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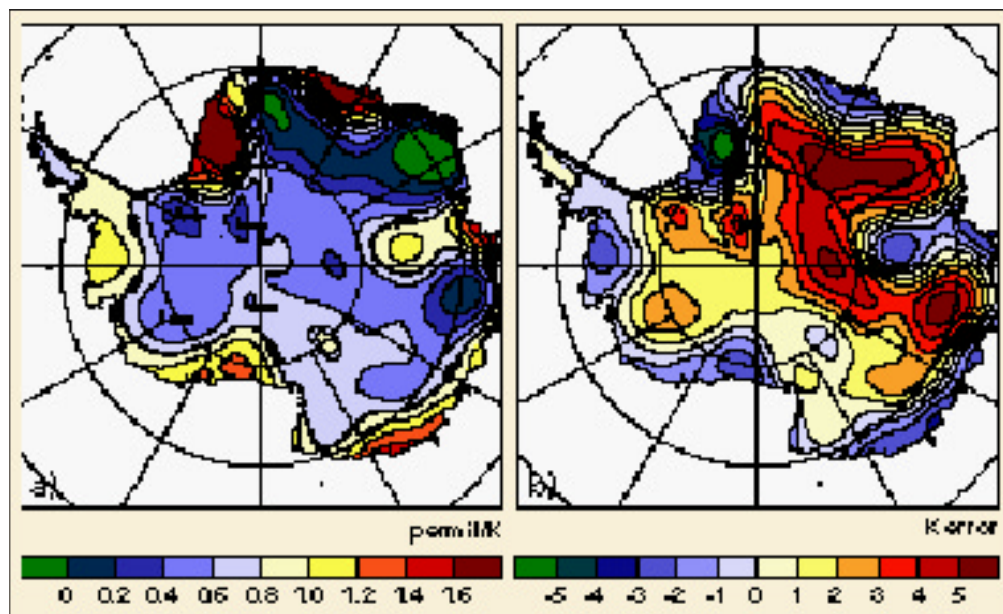
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Paleoclimate Modeling



In one of the science highlights in this issue Noone and Simmonds present a GCM study of the influence of synoptic scale weather patterns on the fractionation of oxygen isotopes in precipitation in Antarctica. Reconstructions of past temperature changes based on isotope measurements in Antarctic ice cores assume that modern spatial temperature/isotope relationship can be used to infer what the relationship was at the location of the ice core in the past. This technique ignores the potential bias introduced by past changes in the frequency and intensity of synoptic activity. In this figure, the ratio between modeled LGM to present isotopic and temperature changes is shown in the shaded field. In contrast, reconstructions of LGM temperatures from isotope measurements in ice cores using the Modern Analog Technique assume a uniform value based on modern day spatial isotope temperature relationship (solid contour). (Figure 1 of Noone and Simmonds, see page 8).

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Editorial

Is PAGES a closed club? Clearly the answer to this question is a matter of opinion, and a matter of degree. As the new executive director at the PAGES International Project Office, my own opinion is that PAGES needs to make a proactive and concerted effort to ensure that it serves as a transparent and useful institution that is perceived of as such by the international Earth system science community. Here are a few of the actions PAGES is now taking in this regard:

Communication and Outreach

Of the 80 countries that receive the PAGES newsletter, 30 are represented by only 1 or 2 individual scientists in our database. Surely, if there are 102 active paleoenvironmental scientists in Switzerland, there must be more than 2 in Turkey. We are now contacting all of the scientists based in underrepresented countries on our mailing with the plea to send us the names and addresses of their colleagues. This is only a first step to ensuring that these individuals can benefit from PAGES activities and, conversely, that PAGES can benefit from their research.

Research Activities

The European Union operates (supposedly) on the principle of "subsidiarity," which is meant to ensure that rules and regulations are only made in areas where there is a genuine need for pan-European legislation. PAGES will adopt a similar litmus test for its research activities. Each PAGES promulgated research activity will be expected to demonstrate a clear need for international coordination in order for the research to be done well. In addition to clarifying their rationale and goals, the leaders of PAGES research activities will be expected to identify proposed products and outcomes, and set timelines for achieving these.

Workshops

PAGES provides funding for approximately 10 meetings per year. Roughly half of these are planning workshops with the goal of furthering specific PAGES activities. This moiety of PAGES workshop funding is top-down in nature and is meant to further targeted research objectives. The remainder of PAGES workshop funding is bottom up in nature. These latter meetings are funded in response mode based on requests from individual scientists in the international community. PAGES has developed new guidelines for its workshop support that are meant to ensure that PAGES funding will strongly prioritize bringing together (1) scientists who have not participated in PAGES workshops in the past (2) young scientists and (3) scientists from developing countries. All PAGES supported workshops are expected to be open to self funding participants.

Given the increasing realization that human activities are influencing the global climate and global environmental systems, a clear need exists for coordinated international attention to past climatic and environmental changes of most relevance to the future. The PAGES program, because of its strong community recognition and its light, flexible and science driven nature is ideally suited to fill this need. The only way the PAGES organization can work though, is as a completely inclusive one.

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Inside PAGES

Changes in the SSC

The PAGES Scientific Steering Committee welcomes two new members in 2001:

Ryuji Tada started his academic career as a field geologist in 1976. He received his doctoral degree from the Faculty of Science, University of Tokyo in 1981 on the study of diagenesis of siliceous sediments. During a stay in U.S. from 1983 to 1985, he became interested in topics such as Milankovitch cycles and geochemical cycles. In 1989, he participated in an ODP Japan Sea cruise, and started work on late Quaternary paleoceanography and paleoclimate, especially in north Pacific region including the Japan Sea. His current interests are the origin and mechanisms of millennial to centennial scale variations of the Asian monsoon and their impacts on global climate.

Carole L. Crumley holds a Ph.D. in Anthropology, specializing in archaeology and ecology (1972), from the University of Wisconsin-Madison, and is Professor of Anthropology at the University of North Carolina, Chapel Hill and Fellow of the Carolina Environmental Program. She is a member of the U.S. DIVERSITAS Committee and vice chairman of the U.S. Committee of the International Union of Anthropological and Ethnological Sciences. She studies the evolution of land use in Burgundy (France) at several temporal scales, employing an interdisciplinary framework that integrates geomorphology, climate history, and biogeography with archaeological and documentary evidence and information from contemporary inhabitants. Her current research focuses on challenges to the region's historic sustainability posed by international agricultural, trade, and tariff agreements.

PAGES thanks the two members rotating off the committee, **Yugo Ono** of Hokkaido University Sapporo, Japan and **Anne DeVernal** of the University of Quebec in Montreal, Canada for their support over the past several years. Both continue their active research careers and involvement

with PAGES through the PEP2 and IMAGES programs respectively.

Changes at the PAGES Office

The International Project Office has also seen turnover in 2001, with Keith Alverson taking over as Executive Director and Isabelle Larocque as Science Officer.

Keith Alverson is no stranger to PAGES, having served as Science Officer since 1997. Keith is a physical oceanographer by training with research interests in numerical modeling of open ocean convection, reconstructing air-sea fluxes at high latitudes, inverse ocean box modeling of glacial CO₂ levels and statistical analysis of high latitude ENSO teleconnections. Over the next few years, Keith hopes to enhance PAGES' role as an international advocate of the value of paleoenvironmental research.

Educated as a biologist, **Isabelle Larocque** has a Masters degree in limnology and studied the sedimentation of phytoplankton in different enclosures. As a Ph.D. student in Environmental Sciences, she began her paleoecology studies with pollen analysis and anthracology in humus and peat bogs. A first postdoc brought her back to lake sediments using chironomids to quantitatively reconstruct climate. As the new Science Officer, she will be the primary contact for the PANASH and Environmental Processes and Human Dimensions foci. She is particularly enthusiastic about widening her knowledge in paleoclimate and paleoenvironments.

Frank Oldfield, executive director of PAGES for the past 5 years, has retired to his home in Liverpool, UK. During his time at the PAGES office, Frank was a consistent spokesman for the use of paleo-archives as not only climate proxies, but rather as a tool for understanding the past dynamics of environmental processes, including the influence of humans. Although stepping down from his duties in the PAGES office, Frank plans to continue a strong involvement with PAGES as chair of the Human Dimensions and Environmental Systems Focus.



**EURESCO
Conferences**

A programme of the European Science Foundation



Achieving Climate Predictability using Paleoclimate Data

Euresco Conference on Abrupt Climate Change Dynamics

Castelvecchio Pascoli, Italy, 10–15 November 2001

Themes

- **What is abrupt climate change and is it important for climate prediction?**
T. Palmer (Reading, UK), W. Broecker (Lamont Doherty, USA), J. Willebrand (Kiel, D), A. Berger (Louvain, B), J. Overpeck (Arizona, USA)
- **Late Glacial Abrupt Change- is it applicable to the future?**
B. Ammann (Bern, CH), B. Huntley (Durham, UK), D. Raynaud (Grenoble, F), E. Cortijo (Gif/Yvette, F), A. Korhola (Helsinki, SF), T. Stocker (Bern, CH), A. Ganapolski (Postdam, D), V. Markgraf (Colorado, USA), F. Trincardi (Bologna, I)
- **Early Holocene Abrupt Change- is it applicable to the future?**
R. Alley (Pennsylvania, USA), U. von Graffenstein (Gif/Yvette, F), E. Ito (Minnesota, USA), C. Hillaire-Marcel (Montreal, CAN)
- **Mid Holocene Abrupt Change- is it applicable to the future?**
M. Claussen (Postdam, D), S. Harrison (Jena, D), J.-C. Duplessy (Gif/Yvette, F), F. Gasse (Aix-en-P., F), B. Zolitska (Postdam, D), S. Joussaume (Gif/Yvette, F), P. DeMenocal (Lamont Doherty, USA)
- **The Last Millennium — detecting anthropogenic change?**
H. Wanner (Bern, CH), J. Mitchell (Hadley Centre, UK), D. Verschuren (Gent, B), M. Latif (Hamburg, D), M. Saarnisto (Geol. Survey SF), K. Alverson (Bern, CH), R. Bradley (Massachusetts USA), K. Briffa (East Anglia, UK)

The goals of this meeting are to summarize the state-of-the-art and guide efforts to answer questions regarding *Abrupt Climate Change Dynamics*.

The conference is open to researchers world-wide. Participation will be limited to 100. The emphasis will be on discussion about new developments. The conference fee covers registration, full board and lodging. Grants will be available, in particular from nationals from EU or Associated States under 35 years old. Additional funding from PAGES will also be available for participants from Eastern Europe and the former Soviet Union, Africa and South America.

