

EUG XI



Symposium CC12

Quantitative Palaeoclimate and
Environmental Reconstructions:
Data - Model Comparisons

Convenors

Toni Rosell-Mele
Masa Kageyama
Joel Guiot

CC12

Palaeoclimate and Environmental Reconstructions

Sunday PO Session

CC12 : Supo01 : PO

The Climate and Vegetation of Europe at 6000 BP: New Datasets and Quantitative Methods

Rachid Cheddadi

(rachid.cheddadi@lbhp.u-3mrs.fr), Joel Guiot, Sophie Gachet & Simon Brewer

Centre universitaire d'Arles, European Pollen Database, Place de la République, 13200 Arles, France

Earlier reconstructions of biomes distribution (Prentice et al., 1996) and climate (Cheddadi et al., 1997) in Europe for the period 6000 BP were performed using pollen datasets from both literature (Huntley and Birks, 1983) and a limited number of raw data from the European Pollen Database. These datasets did not include all the pollen identified by the original authors and the dating control of the period 6 ka was not based on absolute datings. Here we present some major improvements in terms of the datasets used and also of the methods used to quantify the climate and to reconstruct the vegetation. New data have been collected and dated and the quantification methods are also improved. This "new generation" of paleoenvironmental reconstructions is not in contradiction with the previous one. However, it provides robust arguments for data-model comparisons. Concerning the vegetation reconstructions, we compare the results of the exhaustive pollen dataset with the earlier results and show that the new pollen dataset and method for the vegetation reconstruction provides a more accurate plant distribution. Concerning the climate, the reconstructions performed in 1997 were based on a single statistical method. However, the reconstructed climatic parameters may show some bias, dependent on the method used. Here we provide the results of three methods of climate reconstruction and we discuss the accuracy of each climate parameter.

CC12 : Supo02 : PO

The Last Glacial Maximum Climate over Europe: A PMIP Comparison between Models and Data

Masa Kageyama (masa@lscce.saclay.cea.fr)¹, Odile Peyron², Sophie Pinot¹, Pavel Tarasov³, Joel Guiot¹, Sylvie Joussaume¹, Gilles Ramstein¹ & PMIP participants

¹ LSCCE UMR CEA CNRS 1572, CE Saclay L'Orme des Merisiers, Batiment 709, 91191 Gif-sur-Yvette Cedex, France

² IMEP, Marseille, CEREGE, Aix-en-Provence, UQAM, Montreal, Quebec, France and Canada

³ Int'l Research Center for Japanese Studies, Kyoto, Japan

Within the Paleoclimate Modelling Intercomparison Project (PMIP, Joussaume and Taylor 1995), consistent data sets have been developed on a continental scale, for the Mid-Holocene (6000 years ago) and the Last Glacial Maximum (21000 years ago). Here, we compare two of these data sets for Europe and western Siberia at the Last Glacial Maximum (Peyron et al, 1998 and Tarasov et al, 1999) to the results of the 17 climate models that have been run for PMIP, using the same boundary conditions: Peltier (1994) ice-sheet reconstructions, CLIMAP (1981) sea-surface temperature reconstructions, a CO₂ concentration equal to 200 ppm and orbital parameters appropriate for 21000 years ago. This comparison accounts for the uncertainties in the pollen-based reconstructions as well as for the range of the model results.

Overall, when taking these large uncertainties into account, the model results compare quite well to the reconstructions for temperatures (mean annual temperature, temperatures of the coldest and warmest months) and precipitation. There are two exceptions to this: over southwestern Europe, the models simulate warmer temperatures (especially in winter) and more precipitation than depicted by the data; over northwestern Siberia, model-simulated summer temperatures are systematically colder than those reconstructed from pollen data. The numerous modelling results allow a detailed study of the mechanisms leading to climate differences between the present and Last Glacial Maximum climates, and to investigate the possible causes of the discrepancies between model results and climate reconstructions.

Joussaume S & Taylor K, *Proceedings of the 1st AMIP conference, WRCP-92*, 425–430, (1995).

Kageyama Met al, *Climate Dynamics*, in press, (2000).

Peltier WR, *Science*, **265**, 195–201, (1994).

Peyron Oet al, *Quaternary Research*, **49**, 183–196, (1998).

Tarasov Pet al, *Climate Dynamics*, **15**, 227–240, (1999).

CC12 : Supo03 : PO

Impact of Precipitation Seasonality on Isotopic Signals in Ice Cores: An Analysis of Several Atmospheric General Circulation Model Simulations

Gerhard Krinner (krinner@glaciog.ujf-grenoble.fr)¹, Christophe Genthon (genthon@glaciog.ujf-grenoble.fr) & Martin Werner (werner@dkrz.de)²

¹ LGGE/CNRS, DU BP 96, 38402 Saint Martin d'Herès Cedex, France

² Max-Planck-Institut für Meteorologie, Bundesstr. 55, 20146 Hamburg, Germany

For the Last Glacial Maximum (LGM, 21 ky BP) borehole thermometry in Central Greenland is in conflict to water isotope proxy temperatures. Borehole thermometry indicates a present day - LGM surface temperature difference of about 20°C, while water isotope analysis only indicates a warming of about 10°C. Two general circulation model studies have shown that changes in the seasonal cycle of precipitation in Central Greenland might have caused a warm bias in the LGM water isotope proxy temperatures, and that this bias could explain the difference in the estimated paleo-temperatures. Here we present an analysis of a number of atmospheric general circulation model simulations done within the framework of the Paleoclimate Modeling Intercomparison Programme (PMIP). The models suggest that the seasonal cycle of precipitation over Central Greenland at the LGM might have been very different from today. This supports the idea that the accuracy of the water isotope thermometry at the LGM in Greenland might be compromised because of a modified precipitation seasonality. However, the models disagree both on the sign and the amplitude of the error induced on isotope thermometry. On the other hand, the LGM isotopic signal over Central East Antarctica does not seem to be affected by any such effect. Similarly, for the mid-Holocene (6 ky BP), the models do not suggest any major problems with ice core isotopes linked to changes in the precipitation seasonality, neither in Greenland nor in Antarctica.

