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Sabine Wulf & Achim Brauer (eds.)

INTIMATE
INTegrating Ice core, MArine and TErrestrial records: Towards High-Precision Chronologies

Abstracts Volume
INTIMATE Workshop
funded by EU COST Action ES0907
Potsdam, Germany
February 7 – 9, 2011

Scientific Technical Report STR11/01

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Sabine Wulf & Achim Brauer

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Deutsches GeoForschungsZentrum GFZ

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Monday, Feb 7th

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13:45-14:15 Jørgen P. Steffensen: The INTIMATE process: Achievements and future challenges (keynote)

Dating and Chronological Modelling (WG 1)

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14:45-15:20 *Coffee*

15:20-15:50 Raimund Muscheler: Constraining the atmospheric ^{14}C record via comparison of floating ^{14}C records with ice core ^{10}Be records (invited)

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16:30-16:50 Danuta J. Michczyńska: Record of the Late Glacial and Early Holocene palaeoenvironmental changes in different types of terrestrial sediments: Polish territory case study

16:50-17:10 William Austin: The synchronization of palaeoclimatic events in the North Atlantic region during Greenland Stadial 3 (ca. 27.5 to 23.3 kyr b2k)

17:10-17:30 Jesper Olsen: MIS3 ^{14}C reservoir ages changes inferred from the LINK15 sediment core, Faroe-Shetland channel, North Atlantic

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17:50-18:10 *Taking up a drink for the poster session*

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20:00 *Workshop Dinner*

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Hajdas, I. & Michczyński, A.: The last 14,000 years based on ^{14}C chronology and varve counting from lake Soppensee (CH).

John, I., McCoy, W.D., Marković, S. & Endlicher, W.: Speleothems from the Balkan Peninsula – Late-Quaternary records of atmospheric ciculation dynamics and changing seasonality since the Last Interglacial.

Machalett, B., Ches, E.A., McCoy, W.D., Roberts, H.M. & Marković, S.: Deciphering the geochronological frame work of Serbian Loess using Amino Acid stratigraphy and Luminescence dating.

Mingram, J., Stebich, M., Dulski, P., Frank, U., Schettler, G., Liu, Q., Nowaczyk, N., Lücke, A., You, H. & Liu, J.: Last Glacial Monsoon variability as recorded from varved lake sediments of the East Asian mainland.

Pyne-O'Donnell, S. & Svendsen, J.I.: Quantifying Arctic responses to past climate change (QUARCTIC).

Salgueiro, E., De Abreu, L., Voelker, A., Vaqueiro, S., Abrantes, F., Duprat, J. & Turon, J.-L.: Temperature and productivity variations along the western Iberian Margin during the last 50 ky.

Schlolaut, G., Marshall, M., Brauer, A., Nakagawa, T., Lamb, H., Staff, R., Bronk Ramsey, C., Brock, F., Bryant, C., Yokoyama, Y., Tada, R. Haraguchi, T. & Suigetsu 2006 project members: Suigetsu Varves 2006: A novel approach to automated varve interpolation.

Stančikaitė, M., Kisielienė, D., Šeirienė, V., Šinkūnas, P., Martma, T., Zinkutė, R. & Mažeika, J.: Lateglacial and early Holocene environment in northern Lithuania: an approach from Talša Lake.

Winstrup, M., Svensson, A. & Winther, O.: Towards an automated method for annual layer counting in ice cores.

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Tuesday, Feb 8th

Dating and Chronological Modelling (WG 1)

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08:50-09:10 Dirk L. Hoffmann: MC-ICPMS U-Th isotope measurements for precise speleothem chronologies in Quaternary climate research

09:10-09:30 Sune Rasmussen: Ice core records of the last deglaciation: Close bipolar links and implications for the definition of the onset of Younger Dryas

09:30-09:50 Anders Svensson: Update on Greenland ice core chronologies and more

09:50-10:10 Ina Neugebauer: The Rehwiese palaeolake record (Berlin): first continuous Younger Dryas varve chronology in NE-Germany

10:10-10:30 Christine S. Lane: A tephra lattice for the Last Glacial to Interglacial Transition in Europe

10:30-11:00 *Coffee*

11:00-11:20 Stefan Wastegård: Tephrochronology of the North Atlantic region: linking marine, terrestrial and ice-core records from MIS 6-2

11:20-11:40 Ewa Lind: Tephra horizons connected to early Holocene climate fluctuations: new result from the Faroe Islands

11:40-12:00 Victoria Smith: Tephrostratigraphy of the Lake Suigetsu SG06 core, Japan

12:00-12:20 Sabine Wulf: The sedimentary record of Lago Grande di Monticchio, Southern Italy: Implications for the Eastern Mediterranean tephrostratigraphy

12:20-13:30 *Lunch Break*

13:30-15:00 Guided Tour Telegrafenberg

15:00-15:30 *coffee*

15:00-18:00 WG 1 and WG 2 Outbreak

Discover the world of Potsdam (or Berlin) restaurants on your own

Wednesday, Feb 9th

Quantification of Past Climate (WG 2)

08:30-09:00 William Fletcher: Abrupt climate changes of the last deglaciation in the Western Mediterranean: insights from marine palynology (invited)

09:00-09:30 Karine Wainer: Precise chronology and past climate quantification from Southern France speleothems (invited)

09:30-09:50 Marc Luetscher: Quantifying the Younger Dryas climate using alpine speleothems

09:50-10:10 Ana Moreno: Iberian abrupt climate change dynamics during the last glacial cycle: a view from lacustrine sediments and speleothems

10:10-10:30 Antje Voelker: Imprints of Greenland stadial/ interstadial cycles in marine records off southern Iberia: Hemispheric and Regional Signals

10:30-11:00 *Coffee*

11:00-11:20 Richard J. Telford: Significance tests for transfer function-derived quantitative reconstructions

11:20-11:40 Martina Stebich: Lake Sihailongwan - a multiproxy, high-resolution record of Late-glacial vegetation dynamics and monsoon changes

11:40-12:00 Takeshi Nakagawa: SG06 (Lake Suigetsu) updates - Coming attractions

12:00-12:20 Erin McClymont: Challenges for seasonal and ENSO analogues of tropical Pacific climate response to Termination 1

12:20-12:50 Marit-Solveig Seidenkrantz: Glacial ocean circulation, Heinrich event stratigraphy and shelf edge glaciation offshore SW Greenland during the past 60.000 years

12:50-14:00 *Lunch Break*

Climate Impacts (WG 4)

14:00-14:30 John B. Birks: Biotic responses to rapid climate change 10000-12000 years ago – ecological processes, thresholds, resilience, and novel ecosystems (invited)

14:30-14:50 Wim Hoek: Climate or extra-terrestrial impact? The Allerød-Younger Dryas Transition (GI-1 to GS-1) in the Netherlands

14:50-15:10 Hilary H. Birks: Macrofossil evidence for vegetation and climate gradients in the late-glacial and early Holocene in the Nordfjord area, western Norway

15:10-15:30 *Coffee*

15:30-18:00 WG 1 and WG 4 Outbreak

18:00 *End of Workshop*

18:45 *Dinner for the national Management Committee members and keynotes in Forest Brewery*

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Abstracts

The synchronization of palaeoclimatic events in the North Atlantic region during Greenland Stadial 3 (ca. 27.5 to 23.3 kyr b2k)

W.E.N. Austin [(1)], F.D. Hibbert [(1)], S.O. Rasmussen [(2)], C. Peters [(1)], P.M. Abbott [(1)] and C.L. Bryant [(3)]

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[(2)] Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen, Denmark
[(3)] NERC Radiocarbon Facility (Environment), East Kilbride, Glasgow, United Kingdom

Two high resolution marine sediment cores located 83 km apart in the NE Atlantic have been studied: MD95-2006 (Barra Fan; 57°01.82 N, 10°03.48W; 2120m water depth) and MD04-2822 (Rockall Trough; 56°50.54 N, 11°22.96 W; 2344m water depth). The records are anchored to the NGRIP ice core stratigraphy and GICC05 chronology by the presence of geochemically characterized Fugloyarbanki tephra and further tested by radiocarbon age control. Replicated sea surface temperature (SST) records show evidence for an abrupt and short-lived warming within Greenland Stadial (GS)-3, to which we tentatively assign an age of ca. 25.6-24.8 kyr GICC05 b2k. Based on these and another marine palaeoclimate record (LINK17) from the Faroe-Shetland Channel, we propose a new three-fold event-stratigraphy for GS-3 within the North East Atlantic region. The recognition of this warming event within GS-3 in NE Atlantic SST records demonstrates that such events may not readily be identified within the coldest stadials of the Greenland ice cores, highlights the need for carefully constructed event-stratigraphies (independently tested by the use of tephra isochrones and radiocarbon) and illustrates pervasive millennial-scale climate variability of the North Atlantic region (Dansgaard-Oeschger (D/O) events) is deeply embedded in the dynamics of Atlantic Meridional Overturning Circulation (AMOC).

Macrofossil evidence for vegetation and climate gradients in the late-glacial and early Holocene in the Nordfjord area, western Norway.

Hilary H. Birks[1] and Marieke van Dinter[2]
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[2] ADC Archeoprojecten, PO Box 1513, 3800 BM Amersfoort, The Netherlands

There are strong east-west gradients in temperature and precipitation in western Norway today, resulting in oceanicity at the coast and a more continental climate at the head of the fjords. The fjord country is mountainous, even at the coast, so altitudinal gradients are also evident, particularly the altitude of the tree-line that increases inland. The distribution and ecology of the modern vegetation types provide analogues for climate reconstruction. To find out if climate gradients occurred during the late-glacial and early Holocene, macrofossil analyses were undertaken at 5 critically positioned sites. Modern analogues for the resulting assemblages could be found in western Norway today, thus allowing reconstructions of the past vegetation and climate and their changes through time. Gradients existed all through the late-glacial and into the early Holocene. Particularly striking was the abundance of *Salix herbacea* at the coast and *Betula nana* inland during the Allerød, indicating that an oceanicity-continentality gradient was established then. All sites became forested in the early Holocene. The tree-line was at about 370 m altitude at the coast but well above 400 m inland.

Reference:
Birks, H.H. and van Dinter, M. 2010. Lateglacial and early Holcoene vegetation and climate gradients in the Nordfjord-Ålesund area, western Norway. Boreas 39, 783-798.

Biotic responses to rapid climate change 10000-12000 years ago – ecological processes, thresholds, resilience, and novel ecosystems

H. John B. Birks
Department of Biology, University of Bergen and School of Geography and the Environment, University of Oxford

Conservation biologists are increasingly recognising that to conserve biological diversity in a rapidly changing world, it is essential to build an understanding of ecological processes into conservation planning. An understanding of ecological and evolutionary processes is particularly important for identifying those factors that might provide resilience in the face of rapid climate change (Willis et al. 2010).

The late-glacial and the rapid transition to the Holocene at 11.7 ka provide 'natural experiments' to study biotic responses to rapid climate change. Such studies are, however, a major challenge as they require a detailed fine-resolution chronology, detailed pollen **and** plant macrofossil stratigraphies as records of population and community responses, and an independent palaeoclimate reconstruction as a predictor variable in modelling biotic responses.

In this lecture I will present data from such studies to illustrate how ecological thresholds driven by climate change can be determined, how ecological resilience to climate change can be identified, and how novel late-glacial ecosystems can be interpreted in terms of a unique combination of biotic interactions and climate change. Such studies provide valuable 'lessons from the past' that are relevant today, for example, in understanding changes in montane and alpine floras and vegetation in response to recent climate change.

Willis, K.J., et al. 2010. Biodiversity baselines, thresholds, and resilience: testing predictions and assumptions using palaeoecological data. *Trends in Ecology and Evolution* 25: 583-591.