**Deadline for applications:
15 August 2001**

www.esf.org/euresco/01/lc01170b.htm

Recent Progress in Paleoclimate Modeling: Climate Models of Reduced Complexity

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Problems and Opportunities of Paleoclimatic Modeling

Among the topics of climate dynamics, modeling past climate and its changes are a special challenge for many reasons. Forcing functions such as solar luminosity, volcanic events and surface albedo are poorly known and uncertainties in these important quantities limit the usefulness of such simulations. For the same reason there is insufficient data for initialization, which is particularly important for the ocean component in these simulations. Furthermore, the credibility of model experiments crucially depends on the availability of additional independent data with which these simulations can be checked. But the scarcity of data is not the only obstacle in paleoclimate modeling. Most of the paleoclimatic data is proxy and therefore, these data cannot be directly used to force, initialize or verify physical model results (see Schmidt this issue).

Besides these data-related aspects, two major challenges in paleoclimate modeling are the long time scales and the number of components and complexity of processes in the climate system. Models need to be integrated over millennia or more if paleoclimatic modeling is to increase our understanding of past climate processes. Such time scales are beyond the current capability of comprehensive 3-dimensional climate models (CCMs). Among the classical, and still unsolved problems of paleoclimatic modeling are glacial-interglacial cycles. Due to their time scale of many hundreds of years and the truly global extent of the problem, a paleoclimate model must include all components of the climate system, the atmosphere, the ocean, land ice and vegetation. It is therefore a truly coupled problem which involves technical knowledge from all sub-systems. Since the modeling community is still working prefer-

entially in compartments such as the atmosphere, ocean or ice sheets, paleoclimate modeling plays an important role in fostering interdisciplinary activities in modeling and model development. It gathers scientists from different backgrounds around one specific problem.

The required breadth is as much a problem as it is an opportunity. There is a risk, that some aspects of such models are not firmly rooted in their respective disciplines, i.e., the models may use formulations or parameterizations of certain climate system components that are ad hoc or would no longer be used by specialists. This is a tall order for paleoclimate modelers: they need to stay in touch with several disciplines both on a technical and scientific level.

But there are also unique opportunities in paleoclimate modeling. Apart from the fact that most problems require coupled simulations, climate changes in the past were large in amplitude, especially during the last glacial period and glacial-interglacial transitions. Large changes manifest much more clearly the underlying dynamics within and between the climate system components. Models are therefore required to exhibit a much wider range of possible transient behaviour than those which are used to simulate, say, the last 1000 years. The long time scales also represent special requirements regarding the stability of coupled simulations: drifts in certain variables must be much smaller than in integrations over much shorter time scales.

The Need for a Hierarchy of Models

Scientific progress demands more than just the best and most comprehensive models. It has become clear over the last decade that climate modeling benefits from a hierarchy of models. This is because simpler models can elucidate impor-

tant mechanisms in a more transparent way than complex models; they also offer the possibility for extensive sensitivity studies with which the parameter space can be explored systematically. If cleverly used, simplified models often provide useful guiding lines for more realistic models.

A possible ordering criterion in such a model hierarchy could be the number of balance equations which constitute the model. Outside this hierarchy, we mention for completeness Boolean delay models (Ghil *et al.*, 1987), threshold models (e.g., Paillard, 1998) and globally averaged models (e.g. Saltzman & Maasch, 1988). The former two types are not based on balance equations and therefore contain no physics. They instead are based on a fixed set of rules linking various climate variables.

At one extreme of the model hierarchy are the well-known energy balance models (EBMs) of the atmosphere which solve one balance equation for the atmospheric energy content (for a review see North *et al.*, 1983). EBMs contain no dynamics. Fluxes of heat and moisture, which in reality are due to complex atmospheric flows, need to be parameterized. This is a limitation especially in paleoclimatic modeling where one considers entirely different climatic conditions, and a specific parameterization based on modern data may no longer be valid. Today, EBMs remain in use but they merely serve as first-order approximations of the atmospheric component of models of the global ocean circulation, or ocean biogeochemical cycles (Stocker *et al.*, 1992; Fanning & Weaver, 1996; Marchal *et al.*, 1998b; Schmittner & Stocker, 2001).

At the other extreme of the model hierarchy are CCMs. The most sophisticated versions now include the atmosphere, ocean, sea ice, vegetation and biogeochemical cycles.

To run experiments with these models over order 104 years or more remains a long-term goal. Due to their demand on computational and human resources, only few centers worldwide can afford to develop and utilize such models. Therefore, they are, unfortunately, still somewhat prohibitive for paleoclimatic modeling although for some specific problems, such as time slice experiments, they have begun to produce useful results (PMIP, 2000). Very few simulations with CCMs exist that cover specific transient events in the past; e.g., the Younger Dryas cold event (12,700–11,650 yr BP, YD henceforth) (Manabe & Stouffer, 1997; Schiller *et al.*, 1997), and a centennial cooling similar to the 8200-yr event (Hall & Stouffer, 2001).

Climate Models of Reduced Complexity

For many years, there existed a gap in the hierarchy of climate models. This gap has been closed in recent years due to the development of models of reduced complexity, also referred to as “Earth System Models of Intermediate Complexity”. There are three strategies to formulate such models.

The first strategy is based on a rigorous reduction of the set of balance equations by reducing the dimensions. For example, an ocean model component of reduced complexity was obtained by zonally averaging the equations of motion (e.g., Marotzke *et al.*, 1988; Wright & Stocker, 1991). This implies that the focus of investigations is restricted to the latitude-depth structure of the flow and to a priori chosen time scales which are accessible with these models. Similar averaging has also been used for the atmosphere (Gallée *et al.*, 1991). The difference in the deep ocean circulation between the Pacific and the Atlantic is a climatically important feature which is represented in multi-basin versions of zonally averaged models (Stocker & Wright, 1991b). This ocean component can be coupled to an EBM (Stocker *et al.*, 1992), or to an atmospheric module which has some zonal resolution but

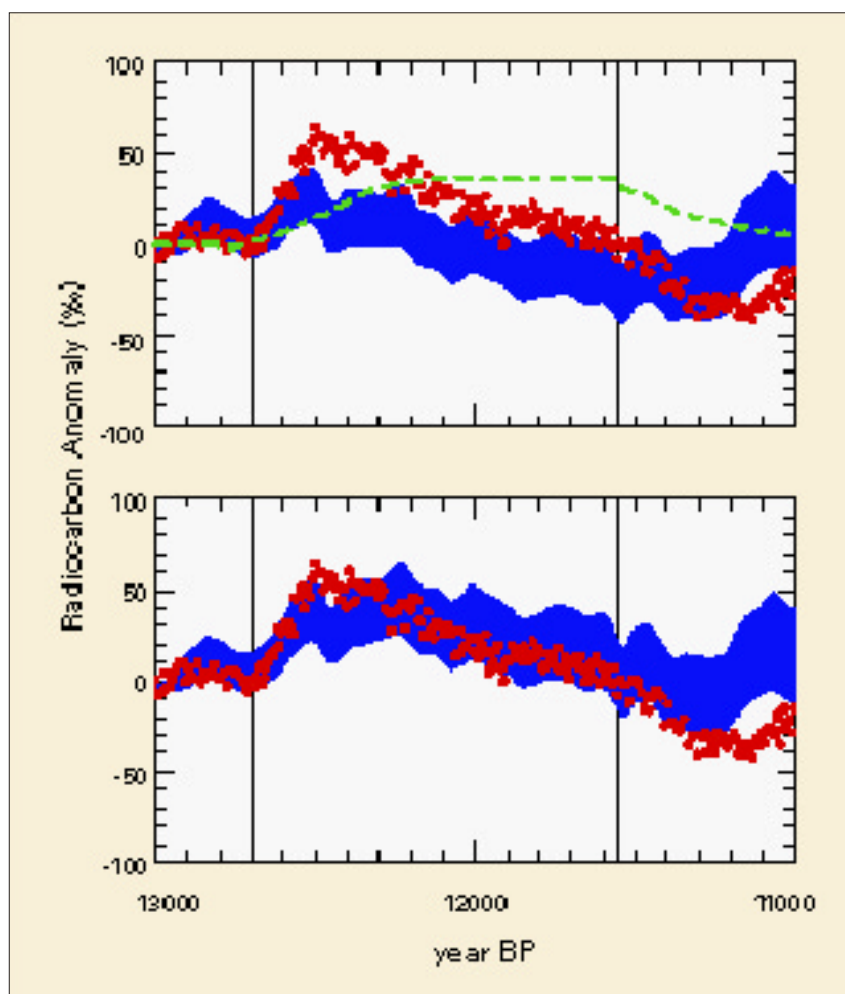


Figure 1: Comparison between $\Delta^{14}\text{C}$ anomalies from the Cariaco basin record and atmospheric $\Delta^{14}\text{C}$ anomalies simulated by a model of reduced complexity (from Marchal *et al.*, 2001). The observed $\Delta^{14}\text{C}$ record (red circles) is from Hughen *et al.* (2000). a: Anomalies simulated with variable deep ocean ventilation and constant production of atmospheric ^{14}C (dashed green line), and mean $\Delta^{14}\text{C}$ anomalies from 100 model experiments with constant ventilation and variable production (solid blue line). b: Mean $\Delta^{14}\text{C}$ anomalies from 100 model experiments with variable ventilation and variable production (solid line). Each experiment has a different random selection of production values between 17 and 11 kyr BP (13 to 11 kyr shown here) consistent with the production rates reconstructed from the Greenland ice core record (Muscheler *et al.*, 2000). The shaded area in panels a and b illustrates one standard deviation of $\Delta^{14}\text{C}$ for the Monte Carlo simulations. The two vertical lines in each panel denote the onset and termination of the YD as dated in the GRIP ice core.

whose dynamics is entirely parameterised involving a large number of tunable parameters (Petoukhov *et al.*, 2000).

The second strategy is to couple model components of different complexity. Three-dimensional ocean circulation models combined with a latitude-longitude EBM (Fanning & Weaver, 1997), or with an atmospheric circulation model of reduced dynamics (Opsteegh *et al.*, 1998), can be integrated for many thousands of years thanks to the relative simplicity of the atmosphere.

The third, and completely alternative strategy is to approximate CCMs by a set of mathematical

functions which describe their linear behaviour (Joos *et al.*, 1996). These “pulse response models” are extremely efficient substitutes for the complex models as long as the climate remains close to the initial state.

Overall, models of reduced complexity are highly useful tools in paleoclimate research provided they are wisely employed. Clearly, they cannot replace CCMs because they only consider a limited set of constraints that are important in the climate system. Their weakness is the incompleteness of dynamics, and their reduced resolution. Their strength, on the other hand, is their

computational efficiency which permits extensive sensitivity studies, ensemble or even Monte-Carlo simulations. Single simulations with reduced models are not particularly useful even if they may happen to agree well with paleoclimatic data. Rather, these models serve as key tools in the process of quantitative hypothesis-building and testing, not only in paleoclimatology but in climate dynamics in general (e.g., Stocker & Schmittner, 1997).

