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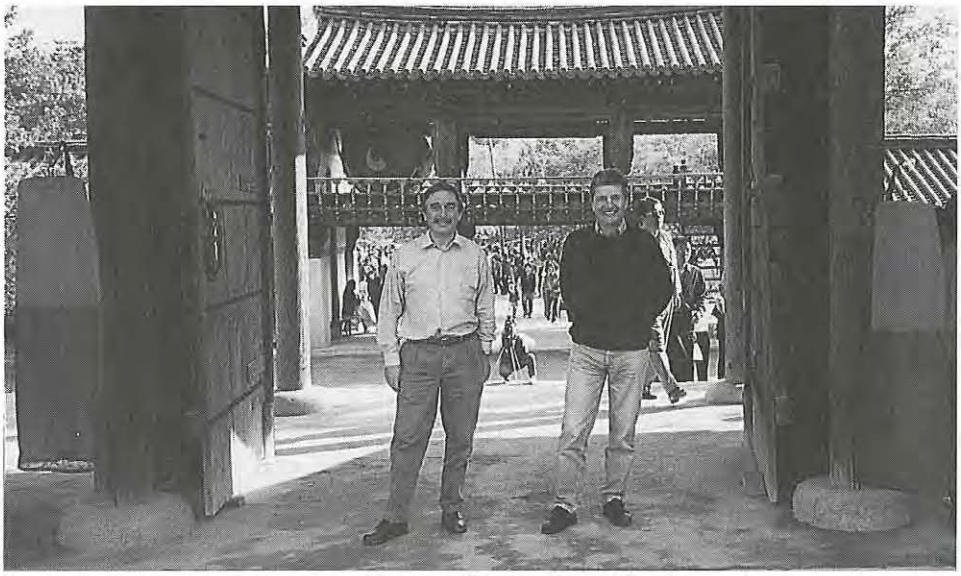
THE INTERNATIONAL GEOSPHERE–BIOSPHERE PROGRAMME: A STUDY OF GLOBAL CHANGE (IGBP)
OF THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

Change of the guard at IGBP



Peter Liss (left) completes his term as Chair and Chris Rapley (right) completes his term as Executive Director at the end of 1997. Both shown off-duty outside Seoul, Korea.

CONTENTS

PAGES: Past and Future

Keith Alverson and Frank Oldfield

For the first time since the establishment of its programme of Foci and Activities, PAGES has held a meeting of virtually all the scientists responsible for coordinating PAGES research throughout the world. This took place in Hilterfingen, Switzerland on the north shore of Lake Thun, November 8 and 9, 1997. The main goals of the meeting were to summarize progress in each area of activity, to review the PAGES project as a whole, to promote synergism between the various research teams and to put PAGES on course for making the best possible impact at the upcoming Open Science Meeting to be held in London, April 19 - 23, 1998. Any account of the leaders meeting, its significance and its highlights is inevitably a personal one, so what follows is a brief synopsis reflecting the perspective from the international project office, viewing the science from the edge and the organization from its centre.

Pole position

The ice core research in Greenland pioneered over two decades ago has reached the stage where key results from the Greenland Ice Core Project (GRIP) and Greenland Ice Sheet Program II (GISP II) have already been published in well over one hundred research papers. The data will soon be available on CD-ROM. This work, along with parallel research on the Vostock ice core in Antarctica, has been seen as the flagship of global palaeoscience by much of the scientific community.

In key respects, the historical record of changing atmospheric composition, and hence past global biogeochemistry, contained in the polar ice caps has set the agenda for research in the polar regions and beyond.

One major development is the proposed initiative of PAGES, GAIM and IGAC to address what has become known as the 'Palaeo Trace Gas Challenge'. This initiative, which subsumes a vast array of interlocking questions spanning all aspects of the Earth system over the last glacial cycle, seeks to address the largely unknown dynamics which governed the tight interplay between climate change and atmospheric greenhouse gas concentrations in pre-industrial times. PAGES is committed to playing its part in addressing these issues, which lie at the heart of the debate about contemporary and future climate forcing by greenhouse gases and aerosols.

The oxygen isotope record from the GRIP/GISP II cores that gives the most dramatic indications for rapid climate changes before the Holocene period (the intergla-