IMPLICATIONS OF THE LATE GLACIAL TERRESTRIAL RADIOCARBON CALIBRATION DATASET FROM LAKE SUIGETSU, JAPAN

Christopher Bronk Ramsey [1*], Richard Staff [1], Fiona Brock [1], Charlotte Bryant [2], Achim Brauer [3], Henry Lamb [4], Michael Marshall [4], Gordon Schlolaut [3], Pavel Tarasov [5], Takeshi Nakagawa [6] and Suigetsu 2006 Project Members [7]

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Radiocarbon provides one important way of placing different records on a common timescale. To use radiocarbon for chronological purposes requires an appropriate record of the past radiocarbon levels in the relevant reservoir. InCal09 (Reimer *et al*. 2009) provides a useful summary for the entire period 0-50ka BP. However, this consensus curve contains principally marine data prior to the present (≈12.5ka) tree ring limit.

The new SG06 sediment core from Lake Suigetsu, central Japan (Nakagawa *et al*. 2011) provides an opportunity to compare atmospheric and marine radiocarbon measurements over the full range of the technique since the record is varved throughout the pre-Holocene period and contains short-lived terrestrial plant remains suitable for AMS dating. The use of this record for informing calibration issues relies on high-quality and robust varve analysis, together with a large number (≈600) of radiocarbon dates.

This paper will examine the Late Glacial period, for which the varve analysis is now complete, and discuss the implications for our understanding of the leads and lags in $\Delta^{14}C$ between the atmosphere and oceans during this period. Specifically, this has important implications for the timing of the Younger Dryas as determined by terrestrial and marine radiocarbon dates.

References:

Nakagawa T *et al*. (2011) *Quaternary Science Reviews*, in press.

Reimer PJ *et al*. (2009) *Radiocarbon* **51** (4), 1111-1150.

DOI: 10.2312/GFZ.b103-11019

Palaeogeographical study of inland sand dunes from Tyrrhenian marine deposits of Varda area (north-western Peloponnesus), Greece.

By

*L. Stamatopoulos, **N.Evelpidou** & N. Kontopoulos*

Abstract. Samples of Cladocora coespitosa were collected and dated by $^{230}Th/^{234}U$ from Pleistocene sediments exposed in the western Peloponnesus, in marine terraces located within the Ellis graben, formed during the middle Pliocene. The dating results indicate a Tyrrhenian interglacial age for the marine terrace sampled bed. In particular, the altitude of approximately 45 m a.s.l., reflects a shoreline during 5.3 isotopic sub-stage. Moreover, sedimentological research was carried out in order to determine the origin and provenance of coastal dunes in the study area. Marine terrace is partially covered onlap by the coastal dunes, when the landmass rate of tectonic uplift exceeded the rate of eustatic sea level rise. Onshore winds supply with fine, well sorted, near symmetrical dune sands with mesokurtic distributions from nearby sand sources, such as the beach sands of the Ionian sea.

Abrupt climate changes of the last deglaciation in the Western Mediterranean: insights from marine palynology

William J. Fletcher[1,2], Maria Fernanda Sanchez Goñi[2], Odile Peyron[3]

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Abrupt changes in Western Mediterranean climate during the last deglaciation (20 to 6 cal ka BP) are detected in marine core MD95-2043 (Alboran Sea) through the investigation of high-resolution pollen data and pollen-based climate reconstructions by the modern analogue technique (MAT) for annual precipitation (P_{ann}) and mean temperatures of the coldest and warmest months (MTCO and MTWA). Changes in temperate Mediterranean forest development and composition and MAT reconstructions indicate major climatic shifts with parallel temperature and precipitation changes at the onsets of Heinrich stadial 1 (equivalent to the Oldest Dryas), the Bölling-Allerød (BA), and the Younger Dryas (YD). Multi-centennial-scale oscillations in forest development occurred throughout the BA, YD, and early Holocene. Shifts in vegetation composition and P_{ann} reconstructions indicate that forest declines occurred during dry, and generally cool, episodes centred at 14.0, 13.3, 12.9, 11.8, 10.7, 10.1, 9.2, 8.3 and 7.4 cal ka BP. The forest record also suggests multiple, low-amplitude Preboreal (PB) climate oscillations, and a marked increase in moisture availability for forest development at the end of the PB at 10.6 cal ka BP. Dry atmospheric conditions in the Western Mediterranean (average P_{ann} anomaly of -65 mm/yr) occurred in phase with Lateglacial events of high-latitude cooling including GI-1d (Older Dryas), GI- 1b (Intra-Allerød Cold Period) and GS-1 (YD), and during Holocene events associated with high-latitude cooling, meltwater pulses and N. Atlantic ice-rafting. The sensitivity of Western Mediterranean forest vegetation to winter season precipitation suggests multi-centennial variability in the westerly atmospheric flow over the European continent. A possible climatic mechanism for the recurrence of dry intervals and an opposed regional precipitation pattern with respect to Western Central Europe relates to the dynamics of the westerlies and the prevalence of atmospheric blocking highs. Comparison of radiocarbon and ice-core ages for well-defined climatic transitions in the forest record suggests possible enhancement of marine reservoir ages in the Alboran Sea by ~200 years (surface water age ~600 years) during the Lateglacial.

Lateglacial and early Holocene palaeoenvironmental pattern in the surroundings of Lake Lieporiai, North Lithuania

Gaidamavičius, A., Kisielienė, D., Stančikaitė, M.

In order to reconstruct the Lateglacial and early Holocene environmental pattern in the northern part of Lithuania between 14 000 and 8200 cal yr BP, results of the detailed multi-proxy analysis e.g. pollen, plant macrofossil, AMS ^{14}C radiocarbon data and loss-on-ignition measurements were used.

The results of LOI show that investigated sediment sequence consisting of silt with remarkable admixture of carbonates in particular intervals was covered by organic-predominating layer after 8200 cal yr BP. Both the diversity and number of plant macroremains was rather low and aquatic taxa prevailed all along the sequence. Scattered seeds of Betula nana were discovered during the initial stages of the sediments formation suggesting local presence of these trees shortly after 14000 – 13900 cal yr BP. Later, at about 13700 – 13800 cal yr BP, these were accompanied by Betula sect. Albae. Presence of cold-tolerant plants e.g. Selaginella selaginoides (L.) Link and Potamogeton vaginatus Turcz. suggests severe climatic regime before the Allerød Interstadial. Pinus predominating forest flourished during the Allerød while the Younger Dryas was characterized by open shrub/herb/grass vegetation with Juniperus according to pollen data. The further development of the vegetation cover indicates formation of open birch vegetation subsequently followed by pine forest during the early Holocene. Collected data indicate instability in vegetation composition and sedimentation regime, suggesting cooler and warmer intervals as well as humidity changes between 14000 and 8200 cal yr BP in area.

The last 14,000 years based on ^{14}C chronology and varve counting from lake Soppensee (CH).

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The quest for high-resolution records of past climate changes that are comparable to ice cores underlines the importance of records with laminated sediments. Despite the impressive number of sites discovered around the world that are known to have laminated or even annually laminated sediments, most archives are not laminated but are equally vital to past climate research. For these records, reliable chronologies are needed and are usually based on ^{14}C ages of deposits selected at various depths. However, it is often argued that chronologies are impaired by the complicated nature of the ^{14}C time scale and calibration of ^{14}C ages.

In this study, we present the potential of radiocarbon dating to construct high-resolution chronologies of sedimentary records that are comparable to counting annual laminations i.e. varves. To demonstrate this, we applied a *P_Sequence* model that is implemented in OxCal 4.1 (Bronk Ramsey 2008) and the updated INTCAL09 data set (Reimer et. al 2009) to obtain calendar chronology based on ^{14}C ages of macrofossils from Soppensee sediments and compared with the varve chronology of the sediment core that was sampled for ^{14}C dating (Hajdas 1993; Hajdas et al. 1993). The resulting calendar chronology is compared with the varve chronology that was built for this record in the previous study; there is a very good agreement between the two approaches. This illustrates ability of high-resolution radiocarbon dating for construction of reliable, high-resolution calendar time scale for sedimentary records. Based on the age-depth model of this study the Vasset Killian Tephra found in sediment of Soppensee has calendar age of 9291 - 9412 cal BP and the Lachersee Tephra is dated at 12735 - 12871 cal BP. Moreover such age-depth model provides timing for climatic and environmental changes observed in poorly laminated or not laminated sections of the Soppensee sediment i.e. the Late Glacial and the late Holocene (Hajdas and Michczynski 2010).

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Climate or extra-terrestrial impact? The Allerød-Younger Dryas Transition (GI-1 to GS-1) in the Netherlands

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In the Netherlands, the impact of the Younger Dryas (GS-1) event is recorded in numerous records. Changes in climate, vegetation, geomorphology, lithology, faunal composition, and human cultures occur at the GI-1 to GS-1 transition. The classic Usselo soil layer, containing frequent charcoal remains marks the transition and has been recognised and dated frequently in the Netherlands.
A hypothesised extra-terrestrial impact over North America has been proposed as the trigger for the onset of the global Younger Dryas event. One of the lines of evidence for this impact is the presence of increased values of Iridium as reported from buried soil horizons (palaeosols) in North America and Belgium. The soil horizons are comparable with the Usselo-soil and contain not only increased values of Iridium but also charcoal or soot attributed to the occurrence of large-scale forest fires. However, soil horizons are often characterised by low sedimentation rates, leaching, and accumulation processes. Until the moment of burial, a soil surface is constantly exposed to cosmic radiation; therefore increased values of Iridium in a soil are not unlikely. If these elevated concentrations in Iridium were caused by an extra-terrestrial impact, the obvious place to look for truly increased values would not be a soil horizon, but a continuously accumulating system such as an isolated lake basin. We analysed two records obtained from selected lake deposits from the southern and northern Netherlands. Both lake sequences comprise the Allerod-Younger Dryas Transition and show no indications of hiatuses or oxidation caused by periods of low lake level during the transition. The transition is marked by clear changes in lithology and vegetation composition as indicated by palynology. This lithological change and the change in vegetation, which is characteristic for the onset of the Younger Dryas have both been C14 dated at several locations in the Netherlands and yield an average age of 10,900 BP. Further age control was provided by the presence of both Laacher See Tephra and Vedde Ash in one of the sequences. Consecutive samples over the transition were analysed for the occurrence of Iridium and other elements. No elevated values of Iridium have been found and the values of the other elements measured indicated no disturbances in accumulation rates, leading to the conclusion that an extra-terrestrial impact could not be proven.

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MC-ICPMS U-Th isotope measurements for precise speleothem chronologies in Quaternary climate research

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High precision mass spectrometry is an important technique in palaeoclimate research. For example, isotope measurements of elements such as U, Th and Pb are essential for U-series dating of palaeoclimate archives such as speleothems. There is an increasing demand for higher precisions, smaller detection limits and thus smaller sample sizes that can be analysed.

I will present some recent developments in multi collector (MC) inductively coupled plasma mass spectrometry (ICPMS) U-Th dating. Technical advances in MC-ICPMS lead to higher precisions and enable U-Th dating at per mill precision. Additionally, very small samples sizes that can now be used for MC-ICPMS U-series measurements open up the possibility of very high spatial resolution U-Th dating. I present and discuss a 'conventional' setup for high resolution MC-ICPMS U-Th dating as well as the application of novel techniques in the field of mass spectrometry applied to environmental research including multi ion counter (MIC) arrays available for the ThermoFinnigan Neptune MC-ICPMS and micro sampling techniques such as laser ablation (LA) or micromilling. MIC, for example, increase the efficiency of low level ion beam collection by allowing simultaneous collection of all ion beams which also circumvents problems associated with unstable, transient beams often associated with laser ablation. In situ LA MC-ICPMS is an ideal tool for U-Th measurements at very high spatial resolution without prior chemical separation procedures. However, small beam intensities and matrix effects especially for mass and elemental fractionation pose significant analytical challenges for accurate determinations of U-Th ratios.