Recent Paleoclimatic Simulations Using Models of Reduced Complexity

Here we revisit a few recent examples of paleoclimatic simulations using models of reduced complexity. The climate of the last glacial maximum (LGM) has long been a target for modelers, although the concept of an "equilibrium climate state" representative of the lowest sea level stand is probably flawed, given the very long response time of continental ice sheets. Two models of reduced complexity presented equilibrium states that are consistent with paleoclimatic data (Ganopolski *et al.*, 1998; Weaver *et al.*, 1998). Common to both simulations, however, is a certain amount of tuning, especially with respect to the freshwater balance of the North Atlantic.

Ocean circulation proxies from North Atlantic sediments document a reduced and possibly shallower thermohaline overturning cell during the LGM. The temptation is large to adjust the forcing of these models such that the simulated ocean circulation under glacial boundary conditions agrees with these features. In this case, further independent constraints must be used to lend credibility to such simulations. Given this and serious discrepancies between different paleo-ocean circulation proxies for the LGM (e.g., Boyle, 1992; Yu *et al.*, 1996), we think that we are still very far from a satisfactory understanding of the LGM climate. Moreover, there is a growing availability of further constraints afforded by emerging new paleoceanographic and paleo-terrestrial data (Mix *et al.*, 2001). These data are best employed if the models

also include biogeochemical modules which yield variables that can be directly compared to the proxy data.

Multiple climate states have been suggested as an explanation for rapid climate changes during the last glaciation (Dansgaard/Oeschger, D/O events). Oeschger and colleagues (1984) proposed that the climate operates like a "flip-flop" system. This was confirmed by a model of reduced complexity that exhibited such behaviour in response to changes in the freshwater balance of the North Atlantic (Stocker & Wright, 1991a). It turned out that this property is robust and appears in the entire model hierarchy (e.g., Mikolajewicz & Maier-Reimer, 1994). Quantitatively, however, it depends, strongly on model parameters. In most models, abrupt climate change is triggered by changes in the freshwater fluxes delivered to the North Atlantic. This is an external, prescribed forcing to the climate models, and such simulations are unable to resolve the "chicken-and-egg" question of abrupt climate change. This is the case in simulations of a YD-type event (e.g., Marchal *et al.*, 1999), and also in a recent simulation of a series of abrupt events (Ganopolski & Rahmstorf, 2001). Simulating YD-type events with large freshwater fluxes just prior to the event is in conflict with the apparent lead of a rapid rise of sea level about 1000 years before the onset of YD (Bard *et al.*, 1996). Similarly, a model which has multiple states in only a very narrow range of freshwater flux anomalies, can be forced with a weak 1500-yr freshwater cycle to exhibit D/O-type events (Ganopolski & Rahmstorf, 2001). Because of the imposed periodic forcing, events also appear on that time scale. But this is inconsistent with the variable recurrence time of D/O events observed in the Greenland ice core record (Dansgaard *et al.*, 1993).

In these recent examples, models of reduced complexity exhibited interesting results, but the basic question of abrupt climate change is not solved. One robust lesson is that the freshwater balance of the

North Atlantic, its amplitude and spatial distribution are the crucial determinants. More realistic models and an attempt to reconstruct better the hydrological cycle from paleodata in the North Atlantic, as well as in the tropical Atlantic (Peterson *et al.*, 2000), are urgently needed to make progress.

If physical models are complemented by biogeochemical modules, the gap between proxy data and model results can be significantly reduced. Such models can simulate carbon isotopes (^{12}C , ^{13}C , and ^{14}C) in the ocean and the atmosphere, all of which are important indicators of climate change. These models also contain a number of tunable parameters: they can only be calibrated using data for the modern ocean (Marchal *et al.*, 1998b). This model has been used to simulate changes of atmospheric CO_2 due to large ocean-atmosphere reorganisations (Marchal *et al.*, 1998a; 1999). Extensive sensitivity studies indicated that accompanying changes in the ocean carbon cycle produce atmospheric CO_2 signals of only about 20 ppm consistent with ice core data (Indermühle *et al.*, 2000). Models of reduced complexity can even be used to guide the interpretation of novel paleoceanographic tracers (Marchal *et al.*, 2000). Again, in this case, specific further simulations with physical-biogeochemical CCMs would be desirable to corroborate the results and to overcome the limited spatial resolution.

There has been a debate about what caused the changes in atmospheric radiocarbon content ($\Delta^{14}\text{C}$) during the YD. The high $\Delta^{14}\text{C}$ values of the early YD as found in the varved sediment record of Cariaco Basin were traditionally ascribed to a reduction in deep ocean ventilation at the onset of the cold event (Hughen *et al.*, 1996; Stocker & Wright, 1996). This was put into question based on a recent record from Polish lake sediments, which suggests that these $\Delta^{14}\text{C}$ levels are overestimated and were instead driven by changes in atmospheric ^{14}C production (Goslar *et al.*, 2000). A recent reconstruction of ^{14}C pro-

duction based on ice cores also suggested that most of the $\Delta^{14}\text{C}$ changes during the YD can be attributed to production changes (Muscheler *et al.*, 2000). The new, higher resolution ^{14}C record from the Cariaco basin shows that $\Delta^{14}\text{C}$ changes were synchronous with the YD onset and termination, pointing again to a climatic influence on these changes (Hughen *et al.*, 2000).

A model of reduced complexity is able to reconcile the conflicting interpretations of the $\Delta^{14}\text{C}$ changes during the YD (Marchal *et al.*, 2001). Model experiments with variable ocean ventilation and constant production are inconsistent with the Cariaco Basin record (Fig. 1a, dashed line). Monte-Carlo simulations conducted to constrain the effect on $\Delta^{14}\text{C}$ of uncertainties in the reconstructed ^{14}C production changes. These suggest that the scatter in the lake data set is too large to exclude the probable change in deep ocean ventilation at the onset of the YD. The fit to the high $\Delta^{14}\text{C}$ levels throughout the YD is generally better when both ocean ventilation and production are allowed to vary (Fig. 1b, solid line). The early $\Delta^{14}\text{C}$ drawdown that was initiated during the first half of the YD, on the other hand, could be due entirely to production changes (Fig. 1a). The rapid $\Delta^{14}\text{C}$ rise at the YD onset is still not fully explained. This study illustrates how the direct comparison of paleodata with extensive simulations from a model of reduced complexity can be used to assess the robustness of various interpretations of a paleoclimatic archives and to identify gaps in our quantitative understanding which require further attention.

Outlook

There are a few obvious steps in the development of simplified models. The role of vegetation in climate change has been emphasized in the past few years. Its representation in models of reduced complexity is necessarily limited because vegetation cover is highly heterogeneous. This requires a high degree of parameterization. For long-term integration over glacial-interglacial

cycles, terrestrial ice sheets should be included. Difficulties here will arise with the hydrological cycle in these models since this determines the accumulation of snow on the ice surfaces.

Perhaps a more promising area of development is biogeochemical cycles. This is because paleoclimatic data are often influenced by or directly indicate changes in these cycles. This permits the direct comparison of model outputs and paleodata. The carbon cycle, including isotopes, has provided important information about abrupt change.

For credibility of simplified models needs to be constantly demonstrated by a careful comparison with observations and results from CCMs. Only after this confidence-building process, can novel results produced by reduced models have a wider impact. Modelers must go beyond single-simulation studies by exploiting the computational efficiency of these models. The production of extensive simulations is a major justification of such models in paleoclimate investigations. Model simulations have poor scientific value unless they are corroborated by cleverly designed sensitivity experiments. Such investigations are currently not possible with CCMs.

The forte of climate models of reduced complexity remains hypothesis building and testing. Reduced models thus have the potential to make new discoveries of processes and climate behaviour, which can then be investigated in more detail using CCMs.

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For full references please consult:
www.pages-igbp.org/products/newsletters/ref2001.html



Have you seen ...

◆ Markgraf, V. ed (2001)
Interhemispheric Climate Linkages.



This book is a synthesis of the PAGES PEP I research. It comprises collection of papers assessing interhemispheric climate linkages, primarily in the Americas, based on the plenary talks at the PEP I Synthesis meeting held in Merida, Venezuela in 1998. Academic Press, 454 pp.

◆ Kroepelin, S. and N. Petit-Maire eds. (2000)
Paleomonsoon Variations and Terrestrial Environmental Change During the Late Quaternary.



A Special Issue of *Global and Planetary Change* produced, in part, as a contribution to the PAGES Paleomonsoons activity, 26:1–3, 316pp.

GCM Study of Synoptic Influences on the Isotope Record in Antarctic Ice Cores

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The stable water isotope record from polar ice cores is often used as a proxy for the condensation temperature at the coring site. Increased isotopic depletion in precipitation during glacial times is interpreted as decreased local temperature following the so-called modern analogue technique (MAT). This assumption is based on well-understood physical principles describing the preferential removal of heavy isotopes during condensation. With colder temperatures, greater proportions of the heavy isotopes are removed and increased depletion results. However, such theory applies correctly to individual condensation events rather than climatological mean statistics. Moreover, Antarctic precipitation is characterised by relatively infrequent snowfall episodes that are atypical of the mean state (Noone and Simmonds 1998, Noone *et al.* 1999). As it is these conditions which are represented in the ice, it becomes important to quantify the possibility for bias in the climate signal away from the mean statistics associated with changes in the frequency and intensity of synoptic activity (Simmonds 1998). Understanding this covariant nature of climate is of great importance for prediction as changes in the behaviour of the climate system, such as the frequency of extreme wet or dry conditions, can lead to societal disaster in climatically marginal areas. State-of-the-art atmospheric general circulation models (GCMs) provide a physically based interpretation of isotopic records in polar ice cores through modeled impacts on simulated proxy records. The Melbourne University GCM includes stable water isotope tracers ($\delta^{18}\text{O}$ discussed here) and is used to assess the effects of synoptic variability on the $\delta^{18}\text{O}$ -temperature relationship in Antarctica and the reliability of the MAT.

Isotopically based temperature reconstructions typically assume the present day (PD) spatial correlation between $\delta^{18}\text{O}$ and annual mean surface temperature is applicable also to $\delta^{18}\text{O}$ measurements at a single location but representing different epochs. From the control simulation the spatial slope is estimated as 0.78‰/K using the lowest model level temperature. This compares reasonably well with the observational value of around 0.64‰/K, which is dominated by measurements in the northern hemisphere mid-latitudes. A simulation of the last glacial maximum (LGM) is performed using the CLIMAP surface specification. A temporal $\delta^{18}\text{O}$ -temperature slope can be formed from the differences between the LGM and PD results. Figure 1a (front page) shows that the temporal slope and the spatial slope are of similar magnitude over the Antarctic ice sheet but there are also important regional differences. Inland, the temporal slope is smaller while at coastal locations it is larger and shows greater variability. Using the spatial slope and the simulated LGM-PD $\delta^{18}\text{O}$ difference, MAT can be used to generate a (modeled) temperature reconstruction. This is compared directly to the simulated temperature change in figure 1b (front page). As the spatial slope is not an accurate estimate of the temporal slope, MAT overestimates the magnitude of the continental temperature change by typically 2K although the errors in eastern Dronning Maud Land are 5K. The locations of the largest errors are broadly upstream of increases in the topography of the ice sheet at the LGM.