CC12 : Supo04 : PO

Bi-Plot Analysis for Compositional Data in Multidisciplinary Research. Case Study for the Late Pleistocene-Holocene of Tyrrhenian Sea

Antonella Buccianti (buccianti@unifi.it)

Via La Pira 4, 50121 - Firenze, Italy

Multidisciplinary investigations are fundamental for palaeoecological reconstructions and often require application of descriptive and inferential univariate and multivariate statistical procedures. The aim, in general, is the evaluation of the available qualitative and quantitative information and consequently the research of correct tools for data treatment. In this context particular attention has to be devoted to the investigation of abundance data affected from the so called *closure constraint* problem (Aitchison, 1986). The features of compositional data were discussed for the first time by Karl Pearson as long as 1896 in his classical paper on Mathematical Contributions on the Theory of Evolution published in the Royal Society of London Proceedings (Pearson, 1896). He recognised that the analysis of compositional data, based on relationships between proportions of some hole, were likely difficult to treat and a coherent solution was proposed only in 1981 by John Aitchison (Aitchison, 1986). However, his approach, based on sound statistical theory, is not so well diffused in Earth Sciences as expected. In this work an application of *bi-plot analysis* for compositional (abundance) data (Aitchison, 1997) is proposed with the aim to point out correlations among different species to be interpreted from a palaeoecological point of view. Data are given by planktonic Foraminifers, calcareous Nannofossils, Pteropods assemblages and pollen spectra of two cores collected in the Gulf of Salerno (Southern Italy), named C106 (20 km offshore the Sele River mouth) and C18 (10 km offshore Cape Palinuro). Volcanological, sedimentological and geochemical results obtained from the same cores will be related with abundance data in a multivariate framework to point out features useful for the reconstruction of the paleoenvironmental conditions of the Late Pleistocene-Holocene of Tyrrhenian sea (Geoteam99, 2000a, b).

Aitchison J, *The Statistical Analysis of Compositional Data*, Chapman and Hall, (1986).

Aitchison J, *Proceedings of IAMG'97*, Pawlowsky-Glahn Ed., CIMNE, Barcelona, 3-35, (1997).

Geotem99, *Proceedings of the Workshop on Impact of Natural Events on Biological Communities since 29 ky B.P. - Climatic and Volcanic Events, Benevento (I), June 29-30*, (2000a).

Geotem99, *Proceedings of the Workshop on Impact of Natural Events on Biological Communities since 29 ky B.P. - Climatic and Volcanic Events, Benevento (I), June 29-30*, (2000b).

Pearson K, *Proceedings Royal Society of London*, **LX**, 489-502, (1896).

CC12 : Supo05 : PO

Paleoceanographic Impact of Heinrich Events Based on Marine Sediments off Portugal

Edouard Bard (bard@cerege.fr), Corinne Sonzogni (sonzogni@cerege.fr) & Frauke Rostek (rostek@cerege.fr)

CEREGE, Europole de l'Arbois BP 80, 13545 Aix-en-Provence cdx 4, France

Alkenones were measured in new deep-sea sediments raised off Portugal in order to complement the short record based on core SU8118 (Bard et al. 2000). These biomarkers were quantified by standard GC procedures but the presence of minor alkenones and alkenoates was precisely monitored by GCMS-EI in both SCAN and SIR modes. The new profiles allow to study the relationships between sea-surface cooling and Heinrich events. These events are well expressed by high values of the magnetic susceptibility (MS; Thouveny et al. 2000) and of tetra-unsaturated alkenone content (C37:4%). The new records for the last 35 kyr confirm our previous observations in core SU8118. The new section corresponding to the period between 35 and 120 kyr BP clearly shows SST minima in phase with MS and C37:4% maxima. H4 to H9 are all prominent and the most extreme coolings (>4°C) occurred during H6 and H8. As previously described for the last 35 kyr, several H events are clearly twinned (e.g. H7 and H9). Between H events, the profiles exhibit a high-frequency variability with similar characteristics: low SST corresponding to high C37:4% and MS. The high correlation between these two proxies can be used to study the source of C37:4%, a biomarker which has been associated to low-salinity sea-surface waters (Rosell-Melé 1998), marginal seas and estuarine environments (Schulz et al. 2000). Our paleoceanographic data on the effect of H events at mid-latitudes will be compared to models of the hysteresis behavior of the thermohaline circulation (Paillard & Labeyrie 1994, Ganopolski & Rahmstorf 2000).

Bard E et al, *Science*, **289**, 1321-1324, (2000).

Ganopolski A, Rahmstorf S, *Nature*, in press, (2000).