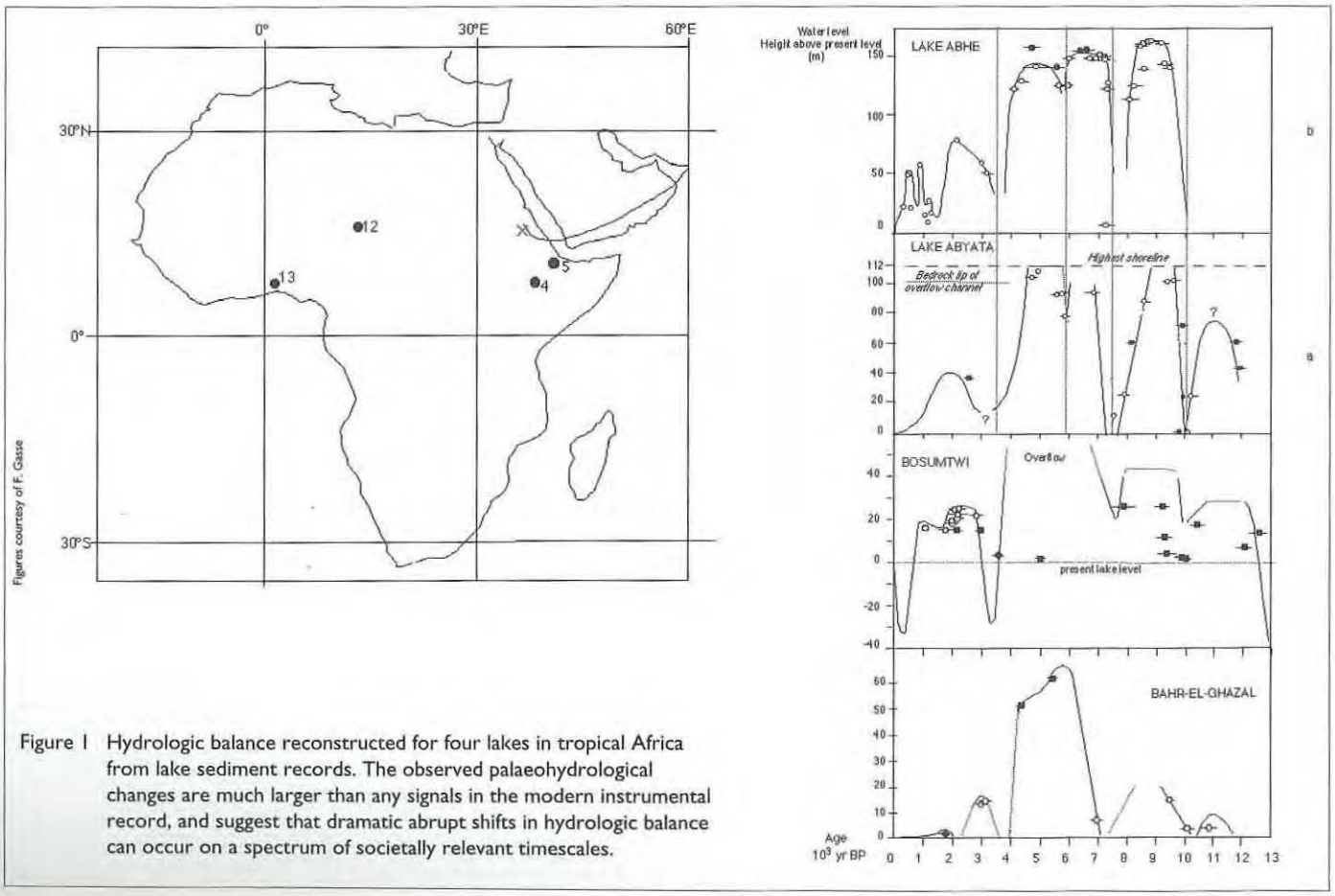


Figure 1 Hydrologic balance reconstructed for four lakes in tropical Africa from lake sediment records. The observed palaeohydrological changes are much larger than any signals in the modern instrumental record, and suggest that dramatic abrupt shifts in hydrologic balance can occur on a spectrum of societally relevant timescales.

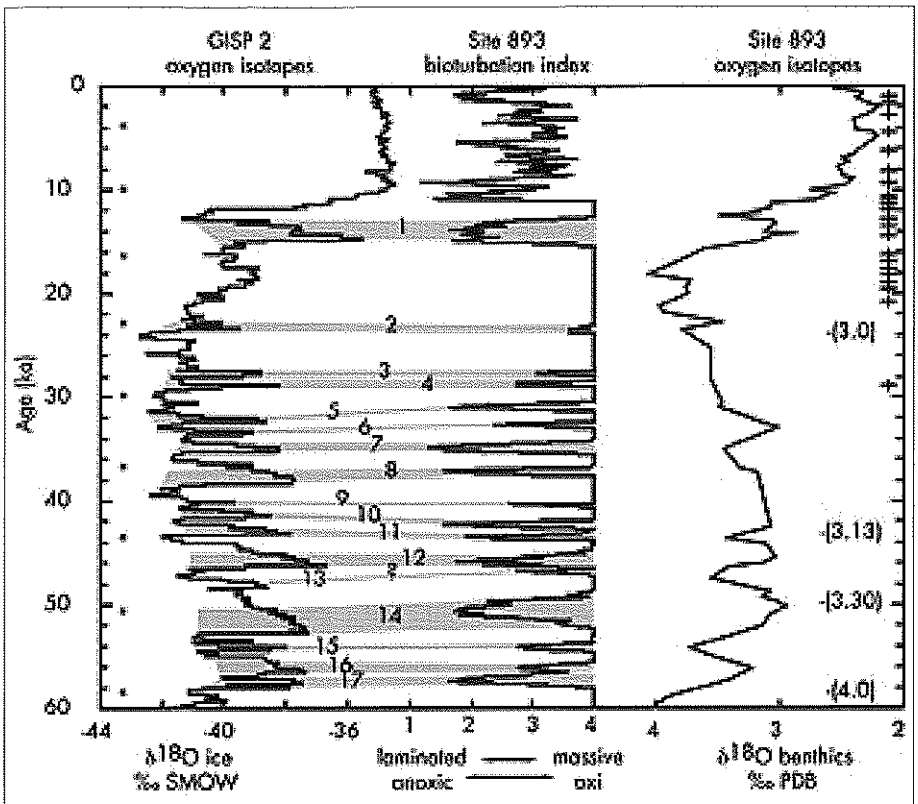


Figure 2 Comparison of ODP site 893 (Santa Barbara Basin, California) bioturbation index and benthic foraminiferal $\delta^{18}O$ records with $\delta^{18}O$ ice time series from GISP II. Note the strong signal of Holocene variability seen in the sediment record but not in the isotope record from the Greenland ice core. Strong millennial scale variability associated with Dansgaard-Oeschger oscillations is present in both records.
Figure adapted from Behl and Kennett (1996) Nature **379**, 243-246

cial in which we now live) shows little variation over the last eleven thousand years. This has led many scientists to view the Holocene as a period of relative constancy in global climate. However, many other indicators of climate change within these cores provide ample evidence for Holocene variability. Indeed, to the north of the GRIP/GISP II sites the oxygen isotope record itself shows greater Holocene variability.

Independent sites throughout much of the world provide numerous lines of evidence pointing to major changes in climatic and hydrological regimes during the Holocene.

At high latitudes, deep sea sediment cores from the North Atlantic and terrestrial pollen data suggest major shifts in climate on millennial timescales. One of the most well known of these periods was the 'Little Ice Age', which locked much of Europe in significantly cooler conditions than present from about 1500 to 1850 AD. Even more striking millennial scale Holocene events are seen in reconstructions of North African lake levels, which show swings from periods of intense desiccation to water levels sometimes more than 100 meters higher than today (see Figure 1).

One interesting line of evidence for Holocene variability from the GRIP/GISP II cores themselves is provided by measurements of sea salt ion concentrations. Increases in ion concentrations are thought to reflect stormy conditions in the nearby North Atlantic. The reason for the apparent constancy in the isotope record at GISP II and GRIP during the Holocene remains an unanswered question, although it probably involves competing influences of the many independent climatic variables which influence isotopic fractionation. Although the changes in African Lake levels shown in Figure 1 diminish through time, they do not disappear, as recent evidence from the East African rift lakes confirms. Evidence for lower latitude Holocene climate variability can also be seen in sediment cores from the Santa Barbara basin in the subtropical Pacific (see Fig. 2).

As these examples demonstrate, climate may well be far more variable in space and time than data from the polar record alone can possibly show. In addition, an increasing array of evidence confirms that the rapid climate shifts known as Dansgaard-Oeschger events, which are recorded in the Greenland ice core for the period between the previous interglacial and the last glacial maximum, are common to both continental and marine records across the northern hemisphere (see Figure 3 on page 5). These realizations reinforce the need for growing interaction between the ice core, marine and continental palaeoresearch communities. Facilitating such interaction is one of the main, overarching missions of PAGES.

In the southern hemisphere, the first steps towards coordinating research around the margins of Antarctica will be taken through the new Antarctic Ice Margin Evolution (ANTIME) programme, which seeks to unite ice core, marine and lake sediment records. In the northern hemisphere, the diversity of high latitude records beyond the Greenland ice cap is reflected in a range of different programmes including the Circum-Arctic Polar Environments (CAPE), and International Circum-Arctic Palaeoclimate (ICAPP) programmes.

Just as results from ice core research help to define the research agenda for scientists working on other types of palaeorecord, they also highlight the need for continued efforts in and around the major polar ice caps themselves. Antarctica is a vast land mass. Differences between the palaeorecord from individual sites within its continental boundaries are of great importance for understanding atmospheric and marine processes throughout the southern hemisphere. Such site comparisons are also vital for understanding the dynamics of the massive ice sheet itself, and the role of freshwater storage in the Antarctic ice cap in past and future sea-level changes.