Continental precipitation is associated with strong advection from the north. This maritime air is moist and warmer than the mean. As it is only these biased conditions that are represented in ice cores, suc-

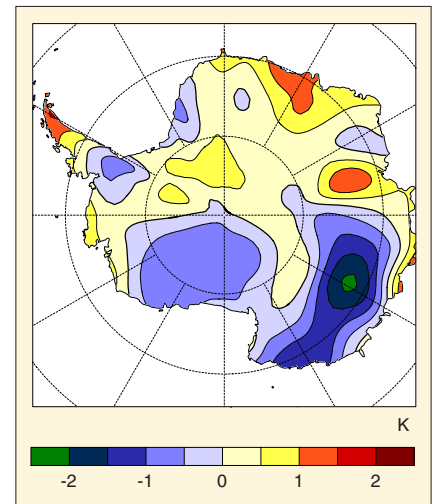


Figure 2: Difference in precipitation temperature bias between last glacial maximum (LGM) and present day (PD).

cessful application of MAT must assume that the amount by which the temperature is above the mean during some epoch (say, LGM) is the same as that of the PD. The difference in the temperature bias between the LGM simulation and PD is shown in Figure 2. Precipitation events are moderately warmer over much of the continent during the LGM. The dominant feature, however, is a decrease in the temperature bias in the Australian sector of around 2K. This response is of opposite sign to the errors in inland temperature reconstruction and is seen in Figure 1b as a reduction in the magnitude of the differences over Wilkes Land. As this reflects a change in the characteristics of the advection in this sector, MAT does not take it into account.

Baroclinic cyclones provide the impetus for advection to inland Antarctica. Figure 3a shows the difference in the cyclone frequency between the LGM and PD. Cyclones are less frequent near the coast south of 60°S and more frequent in the 50–60°S band. Decreases are also found farther north. Part of the response is associated with changes in the dynamic forcing by the increased LGM topography. However, the primary mechanism results from a requirement for thermodynamic balance and provides heat transport to the polar regions. The net meridional transport by cyclones is proportional to the pressure depth of the cyclone centre

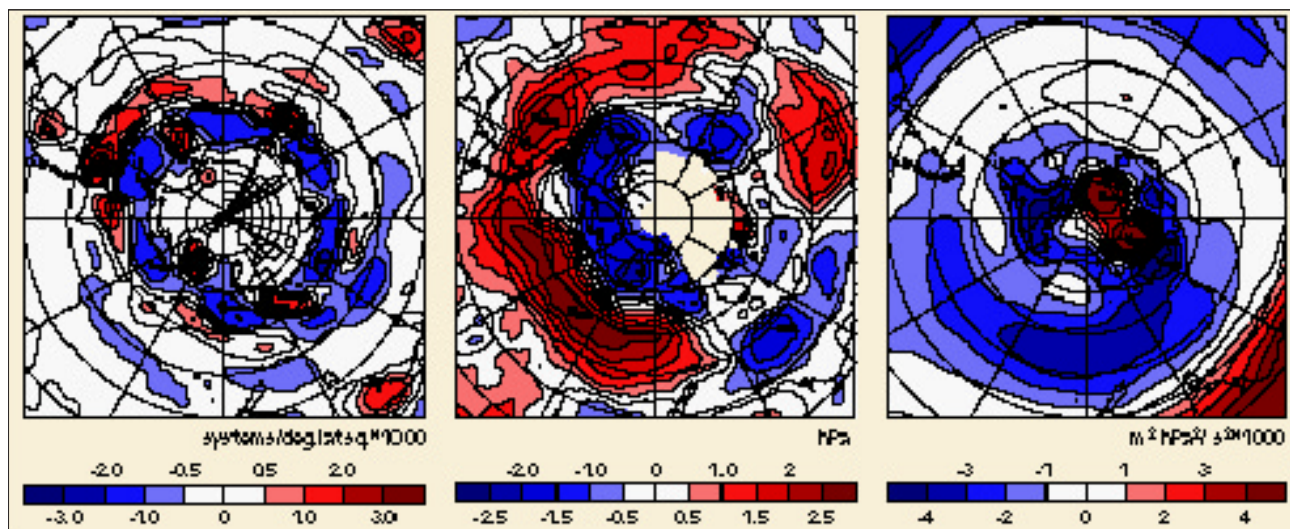


Figure 3: Difference between last glacial maximum (LGM) and present day (PD) cyclone frequency (a), cyclone depth (b) and vertical stability (c).

relative to the background pressure (Simmonds and Keay 2000). Figure 3b shows the change in the cyclone depth between the LGM and PD. Cyclones close to the coast and over West Antarctica are less deep while the depth of cyclones to the north of around 60–65°S has increased. A most notable exception to this zonally symmetric response is a depth decrease in the Australian sector. Conditions here are more stable during the LGM simulation (Figure 3c) and limit the baroclinic growth rates.

Both fewer cyclones and their reduced depth suggests less net heat transport to the Australian sector while the increased stability constrains the vertical extent to which the advection can ascend the Antarctic topography. Although this explains the negative temperature difference in Figure 2, MAT does not produce the largest error in this region. Rather, these are seen in Figure 1b over Dronning Maud Land where only small changes in the $\delta^{18}\text{O}$ values are modeled. This is associated with unsubstantial modification of the vertical stability in the southern Atlantic Ocean. The change in isotopic depletion associated with differences in the cyclonic advection is offset by a shift in the latitude from which the moisture is drawn. As such the $\delta^{18}\text{O}$ values do not vary in phase with the temperature changes and the reconstruction errors result.

These results show that while there are significant changes to the condensation history, other factors can oppose the response and allow the isotope signature to be explained on climatological time scales fortuitously by the simple MAT. However, one may not be able to tell *a priori* if this is the case. Indeed, it remains to be seen if the regional circulation differences identified here are evident in the ice core record. Nonetheless, with GCM simulations to limit the range of climate states possible, an estimate of not only the local or global mean conditions but also the changes in the large-scale circulations and variability could be deduced from ice cores and represents a potentially rewarding pursuit for integrated multi-disciplinary investigations.

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PAGES News

PAST GLOBAL CHANGES

A New Name and a New Layout for the PAGES Newsletter

Over the last few years, the PAGES Newsletter has become an important means of communication among the past global change community. The newsletter benefits from proactive editorial and guest editorial efforts, high quality contributions by a large number of scientists and also the time spent on layout and graphical design. One cosmetic problem has been the long name “PAGES – News of the International Paleoscience Community,” even though most people refer to it as “the PAGES Newsletter” or “PAGES News.” This latter title has now been made official. In addition, the layout also undergone some changes: more empty space, new fonts and an overall fresher look should make reading an even greater pleasure! The new prominent placement of our website URL on the frontpage points interested readers to another primary means of PAGES communication.

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Isotopic Tracers in Coupled Models: A New Paleo-Tool

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General Circulation Model

Comparing General Circulation Model (GCM) simulations to events seen in the paleo-record is becoming ever more important, yet remains problematic. Since most proxy records reflect multiple influences, some climatic, some biological, unambiguously assigning any one event to a particular cause is generally quite difficult. Thus data-model comparisons are hampered by the fact that they do not compare like with like, i.e. temperatures are compared with $\delta^{18}\text{O}$, overturning strength with benthic $\delta^{13}\text{C}$ ratios etc.

Linking multiple proxies

The challenge then, is to link multiple proxies and derive a more integrated view of past climate change. Better chronological control, and more proxies will clearly help, but the advent of more sophisticated GCMs should provide a complementary avenue of research. In our opinion, the key to this improvement is the incorporation of the physics and biology associated with the proxy records into the models themselves.

In particular, the ratio of heavy ^{18}O atoms to the lighter ^{16}O variety (denoted by $\delta^{18}\text{O}$) is a ubiquitous measurement in paleoclimate research. Many different proxies, all linked by the global hydrological cycle, record the variations in the isotope ratio of the water molecules that originally provided the oxygen, modified by their own unique biogeochemical filters. For example, this ratio is measured in ice cores from the polar ice caps and mountain glaciers, in carbonates taken from foraminiferal shells from marine and lake sediments, in corals and speleothems, in cellulose taken from tree rings, and in phosphates and silicates, all from widely varying terrestrial and oceanic environments.

GCMs are now capable of simulating these water isotope tracers, both in the atmospheric (Joussau and Jouzel, 1993; Jouzel *et al.*, 1991; Hoffmann *et al.*, 1998), and in the ocean/ice system (Schmidt, 1998; Delaygue *et al.*, 1999). The remaining task is to put these components together in a fully coupled atmosphere-ocean model and combine them with diagnostic modules that attempt to reproduce the filters that ultimately control the signal recorded by the proxy.

Upgrading tracers

The first stage involves upgrading atmospheric isotopic tracers to incorporate the physics included in state-of-the-art prognostic cloud liquid water and convection schemes. Many processes that are important for the isotopic signal (such as the degree of supersaturation) that were previously estimated independently of the cloud schemes in GCMs, are now treated explicitly, albeit in a parameterized fashion. For the first time, the isotopic signals in precipitation and water vapor should be a fair and accurate representation of the physics contained in the model and thus will start to become useful for diagnosing problems in the cloud schemes as well as for improving our understanding of the isotope response.

A fully coupled water isotope model

Secondly, given more sophisticated ocean models (including isopycnal mixing, eddy-induced tracer mixing, slope convection, more sophisticated diapycnal diffusion schemes etc.) and the full coupling of freshwater fluxes (precipitation, river and glacial runoff, evaporation, sea ice formation and melting), we have assembled a fully coupled water isotope model that includes all of the processes that affect the seawater $\delta^{18}\text{O}$ signal in a physically consistent way. Of course, this does not guarantee accurate simulations

of reality, but does allow us to examine in detail the interactions between the different processes.

However, we are still not done. In order to compare the tracers to the paleo-record, we also need to simulate the processes by which the signals are recorded. Simulating ice cores (e.g. Charles *et al.*, 1994) is relatively simple since there are no biological processes involved. In a slightly more sophisticated fashion, the joint effects of seawater $\delta^{18}\text{O}$ and temperature for coral aragonite or the effects of depth habitat and seasonality for planktonic foraminifera (Schmidt, 1999) can also be simulated. Even a necessarily complicated mechanistic model for $\delta^{18}\text{O}$ in tree ring cellulose (incorporating the ground water, water vapour and the highly fractionated tree water reservoirs (Roden *et al.*, 2000)) can eventually be included.

