reconstruction of past taxonomic composition, the sedaDNA data revealed changes in the functional biodiversity. Particularly, carbon degrading enzymes for lignin and chitin increased in relative abundance in warmer periods, supporting an increase in degradation of complex organic molecules. Thus, our results support that under future warming the expansion of shrubs, accelerated permafrost thaw and the increase of specified degraders in Arctic terrestrial environments might lead to higher carbon cycling with a potential positive climate feedback.

Climate-mediated microbial shifts in lakes from northernmost Ellesmere Island, High Arctic Canada

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At the northernmost fringe of land on Earth, the northwest coast of Ellesmere Island is a highly dynamic region at the interface of the Canadian Arctic Archipelago and the Arctic Ocean ice pack. Northern Ellesmere Island has seen important Holocene climate variability that does not appear to have been uniform across the region, and spatiotemporal climate trends in the region are still poorly constrained. This information is critical for assessing recent changes in climate, ice shelves and sea ice in the context of long-term natural variability. In Stuckberry Valley (82° 54' N, 66° 56' W), a series of four lakes ascends along a transect from the ocean up to 56 m asl. The marine limit in this region was 124 m asl and these lakes were thus submerged sea floor depressions when glaciomarine environments appeared following glacial retreat at around 11 400 years ago. The lakes were later sequentially separated from the ocean by isostatic uplift. We took sediment cores from the four lakes to evaluate the long-term environmental changes in this sentinel region, and analyzed them by geochemical measurements and microbial RNA sequencing. Synchronized transitions in these properties indicated a recent change towards more organic and reducing conditions. These responses reflect recent climate warming and the effects of longer growing seasons in this polar desert region.

Is it possible to study eider populations from Canadian Arctic by applying paleolimnological techniques to their nests?

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Arctic populations of the Northern Common Eider (*Somateria mollissima borealis*) have experienced large-scale variations in colony size during the past century in response to a variety of environmental pressures including 19th century industrialization, unsustainable harvesting practices in the mid-20th century, and recent climate change. However, standardized population surveys of eiders from remote Arctic locations only began at a few locations in the 1950s, without knowledge of baseline conditions. In this exploratory study, we used multiple paleolimnological proxies (diatoms, phytoliths, chrysophyte cysts, protozoan plates, stable isotopes) from a suite of ^{210}Pb-dated eider nests sampled near ponds from Digges Sound and Baffin Island (Canadian Arctic). We asked: Do eider nests archive a reliable geochronological record containing paleoecological proxies? Can dated eider nest profiles establish how long eiders have occupied the region? Can paleolimnological approaches provide insights into long-term changes in the nest environment and eider populations? Our dated nest profiles indicate that eiders have occupied the region since the pre-industrial era. Continuous nest occupation by eiders together with climate amelioration in the 19th century likely provided suitable conditions for in situ siliceous indicators to become well established, with diatom assemblages comprised of aerophilic taxa (mainly *Pinnularia intermedia, P. borealis, Hantzschia amphioxys*). Trends in ∂^{15}N values provide further insights into nesting eider responses to environmental change. This novel approach, especially when combined with paleolimnological studies of adjacent ponds, shows much promise for tracking bird populations in remote locations.

From small tundra ponds to Canada's "Northern Great Lakes": a paleolimnological comparison of regime shift changes linked to climate warming

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Our understanding of the responses of mid-sized and small Arctic lakes to recent climate warming and other stressors has greatly increase recently. However, little data are available on even the basic limnological conditions of the "Northern Great Lakes". In fact, the late David Schindler noted that the dearth of scientific information available for "Canada's Northern Great Lakes" was "a national disgrace". We have been employing paleolimnological approaches to reconstruct how ecosystems from three of the world's largest and deepest high latitude lakes have responded to climatic change and other stressors. Here, we compare lake trajectories, over the last ~200 years, for Lake Hazen (Ellesmere Island, Nunavut), Great Bear Lake (NWT), and Great Slave Lake (NWT), and compare these to changes observed in nearby medium and small-sized lakes in the Canadian Arctic. Using primarily diatom-based paleolimnology, we address questions such as: What were the baseline limnological states for these "Northern Great Lakes"? Has recent warming affected the algal communities of these large, deep Arctic lakes? How do trends compare among sampling locations within and between lakes? The three lakes share similar trends and register major diatom compositional shifts and changes in sedimentary chlorophyll *a*, reflecting accelerated Arctic warming, rapidly declining ice covers and wind speed, and fundamental changes in lake thermal structure. A clear continuum of predictable changes show that climate thresholds have recently been surpassed. These changes will undoubtedly cascade throughout the ecosystem affecting food web changes important to local Indigenous populations and to the global community.

Application of a Bayesian mixing model framework to generate novel 'paleohydroscapes' at a freshwater boreal delta (Alberta, Canada)

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For 60 years, concerns centered on landscape drying have dominated narratives at the Peace-Athabasca Delta (PAD), a boreal floodplain fed by two rivers. Here, we apply a Bayesian mixing model (BMM) framework to generate novel 'paleohydroscapes' from elemental concentrations in individual sediment samples selected at ~10-year intervals in cores from 18 lakes across the PAD to track paleohydrological changes at the landscape scale and their causes. This presents a major advancement over conventional paleolimnological approaches because elemental concentrations can be measured across the full gradient of mineral-rich to organic-rich sediment typical of floodplain lakes, and it provides detailed information on the hydrological pathways of sediment delivery. Results reveal four distinct intervals of differing influence of floodwaters from the Athabasca and Peace rivers during the past ~140 years. The first (~1880 to ~1935) and third (~1965 to ~1975) intervals depict strong influence of Peace and Athabasca river floodwaters. In contrast, lower spatial extent of floodwaters from both rivers is inferred during the second (~1945 to ~1955) and fourth (~1985 to present) intervals. Marked spatio-temporal variation in flood extent since ~1880 suggests a strong role of climate, which is reinforced by less extensive flooding depicted in ~1945, before Peace River flow regulation. The paleohydroscape for ~1975 infers Peace River waters penetrated to the southern Athabasca Delta during the 1974 flood (farther than any time since ~1880), which is new information provided by the BMM. Overall, results from the BMM align remarkably well with prior interpretations from conventional paleohydrological records of individual lakes. Thus, this method provides a powerful approach to improve our spatio-temporal understanding of hydrological change in the PAD and inform environmental stewardship, and is transferable to other dynamic floodplain landscapes where variation of sediment composition challenges efficacy of other approaches.

High-resolution X-ray fluorescence lake sediment records of ice-jam flood frequency and intensity in the Peace-Athabasca Delta, Canada

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The Peace-Athabasca Delta (PAD), Canada, is an ecologically and culturally important floodplain landscape of ~6,000 km^2 subject to multiple potential stressors. Concerns persist over declining ice-jam flood frequency, a critical hydrological process that sustains the delta, highlighted by ongoing assessment by UNESCO to determine whether Wood Buffalo National Park (in which 80% of the PAD is located) should be designated as a World Heritage Site in Danger. For 20 years, paleolimnological investigations have sought to establish baseline conditions and the range of natural variability in the PAD, to enable insight into the causes of hydrological change. Pivotal findings include evidence of declining flood frequency from magnetic susceptibility measurements in oxbow lake sediment records beginning decades before hydroelectric regulation of the Peace River in 1968, attributed to climate change. In 2019, new sediment records from the same oxbow lakes were obtained with gravity and Russian corers to further explore flood history during the past three centuries using high-resolution X-ray fluorescence (XRF). We demonstrate excellent reproducibility of the magnetic susceptibility measurements for the two sets of sediment cores collected 18 years apart. XRF and grain size analysis of gravity cores identified elemental ratios which serve as grain size proxies (Coarse: Zr/Ti, Zr/Fe, W/Fe, Si/Al, Si/Al/Fe/K, Si/Al/Fe/Ca, Fine: Fe/K/Zr/Ti, Fe/Ca, Rb/Ti), to reliably interpret the high-resolution (0.5 mm ≈ bi-weekly) XRF scans of the Russian cores. Principal Component Analysis of the XRF elemental ratios provides an index of grain size variation in the form of PCA 1 scores and a robust stratigraphic record of Peace River ice-jam flood frequency and intensity. Key results include interdecadal flood frequency variability corresponding to the El Niño-Southern Oscillation and declining flood frequency and intensity since ~1890 likely due to decreasing river discharge and weakening river ice as a consequence of global climate change.

Investigating lake ecosystem response to increased temperatures and wildfire occurrence

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Globally, oligotrophic lakes are disappearing; however, owing to multiple stressors, it can be difficult to pinpoint a specific cause for a trophic shift in a given lake. At high latitudes, where nutrient inputs are typically low, warming is often an important factor affecting algal production. Here we investigate the direct and indirect effects of warming temperatures on algal production. We evaluate whether increased temperatures (direct effect of warming) and wildfire occurrence (indirect effect of warming) lead to increased algal production in northern boreal lakes. Warming temperatures can alter ice-on/ice-off periods and thermal stratification, whereas wildfire occurrence may alter light penetration and nutrient deposition, all of which can change primary production. We retrieved sediment cores from six lakes located near Yellowknife, NWT, Canada. The lakes include three >5 m and three <3 m deep in recently (<5 years) and more historically (>20 years) burned catchments. Based on ^{210}Pb and ^{14}C dating, these sediment records span the last 500 to 1200 years. Diatom community composition, organic content, and sedimentary chlorophyll-*a* were determined to investigate direct and indirect effects of warming on primary production. We found that warmer temperatures are likely directly driving the increase in algal production in all lakes. In contrast, we found that wildfire occurrence is not affecting long-term changes in algal production. Instead, the effect of wildfire occurrence on algal production is short-lived, if any, and affects shallow lakes more than deep lakes. Therefore, as warming continues, the direct effect of increased temperatures over the indirect effect of wildfire occurrence is of greater concern in northern boreal lakes. Our research contributes to our understanding of the effects of a warming climate on northern boreal lakes.

Rapid permafrost degradation impacts on western Canadian Arctic lakes: a decadal to centennial scale perspective

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In ice-rich permafrost regions, hillslope thermokarst disturbances can result in the mass movement of soils and sediments following thaw. Retrogressive thaw slumps are among the most spectacular forms of permafrost thaw and are common in ice-rich permafrost regions across the western Canadian Arctic, Alaska, and Siberia. Thaw slumps commonly form on the margins of lakes, rivers, and coastal areas, and can potentially contribute large quantities of sediment to receiving these waterbodies. Lake sediment-based techniques are well suited to studying thaw slumps, due to a lack of pre-impact monitoring data, and their ability to simultaneously track inputs of terrigenous materials, while inferring limnological changes in impacted lake ecosystems. Our previous paleolimnological work in the Mackenzie Delta uplands region of the western Canadian Arctic used diatoms to track limnological changes because of thaw slumping. As these sediment cores were collected ~15 years ago, here we present updated research exploring how previously studied lakes have changed, and how new, highly active slumps are impacting lakes. We used remotely sensed images to determine changes in thaw slump size and activity status between 2005 and 2016. These changes were compared to water chemistry samples taken over the same time periods, to infer limnological changes associated with changing permafrost thaw impacts. We will also present results of a multiproxy (TOC, TN, particle size, diatoms) analysis of a lake with a highly active thaw slump, as a potential window into how new slumps will impact lakes in this rapidly warming location. Finally, we will describe sediment proxies for tracking thaw slump activity that have been identified from a broad paleolimnological survey. This research will demonstrate the important role paleolimnology plays in tracking thermokarst in ice-rich permafrost locations.

Paleoclimate reconstruction in Debauchery Bay, Northwest Territories Canada using particle size analysis and geochemical proxies

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Climate variability significantly influences lacustrine systems, impacting physical, chemical, and biological components. This is particularly true of lakes situated in high-latitude northern environments, such as in Walsh Lake, near Yellowknife, Northwest Territories, Canada, where the impact of a changing climate is particularly pronounced. Of particular concern in this region is the widespread contamination by arsenic associated with mineral processing at the former Giant Mine. In this study, high resolution ITRAX XRF and particle size data obtained from two freeze cores recovered from sites in Walsh Lake were analyzed to infer and quantify late Holocene changes within this lake system and implications for the mobility and fate of arsenic and other elements of concern in surface water environments. Through examining proxy data preserved in freeze cores dated to ~1100 cal yr BP, results suggest that arsenic sequestration in sediments has been linked with the presence Fe and Mn (oxy) hydroxides in oxygenated shallow sedimentary environments. Climate warming associated with the Medieval Climate Anomaly and subsequent cooling associated with the Little Ice Age impacted sediment geochemistry, demonstrating climate controls on mobility and sequestration of trace metals in high latitude lacustrine environments.

Mercury deposition from terrestrial reservoirs is a predominant process in sub-arctic and low Arctic lakes: evidence from a spatial survey and a ~1270 year lacustrine sedimentary record from northern Canada

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In sediments of high northern latitude lakes mercury (Hg) is scavenged by autochthonous organic matter, and recent increases in primary production have resulted in increased accumulation of Hg. Terrestrial reservoirs (e.g. permafrost soils, peat bogs) also contain Hg that can be liberated by climate-mediated processes. A combined survey and paleolimnological approach was applied to better understand processes associated with Hg accumulation in lake sediments. Near surface sediments from 66 lakes spanning a 3° latitudinal gradient in the central Northwest Territories (NT), Canada, were sampled and analyzed for elemental geochemistry, Hg, organic matter type, and sedimentary grain size. Total Hg concentration (5.08 to 222.51 $\mu g \cdot kg^{-1}$) is significantly (p<0.05) correlated with terrestrially-derived S3 carbon (r_s=0.51). Mercury and total organic carbon (TOC), S1, S3, and grain size do not differ significantly (Kruskal-Wallis test) in lake sediments below vs. above treeline, but algal-derived S2 carbon is significantly higher in boreal lakes. The relationship between Hg and S3 indicates export of organic-bound Hg from lake catchments in boreal and tundra environments. In a *ca.* 1270 year sedimentary record from Walsh Lake, NT, Hg peaks to 546 $\mu g \cdot kg^{-1}$ at 1070 CE and 246 $\mu g \cdot kg^{-1}$ at 1300 CE, contemporaneous with onset of the Little Ice Age, and concentrations are low (11 to 30 $\mu g \cdot kg^{-1}$) in sediments younger than 1400 CE. Mercury is positively associated with clay, sand, and Se, and negatively with silt, S1, S3, and TOC. Principal Components Analysis reveals a relationship between Hg and Cu and Zn. Arsenic is positively correlated to Fe and Mn, suggesting deposition in an oxic setting. Geochemical profiles and relationships in the Walsh Lake core suggest that Hg is associated with clay minerals deposited in a well-oxygenated setting, and partially sourced from mineralized bedrock and derived surficial materials.

A continental-scale chironomid training set for estimating Arctic temperatures

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We present chironomid species assemblage data from 402 lakes across northern North America, Greenland, Iceland, and Svalbard to inform interpretations of Holocene subfossil chironomid assemblages used in paleolimnological reconstruction. This calibration-set was developed by re-identifying and taxonomically harmonizing chironomids in previously described surface sediment samples, with identifications made at finer taxonomic resolution than in original publications. The large geographic coverage of this dataset is intended to provide climatic analogs for a wide range of Holocene climates in the northwest North Atlantic region and North American Arctic, including Greenland. A suite of chironomid-based temperature models based upon this training set are evaluated here to reconstruct late glacial and Holocene paleotemperatures at five non-glacial lakes representing a wide range of climate zones across Greenland. The new continent-scale training set offers more analogs for the majority of Greenland subfossil assemblages than existing smaller training sets, with many analogs in Iceland and northern Canada. We find strong agreement between chironomid-based reconstructions derived from the new model and independent glacier-based evidence for multi-millennial Holocene temperature trends. Some of the new Holocene reconstructions are very similar to published reconstructions, but at a subset of sites and time periods we find improved paleotemperature reconstructions attributable both to the new model's finer taxonomic resolution and to its expanded geographic/climatic coverage, which resulted in increased characterization of species optima. In the late glacial, the new model's finer taxonomic resolution yields unique ability to resolve temperatures of the Allerød from colder temperatures of the Younger Dryas, although the magnitude of that temperature difference may be underestimated. This study demonstrates the value of geographically and climatically broad paleoecological training sets. The large, taxonomically harmonized dataset presented here should be useful for a wide range of future investigations, including but not limited to paleotemperature reconstructions across the Arctic.