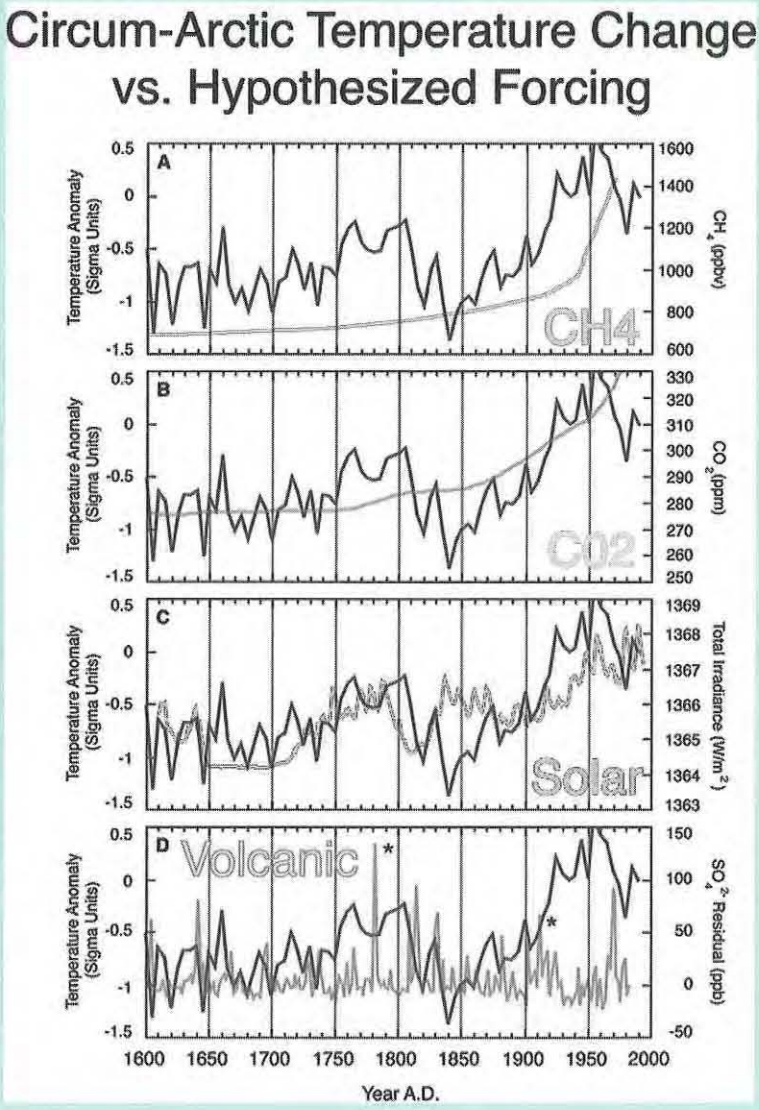
Finally, there is a clear need to bring the Arctic and Antarctic records together in order to more fully understand their commonalities, their differences, and the phase relationships between them. The advent of high resolution records from the Vostock and Dome Concordia sites in Antarctica, as part of the joint PAGES/SCAR Palaeoenvironments for Ice Cores (PICE) programme, should provide the basis for detailed inter-hemispheric comparisons in polar ice core records. Quantitative calibration of Antarctic ice core records alongside comparison with the Arctic records is a vital stepping stone to an understanding of the extent to which polar records can be used to infer global climate change. The relevance of interhemispheric comparisons goes, of course, far beyond the poles. The full extent of latitudinal variability is incorporated within PAGES programmes as a series of three pole-equator-pole (PEP) transects which girdle the Earth.

Present highlights and future challenges

PAGES science, by demonstrating the parallels between trace gas concentrations and past temperature changes as recorded in polar ice cores, contributes one of the most compelling empirical arguments for linking enhanced CO_2 and methane concentrations in the atmosphere to global warming. Exploring the phase relationships and process linkages which this correlation reflects is an urgent task. Through this and parallel research on solar and volcanic influences, we anticipate a growing understanding of the forces, both beyond and within the earth system, that have driven climate change in the geologically recent past. The complex interaction between various forcing factors and the pattern of recent climate change in the Arctic region, for example, is shown in the figure below, from Overpeck et. al. (1997) "Arctic Environmental Changes of the Last Four Centuries" in: *Science*, 278, 1251-1256.This type of research points towards a time when we shall be able to assess more confidently not only the link between climate change and trace gas concentrations, but also the temporal and spatial patterns of natural climate variability which will likely be reflected in, and interact with, potential future greenhouse gas warming.

Already, PAGES science allows us to make some important statements about past climate variability and its significance for future planning and prediction:

- Many independent lines of evidence show that during the warm period since the last glaciation - the period we live in - climate has varied over a much greater range than instrumental records are able to demonstrate
- The recorded impact of these past, *natural* variations on, for example, lake levels, river regimes and the incidence of extreme events such as droughts and floods, lies beyond the range that human planning typically envisions. Such impacts would also lead to changes in the resource base of human populations well beyond the scope of adaptation within many social and economic systems.
- Looking to longer timescales in the past, beyond the 'interglacial' in which we live, it is clear that the earth's coupled ocean-atmosphere system has been highly unstable, with massive swings of ocean circulation and associated dramatic changes in climate taking place over the space of a few decades at most. Even though such dramatic 'switches' are more typical of cool, glacial times, there is growing evidence, from both empirical studies and model simulations, that they cannot be excluded from the range of future possibilities.
- Increasingly, past climatic conditions are employed to provide a natural laboratory of benchmarks against which to test model simulations upon which predictions of future climate change depend. Since past climate changes include global effects as well as a wide variety of spatial and temporal patterns, there is scope for palaeodata to constrain model simulations at all spatial and temporal scales.



Comparison of hypothesized external climate forcing (colored lines) and standardized proxy Arctic-wide summer-weighted annual temperature [gray lines, plotted as sigma units for (A) atmospheric CH_4, (B) atmospheric CO_2, (C) solar irradiance, and (D) Greenland (GISP II) ice core volcanic sulfate. Eruptions known to be overrepresented in the GISP II record are marked with an asterisk.

Girdling the Earth

The fact that past climate change has shown both global coherence as well as highly differentiated regional expression, implies that any reconstruction of past global change must be placed within a robust, spatial framework. A major step in this direction has been the establishment of the PEP transects. Each transect presents unique challenges and opportunities.

The vast latitudinal span of the American continent provides the PEP I transect with a wealth of topographic and climatic parallels across many climate zones in both hemispheres. The transect comprises a rich tapestry of high quality archives of past environmental change, providing unparalleled scope for detailed interhemispheric comparisons.