The first (very!) preliminary coupled results are shown in figures 1 and 2. They show a snapshot of the isotopic concentration in the precipitation field and the associated surface seawater values. Most of the features observable in the real world are also present in the simulation and continuing development will hopefully reduce any substantial discrepancies that may exist.

Further analysis of longer runs will hopefully allow us to see how natural inter-decadal variability of the climate is recorded by the proxies, and what exactly the different proxies are related to. For instance, the deuterium excess value in the ice cores is assumed to be a function of the source region temperature (Merlivat and Jouzel, 1979), however this interpretation is complicated by source region variability, and atmospheric processes [see Noone and Simmonds, this issue]. In the model, such correlations can be clearly delineated and their accuracy and stability quantified.

The next stage will be to perform perturbation experiments such as the addition of meltwater pulses in

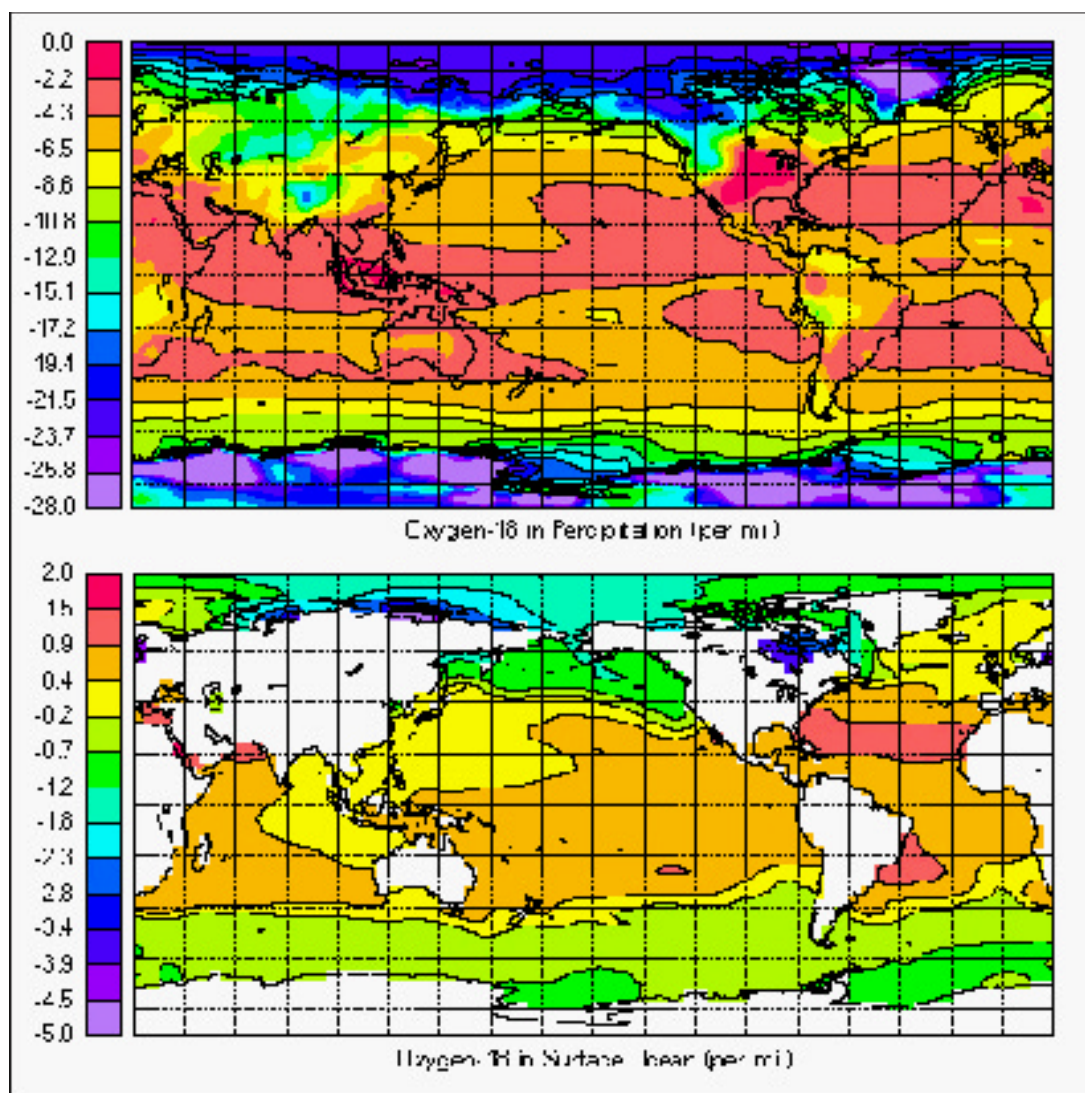


Figure 1: Preliminary results for the present day $\delta^{18}\text{O}$ in precipitation and in the surface ocean from the GISS coupled isotopic tracer model.

the North Atlantic, varying insolation, and LGM experiments. By looking at the transient response of the proxies, we hope to be able to determine the possible leads and lags between the various repositories (such as the Greenland ice cores and North Atlantic sediments), as a function of the climate forcing. This may possibly shed light on the relative chronologies of these disparate paleo-records.

Summary

In summary, this forward modeling approach is a very powerful method for estimating the fingerprints of various climate forcings and internal variability in many different paleo-isotope repositories. Hopefully, we will be able to use these patterns to deduce likely sets of forcings from the paleo-records

themselves and improve our understanding of the links between the terrestrial, oceanic and glaciological systems.

ACKNOWLEDGEMENTS

We would like to express our thanks to David Rind and Jean Jouzel who have been unstinting in support of this work. Support for GAS and DT was provided from NSF grant OCE-99-05038.

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Skating-rink on the Vltava River near Zofin Island, Prague. The Painting by Antonin Waldhauser (courtesy of Prague Municipal Museum) shows the river frozen. Such severe winters in the late Little Ice Age often preceeded catastrophic spring floods.

Upper Pleistocene and Holocene Climatic Variations

PRAGUE, CZECH REPUBLIC, 6–9 SEPTEMBER 2000

A wide-ranging interdisciplinary meeting focused on 'Upper Pleistocene and Holocene Climatic Variations' was held in Prague. This event was organised by the Czech PAGES community under the auspices of the Institute of Geology of the Academy of Sciences of the Czech Republic and the Czech Geological Survey with support from the PAGES International Project Office in Bern. The conference dealt with long-term climatic and environmental changes with special reference to the glacial/interglacial cycles, as well as high-resolution short-term climatic variations. An assessment of anthropogenic impacts on the environment also belonged to the hot topics of the meeting.

Nearly one hundred climatologists, geologists, paleontologists, archeologists and other specialists from 19 countries joined the conference to discuss the problems of past climatic and environmental changes. Most of the contributions related to proxy archives preserved in the central and eastern European regions. The papers and posters presented covered a wide range of mostly continental paleoenvironmental records.

Papers in the areas of archaeological evidence of human impacts on the environment and historical evidence of climatic variations were presented, mapping environmental influences on biodiversity and modeling past and future climatic conditions were presented. The meeting included a walk to historic Prague focusing on the environment-induced stone diseases affecting architectural monuments. One-day field trips documented the Holocene development of the Bohemian Karst and the Labe River flood plain, considering both the geological and archeological viewpoints.

Extended abstracts of almost all papers and posters were published in Vol. 11/2000 of *Geolines*, the Journal of the Institute of Geology of the Academy of Sciences of the Czech Republic. A selection of results will be published in *Quaternary International* in 2001.

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Correlation of Post-Glacial Climatic Events in the Arctic and Far-East Seas

MOSCOW, RUSSIA, 17–20 APRIL, 2000

The main target of this workshop was to bring together Russian and foreign scientists involved in high-resolution climatic and paleoceanographic studies in the Russian Arctic and Far East seas, to discuss new results and to make preliminary paleoclimatic correlations between different seas. The workshop was organized by Russian participants in IMAGES (M. Levitan, chairman; I. Murdmaa, M. Barash and E. Ivanova, members of the organizing committee), by the Shirshov Institute of Oceanology, Russian Academy of Sciences (RAS) and by the working group "Stratigraphy" of the Council of the World Ocean problems RAS; and was funded by IMAGES. One of the sessions was combined with the meeting of Russian-German Program KOMEX. In total, more than 40 scientists from several Russian and foreign institutions took part in the workshop sessions. 29 reports were presented, about one third of which contained results of co-operative Russian-French, Russian-American and Russian-German research.

The joint Russian-French team (Duplessy *et al.*, Levitan *et al.*) presented millennium to century scale Holocene paleoceanographic records from the Barents and Kara Seas revealing the history of climate-related Atlantic water inflow (Fig. 1) and local events linked to sea level changes. A high resolution sedimentary record from the Russkaya Gavan' fjord (Novaya Zemlya) reflects migration of Shokalsky glacier front related to climatic oscillations during the past millennium, including the Little Ice Age (Murdmaa *et al.*). I. Andreeva with co-authors (VNIIOkeangeologiya, St. Petersburg) presented a detailed Late Holocene sedimentary record from the Kola Bay.

A series of reports by the KOMEX team from the Pacific Institute of



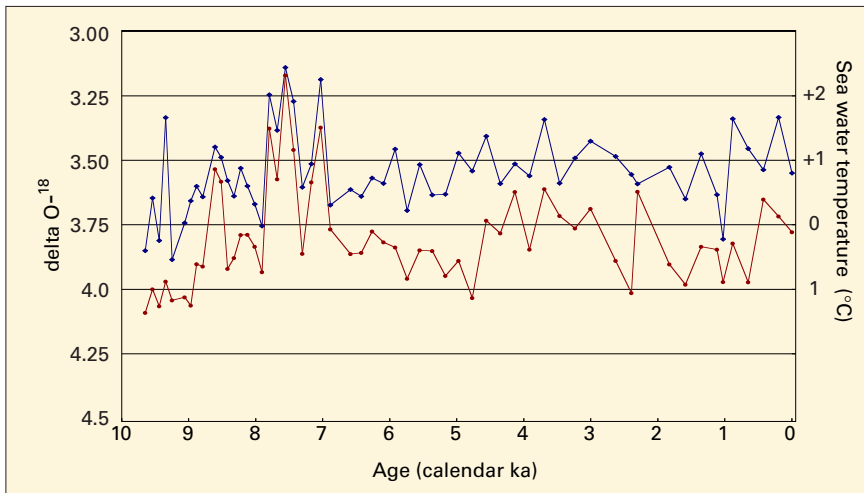


Figure 1: Local $\delta^{18}\text{O}$ changes versus age in the planktonic species *Neogloboquadrina pachyderma* left coiling and the benthic species *Elphidium clavatum* in core ASV 880 (79°55'5" N, 47°08'2" E, water depth 388 m). The approximate temperature scale has been established assuming that the core top reflects modern conditions and that the water temperature decreases by 1°C when the foraminifer $\delta^{18}\text{O}$ value increases by 0.25‰ [Reference: Duplessy et al. (in press) Holocene paleoceanography of the Northern Barents Sea and variations of the northward heat transport by the Atlantic Ocean, Boreas.]