Paillard D, Labeyrie LD, *Nature*, **372**, 162-164, (1994).

Rosell-Melé A, *Paleoceanography*, **13**, 694-703, (1998).

Schulz HM, Schoener A, Emeis KC, *Geochim. Cosmochim. Acta*, **64**, 469-477, (2000).

Thouveny Net al, *Earth Planet. Sci. Lett*, **180**, 61-75, (2000).

CC12 : Supo06 : PO

The Past Climate Reconstruction from Pollen Data by Inversion of a Coupled Vegetation/Pollen Transport Model

Christophe Cassinat (cassinat@cerege.fr)¹,

Joel Guiot (joel.guiot@lbhp.u-3mrs.fr)²,

Dominique Jolly (jolly@isem.univ-montp2.fr)³,

Hilaire Elenga (elen10@calva.com)⁴,

Odile Peyron (c2200@er.ukam.ca)⁵ &

Franck Torre (ftorre@stats.warwick.ac.uk)⁶

¹ CEREGE, CNRS UMR 6635, BP 80, F-13545 Aix-en-Provence cedex 04., France

² IMEP, CNRS UMR 6116, Faculté de St-Jérôme, case 451, F-13397 Marseille Cedex 20, France., France

³ ISEM, CNRS UMR, Université de Montpellier II, F-34095 Montpellier cedex 5, France., France

⁴ IRD Pointe Noire, BP 1286, Pointe-Noire, Congo, Congo

⁵ GEOTOP, UCAM, Montreal, Canada

⁶ University of Warwick Fax: 00 44 (0)2476 534 532

Mathematical Science Building Gibbett Hill

RoadCoventry CV4 7AL, United Kingdom

Classical climate reconstruction based on statistical method

implicitly assumes that the atmospheric CO₂ concentration, which has greatly fluctuated during the Quaternary, has no influence on the vegetation. In order to correct this assumption

tion, the use of a process-based vegetation model (BIOME4) in inverse mode to reconstruct from pollen data the most probable climate under lowered CO₂ concentration in the biosphere is necessary (Guiot et al., 2000). In this study, appropriate tools to match the model outputs with the pollen data are developed to generate a probability distribution associated with the reconstruction (Monte Carlo sampling and neural network techniques). We propose here, a complementary method to compare model outputs and pollen data by using an explicit wind pollen transport model. This model makes the link between the Net Primary Production of the Plant Functional Type (PFT) simulated by the vegetation model and the PFT scores calculated from the pollen data. The pollen transport model simulates the pollen grain abundance arriving from the surrounding vegetation as a function of the PFT, its abundance around the site and its mean grain size. The main parameters of the model are calibrated by inversion on a modern dataset. This method based on physical processes could bring more robustness compared to the neural network techniques. It will be coupled to the vegetation model (BIOME4, CARAIB or ORCHIDEE) to reconstruct last glacial maximum climate in Africa.

Guiot J. et al., *Ecological Modelling*, **127**, 119-140, (2000).

CC12 : SUPo07 : F1 Environmental Modelling and Quantitative Palaeoenvironmental Reconstructions of Holocene Sea-Level Data

Ben Horton (b.p.horton@durham.ac.uk)¹ & **Robin Edwards** (edwr@geo.vu.nl)²

¹ Department of Geography, University of Durham, Durham, DH1 3LE, UK

² Faculty of Earth Sciences, Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, Netherlands

Many studies have sought to reconstruct variations in relative sea-level (RSL) using microfossil data (e.g. diatoms, foraminifera and pollen) contained in a range of sedimentary deposits. These microfossil data can provide information on a diverse range of processes such as changes in ice sheet extent, crustal movements, coastal evolution and sedimentary processes, which are vital for engineers and decision makers alike. Regardless of their application however, these microfossil data and their associated RSL reconstructions are all subject to fundamental errors associated with the precise determination of age and altitude. One major source of altitudinal error is introduced when attempting to quantify the indicative meaning. The indicative meaning of a coastal sample is the relationship of the local environment in which it accumulated to a contemporaneous reference tide level. This study provides a quantitative method of estimating the indicative meaning based upon the contemporary relationship among RSL, environmental conditions and the succession and seasonal variations of foraminiferal and diatom assemblages. This technique is used to produce Holocene sea-level data from eastern England.

These sea-level data were used to construct trends of RSL where both the regional (glacial rebound) and the local (sediment consolidations and tidal range) factors are identified. The effect of the glacial rebound process explains regional scale differences within eastern England of approximately 20 m range at 8000 BP. Furthermore, by 4000 BP RSL in Northumberland was above present, whereas in areas to the south RSL has been below present throughout the Holocene. Models of RSL and continental shelf bathymetry combine to produce palaeogeographic reconstructions for the last 10000 years at 1000-year intervals of the western North Sea. The key stages include: a western embayment off northeast England as early as 10000 BP; the evolution of a large tidal embayment between eastern England and the Dogger Bank before 9000 BP with connection to the English Channel prior to 8000 BP; and Dogger Bank as an island at high tide by 7500 BP and totally submerged by 6000 BP. After 6000 BP the major changes in palaeogeography occurred inland of the present coast of eastern England.