Study of lake sediments on King George Island (West Antarctica)

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Climate warming is reducing the area of glaciers, which are being replaced by lakes. In the context of scientific interest in modern climatic changes on the Earth, the study of changes in natural and climatic conditions in the Holocene is of obvious value. One of the most promising locations for paleoenvironmental study is the Fildes Peninsula of King George Island (West Antarctica). Paleogeographic research in this area was conducted by the AARI in 2008-2015. Analysis of the materials revealed a lack of detailed data on changes in the island's climate during the last 10,000 years. On King George Island, the sediments of several lakes were studied, but they reflect distinct paleoclimatic signals only for the last 5000 years, as previously these lakes were part of the sea. In 2019 field work was conducted on King George Island on the lake above the level of Early Holocene marine transgression. Bottom sediment cores were sampled from the ice using a peat corer. As a result of the work, bottom sediments of 6 lakes (Geographov, Jura, Slalomnoye, Gostinichnoye, Trigorskoye and Mesyats) were sampled and described. The results of lithological analysis and XRF scanning will be presented at the conference. Interpretation of changes in the considered parameters in each of the distinguished stages of sedimentation will make it possible to establish under what conditions sedimentation took place and to reconstruct the climatic signal in detail.
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Arctic lakes: Archives of Quaternary paleoclimate, paleoglaciology, and paleoecology

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Seasonal distribution of precipitation on Svalbard modulated by regional ocean surface conditions and sea ice during the Holocene

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Climate on the Svalbard archipelago is sensitive to changes in large-scale atmospheric circulation, ocean heat content, and sea-ice cover. Precipitation is projected to increase this century, most notably in the northeast and during the winter months. However, model uncertainties are large, partly due to sparse and temporally limited observational records. We reconstruct Holocene precipitation seasonality and summer humidity using the hydrogen isotopic composition (δ^2H) of leaf waxes from four lake sediment records. Sediment cores were collected along a climatic gradient from relatively warm and humid western Svalbard to relatively cold and arid northeastern Svalbard. We measured δ^2H of long- and mid-chain *n*-alkanoic acids, reflecting terrestrial (δ^2H_{terr}) and aquatic (δ^2H_{aq}) plant source water. δ^2H_{terr} mainly represents summer precipitation and evapotranspiration, whereas δ^2H_{aq} can reflect varying precipitation seasonality depending on lake hydrology. For one lake, we inferred summer evapotranspiration changes using the difference between δ^2H_{terr} and δ^2H_{aq} (ε_{28-22}). In the Early and Middle Holocene, relatively ^2H-enriched δ^2H_{terr} and higher ε_{28-22} indicate warmer and drier summers, or more proximally sourced summer moisture. Decreasing δ^2H_{aq} in two lakes on northern Svalbard suggests an increasing proportion of winter precipitation (relative to summer), associated with regional warming and diminishing sea ice. After 6-5.5 cal. kyr BP, summers became cooler with less evapotranspiration or more distally derived moisture, as indicated by ^2H-depleted δ^2H_{terr} and lower ε_{28-22}. Furthermore, δ^2H_{aq} increased as a response to ocean surface cooling, more sea ice, and reduced moisture supply, limiting the amount of winter precipitation. Large δ^2H_{aq} shifts in the Late Holocene suggest changing sensitivity of two of the lakes to the seasonal distribution of precipitation. We find that Holocene summer precipitation δ^2H on Svalbard mainly follows changes in summer insolation and temperature, whereas the seasonal distribution of precipitation is sensitive to regional ocean surface conditions.

Post-glacial species arrival and diversity build-up of northern ecosystems took millennia

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What drives ecosystem build-up, diversity and stability? We assess species arrival and ecosystem changes across 16 millennia by combining regional-scale plant sedimentary ancient DNA from Fennoscandia with near-complete DNA and trait databases. We show that postglacial arrival time varies within and between plant growth forms, with mean estimated arrival tending to be later for dwarf shrubs than for other growth forms. Further, arrival times were mainly predicted by adaptation to temperature, disturbance, and light. We used the abundance of plant taxa in each plant trait category as an estimate of niche space presence and occupation through time, which allows a reconstruction of past changes in temperature optimum, continentality, moisture, light, phosphorus, soil disturbance, dispersal mode, mycorrhiza and pollinator dependence. Major breakpoints in ecological trait diversity were seen between 13.9 to 10.8 cal ka BP, shifting from a state of ecosystem build-up to a state where most habitat types and biotic ecosystem components were in place. Similarly, the functional diversity showed a breakpoint at 12.0 cal ka BP, and plants of most trait values had arrived by that time. Trait and functional diversity stabilised around 8 cal ka BP, after which both remained stable, even though changes in climate took place and species inflow continued. Our ecosystem reconstruction indicates a millennial-scale time phase of formation to reach stable and resilient levels of diversity and functioning.

Deglacial and Holocene paleoclimatic events in southcentral Alaska from carbonate lakes

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New sedimentary, geochemical, and paleoecological evidence from multiple carbonate lakes indicate rapid change in water balance, carbon cycling, and meteoric source water during global deglaciation, which followed local deglaciation of Upper Cook Inlet in southcentral Alaska. Early carbonate lakes formed in the newly deglaciated herbaceous landscape by ~14,500 cal yr BP under the influence of reorganized North Pacific conditions with final Cordilleran ice sheet decay during a period of human migration. Prominent periods of change include the Bølling-Allerød transition, with trends expressed clearly from all lakes in organic and inorganic carbon abundances. Unusually large organic carbon isotope signatures and trends reflect the onset of carbon utilization, which possibly include thawed permafrost sources and groundwater flow initiation. Reversal in all isotopic trends for organic and inorganic carbon and carbonate oxygen occurred across the Younger Dryas and early Holocene chronozones. They are associated with a rise in Birch pollen and appear to correlate with closing of the Bering Strait and subsequent changes in North Pacific temperature, salinity, and sea ice extent. A relatively quiescent early to middle Holocene period is characterized by high lake biological productivity and paleosol development as the near-modern Boreal-hardwood Forest developed. During the late Holocene, higher carbonate production and preservation occurred during a period of well-known loess accumulation. Between 3000 and 2500 years ago, a shift occurred to high frequency carbon and oxygen isotope variability, with magnitudes that approached deglacial extremes, although differentiated by unique climatic forcing mechanisms such as ENSO/PDO-like North Pacific dynamics. A better understanding of the climate scenarios during each of these periods of time is developed by comparison between oxygen isotopic data in carbonate lakes with contrasting hydrologic controls and the additional environmental proxy data.

Late Holocene vegetation and fire history in Western Putorana Plateau (subarctic Siberia, Russia) inferred from pollen and charcoal analysis of the lake sediments

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We present a reconstruction of vegetation dynamics and fire history from the western part of the Putorana Plateau during the Late Holocene. The study area is located in the remote and poorly investigated region of Central Siberia, which represents an important area for understanding climate and environmental changes in the Russian Subarctic. Pollen and macroscopic charcoal data from three closely located lakes along an altitudinal transect in the Khantaika River basin show no major changes in vegetation in the study area during the last 3.9 ka BP. However, a detailed analysis of the data reveals an extension of forest coverage in lake catchments at about 3.1 ka BP followed by a gradual degradation of woodlands, and an expansion of shrubs and tundra vegetation at around 2.7-2.5 ka BP. Fire activity was relatively high between 3.0 and 2.0 ka BP compared to all but the most modern part of the record, while macroscopic charcoal accumulation reaches a maximum in the most recent surface sediments. This suggests an increase in the frequency and area of fires in the region since the end of the 19th century, which has no analogue during the Late Holocene.

PolarCH4ives: Reconstructing long-term methane cycling from Arctic lakes

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Arctic landmasses and lakes release significant amounts of methane (CH_4), a potent greenhouse gas that contributes to global climate change. Yet, the effect of rapid warming in the Arctic on the fate of CH_4 emissions is poorly understood, particularly over decadal to millennial timescales. The PolarCH4ives project uses ancient environmental DNA (eDNA) to uncover the environmental genomic information naturally archived year after year in lake sediment to determine the impact of long-term climate change on CH_4 cycling by microbes in the Arctic. New Holocene sediment cores were collected along major environmental gradients in northern Norway (4 lakes), Sweden (3 lakes), and Svalbard (2 lakes). These will be analysed for ancient eDNA and add to our currently high-quality metagenomic sequenced dataset of 180 lake sediment samples from 13 sites in Greenland and Svalbard. Preliminary analyses show that CH_4 microbial dynamics recorded are sensitive to climate change on the Holocene time scale, particularly in relation to shifts in quality of the substrate available for methanogenic production. Surface sediment cores (covering the last 2000 years) were collected to determine potential lags and historical legacies between climate change and microbial processing of organic matter into CH_4. Specifically, we 1) quantify the concentration and stable isotopic signature of sediment CH_4 and dissolved inorganic carbon to determine the origin and age of organic matter serving as a source for CH_4 production and 2) reconstruct past primary production as well as terrestrial plant and minerogenic inputs. We find that processing of CH_4 by microbes is accelerated within the most recent 4-10 cm of sediments, corresponding to materials deposited over the last <200 years. By combining geosciences and ancient eDNA analysis, PolarCH4ives is improving our understanding of microbial diversity in the Arctic and the role of past climate change on microbial ecology and biogeochemical cycling of greenhouse gases.

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Proglacial lakes

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Multidecadal delay between deglaciation and formation of a proglacial lake sediment record

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Basal ages obtained from proglacial lake sediments are often used to constrain deglaciation histories, based on the assumption that fine-grained stratigraphic records start forming immediately after glacier retreat. Here, we test this assumption by studying the onset of sedimentation in Calluqueo Lake, Chilean Patagonia, which progressively deglaciated between the 1940s and the end of the 20th century. Although the glacier-proximal basin has been ice-free for at least three decades, it does not yet contain a fine-grained stratigraphic record, despite the modern sedimentation rate of ~3 cm yr^{-1}. By comparison, the distal basin contains a fine-grained stratigraphic record starting in 1997 ± 2 CE, i.e., 20 – 50 years after it was deglaciated. Based on these results, we show that several decades are required for ~1 m of fine-grained sediments to accumulate between the coarse till material and sufficiently smoothen the uneven lake floor to start forming a fine-grained stratigraphic record. Although the exact timing depends on lake floor morphology and sediment accumulation rates, our results suggest that proglacial lake sediment records lack the first decades of sedimentation. This delay is mostly negligible when using radiocarbon ages from basal sediments to date glacier retreat since it falls within the range of radiocarbon uncertainties, though its importance increases throughout the Holocene. It is however significant for chronologies entirely based on varve-counting. Therefore, our results support the use of basal ages to establish deglaciation chronologies but they call for attention when using them to reconstruct Holocene ice retreat, especially with varve chronologies.

Submerged morphologies in Punta Banderas, Lago Argentino, Patagonia

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Lago Argentino is located in the Santa Cruz province, Argentina, between 50 to 50.5º S, next to the city of El Calafate. It is one of the largest Patagonian lakes, and is characterized by the presence of the most emblematic glacier of the region, the Perito Moreno glacier. Whereas most of the Lago Argentino outlet glaciers underwent considerable ice mass loss and retreated during the last 80–100 years, Perito Moreno glacier shows an apparent anomalous behavior and may be regarded as having been stable since 1920. The periodic advances of the Perito Moreno glacier's front form a natural ice dam as it progresses across the rocky shore of the Magallanes Península. This event blocks the water flow from Brazo Rico towards the Canal de los Tempanos, allowing the rise of the water level. As the ice-dam collapse, the water outburst occurs in semi-periodically events. Between November 2017 and December 2019, the IGeBA (CONICET-UBA, Argentina) and OGS (Italy) performed several geophysical surveys in the lake arms hosting Perito Moreno glacier. High-resolution seismic profiles, complemented with bathymetric profiles, have allowed to map the whole lake floors of Brazo Rico/Brazo Sur and the southern part of Canal de Los Témpanos, and to identify the main seismostratigraphic units within the glacio-lacustrine cover. A new data set of high-resolution seismic profiles located northern of Puerto Banderas has been analyzed. A few submerged morphologies identified as the continuation of onland moraines has been recognized, in addition with mass-wasting deposits and erosive features within the sedimentary record. The integration of the analysis of these morphologies, along with the previous results of our group, allowed the development of an evolution model of a wide area of the Lago Argentino system.

A new ostracod record from Lake Simcoe, Canada, sheds light on the meltwater pathways of glacial lakes in the Laurentian Great Lakes basin

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Melting of the Laurentide Ice Sheet led to a freshening of the North Atlantic Ocean that may have caused brief periods of global cooling. The pathways of this meltwater flow across North America remain contested. One proposed route is through the modern-day Georgian Bay, followed by the Kirkfield-Fenelon Falls (K-FF) outlet, Lake Ontario and the St. Lawrence River. We attempted to better constrain the timing of glacial meltwater travelling along this route by collecting a piston core (PC-5) from the Lake Simcoe basin, which is between the Georgian Bay and K-FF outlet. Ostracod species from PC-5 were enumerated and analyzed to determine their oxygen isotope composition ($\delta^{18}O_{valve}$), which was used to estimate $\delta^{18}O_{lake\ water}$. The basal sections of PC-5 were likely deposited by glacial Lake Algonquin because *(i)* these sections were comprised of grey, laminated clays typical of glacial lakes; *(ii)* ostracod assemblages in this section were dominated by the cold-tolerant species *Candona subtriangulata*; and the mean $\delta^{18}O_{lake\ water}$ of ostracods in this section was ~ –16 ‰, consistent with previous estimates of $\delta^{18}O_{lake\ water}$ of glacial Lake Algonquin. A ~12 ‰ rise in $\delta^{18}O_{lake\ water}$, the disappearance of *C. subtriangulata*, and an increase in grain size suggest that Lake Algonquin began to stop flowing through the Lake Simcoe basin ~12 050 cal yr BP. A reappearance of *C. subtriangulata* between ~10 699 and 10 591 cal yr BP is indicative of a final meltwater pulse. The timing of this meltwater pulse, coupled with the return to low $\delta^{18}O_{lake\ water}$ (–16.1±1.6 ‰ to –13.6±1.6 ‰), is consistent with the discharge of Early Lake Mattawa through the Lake Simcoe basin. This finding suggests that meltwaters may have passed though the K-FF corridor as late as ~10 591 cal yr BP, although additional research is needed to confirm this possibility.

Last glacial termination in the Iberian mountains: the stratigraphic analysis of a lake sequence from Serra da Estrela (Portugal)

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Understanding the environmental response to the last deglaciation in regions located in transitional climate zones such as the Atlantic Iberian mountains is crucial to estimate potential changes in regions affected by current glacial melting. We present an 8.5-m-long, robust Late Glacial and Holocene chronostratigraphic record including detailed sediment analysis from Lake Peixão, a pro-glacial lake in the Serra da Estrela (Portugal). The age-depth model relies on a Bayesian approach that includes 16 AMS ^{14}C dates and ^{210}Pb-^{137}CS measurements, dating the lake formation at 14.7±0.32 cal. ka BP. This chronological reconstruction shows an average sedimentation rate of 15 yrs·cm^{-1}, enabling proxy analyses at decadal timescales. The sediment sequence is composed of 5 lithological units: U1) coarse and unsorted fluvioglacial lacustrine deposits, U2) massive fluvioglacial lacustrine deposits (863-790 cm below surface (bsf); 14.7±0.32-13.8±0.12 cal. ka BP); U3) water current fluvioglacial lacustrine deposits (790-766 cm bsf; 13.8±0.12-12.9±0.29 cal. ka BP); U4) laminated/banded lacustrine deposits characterized by terrigenous deposits from ice-covered lake periods and episodic events of ice and snow melting (766-752 cm bsf; 12.9±0.29-11.7±0.15 cal. ka BP); and U5) massive muddy lacustrine deposits (752-0 cm bsf; 11.7±0.15 cal. ka BP-present). The occurrence of U2 to U4 deposits defines the transition from glacial cold (U1) to net warm postglacial conditions (U5). These climate transitions are marked by changes in sediments and the presence of very low sedimentation rate periods possibly related to the Intra-Allerød Cold Period and the coldest phase of the Younger Dryas. Our results propose the timing of the retreat of the Serra da Estrela glaciers at ca. 13.8±0.12 cal. ka BP. The robust chronology of Lake Peixão highlights the potential of Iberian pro-glacial lakes for dating deglaciation processes and will lead to unprecedented decadal-to centennial timescale paleoclimate reconstructions in this region since the last glacialinterglacial transition.