Oceanology (Vladivostok), Shirshov Institute of Oceanology (Moscow) and German institutions demonstrated new results on the Late Quaternary paleoceanography of the Sea of Okhotsk, including tephrochronology, micropaleontology, climatostratigraphy, stable isotopes, radiocarbon datings, ice-rafted debris, geochemical and mineralogical proxies (A. Abelman, A. Astakhov, M. Barash, N. Biebow, S. Gorbarenko, A. Kaiser, S. Kruglikova, A. Matul, R. Tiedemann and others).

Some authors attempted to correlate the major Holocene and Late Pleistocene paleoclimatic events in different Arctic and Far East areas (A. Svitoch, Y. Pavlidis, Y. Polyakova, and others) and link them with global changes and orbital signals. During the discussion, participants of the workshop noted considerable progress in the high-resolution Holocene paleoceanography and paleoclimatology of most Russian Arctic and Far East seas, except for the East Siberian Sea, which still represents a gap in our knowledge. New statistical approaches were also discussed (M.S. Barash and I.G. Yushina). All participants appreciated the fruitful discussion, and pointed to the importance of international co-operation in paleoceanographic studies within the IMAGES program.

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IGBP Sediment Workshop

BOULDER, USA, 25–27 SEPTEMBER, 2000

The IGBP Water Group held its first meeting in Stockholm (Feb 7–9, 2000), to discuss our knowledge of continental aquatic systems, how they have been impacted by climate and humans over the last 50 years, and how they may change over the next 50 years. Participants included members of the scientific steering committees of GCTE, LUCC, GAIM, PAGES, LOICZ, and BAHG. This follow-up workshop concentrated on anthropogenic influences on the supply and flux of sediment along hydrological pathways on a global scale. Attendees representing the PAGES Ecosystem Processes and Human Dimensions Focus included John Dearing, Aleksey Sidorchuk, Des Walling and Bob Wasson.

The key question addressed at the workshop was 'What is the flux of sediment to the coast, presently, and what was it in the past and under pristine conditions?' Other issues discussed included 'Global Change and Sensitive Areas' and 'Data and Typology'. The group recognized that because river systems evolve through time modern river systems are strongly influenced by past conditions within the watershed as well as modern conditions. Understanding the discharge of sediment across a broad time-scale will allow us to make better predictions for the future. Analysis of historic river data was shown to provide high resolution information about

the recent trajectories of sediment flux driven by climate, land use and reservoir construction. Discussion about the role of paleo-reconstruction focused on using sedimentary archives to provide baseline data in pre-disturbance times and recent trajectories of change. Numerous existing examples from lake sediment, reservoir, floodplain, deltaic and nearshore marine sequences testify to the ability for paleo-methods to contribute strongly to this area across a range of spatial and temporal scales.

The workshop concluded that the IGBP community should strive to:

- Develop globally integrated sediment databases and budgets (error checking, harmonization, verification, temporal compatibility),
- Develop community-wide sediment models (both numerical and conceptual) and analysis,
- Understand the geographical differences in sediment fluxes (regional analysis, high vs. low, humid vs. arid, tropical vs. temperate, temperature effects)
- Determine the impacts of sediment fluxes on broader Earth and human systems.

The full report on which this summary is based is available from James Syvitski (James.Syvitski@colorado.edu), and papers from the Boulder meeting will be published as a special issue of *Global and Planetary Change*.

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Dendrochronology for the Third Millennium

MENDOZA, ARGENTINA, 2–7 APRIL, 2000

The International Conference on Dendrochronology for the Third Millennium was hosted by the Laboratorio de Dendrocronología in Mendoza, Argentina, April 2–7, 2000. The meeting attracted 183 scientists from 31 countries. The reports were divided into oral and poster presentations and grouped in the following sessions:

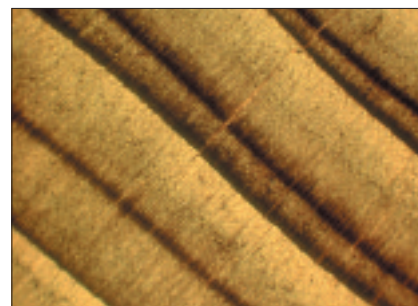
- Biological Basis and General Dendrochronology.
Chair: M. Hughes
- Mathematical and Statistical Methods in Dendrochronology.
Chair: E. Cook
- Stable Isotopes in tree-rings.
Chairs: G. Schlesser and S. Levitt
- Tree-ring Records of Ocean-Atmospheric Circulation.
Chair: D. Sthale
- Modern and Sub-fossil Millennial Tree-Ring Records.
Chairs: K. Briffa and F. Roig
- Global Change as Evidenced by Tree-Ring Studies.
Chair: G. Jacoby
- Tree Ring Research in Tropical Environment.
Chair: M. Worbes
- Applications of Dendrochronology to Geomorphology.
Chair: G. Wiles
- Using Dendroecology in Forest Dynamics Research.
Chair: M.D. Abrams
- Reconstructing Climate Variability and Changes from Treelines.
Chair: B. Luckman
- Dendrochronological Applications in the Southern Hemisphere.
Chairs: J. Boninsegna and R. Villalba

There were a total of 256 presentations at the conference, of which many addressed PAGES-related issues. In particular, the sessions on "Tree-ring Records of Ocean-Atmospheric Circulation," "Modern and Sub-fossil Millennial Tree-Ring Records" and "Global Change as Evidenced by Tree-Ring Studies" were devoted to studies on the reconstructions of past meteorological parameters, past variations of forcing

factors and on the reconstructed variations of the atmospheric circulation. Noticeable advances were reported in the development of long tree-ring chronologies in the Central Asia region and the Arctic. Also, an important increase in the number of long chronologies worldwide was presented. "Stable isotopes in tree-rings," a somewhat controversial issue, was dealt with principally in terms of methodological aspects and the modeling the isotope contents in the rings to assess the significance of intrannual variations in terms of meteorological parameters.

Tree-ring networks over tropical regions are rather scarce. However extremely encouraging progress was reported during the conference. Many fundamental requirements such as evaluation of growth rates and growth behavior of tropical trees, the anatomical description and proof of the annual nature of tree-rings, the climate-growth relationship and dating procedures in tropical trees were discussed. An analysis of the anatomical structures of African woods and their relation to seasonal climate provides for the first time the potential to obtain climatic information from African tropical trees. Similarly, several reports dealt with trees of tropical Latin America including Amazonia. The presence of visible, cross-datable tree-rings in some regions of tropical Australia was also presented.

One special session was devoted to the studies of tree-line environments. Tree-line research in regions of Siberia, Europe and New Zealand were important contributions to the session. A group of 21 presentations dealt with studies developed along the PEP I transect from Alaska to Tierra del Fuego. These presentations were all communication reports from the Project "Assessment of Present, Past and Future Climate Variability in the Americas from Treeline Environments" which was carried out with the financial support of the Inter-American In-



False rings in Mexican Cypress (*Cupressus lusitanica*). Photo by Peter Brown.

stitute for Studies of the Global Change (IAI). The primary scientific goal of the ongoing project is to assess climate variability from climate sensitive tree-ring records along the above-mentioned transect. These series will be used to develop long proxy records of temperature and precipitation from which other parameters such as stream-flow, drought and atmospheric circulation indices (ENSO, PDO, PNA, the Mexican Monsoon and various Antarctic indices) can be derived.

The reports to this tree-line session included the development of tree-line chronologies from sites ranging from 69°N to 55°S including the tropics. In Mexico, sampled sites and new species were reported from ca. 17°N. In the Southern Hemisphere, some reports indicated the results of promising exploratory sampling in subtropical Argentina, Bolivia and Peru. The development of the highest tree-ring chronology in the world from *Polylepis tarapacana* growing at 4900m a.s.l. near Volcan Sajama in Bolivia at 18°S and its relations with climate was also presented in this session. This was the first International Conference on Dendrochronology hosted in the Southern Hemisphere. Consequently, a session on the Southern Hemisphere was also presented. There, several presentations accounting on the progress in the development of chronologies, studies on ecology, forest dynamics and new species suitable for dendrochronological studies.

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Participants at Mendoza Conference on Dendrochronology supported by PAGES

PAGES supported travel of five young scientists to the international Conference on Dendrochronology (see Boninsegna, p.14). They briefly describe their works as follows:

Marcin Makocki

MS Student at Colegio de Postgrados Mexico

I am working with periodicity in radial increments of nine tropical trees. Growth rings are my main object of interest. Attending this International Conference was for me a great opportunity to obtain information on the state-of the art in Dendrochronology. My presentation concerned the anatomical part of my research: "Radial variations of tracheid elements within a growth ring"

Thomas Zielonka

Research Assistant at the Institute of Botany, Polish Academy of Science, Kramon, Poland

My main area of interest is forest dynamics of spruce mountain forests in the Tatra Mts (Carpatians). I study segregation process, especially on dead wood, age and spatial structure of forest and dead wood dynamics. I am using dendrochronology to determine the decomposition rate of dead trees on the forest floor. My poster concerned a part of my studies – using pointer years to assess the calendar year of tree death.

Zewdu Eshetu

PhD student at the Forest Ecology Department, Swedish University of Agriculture

I am a PhD student from Ethiopia doing research work in the Department of Forest Ecology, Swedish University of Agricultural Science. I studied causes of growth decline of *Eucalyptus globulus* in Ethiopia based on ^{13}C and ^{15}N natural abundance and plant nutrient analysis.

A.B. Sikder

Research Assistant at the Indian Institute of Tropical Meteorology, Pune, India

I presented a paper entitled "Tree-Ring Analysis over Indian Himalayas and their Climate Implications" co-authored with H.P. Borgaonkar and K. Rupa Kumar. The main results for the study:

1. Western Himalayan tree-ring chronologies display a prominent response to pre-monsoon climate (March–May) 2. Reconstructed time-series of temperature and precipitation indicate that pre-monsoon climatic conditions during the 18th and 19th centuries were not much different from the present, and that the Little Ice Age phenomenon was not prominent in this part of the Himalayas.