CC12 : SUPo08 : PO Comparison of the Glacial TEMPUS UK37'- SSTs with PMIP Modelling Results

Antoni Rosell-Mele (antoni.rosell@durham.ac.uk)¹, **Edouard Bard** (bard@cerge.fr)², **Kay Christian Emeis** (kay.emeis@io-warnemuende.de)³, **Joan Grimalt** (jgoam@cid.csic.es)⁴, **Peter Muller** (pmueller@uni-bremen.de)⁵, **Ralph Schneider** (rschneid@uni-bremen.de) & **Bjoern Grieger** (mail@bjoern-grieger.de)⁶

¹ Dept. Geography, South Road, University of Durham, Durham, DH1 3LE, United Kingdom

² CEREGE, Université d'Aix-Marseille III, Europole de l'Arbois, BP80, 13545 Aix-en-Provence cdx 4, France

³ Institut für Ostseeforschung Warnemünde, Seestrasse 15, D-18119 Warnemünde, Germany

⁴ Dept. Química Ambiental, CID-CSIC, Jordi Girona 18, Barcelona 08034, Catalonia, Spain

⁵ Universität Bremen, FB 5 - Geowissenschaften, Postfach 330 440, D-28334 Bremen, Germany

⁶ Max-Planck-Institut für Aeronomie, Max-Planck-Str. 2, D-37191 Katlenburg-Lindau, Germany

The Climate/Long-Range Investigation Mapping and Prediction (CLIMAP) project represented a turning point in the study of climate change and helped to fuel explosive growth in climate research based on the analysis of sediment cores. Maps produced more than 20 years ago from CLIMAP data are still at the core of much groundbreaking research. However, it is not surprising that many aspects of CLIMAP work remain controversial and are the subject of considerable debate, for instance in relation to tropical sea surface temperature (SST) and the extent of sea ice at high latitudes. Until recently there have not been other comprehensive study to validate such data. A critical examination of CLIMAP results is long overdue, particularly using other proxies which do not suffer from the same uncertainties associated with microfossil transfer function analyses to reconstruct SST.

The TEMPUS project, funded by the European Commission, was set up as a concerted effort to reassess current thinking on SST evolution especially for the Last Glacial Maximum, at the moment mainly based on CLIMAP. In TEMPUS, SST estimates have been derived from the UK'37 proxy, which is based on the relative abundance of double bonds (2 or 3) in alkenones (ketones with 37 carbon atoms) found in marine sediments.

In this communication a synthesis of SST for the LGM is presented and compared to modelling results from the Paleoclimate Modelling Intercomparison Project, PMIP.

CC12 : SUPo09 : PO Quantitative Reconstruction of Younger Dryas to Mid-Holocene Paleoclimates at Le Locle, Swiss Jura, using Pollen and Lake-Level Data

Michel Magny (michel.magny@univ-fcomte.fr)¹ & **Joël Guiot** (joel.guiot@lbhp.u-3mrs.fr)²

¹ Lab.Chrono-Ecologie, UFR Sciences, 25030, Besançon, France

² IMEP, Faculté Saint Jérôme, 13397 Marseille, France

Quantitative reconstruction of climatic parameters over the Younger Dryas event and the first half of the Holocene period was developed using both pollen and lake-level data from Le Locle, in the Swiss Jura. According to this reconstruction, the Younger Dryas cold event at Le Locle was characterized by (i) a general trend towards a slight increase in summer temperature and a decrease in annual precipitation, and (ii) a marked drying phase at ca 11,900 cal yr B.P. bracketed between two wetter ones. Further phases of major deficit in moisture occurred at ca 11,500 cal yr B.P. (Younger Dryas-Holocene transition), 10,800 cal yr B.P. (late Preboreal pollen zone), 8700 cal yr B.P. (transition between the Boreal and Older Atlantic pollen zones) and 6500 cal yr B.P. (transition between the Older and Younger Atlantic pollen zones). Climatic parameters reconstructed here suggest that phases of higher lake level developing at ca 12,500-12,000, 11,750-11,600, 11,200-10,900 (synchronous with the Preboreal oscillation), 10,400-8900, 8400-8300 (possibly related to the 8200 yr event) and 7800-7000 cal yr B.P. coincided with an increase in annual precipitation, a decrease in summer temperature and a shorter growing season. Conversely, periods of low lake level corresponds to a decrease in annual precipitation, an increase in summer temperature and a longer growing

season. This general pattern could have resulted from alternative southward-northward displacements of the Atlantic Westerly Jet.

Cheddadi Ret al, *Climate Dynamics*, **13**, 1-9, (1997).

Guiot J, Harrison SP & Prentice IC, *Quaternary Research*, **40**, 139-149, (1993).

Magny M, *The Holocene*, **3**, 306-313, (1993).

Magny M, Schoellammer P, *Géogr. Physique et Quaternaire*, **53**, 183-197, (1999).

Monday PM Session

CC12 : MOpM22 : F1

Modeling Extreme Climates of the Past: What we have Learnt from Model-Data Comparisons within the Palaeoclimate Modeling Intercomparison Project

Sylvie Joussaume (syljous@lsce.saclay.cea.fr)
Laboratoire des Sciences du Climat et de
l'Environnement, Orme des Merisiers bat 709, CE
Saclay, Gif sur Yvette, France 91191

The Paleoclimate Modeling Intercomparison Project (PMIP) was created by climate modeling groups with the aim to improve our understanding of past climatic changes and to assess their representation by climate models. This project focuses on two past extreme conditions, relatively well documented: the last glacial maximum, 21 000 years before present (BP) and the mid-Holocene climate, 6000 years BP. This project has involved about twenty modeling groups as well as several groups involved with paleodata (PMIP, 2000).