The late MIS 6 proglacial lake in the Arctic-Caspian watershed, northeastern European Russia

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The Arctic and Caspian Sea basins divide in the north of the East European Plain, and is crossed by a palaeovalley of River Kama (now flows to the Caspian Sea) formed in the Pliocene - Early Pleistocene when Kama flowed to the Arctic basin. In a 45 m deep core in the middle part of the palaeovalley, the alluvial-lacustrine succession was found at depth of 24-45 m and OSL-dated to 160-140 ka (late MIS 6). A set of lithological analyses revealed a change up the section from alluvial sands to lake silts and loams formed first in a low-flow and then in a closed lake. Pollen and macrofossil data show replacement of taiga forests by forest-tundra and then tundra, but even in the most unfavorable climatic conditions (upper part of the section) some woody species were preserved in the lake vicinity, which was facilitated by high enough summer temperatures. The lake was dammed by the MIS 6 ice sheet, which boundary is assumed to lie some 50 km to the north, and drained around 140 ka due to the ice sheet decay. The alluvium in the lower parts of the section could belong to the Kama River as well as the local rivers. Therefore, it is still uncertain whether the turn of the Kama into the Caspian Sea occurred exactly in MIS 6 or earlier. However, it can be considered proven that this event did not happen in MIS 2, as assumed by many authors earlier.

Paleolimnological evidence of post-LIA glacial fluctuations in Canal de Los Témpanos, Patagonia

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Canal de los Témpanos is one of the *Brazos* of Lago Argentino, which is the largest ice-contact lake in the world (1500 km^2). It is located in southwestern Patagonia, on the eastern flank of the Patagonian Andes, where outlet glaciers from the Southern Patagonian Icefield drain. The controls on sedimentation in very large proglacial lakes, and its link to glacier retreat remain poorly understood. With this study we seek to contribute to the efforts to reconstruct and better understand glaciolacustrine sediment production and deposition in one of the regions of the globe that has been most affected by climate change during the last decades. We analyze the sedimentological and geochemical characteristics of sediment cores retrieved from this site and use this data to associate changes in sedimentary input with seasonal glacial fluctuations. We evaluate changes in Perito Moreno and Ameghino glaciers since the Little Ice Age maximum, as well as the development of an up-gradient ice-contact lake in the Ameghino Glacier basin during the second half of the twentieth century. We also analyze cores for sedimentary evidence of the ice-dam rupture events periodically generated by Perito Moreno glacier. We show that the dominant sediment source for our study site switched from Ameghino to Perito Moreno glacier after the recession of Ameghino glacier and the formation of the ice-contact lake to which it currently drains.

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Human Traces in the aquatic sedimentary record

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170 mysterious neolithic mounds on the shallow shelf of Lake Contance and their relation to paleoenvironmental change

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Recently acquired high-resolution bathymetric data (merged mutlibeam and airborne laser data) of Lake Constance revealed ~170 mounds located along the southern shelf of the lake in water depths of ~4 m. These mounds, aligned like a pearl necklace over 10 km distance, range in width between 10 and 30 m and reach heights of almost 2 m. Reflection seismic and ground-penetrating radar (GPR) surveys document that these mounds do not root in the underlying glacial substrate but were deposited artificially on the edge of the Holocene paleoshelf. The 170 mounds are estimated to comprise ~60 million rock boulders (~80,000 tons) collected from the nearby outcropping moraines. GPR data image a shelf entirely composed of basinward prograding clinoforms. A drilling campaign with four piston cores along a shore-to-shelfe dge transect (core lengths between 3.7 and 5.9 m) recovered the complete Holocene and Late Glacial sedimentary succession dating back to ~14,400 cal BP and down to the basal till. The four cores could be merged into a 12 m long composite section reflecting continuous sedimentation from the detrital siliciclastic-dominated Late Glacial to the carbonate rich Late Holocene. The stratigraphic horizon representing the mound's construction was radiocarbon-dated to ~5,500 cal BP placing them in the neolithic period. This assignment was confirmed by ^{14}C-dating of wood samples collected during underwater excavation of the mounds. Sedimentologic analysis of the Holocene sediment succession shows Ca-carbonate contents averaging 70%. The mound period, however, is characterized by an overall minimum in carbonate content (~50-60%). Comparing these low values with those from a surface-sediment depth transect indicates that this period was characterized by rather low lake levels, which might have favored mound construction. How these low lake levels were reached, which paleoclimatic and paleoenvironmental conditions prevailed, and what the purpose the mounds served for, is currently investigated and widely debated.

Biomarker evidence for the construction and occupation of crannogs in Scotland and Ireland from lake sediment records

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Crannogs are artificial islands constructed in lakes and wetlands across Scotland and Ireland from the Iron Age to the Medieval period. Excavations of partially or fully submerged crannog structures are logistically and financially challenging, therefore the timing of crannog occupation and function remains poorly constrained. We present analysis of lake sedimentary archives adjacent to crannog structures as an alternative approach to excavation, to establish construction and occupation histories at two sites: Lough Yoan (N Ireland) and White Loch of Mytron (SW Scotland). Our data provide direct anthropogenic evidence using steroid biomarkers contained within lake sediments. Evidence of human faecal matter is identified at both sites, demonstrating preservation of faecal steroids within aquatic sedimentary environments. The ability of these steroids to provide direct evidence of human occupation is supported by occupation dates independently obtained from archaeological excavations. Steroid ratios also indicate the presence of ruminants within the settlements, which is confirmed by sedimentary DNA (*seda*DNA) analyses and supported by palaeoecological derived nutrient-driven changes in aquatic ecology (biogenic silica, diatoms, and chironomids), wider landscape changes (pollen, *seda*DNA) and parasite eggs (*Trichuris)*. The similarities between faecal steroid records and independent lines of chronological and palaeoenvironmental evidence highlights the ability of lipid biomarkers to provide direct evidence of human occupation of crannogs from lake sediments. Specifically, bile acids have been used to directly isolate human presence. More broadly, our palaeolimnological data characterise occupation phases by identifying when humans were first in the landscape and when crannogs were constructed and used. The data show sites were occupied earlier than structural timber dates and highlight a decline in activity through disuse and abandonment.

Application of faecal sterols to document human presence in the Alaskan landscape: a cautionary tale

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In recent years there has been an expansion of the use of faecal sterol biomarkers to generate records of human occupation in the landscape from lake-sediment profiles. Faecal steroid biomarkers (5β-stanols, bile acids) were initially used in archaeological settings in the late 1980s and have since been successfully developed and applied to characterise the presence of humans and animals from archives of concentrated faecal waste e.g., coprolites and archaeological soils. Faecal steroids are well-preserved within lake sediments, indicating they have the potential to be direct archives of anthropogenic activity. The application of faecal biomarkers within diffuse depositional environments of lake basins, however, presents new methodological challenges, which are currently being overlooked. We investigate the efficacy of lacustrine faecal biomarkers to trace human presence within the landscape using steroid records generated from a lake in central Alaska, with independent records of human activities over the past 2000 years. Comparisons of steroid data obtained from modern dung, catchment soils and lake sediments show that the use of sterol concentrations alone is insufficient to conclusively characterise faecal input within lake sediments. Whilst diagnostic stanol ratios can identify faecal matter, the standard archaeological threshold values require systematic testing for robust application in aquatic sediments, to account for processes such as dilution and *in-situ* primary productivity. Findings from the modern environment demonstrate that stanols alone are insufficient for characterising faecal inputs to lake cores, but that the incorporation of both stanols and bile acids, the latter of which are solely produced from digestive processes, is reliable. Overall, we demonstrate that lacustrine faecal biomarkers are effective tools to trace human presence when corroborated with additional proxies of anthropogenic impact, historical records and/or archaeological evidence. However, we highlight uncertainties relating to lake-taphonomic processes that must be addressed to optimize applications of this proxy within aquatic sedimentary archives.

Molecular traces of human arrival in Remote Oceania

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The colonization of Remote Oceania ~3000 years ago is attributed to the Lapita people, a population originating from South East Asia. First human settlements on these islands are associated with major landscape modifications. However, past hydroclimatic variations, which played a role in the colonization of remote islands, challenge a clear anthropogenic attribution of ecosystem changes. The archipelago of Vanuatu, with its extensive archeological remains of the Lapita culture, is considered a crucial location in the colonization of Remote Oceania. Here we present a sediment record retrieved near the Teouma archeological site, the earliest confirmed Lapita cemetery found in the Pacific Islands. We dated 43 macrofossils from a 4 m long peat core spanning the last 5000 years. Fecal sterols associated with human presence become more abundant during the Lapita period as well as the later Erueti phase. Palmitone downcore concentrations were quantified as a signature for taro, a staple crop introduced by early settlers, and applied as a proxy for the establishment of agriculture. Elemental changes were measured with X-ray fluorescence core-scanning to track soil erosion and provenance. The hydrogen isotopic composition of plant waxes, namely long-chain fatty acids, was measured as a proxy for hydroclimatic changes. A transition towards wetter climatic conditions corresponds to the initial human settlement indicated by archeological remains and fecal sterols. Coupling human-related and climatic proxies on a record spanning the last 5000 years allows us to reconstruct the pre-anthropogenic state of the site, and add insights to the timing of human arrival and the consequent landscape modifications.

The voyage of humans in the South Pacific: the view from Lake Lanotō, Sāmoa

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Archaeological data suggests that humans commenced inhabiting the remote islands in the South Pacific around 3000 yr BP. Human occupation brought tremendous modifications to these small islands: clearing forests through burning, introduction of new flora and fauna, horticulture practices and the like. These practices were either drastic or gradual in some areas in the region, and may have been related to patterns of climate change. To better understand the peopling of this area, a 4.75 m composite sediment core, encompassing the period of human settlement, was retrieved from Lake Lanotō, Sāmoa. A multi-proxy approach, including micro-XRF scanning of the cores, grain size distribution, organic carbon content and molecular biomarkers from human and plant remains engraved in the sediment, is used to reconstruct past environmental changes. Combining these biomarker and elemental proxies will help us advance our knowledge on the timing of human expansion in Sāmoa, and in the South Pacific region. The generated data will shed valuable light on Pacific prehistory and complement the knowledge gained from archaeological data.

Paleolakes of Gebel Ramlah in the context of the Middle/Late Pleistocene and Holocene human habitation of the Southern Egyptian Desert

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Today the Sahara is the largest hot hyperarid desert on Earth and the Egyptian Western Desert is one its most uninhabitable regions. However, in the past, during wet climatic oscillations, rains created temporary lakes (*playas*) that were a characteristic feature of the landscape in the Eastern Sahara. The changing environments are documented by Pleistocene and Holocene lacustrine, alluvial, and eolian sediments. The lake settings attracted human populations at least since the Last Interglacial (MIS 5e). Two such lakes existed in Gebel Ramlah area; a pronounced offset mountain exposed over the Nubia–Shab Pediplain. One is located at the base and second at the top of Gebel Ramlah. A sequence of two major lake events have been recorded within the lower paleo-lake, with thick Holocene lake deposits covering an older lake from Last Interglacial (MIS 5e) or possibly earlier (Middle/Late Pleistocene). There is evidence for a connection between the lake events and human presence, indicated by artifacts. A similar sequence is expected in the case of the playa sequence at the top of Gebel Ramlah where Middle Paleolithic/Middle Stone Age (MP/MSA) sites have also been recorded. That unique upper lake developed in an erosional basin within an impermeable Eocene limestone cap and was surrounded by a high rocky crown of a bedrock limestone. Due to its location the basin of the upper lake and its infilling sedimentary deposits were hydrologically isolated from any direct influence with the area below. Therefore, it serves as a control for comparison with the geomorphic and sedimentary processes and as a reference site for paleoenvironmental studies carried out within the lower paleo-lake basin. Exposed stratigraphic sequences in dry river channels and yardangs contain artifacts and archaeological features reflecting human activity, and document the dynamic changes in the local paleoenvironment during the Middle/Late Pleistocene and Holocene.

A great history in a small wetland: human-environment relationships on the East European Plain in the last 13 thousand years

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The subject of the study is the reconstruction of palaeoenvironmental conditions in the Western Dvina Lakeland, a part of the East European Plain, as a basis for the study on human-environment relationships in the last 13,000 years. The multi-proxy analyses are performed based on organic deposits core collected from the Serteya mire (55°40’33.7”N 31°30’32.1”E). Archaeological research resulted in documentation of over 60 archaeological sites in studied area: mostly the remnants of seasonal and permanent settlements of Stone Age hunter-gatherer groups, fortified settlements from the Early Iron Age, or more-or-less permanent settlements from Middle Ages. Neolithic pile-dwelling settlements from 3rd mill. BC were found within lacustrine deposits. The long inhabitation history of hunter-gatherer settlement models was dependent on climatic and hydrological changes and local landscape diversity. A 13.5 m thick core of organic deposits was collected from the central part of the small (ca. 7 ha) mir and covers: sand with organic mud (13.5-13.22 m), basal peat (13.22-13.19 m), clayey gyttja (13.10-11.89 m), gyttja (11.89-4.20 m), and *Sphagnum* peat (from 4.20 m b.g.l.). As confirmed by the primary radiocarbon (^{14}C) data set, collected geoarchive bears a record of the palaeoenvironment history of the last 13 thousand years. Complex multi-proxy palaeoecological analyses of the organic deposits are based on palaeobotanical analyses (pollen, plant macrofossils, charcoal, phytoliths, and diatom) and palaeozoological examinations comprise Chironomidae and Cladocera analyses. The chronology of deposits is based on detailed geochronometrical research - mainly AMS ^{14}C dating of selected terrestrial plant macrofossils and depth/age modelling. The palaeoecological research is supplemented with geological and geomorphological mapping of the studied kettle hole and a study on human occupation history and settlement pattern. The collected geoarchive is an uninterrupted record of palaeoenvironment history on regional scale for the Western Dvina Lakeland, which allows to trace the impact of global changes along with local human impact and human-environment relationships. The research is financed by grants from the “National Science Centre, Poland” based on the decision No. 2021/41/B/HS3/00042

The PAGES Human Traces working group: developing tools and knowledge to gain a better global perspective of anthropogenic impacts using sedimentary archives

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Anthropogenic impacts on the natural environment vary in origin and proportion in various regions of the world through time. Even if the case can be made that pristine environments no longer exist, there is a vast range in the degree of environmental degradation caused by human activities on our planet. This is due to a multitude of factors, including the timing and direction of human migrations and historical technological development. There is still a paucity of long-term environmental regional data and a global synthesis of human impacts on ecosystems through time is lacking. The principal aim of this PAGES working group is to develop tools and reviews to help synthesize information based on data gathered from aquatic sedimentary archives, that will lead us to a better understanding of the timing, nature and magnitude of human impacts on the environment. Sediments from lakes, ponds, wetlands and coasts serve as stratigraphic archives and long-term records of natural variability and human-induced changes, allowing us to assess responses to change on various timescales and to link them with either climatic or anthropic drivers. They also serve as a way of defining targets/reference conditions for ecosystem management and conservation, providing a longer-term perspective for recent global changes in the context of the Anthropocene. In this presentation, we will describe the scientific activities and projected outcomes of the working group, which has been running since 2021 and is planned to continue for the next 4 years.

IAL IPA 2022

FOCUS SESSION 30

Using Palaeolimnology to Understand Recent Human Impacts on Tropical Lakes

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Using paleolimnologic data to understand the tempo and mode of anthropogenic ecosystem change in tropical African Lake Tanganyika

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Lake Tanganyika, in the western branch of the African rift valley, is one of the largest, oldest and most biodiverse lakes on Earth. It is also an extremely important resource for fisheries, freshwater and transportation for the millions of people living around the lake. Threats to the lake's extraordinary biodiversity and fisheries primarily arise from the effects of climate change and deforestation/soil erosion in the lake's watershed. Specifically, rising surface water temperatures are causing a shoaling of the thermocline and oxycline of the lake, resulting in reduced nutrient regeneration to the photic zone and reduced primary productivity in the pelagic zone, and a reduction in the habitable lake floor for benthic and demersal communities. Additionally, excess soil erosion is causing siltation of highly biodiverse nearshore habitats, such as rocky coastlines and sublittoral shell beds. Understanding the geologically recent history and ongoing impacts to these habitats and realistically forecasting their future states requires a paleolimnological approach. In this presentation we summarize prior work documenting the tempo and mode of paleoecological change in the lake as a consequence of such ongoing anthropogenic impacts. C^{14} dating of shell samples from the extensive shell beds of Lake Tanganyika shows that their accumulation has varied with changes in climate and lake level, with shell production reduced during times of wetter climates and rising lake levels, and more recently in some areas by anthropogenic sedimentation. Pre-anthropogenic climate-driven changes in Lake Tanganyika during the Holocene, coupled with circulation modeling forecasts also offer an opportunity to understand likely future changes in lakewide circulation and vertical mixing as a consequence of warmer temperatures and variable wind regimes.