I will discuss precision and accuracy as well as potential and limitations of MC-ICPMS U-Th dating methods specifically in the light of instrumental biases. I will also address sample related limitations for high precision dating, such as detrital components and associated corrections. Furthermore, the important topic of generating a distance-age model based on U-series ages for speleothems will be addressed and examples for applications of speleothem high resolution U-Th chronologies for palaeoclimate research will be presented

Speleothems from the Balkan Peninsula – Late-Quaternary Records of Atmospheric Circulation Dynamics and Changing Seasonality since the Last Interglacial

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Mid-latitude speleothems often contain detailed, high-resolution records of local and regional interglacial climate changes. Many speleothem records of Holocene (MIS 1) and Eemian (MIS 5e) climate evolution have been investigated, but there is very little work being done in the Balkan region, despite the fact that the area is very rich in limestone caves with speleothems. We are investigating speleothems from the Western Balkan Peninsula that are likely to contain one of the most detailed, high-resolution records of local and regional interglacial climate changes in Southeast Europe. Here we present the first stalagmite under study, collected in Vernjikica Cave, Serbia (Carpatho-Balkans).

Vernjikica-4.2, a fine-laminated calcite stalagmite, is about 50 cm tall and extends conically from the base to the top, presenting at least two visible growth discontinuities. The construction of the chronology of the stalagmite by means of uranium-series dating ($^{234}U/^{230}Th$) is still underway, however, preliminary derived ages constrain the general period of growth to the late MIS 5.
The $\delta^{18}O$ and $\delta^{13}C$ values along the growth axis display opposing gradual trends with $\delta^{18}O$ decreasing from averagely -8.5 ‰ (PDB) to about -9.4 ‰ and with $\delta^{13}C$ increasing from -8.8 ‰ to about -6.0 ‰. Both isotopic records show simultaneous and distinct shifts towards more positive values that coincide with pronounced accumulations of denser and darker laminae.

In regard of present isotopic compositions in rainfall in the study area, the Vernjikica-4.2 proxy record shows a change from more humid to drier conditions during the growth period. The distinct increases in isotopic values likely reflect short warm and dry intervals during which calcite precipitation is primarily affected by non-equilibrium conditions. Altogether then, in light of modern atmospheric circulation features active in the region, these findings suggest that the proxy record reflects alternating precipitation regimes, primarily connected to long-term shifts in the relative position of the subtropical high-pressure ridge and its seasonal duration. Once the temporal resolution of the Vernjikica-4.2 record is improved, the precise timing and duration of described events in the proxy record, including the observed shorter-termed increases in $\delta^{18}O$ as well as $\delta^{13}C$, will be fully explored.

A tephra lattice for the Last Glacial to Interglacial Transition in Europe

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By compiling tephrostratigraphic data from Last Glacial to Interglacial Transition (LGIT) palaeoenvironmental records across Europe, a lattice of tephra layers is established that connects sites within a unified event-stratigraphic framework. Key sites that contain tephra layers from multiple volcanic centres, act as important link-points in the lattice, allowing regional tephrostratigraphies to be interconnected. One such archive is found in Lake Bled in Slovenia, which contains tephra layers from both Icelandic and Italian eruptions and connects the existing northwest Europe and North Atlantic tephra record to that of the Mediterranean region. Other important link-point sites, such as Soppensee on the Swiss Plateau, have high-precision chronologies and detailed palaeoenvironmental records, which help to establish the exact timing of the volcanic eruption event, in terms of both the calendrical age and the palaeoclimatic context. This information can then be imported into other less well-dated records, which may in turn enhance individual site chronologies. One key tephra layer, the Vedde Ash, which was deposited in sites across Europe ~12 ka BP, is able to connect sites from Greenland to Northern Italy, connecting important palaeoclimate records. However, where multiple common tephra layers are found within more than one palaeoenvironmental archive, it becomes possible to compare and contrast not just the timing, but also the rates of environmental responses to climatic forcing, within a common chronological framework. Within the presented tephra lattice, sites with more than one common tephra are seen to reach from southern Scandinavia to southern Italy, highlighting the potential to evaluate environmental responses to the abrupt climatic changes of the LGIT across important climatic system boundaries (e.g.: North Atlantic vs. Mediterranean climate systems). This tephra lattice offers a robust framework for evaluation of the pace of palaeoclimate forcing of environmental changes over continental distances during the LGIT. Investigation of longer and more widespread palaeoenvironmental records, will allow this valuable chronological tool to be extended both across a greater area and throughout the duration of the INTIMATE timeframe.

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Tephra horizons connected to early Holocene climate fluctuations: new result from the Faroe Islands

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The climate in the North Atlantic region was rather unstable and three cold events superimposed upon a general warming took place during the earliest part of the Holocene: the Preboreal oscillation (11,300-11,100 cal. yr BP), the Erdalen event (10,300-10,200 cal. yr BP) and the 9.3 ka BP event (e.g. Dahl *et al.*, 2002). New results from the Faroe Islands could give the opportunity to test hypothesis regarding synchronous or non-synchronous response to climate forcing in the North Atlantic area. Seven tephra layers have been identified in a palaeo-lake core from the island of Sandoy on the Faroe Islands, dated to 11,600-9500 cal. yr BP. Three tephras were found below and three above the visible Saksunarvatn tephra (ca. 10,300 cal. yr BP; Rasmussen *et al.*, 2006). The rhyolitic Hässeldalen tephra ca. 11,300 cal. yr BP previously only found in Sweden (Davies *et al.*, 2003; Wohlfarth *et al.*), a basaltic tephra from the Veidivötn volcanic system at the same depth and a tephra from the Askja volcanic system dated to ca. 10,400 cal. yr BP, tentatively correlated with the Askja-S/10 ka tephra. Askja-S has earlier been found in large part of the terrestrial North Atlantic region (e.g. Davies *et al.*, 2003; Turney *et al.*, 2006) but not on the Faroe Islands. The three tephra layers above the Saksunarvatn tephra are all unreported tephras. A rhyolitic tephra with an age of c. 10,200 cal. yr BP, that is still unidentified, one silicic layer from the Katla volcano (SILK) and a tephra correlated with the Torfajökull volcanic system, both with an estimated age of ca. 9500 cal. yr BP. These tephra horizons provide a unique potential to link the terrestrial records from NW Europe as well as with ice-cores from Greenland. The findings of the Hässeldalen tephra and the Askja-S tephra could become important time-markers for correlating the Preboreal Oscillation and the Erdalen event around the North Atlantic region.

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Quantifying the Younger Dryas climate using alpine speleothems

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Speleothems have proven to be valuable archives for establishing accurate chronologies of climatic excursions identified from stable isotope time series. This independent age control is crucial for the identification of particular climate forcings and the interpretation of atmospheric teleconnections. Here, we present a high-resolution alpine speleothem record of the Younger Dryas which is compared to available proxies from the Northern Hemisphere. The dataset is based on 12 U/Th dates and is reproduced by a second stalagmite. The quantification of the proxy data in terms of environmental change, however, remains challenging due to site-specific hydrological characteristics. A multi-proxy approach including stable isotopes of the speleothem carbonate and its fluid inclusions as well as trace elements offers promising perspectives to decipher the Younger Dryas signal at a sub-annual resolution.

Late Pleistocene Aeolian Dust Dynamics in Central Asia and their Teleconnection with Short-term Climate Oscillations and Abrupt Climate Events in the Northern Hemisphere

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Past climate dynamics associated with the Eurasian continent are well studied. However, the impact of intra-hemispheric-scale climate variability on the entire Eurasian landmass, as well as the self-generated effects of the continent on the global climate system, is still a matter of considerable debate. While western Atlantic polar and tropical air masses penetrate into the continent and are modified and transformed as they cross Eurasia, the interior regions of Eurasia strongly influence Earth's climate system. Significant cooling and heating of Central and High Asia drive interactions between atmosphere and ocean processes and regulate teleconnection patterns of the Northern Hemisphere.

This paper utilizes high resolution particle size data from the Central Asian loess sequence at Remisowka, to reconstruct past atmospheric circulation and aeolian dust dynamics within interior Eurasia since the last interglacial period. The observed dynamics in aeolian dust transport closely mirror δ18O and fine dust variations seen in Greenland ice cores, suggesting a correlation with short-term climate oscillations (DO events) recorded therein. An Asian origin of fine aeolian dust preserved in Greenland ice cores has been discussed previously, and recent papers reveal a close link between Asian aeolian dust dynamics and DO events recorded in Greenland ice cores.

In this context, our data represent the first Central Asian aeolian dust record in which DO events are recorded, providing a means to verify hypothesized links between short-term climate variability recorded in Greenland and associated climate dynamics at Asian dust source areas. Ultimately, the data extend existing theories, suggesting that the Central and High Asian mountains are a crucial element within the sensitive glacier-desert-dust response system in interior Eurasia and may be considered a pacemaker of suborbital global climate changes and an initiator of abrupt climate oscillations in the Northern Hemisphere.

Deciphering the Geochronological Frame work of Serbian Loess Using Amino Acid Stratigraphy and Luminescence Dating

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Serbian loess deposits preserve the most widespread, semi-continuous terrestrial records of glacial-interglacial climate variability in Europe. The sedimentary deposition, distribution, and thickness of loess in SE Europe are closely linked with major fluvial systems draining the continental interior. During glacial periods, under predominantly cold, semiarid climatic conditions, the extensive floodplain of the middle and lower Danube River was exposed to aeolian deflation, resulting in the accumulation of loess deposits up to 50 m thickness on adjacent fluvial terraces. The geomorphic setting of these loess formations, however, made them vulnerable to fluvial erosion and reworking, resulting in unconformities that may not be visually recognized in sedimentary sequences. Such unconformities, often of unknown duration and spatial extent, confound regional chronostratigraphic and paleoclimatic interpretations.

Amino acid racemisation (AAR) geochronology, although primarily a relative dating method, offers an independent assessment of numerical age estimates when results are at or near their methodological limits and can assist in the chronostratigraphic evaluation of loess units beyond the applicable range of numerical dating methods. In this study we present the first comprehensive aminostratigraphic results measured on fossil gastropod shells of the genera *Pupilla*, *Helicopsis*, and *Vallonia* from the loess series at Stari Slankamen and Mosorin/Dukatar (Titel Plateau) in Vojvodina, Serbia, in order to verify the chronostratigraphic position of the upper stratigraphic units and to establish a reliable correlation between older loess-paleosol couplets. Given the interpreted stratigraphic continuity and the high sedimentation rates at Mosorin/Dukatar, we established this site as a chronostratigraphic reference for correlation with the long-studied loess profile Stari Slankamen, where at least two unconformities have led to ambiguous paleoclimatic and stratigraphic interpretation in previous studies.

AAR analyses allow us to establish an independent chronostratigraphic framework for Serbian loess sequences correlated with marine oxygen-isotope stages 16-2. The results are now supported by a luminescence derived chronology for Serbian loess using optically stimulated luminescence (OSL) and thermally transferred optically stimulated luminescence (TT-OSL) signals from quartz. The results demonstrate the vast potential of amino acid stratigraphy to identify and constrain the extent, continuity, and duration of erosional discontinuities in long sedimentary sequences, such as those at Stari Slankamen. Ultimately, these results contribute to the development of a robust regional chronostratigraphic framework in support of paleoclimate reconstructions from high-resolution proxies, such as grain-size data, toward an improved understanding of the paleoenvironmental dynamics of SE Europe in an intra-hemispheric context.