For the mid-Holocene, a major emphasis has been put on the sensitivity of the African summer monsoon to insolation changes. Results have emphasized that all atmospheric models are able to simulate an increase in the summer monsoon over Africa and Asia as a result of increased summer insolation, but, when compared quantitatively to biome reconstructions over Africa obtained within the BIOME 6000 project, all the models underestimate the northward displacement of the desert-steppe transition (Joussaume et al., 1999). Several complementary simulations have shown that ocean and vegetation processes introduce important feedbacks which are necessary to explain the observed monsoon changes. Above all vegetation feedbacks play a key role in the strength of the monsoon intensification due to local water recycling (e.g. Braconnot et al., 1999). These results urge for a systematic evaluation of coupled atmosphere-ocean-vegetation models for the mid-Holocene as well as for an investigation of vegetation feedbacks in future climate change studies.

The last glacial maximum gives an opportunity to evaluate the capability of climate models to reproduce an important climate change. When forced by large ice sheets and lower CO₂ values that prevailed 20 000 years BP, models exhibit a global cooling of the order of 4°C. When compared to a new synthesis of terrestrial data in the tropics (Farrera et al., 1999), some models exhibit a reasonable amplitude of cooling over both land and ocean (Pinot et al., 1999) enhancing our confidence in using these models for future climate studies. However, models still neglect ocean circulation and vegetation feedbacks and further studies will be required to further evaluate models under ice age conditions.

PMIP, *WCRP Report*, **111**, 271 pp, (2000).

Joussaume S., Taylor K.E and 34 coauthors, *GRL*, **26**, 859-862, (1999).

Braconnot P., Joussaume S., Marti O. and de Noblet N., *GRL*, **26**, 2481-2484, (1999).

Farrera I., Harrison S. and 17 coauthors, *Clim. Dyn.*, **15**, 823-856, (1999).

Pinot S., Ramstein Gand S. coauthors, *Clim. Dyn.*, **15**, 857-874, (1999).

CC12 : MOpM24 : F1

Environmental Processes of the Ice Age: Land, Oceans, Glaciers (EPILOG)

Alan C. Mix (mix@oce.orst.edu)¹,
Edouard Bard (bard@cerge.fr)² &
Ralph Schneider (rschneid@uni-bremen.de)³

¹ Oregon State University, Corvallis, OR, USA

² CEREGE BP80, 13545 Aix-en-Provence, France

³ University of Bremen, Bremen, Germany

Knowledge of the state of the Earth at the Last Glacial Maximum (LGM, an interval around 21,000 years ago) is an important benchmark for understanding the sensitivity of global environmental systems to change. Much progress in understanding climates of the LGM has occurred in the last 20 years since the end of the CLIMAP project of the 1970's (Climate Long-range Investigation, Mapping and Prediction; CLIMAP Project Members 1976). Here we review this progress, based on presentations and discussion at a first open science meeting of the EPILOG project (Environmental Processes of the Ice age: Land, Oceans,

and Glaciers) held in Delmenhorst, Germany, May 1999. We outline key controversies and document protocols for EPILOG contributions, so that a new synthesis of the LGM Earth (in particular the surface temperatures) can emerge as an open project of the world's community of scientists (Mix, et al., 2001).

CLIMAP Project Members, *Science*, **191**, 1131-1137, (1976).
Mix AC, Bard E, Schneider RR, *Quat. Sci. Rev.*, in press, (2001).

CC12 : MOpM26 : F1

Ice Sheets and Sea Level of the Last Glacial Maximum

Peter U. Clark (clarkp@ucs.orst.edu)¹,
Alan C. Mix (mix@oce.orst.edu)² &
Edouard Bard (bard@cerge.fr)³

¹ Dept. Geosciences, Oregon State University, Corvallis, OR 97331, USA

² College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331, USA

³ CEREGE, Université Aix-Marseille III, Aix-en-Provence cedex 4, France

One of the fundamental issues surrounding Pleistocene glaciations concerns the extent and volume of ice during the Last Glacial Maximum (LGM) around 21,000 years ago. These ice sheets had a tremendous influence on global climate, affecting the planetary albedo, atmospheric and ocean circulation, and the hydrological cycle. Moreover, the redistribution of mass associated with growth and decay of ice sheets and concomitant sea-level changes caused global isostatic adjustments that are continuing today thousands of years following the final deglaciation of Northern Hemisphere ice sheets. Despite the focus of study for over 150 years, however, large uncertainties remain in identifying the three-dimensional geometry of the large ice sheets that are the defining components of an Ice Age. Most of the excess ice was locked up in large Northern Hemisphere ice sheets where today only the Greenland Ice Sheet remains, but resolving the distribution of this ice as well as the volume of excess ice in the Antarctic Ice Sheet represents a critical but unrealized objective in understanding the climate dynamics of glacial cycles. These issues were among those discussed at an international workshop on "Ice Sheets and Sea Level of the Last Glacial Maximum" held October 1-5, 2000. The workshop was the second in a series of planned workshops that are addressing various issues surrounding the Last Glacial Maximum under the auspices of the EPILOG (Environmental Processes of the Ice Age: Land, Oceans, and Glaciers) program. Major conclusions drawn from the meeting include the following. (1) The ice-equivalent maximum lowering of global sea level of ~135 m extended from 19,000 to at least 23,000 yr B.P. (2) The spatial extent of the global ice sheets is well known with the exception of the western portion of the Kara Sea ice sheet. (3) Inverse modeling of the isostatic changes associated with changes in sea level and ice volume can accommodate thicker ice masses than would otherwise be modeled if significant deglaciation occurred early on. (4) Ice sheet model estimates of global ice volume currently underestimate the global ice-equivalent sea level lowering by 10-20%. (5) The age of the last oxygen-isotope minimum (LIM) (~18 ka) signal post-dates the LGM by ~3 kyr, and the first post-LIM shift (16-17 ka) predates meltwater pulse 1A (14.2 ka). Continuing issues include the following: (1) The location(s) of the missing ice; (2) the amplitude of the ice-equivalent oxygen-isotope signal; (3) the origin of abrupt sea-level rises during the last deglaciation; (4) the origin of the delay in the oxygen-isotope signal with respect to sea level during the last deglaciation.