These interhemispheric comparisons are the dominant linking theme of the first PEP I Symposium, to be held in Merida, Venezuela, March 16 - 20, 1998. (see box on page 7). Within the Americas transect, there are also geographical regions of outstanding interest to the whole of the IGBP, notably the Amazon Basin where the Large Biosphere Atmosphere (LBA) Experiment is currently underway. The PAGES component provides the palaeoenvironmental underpinning of this research project.

PEP II runs from the north-eastern limits of the Eurasian landmass to the southern edge of Australasia. It includes some of the most detailed, continuous, high resolution records of terrestrial environmental change available anywhere in the world in the form of the loess deposits in the central China plateau.

Close to these major loess-based archives lies the Tibetan/Himalayan region, whose ancient glacial ice masses make it in many senses the world's third pole. Linking together results from records as diverse as ice cores, loess sections, lake sediments and, for more recent periods, tree rings, requires a strong emphasis on calibration. One of the best methods for ensuring accurate calibration is to monitor the present day workings of the processes which formed these magnificent records of past change. Such a monitoring effort, together with research on the palaeoclimatic significance of loess and palaeosol sequences, is one of the main initial priorities of the Himalayan Interdisciplinary Palaeoclimate Project (HIPP) Program. Recent analysis of the stable isotope ratios of lead in loess deposits, has shown links between the history of loess deposition in China and changes in

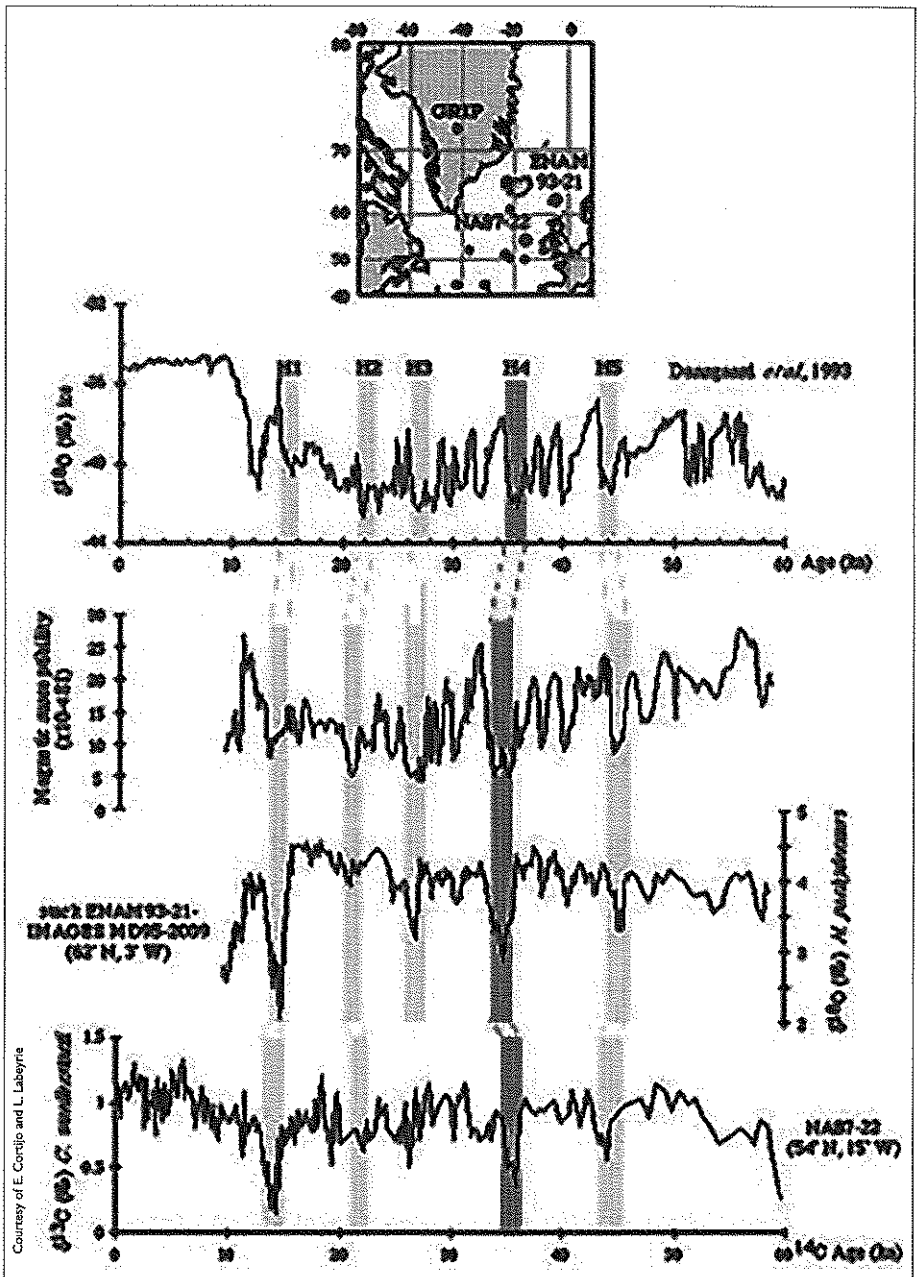


Figure 3 Rapid changes in air temperature and ocean hydrology during the last glacial period from a selection of high latitude North Atlantic marine sediment cores as well as the GRIP ice core from central Greenland. Heinrich layers are shaded. Dansgaard-Oeschger oscillations are clearly visible on millennial timescales, often with a notable correlation between the diverse records. (From PAGES Newsletter, Vol.5 No.2)

dust concentrations found in the Greenland ice cap, providing additional evidence for the spatial coherence of past environmental changes as well as vital insight into the processes responsible for this coherence. Lacustrine records from Lake Baikal provide another important palaeoclimatic record from this region within PEP II (see Figure 4 on page 6).

The South Asian portion of PEP II encompasses the most densely populated portion of the Earth. The livelihood of a large percentage of this immense population is strongly dependent on the timing and nature of monsoon systems. In order to understand how the Asian monsoon systems vary in response to changing boundary conditions, it is essential to be able to reconstruct their behaviour in the past. The theme of understanding the past natural variability in Asian monsoon systems unites a high proportion of the work, both continental and marine, along the PEP II transect from Northern Australia through Southeast Asia to Japan and from the West Pacific to the Indian subcontinent.