Understanding long-term environmental impacts to inform sustainability in Lake Victoria, Kenya

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Lake Victoria, the second-largest freshwater lake globally, has undergone significant changes over recent decades. Winam Gulf in Lake Victoria is a hotspot of human activities, which is particularly sensitive to the increasing trends in nutrient enrichment and water level change. Preliminary data from a core collected in central Winam Gulf show how cultural eutrophication and aquaculture practices have led to the deterioration of water quality and how these changes are concomitant with the transition from diatoms to cyanobacteria after 1950. These increased harmful algal blooms are coincident with a change from finely silicified *Nitzschia* to silica-rich *Aulacoseira* species, which is contrary to the late 20th century trends identified in the main basin of Lake Victoria. $\delta^{13}C_{bulk}$ show a more general decreasing trend in compositions from the 1800s (from c. -16 to -20 ‰) followed by a greater decline in signatures over the past 20 years (< -21‰). This source is algal in nature (C/N <10). Together, these data suggest a significant alternation to biogeochemical cycling in Winam Gulf. These data will be corroborated by two littoral cores close to environmental stressors (aquaculture and pollution hotspots) and a pristine location. Biogenic silica, stable isotopes, diatoms, and further biomarker analysis will comprehensively view regional ecosystem change. Our research aims to better understand how the development, intensity of aquaculture and other catchment disturbances affect Lake Victoria and how the nature and timing of these events in the palaeorecord of the Winam Gulf differ from the deeper Lake Victoria basin.

Using palaeoecology to determine the effects of recent human impacts on a shallow lake in Madagascar

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Lake Sofia is a large shallow lake in Northwest Madagascar that was identified as the most suitable site for the reintroduction of the Madagascar Pochard, the world's rarest duck. It was chosen because of its large, intact papyrus marsh system however, there are multiple human pressures affecting the lake's catchment. A wide-diameter sediment core was taken and successfully dated using Lead-210 and Radiocarbon dating. The age-depth model revealed the start of a rapid increase in sedimentation from 40 cm, around 1900. This change is also reflected in the macrofossil and geochemical records, the results of which suggest that a state shift has occurred. Where submerged charophyte and invertebrate remains were abundant, they significantly reduce. There is also a sudden change in the Loss on Ignition, Mercury and XRF data, including an increase in several erosion indicators. The timing of this change means the lake had shifted to a turbid and algal dominated state prior to the introduction of tilapia or use of synthetic pesticides in the catchment. Land-use change could be responsible, however, macrocharcoal data reveals that the peak in macrocharcoal fragments commonly associated with the arrival of agropastoralists to the catchment, occurs much earlier at the very bottom of the core, around 1590. Further analysis of the core and sediment trap data, including stable Carbon and Nitrogen isotope analysis, will hopefully indicate the cause of this shift. These findings are being used by the Wildfowl and Wetlands Trust to inform lake restoration work being done at the site, by indicating baseline conditions for the lake's sedimentation rates and ecology.

Studies of paleolimnology in Ecuador: using diatoms from sediment cores to separate human and climate impacts.

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Ecuador has a large diversity of lakes in the high Andes (páramo), in the inter-Andean plateau, in the Amazon rainforest and in the Galapagos Islands. These lakes are subjected to different levels of both human and climate change impacts. A modern-analog diatom database has been assembled over the past 40 years from 91 lakes in the country and is now part of the Tropical South American Diatom Database (https://github.com/xbenitogranell/diatomsbiogeography-southamerica). It shows differences in diatom communities in lakes from different ecoregions encompassing gradients of climate, topography, and water chemistry. The database is being used to interpret the paleo-environmental record from lake cores. The climate signal for El Niño events is easy to see in diatom records from lakes of the Galapagos Islands where human impact is minimal. A brackish lake in the Andes also shows this signal. Climate change explains recent diatom inferred changes in stratification regimes in paramo lakes. Yet, much of the changes we see in the diatom communities in cores from the high Andes, the inter-Andean plateau and the Amazon basin can be attributed to a response to recent human impacts.

Using palaeolimnology to inform conservation of a rare Malaysian flood pulse wetland

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There are few natural standing waters in Peninsular Malaysia. Tasik Chini is one such rare shallow lake-wetland complex located in the state of Pahang. The lake hydrology is maintained by numerous small rivers that drain the local uplands, and flooding from the much larger Pahang River, which inflows during the wet season. The site is UNESCO-designated for its cultural heritage, including local indigenous communities. The fringing lake-swamp vegetation has rare hydrosere communities. Due to the scarcity of similar sites and long-term monitoring data, deriving targets for conservation of natural and cultural heritage at this site is a challenge. Therefore, we used palaeolimnology (lake sediment cores) in combination with analysis of local documentary archives to understand the nature, rates and drivers of change at this site. Documentary archives indicate multiple changes in the lake catchment in recent decades, including extensive farming in the Pahang River watershed and mining and logging activities in the local subcatchment, which have increased soil erosion and nutrient pollution. A dam constructed in 1995 to boost ecotourism has prevented ingress of polluted water from the Pahang River, but together with ongoing climate change, has altered the natural hydrology of the lake. Pb-210 dating on several cores from the lake basin indicates major increases in sediment infilling over the past 50 years, set against a baseline of much reduced sedimentation rates since the lake formed around 4500 years ago. Diatoms, elemental analysis, chlorophyll and carotenoid pigments, and carbon and nitrogen stable isotopes, indicate large changes in hydrology and water quality over the past 150 years, especially since the 1950s. Together these sedimentary indicators demonstrate major shifts in the ecosystem of this tropical lake system, which were initiated by land use changes and many of which are likely to continue in this rapidly developing region undergoing climate change.

Paleolimnological evaluation of the recent evolution of two lakes in Lagunas de Montebello National Park, Chiapas, Mexico

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Since 2003, population and authorities in the Lagunas de Montebello National Park (LMNP, Chiapas, southern Mexico) have reported a reduction in water transparency in some of the lakes of this protected area. Previous research has associated these changes with anthropogenic impacts due to agriculture, deforestation, and sewage inflow. The present research compares the lacustrine evolution during the last hundreds of years of two lakes within the LMNP with similar morphometric characteristics, but contrasting water transparency and trophic levels: i) pristine, ologotrophic Montebello and ii) impacted eutrophic Bosque Azul. To document the recent history of these lakes a short sedimentary sequence from each one was recovered and dated with ^{210}Pb y ^{137}Cs. Elemental geochemistry was determined by X-R fluorescence (XRF), and biological indicators (diatoms, testate amoebas, chironomids, cladocerans, ostracods, and molluscs) were analyzed. The sequence from Lake Montebello (80 cm) dated to the last ~140 years and allowed to identify that the highest human impact was between the years 1930 to 2010, when the lake had higher sediment input and erosion rates in its basin. On the other hand, the sedimentary sequence from Lake Bosque Azul (82 cm) allowed to reconstruct the last ~180 years, and to identify that prior to 1926 the lake had clear waters and a lower trophic status (oligotrophic) but that after this date the lake changed drastically towards an eutrophic ecosystem with more turbid waters and a shallower thermocline, similar as modern conditions. The high human impact recorded in both lakes since 1926-30 corresponds in time with an increase in population and agricultural activities in the area after the 1920s. When comparing both sedimentary sequences, we found that Lake Montebello, currently considered a pristine lake, also had a long history of human impact in its basin. Nevertheless, Lake Montebello had an impact history that mostly reflected local land use changes; while Lake Bosque Azul, was more susceptible to changes at the basin level.

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FOCUS SESSION 31

Rapid environmental change in tropical and subtropical lakes during the Holocene

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Late Holocene limnological changes in a freshwater lake, Lower Nhecolândia region, Pantanal, Brazil

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The Pantanal is considered to be the largest wetland in the world, and the lower Nhecolândia sub-region is composed of thousands of shallow freshwater and saline-alkaline lakes, isolated from one another by sandy ridges. ^{14}C dating, diatom, pED-XRF, elemental (Total Organic Carbon - TOC and Total Nitrogen - NT), and C and N stable isotope analyses were performed on a sediment core (B02SR) from a freshwater lake (Reserva São Roque - Mato Grosso do Sul). Results suggest two distinct environmental phases in the Late Holocene. In phase I (50-20 cm), from ~3120 cal yr BP (44 cm) to ~1720 cal yr BP (24 cm), the pED-XRF results indicate high values of K, Ti, Mn, Ca, Sr, and Fe. TOC values reached ~3 %, and $\delta^{13}C$ ~-22.0 ‰, $\delta^{15}N$ ~+6.5 ‰, and C/N ~12, suggest the predominance of C3 plants and phytoplankton in sediment organic matter. Diatom analysis revealed high relative abundances of *Anomoeoneis* sp. and *Craticula* sp. (~37 to ~74 %). *Anomoeoneis* sp. tolerates a wide range of salinity and is considered euryhaline, whereas *Craticula* sp. is usually found in brackish water with high electrical conductivity and hyper-alkaline pH. In Phase II (20-0 cm), from ~1320 cal yr BP to the present, pED-XRF analysis showed low values of Ti, Zr, Ca, K, Fe, and Si. TOC increased up to ~35 %, $\delta^{13}C$ values reached ~-27.0 ‰, $\delta^{15}N$ was <+5.0 ‰, and C/N was ~10, indicating the presence of C3 plants and a mixture of terrestrial and aquatic sources in the organic matter. This phase was characterized by high relative abundances of benthic diatoms, and four genera prevailed in the diatom assemblage (*Gomphonema* sp., *Eunotia* sp., *Encyonema* sp., and *Nitzschia* sp.). Most of these benthic species are found in slightly acidic waters with relatively low to moderate conductivity values.

Climate variability during the last 2000 years in a tropical sub-humid environment in central Mesoamerica

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Central Mesoamerica has several mid-altitude (~1000 m asl) basins, where temperature and evaporation are high, and that stand out as particularly sensitive to small moisture fluctuations. These basins preserve good records of hydroclimate variability in this region during the last 2000 yrs. Such records provide a valuable paleoclimatological background for the analysis of human – environment interactions in central Mesoamerica, where the great Teotihuacan, Toltec and Aztec cultures developed. Of particular interest are the climate conditions during the Epiclassic period (AD 600 to 900), which preceded drought conditions that have been associated with cultural demise that occurred around AD 900 - 1000. Here we present pollen, microalgae palynomorphs, diatom and geochemical data from a sediment core taken in a mid-altitude lake located 10 km south of one of the main Epiclassic city-states in central Mesoamerica (Xochicalco). Our results revealed five dry events marked by low Ti concentrations and changes in the biological associations that point to shallower lake conditions. These shallow lake phases occurred around i) AD 50 - 250, ii) AD 700 - 950, iii) AD 1200 - 1300, iv) 1450 - 1555 and v) 1760 - 1820. Droughts were mostly associated with cooler climate conditions, and they framed major historical events. Dry conditions occurred during the Epiclassic (AD 600 - 900) and our results confirm that the fall of the Toltec culture (AD 1300), European contact (1521) and the war of independence (1810-20) happened during times of drought.

Evaluation of Lake Sediment Thickness from Water-Borne Electrical Resistivity Tomography Data

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Seismic methods, such as sonar surveys or reflection seismics, are commonly used to map sediments and determine sediment thickness in lakes. However, seismic measurements may be affected by gas in the sediments, anthropogenic noise, or similarity of seismic velocities between adjacent layers, hindering the ability to identify the lake-bottom sediments. Electrical and electromagnetic methods adapted for water-borne surveys provide important complementary information. Here, we present a case study for which we used seismic and electrical resistivity tomography (ERT) with floating electrodes to determine the sediment thickness at the bottom of lakes in karst terrain. Sediment layers with high clay content often have higher conductivities than adjacent layers such as water and bedrock, and are therefore visible in resistivity images of the subsurface. We collected ERT data at Lake Nahá in southern Mexico in March 2018 using a dipole-dipole configuration consisting of 13 floating electrodes (at 5-m spacing) towed behind a boat. We used different inversion algorithms to recover the sub-bottom resistivity distribution from the measured raw data. Although a straightforward 2D inversion in this case is not able to resolve sediment layers, we adopted a 1D inversion approach, which includes several constraints like water depth, water resistivity and sediment resistivity as *a priori* information. We also inverted the data in a real 3D model using PyGIMLi, which enables including a detailed bathymetry as a fixed interface, as well as the often curved shape of the cable as it is towed behind the boat. We propose a routine to map the sediment distribution in lakes using a first estimation of the sediment thickness at depths up to 20 m by a 3D inversion, before determining the exact sediment thickness in the case of horizontal layering, using our highly constrained 1D inversion approach.

Multi-method land and water-borne geophysical survey sheds light on the sudden drying of karst lakes in southern Mexico

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We present results of a multi-method geophysical survey that was used to investigate the sediment infill and sub-bottom geology of two karst lakes in the Lacandon Forest of Chiapas, southern Mexico. Both lakes typically present large seasonal lake-level fluctuations and experienced an unusually sudden and profound water-level decline in the first half of 2019, leaving Lake Metzabok (maximum depth ~25 m) completely dry and Lake Tzibaná (depth ~70 m) with a water level reduced by ~15 m. Besides identifying suitable drilling sites for paleolimnological investigations, our study investigated the link between the local karst conditions and the 2019 water-level decline. Before this event, during a water-level peak in March 2018, we collected water-borne seismic data with a sub-bottom profiler (SBP) and transient electromagnetic (TEM) data with a newly developed floating single-loop configuration. In October 2019, after the sudden drainage event, we carried out complementary measurements directly on the exposed floor of Lakes Metzabok and Tzibaná. During this second campaign, we collected time-domain induced polarization (TDIP) and seismic refraction tomography (SRT) data. By integrating the multi-method data set, we: (1) identified 5–6 m thick, likely undisturbed sediment sequences on the bottom of both lakes, which are suitable for future core-recovery campaigns, (2) developed a hydrogeological model that implies strong connectivity between surface water and the deeper karst aquifer, which enables rapid drainage through karst conduits, and (3) evaluated the potential of our multi-method approach for reconnaissance of the sediment lithology in karst lakes. Our results show that resistivity-based methods such as TEM and TDIP, when combined with seismic methods that are widely used for lake-bottom reconnaissance, can significantly improve interpretations by resolving geological units or bedrock heterogeneities that are not visible from seismic data. The use of such complementary methods is required to provide sufficient information to develop comprehensive geological models in complex karst environments.

Aquatic invertebrate assemblage changes since the refilling of Lake Victoria

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Assemblages of invertebrate remains preserved in lake sediments provide continuous proxy time series of community composition that accompanied varying environmental conditions over millennial timescales. Lake Victoria (Africa) has a dynamic environmental history and previous paleolimnological research revealed evidence of multiple lake level regressions, desiccation and subsequent refilling of the lake after ~17-15 ka BP. During this relatively short geologic history, changing climate conditions led to changes in lake conditions, including distinct intervals of planktonic diatom production. We examined subfossil Chironomidae, Chaoboridae, and Cladocera remains in a sediment core from Lake Victoria to assess changes in the invertebrate community composition throughout the Holocene. Three major zones of interest were identified based on changes in the relative abundances of invertebrate taxa throughout the core. First, Chaoboridae and Chironomidae taxa exhibited a small increase during the Middle Holocene that coincided with a period of increased diatom production near the end of the African Humid Period. Second, *Alona* was the first cladoceran taxon to appear at relatively low abundances ~5000 cal yr BP, following its absence since lake refilling. Lastly, following the emergence of *Bosmina longirostris* and *Chydorus* ~2000 cal yr BP, all invertebrate taxa displayed major increases in relative abundance, also coinciding with increased diatom production. These results suggest that bottom-up processes in Lake Victoria may control invertebrate dynamics, rather than fish predation, which corresponds with other tropical East African lakes. Additionally, the emergence and increase of Cladocera indicates that a major environmental change occurred ~5000 cal yr BP and led to restructuring of the lake food web. This study provides the first multi-millennial record of an invertebrate community assemblage in Lake Victoria and contributes valuable insights into the temporal dynamics of food web assembly and ecosystem change in the world's largest tropical lake.