CC12 : MOpM29 : F1

Climatic Changes in Africa and Eurasia since the Last Glacial Maximum

Odile Peyron (c2200@er.uqam.ca)¹,
Joel Guiot (joel.guiot@vmesa12.u-3mrs.fr)²,
Dominique Jolly (jolly@isem.univ-montp2.fr)³ &
Pavel Tarasov (p-tarasov@mtu-net.ru)⁴

¹ GEOTOP, UQAM, CP 8888, succursale Centre-ville, H3C3P8 Montreal, Canada

² CEREGE, europe de l'Arbois, BP 80, 13545 Aix-en-Provence, France

³ Dpt Paléoenvironnements & Palynologie, Case 61, ISEM, Université Montpellier II, 34095 Montpellier, France

⁴ Department of Geography, Moscow State University, Vorobiev Gory, 119899 Moscow, Russia

Reliable estimates of past environmental conditions are essential for the validation of models used to simulate past climate key-periods. It's strongly true for two remarkably distinct periods in the past: the Last Glacial Maximum, 18000 yrs ago, and the Mid-Holocene period, 6000 yrs ago, which are often considered as key periods by the modelling researchers. Over the last few years, rapid progress has been made in quantitative reconstruction of past climatic conditions from proxy data (pollen, speleothems, ground-water, lake-levels...). Furthermore, several new approaches (pft method, inverse modelling...) and datasets (Europe, Africa, Eurasia, China...) are now available. Therefore we propose here a synthesis of the climatic conditions which occurred in Africa and Eurasia at 18000 and 6000 yrs B.P. (1) Eurasia: During the last glacial maximum, mean temperatures estimated from pollen data were 20-29°C colder than today in winter and 5-11°C colder in summer in European Russia and Ukraine. Annual precipitation sums were 50-750 mm lower than today across northern Eurasia, and 200-400 mm lower in central Siberia. Moisture index shows much drier conditions in northern and mid-latitude Russia, but similar or slightly wetter than today around the Black Sea and in Mongolia. In north Eurasia, there is a good agreement between previous estimates based on statistical methods and inverse modelling which allow to reconstruct the climate under low CO₂ atmospheric concentrations. During the Mid-Holocene winter temperatures was 1 to 6°C higher than today across northern Eurasia. This pattern is only partially confirmed by the inverse modelling. Northern Eurasia was wetter than today. (2) Africa: During the last glacial maximum, a cooling of 3 to 6°C coupled with a drying of 300 to 600 mm is reconstructed around the Equator. These results seem to be in agreement with those performed with the inverse modelling method, but these need to be further investigated because of the potentially strong CO₂ effect on the tropical vegetation. During the Mid-Holocene, results show that annual rainfall was considerably higher 6000 years ago in the Sahara (between +130 and +450 mm/year), and also in South Africa. Precipitation was comparable or slightly lower in central Africa and in Madagascar (0 to -300 mm/year). Results show that 6000 years BP was not an optimum climatic everywhere in Africa. All these estimates will then be compared with models simulations in order to help to understand the mechanisms of the climatic changes.

CC12 : MOpM30 : F1

High Resolution Models of Western European Climates at the LGM: Towards Reconciling Model-Data Disagreements

Paul Valdes (p.j.valdes@rdg.ac.uk)

Department of Meteorology, University of Reading,
Earley Gate, PO Box 243, Reading, RG4 7EP, UK

The Paleoclimate Model Intercomparison Project showed that almost all climate models were consistently underestimating changes in Western European temperatures at the Last Glacial Maximum. The temperature estimates are mainly based on pollen data. However, the typical spatial resolution of the models was 200-400 km. This is insufficient to resolve European ice sheets, such as occurred over the Alps and parts of the Massif Central. We will present results from a regional climate model, with a grid size of 40 km. This resolution is sufficient to provide a reasonably accurate treatment of the complex terrain. The results suggest that much of the model-data disagreement is related to the neglect of the local ice sheets. The work highlights the importance of matching the model spatial resolution to the data resolution.

CC12 : MOPm31 : F1 How Variable was the LGM?