Events in 1997 have highlighted the links between the Asian monsoon and the

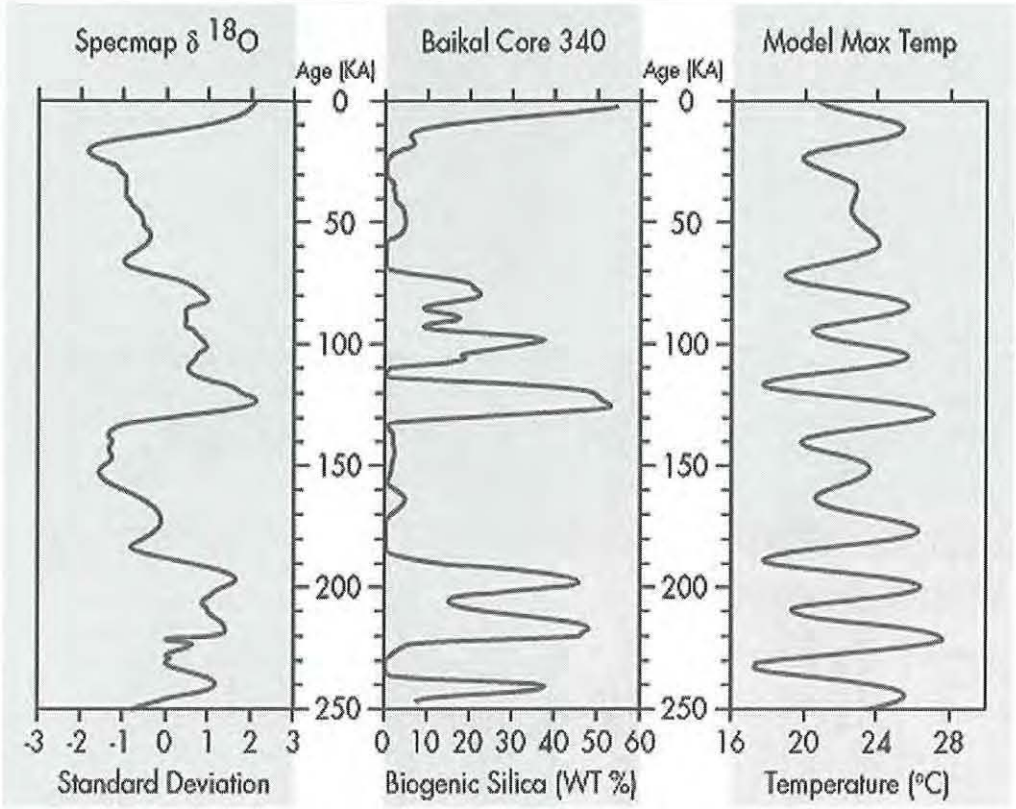


Figure 4 An example of a lacustrine palaeoclimate record. Biogenic silica, a measure of diatom productivity from Lake Baikal, compared to the SPECMAP oxygen isotope record and modelled maximum summer temperatures. The record of diatom productivity is probably linked to the duration of snow and ice cover on the lake. Figure adapted from Colman, *et.al.* (1995) Nature **378**, 769-771.

El Niño-Southern Oscillation (ENSO) phenomenon. Exploring this connection, which strongly links PEP I and PEP II, requires records of past variation with annual, preferably even seasonal resolution. Typically, such resolution is found in systems which show annual banding such as tree rings and corals. The investigation of tropical coral records in the context of historical ENSO reconstruction over the past several centuries is being actively investigated as part of the PAGES Annual Records of Tropical Systems (ARTS) programme (see box on opposite page).

The European-African transect, PEP III, provides its own distinctive opportunities, including a wealth of accessible historical documentation recording human history, land degradation and climate change in the semi-arid areas in and around the cradle of western civilization.

Further south, conveniently straddling the equator, lies the East African rift lake system, which provides a unique opportunity for interhemispheric comparison of hydrological events. Research in sub-Saharan Africa reveals dramatic climate variability, even within the past few millennia, which greatly exceeds anything

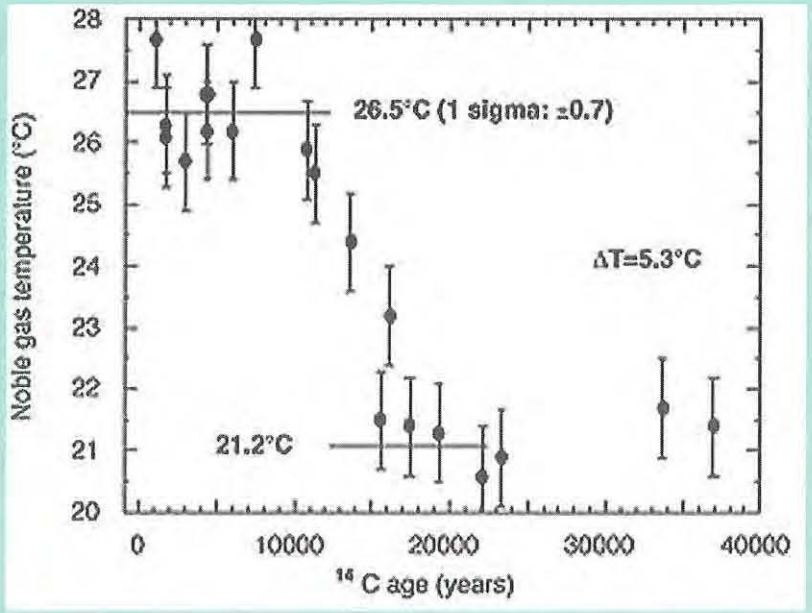
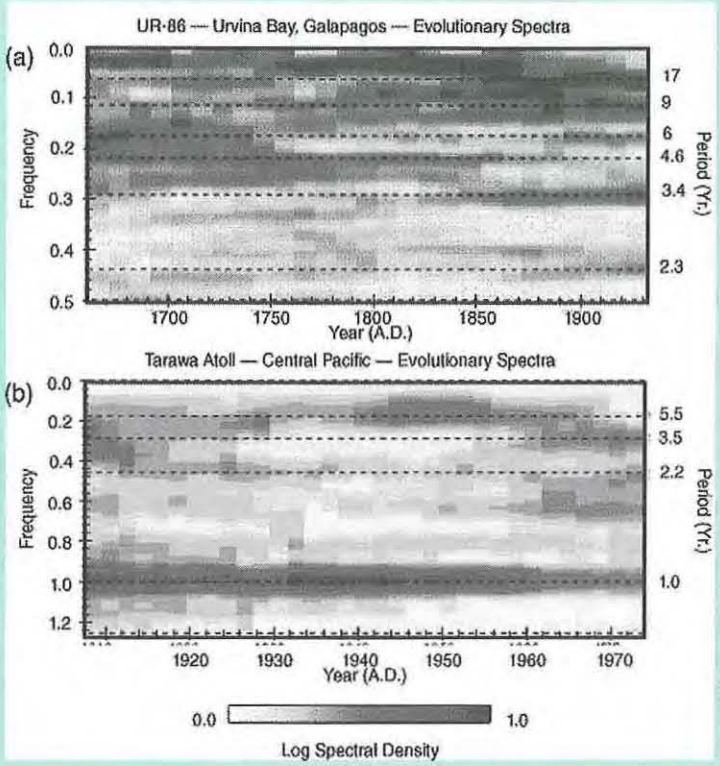


Figure 5 Mean annual ground temperature as measured from noble gas concentration in ground water as a function of corrected radiocarbon age derived from the Stampriet aquifer, Namibia. This record indicates that the mean annual temperature in Namibia was 5.3°C lower during the last glacial maximum as compared to today. Figure from M. Stute and S. Talma (1997) Glacial temperatures and moisture transport regimes reconstructed from noble gases and $\delta^{18}O$, Stampriet aquifer, Namibia. In: Isotope techniques in studying past and curent environmental changes in the hydrosphere and the atmosphere, IAEA, Vienna, in press.