Challenges for seasonal and ENSO analogues of tropical Pacific climate response to Termination 1

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The transitions from glacial to interglacial states (terminations) provide important means of understanding the sensitivity of the global climate system to evolving boundary conditions. The most recent termination (T1, c. 19 – 10 ka) was punctuated by a series of abrupt climate events that raise questions about climate forcing mechanisms at millennial timescales. Observed climate trends in the eastern tropical Pacific across T1 offer key tests of mechanisms for rapid climate change. Specifically, evidence for dynamic tropical Pacific climate across T1 drives debate over whether modern analogues of Intertropical Convergence Zone (ITCZ) migration (Leduc et al., 2009) and/or El Niño-Southern Oscillation (ENSO)-like variability (Pena et al., 2008; Prange et al., 2010) are appropriate. Using high-resolution (~66 yr resolution) analyses of marine sediments from the Gulf of California, we present evidence for southern-hemisphere forcing of sea-surface temperatures but a biological response to northern hemisphere events during T1. We draw on two organic geochemistry proxies (the U^{K}_{37}' and TEX_{86} indices) to investigate different expressions of the deglacial sea-surface warming, and attribute the observed differences to upwelling intensity. Millennial-scale variability in upwelling intensity reflects a dynamic tropical Pacific climate system during the glacial and termination. Enhanced precipitation and runoff into the Gulf of

California coincide with the Heinrich 1 and Younger Dryas stadials, reflecting an atmospheric response to these North Atlantic events. To investigate the mechanisms driving the events seen in the marine sediment core, we draw on fully-coupled climate model simulations for the glacial maximum, Heinrich events and late Holocene. Neither the proxy data nor model simulations of key snapshots across T1 support the application of modern seasonal or inter-annual cycles as valid analogues for glacial or deglacial climates in the tropical Pacific.

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RECORD OF THE LATE GLACIAL AND EARLY HOLOCENE PALAEOENVIRONMENTAL CHANGES IN DIFFERENT TYPES OF TERRESTRIAL SEDIMENTS: POLISH TERRITORY CASE STUDY

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It is well known that limited funds imply that every researcher carefully selects samples for all analyses, also for radiocarbon dating. As a result samples from places of visible changes in sedimentation, or in palynological diagram are collected and dated more frequently than others. Because of that databases of radiocarbon dates are potential sources of information about boundaries of chronozones.

The presented results utilized data collected in the earlier studies: 709 ^{14}C dates for peat samples (Michczyńska and Pazdur 2004), 334 ^{14}C dates for fluvial sediments (Starkel *et al*., 2006), 69 ^{14}C dates for landslides (Margielewski, 2006), 98 ^{14}C dates for minerogenic horizons (Margielewski, 2006), 100 ^{14}C dates for tufas (Michczyńska *et al*. 2007) and 98 ^{14}C dates for speleothems (Michczyńska *et al*. 2007). For each set probability density functions (PDFs) were constructed (see **Fig. 1**) by calibration of individual dates and summing up received distributions (Bronk Ramsey, 2010; Reimer *et al*., 2009).

The selection of ^{14}C dates for various sets was based on different principles and therefore climatostratigraphic and chronostratigraphic interpretations are subjected to different limitations:

- The set of peat samples is an example of random dates. The weak side of this collection is that peat is deposited in various environments and may reflect either wet phases with intensive peat growth, or just opposite the drier phases connected with lowering of lake levels and overgrowth of them. Nevertheless for this set preferential sampling results in fact that boundaries of chronozones are well marked by high peaks of PDF for: AL/YD, PB/BO, BO/AT1 and AT2/AT3;
- The main aim of collecting fluvial samples was to find horizons reflecting changes in the fluvial regime, mainly in the frequency of floods. PDF received for dates from the bottom of paleochannels (151 dates) clearly reflected the age of avulsion of river channels and then major wetter phases of the Holocene. The clearest boundaries reflected in the shape of PDFs are: AL/YD, PB/BO, BO/AT1, AT1/AT2 and AT2/AT3;
- Dates for landslides and minerogenic horizons are connected with mass movements' intensification. They can be considered as connected with the climate moistening (growth of heavy rainfalls and/or long-lasting rainy seasons). The well marked are boundaries: BO/AT1 and AT2/AT3 for landslides and PB/BO and AT1/AT2 for minerogenic horizons;
- Speleothems are indicators of high temperature and relatively high precipitations. There are well marked boundaries: AL/YD, and AT1/AT2. Also Boreal is marked by wide peak;
- Tufas are first of all a good indicator of warm climate. For this set boundaries: AL/YD, PB/BO and BO/AT1 are well marked.

Other remarks:

- The wetter phases have usually very distinct start and then gradually the indicators of humidity are more difficult to recognize;

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- The climato-chronostratigraphy of Polish territory differs from stratigraphy founded on ice cores. There is visible some shift between these records. Terrestrial ecosystems need some time for reaction on climate changes;
- Short event 8.2 ka cal BP has not been recognized till now on Polish territory.

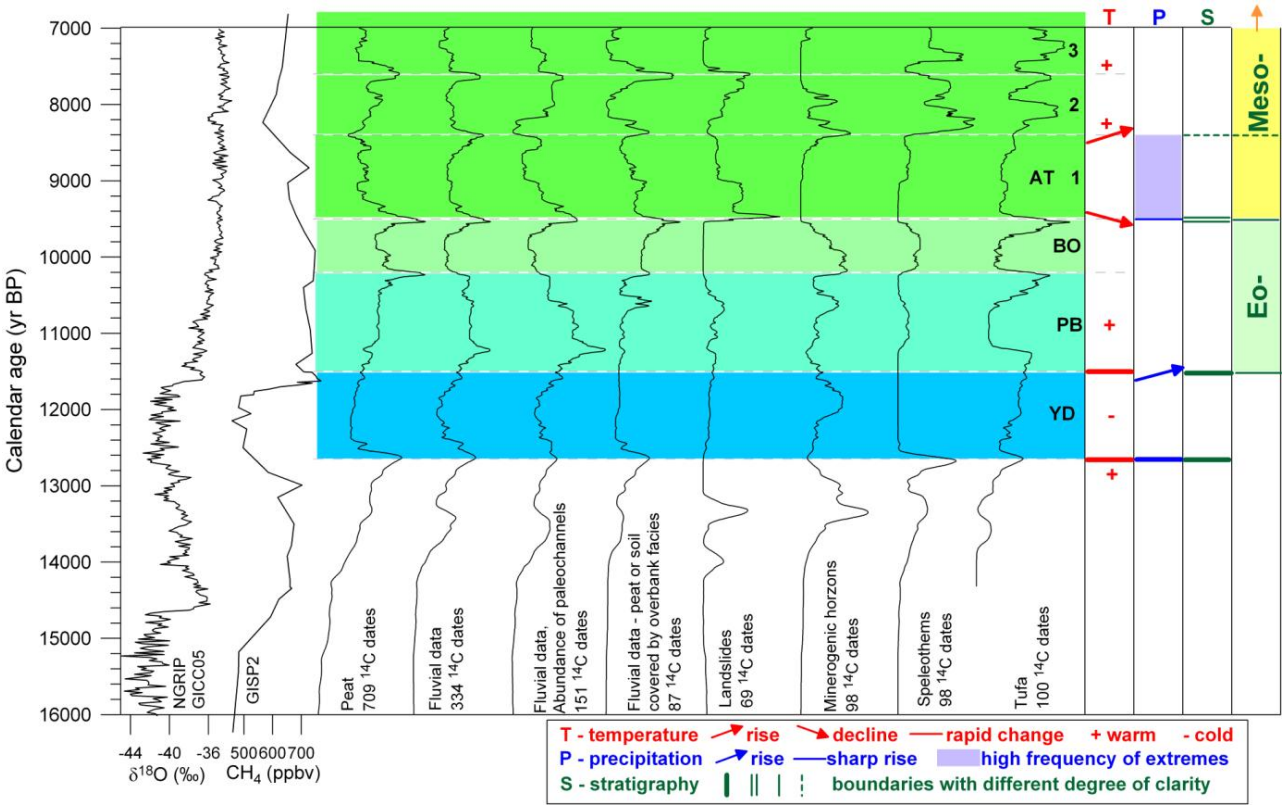

Fig. 1. Selected Greenland ice core data vs. probability density functions constructed for different type of sediments from Polish territory. There are marked changes in temperature, precipitation and stratigraphy and proposed boundaries of chronozones.

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Last Glacial Monsoon variability as recorded from varved lake sediments of the East Asian mainland

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Maar- and crater lakes of the LongGang Volcanic Field (Jilin province, NE China) have been the subject of intense research over the last 10 years in the frame of a Chinese-German cooperation programme (Liu et al., 2000; Mingram et al., 2004; Chu et al., 2005; Schettler et al., 2006; Frank, 2007; Stebich et al., 2009). Two long sediment profiles from Lake Sihailongwan (SHL) and Lake Erlongwan (ERL) provide continuous records of more than 65 ka and about 37 ka, respectively. Sediments of Lake Sihailongwan are varved nearly continuously; hence an age model could be established based on varve counts and AMS-^{14}C dating of terrestrial plant remains. Beside several local basaltic tephra horizons, a 0.5 mm thick rhyolithic ash layer has been found in petrographic thin sections from both lakes. The age of this tephra as derived from the SHL varve chronology is 29,741 cal. a BP, and 29,682 cal. a BP according to the ERL age model. Major element chemistry of individual glass chards from both tephra layers shows striking similarities to the Japanese Aira-TN tephra, which dates to 29651-30231 cal. a BP (1-sigma range using Calib 6.0 and Aira-TN ^{14}C age from Miyairi et al. 2004). The discovery of the Aira-TN tephra in two Chinese lakes offers the chance of detailed comparison of palaeoclimate reconstructions from East China and Japan, and of terrestrial – marine correlations.

A multi-proxy lake sediment data base including detailed sedimentological (varve micro-facies), palynological, geochemical (major element µ-XRF scanning, carbon, nitrogen, biogenic silica, δ^{13}C, δ^{14}N) and geophysical (rock- and palaeomagnetic) information provides high-resolution records of environmental changes during the last glacial period in NE-China. Millennial-scale vegetation changes during the last glacial period observed in Lake SHL sediments mirror Dansgaard-Oeschger (D/O) cycles observed in Greenland ice-cores and East Asian speleothems. During some interstadials (e.g. D/O cycles 13-17) autochthonous productivity as deduced from varve microfacies and µ-XRF Si/Al ratios can even rise to levels comparable to those observed during the Late glacial warming. However, vegetation as well as clastic influx clearly exhibit glacial features, hence a comprehensive view on all

available proxies is needed to decipher threshold effects of the lake ecosystem and complex environmental responses during periods of rapid climate change.

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Iberian abrupt climate change dynamics during the last glacial cycle: a view from lacustrine sediments and speleothems

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We present a palaeoclimatic reconstruction of the last glacial cycle in the Iberia Peninsula (ca. 120,000 – 11,600 cal yrs BP) based on a compilation of multiproxy reconstructions from terrestrial archives, including lake sediments and speleothems. The selected lake sequences provide an integrated approach, exploring temperature conditions, humidity variations and land-sea comparisons during the most relevant climate transitions of the last glacial period. Studies based on speleothems are really scarce but the available data support previous reconstructions obtained from lake records. Thus, we present evidence that demonstrates: i) cold but relatively humid conditions during the transition from MIS 5 to MIS 4, which prevailed until ca. 60,000 cal yrs BP in northern Iberia; ii) a general tendency towards greater aridity during MIS 4 and MIS 3 (ca 60,000 to 23,500 cal yrs BP) punctuated by abrupt climate changes related to Heinrich Events (HE) and iii) a complex, highly variable climate during MIS 2 (23,500 to 14,600 cal yrs BP). The “Mystery Interval” (MI: 18,500 to 14,600 cal yrs BP) including HE1 and not the global Last Glacial Maximum (LGM: 23,000 to 19,000 cal yrs BP) has been recorded as the coldest and most arid period. The last glacial transition starts in synchrony with Greenland ice records at 14,600 cal yrs BP but the temperature increase was not so abrupt in the Iberian records and the highest humidity was attained during the Allerød (GI-1a to GI-1c) and not during the Bølling (GI-1e) period. The Younger Dryas event (GS-1) is discernible in Iberian lake sequences as a cold and dry interval, although Iberian vegetation records present a geographically variable signal for this interval, perhaps related to vegetation resilience. This research provides an integrated view of the evolution of Iberian Peninsula during the last glacial cycle and emphasizes its peculiarities with respect to other N Atlantic records.