Late Holocene hydroclimate changes inferred from the sediments of crater Lake Karif Shawran, southern Yemen, using chemical, physical and biological variables

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Climate and environment of the southern Arabian Desert is extremely sensitive to fluctuations and intensities of Indian monsoon fronts. The unique geographic location of this region can hence provide an excellent opportunity to understand interactions between the monsoons, zonal migrations of the Inter-Tropical Convergence Zone and regional environmental change. This project aimed to provide high-resolution information on climate variability in the southern Arabian Peninsula during the Middle to Late Holocene. Lake Karif Shawran occupies a volcanic crater in close proximity to the Arabian Sea, at an elevation of 150 m above sea level. A multi-proxy approach involving analyses of elemental concentrations, TOC/TIC, grain size, ostracods and *n*-alkanes was carried out on a ~1-m-long sediment core retrieved from the lake. The age model was developed using four ^{14}C dates and provided an estimated age of ~3500 yr BP at the base of the core. Alternating wet and dry intervals were revealed by the presence of fine-scale alternations of aragonite and organic layers in the core. The µ-XRF data revealed higher Ca counts and lower K/Ti values in the interval ~1700 to 1300 BCE, indicating lower lake levels, i.e., dry climate conditions. Furthermore, increased TIC and decreased MS values in the same interval further indicate drought in the region. The euryhaline ostracod species *Cyprideis torosa* constitutes a monotypic assemblage in the sediment record. This species is adapted to a wide range of salinities (0.4-150.0‰) through osmoregulation changes that produce modifications on the shell surface and in the shapes of sieve-type normal pore canals. Analysis of such salinity-dependent ecophenotypic characters provides valuable quantitative information on past salinity values in the lake, which in turn can be associated with past climate and limnological conditions. This study provides insights into past abrupt climate changes and explores their potential causes and relevance to future climate studies.

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Environmental records of the Anthropocene in artificial lakes

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Environmental changes in Laguna de Yuriria (Central Mexico) using a paleolimnological approach

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Laguna de Yuriria is a shallow artificial reservoir (4 m depth) located in the state of Guanajuato (20°14' S and 101°07' W, central Mexico). It was built in 1548 over a wetland, becoming the first hydraulic engineering construction of Latin America. Currently, its main functions are agricultural irrigation, fishing, and recreation. Laguna de Yuriria has been receiving water affected by anthropic activities, such as agriculture runoff and wastewater discharge. Until now, the studies have focused on the water quality assessment, with a limited temporal scope. The present study aims to reconstruct the history of environmental changes in Laguna de Yuriria through its sedimentological record and a multi-proxy approach. A sedimentary core (133 cm length) was collected in the center of the reservoir. The proxies analyzed were carbonates ($CaCO_3$), total carbon (TC), total nitrogen (TN), total phosphorus (TP) and the carbon-nitrogen ratio (C:N). Three main environmental stages were identified: Stage 1 is considered the environmental base level of the reservoir with the lowest C:N ratio (mean=21.12%) and the highest TC (mean= 3.32%) and TN (mean= 0.17%) content that support the hypothesis of an old wetland. Stage 2 indicates an increase in the limnimetric level and is characterized by a decreased in TC (mean= 2.64%) and TN (mean=0.12%) contents and an increase in C:N ratio (mean= 22.33%), as a response of an increased terrestrial organic material input. Stage 3 is characterized by an increase in CT (mean= 7.13%), NT (mean= 0.47%) and PT (mean= 302.63 mg/kg) with respect to stage 2, indicating a high level of eutrophication, probably related to a higher anthropic impact. This is mainly associated with more urbanization and extensive agricultural activity in the surrounding area. Our findings show pronounced environmental changes in Laguna de Yuriria through time. These results might be useful tools for co-management of this watershed.

Integrating sediment core and satellite sensing approaches to assess recent phytoplankton bloom trajectories in a large reservoir

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In this work we integrated two approaches that are rarely used together in addressing the responses of biota to multiple environmental stressors –sediment cores and satellite images. The study area is a large subtropical reservoir (750 km^2) that recurrently suffers severe cyanobacteria blooms, yet the trajectory of blooms since the building of the reservoir (in 1979) until the onset of the ongoing water quality monitoring program (ongoing since the year 2000) was unknown. In 2015 we performed sediment core studies, which were published in 2020, and our findings suggested that phytoplankton blooms initiated in 2003, about 24 years after the reservoir was built. Moreover, in this reservoir, as part of the current monitoring program, specific algorithms for chlorophyll estimation using satellites have been developed and published. Such algorithms allow phytoplankton chlorophyll estimation since 1984, thanks to the continuity of the Landsat mission (about 16 years prior to the monitoring program). Hence, we used images from 1984-2015 to explore if we could complement the information obtained using sediment cores. For this, we processed Landsat 5, 7 and 8 Landsat images (482, 350 and 67, respectively) in different areas of the reservoir, and calculated anomalies in chlorophyll (whenever chlorophyll was > 85 µg L^{-1}). We found that before 2003, in average anomalies were only recorded about one time per year, whereas after 2003 the frequency of anomalies markedly increased (average 8 anomalies per year). Overall, the patterns found using sediment cores were like those encountered using satellite estimation of chlorophyll. Thus, these tools could be complementary used for analyzing recent trends (last 30 years, since satellites are operative in space) of phytoplankton trajectories.

Multi-proxy analysis of the Pihué dam, as an indicator of environmental variability in the Aconcagua River Valley, Valparaiso Region, Chile, between 1960 and 2019

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The Central Valley of the Aconcagua River located in the Valparaíso Region in Chile (32°S, 70°W) has been affected by multiple environmental events. In high sedimentary deposition systems, it is possible to obtain records of the environmental conditions commonly preserved in sediments. With the purpose of evaluating the environmental variability of the valley, the sediments of the Pihué dam, created in 1960, were analyzed. In 2019, a sedimentary core was extracted, which was analyzed for magnetic properties (susceptibility, hysteresis cycles and Curie temperature), carbon content, macroscopic mineralogy, radiographs, elemental content (ICP-OES) and NDVI images. Our results allowed to identify an alternation between dark brown horizons enriched in water and organic matter and light brown horizons depleted in water and organic matter, associated with the formation of authigenic and allogenic magnetite, respectively. Metal(loid)s such as copper, molybdenum and arsenic were found in concentration above the maximum allowed by chilean standard n°1.333 as a result of mining and agricultural activity. The vegetation cover decreases from the year 2000 to the present, associated with wet/dry periods (1-2 years each period), which allows the formation of fine-grained magnetite (simple and superparamagnetic domain) in wet periods and deposition of magnetite from coarse grain (multidomain) in dry periods. This, could be related to cycles of El Niño/La Niña events, such as those which occurred in the years 1982-1983, 1987-1988, 1997-1998 and the dominant mega-drought in the region since 2010. Our results suggest the parameters analyzed from the sediments are sensitive indicators of changes in water quality and environmental variability in the Central Valley of the Aconcagua River.

Reconstructing biogeochemical cycling and primary producer community change at Hoa Binh Reservoir, Vietnam

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The Hoa Binh reservoir is a major impoundment upstream of the Red River Delta (RRD), Northern Vietnam. Since its construction in 1988, downstream mean discharge has reduced in tandem with suspended sediment transport, which together with sea level rise, have contributed to an increased risk of saline water intrusion in the RRD. In June 2017, a 48-cm-long core was collected from the central region of the reservoir and dated via ^{210}Pb and ^{137}Cs analysis. The age model of the core shows it covers the history of the reservoir since its creation from river impoundment in 1988. First changes in sediment composition are identified after c. 1997, when an increase in organic content and $\delta^{15}N$ values takes place. After c. 2004 there is evidence of increasing Fe_2O_3 deposition, concomitant with an increase in sedimentation rates to 1.39 g $cm^1 yr^{-1}$. Algal pigments also show a general increasing trend after 2004, with prevalent concentrations of cryptophytes (alloxanthin), siliceous algae (diatoxanthin), chlorophytes (lutein) and cyanobacteria (canthaxanthin). Further increases of these algal groups are documented post c. 2010 with sedimentary preservation indicators (Chl a: Pheophytin a) also showing an increasing trend; the latter possibly reflecting the increases in sedimentation rates. Similarly, diatom concentrations (*Aulacoseira* and *Cyclotella species*) show a sharp increase after c. 2010. While %C shows a gradual increasing trend since dam implementation, $\delta^{13}C$ values decline (from c. −24 to −29‰). C/N values (<10) indicate that throughout the core carbon is sourced from aquatic productivity. Microcystin occurrences also indicate the presence of cyanobacterial toxins throughout the sediment record (reaching up to c. 50 ng g^{-1} OC^1) with highest fluxes being recorded in the surface sediments (>750 ng cm^{-1} yr^{-1}). This is concomitant with the appearance of *Cyclotella stelligera* after c. 2016. Together, the multi-proxy stable isotope, geochemical and algal analysis adopted in this study aim to reconstruct sediment and nutrient retention in the reservoir (since installation) and estimate downstream delivery impacts to the RRD.

Increasing cyanobacteria dominance and water quality concerns in artificial lakes along the Rideau Canal system, Canada

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The Rideau Canal is a 202 km series of lakes, rivers, and locks that was built in 1832 to link the Ottawa River to the Great Lakes to provide an alternate military route for defending the City of Montreal from potential American attack in the early 1800s. Today the Rideau Canal is a Canadian National Historic Site and primarily used for water related tourism such as fishing and boating. During canal construction the hydrology of the region was changed substantially and water levels were raised in a number of wetlands and rivers to create lakes for boat passage. These artificial lakes now have a large number of recreational properties and homes on their shoreline and residents are increasingly worried about water quality deterioration in these ecosystems. The objective of this study was to assess if artificial lakes along the Rideau Canal are undergoing deterioration in water quality since they were artificial and if there is a greater instance of management intervention in artificial lakes compared to natural lakes in the Rideau Canal. To meet this objective, we analyzed diatoms and cyanobacteria pigments from the artificial Dog Lake and examined recent permit applications for aquatic plant removal in the Rideau Canal. We show using monitoring data that these artificial lakes are some of the most nutrient rich lakes in the Rideau Canal system and that residents are removing macrophyte biomass in these lakes more often than naturally occurring lakes. We further show based on an analysis of a dated sediment core from Dog Lake that this artificial lake has likely been nutrient rich from canal construction, however, cyanobacteria toxins really only start increasing in the around the year 2000, suggesting that recent reported changes in water quality may be influenced by both high phosphorus concentrations and climate warming. Combined these data indicate that artificial lakes may be more susceptible to environmental degradation in the face of a changing environment.

Multi-proxy record of hydropower and mining activities in northern Québec: case study from Manicouagan

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The impact crater of Manicouagan is a prominent landscape feature in northern Quebec (Canada) highlighted by the dam impoundment forming the annular reservoir in 1970. The damming of the Manicouagan River and the flooding of a large lake upstream had dramatic socio-cultural repercussions on the Innu community, with the disappearance of a traditional lifestyle defined by seasonal migrations along natural river courses. The environmental impacts of the conversion of Lake Manicouagan into a reservoir (+ 140 m) have long been overlooked. Here we explore these impacts from a sediment perspective using a transect of short cores collected at various depths and locations. Applications of core scanning techniques (CT-Scan, ITRAX, hyperspectral imaging) provided a set of geochemical and sedimentological proxy documenting environmental changes occurring over the past century. This dataset allows discussing the spatial variability of reservoir impoundment, water-level rise and post-impoundment sediment dynamics across proximal, distal, deep and shallow environments. The flooding event correlates lake-wide with a ^{210}Pb-^{137}Cs-dated thin clay layer deposited by the remobilization of shelf sediments into the deep basins, except at proximal locations where a thicker flood event suggests a delta slope failure. Above this layer, the reservoir sediments show a drastic change from pre-impoundment deposits. Since the damming, organic-rich laminated sediments deposited, with a noticeable mercury enrichment attributed to biogeochemical cycling and remobilization from flooded forest soils. In addition, a pink-red layer recorded below the clay layer constitutes a benchmark level across the lake, reflecting iron mining activities that prevailed between 1960 and 1985. This study illustrates how recent hydropower and mining activities affected large and deep aquatic ecosystems in boreal landscape.

Disentangling the evolution of trophic state of San Roque reservoir (Córdoba, Argentina) by paleolimnological reconstruction and land-use history

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Paleolimnology has become a valuable tool for assessing the environmental degradation suffered by reservoirs during the last decades. Water quality in reservoirs of central Argentina has been affected by the progressive eutrophication as a consequence of the land use change and climatic variability. The San Roque reservoir (SRr; 31° 22' S, 64° 27' W) has reached a hypereutrophic state in the last two decades. Multi-proxy analyses (MS, grain size, TOC, TIC, P, fossil pigments) of the paleolimnological record of radiodated sediment cores allow to reconstruct the 20th-21st century environmental history of the SRr and the identification of four main environmental stages. The record of stage 1 (1914–1958 CE) can be considered as the environmental base level of the reservoir when anthropic activity was low. Stage 2 (1958–1978 CE) includes a volume increase of SRr, due to a second dam construction, while the trophic state remained low. Stage 3 (1978–2000 CE) is characterized by an increase in the internal primary production (eutrophic state), mainly caused by anthropic input of nutrients (*e.g.*, sewage effluents) due to urban expansion in the SRr river watershed. Stage 4 (2000–2018 CE) corresponds to the highest trophic scenario, which has led to hypereutrophic conditions associated with increased urbanization in the littoral zone of the reservoir. SRr environmental reconstruction indicates that the system has been impacted by multiple factors: a) structural modifications (*e.g.*, changes in the base level by the second dam construction) and b) land use changes (*e.g.,* increase in nutrient load). In addition, precipitation increase after the 70s is an additional factor affecting eutrophication. Our results mostly highlight that the generalized degradation of SRr water quality has been promoted by the synergistic action of anthropic and natural forcing. These results can provide tools for modeling future scenarios and improving watershed management policies.

FOCUS SESSION 34

Paleoenvironment and paleoclimate records from long-lived lakes and paleolakes

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Heterocyte glycolipids: novel tools to obtain high-resolution climate records from long-lived lakes

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Sediment sequences of long-lived lakes represent highly valuable, continuous records of continental climate change. As such, they provide vital information on both the timing and magnitude of long-term climate trends as well as abrupt climate change events. Assessing this information, however, is often not straight forward as many conventional climate proxies are affected not only by temperature but also other biological and environmental parameters. Here, we show that the distribution of heterocyte glycolipids (HGs), which are synthesized by N_2fixing heterocytous cyanobacteria and abundantly present in modern freshwater environments, are strongly correlated to lake surface water temperatures. In form of the novel lipid paleothermometer HDI_{26}, we used these components to simultaneously reconstruct climate variations in tropical East Africa and Asia in high-resolution, employing sediment records from the two long-lived lakes Tanganyika (Tanzania) and Towuti (Indonesia). HDI_{26}-reconstructed surface water temperatures varied from ~22 °C to 26 °C in Lake Tanganyika and ~25 °C to 28 °C in Lake Towuti over the last 60,000 years. Lowest temperatures in both records were observed during the Last Glacial Maximum, which is followed by a 3 to 4 °C deglacial warming to yield highest temperatures in the Late Holocene. This general warming trend is interrupted by up to 1 °C cooling during abrupt climate change events (e.g. Younger Dryas). Our data thus provides new insights and quantitative estimates on Pleistocene to Holocene climate changes in tropical regions. Given that HGs are present ubiquitously in polar to tropical lakes and that they have been identified in lacustrine sediments of Early Cenozoic age, the HDI_{26} and other HG-based indices provide valuable novel tools to extract the highly sensitive climate information that is stored in sediments of (short- and) long-lived lakes worldwide.

Reconstructing Pliocene environmental conditions in the Levantine Corridor (Near East) with a multi-proxy study on a lacustrine record

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The Pliocene was the last significant sustained warm period in Earth climate history. Atmospheric carbon dioxide and global temperatures during this interval are comparable to those modeled for the near future. Considering a similar to current continental and oceanic positioning, it is possible to assume similar oceanic and atmospheric circulation patterns, and hence reliable climate archives dated to this interval may serve as a good analogue for providing a base of comparison to the future. Current data on the Pliocene mostly focus on marine sediments with terrestrial data arriving from loess and paleosol records. Yet, there is a lack of information from continental datasets, especially from the Eastern Mediterranean. The Erk'-el-Ahmar Fm. (3.15-4.5 Ma) is a ~150 m lacustrine succession exposed in the Jordan Valley and includes clay to very find sand layers with carbonate units and excellent preservation of freshwater mollusks, ostracods, and mammal bones (rodents and even a mammoth tusk). This study aims to reconstruct the environmental conditions in the region during this time interval using a multi-proxy approach that includes physical, chemical, and biological measurements carried out on a 23 m long push-core. Our results show major fluctuations in the lake hypsometry, as evidenced by the different parameters, which appear to reflect the local hydro-climate conditions. An orbital-scale dry-wet climate cycle is well identified, which influenced the lake depth, its redox conditions, and sedimentary provenance. The sediment cores capture transitions between a continuous deep to a shallow lacustrine environment, with potential short intermittent events (perhaps seismic or climate-induced), indicating the sustainability of this perennial water body. Results from this study provide an important understanding of the hydrological conditions that may have dominated the region during a warmer climate phase, challenging previous estimations on the governing mechanisms for climate variability in the region including precipitation patterns.