El Niño - Southern Oscillation

One of the most interesting facets of the current climate system is large scale interannual variability. As emphatically demonstrated by ubiquitous references to this year's powerful El Niño in weather reports around the globe, processes such as the El Niño-Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO) make dominant contributions to the spectral variability of today's climate. Clearly, in order to forecast future climate it is imperative to understand possible changes in these processes under perturbed boundary conditions. The PAGES Annual Records of Tropical Systems (ARTS) project has as its primary goal an improved understanding of tropical variability over the past several centuries. Tropical proxy records with annual or better resolution which are being tapped as part of this project include tree rings, corals, tropical glaciers and historical records. The calibration of these diverse sources of data comprises a major initiative which should lead to a reliable ENSO record over at least the last 500 years. Especially in the case of historical records, major effort is required in order to construct calibrated, quantitative records from aesthetically appealing, but qualitative and subjective, historical writings.

As shown in the accompanying figure, indications from coral data suggest that mode of quasi-periodic variability of ENSO which has been prevalent over the past few decades may be quite unique within the longer record. Understanding the causes for the apparent radical shifts in the dominant modes of variability in the tropical ocean is clearly of utmost importance given the widespread climatic, as well as economic, implications of El Niño in 1997.



Evolutionary variance spectra from (a) a 97 year coral-based precipitation record from the Tarawa Atoll in the central Pacific, and (b) a 375 year coral-based SST record from the Galapagos, illustrating how the variance of tropical Pacific climate has changed over the past four centuries. Note how the variability mode of the last few decades is unique with respect to the longer record.

PEP I meeting in Merida, Venezuela March 16 to 20, 1998.

This meeting represents the first attempt to address the goals defined by the IGBP-PAGES initiative "Pole-Equator-Pole Paleoclimates of the Americas" (PEP I). These goals are:

1) to document the inter-relation between climate change patterns in the Americas in terms of amplitude, phase, and geographic extent; and

2) to determine the forcing factors which affected climate change patterns in each hemisphere individually as well as inter-hemispheric changes.

Sixty speakers have accepted the invitation to present an inter-hemispheric overview of climate change and climate variability from atmospheric, terrestrial, ice core and marine records in the Americas, for specific time intervals in the past. In addition, twenty-four posters have been submitted for the poster session, representing specific research projects along the PEP I transect. The outcome from the meeting will be a book comprised of chapters on the individual session topics.

The presentations are organized under the following themes:

Modern Climate Variability *(Henry Diaz, coordinator)*

Last 2000 Years Climate Variability *(Malcolm Hughes, Tim Baumgartner, Lonnie Thompson, coordinators)*

ENSO Climate Variability *(Robert Dunbar, coordinator)*

Human Dimensions *(Diana Liverman, coordinator)*

Mid-Holocene Climate Variability *(Julio Betancourt, Wolfgang Volkheimer, coordinators)*

Late Glacial Climate Variability *(Henry Hooghiemstra, Vera Markgraf, Cathy Whitlock, coordinators)*

Fullglacial Climates *(Thomas Pedersen, Miguel Angel Gonzalez, coordinators)*

For further information contact:
Vera Markgraf
INSTAAR, University of Colorado, Boulder CO 80309-0450
Tel: 303 492 5117; Fax: 303 492 6388
E-mail: markgraf@spot.colorado.edu
http://instaar.colorado.edu/misc/pep.html

seen in the relatively short period of modern meteorological observations. Complementary analyses of lake levels, vegetation change, and archaeological remains confirm that there were periods during the last eight thousand years when the southern Sahara supported extensive greenery and the currently arid land to the south was awash in an extensive system of swamps and lakes. The stark and dramatic contrast to modern conditions serves as a sharp reminder of the range of natural variability that has occurred in the geologically recent past. It also provides a challenge to climate modellers seeking to validate their models using hindcast simulations that can be compared with data-based reconstructions. One of the distinctive features of PEP III is the importance of groundwater, both as an archive of past environmental change (see Figure 5 on page 6) and as a contemporary resource. Without understanding the age, origin and recharge rates of the extant groundwater supply currently being mined for human use, realistic planning for sustainability can not be contemplated.

PAGES coordination of efforts like the PEP transects is helping to forge links between scientists working on a wide diversity of continental and marine records. These latter marine records are especially important to PAGES as they enable long time series, high resolution climate reconstructions from the sediment layers at the bottom of the sea.

At the bottom of the sea

Sediment cores taken from the deep ocean were the first data to clearly confirm that on timescales of 10^4 to 10^6 years, there is a remarkable correlation between global average temperature and the level of solar insolation incident on the northern hemisphere in summer. The pattern of these astronomical changes - often referred to as Milankovitch Cycles after their early proponent - has now been well established, and indeed forms the chronological template for long timescale PAGES related research. The one hundred thousand year glacial cycle cannot be a straightforward result of astronomical forcing alone. Solar irradiance is known to vary more drastically with twenty thousand and forty thousand year periodicity - periods in which there is usually a much less energetic signal in palaeoclimatic records. In addition, the glacial cycle shows a strong signal in the southern hemisphere, yet matches the insolation record at high *northern* hemisphere latitudes. The dynamical, mechanisms responsible for amplifying the one hundred thousand year signal and connecting southern hemisphere glaciation with the northern hemisphere insolation record are not yet clear but probably involve atmospheric greenhouse gas levels, ocean circulation, and the dynamics of continental ice sheets.

Because of the direct relevance to potential future climate change, many palaeoceanographers have turned their attention away from the glacial cycles themselves to the investigation of much more rapid climate shifts seen in high resolution sediment cores.

A stunning series of climate oscillations known as Dansgaard-Oeschger events punctuate the period from the last interglacial up to the last glacial maximum. The most severe cold periods brought armadas of icebergs into the North Atlantic, deposited volumes of ice rafted debris into the sediment record (the so-called Heinrich layers) and plunged much of the globe into near full-glacial conditions.

Perhaps the most well known of the rapid climate swings from the pre-industrial past is the Younger Dryas, a retreat to near glacial conditions which occurred around eleven thousand years ago disturbing the general warming trend following the last glacial maximum. The cooling associated with the initiation of the Younger Dryas event occurred so rapidly, taking perhaps only a few years, that it is not well temporally constrained in many records.

The major PAGES/SCOR initiative in the investigation of marine records of these rapid climate change events of the past, the International Marine Global Change Study (IMAGES) Program, targets the coring and detailed analysis of high resolution marine sedimentary records from those areas of the world's oceans where high rates of horizontal heat transport, biological productivity and wind driven upwelling occur (see Figure 6). Successful coring cruises have already provided a wealth of information from the North Atlantic, while ongoing research continues in the South Atlantic, Indian and West Equatorial Pacific Oceans, promising to extend this valuable database in the near future.