Constraining the atmospheric ^{14}C record via comparison of floating ^{14}C records with ice core ^{10}Be records

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The radiocarbon calibration curve is most accurate for the period where it is inferred from ^{14}C measurements on dendrochronologically-dated trees. Prior to this period it is based on less direct recorders of the atmospheric ^{14}C variations (e.g. corals, foraminifera) that are usually also connected to more uncertain time scales.

Recent progress in the development of floating tree ring chronologies has the potential to push the tree-ring based atmospheric ^{14}C reconstructions further back into the past. Independent age estimates can be obtained from the comparison to ^{10}Be records from ice cores since ^{10}Be and ^{14}C records contain a common production rate signal caused by the varying cosmic ray flux impinging on the atmosphere.

We will show a new high-resolution ^{10}Be record covering the last deglaciation that reveals details of the variations in the ^{10}Be production rates. These can be used to synchronize floating ^{14}C chronologies to the ice core time scales. This approach can help to (i) expose ^{14}C calibration uncertainties, (ii) improve ice core time scales and (iii) allow us to assess carbon cycle and production rate changes in more detail and accuracy.

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SG06 (Lake Suigetsu) updates -Coming attractions-

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A fully continuous and annually laminated (varved) sediment core (SG06) was recovered from Lake Suigetsu, Japan in the summer of 2006. Since then an international and multidisciplinary research project has been examining the core to establish (i) high-precision chronology of the core by varve counting using two independent methods (thin-section microscopy and ultra-high resolution Itrax radiograph-XRF scanning), (ii) high-resolution ^{14}C stratigraphy, (iii) visible- and micro-tephra stratigraphy using chemical properties, and (iv) multi-proxy palaeoclimate reconstructions. By combining this information, as well as correlation with existing datasets, we are able to (i) extend the terrestrial radiocarbon calibration model to the limit of the method (c. 50 ka), (ii) reconstruct lead-lag of climate changes between regions, (iii) reconstruct changes in the marine carbon reservoir effect through time as well as examine its link to the climate changes, and (iv) establish a regional stratotype of the last c. 150 ka.

So far (13th Jan 2011) the project has completed radiocarbon dating of 599 horizons, finalised varve chronology down to c. 15 ka horizon, and high-resolution pollen, diatom, biomarker and geochemical analysis of the period encompassing (i) the Lateglacial to early Holocene transition, (ii) Heinrich events 4 and 5, and (iii) the 8.2 ka event. In this presentation we will briefly introduce latest findings from the project. Topics of particular interest to the targets of INTIMATE include (i) extension of the terrestrial radiocarbon calibration model, (ii) synchronous Younger Dryas between the N. Atlantic and Japan, (iii) earlier onset of the Bolling-equivalent interstadial in Japan, (iv) muted D-O and 8.2 ka event signals in Japanese palaeo-temperature proxies, (v) evidence of perturbation of the atmospheric circulation pattern linked to temperature change, and (vi) possible solar cycle as a pacemaker of centennial-millennial scale climate changes.

The Rehwiese palaeolake record (Berlin): first continuous Younger Dryas varve chronology in NE-Germany

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Varved lake sediments of the palaeolake Rehwiese, SW-Berlin, provide climatic and environmental information of the last Glacial to Interglacial transition (LGIT) in northeastern Germany on a sub-annual timescale. Rehwiese sediments contain an approximately 3 m thick sequence of continuous biochemical calcite varves, covering the time interval from the early Allerød to the onset of the Holocene. A distinct volcanic ash layer has been correlated with the late Allerød Laacher See Tephra (LST) which has been dated at 12,880 varve years BP in varved lake sediments of Lake Meerfelder Maar, Eifel (Brauer et al., 1999). A 1,400-year varve chronology with the LST forming the basal chronostratigraphic marker horizon has been established through annual layer counting in petrographic thin sections, comprising the late Allerød and the Younger Dryas until the onset of the Holocene. This represents the first varve chronology covering the entire Younger Dryas cold period in northeastern Germany. Pollen data provide biostratigraphical background for the Weichselian lateglacial classification.
Two composite profiles, that were taken in a distance of approximately 20 m and consist of two core sequences each, have been compared in great detail by independent, precise varve counting based on the definition of micro-marker layers. Hence, minor hiatuses as well as disturbed sections have been identified and were bridged with better preserved varves from the other composite profile, respectively. Precise microfacies analyses on large-scale thin sections in combination with µXRF element scanning data (Brauer et al., 2009) allow to discuss even seasonal aspects of climate and environmental change. In addition, stable isotopes on authigenic calcite ($\delta^{18}O$, $\delta^{13}C$), TOC and C/N-ratio analyses have been performed with a five-year resolution.
These high-precision multi-proxy data provide new insights into the inter-annual and decadal-scale variability during the course of the Younger Dryas. The Rehwiese sediment record will be compared in detail with the Meerfelder Maar varve data on the base of independent varve chronologies.

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MIS3 ^{14}C reservoir ages changes inferred from the LINK15 sediment core, Faroe-Shetland channel, North Atlantic

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In ice cores the last glacial period is characterised by millennial-scale Dansgaard-Oeschger (D-O) events of warmer and colder climates. Similar millennial-scale variability (linked to D-O events) is evident from oceanic cores suggesting a strong coupling of the atmospheric and oceanic circulations system. Cooling and sinking of dense saline water originating from the North Atlantic Drift current in the Norwegian-Greenland Sea is essential for the formation of North Atlantic Deep Water. The convection in the Norwegian-Greenland Sea allows for a northward heat exchange and southward transport of cold saline water. This circulation system is highly sensitive to climate change and has been shown to operate in different modes.

The different oceanic circulation modes further have a large influence on the carbon exchange between atmosphere and the deep ocean. Such reorganisations of the North Atlantic circulations system and deep water formation cause changes in the ^{14}C activity of the surface ocean. Here we present 29 new AMS ^{14}C dates of planktonic foraminifera covering Marine Isotope Stage 3 from the LINK15 core taken from the Faroe-Shetland channel. The Faroe-Shetland channel is situated in the main path of the warm North Atlantic Drift current and further provides an escape route for the cold Norwegian Sea Deep Water. Hence LINK15 has an ideal position for studying paleo variability of ^{14}C reservoir ages. Based on *N. Pachyderma* δ^{18}O and IRD the LINK15 sediment core has been correlated to the NGRIP ice core (GICC05 age scale). The correlated GICC05 ages of the LINK15 sediment core are then used to calculate marine reservoir ages (ΔR) using the marine radiocarbon calibration curve (Marine09). Our results show significant ΔR variability through the course of 6 D-O events.

Construction of calendar chronology of Vydrino site, Lake Baikal, since the Late Glacial

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Plant macrofossils are rarely preserved in the pelagic sediments of Lake Baikal. Consequently, previous programmes such as BDP dated total organic carbon (TOC), which is present in only very low concentrations (<1%). Radiocarbon dates of surface sediments were consistently, excessively old, and this is likely to be in part due to the influence of old redeposited organic matter (Colman *et al*. 1996; Prokopenko *et al*. 2007). More recently, Watanabe *et al*. (2009) described the occurrence of positive linear sedimentation rate anomalies (i.e. a ^{14}C plateau) during the Younger Dryas from AMS ^{14}C dating of total organic carbon (TOC) from several cores extracted from the Academician Ridge.

To try and partly compensate for these problems, as part of the EU funded Continent Programme, Piotrowska *et al*. (2004) and Demske *et al*. (2005) obtained AMS ^{14}C dates from pollen and spore concentrates. The present work is an update of previous age-models published in the abovementioned papers, carried out for the needs of new research undertakes (Mackay *et al*., in print).

The Late Glacial - Holocene age model for Vydrino Shoulder is based upon twelve AMS ^{14}C pollen dates from the box core (CON01-605-5) (Piotrowska *et al*. 2004) and an additional five AMS ^{14}C pollen dates from the piston core (CON01-605-3) (Demske *et al*. 2005). Pollen purity was excellent (80% – 95%) in each box-core sample due to the presence of very high concentrations of large bisaccate pollen grains; unfortunately purity data for the pollen extracts obtained from the piston cores are not available.

All radiocarbon dates were calibrated using OxCal 4 programme (Bronk Ramsey 2009) and IntCal09 radiocarbon calibration curve (Reimer et al. 2009). To estimate a relationship between age and depth we used a generalized mixed-effect regression based on a generalized additive model (GAM) with constant variance (Heegaard *et al*. 2005). The year of sampling (2001 AD) was also included in model calculations. The complete age-depth model covers the last 16,000 years, and reveals almost constant sedimentation rate. The mean

uncertainty of age-depth model is ca. 200 year. However, it amounts to ca. 50 years for the uppermost part (up to 350 BP) and afterwards slowly rises to ca. 150-200 years for the most of the core (ca. 350-13,500 BP). Because of the considerable uncertainty of calibration curve IntCal09, from ca. 14,000 the uncertainty of the model rises relatively sharply to 670 years for the lowermost part.

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Quantifying Arctic responses to past climate change (QUARCTIC)

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The ability to anticipate the consequences of future climate change is crucial if policy makers are to implement effective and achievable mitigation measures. The levels of predictive precision currently available through global circulation models (GCM's) is however insufficient for this task due to limitations in their ability to realistically simulate real-world complexities in global climate. This is especially the case in the Arctic, where some studies suggest temperature increases will exceed the global average, and where GCM's underperform in comparison with other regions. A possible solution is to use palaeodata to provide quantitative model parameters, and against which to test model predictions. The potential value of much of this data is however limited due to its predominantly qualitative nature combined with chronological problems associated with conventional dating methods.

QUARCTIC (Quantifying Arctic responses to past climate change) aims to produce high precision quantitative palaeotemperature data sets from Arctic lake sequences by the use of sub-fossil chironomid (midge) temperature reconstructions with chronological control by distal volcanic ash ('microtephra'; shards <100 μm) isochrons. One important Arctic region for this work is the northern Ural Mountains. Here, a number of large lakes occur with exceptionally deep sediment archives spanning much of the last glacial. Correlation of ash isochrons between these sequences (as well as with those elsewhere in the marine and ice realms) would offer the potential for high-precision chronological control of proxy-inferred palaeoenvironmental reconstructions. Regional events may thus be more securely correlated with those occurring elsewhere, possibly under the influence of forcing factors such as North Atlantic thermohaline changes.

Large-scale eruptions in the Northern Hemisphere high latitudes inject ash high into the stratosphere enabling long distance transport on predominating winds. Detectable ranges of, for example, Icelandic isochrons may thus extend farther eastwards to the Urals and elsewhere in northern Eurasia. Deposition may possibly overlap in these sequences with ashes derived from other volcanic centres, especially if deposition ranges from these centres are comparable with those demonstrated throughout Europe. Hence, there exists the potential of linking distant tephrostratigraphic frameworks together to allow correlations over a large swathe of the mid- to high-latitudes of the Northern Hemisphere.