Mara Weinelt (mw@gpi.uni-kiel.de),
Uwe Pflaumann (up@gpi.uni-kiel.de),
Michael Sarnthein (ms@gpi.uni-kiel.de) &
Elke Vogelsang
IFG, University of Kiel, Germany

Sea surface temperature (SST) reconstructions of the Last Glacial Maximum (LGM) are marking an equilibrium state differing decidedly from today and are therefore employed as boundary conditions to initiate and validate climate models. Any reconstruction of Atlantic SST based on a 3000-5000 year period of the LGM (CLIMAP Project Members, 1979, 81; GLAMAP 2000; Sarnthein et al., in press; EPILOG; Mix et al., in press) implies the question: How stable or variable was the LGM? Because of the role of the high-latitude North Atlantic controlling the strength and configuration of Atlantic THC, here short-term changes in factors controlling the surface water density and convection are expected as especially efficient in perturbing climate stability. Assessing the centennial-scale variability of glacial surface conditions in the northern North Atlantic may therefore provide a key to the understanding of glacial boundary conditions, moreover, new insights into the processes possibly ruling the onset and end of the LGM, to be tested in future climate models.

To address these questions here we aim: i) To establish a chronology of short-term SST fluctuations in the mid-to-high latitude North Atlantic during MIS 2, and to compare SST variability related to Dansgaard-Oeschger (D-O) cycles and the LGM variability. (In a transect of 5 sediment cores beneath the modern North Atlantic Drift and the Norwegian Current; 53°N-72°N). ii) To identify the North Atlantic regions which underwent major SST variability during the LGM. (based on the GLAMAP 2000 data base; available at www.pangaea.de). iii) To outline patterns of maximum and minimum sea-ice distribution.

SST along the transect reveals warm fluctuations amounting 2-6°C related to D-O interstadials 4-3 and 2. Northwards, interstadial SST decreased gradually from 8°C (at 53°N), to 5°C (at 62°N) to 4°C (at 72°N), suggesting a weak paleo-Norwegian Current. Duration of warm oscillations decreased northwards (>1000 to <500 years). In the northeast Atlantic warm oscillations continued during the LGM with similar magnitude (at 20.8-20.3 ka and 19-18 ka), but ceased in the Norwegian Sea. The spatial patterns document maximum SST-variability in the northern NE Atlantic (3-4°C) and in the eastern boundary currents (>5°C), suggesting episodic incursions of subtropical and subpolar water-masses respectively. Low SST variability and a lack of meltwater flux in the Nordic Seas suggests the stability of the ambient ice-sheets. Surprisingly, the limit of perennial sea-ice during warm LGM interval resembled the modern one. During coldest intervals, Fram Strait was blocked and sea-ice extended along the Norwegian Margin. In any case, the central region of the Nordic Seas remained ice-free during summers.

CC12 : MOPm32 : F1 Mid-Holocene Validation of the PMIP Models over Europe and North America

Celine Bonfils (bonfils@lscce.saclay.cea.fr)¹,
Nathalie Ducoudre-De Noblet, **Joel Guiot**²,
Patrick Bartlein³ & **PMIP Participants**

¹ LSCE, UMR CEA CNRS 1572, CE Saclay, L'Orme des Merisiers, Bat 709, 91191 Gif-sur-Yvette Cedex, France

² IMEP UPRES A6116 CNRS, Faculté Saint-Jerome, case 452, 13397 Marseille, France

³ Department of Geography, University of Oregon, Eugene OR 97403-1251, USA

The problem of validating the paleoclimates simulated by general circulation models has been the subject of many studies within PMIP. Different methodologies have been used, the data being bioclimatic variables inferred from pollen assemblages or lake status (temperature of the coldest month, growing degree days temperature, moisture index or water budget defined as the difference between precipitation and evapotranspiration). They have all compared the simulated and observed variables one by one, instead of trying to use the combination of observed changes as an indication of a regional climate change. The latter is indeed better described when using several rather than just one variable.

We have developed a new methodology in which all bioclimatic variables available are considered simultaneously. The number and the characteristics of regional climate changes are determined by means of a clustering method. An objective method is then used to attribute, to each grid point of a climate model, the closest cluster as well as a distance (computed using fuzzy logic) which is a measure of how far the simulated change is to the observed one. This is done for all PMIP models and we then use the 'collection' of grid-points which get the 'correct' climate change to infer the seasonal variations of any climate variables that one wants to look at (provided they have been simulated by the climate model). This allows the development of a scenario, in terms of general circulation changes, that can consistently explain the simultaneous differences in the climatic variables.

This method sheds new light on the paleoreconstructions themselves, as well as it helps in their interpretation through an alternative analysis of model simulation.

We have applied this methodology to Western Europe and North America.

CC12 : MOPm33 : F1 New Transfer Function from Terrestrial Molluscs using the Mutual Climatic Range Method

Olivier Moine (omoino@isem.univ-montp2.fr),
Denis-Didier Rousseau
(denis@dstu.univ-montp2.fr) &
Dominique Jolly (jolly@isem.univ-montp2.fr)
Université Montpellier II, Paléoenvironnements &
Palynologie, case 61, Pl. E. Bataillon, 34095,
Montpellier

Transfer functions have been successfully applied for the past thirty years on several continental proxies: pollen, insects, molluscs, diatoms, ostracods and rodents. They used different modes of calculation which reflect the sensitivity of the biological organisms to their environment.