Recent modelling studies suggest that the strength, and indeed the very presence, of the meridional overturning circulation which ventilates the depths of all of the great ocean basins may be highly sensitive to surface temperature and salinity in the subpolar North Atlantic. This overturning circulation, called the thermohaline circulation because it is driven by fluxes of heat and salt at the ocean surface, is responsible for immense poleward fluxes of heat, and serves to link the world's oceans together. The presence of such a circulation provides one potential mechanism for the interhemispheric transmission of widespread climate changes in the past, for example the enigmatic correlation between glaciation in the southern hemisphere and levels of solar insolation in the northern. Furthermore, the apparent sensitivity of this circulation to heat and fresh water perturbations in the subpolar North Atlantic, creates a possible explanation for rapid global, and regional, climate change such as the Dansgaard-Oeschger events and the Younger Dryas.

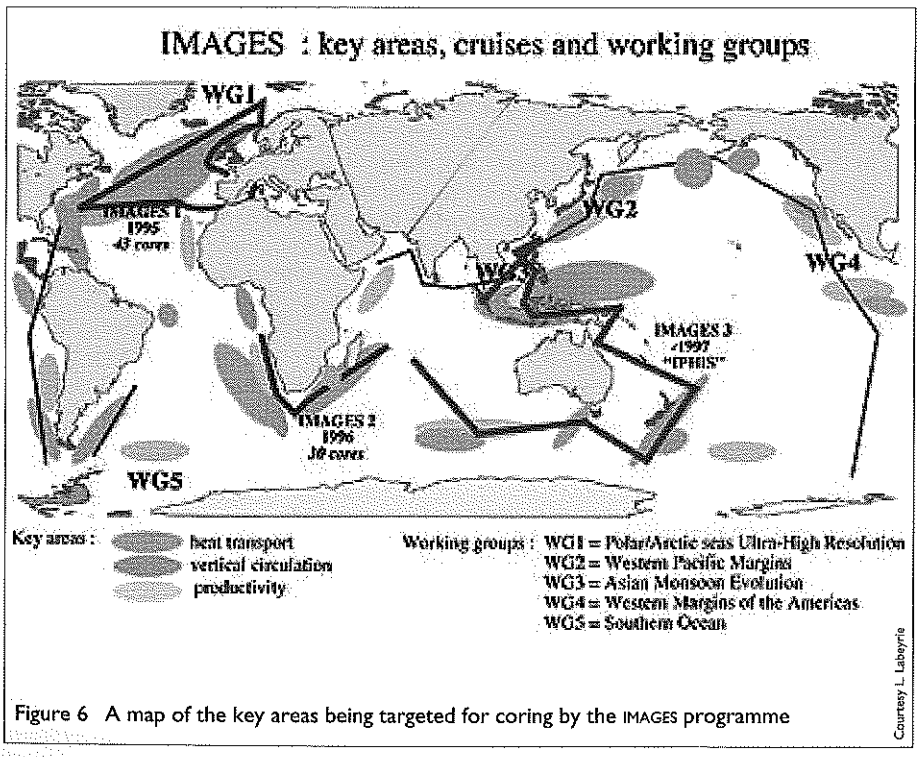


Figure 6 A map of the key areas being targeted for coring by the IMAGES programme

By elucidating the range of ocean circulation states that have existed in the past, palaeodata can serve to confirm the oceanic feedback mechanisms which are thought to modulate external climate forcing, translating low frequency orbital forcing into the dynamic mosaic of spatial and temporal patterns of climate change that have occurred on Earth.

This stark comparison between the smoothness of the orbital forcing and strong millennial variability in local temperatures is highlighted by an example from the North Atlantic for the period of the last interglacial, shown in Figure 7. Although the present interglacial remains relatively quiescent compared to this example, it is nonetheless indicative of potential climatic modes which cannot be ruled out as occurring in a potentially warmer future.

In addition to the direct role the ocean plays in modulation of climate, it also serves as a vast reservoir of carbon, thereby influencing the concentrations of greenhouse gases in the atmosphere. Palaeodata can also be employed to unravel the locations and magnitude of oceanic sources and sinks of carbon which have accompanied climate change in the past, thereby shedding light on the potential future role the ocean may play in modulating increasing atmospheric carbon dioxide levels.

The state of the art in palaeoceanographic data and modelling research will be on display at the International Conference on Palaeoceanography, August 23-28, 1998 in Lisbon, Portugal. Unravelling the full story of the oceanic contribution to past global change is a task that palaeoceanographers within PAGES share with many other empirical researchers, as well as with the climate modelling community. This common interest brings a sharp focus on the most recent past and the transition to the future.

A sharp focus on the most recent past

The prediction of future climate is an extraordinarily difficult task. Although the fundamental physics of greenhouse warming is not in question, the presence of various system feedbacks makes the connection between changes in levels of atmospheric greenhouse gases and changes in global average temperature far from straightforward. Compounding this difficulty is the fact that global average temperature changes in the coming decades will be influenced by changes in many variables unrelated, or related only tangentially, to greenhouse gas levels, such as surface albedo, solar forcing, and cloud cover.