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Ice core records of the last deglaciation: Close bipolar links and implications for the definition of the onset of Younger Dryas

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Ice core records from Antarctic and Greenland have revealed that the last deglaciation (ca. 19,000 to 11,000 years before present) was dominated by a sequence of large, hemispheric climate variations. Precise information on the relative timing of these north-south climate variations is a key to resolving questions concerning the mechanisms which force and couple climate changes between the hemispheres. Here we present a comparison of a proxy for regional Antarctic temperature derived from a composite of four high-dating-precision Antarctic ice cores with a proxy for regional Greenland temperature from the North-Greenland ice core. All records are synchronised to the common Greenland Ice Core 2005 Chronology (GICC05), using dating ties provided by fast variations in global methane gas concentrations. We observe clear anti-phase behaviour between Antarctic and Greenland temperature. This pattern may be explained by shifts in the balance of meridional ocean heat flux between the hemispheres, consistent with the bipolar seesaw hypothesis in which warm Greenland periods align with periods of Antarctic cooling, and vice versa.

The resolution present study allows for the first time a high-resolution comparison of the timing of the sub-events of the Greenland Isotope Interstadial (GI-1a through e) in relation to their southern counterparts, and confirms that the bipolar seesaw is active on centennial time scales. The analysis also reveals that GI-1a and b (aka the youngest part of the Allerød period) line up with a period of Antarctic warming, and thus must be regarded as a cold period in a bipolar seesaw context, although GI-1a is generally regarded as a mild period. If this observation is a more general feature, it calls for caution in defining the GI-1 – GS-1 boundary (aka the onset of the Younger Dryas) and may complicate comparison of records of the deglaciation between different parts of the climate system.

All in the timing: the importance of chronology in palaeoclimate reconstruction

Paula Reimer

A robust chronology is essential for the use of paleaeoclimate proxy data in the reconstruction of abrupt and extreme climate events especially when attempting to identify leads and lags in proxy responses to climate forcing. A number of dating techniques can contribute to the chronology of a record including radiocarbon, OSL and tephra horizons which can also be used to cross-date records even if not independently dated. The extension of the IntCal radiocarbon calibration curves to 50 ka cal BP (Reimer et al. 2009) provides the opportunity for constructing more reliable chronologies with multiple dating methods, although uncertainties in marine reservoir corrections and difficulties in sufficiently removing contamination in some older sample materials can still be problematic.

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Temperature and productivity variations along the western Iberian Margin during the last 50 ky

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Present day oceanographic conditions along the western Iberian margin is characterized by seasonal coastal upwelling associated with cold waters and high primary productivity, which leaves an imprint in the sediments beneath these areas. Thirteen sediment cores (SU92-03, MD95-2039, MD95-2040, MD95-2041, MD95-2042, MD03-2699, PO200/10-28-1, OMEXII-5K, OMEXII-9K, N3KF24, D1195-7P, MD03-2697, MD99-2331) located along the Iberian coast, between 43º12´N and 35º89´N, were investigated to reconstruct spatial and temporal gradients in temperature and productivity conditions during the Holocene, the last glacial maximum (LGM), and Heinrich events (HE) 1-3. Planktonic foraminifera census counts were used to estimate summer sea surface temperature (SST) and export productivity (Pexp) using the modern analog technique SIMMAX 28 and the extended North Atlantic modern analog data base, currently with 1066 and 1039 modern analogs for SST and Pexp, respectively. During the Holocene all sites exhibit estimated mean SST and Pexp values similar to modern satellite data, including the North to South and East to West temperature increase (from 17 to 21 ºC) and productivity decrease (from 110 to 30gC m^{-2} yr^{-1}). This demonstrates the accuracy of the transfer function calibration used. During the LGM the estimated SST were relatively warm (~17ºC) along the Iberian margin, similar to the present-day conditions and consistent with other reconstructions for the Portuguese margin using planktonic foraminifera, alkenones, and pollen data. The warm SST are equally in agreement with the GLAMAP results. While, the Pexp increased at nearly all sites, particularly within the filament off Porto (MD95-2039, MD95-2040). The increase of productivity could be attributed to strong winds in synchrony with other upwelling regions around the world. During HE 1 - 3, the short-term cooling periods associated with extreme iceberg discharges into the North Atlantic during the last 30 cal kyr BP, temperature increased from North to South (on average 4ºC), marking the decreasing influence of melting iceberg along the Iberian margin, with HE 1 being the coldest one. Productivity shows a more complex pattern: productivity in the areas under modern upwelling influence was reduced, but not terminated, and highest/increased Pexp occurred in those areas with lowest modern productivity, most likely linked to frontal upwelling.

Suigestu Varves 2006: A novel approach to automated varve interpolation

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The varved sediment profile from Lake Suigetsu is one of the most comprehensive terrestrial radiocarbon records. It is extremely rich in leaf fossils, providing a unique, truly atmospheric record of radiocarbon for the last 10-50 kyr BP (Kitagawa & van der Plicht, 2000). However, the calibration model established on a sediment core obtained in 1993 (Kitagawa & van der Plicht, 2000) diverged from alternative, marine-based calibration datasets, due to gaps in the sediment profile and varve counting uncertainties (Staff et al., 2009).

In 2006 four new parallel cores were recovered from Lake Suigetsu and combined to construct the complete and continuous SG06 master profile (Nakagawa et al., accepted). Along with a large number of new AMS radiocarbon measurements, varve counting is being carried out using two different techniques: i) thin section microscopy and ii) high-resolution X-ray fluorescence and X-radiography.

Due to insufficient varve preservation in some sediment intervals, layer counting must be complemented by interpolation. Therefore, a novel approach has been developed based on an automated analysis of frequency distributions of annual sub-layers from the compromised section itself, allowing an estimate of sedimentation rate that is unbiased by neighbouring sections or subjective interpretation.

Due to poor varve preservation in some sediment intervals, the counts of these sections have to be interpolated. The new approach presented here is based on an automated analysis of frequency distributions of annual sub-layers from the compromised section itself, allowing an estimate of sedimentation rate that is unbiased by neighbouring sections or subjective interpretation.

The interpolation is tested on artificial data in order to determine the ideal settings for the interpolation. The settings are mainly dependent on the sedimentation rate and the percentage of interpolated years. As these are actually the desired results the interpolation runs in an optimisation loop. Starting with standard settings, an estimate for each variable is calculated which in turn leads to improved settings. The loop ends when constant settings are reached.

Additionally, the raw count is split into different versions based on quality criteria, e.g. using only sub-layers (counts) that can be clearly distinguished. Comparison between the interpolation of the complete raw count and the quality-selective counts help to identify ambiguous sections. The uncertainty within these sections can be characterised and reduced

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by comparing and combining the results from the different and independent counting techniques (microscopic and μXRF). Error estimates have been calculated by comparison with the artificial data as well as the differences between the various counts.

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Glacial ocean circulation, Heinrich event stratigraphy and shelf edge glaciation offshore SW Greenland during the past 60.000 years

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A multi-proxy study has been made of two gravity cores retrieved in 2003 from a water depth of 2381 m and 1033 m, respectively. We have analysed benthic and planktonic foraminifera as well as sediment paramaters such as magnetic properties, IRD and Fe2+/3+ rations. The chronology is based on 14C datings and correlation of IRD peaks to Heinrich event chronology. Our data reveal that the most extreme West Greenland Weichselian glaciations occurred during MIS 4, when an ice shelf may have extended beyond the SW Greenland shelf edge. Our results further suggest a long-term (intermittent) increase in both deep and surface water inflow of Atlantic water. This indicates that Irminger Sea Water (ISW) transport by the West Greenland Current may have been a major controlling factor for the extent of stadial shelf glaciation in course of the last glaciation. Deep convection during most late MIS 3 and most of MIS 2 characterised the area possibly as a combined influence of inflowing Glacial North Atlantic Deep Water and brine-related Labrador Sea deep-water formation. Ice sheet melting intensified after 18 kyr BP significantly influencing deep convection in the area.

Tephrostratigraphy of the Lake Suigetsu SG06 core, Japan

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The 70 m SG06 sequence from Lake Suigetsu is an invaluable palaeoclimate archive for the Japan region. This continuous archive is also a record of explosive volcanism from the arc volcanoes that span the entire length of Japan. Over 25 tephra occur as visible layers, and density separation techniques carried out on a sections of the core spanning ~30-40 ka and have shown that there are numerous discrete microtephra cryptically recorded within the sequence (~2 every 1 m). This tephrostratigraphic record is important for linking this core to others, and building up a chronological framework for the region and beyond. Ages of these tephra will also be employed in the new terrestrial radiocarbon calibration dataset that is being generated from the Suigetsu cores using varve chronology (annual layer counting) and >600 ^{14}C determinations of terrestrial macrofossils. The dates of the volcanic eruptions will help reduce the uncertainties and ensure that the age model is robust.

Here we present the some of the results of this study. Including a preliminary tephrostratigraphy of the core, composition of most tephra units, and some ^{40}Ar/^{39}Ar eruption ages. Previous correlations of Japanese tephra relied on dispersal information, and refractive indices of the glass shards. Although dispersal is well constrained for the largest eruptions and thus can be employed to aid correlations of the widespread tephra, it cannot be used to for the smaller eruptions. Furthermore, refractive indices are rarely unique and can't ensure robust correlations. However, major and trace chemistry of the glass shards that comprised the eruption deposits is unique for individual events. Precise chemistry determined using a wavelength-dispersive electron microprobe and LA-ICPMS provides a fingerprint, which is vital for correlation.

Young sandine-bearing deposits from Ulleung volcano, South Korea were dated using the ^{40}Ar/^{39}Ar technique. Deposits of explosive eruptions from this island deposited ash within Suigetsu, 500 km from source. Sanidines (K feldspar) in the deposits range from ~80 micrometres to a few millimetres, and the crystals of all sizes were dated. The ages indicate that only ~66% of the crystals grew in the magma (phenocrysts) and record the eruption age, while the others are significantly older (up to 2 Ma) and were clearly plucked from the crust on the magma's ascent. The 54 age determinations allowed us to identify the different components so the xenocrysts and antecrysts can be excluded, and has yielded a precise ^{40}Ar/^{39}Ar age of 12.5 ± 0.3 ka (1σ) on one of the youngest eruptions.

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In search of "glacial" speleothems in alpine caves

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The seminal study of stalagmites from Hulu Cave (Wang et al., 2001) has jump-started the research on cave deposits as precise chronometers of millennial-scale climate variability during the last glacial cycle. With U-series dates now routinely approaching per-mil precision speleothems are obvious candidates to improve the current reference timescales.
We have been involved in the search of speleothems from MIS 2 to 5, which are of high geochemical quality for U-Th dating, and whose proxy data allow an unambiguous identification of millennial climate events. The European Alps have been previously shown to be of high climate sensitivity with speleothems yielding high-resolution stable isotope records which provide a near-perfect match of the same proxy pattern seen in the Greenland ice cores.
The previously held view that physical thresholds (freezing of water feeding stalagmites in caves) limit the formation of speleothems in alpine environments to climatically favourable intervals has been challenged by recent findings of our group. U-Th-dated records of calcite deposition from three alpine caves located above today's timberline demonstrate that locally calcite deposition occurred during glacial periods starting with the prominent MIS 12. Preliminary data from a cave in the Swiss Alps are presented and provide a unique high-precision record of O isotopes in paleoprecipitation between 29.9 and 14.7 kyr. Given the scarcity of continuous, well-dated terrestrial records of the LGM these cave deposits offer unprecedented climate insights and a direct proxy link to Greenland ice core data.