We studied terrestrial molluscs because, like pollen and insects, they are very sensitive to climate, mainly temperature which determines for each species an optimal interval of life, and they record its variations (Rousseau, 1989). Fossil molluscs species are assumed to show the same ecological tolerances, all along the Quaternary, than modern representatives (Lozek, 1964). Finally they are abundant in sedimentary loess series and are often the only available fossil remains.

In the past, the only temperature estimates based on terrestrial molluscs were reconstructed with using analogue method (Rousseau, 1991). However this method seems to be limited by a lack of modern analogue assemblages and a restrained area of use (mainly West Europe). We decided then to adapt the Mutual Climatic Range method (MCR) (Atkinson et al., 1987) on malacological assemblages and used it for comparison on the same data that Rousseau did (1991).

1. A grid, whose knots are spaced by 0.5° in longitude and latitude, was defined for Europe to homogenize the biological and climatic European data. The distribution, from the Kerney et al. (1983) malacological atlas, of each determined species, and temperature values, from a climatic databank (Leemans and Cramer, 1991), were respectively binary coded and calculated by interpolation at each knot.

2. General linear models, linking each species distribution with each of the fifteen temperature distributions (twelve monthly mean temperatures, minimal and maximal monthly mean temperature (TMIN and TMAX), and annual thermal magnitude (TRANGE)) by a quadratic polynomial, were computed. The calculation of the Akaike's criterion indicated that the modern species distribution is mainly constrained by isotherms of TMIN and TRANGE, and thus that TMAX must be reconstructed by addition.

3. MCR method was applied on present assemblages from northern Norway to southern France. The reconstructed values follow the North-South European thermal gradient. Nevertheless, temperature estimates are drifting from the observed values. Thus a linear regression was calculated for TMIN and TMAX, to correct the reconstructed values and then define transfer functions.

4. The fossil assemblages from the upper Pleistocene of the loess sequence of Achenheim (Alsace, France) were analyzed using the new transfer functions. The minimal and maximal temperature estimates show similar trends to those of the analogues method applied on the same assemblages. Furthermore, the Last Glacial Maximum reconstructions from insects, pollen and General Circulation Models at La Grande Pile, Vosges support the estimates obtained in Achenheim.

Our results show that the MCR method can be applied on mollusk assemblages and used in different geographical domains.

Atkinson TC, Briffa KR & Coope GR, *Nature*, **325**, 587-592, (1987).

Kerney MP, Cameron RAD & Jungbluth, JH, *Die Landschnecken Nord- und Mitteleuropas*, Paul Parey edit, 384, (1983).

Leemans R & Cramer W, *The IIASA Climate Database for mean monthly values of temperature, precipitation and cloudiness on a global terrestrial grid*. RR-91-18. Laxenburg, International Institute of Applied Systems Analysis, 62, (1991).

Lozek V, *Verlag der Tschechoslowakischen Akademie der Wissenschaften*, **31**, 374, (1964).

Rousseau DD, *Palaeogeography, Palaeoclimatology, Palaeoecology*, **69**, 113-124, (1989).

Rousseau DD, *Quaternary Research*, **36**, 195-209, (1991).

CC12 : MOPm34 : PO Interoceanic Anti-Phasing of Late Pleistocene Millennial-Scale SST Cycles in the N.W. Pacific Contradicts Coupled O-A-GCM Prediction

Michael Sarnthein (ms@gpi.uni-kiel.de)¹,
Thorsten Kiefer (tk@gpi.uni-kiel.de)¹,
Andrew P. Roberts
(andrew.p.roberts@soc.soton.ac.uk)²,
Helmut Erlenkeuser
(herlenkeuser@leibniz.uni-kiel.de)³ &

Pieter Grootes (pgrootes@leibniz.uni-kiel.de)³

¹ Institut fuer Geowissenschaften, Universitaet Kiel, Olshausenstrasse 40, 24098 Kiel, Germany

² School of Ocean and Earth Science, University of Southampton, European Way, Southampton SO14 3ZH, U.K.

³ Leibniz-Labor, Universitaet Kiel, Max-Eyth-Str. 11, 24118 Kiel, Germany

Various published GCM simulations (e.g., Mikolajewicz et al., 1996) suggest that a shutdown of NADW implies a cooling in the North Pacific, primarily induced by atmospheric forcing and further enhanced by deep-water advection to the Pacific from the Southern Ocean. On the other hand, a recent model simulation of Huang et al. (2000) implies that any slowdown or shutoff of NADW formation will cause a deepening of the thermocline elsewhere, which tends to make SSTs warm. To validate the different model results we established a new submillennial-scale sea surface temperature (SST) record from the subarctic Northwest Pacific for comparison with the Dansgaard-Oeschger (DO) climate cycles in the North Atlantic on the basis of geomagnetic age control. Accordingly, warm SST in the Northwest Pacific have consistently paralleled the cold DO stadials in the North Atlantic 60-35 ky ago and over the last glacial termination. On the other hand, the paleomagnetic records from the different sea regions strongly deviate, if North Pacific warm phases are directly tuned to DO interstadials on Greenland. We conclude that the enigmatic anti-phase SST trend in the subarctic North Pacific was dominated by forcing of the ocean thermohaline circulation sensu Huang et al. (2000).

Mikolajewicz U, Crowley TJ, Schiller A & Voss R, *Nature*, **387**, 384-387

Huang RX, Cane MA, Naik N & Goodman P, *Geophysical Research Letters*, **27**, 759-762