A chironomid-inferred summer air temperature reconstruction from the Middle Pleistocene (~ 300,000 yr BP) site Schöningen 13 II, Northern Germany

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Climate reconstructions based on fossil remains of aquatic organisms from Middle Pleistocene sites are scarce due to their often poor preservation. Subfossil head capsules of chironomid larvae from the archaeologically well-known site Schöningen 13 II, the Reinsdorf sediment sequence, correlating to Marine Isotope Stage 9, were studied, with the aim to reconstruct changes in summer air temperature as well as lake level and productivity fluctuations in the former lacustrine environment. Chironomid-inferred mean July air temperatures were estimated by applying weighted averaging partial least-squares regression (WA-PLS) based on a merged Swiss-Norwegian-Polish chironomid–temperature calibration data-set. The temperature reconstruction has an error prediction of ±1.45 - 1.75°C. High abundances of *Propsilocerus lacustris*-type (25%), *Chironomus anthracinus*-type (20%) and *Sergentia coracina*-type (15%) characterize Level 2c4/5 – 2c3, indicative of intermediate to warm temperatures (~16 – 19°C) and high productivity, associated with a shallow-lake environment. The chironomid assemblage of Level 2c3 – 3b1 is dominated by thermophile chironomid morphotypes *Microtendipes pedellus*-type (20%), *Glyptotendipes pallens*-type (20%) and *Polypedilum nubeculosum*-type (15%), that suggest warm climate conditions (~18 – 21°C). Level 4 is characterized by increasing abundances of *Propsilocerus lacustris*-type (50 %) and *Chironomus anthracinus*-type (20%) as well as *Psectrocladius sordidellus*-type (20%), *Cladotanytarsus mancus*-type (15%) and *Cricotopus intersectus*-type (10%), which are associated with macrophyte growth. This suggests continuous water coverage and a productive environment. Paleotemperatures range between 16 – 22°C, a cooler phase (~ 16°C) is associated with higher abundances of the cold-stenothermic morphotype *Corynocera ambigua*-type (15%). Data shows that paleotemperatures were more fluctuant during MIS 9 in Central Europe than expected and up to ~4 ±1.56°C warmer than the average July air temperature during 1961 – 1999 CE (17.6°C).

Depositional processes and climate-change signatures recorded in the 250-kyr sediment record of Lake Chala, equatorial East Africa

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Drilling by the International Continental Scientific Drilling Program (ICDP) project DeepCHALLA in November 2016 recovered a 214.8-m long sediment sequence from Lake Chala, a 91-m deep crater lake near Mt. Kilimanjaro in equatorial East Africa. Overlapping 3-meter cores from adjacent drill holes together achieved 100% recovery in the upper 133.3 m below the lake floor (mblf), and 75% recovery in the lower part. Here we present a detailed lithostratigraphic analysis of the DeepCHALLA composite sequence, and using down-hole logging data we integrate it with the seismic stratigraphy in order to characterize changes in depositional environment related to paleohydrological signatures of past climate variability superimposed on the evolution of basin morphometry. Lake Chala sediments entirely consist of either mm-scale laminated or cm-scale banded organic diatomaceous clayey mud, interbedded with 1285 turbidites (0.1-103.2 cm), 31 visible tephra layers (0.1-3.0 cm) and sections of slumped mud totaling 4.4 m. We distinguish two lithofacies: mm-scale laminated mud and cm-scale banded mud. Mm-scale lamination reflects marked seasonality in the settling of different sediment fractions on a quiet and permanently anoxic bottom (i.e., varved or varve-like); cm-scale banding is interpreted to represent modest post-depositional disturbance of mm-scale lamination under conditions of reduced water-column stability, rather than changes in sedimentation rate or reduced seasonality in the settling sediment fractions. Based on the age model derived from seismic stratigraphy, the sediments recovered by DeepCHALLA covers ca. 250 kyr, and the complete history of Lake Chala since shortly after its formation. Direct comparison with seismic stratigraphy highlights that seismic-stratigraphic units are defined primarily by the mechanisms in which water-column depth affect the degree of sediment focusing, while lithofacies variability reflect changes in water-column stability. Our analysis thus shows that there has been no one-on-one relationship between lake depth and mixing regime in Lake Chala.

Establishing the reliability of GDGT-based climate proxies in the 250-ka Lake Chala record by integrating basin evolution information

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Biomarker studies on the sediment records of long-lived lakes can provide much needed high resolution paleoclimate reconstructions from continental settings. Traditionally, such reconstructions are only supported by regional or global calibrations relating biomarker proxies to targeted climate variables. Recent realization that aquatic microbial communities responsible for producing certain biomarkers are sensitive to water-column variables such as oxygen availability and light penetration depth has prompted investigation of modern lake systems to validate proxy-climate relationships. However, monitoring of system and proxy variation at the seasonal to interannual time scale does not necessarily suffice to explain proxy variation at the much longer time scale of paleoclimate reconstruction. In particular, the degree to which biomarker proxy records from lakes are impacted by long-term lake-basin development is rarely discussed. The International Continental Scientific Drilling Program (ICDP) project DeepCHALLA recovered a continuous sequence of diatom and organic-rich sediments from Lake Chala, a permanently stratified crater lake in equatorial East Africa, spanning the last c. 250,000 years (250 kyr). Glycerol dialkyl glycerol tetraethers (GDGTs), membrane lipids of archaea and bacteria, form the basis for several paleoclimate proxies. Multi-year studies of GDGTs in the modern system revealed critical information about their spatial distribution and relationship to temperature and moisture balance variation. Here we analyze GDGTs throughout the DeepCHALLA sequence, adding insights from comparison with major phases in basin evolution as indicated by independent proxies (seismic reflection data, lithology and diatom assemblages). During the early stages of lake history certain chemical, physical and biological aspects were dissimilar to the current system. Importantly, the clearly defined mixing zones to which specific GDGT producers are associated today were likely not yet established. As a consequence, before ~150 ka many of the GDGT-based proxies show irregular trends, and periodicities reflecting expected orbital insolation forcing of the local climate are mostly absent. Therefore, we conservatively surmise that our GDGTbased proxy records from Lake Chala reliably reconstruct temperature and moisture variability in equatorial East Africa from 150 ka onward, i.e. covering the last glacial-interglacial cycle.

The diatom record from Lake Chalco, central Mexico: a 150 ka record of climatic and environmental changes

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Lake Chalco in central Mexico, has an extraordinary sedimentary record that provides paleoenvironmental information of repeated changes from glacial to interglacial climates in the northern limit of the Neotropics. The objective of this work was to characterize the diatoms that are present in these sediments and to use them as paleolimnological indicators to infer hydrological balance changes in the region during the last 150 ka. Detrended correspondence analyses were used to evaluate the ecological turnover and to identify diatom species associations along the sequence. At orbital scale, a species turnover that involved changes between freshwater *Stephanodiscus* spp. – small Fragilariaceae spp. – *Cocconeis placentula* assemblages, present during the coldest intervals (late MIS6, MIS5d, MIS2) against salt tolerant taxa, dominated by *Cyclotella* spp., in higher evaporation conditions (MIS5e, MIS5ca, MIS4, MIS3, early MIS1). Millennial-scale climatic fluctuation were also identified as peaks in freshwater (mostly small Fragillariaceae spp.) or as peaks in salt-tolerant species. Comparatively, MIS6 and MIS5d were colder (-7 to -6°C) and wetter than MIS2 (-5 to -4°C). In contrast, MIS5e and early MIS1 (11.5 to 6 ka) had similar low lake level, saline conditions (+2 - +3°C). Besides, MIS5 was a time of intense climatic change associated to wide amplitude orbital forcing that favored a *Cyclotella* spp. succession (*C. meneghiniana, C. tlalocii, C. poyeka, C. quillensis*). Contrastingly, smaller temperature changes (-1 to +1°C) were inferred during MIS4 and MIS3.

Millennial hydrological variability in the northern Neotropics during MIS3-2 archived in Lake Petén Itzá sediments

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Sediments from Lake Petén Itzá (Guatemala), located in a highly biodiverse and geographically sensitive climate area, preserve one of the oldest paleoclimatic records in the northern neotropical lowlands (>75 kyr). We used geochemical and mineralogical data to infer changes in runoff, lake evaporation, organic matter sources and redox conditions associated with water-level variations during Marine Isotope Stages (MIS) 3 (57-29 cal ka BP) and 2 (2915 cal ka BP). During MIS3, high values of Total Organic Content (TOC) and Ti as well as low ratios of Fe/Mn indicate high primary productivity and anoxic bottom waters associated with humid conditions. High and variable Ca/(Ti+Al+Fe) ratios and an increase in gypsum content suggest enhanced but variable evaporation of lake water during the transition to MIS2 (39.023.0 cal ka BP). During the Last Glacial Maximum (23.0-18.0 cal ka BP), the area was dominated by higher runoff that resulted in a lake level rise. We also identified abrupt climate oscillations known as Heinrich Stadials (HS), Greenland Interstadials (GI), and Greenland Stadials (GS). Our record indicates that HS and GS were generally dry, particularly HS1-3 and GS5, 7 and 8. Contrastingly, GI were characterized by higher runoff and wet conditions, especially GI7-10. A regional comparison of changes in runoff in Petén Itzá with other records from the Caribbean, Central Mexico and the Gulf of Mexico suggests shifts in the average position of the Intertropical Convergence Zone and changes of the Atlantic Meridional Overturning Circulation that may have modified moisture transport to the northern Neotropics.

Sex, size and quantity matters in the Neotropics: the ostracode record of ancient Lake Petén Itzá, Guatemala

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Neotropical ostracode species in ancient Lake Petén Itzá (Guatemala) are sensitive to changes in water conductivity and temperature. This allows using the lake's ostracode assemblages in sediment cores as climate-proxies. In this study, we characterize hydrological conditions during past episodes of abrupt climate change in the northern Neotropics, including Heinrich Stadials 6-1 (HS6-1). Quantitative paleoecological analysis reveals that HS5-HS1 were cold and dry as suggested by lower ostracode richness and diversity, whereas HS6 and HS5a were slightly warmer and dry, leading to greater values of both indices. While fluctuations in the relative abundance of ostracode taxa have been used to infer past environmental conditions, there has been little work on long sediment records to explore the effects of past climate change on the reproductive strategies of ostracodes. Therefore, we examined stratigraphic changes such as the ratios of males/females, and body size of the endemic ostracode *Paracythereis opesta* over the last ~23 ka in sediment core PI-6 (water depth 71.0 m, length 75.9 m). Length and height of adult and juvenile ostracode shells since the Last Glacial Maximum (LGM, ~23-19 ka BP) were measured and their sex was determined, as the taxon displays clear sexual dimorphism. Results indicate: (1) a reduction in size over time, which we attribute to higher temperatures and fresher lake water conditions during the late Holocene, (2) female dominance during dry and stable conditions, while more males appear mostly during wetter periods of higher water levels such as the cold LGM (ca. 21 ka BP) and the warm early Holocene (~9.8 ka BP), and (3) sexual dimorphism, which is already visible in the last larval stages (A-1). Our preliminary observations of *P. opesta* populations reveal novel information about the morphological and reproductive responses of freshwater ostracodes in the Neotropics.

Interstadial-stadial climate variability during MIS 3 recorded in the Nesseltalgraben paleolake (German Alps)

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The 21 m thick sediment profile at the Nesseltalgraben site (SE Germany) is presently the best-dated, high-resolution lacustrine record of Marine Isotope Stage 3 (MIS 3) in the northern Alps. A revised age model, based on 30 radiocarbon-dated plant remains calibrated with IntCal20, places the record at 50-29 ka cal BP. The age model is corroborated by detection of the Laschamps paleomagnetic event (42 ka cal BP). The pollen record suggests repeated changes from tundra to open shrub and forest vegetation. Maxima of arboreal pollen coincide with Greenland interstadials 5.1, 5.2, 6, 7, 8, 11, and 12, indicating a significant increase in (summer) temperatures during these short episodes. A chironomid-based reconstruction of ambient temperature suggests changes in July air temperature between ca. 10 and 14 °C, i.e. ca. 4-8 °C below present-day values (1981-2010). This is generally in line with branched glycerol dialkyl glycerol tetraether (brGDGTs)-reconstructed mean annual air temperatures, which range from 5 to 11 °C with maximum temperatures observed during interstadials. Isotope records from organic matter, sediment cellulose, moss cellulose, and humic acids complement the reconstruction of this Alpine paleoenvironment during the last glacial. Hydrogen isotope records of humic acids show a major anomaly at 39 ka cal BP, around Heinrich Stadial 4 (H4). At the same time, increased lithologic variability and coarser grain sizes suggest a more dynamic hydrologic regime and shifting isotopic records suggest that a climatic tipping point has been reached. Presumably, these changes around H4 are the result of a change in atmospheric circulation and cooling of the North Atlantic, which is also expressed by increased occurrence of permafrost around that time in Central Europe.

Clumped-isotope thermometer applied on ostracod shells: a new proxy to identify continental climate changes

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In many modern and ancient lakes, ostracod shells constitute the only carbonates capable to record climatic and environmental changes at high-resolution. Ostracods are small aquatic crustaceans (mostly 0.3-5 mm) with a stable low-Mg calcite shell mineralogy, which makes them ideally suited for targeted geochemical analyses. Therefore, ostracods represent the best candidate to develop a new Carbonate Clumped Isotope (Δ_{47}) lacustrine paleothermometer able to disentangle the effects of global climate changes at regional scale. Δ_{47} paleothermometry constitutes a tool that significantly reduces the uncertainties associated with lake temperature reconstructions and combined with $\delta^{18}O$ of carbonate enables the reconstruction of the isotopic composition of the water from which the carbonate precipitated and thereby changes in the precipitation over evaporation relationship. To establish the relationship between Δ_{47} and the temperature for ostracod shells, the species Eucypris sp. and *Herpetocypris* sp. have been collected in monitored environment at 4°C and 12°C. Preliminary analyses were performed at the Vrije Universiteit Brussel (AMGC-VUB lab) using a Nu Instruments Perspective-IS stable isotope ratio mass spectrometer in conjunction with a Nu-Carb carbonate sample preparation system. First results show a linear regression between ostracod-Δ_{47} and calcification temperature that is in good agreement, within the uncertainties, with previous I-CDES published calibrations. A first application made on a late Pleistocene record from shallow Lake Trasimeno (Italy) allowed to identify warmer/colder and humid/dryer conditions during Greenland Interstadial and Greenland Stadial respectively.

The Holocene vegetation and fire history of Western Caucasus (Russia) reconstructed by multi-proxy data from the high-altitude Lake Khuko

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The new multi-proxy records of the Holocene environmental and climatic changes in the Western Caucasus revealed from mountainous Lake Khuko (Caucasus State Natural Biospheric Reserve, 1744 m a.s.l.) are presented. Palaeoecological analyses of a sediment core for loss on ignition, pollen, plant macrofossil and macroscopic charcoal allowed us to determine five principal climatic phases with several subphases since 10.5 ka BP. The age model is based on seven AMS ^{14}C dates, supplemented by ^{210}Pb data for the uppermost part of the sediment core. Warm periods (10.5-6.7, 6.7-5.5, 3.5-2.4, 0.8-0.5 ka BP) were characterized by expansion of forests, typical of modern low and middle mountain zones, as indicated by the increase in abundance of *Quercus, Ulmus*, *Corylus* and *Tilia* in the pollen assemblages. Cold periods (5.5-3.5, 2.4-0.8, and 0.5 ka BP-present) are marked by a consistent decrease in organic matter content in lake deposits and possibly higher intensity of the catchment erosion. The changes in pollen assemblages (for instance peaks of *Abies, Picea,* and *Pinus*) suggested a potential elevational decline in the boundaries of vegetation belts and expansion of high-altitude woodlands. Abrupt changes in the lake ecosystem were identified between 4.2 and 3.5 ka cal BP marked by a short-term variation in sediment regime and the extremely high concentration of macroscopic charcoal particles, probably caused by intensive fires and climatic fluctuations in the Western Caucasus region during the 4.2 ka event. The study was supported by the Megagant project (agreement No 075-15-2021-599, 8.06.2021) of the Ministry of Highest Education of Russia.