LATEGLACIAL AND EARLY HOLOCENE ENVIRONMENT IN NORTHERN LITHUANIA: AN APPROACH FROM TALŠA LAKE

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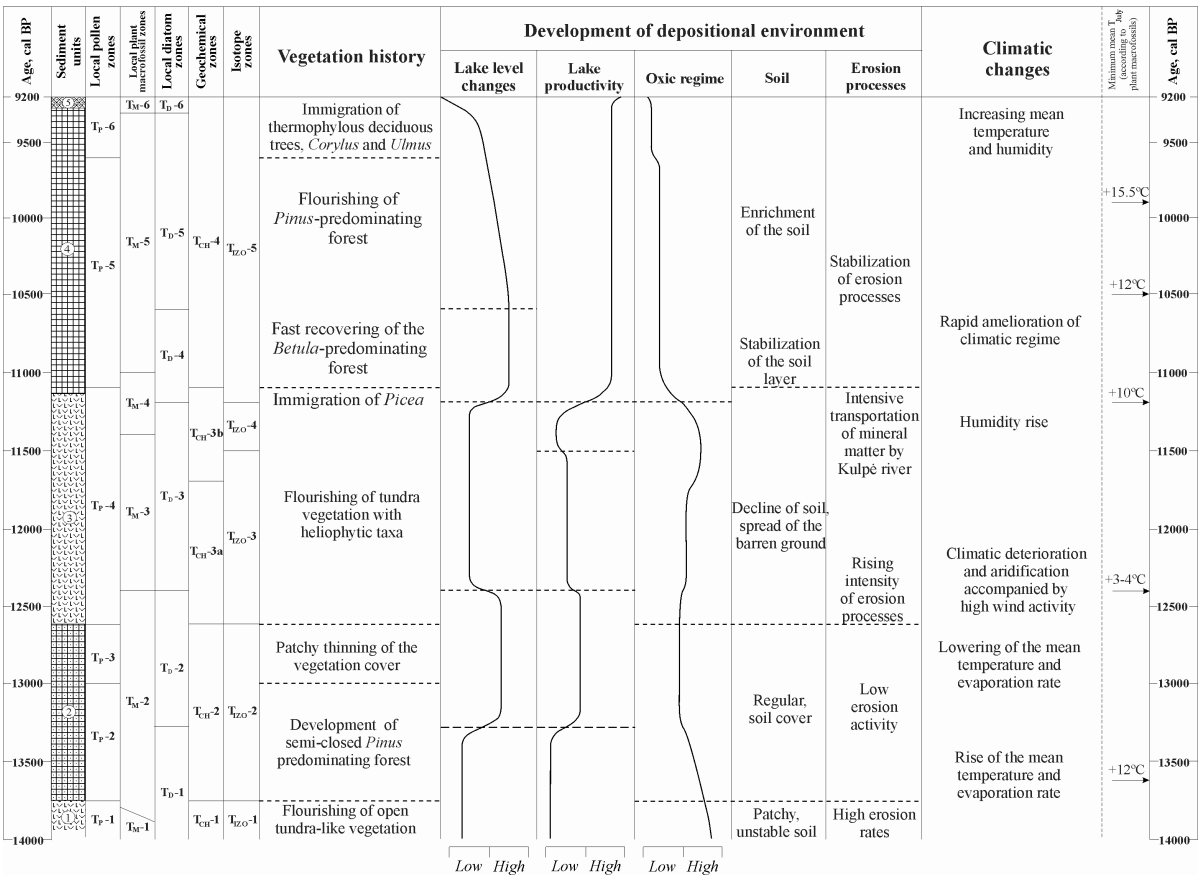
In order to reconstruct the Lateglacial and early Holocene environmental pattern (vegetation composition, depositional environment, palaeoclimatic fluctuations) in the northern part of Lithuania, the terrestrial record from Talša Lake, near present day Šiauliai Town, was investigated. Detailed multi-proxy analysis, including pollen, diatom, plant macrofossil survey as well as $\delta^{18}O$, $\delta^{13}C$, ^{14}C and loss on ignition (LOI) measurements, together with geochemical investigations, were carried out with high temporal resolution. The results show that the formation of the bottom-most part of the investigated sequence took place before 13,700 cal BP in the shallow, oxygen-rich, alkaline transparent water basin with predominantly terrigenous sedimentation and a negligible input of organic matter. The obtained palaeobotanical records display the scarcity of the vegetation cover and flourishing of the non-arboreal taxa in the local flora, which indicates a severe climatic regime. After 13,700 cal BP, following the climatic amelioration, forestation by open, *Pinus*-predominating vegetation began around the lake where the deposition of autochthonous carbonates with rising amount of organic constituent coincided with rises in the water level. However, from about 13,300 cal BP, the recorded spread of light-demanding and pioneer taxa, along with the gradual lowering of the water level, suggests some instability in the environmental conditions. This was perhaps due to a diminished evaporation rate related with increasing air humidity and gradual climatic cooling. The flourishing of pioneer shrub/herb/grass communities with low organic productivity around the shallow water body started after 12,600 cal BP. This coincided with the onset of Younger Dryas cooling distinguished as an especially dry interval, particularly during its initial stages. While the gradual amelioration of the environmental situation *e.g.* rise of the mean temperature accompanied by increasing humidity, followed by the immigration of *Picea* started in area at about 11,500 cal BP, a period of high stress and physical disturbance, including an intensive supply of allochthonous material into the basin, lasted until about 11,100 cal BP. Afterwards, continuous improvement of sedimentary environment, together with a deposition of autochthonous carbonates in the shallow, slightly acidic mesotrophic-eutrophic lake and rising organic input, was

recorded. Starting with 10,300 cal BP, the formation of a closing woodland with *Corylus* and *Ulmus* began across the region.



Summary chart of the Lateglacial and early Holocene environmental variations in the surroundings of Talša Lake, northern Lithuania

Lake Sihailongwan - a multiproxy, high-resolution record of Late-glacial vegetation dynamics and monsoon changes

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Annually laminated sediments from Lake Sihailongwan (Jilin Province, P.R. China) provide a continuous high-resolution climatic record for the monsoonal Northeast China over the last 80,000 years. Analyses of pollen spectra and sediment composition allow reconstructing the regional vegetational and climatic changes during the last glacial-interglacial transition in more details than has been previously done. A reliable chronology is based on both varve counting and 40 calibrated AMS ^{14}C age determinations. Comparison of the Late-glacial palynological signals observed in the Sihailongwan record with those from Siberia, Europe and Greenland suggest that at least the beginning of the Late-glacial and the timing of the Younger Dryas event are - within errors margins - synchronous. Two further Late-glacial climate reversals are recorded in the pollen data between 13.9 and 13.8 kyr BP and 13.1 and 12.9 kyr BP. These correspond to the Greenland Interstadial 1d and the so called Gerzensee/Intra-Allerød-Cold-period (Greenland Interstadial 1b), respectively.

Here we present a new quantitative climate reconstruction using the Best Modern Analogue (BMA) approach, and a quantitative biome reconstruction method. The latter reveals a mosaic like occurrence of taiga, cool-coniferous forests, cool-mixed forests and steppe indicating sensitive ecotone situations during the Late-glacial and complements the qualitative interpretation of the Sihailongwan pollen record. Nevertheless, it seems that rapid climate changes (in the direction of more favorable climate) may not be indicated immediately by pollen data, if the rate of environmental change exceeds the rate of vegetation response. Correspondingly, the climate reconstruction reveals only moderate changes at the transitions to the Late-glacial and to the Holocene, when large-scale re-organizations of the vegetation took place. In contrast, the climate reconstructions during the Gerzensee fluctuation and at the beginning of the Younger Dryas, which are clearly visible in pollen percentage curves and biome shifts, display marked temperature and precipitation changes without time lag. Finally, a discussion of the reconstructed temperatures and precipitation in the context of sedimentological and geochemical data is required in order to achieve consistent and reliable interpretation of the past environments.

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The integration of ice core, marine and terrestrial records during the last glacial termination (and last glacial) is the core activity of INTIMATE. Good time scales and good event-stratigraphical control of sediments have always been keys for a successful integration. In the past 15 years, INTIMATE has achieved several important goals: Set a standard for a common reference to the Greenland ice core event stratigraphy, e.g. GS-1, GI-1a,b,c, GS-2 etc., beginning the process of collecting a set of tephra-stratigraphic markers for syncronization and providing a forum for the comparison of dating methods. With the huge improvements of dating techniques and time scales, such as the extended reach of the Carbon-14 method, U/Th dating and the GICC05 of ice cores, and improved stratigraphical resolution of records available, the INTIMATE process is facing new challenges. With good resolution comes the demand for more precission in dating, both absolute and differential, and the need for more tephra-stratigraphical fix-points. As it becomes more and more apparent that we can define the on-sets of Greenland Isotope Stadials and Inter-stadials happen in 3 years or less, we can no longer relate the terrestrial event stratigraphy, e.g. Younger Dryas, Bølling, Allerød, Glinde, Oerel, Denekamp and Hengelo and marine periods, e.g. MIS-2, MIS-3, Heinrich 2, Heinrich 3 to Greenland's GIS-1, GS-2, GIS-2 etc. on a one-to-one basis in comparisons. Obviously, we have to achieve great precission in dating. However, as the dating methods employed are independent: Carbon-14, Carbon-14 with reservoir ages, U/Th and Ice layer counting, we should be very careful in linking records based on dating alone. As ever before, we need fixpoints from tephra horizons. But a few well placed fix-points will enable us to critically compare datings and collect terrestrial, marine and ice core evidence for good reconstructions of environmental conditions during past climatic events.

Update on Greenland ice core chronologies and more

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Since the release of the layer-counted Greenland Ice Core Chronology GICC05 some years ago, several accurately dated speleothem records from the last glacial period have become available. Comparison of those records to the Greenland records allows to constrain the accuracy of GICC05 and/or to estimate the magnitude of leads and lags in the onset of DO or DO-like events in various locations of the northern hemisphere. The new speleothem records also give some indication about what precision to expect when comparing IntCal09 calibrated C-14 dates to the GICC05 timescale in the last glacial period. There are attempts of trying to extend GICC05 beyond 60 ka and the goal is to have a layer-counted time scale covering most of the last glacial cycle. Furthermore, there is work in progress on expanding GICC05 to other Greenland ice cores, such as the newly obtained NEEM ice core, and the GISP2 and Dye-3 ice cores. Concerning Antarctica, there is progress in annual layer counting of the EDML ice core. This may allow for identification of inter-hemispheric volcanic reference horizons whereby the synchronization of Greenland and Antarctic ice cores may be improved.

Significance tests for transfer function-derived quantitative reconstructions

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Quantitative palaeoecological reconstructions lack significance tests. Since a transfer function for any variable will generate a reconstruction for any fossil data where there are some species in common, the absence of robust statistical tools for evaluating the significance of these reconstructions is a major weakness for palaeoecology.

Current practice is to test if an environmental variable is a significant predictor of the distribution of species in the modern training-set, typically with an ordination. Such tests are inadequate, as with judicious choice of enough sites over a long-enough gradient with minimal nuisance gradients, any ecologically relevant variable will be significant. At best, such tests indicate which variables might be possible to reconstruct, they provide no guarantee that variables can be reconstructed from a particular site.

We present a test of reconstruction significance. A reconstruction is significant if it explains more of the variance in the fossil data than most reconstructions from transfer functions trained on random data. Redundancy analysis is used to determine the amount of variance explained. This test can be extended to test if multiple reconstructions from the same biotic data are significant by using forward selection on the different reconstructions.

Preliminary results show that several published reconstructions explain no more of the fossil record than expected by chance. Such reconstructions should be interpreted only with extreme caution. We also find that it is rare for it to be possible to reconstruct two or more independent variables from the same fossil data.

These tests can be extended to determine the environmental variable most likely to be influencing the fossil data, and how this changes over space and time, providing new information on how biota reacted to Quaternary climate change.

Imprints of Greenland stadial/ interstadial cycles in marine records off southern Iberia: Hemispheric and Regional Signals

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The western Iberian margin has been one of the key locations to study abrupt glacial climate change and associated interhemispheric linkages. Combining various high-resolution records allows mapping how the Greenland stadial (GS)/ interstadial (GI) cycles and the Heinrich stadials (HS) affected the water column along the southwestern Iberian margin and which latitudinal and vertical boundaries existed. Most surface, intermediate or deep water records from this region reveal GS/ GI-type millennial-scale variability with the $\delta^{18}O$ record of the planktic foraminifer *G. bulloides* often being the better record for correlations between marine and Greenland ice core records. However, regional signal modification is also evident and will be the main focus of this presentation.