Vandana Chaudhary

Research Associate, Department of Science and Technology, India

I am working as a Research Associate with Dr. Amalava Bhattacharyya in a Department of Science and Technology, Govt. of India, sponsored project, entitled "Analysis of climatic changes in the Eastern Himalayan region using tree ring data". The Eastern Himalayas is considered as one of the world's highest rainfall zones, with annual total rainfall of 4,000–5,000 mm. In this region conifers are represented by 11 genera and 22 species. To explore the potential of conifers here for dendroclimatic studies we collected samples from eight different conifer species growing at different altitudes ranging from 1,500 m. to 3,950 m. All the conifers studied so far have clear ring boundaries and can be well cross dated except *Taxus baccata*, where wedging of rings make dating difficult. It is difficult to find old trees in this region due to anthropogenic disturbances. The longest chronology prepared from this region is of *Abies densa* from Yumthang, north Sikkim region, of 491 years (1504–1994



The oldest known living trees: Bristlecone Pine (Pinus longaeva), White Mountains, California. Photo by Jonathan Pilcher.

AD). Tree growth/climate relationship was analysed. A first, approximate estimation of past climate from this region was presented in my poster entitled, "Dendroclimatic perspective of conifers of the eastern Himalayan region" co-authored with A. Bhattacharyya. In addition, I was able to use this travel opportunity to participate in a field week at the Forestry school, San Martin de los Andes, Argentina.



START Young Scientist Award

Chen Jing'an of the Institute of Geochemistry, Chinese Academy of Science has received a START young scientist award for excellence in PAGES related global change research as demonstrated by his paper "Recent Climate Changes Recorded by Sediment Grain Sizes and Isotopes in Erhai Lake."

Paleoclimates of the Central Andes

TUCSON, ARIZONA, 11–16 JANUARY 2001

The tropical Andes contain archives of late Quaternary climate change in lake and wetland sediments, glaciers, rodent middens, and other deposits. The analysis of these records provides a unique perspective on tropical climate change, and a variety of questions can be considered in this context. For example, when did the last glacial maximum (maximum ice volume) occur in the tropics and what were climate conditions at the time? Were there millennial-scale climate changes in tropical South America, such as the Heinrich Events and the Younger Dryas, and how do these changes compare with those at higher latitudes? What was the pacing of El Niño during the Holocene and did this pacing change as a result of forcing from external factors (e.g. seasonal insolation overhead or over remote regions teleconnected with the South American tropics)? These questions and more were discussed by ~50 scientists who attended the workshop.

The workshop was prompted by the wealth of information that is now coming out of South America on tropical paleoclimate from high elevation ice cores, large and small lakes, the Amazon Fan, and the Atacama Desert. In general, the height of the last glacial maximum appears to be coincident with high northern latitudes and conditions were significantly colder (5–6°C lower than today). However, it is still debatable if conditions were wetter or drier throughout the vast region of the Amazon drainage basin and the adjacent Andes. Also, the late Glacial interval remains somewhat enigmatic. Glaciers were in fast retreat during the Younger Dryas, but it is unclear what conditions drove this retreat. It is also clear that many sites on the Altiplano and the eastern flank of the Andes showed relatively warm and dry conditions in the early to middle Holocene. Paradoxically, during the late glacial/early Holocene, sum-



Lullailaco (6739m) standing high above the Altiplano covered with a dusting of snow, but no glacier. In the foreground is the Altiplano, at about 4000 meters above sealevel, which receives only about 200mm of rain annually today. On the left a small "salar" (salt pan) with open water in the center and exposed higher lake level terraces on the right, indicating moister conditions in the past. (for more information see Baker et al. (2001) The History of South American Precipitation for the Past 25,000 years, Science 291:640–643. Photo by Bruno Messerli)

mer precipitation was more than 3 times greater than today on the Pacific slope of the Andes, in the Atacama Desert, according to several proxies. For the middle Holocene, however, the same proxies have been interpreted to show both wet and dry conditions in the Atacama Desert. Resolution of these discrepancies is not trivial, but some of the differences between the Altiplano and the Atacama might lie in the sharp climatic gradients across the region. Finally, the latest Holocene is characterized by neoglaciation and wet conditions on the Altiplano. Variations in climate also appear to have affected prehistoric cultures that may be evident in changing settlement patterns on the Pacific coast and the Andean highlands.

The Andes provide a great diversity of archives from which records of tropical paleoclimate can be derived. The strength of the paleoclimatic analysis from the region may ultimately be the diversity of these records and their geographic distribution. Certainly for tropical South America the Andes will contain some of the best clues for late Pleistocene and Holocene climate change. Further refinement and syn-

thesis of these records could determine the relative phasing and relationship of climate change in the tropics with higher latitude regions on decadal to millennial time scales.

Additional information, including extended abstracts and author contact information, can be found at <http://www.paztcn.wr.usgs.gov/pcaw/>.

The workshop was funded by the US NSF and was an activity of the PEP I activity of PAGES. The conveners of the workshop were: Julio Betancourt, Jay Quade, and Geoffrey Seltzer

GEOFFREY SELTZER

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Correction

The brief description of the LUCIFS Project that appears on page 10 of PAGES News Vol.8 No.3 omitted to list the co-author:

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8th International Paleolimnology Symposium: The Year of the Chironomids

QUEEN'S UNIVERSITY, KINGSTON, ONTARIO, CANADA, 20–24 AUGUST, 2000

Co-chaired by John Smol and Brian Cumming, the 8th International Paleolimnology Symposium brought together more than 250 scientists in Kingston, Ontario. Six keynote speakers, 52 oral presentations and 108 posters were presented over four days. Seven main themes were discussed: Arctic research, Alpine research, Tropical and Subtropical research, Climate, Lake Management, New Developments, and Rivers and Reservoirs.

One of the emerging topics at this conference was chironomid research. A pre-conference workshop, followed by one afternoon during the conference were dedicated to the basic learning of chironomids as well as advanced identification, methods and modeling questions. 23 scientists from Europe and America were grouped and reviewed the evolving taxonomy. While chironomid research has previously been considered somewhat marginal, with only one presentation by Walker at the 7th International Symposium, the current Symposium boasted no less than 34 presentations with chironomid research as a major focus. These studies were undertaken in 16 different countries. A major indication of the importance of chironomids was provided by Stephen Brooks from the Natural History Museum, London who presented his talk wearing a T-shirt stating "Chironomids eat Diatoms." Chironomids were used to reconstruct mean July air temperature, major human impacts, and the eutrophication or natural evolution of lakes. To learn more about chironomids try the websites:

- www.zoo.uib.no/systematikk/paleo/intro1.php3
- www.okanagan.bc.ca/fwsc/iwalker/infpanis/

An additional topic of discussion during the meeting was the importance, potential, limits, challenges

and methodology of multi-proxy paleolimnological studies. André Lotter and John Birks presented keynote talks on this subject. Human practices and climate variations in the Yucatan Peninsula through the late Pleistocene and Holocene were discussed by Mark Brenner. Coring equipment was reviewed by Daniel Livingston including a warning on the interpretation of possibly sectioned cores. Patrick De Deckker stressed the importance of collaboration between paleolimnology and paleoceanography and Walter Dean presented a video on the new Global Lake Drilling to 800 meters (GLAD800) drill rig. Overall, in the study of these seven main themes, many tools were used: 87 presentations concerned diatoms, pollen (22), Cladoceran (7), Ostracods (6), Chrisophytes (7), Foraminiferes (2), Brachiopods (1), macrofossils (6), pigments (4), tephra (3), isotopes (7), minerals (7), sedimentology (33) and NIRS (1).

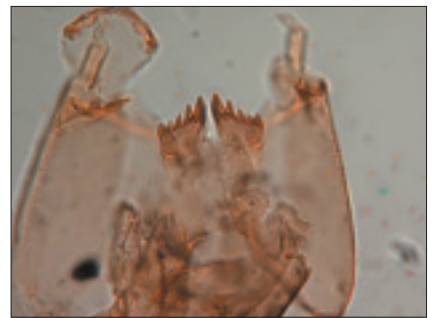
Other workshops were organized: the Arctic-Antarctic Diatom workshop was held to create a consensus on taxonomy, a Lake Baikal workshop showed the progress of research in this important lake and a LIMPACS (Human Impact on Lake Ecosystems) workshop, chaired by Rick Battarbee, introduced this new PAGES initiative.

The next International Paleolimnology Symposium will be held in Helsinki, Finland in 2003. V.P. Salonen and A. Korhola will be the co-chairs for this event. For further information about the Paleolimnology Symposium, visit the website at: <http://biology.queensu.ca>.

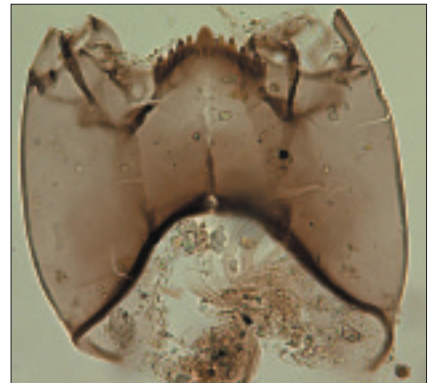
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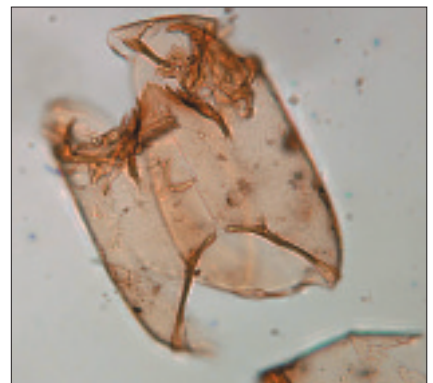
Chironomid Photos courtesy of Oliver Heiri



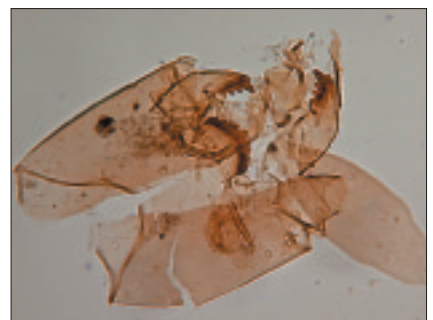
Heleniella sp.



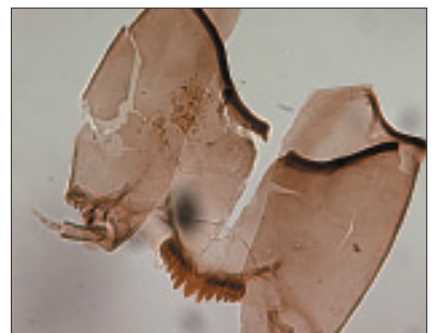
Einfeldia sp.



Parakiefferiella sp.



Paratanytarsus sp.



Dicrotendipes sp.