A 270,000-year-long probabilistic quantitative temperature reconstruction from Laguna Fùquene, Colombia

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Quantitative climate reconstructions are fundamental to contextualising past environmental changes. In particular, the proliferation of pollen-based reconstructions during the past decades has been instrumental in improving our understanding of past climate dynamics across various spatial and temporal scales. However, this knowledge has been mainly concentrated in North America and parts of Eurasia, and very few quantifications exist in the tropics. This global data imbalance is partly due to the sparser network of supporting pollen records in the tropics and, in equal proportions, to the limitations of the most commonly used reconstruction techniques (e.g. the analogue technique or WA-PLS) in dealing with the specificities of tropical vegetation. To address this problem and produce the much-needed climate quantification from tropical regions, we propose using the probabilistic method CREST (Climate REconstruction SofTware) that uses probability density functions ('pdfs') fitted on modern occurrence plant data to reconstruct environmental parameters. CREST, which has been successfully employed in the African subtropics, offers many advantages over the classical approaches, such as 1) higher flexibility of application, 2) a better capacity to estimate uncertainties, and thanks to the recent developments of a dedicated R package *crestr* that includes a global calibration dataset, 3) is applicable in every environment where plants currently grow. Here, we present the fundamentals of the method and the package and illustrate their use with a novel temperature reconstruction derived from the 270,000year-long, high-resolution pollen record from Laguna Fùquene in Colombia, highlighting the influence of high-latitude forcing in the region at this timescale.

Early Pleistocene Paleoenvironmental Conditions in the Levantine Corridor: A new sediment core sequence from Lake 'Ubeidiya

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Lake 'Ubeidiya (central Jordan Valley) was a key site in the route of faunal and early hominin migrations out of Africa 1.6-1.2 million years ago. Previous studies examined the 310 m thick outcrop and described the sedimentary sequence as two major cycles of intercalating fluvial and lacustrine stages. However, much is still unknown about the environmental settings of the region and the lake properties. The current study uses XRF and granulometry, including end-member analysis, carried out on a ~16 m long core recently retrieved from the lower lacustrine cycle at the 'Ubeidiya site, with the aim of reconstructing the hydroclimatic conditions that prevailed in the region and may have facilitated early hominin migrations. The core preserves well-layered lacustrine sequences of alternating clays and silts, carbonates, massive clayey silt beds, and silts or sandy silts. Our initial interpretation suggests that the core's pristine mm-thick laminations indicate anoxic to sub-oxic conditions (and perhaps a deep lake environment), which experienced regular environmental changes in evaporation (coupled by precipitation of carbonates), along with occasional high-energy events (tectonic or climatic induced) indicated by siltier sediments. The thick carbonate facies suggest a larger-scale cycle or transition to carbonate precipitation in a low lake stand with greater evaporation. The new geochemical and sedimentological data provide a high-resolution record of variable environmental conditions, which appear to have responded to changes in both the surrounding terrestrial setting (increase or decrease in precipitation) and internal limnic regime (e.g., the oxic state of the hypolimnion). Moreover, our data shows that the lake might have occasionally shifted from open, closed, to semi-closed conditions.

Revision of *Lychnothamnus barbosai* occurrences

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Charophytes and ostracods were able to colonize long distance habitats, because they were dispersed by wind or animals, and had viable and resistant oospores and eggs. Therefore, it makes they are useful tools to biostratigraphic studies. An Upper Cretaceous charophyte (*Chara barbosai*), described to Adamantina Formation (Campanian-lower Maastrichtian), Bauru Group, Paraná Basin, Brazil, was synonymized with extant genus to *Lychnothamnus barbosai*. This species, *L. barbosai*, was related to occurring between Turonian and Santonian, Argentina (Plottier Formation, Neuquén Basin) and China (Qingshankou, Quantou and Yaojia formations, Songliao Basin). We do not agree about these occurrences, because these morphotypes are smaller, with less convolutions and ovate or sub-prolate in lateral view. This is probably a new species needing further investigations and revisions. On the other hand, the Campanian-Maastrichtian *L. barbosai*, described in Brazil (Adamantina Formation) is significantly bigger and has a prolate, or more cylindrical shape in lateral view. This *L. barbosai* "*sensu stricto*" resembles other Campanian-Maastrichtian species, such as *L. barbosai* from Wangshi Group (Campanian-Maastrichtian of Jiaolai Basin, China). This morphotype is smaller, but the number of convolutions and the prolate shape is closer to the Brazilian species. Other Campanian-Maastrichtian species resemble Brazilian *Lychnothamnus barbosai.* They are *Lychnothamnus* sp.1 (Campanian, Santos Basin), *Nemegtchara grambast* (Campanian-Maastrichtian, Deccan, India) and more precisely Maastrichtian Indian spp. *Chara* sp.1 Khosla *et al.*, 2022 (Jhilmilli Deccan) and *Chara* sp. Kania *et al.*, 2022 (Chhindwara, Deccan). Other similarities were pointed out with *Mesochara biacuta* from China (Wangshi Group, Jiaolai Basin) and Peru (Vilquechico Formation.). Finally, we reinforce the Campanian-Mastrichtian ages to Bauru Group, based on charophytes and non-marine ostracods.

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FOCUS SESSION 35

Ancient Lake Basins

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An integrated lacustrine record of warm climate dynamics: the Green River Early Eocene Climatic Optimum project (GREECO)

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Deep-time geologic records of unusually warm climate are vital for ascertaining how the Earth system will respond to rising temperatures in the future. Recent studies have shown that the Early Eocene Climatic Optimum (EECO), between ~50-53 Ma, may be particularly instructive because it embodied a number of relatively abrupt warming episodes. Two factors currently impede our understanding of these hyperthermal events however. First, the early Eocene timescale is only sparsely populated by radioisotopic dates and therefore subject to relatively large uncertainties. Second, the elevated pCO_2 levels associated with hyperthermals caused oceanic pH to decrease and the carbonate compensation depth (CCD) to rise. Oceanic records of hyperthermal events are therefore typically condensed and associated with evidence for carbonate dissolution. Alkaline lake strata offer an alternative class of climate archives, that are not subject to the same limitations. The lacustrine Green River Formation and equivalent alluvial deposits offer an especially important opportunity to complement the marine record of the EECO. These nonmarine strata contain a uniquely rich, expanded stratigraphic record of climate change, as well as numerous tephras. In addition to advancing our understanding of EECO climate, these deposits offer a rare opportunity to intercalibrate early Eocene radioisotopic, magnetostratigraphic, and astrochronological timescales. GREECO is addressing these questions through a multidisciplinary, collaborative study involving researchers from eight institutions, funded by the U.S. National Science Foundation. This study is integrating results from geochronology, astrochronology, magnetotratigraphy, sedimentary provenance, evaporite sedimentology, paleosol-derived paleoclimatic proxies, and stable isotope geochemistry (Δ47, Δ17O, δD), to produce a novel lacustrine view of early Eocene climate oscillations.

Integration of tetrapod-track taphonomic modes and taphonomic pathways with the Lake-basin type model

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Lake systems contain outstanding sensitive integrated stratal records of environmental fluctuations that have been summarized in the lake-basin type (LBT) model. This model classified the stratigraphic record of ancient lake systems according to rates of potential accommodation relative to sediment+water supply. The LBT model convolved all modes and paths of water supply with amounts and types of sediment supply into a single basin-fill term (sediment+water) to provide widespread applicability. More recently, the model was enhanced and expanded. The elements of sediment+water supply were explicitly deconvolved (into through-flow, recharge, and discharge groundwater modes), the influence of the volume of sediment relative to water on lake hydrodynamics and ecosystems distinguished, and other parameters, such as invertebrate ichnofacies occurrence and distribution and groundwater hydrology, were integrated. Our detailed studies of vertebrate tetrapod tracks, their taphonomic modes, and ichnologic taphonomic pathways demonstrate their utility as sensitive indicators of environmental conditions of the track-bearing beds during imprinting and depositional processes in lacustrine systems. Three main tetrapod-track taphonomic-modes (TTTM) are defined based on the fidelity of anatomical features preservation: High-, Moderate-, and Low-fidelity. These modes strongly depend on the rheological condition of the sediment influenced by grain size distribution, mineralogy, stratal stacking at the bed scale, and moisture content—all of which are closely related to LBT, especially through the sediment+water supply factors. We propose integrating TTTM, ichnologic taphonomic pathways, and the spatial and stratigraphic distributions of vertebrate tracks with the LBT model to provide additional detailed insights into environmental and sedimentological conditions at the time of track imprinting. The wide array of Triassic Argentine paleolake records provide an excellent opportunity to characterize tetrapod footprint preservation and ichnofaunal taphonomic pathways in underfilled, balanced-filled, and overfilled lake-basins and to test this expansion of the LBT model.

Modern analogs for discharge and through-flow underfilled lake basin types

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The lake-basin-type model classifies ancient lake systems according to rates of potential accommodation relative to sediment+water supply as inferred from the stratigraphic record. This model integrated different pathways of water supply (direct fall, surficial, subsurface) into a single basin-filling volume variable (i.e., sediment+water). Subsequent studies widened its application but also showed its limitations, mainly for subsurface (groundwater) fed lake basins. Recently, we integrated the lake-basin-typemodel with the hydrological classification of playa lakes to differentiate subtypes of balanced-fill and underfilled lacustrine systems. This explained the hydrological complexity of those systems and their evolution through time and space by adding two major subdivisions of the sediment+water term: 1) water-supply paths; and 2) the volume of water supply relative to sediment supply. Water-supply paths are categorized as ‘through-flow’ (for overfilled, balanced-fill, and underfilled lake-basin types), ‘recharge’ (for balanced-fill and underfilled), and ‘discharge’ (for underfilled). These hydrological paths can be recognized using carbon and oxygen stable isotope compositions of primary lacustrine limestones, detailed sedimentology, and mineralogy. We propose two modern spring-fed lakes, Little Salt Spring (LSS) and Slope Spring (SLS), located in Pilot Valley, (easternmost Nevada, U.S.A.) within the Bonneville Basin to be discharge underfilled and through-flow underfilled lake systems respectively. LSS is saline with various evaporite crusts precipitated at its margin whereas SLS is freshwater with charophytes thriving in its waters. The oxygen stable-isotope signature ($\delta^{18}O_{vpdb}$) from carbonates in sediment cores ranges between -8.1 and -12.7 ‰ and -8.0 and -12.2 ‰ respectively. These modern examples of the newly expanded categories within the lake-basin-type model have been so far only applied to ancient lake basins. They demonstrate that expanding the model enables more detailed hydrological interpretations of lacustrine systems using data that match those available from deep-time lake basins, thus improving our understanding of lake basin controls across modern and ancient lacustrine systems.

Paleolimnological interpretations from organic matter data for the Santa Clara Abajo paleolake, Triassic, Cuyana Basin, Argentina

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The Santa Clara Abajo Formation (Peñasco Group) outcrops at the north of Mendoza province, as part of the Triassic infill of the Santa Clara subbasin, Cuyana Basin. It is composed of siltstones, fossiliferous shales, sandstone and subordinated conglomerates, corresponding to fluvial, deltaic and lacustrine deposits. The organic matter content was analyzed stratigraphically from five samples representing two facies association: a marginal lake facies association (samples M1 and M2 in lower section); and a lake center facies association (samples M3, M4, M5 in the middle and upper section). Organic matter (OM) extraction was carried out according to conventional techniques with hydrochloric (HCl) and hydrofluoric (HF) acids to obtain kerogen that was filtered through 10 and 150 um meshes. The retained material was mounted on glass slides and observed under a transmitted light optical microscope. All the samples were fertile and allowed the recognition of organic elements such as phytoclasts, palynomorphs and amorphous organic matter. The OM identified is mixed presenting both terrigenous and algal content in similar quantities, without variations in the proportions of the elements throughout the sequence. The recognized terrestrial components correspond to well preserved brown biostructured plants debris of woody particles, tracheids, cuticles and translucent plant tissues and various terrestrial palynomorphs (pollen and spores). Fluvio-lacustrine elements appeared as granular or spongy aggregates without defined structure, translucent, yellow to pale brown in color, corresponding to debris of algae in association with *Botryococcus* sp. The similarity in the composition of the OM both for the marginal subenvironment and for the center of the lake would indicate a shallow lacustrine body of reduced extension. This is coherent with previous findings of the overlying and more extensive Santa Clara Arriba paleolake with well differentiated palynofacies for the lake center facies association.

Palaeoenvironmental reconstruction of the upper Eocene lacustrine-palustrine facies of Loza-Moraza Formation, Miranda-Trebiño piggy back basin, Western Pyrenees, N Spain

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The Miranda-Trebiño basin is a piggy-back style trough located onto the western prolongation of the south Pyrenean thrust front (Basque Pyrenees, N Spain). The basal unit of the continental sedimentary infill of this piggy-back basin corresponds to the Loza-Moraza Formation, which is exposed along 35 km on the southern margin of the basin. The Loza-Moraza Fm. consists of up to 286 m thick siliciclastic, mixed and calcareous deposits representative of alluvial to palustrine-lacustrine environments and comprises vertebrate faunas pertaining to the MP 18 Biozone (Priabonian, late Eocene). This work focusses on the facies architecture, sedimentary model and main processes controlling sedimentation in the piggy back basin during the late Eocene. The Loza-Moraza Fm. internally is subdivided in three depositional sequences (SEQ1 to SEQ3) showing similar vertical facies trends. These units occur bounded by erosional discontinuities associated to net changes in the sedimentary regime. From base to top, the three sequences consist of conglomerates, sandstones and mudstones that grade vertically and laterally to deposits of massive to well-stratified carbonates, marlstones and limestones. Detailed facies analysis enabled the identification of four main facies associations corresponding to distal alluvial, palustrine, freshwater and brackish water lacustrine depositional environments. The spatial distribution and interrelationships between siliciclastic and carbonate lithofacies seem to have been controlled by basin-scale tectonic pulses associated to the emplacement of the southern thrust front, the local influence of diapirs of Triassic salts and clays and subtle changes in local climate. Further work is needed to understand the precise relationships of the Loza-Moraza Fm. with the regional climate conditions inferred for western Europe during the Priabonian and the Eocene to Oligocene transition (EOT). ZL acknowledges funding through a pre-Doctoral research grant from the University of the Basque Country UPV-EHU. This is a contribution to the Consolidated Research Group IT-1602-22 of the Basque Government Research System.

The Middle Miocene Climatic Optimum in lacustrine sequences as recorded by stable isotope composition in the Ebro Basin, NE Iberia

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The Middle Miocene Climatic Optimum (MMCO) represents the latest, longer global warming period on Earth. It has been set between 17 and 14.5 Ma in the marine record. The age and evolutionary trend of the beginning and ending of the MMCO have not been characterized in detail in the continental record, mainly due to the lack of reliable absolute chronology. In the Ebro Basin, the youngest southern foreland basin of the Pyrenees (NE of the Iberian Peninsula), the available magnetostratigraphic analyses through a dominantly lacustrine succession allowed location of rock strata corresponding to 17 and 14.5 Ma. Samples taken below and above these two dates were dated by interpolation within each magnetic polarity chron. $\delta^{13}C$ and $\delta^{18}O$ analyses were performed on calcite in marlstones, limestones and mudstones. Sampled rocks span two wide time intervals around these two dates. In the lower interval, between 17.7 to 16.2 Ma, the $\delta^{18}O$ composition evolves towards less negative values until 16.4 Ma; from this age onwards, the composition becomes lighter and less variable. The $\delta^{13}C$ overall trend is towards less negative values. This trend consists of a relative decrease until ca 17.1 Ma followed by a change to an increasing trend. The inflexion may represent a change towards lower Precipitation/Evaporation. In the upper interval, between 15.1 and 14.0 Ma, the $\delta^{13}C$ and $\delta^{18}O$ values have a complex evolution, with an overall decreasing trend. $\delta^{13}C$ and $\delta^{18}O$ show parallel evolutionary trends until 14,4 Ma; from this age onwards the $\delta^{18}O$ trend changes towards less negative values. An outstanding increase in both isotopes between 14.8 and 14.5 Ma denotes a marked decrease in P/E that interrupts the overall tendency toward more humid conditions, as indicated by decreasing $\delta^{13}C$ values. Sedimentological, mineralogical and magnetic properties support these evolutionary trends. Acknowledgements: Grant PID2019-106440GB-C22, funded by MCIN/ AEI/ 10.13039/501100011033.