Based on the existing sea surface temperature (SST) and *% N. pachyderma* (s) records, the polar front reached the northern Iberian margin (ca. 41°N), while the subpolar front (and atmospheric Polar Front) was located in the vicinity of 39°N during the HS of the last glacial cycle. Along with these fronts SSTs increased southward by about 1°C per one degree of latitude leading to steep temperature gradients in the eastern North Atlantic and pointing to a close vicinity between subpolar and subtropical waters. The front at 39°N marks roughly the southern boundary of the North Atlantic's Heinrich ice-rafting belt (Hemming, 2004 Rev. Geoph.) allowing the southern Iberia margin to be influenced mostly by subtropical water masses and leading to some modifications in the climate records (e.g., Voelker et al., 2009 GC; Salgueiro et al., 2010 QSR). For Marine Isotope Stage 3, some of the best examples are the records from site MD99-2339 (35.9°N 7.5°W), located in the central Gulf of Cadiz and in the vicinity of the subtropical front during the HS. All surface to subsurface water records from this core reveal millennial-scale variability but the GS/ GI and GI/ GS transitions were often more gradual than in the Greenland $\delta^{18}O$ records and response in the subsurface waters differed between some of the GI. The most pronounced difference to the Greenland $\delta^{18}O$ records is, however, seen in the SSTs (based on planktic foraminifer assemblage data) that did not drop at the GI/ GS transitions but remained warm throughout nearly half of the GS. GS 10 even experienced no cooling at all (also not in the subsurface waters). Thus in this region hydrographic conditions varied between the GS/ GI cycles.

Not only the influence of subtropical waters can modify surface water signals but also upwelling, the dominant hydrographic feature along the western margin. This is clearly evidenced by the difference between the *G. bulloides* $\delta^{18}O$ records of cores MD95-2042 (37.8°N 10.2°W), showing a clear Greenland ice core-type pattern (Shackleton et al., 2000 Paleoc.), and MD95-2041 (37.8°N 9.5°W). Core MD95-2041, located closer to the coast and thus the upwelling filaments, recorded much more variability in its *G. bulloides* record that can only be explained by a strong upwelling influence and that made correlation to the GS/ GI cycles difficult; a problem that could only be solved by including the *% N. pachyderma* (s) data.

A third regional hydrographic phenomenon affecting the (vertical) water column in the eastern North Atlantic is the Mediterranean Outflow Water (MOW). During glacial times and especially the HS and GS, the MOW settled deeper in the water column (e.g., Rogerson et al., 2005 Paleoc.; Voelker et al., 2006 EPSL) allowing it to be admixed into the Glacial North Atlantic Intermediate Water (GNAIW). Thus Iberian margin records from 2465 m water

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depth indicate imprints of MOW by warming events during HS 4 and 5 (Skinner et al., 2007 AGU Monogr.) and by a better ventilation of these water depths relative to the western basin. Due to the MOW admixing the boundary between the GNAIW and Antarctic Bottom Water during HS was located between 2465 and 3100 m on the Iberian margin (*vs*. 2000-2200 m in western basin). Greenland-type climate oscillations can be therefore be traced down to this level, while the deeper sites follow the Antarctic patterns of climate change (e.g., Shackleton et al., 2000 Paleoc.).

Despite the regional signal modifications sufficient paleo-data evidence exists now for this area to validate regional climate models for abrupt climate change events such as GS/ GI.

Precise chronology and past climate quantification from Southern France speleothems.

K. Wainer, D. Genty et al.,

Thanks to radiometric dating and its recent technological improvement, the absolute chronology of speleothem records is getting more and more precise (<1%, 2σ for MIS3). Micromill use allows sampling resolution up to 100μm leading up to seasonal resolution studies. The ability of speleothems composition to reflect past climates and past-environnements has often been considered as being challenging in particular because the interpretations of the isotopic and geochemical signals vary from one karstic site to the other depending on the location climatic features and the karst characteristics. Recent studies provide promising insights about reconstructing vegetation density evolution and quantitative paleothermometry from speleothem composition.

First, I will focus on rapid climatic events: their characteristics (vegetation density, water availability, permafrost settlement…) and precise chronology as recorded in Villars Cave (SW France) from different stalagmites of the last glacial period and in one archeological Chauvet Cave deglaciation sample. Then, we will switch to climate quantification of Termination II. I will explain how we reconstructed quantitatively the warming magnitude between the end of the penultimate glacial period (MIS6) and the Last Interglacial optimum by combining calcite and fluid inclusion $\delta^{18}O$ to calcite Δ_{47} from a Villars Cave flowstone. Additionally, the development of speleothem fluid inclusions isotopic composition measurement potentially provides information about rainfall quantity, infiltration modality and provenience of the air masses which are scarcely documented paleoclimatic parameters.

INTIMATE 1995-2011

History, Achievements and Prospects

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This introductory paper provides a context for the EU-COST INTIMATE meeting by examining the development of the INTIMATE project over the course of the last fifteen years. It explains how INTIMATE evolved from its precursor, the *North Atlantic Seaboard Programme* (NASP), how the initial focus on the North Atlantic region during the Last Termination (15-10 ka BP) has expanded geographically to include other regions of the world, most notably Australia and New Zealand, and temporally to cover the period initially from 30-8 ka BP and subsequently from 60-8 ka BP. The paper also describes the links that have been established between INTIMATE and other international research groups and organisations, including the *International Union for Quaternary Research* (INQUA), the *Subcommision on Quaternary Stratigraphy* (SQS) of the *International Commission on Stratigraphy* (ICS), and the *Past Global Changes* (PAGES) initiative of the *International Geosphere Biosphere Programme* (IGBP). Notable achievements of the INTIMATE community include the development of an event stratigraphy for the North Atlantic region during the Last Termination based on the oxygen isotope record in Greenland ice cores; the formulation of protocols for the synchronisation of events in the North Atlantic region over the 30-8 ka timescale; the refinement of age models based on radiocarbon dating; the application of tephrostratigraphy as a basis for correlating events in marine, terrestrial and ice-core records; and the ratification by the ICS of the joint INTIMATE/SQS proposal that an archived ice core from NorthGRIP in Greenland should constitute the *Global Stratotype Section and Point (*GSSP) for the base of the Holocene Series/Epoch, with an age of 11.7 yr b2k (before AD 2000). The paper concludes with some thoughts on the directions that INTIMATE might take, both within the framework of the EU-COST initiative and at the global scale, and also in conjunction with INQUA and the SQS.

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Tephrochronology of the North Atlantic region: linking marine, terrestrial and ice-core records from MIS 6-2

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Major achievements have been made recently regarding the tephrochronology of the North Atlantic area. Here we will report on the work being undertaken to identify, date and geochemically characterise tephra horizons in marine cores from the North Atlantic and the Greenland ice-cores. The new NERC-funded SMART (Synchronising MARine and ice-core records using Tephrochronology) project aims to test the degree of regional climate synchronicity for key climatic events that occurred within the North Atlantic region over the last interglacial period (Eemian); including Termination II and the onset of the subsequent glacial period.

The SMART project builds on previous work in the North Atlantic region where examples of recent success is the identification of the FMAZ III and the Fugloyarbanki tephra/FMAZ II in NGRIP, providing key tie-points between marine and ice-core records from MIS 3 and 2 (Davies et al., 2008, 2010). The FMAZ III (Faroe Marine Ash Zone III) is an important marker horizon in several marine records within the Faroe Islands margin and is dated to 38,122±723 yr b2k (before year AD 2000) according to the Greenland Ice Core Chronology (GICC05). The event falls directly at the thermal peak of Greenland Interstadial 8 (GI-8) and a marine-ice correlation, based on the position of this tephra, suggests a close coupling of the marine and atmospheric systems at this time (Davies et al., 2010). The FMAZ II/Fugloyarbanki tephra occurs in several marine cores in the Faroe Islands region and in NGRIP. It is dated to 26,740 ± 390 b2k according to GICC05. This tephra falls right after the warmest peak of Greenland Interstadial 3 (GI-3) in both the NGRIP and marine records and provides an important tie-point for marine and ice-core sequences for the last glacial period (Davies et al., 2008).

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Towards an Automated Method for Annual Layer Counting in Ice Cores

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Due to their high temporal resolution, Greenland ice cores can be dated very precisely by annual layer counting. An effort of manual annual layer counting using multiple chemical components has resulted in the Greenland Ice Core Chronology (GICC05), common to several Greenland deep ice cores. The oldest part of the chronology is based on data from the NGRIP ice core, which has particularly high temporal resolution with depth. But as the annual layers get thinner towards the bed, the annual signal in most components weakens. At depths below 2430m, corresponding to an age of 60 ka, only the annual layering in the visual stratigraphy is still intact. However, due to a high noise level in this record, it is difficult to count annual layers in an objective manner only using these data.

Therefore, an automated method is being developed, which takes into account the underlying statistical properties of the visual stratigraphy data sequence. The data sequence is modeled using a Hidden Markov Model (HMM) using algorithms that were originally developed for speech recognition. Preliminary studies are promising, and agree to within 5% of the GICC05 counting. Due to more noise in the visual stratigraphy data during warm periods, the method is likely to give better results in cold periods than during warm. However, as the annual layers are thicker during warm periods, it seems to be possible to use other parameters than the visual stratigraphy for counting annual layers during these. Using the combined data, it should therefore be possible to develop a high-resolution timescale for the NGRIP ice core extending back to 90 ka. In the future, a similar approach might be used for a general multi-parameter annual layer counting of ice cores and other paleoclimatic records, which display annual layering.

The sedimentary record of Lago Grande di Monticchio, Southern Italy: Implications for the Eastern Mediterranean tephrostratigraphy

Sabine Wulf, Achim Brauer, Jens Mingram & Jörg F.W. Negendank

Varved sediment sequences from small and deep maar and volcanic crater lakes in central and southern Europe have found to be ideal for tephrochronological investigations. They are qualified by the permanent supply of tephra material from nearby explosive volcanoes, and tephra layers show a perfect preservation within the sediments due to the absence of bioturbation and retarded glass alteration processes. The continuous sedimentation of lacustrine deposits, the clear stratigraphic order and the dating of tephras by temporal high-resolution varve chronologies can lead to the establishment of detailed tephrostratigraphies of nearby explosive volcanoes, which, in general, is difficult to obtain from proximal, near-vent areas.

One of the most important archive for tephrostratigraphic studies in the Central Mediterranean is the maar lake *Lago Grande di Monticchio* in the Monte Vulture volcanic massif in Southern Italy. The lake is situated in a medial-distal and favourable downwind position to nearby explosive volcanoes of the Campanian, Roman and Sicilian-Aeolian Provinces and, therefore, provides an ideal trap for tephra fallout material. A 102 m annually laminated sediment sequence recovered for palaeoclimate studies comprising the last 135 kyrs contains a total of 344 distinct ash layers deriving from Italian provinces. Intensive microscopic investigations and geochemical analyses using electron microprobe techniques on both, prominent tephras and cryptotephras have been carried out in order to independently date the sediment sequence and to get new insights into the explosive history of nearby volcanoes. The result show, for instance, that explosive activity of Campanian volcanoes extends further back in time and/or was of larger magnitude than previously supposed (e.g., Campi Flegrei, Ischia, Procida-Vivara). Furthermore, tephras from the Roman volcanic province have been detected for the first time in distal sites; here, the new findings in Monticchio helped to date tephra events by the high resolution varve and sedimentation rate chronology. Some of the Roman-Campanian tephras and the most distal ashes in the Monticchio record originating from the Sicilian-Eolian Province represent essential marker horizons for linking the lacustrine palaeoclimate archive with other terrestrial and marine records in the Central and Eastern Mediterranean.

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