In Memory of Kerry R. Kelts, 1947–2001

Kerry Kelts, professor in the department of Geology and Geophysics, and director of the Limnological Research Center (LRC), University of Minnesota, died on February 8, 2001, after a long battle with Hodgkins Disease.

Kerry received his undergraduate degree in Geophysics at the University of California-Riverside in 1967 and his PhD from the Swiss Federal Institute for Technology (ETH), Zürich, Switzerland, in 1978. From 1978 to 1980 he was the Deep-Sea Drilling Project Staff Scientist for Leg 64 at the Scripps Institute for Oceanography, La Jolla, California, before joining the Geological Institute at the ETH, Zürich, as lecturer, from 1980 to 1985. From 1985 to 1990 he was Head of the Geology Group of the Swiss Federal Institute for Water Resources (EAWAG). From 1988 to 1990 he served as the first director of the newly formed Swiss National Climate Program (Proclim) and was instrumental, jointly with Prof. Dr. H. Oeschger, in the development of the IGBP-PAGES program. In 1990 he answered a call to lead the LRC at the University of Minnesota.

Kerry edited and co-edited two books and nine special journal issues and monographs, including "Lacustrine Petroleum Source Rocks" (1988), "The Phanerozoic Record of Lacustrine Basins and their Environmental Signals" (1989), "Comparative Lacustrine Sedimentation in China" (1990), and "Global Geological Record of Lacustrine Basins" (1994). He authored and co-authored over 100 papers. His research interests focused on reconstructing paleoclimate history from isotopic, geochemical and sedimentological signatures in lake deposits from the Americas, Africa, Near East and China. As a participant and later staff

scientist of deep-sea drilling projects he brought to the lake community oceanographic expertise in terms of technological advances for field operations and what he called the "DSDP way" of processing cores. The core processing and archiving facility that he created at the LRC with NSF support, and which is available to our whole community, is the best such facility in the United States. Kerry was the main driving force behind the funding, building, and testing of the versatile and powerful Global Lake Drilling System capable of handling up to 800 meters of drill string (GLAD800). He was on the deck of the Glomar Challenger in 1978 on DSDP Leg 64 when the first hydraulic piston core was collected in the ocean, and he was on the deck of the GLAD800 barge last summer when the first hydraulic piston core was collected from Great Salt Lake, a dream that took 22 years to realize. In his honor, the GLAD800 drill rig has been named the *R/V Kerry Kelts*. In the years to come, the *R/V Kerry Kelts* will core large lakes all over the world, a fitting tribute.

Kerry's enthusiasm for his research was infectious, inspiring students and colleagues. His holistic approach to the study of lakes and his vision were the catalysts for interdisciplinary and international collaboration. He was the co-founder of the International Decade for East African Lakes (IDEAL), the founder and first president of the International Association of Limnogeology, and coordinator of Project 219 (Comparative Lacustrine Sedimentology in Space and Time) and Project 324 (Global Paleoenvironmental Archives in Lacustrine Systems: GLOPALS) of the International Geological Correlation Program (IGCP).



All of us who crossed paths with Kerry learned from his passionate pursuit of science and profited from his generosity, scientifically and personally. He represented the perfect blend of the best characteristics of the New and Old World science. His New World enthusiastic "can do" attitude coupled with his personal charm and persuasiveness was the stimulus for many of the ongoing international global change research initiatives. From the Old World he projected the technological precision, quality and dedication, which gave all his projects perfection and a touch of class. We will all miss him.

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images

RV Marion Dufresne

News from the International Marine Global Change Study

In its fifth year, the IMAGES program now includes 24 countries as members: Australia, Canada, Denmark, France, Germany, Iceland, India, Indonesia, Japan, Mexico, The Netherlands, New Zealand, Norway, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, Taiwan, Tunisia, United Kingdom and USA.

The IMAGES Office relocated last year to Kiel University, Germany, where Michael Sarnthein serves as Executive Director, Ann Holbourn as Assistant Director and Stefan Rothe as Data Manager.

IMAGES was initiated to respond to the challenge of understanding the mechanisms and consequences of climatic changes at time scales of decades to millennia using oceanic sedimentary records. IMAGES plans and coordinates oceanic cruises to retrieve giant sediment cores and supports relevant workshops and symposia. Specific information can be found on the IMAGES website: <http://www.images-pages.org>.

Cruises

Over the last five years, the IMAGES program has retrieved more than 400 long cores (30–60 m) from the major ocean basins. In the next three years IMAGES plans a series of cruises with *RV Marion Dufresne* to retrieve cores from key areas with sufficiently high sedimentation rates (20 cm/kyr or more) to allow paleoclimatic studies with a temporal resolution of decades to centuries or better. Currently, preparations for three IMAGES cruises in 2001 are being finalized: West Pa-

cific (May-June), Pakistan (October) and Mediterranean and Iberian margin (mid August-mid September). A cruise program along the west American margin, Gulf of Mexico and Caribbean is in preparation for 2002, and a Southern Ocean cruise is planned for 2003.

Working Groups

Terminal Millennial Synthesis of Decadal-to-Millennial-Scale Climate Records of the last 80 kyr, co-chaired by M. Sarnthein and J. Kennett, held a workshop with more than 50 scientists in Trins, Austria in February 2000. A short report was published in EOS. A third workshop is now planned for late May 2001 at the University of California, Santa Barbara to actualize publication of a special issue of Quaternary Science Review and to synthesize the present state of knowledge and future perspectives.

WEPAMA (West Pacific Margins), chaired by M.-T. Chen, will hold a meeting on 22nd-23rd February 2001 in Taipei, Taiwan, with main focus on "Western Pacific Oceanography: New Techniques and Directions".

EPILOG (Environmental Processes of the Ice Age: Land, Ocean and Glaciers), co-chaired by A. Mix, E. Bard, and P. Clark, organized a workshop with approximately 50 scientists last October in Oregon. Outcome of the meeting was a short report published in EOS. A special volume is now in preparation.

SEAMONS (South East Asian Monsoon), chaired by P. Wang,

plans to hold an informal meeting in May 2001 together with the Leg 184 Postcruise meeting in Beijing. A final synthesis meeting is planned for 2002.

Three new Working Groups have been created:

- 1) The Ice-Ocean Interaction WG co-chaired by Eystein Jansen and John Andrews.
- 2) The Southern Ocean WG co-chaired by Andreas Mackensen and Rob Dunbar.
- 3) A Paleo-JGOFS joint task team representing a cooperation between the IGBP core projects PAGES and JGOFS with Karin Lochte as chair.

Upcoming Meetings:

Global Change Open Science Conference: "Challenges of a Changing Earth", 10–14 July 2001, Amsterdam, The Netherlands. A special Poster Session is being organized on IMAGES related research. Chair will be Michael Sarnthein.

International Conference on Paleoceanography VII, 16–22 September 2001, Sapporo, Japan. IMAGES funds will be available to subsidize the travel costs of young scientists (students and postdocs within three years of their PhD) who receive no travel support to attend the ICPVII in Sapporo. (see IMAGES website for details).

ANNE HOLBOURN

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CALENDAR 2001

24–25 May: "Conference on History and Climate" Williamsburg, Virginia, USA

<http://www.wm.edu/CAS/WMCAR/confer/index.htm>

6–8 June: "Climate Change and Variability in Northern Europe - Proxy Data, Instrumental Records, Climate Models and Interactions" Turku, Finland

Contact: Mia Rönkä, Programme Secretary, FIGARE Coordination, University of Turku, FIN-20014 Turku, Finland,
E-mail: miaron@utu.fi.

<http://figare.utu.fi/notice.html>

13–18 June: "Millenial Scale Events in the North Atlantic Regions During Termination 1" Ulster, Northern Ireland, UK

<http://www.ulst.ac.uk/faculty/science/crg/t1/t1intro.htm>

24–28 June "Earth System Processes" Edinburgh, Scotland, UK

Geological Society of America and Geological Society of London

<http://www.geosociety.org/meetings/edinburgh/index.htm>

10–14 July: Global Change Open Science Conference "Challenges of a Changing Earth" Amsterdam, The Netherlands

<http://www.sciconf.igbp.kva.se/>

16–20 July: "Detecting Environmental Change: Science and Society" London, UK

Contact: Dr Catherine E. Stickley, Environmental Change Research Centre, Department of Geography, University College London, 26 Bedford Way, London WC1H 0AP, UK
E-mail: c.stickley@ucl.ac.uk

27–31 August: "PAGES-PEP III & ESF-HOLIVAR Conference: Past Climate Variability in Europe and Africa", Aix-en-Provence, France

Contact: Catherine Stickley, ECRC, University College London, 26 Bedford Way, London WC1H 0AP, UK
E-mail: c.stickley@ucl.ac.uk

<http://www.geog.ucl.ac.uk>

16–22 September: "International Conference on Paleoceanography VII", Sapporo, Japan

Contact: Hisatake Okada, Department of Earth and Planetary Sciences, Hokkaido University, North-10 West-8, Kita-ku, Sapporo 060-0810, Japan
E-mail: icp7@cosmos.sci.hokudai.ac.jp

<http://www.ijnet.or.jp/JTB-CS/icp7/>

10–15 November: "Abrupt Climate Change Dynamics", Il Ciocco, Italy

Contact: Keith Alverson, PAGES IPO, Bärenplatz 2, 3011 Bern, Switzerland

E-mail: alverson@pages.unibe.ch

<http://www.pages-igbp.org/calendar/calendar.html>

THE 11th Annual North American Dendrochronology Fieldwork (NADEF)

Satillo, Mx, 12–19 August 2001

The Collaborative Network No. 3 of the Inter-American Institute for Global Change Research: Reconstructing Past, Present and Future Climates of the Americas from Treeline Environments plans to assist a number of Latin American students to attend.

Funds will be available to cover the cost of registration, accommodation, and meals for 8 student participants at this meeting (US \$580). These awards would be limited to students coming from Mexico and other Central American, Caribbean, and South American countries. Students must cover (or obtain separate funding for) their travel to Saltillo.

Students interested in attending the meeting and applying for a registration grant should send an application that includes:

- a brief summary vita (one page maximum) of education and work experience
- a brief discussion of the reasons for attending the Fieldweek and
- a supporting letter from a researcher or university professor.

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Applications, in writing or by e-mail (preferably by e-mail) should be sent to:

DR. B. H. LUCKMAN

Department of Geography,
University of Western Ontario,
Canada N6A 3K1
Fax 519-661-3750
e-mail luckman@uwo.ca

with copies to

PETER BROWN, DIRECTOR

North American Dendroecological Fieldweek
2901 Moore Lane, Ft. Collins,
CO 80526, USA
Phone and Fax: 970/229-9557
<http://www.rmtrr.org>
e-mail: pmb@rmtrr.org

Applications must be received by 1 May, 2001, and candidates will be notified by 15 May.

<http://www.rmtrr.org/nadef/nadef2001.html>