GENERAL SESSION I

Tectonic and volcanic large lakes

Lakes as sensitive records of ancient tectonic processes in continental interiors: Examples from the North American Cordillera

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Histories of ancient tectonic plate motion and mountain building focus on paleomagnetic poles and piercing points to define relative plate motions, and kinematics, thermochronology and detrital provenance to define orogenic evolution, and focus on regions adjacent to plate boundaries where most horizontal and vertical motions typically occur. Intraplate settings affected by flattened subduction present an interesting challenge because the effective 'plate boundary' lies 100-250 km beneath the plate. Because lakes integrate the local landscape and paleoclimate of their catchments and establish local datums, their deposits are rich but often underutilized tectonic archives. We present several examples from the North American Cordillera which illustrate their usefulness in tracking tectonic processes. Most published models for the central North American Cordillera depict flattening of the Farallon slab beneath the North American plate beginning in the Late Cretaceous, which 'refrigerated' and hydrated the mantle lithosphere beneath the North American plate and transferred magmatism and contractile deformation from the orogenic hinterland to the foreland to the east, in a manner analogous to the Pampean flat slab beneath the South American plate. The flattened Farallon slab began progressively detaching beginning in the early Eocene, returning to normal-angle subduction by the late Oligocene. Cenozoic lake deposits can be grouped into two distinct types depending upon slab position. 'Early phase' lakes (lower Elko, Green River, and Tatman formations) coincide with structural lows, and captured large catchments. 'Late phase' lakes (upper Elko, Wagon Bed, and Browns Park formations) occur on structural highs and had small catchments. During the early phase, hinterland-headed streams are interpreted to have become ponded due to subsidence above the sinking slab paired with uplift where asthenosphere had already detached. During the late phase, the lakes with small catchments formed due to landscape disruption by faulting and magmatism induced by asthenosphere emplacement and isostasy.

GENERAL SESSION 2

Present-day lacustrine systems

Spatiotemporal patterns in lake ice phenology in New Brunswick and eastern Maine

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Annual ice out records (the date of disappearance of ice cover from a water body) from closely-spaced lakes in New Brunswick and eastern Maine were analyzed for regional spatial and temporal patterns. LOWESS regressions indicate that since the 1870s ice out has shifted approximately 5 – 10 days earlier in this region, a pattern consistent with warming climate. Wavelet coherence analysis of the records indicate that ice out was coherent, indicating regional climatic influencers to be the primary forcings of observed ice out patterns. Given the regional coherence, further temporal analyses were carried out for only one lake, Oromocto Lake, as it had the longest ice out record, extending from 1876 to 2021. Cross wavelet analysis was carried out between the Oromocto Lake ice out record and a variety of large-scale climate teleconnections to assess linkages between observed trends and cycles observed in the ice out to specific climatic phenomena. Interannual oscillations in ice out were most strongly influenced by the North Atlantic Oscillation and the El Nino Southern Oscillation, whereas decadal and interdecadal oscillations in ice out were associated with the 11-year solar cycle and the Pacific Decadal Oscillation, respectively.

High-resolution lake infill time modeling at Jackson Lake, Wyoming

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Accurate models of lake infill time are exceptionally rare despite their importance to lake ontogeny studies, hydrographic studies, reservoir management, and any research requiring accurate lake morphology and particulate flux data. We combined sedimentological and radiochemical (^{137}Cs, ^{210}Pb) data from 20 sediment cores taken lake-wide with >100 line-km of seismic reflection data (CHIRP) collected from 2018-2021 to produce an extensive data set at Jackson Lake, Wyoming. With these data we produced a high-resolution bathymetric map, quantified historical (last ~150 yr.) linear (cm yr.$^{-1}$) and mass-based (g cm^{-2} yr.$^{-1}$) sedimentation rates, and forward modeled 1-D and 3-D estimates of lake infill times and compared the results to the stratigraphy constructed in the lakes deep depocenter since the last major glaciation (Pinedale, ~15 ka), as revealed by geophysics. Jackson Lake has a maximum depth of ~140 m and was divided into depth swaths at 20 m intervals. Each swath contains 1-5 coring stations, yielding discrete or mean sedimentation rates for each. 1-D and 3-D "spillover" infill time models were developed, which all conserved mass (sedimentation in a filled zone "spilled" into the next deeper interval). Two iterations of the 1-D model (centroid, mean depths), and one of the 3-D model yielded infill times in close agreement (20,970, 20,920, and 18,800 yr., respectively). These values are in accord with historical basin infill revealed by geophysics, which indicates that the acoustic basement maximum at the deepest depocenter is at 251 m, with a maximum sediment thickness there of 113 m, which represents infill of 45% since Pinedale glaciation (assuming evacuation of all pre-Pinedale sediment). This equates to a long-term basin infill rate of 0.003% yr.$^{-1}$, meaning that the lake would require another ~18,330 yr. to completely infill, which is in close agreement with all the infill times modeled here, particularly the 3-D model (18,800 yr.).

Integrating water quality monitoring and diatom community trends to determine landscape-level change in protected lakes

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Lakes in protected or remote regions are not immune to anthropogenic impacts and face stressors ranging from the atmospheric deposition of pollutants to global climate change. Monitoring programs in remote and protected lakes can be constrained by sampling logistics, leaving an incomplete picture of how the systems may be changing. Here, we use diatoms as early indicators of change in relatively undisturbed lakes from five national park units across the Great Lakes region (USA). Even with their protected status, the most remote and isolated of these lakes have been showing signs of change in recent years, including nuisance cyanobacterial blooms. To determine which environmental parameters were having the biggest effect on lake ecology, surface sediment samples were collected repeatedly over more than a decade to analyze diatom community turnover. This diatom community change was compared to measured water quality data collected over the same period in order to identify the predominant drivers of ecological change. The most striking result of this study was the synchrony of diatom change across lake types within most parks. Many of the stressors found to be affecting lake ecology at the primary producer level in these protected lakes were acting on a landscape scale and across biomes. Changes in thermal regime and water-column mixing appeared to drive much of the change across parks, although much of the diatom turnover also followed a sulfate or pH gradient. Nutrients did not appear to play a major role in diatom community change. This method of using diatoms in conjunction with water quality monitoring allows for an integrated response over a number of years and provides managers with a complementary tool to determine which environmental parameters are having the biggest effect on lake ecology.

Algal and bacterial pigments from the sedimentary archive of a high-use coastal marine embayment

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The Bay of Sept-Îles (BSI), located in the Gulf of St-Lawrence (Canada), is home to one of the busiest mineral ports in North America and harbors a diverse industrial sector, including an aluminum smelter, iron ore pellet production and seafood industry. However, the effects of anthropogenic activities on the Bay's ecosystem and biodiversity remain little-studied. Our objective was to explore the usefulness of algal and bacterial pigment assemblages preserved in a sedimentary archive from the BSI to infer temporal variability of primary producers prior to and following the permanent establishment of European settlers in the region in the late 19th century. Using high performance liquid chromatography (HPLC), we hope to be able to detect a signal of industrialization, which should correspond to the mid-20th century, and compare recent with pre-industrial variability in the structure and abundance of organisms at the base of the food chain. We identified and quantified a total of 13 pigments at various temporal resolution throughout the core. Combined with a ^{14}C-based age-depth model, this information will allow us to better assess recent local anthropogenic effects and global change on this important component of the aquatic ecosystem, and hopefully contribute to improving environmental management strategies for the BSI.

Spatial variability of sediment accumulation in Jackson Lake, Wyoming

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Jackson Lake, Wyoming (USA) represents a unique environmental setting for limnogeological research due to the complexity of its formation. Interacting processes shaped the basin, including tectonic forcing (active Teton Fault on its western margin), multiple episodes of glaciation (Bull Lake, ~125 ka; Pinedale, ~15 ka), and anthropogenic influences (dam construction, tourism). The objective of this study is to identify linkages between basin development (tectonic, glacial, hydrologic, and anthropogenic factors) and modern limnogeological processes driving variability in sediment deposition across Jackson Lake.
Twenty short (< 1m) sediment cores were collected throughout Jackson Lake in 2019 and 2021 with the purpose of capturing the spatial complexity in sedimentation. Utilizing radionuclide dating (^{137}Cs and ^{210}Pb), near-term (< 150 years) sediment accumulation rates were modelled showing a heterogenous distribution of sedimentation. Rates range between 0.07 – 0.46 cm y^{-1}, with four spatially distinct ‘zones’ of sediment accumulation apparent. These include, (1) high sedimentation rates (0.32 – 0.46 cm y^{-1}) within a deep (~140 m) depocenter. This zone was glacially scoured, bounded to the west by the Teton Fault, and is believed to capture most of the sediment flowing in from the Snake River to the north. Next, (2) high rates (0.32 to 0.41 cm y^{-1}) are found adjacent to Jackson Lake dam in the southeastern area of the lake, a product of sediment trapping following dam construction. Next, (3) Moderate to high rates (0.14 – 0.42 cm y^{-1}) are present across the Snake River delta, associated with hydrologic input from the Snake River, in addition to the raising of base level following dam emplacement that submerged this area. Last, (4) low to moderate rates (0.07 – 0.23 cm y^{-1}) are distributed along the lake’s shallow margins, identified as a factor of minimal sediment input from few, small tributaries around the basin and sediment focusing to the steep-sloped depocenter.

Sea level changes and coastal aeolian processes on the Gorlo Strait coast (The White Sea, Russia) in the Holocene

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Activation and stabilization of coastal aeolian processes depends on changes in sea level. The White Sea level in the Holocene changed as a result of the interaction of glacioisostatic movements and eustatic fluctuations in the World Ocean level. We have studied the sea level dynamics and rhythms of aeolian processes in the area of the mouth of the Maida River (White Sea, Gorlo Strait). The current amplitude of the tides reaches about 4 m. There is an active sand accumulation at the mouth. The sands are brought in by a longshore drift and river discharge. Field work included paleolimnological study (coastal lake and peat bogs deposits coring), geomorphological study, ground penetration radar profiling, aerial imagery and topography surveys. Analytical studies including grain-size, geochemical, diatom analyses and radiocarbon dating of bottom sediments were performed. Accumulative aeolian relief was formed in areas with a positive coastal-marine sediment balance. The present-time coastal dunes have been forming since the late Holocene. Four stages of aeolian processes activation have been recorded. At the same time, mean sea level fluctuations in the late Holocene did not exceed 1 m.Acknowledgments: Ministry of Education of the Russian Federation (project No. FSZN-2020-0016) - paleolimnological research, sea-level reconstruction; Russian Science Foundation Project No. 22-27-00499 - geomorphological and GPR-research.

GENERAL SESSION 5

Big Data

Assessment of sedimentary chlorophyll-a concentration algorithms using hyperspectral imaging

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Chlorophylls are commonly used to infer changes in lake primary production over decades to millennia based on concentrations in sediment cores. Sediment chlorophyll concentrations may be measured through visible reflectance spectroscopy or through extractions followed by HPLC or spectrophotometry. Hyperspectral imaging, a form of spectral reflectance measurement of core surfaces, is increasingly being used in paleolimnology because of its detailed high-resolution representation of sediment features. Numerous bio-optical spectral indices have been introduced over the past two decades to estimate chlorophyll concentrations from sediment cores based on the interaction between light and chlorophyll components on the sediment surface. Such models are then applied to cores with highly variable sediment compositions, although matrix effects on model precision often remain untested. In this study, we explored the development of a standard model for different sediment matrices by pairing traditional spectroscopic measurements with chlorophyll indices using hyperspectral data from several cores collected across Canada. We considered multiple scenarios for assessing indices individually and in combination, while also considering the full potential of state-of-the-art regression algorithms. Moreover, we studied the impacts of two important parameters – particle size and sediment brightness – on chlorophyll inferences. Finally, we assessed the performance of all models with the goal of developing a universal model for reconstructing past chlorophyll concentrations. Our findings indicate that particle size had no systematic impact on chlorophyll indices, but that greater sediment brightness resulted in underestimation of inferred chlorophyll concentrations. In general, indices that highlighted chlorophyll absorption features through ratios or normalized differences performed better than those based on differential equations, however, no index emerged as a universal model appropriate for inferring absolute chlorophyll concentrations across all sediment characteristics. The integration of all chlorophyll indices using machine learning showed promising results that may lead to a single model for estimating chlorophyll concentrations applicable to all lakes.

The Neotoma Paleoecology Database: Overview and diatom data analysis

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The Neotoma Paleoecology Database (www.neotomadb.org) is a community-curated data resource that supports regional and global change research. It includes a wide range of data types (e.g., pollen, diatoms, ostracods, fauna, chronology) from 40 constituent databases, and contributed by a large number of investigators. It is worldwide in scope and represents a wide range of time periods. Data are used to address issues such as natural ecosystem development, and a wide range of human impacts including climate change, land use development and eutrophication. Neotoma contains datasets from over 18,000 sites. Data can be viewed and downloaded using the website's Explorer application and the neotoma2 R package. Data from contributors are uploaded by or under the supervision of Data Stewards. We use diatom data to provide examples of how Neotoma can be used. The database includes diatom counts from over 1200 sediment cores, many of which have top and bottom samples only, from 1100 sites. It also has more than 2200 surface sediment counts, most of which are part of calibration datasets and have corresponding water chemistry data. Most sites are in North America. Surface sample data from the South American Tropical Diatom Database are in the process of being entered into Neotoma. We show how neotoma2 R code, available in an R Markdown document, can be used to retrieve and process large amounts of diatom data to address ecological questions. For example, mapping geographic distributions of taxa in surface samples at a continental scale. Or making stratigraphic diagrams that show changes in the abundance of individual taxa during specific periods of time using counts from several stratigraphic cores. Also, plots of the abundance of specific taxa vs water chemistry and climate variables which show distributions over much longer gradients than is typical in most studies.

Advancing Our Understanding of Dust Stress and Its Feedbacks with Our Climate System by Monitoring of Climatic Factors (A Case Study of South Khorasan Province, Iran)

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Wind erosion and the movement of sand, which is one of the most important processes of land degradation and a serious challenge in Iran, occurs as a result of the interaction between climate and land surface processes. The understanding of causes, processes and factors influencing the movement of sandy and dusty particles by wind in the boundary layer are basic purpose of this paper. In order to investigate the effects of dry and wet years in the number of days with dust in the South Khorasan province (SKp), the status of drought years and periods was examined using SPI and SPEI Indices in the statistical period of 1987-2016. DSI Index was also used to study the frequency and intensity of the dust phenomenon. The mobility of the sand was assessed with the Lancaster Index and danger of desertification was measured by UNEP model in order to predict future sand mobility. Finally, the relationship between sand mobility index and drought index for studied area was investigated. The results showed that according to the SPI and SPEI Indices, the whole province is experimenting a drought but the northern and central regions are showing drier conditions. Tabas station (western SKp) had the highest DSI values while Qain station (northern SKp) had the lowest DSI (Dust Storm Index). Generally, the intensity of dust storms in western SKp has been higher than in other areas along the three decades. In southern and western SKp, which are the gathering places of sand dunes, the mobility of sand (Lancaster index) has been fully active. The southern SKp stations showed an increasing rate of wind speed. The results showed a very severe risk of desertification implying a high sand mobility. According to the UNEP model, all SKp, except for the rainy areas of Qaen and Birjand regions, are in great danger of desertification.

Automatic lake's bottom detection from GPR B-scans using convolutional neural networks

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Ground Penetrating Radar (GPR) has proven to be an excellent technique to profiling lake's underwater environments. Either when a model inversion is performed or when geomorphology studies are done, it is necessary to pick the lake's bed reflection. This is a time-consuming task that usually is done manually picking trace by trace the reflection. In this work a convolutional neural network is proposed to automate this task. This method consists in three steps: The first one is to choose a sample size to split each trace and every sample is labeled as positive (bottom's lake) or negative (water column and other reflections). The second is to design a convolutional neural network adequate for the problem and train it with the labeled data in a supervised manner. Lastly a post-processing step is performed to improve the results and ensure each trace only gets one prediction. Also, predictions with different types of pre-processing are compared to the raw data. The network was trained with data from the Frías and Nahuel Huapi (Brazo Blest) lakes and tested in the Espejo lake getting preliminary results as good as 95% accuracy on the test data.

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