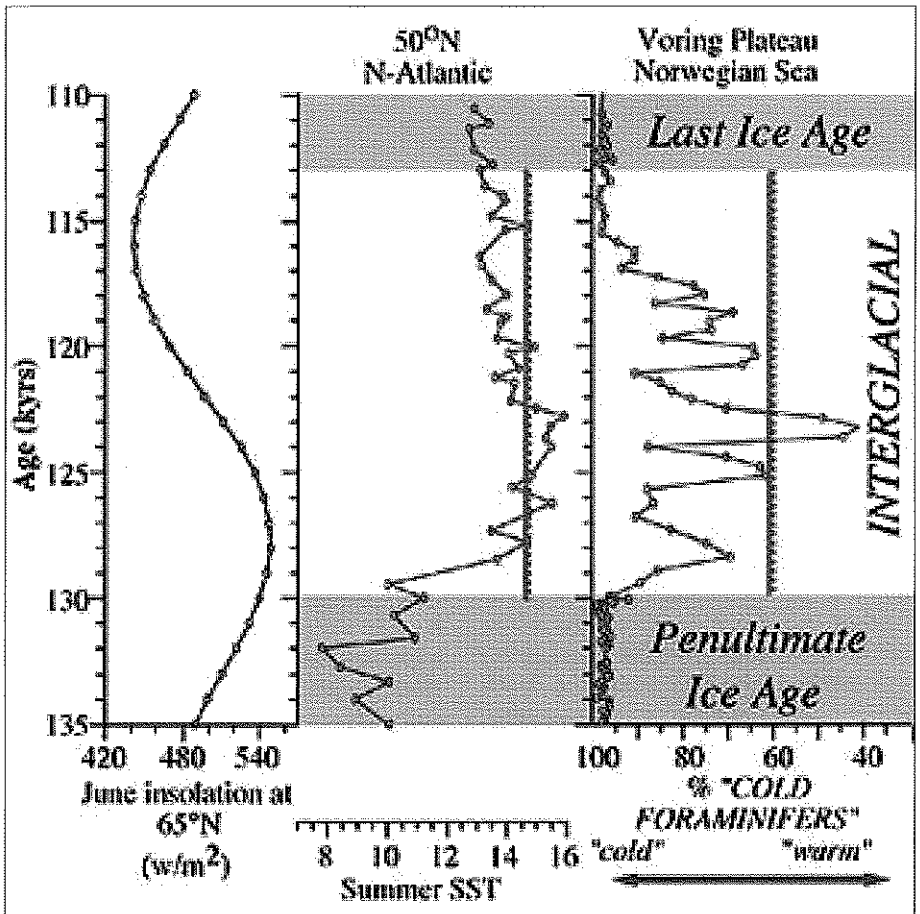


Figure 7 Comparison of insolation curve at 65° North compared proxy sea surface temperature records from sediment cores from the Northeast Atlantic at 54° North (Cortijo *et.al.* Nature **372**, 446-448) and Eastern Norwegian Sea at 66° North (Fronval and Jansen, Nature **383**, 806-810)

Even without anthropogenic changes in greenhouse gas concentrations, the future global average temperature of the Earth would be expected to vary on all timescales, just as it has in the past.

To add yet another difficulty, global average temperature is a relatively "uninteresting" climatic variable. Of far more concern to humanity, and indeed to ecosystems in general, are the detailed temporal and spatial patterns in surface temperature and, especially, in precipitation.

Given this seemingly unending list of complicating factors, at least one fact becomes readily apparent. In order to understand and predict potential future anthropogenic climate change, it is essential to first characterize the envelope of natural variability on the timescales for which a prediction is desired. Climate prediction research has, for the most part, been centred on forecasting climate over the next several decades. Therefore, for this particular problem, it is vital to characterize the nature of annual and decadal variability that was prevalent before the advent of major anthropogenic influence on greenhouse gas levels. Accomplishing this task requires proxy records with annual or better temporal resolution extending back at least several hundred years before industrialization, the central theme of PAGES time stream I research. This is the segment of PAGES research most recognizable for its immediate societal relevance and is highlighted by ongoing fruitful interaction between PAGES and the World Climate Research Program Climate Variability and Predictability (CLIVAR) Program. Some of the key elements of PAGES time stream I research, with particular relevance to climate prediction and greenhouse forcing are discussed below.

Greenhouse gases

The most fundamental variables required for predicting greenhouse warming are the greenhouse gases themselves. At present the most well studied and most radiatively important (next to water vapour) of the radiatively active trace gases is carbon dioxide. Beginning just over forty

years ago the concentration of carbon dioxide in the atmosphere has been measured to a high accuracy at Mauna Loa, providing a remarkable window into the workings of the carbon cycle.

It is only in the context of the palaeorecord that the recent rise in atmospheric CO_2 levels can be recognized as occurring at a rate unprecedented in the natural record with a magnitude of change already as large as that associated with the largest global climate change events in the past million years, such as the glacial cycle itself.

A high resolution CO_2 record over the past five centuries is available from several independent PAGES projects including the GRIP and GISP II in Greenland, and the Vostock core in Antarctica. The PAGES Palaeoenvironments for Ice Cores (PICE) programme seeks to compare the Arctic and Antarctic records to examine, among other things, the interhemispheric phasing of climate change events. Atmospheric mixing of greenhouse gases, unlike more dilatory ocean circulation changes, provides a potential mechanism for synchronous southern hemisphere response to northern hemisphere insolation changes.

Measurements of other important greenhouse gases, such as methane, provide additional information, particularly in terms of the biospheric response to large climate changes of the past. Because methane is not latitudinally well mixed, tropical ice core records can be employed to enhance the polar records, providing additional information sources and sinks of methane in the pre-industrial atmosphere.

Regional variability

Multiple lines of palaeoevidence show that regional climate has been highly variable in the past. Because of the enormous impact of regional climate change on human populations it is vital to understand how such regional events may interact with future global change. Several PAGES projects, including for example that on Palaeomonsoon, are involved with the study of regional climate variability which has occurred in the relatively recent past.

Massive shifts in hydrological regimes have occurred relatively recently in Saharan and sub-Saharan Africa beside which famous modern events such as the Somalia drought of the 1980's and great U.S. 'dustbowl' of the 1930's pale by comparison.

The International Decade of East African Lakes (IDEAL) programme shows similar regional hydrological changes in Equatorial Africa. Intense regional shifts in hydrological regime have also been reconstructed from tree ring data from the continental US as part of the PEP I programme. Of particular interest are several periods of multidecadal drought in California, a region now heavily populated and already experiencing fresh water shortages.

Global average temperature

In many ways the modern instrumental record of global average surface temperature is regarded as the bellwether of anthropogenic influence on climate. However, constructing a global average temperature history is not a trivial task, as is clear from purported discrepancies between the modern terrestrial and satellite records. Clearly, given that the resolution of palaeodata is nowhere near that of the modern instrumental data, global temperature reconstructions are fraught with difficulty. Nonetheless, it is essential to establish the envelope of natural variability in average temperature over the past centuries using networks of multiproxy indicators. This is a major goal of both PAGES and WCRP-CLIVAR.

Natural variability is the "noise" from which the "signal" of anthropogenic climate change has been so difficult to detect. Since anthropogenic and natural forcing factors are superimposed, quantitative reconstruction of climate variability over the last few centuries to millennia is a critical need.

The focus on the recent past, regionally, temporally, and globally, inevitably leads to the study of climate change events which are of particular interest because they occur on time and space scales which correspond with those in which we humans tend to view the world. This intersection between the scales of palaeoclimatic events and the scales of human perception is a powerful reminder of the importance of PAGES research as an appropriate ruler by which to measure potential anthropogenic climate change. It is in this realm that PAGES has its most tangible human dimension.

A human dimension

Incorporating a human dimension in PAGES poses some interesting questions. The impact of land use and land cover change on atmospheric composition in recent times is not yet well quantified. This is a theme to which PAGES, working alongside LUCC and GCTE, can contribute by reconstructing past land cover with adequate temporal resolution and on a global scale. This task is a daunting one, which must nonetheless be undertaken. Complementary, to the global approach is the potential focus on more detailed case studies where LUCC or GCTE have a strong interest in past conditions. These are likely to be areas where the antecedents of present day vegetation and land cover, or the operation of processes beyond the time frame of direct observations, are important to characterize. Especially important are areas where the impact of land cover change has led to significant atmospheric feedbacks at least at regional scale through, for example, changes in radiative balance and transpiration. Case studies of this kind should emerge within the IGBP, wherever the 'historical' questions posed by present day and future-oriented studies match the availability of suitable palaeoarchives.

The continental palaeorecords that are a major focus of PAGES activities contain evidence of human impact on vegetation, soils, rivers and aquatic ecosystems. To what extent are these records of human impact a key concern of PAGES? So far, they have not been prioritized.

The global significance of land use and land cover change, soil degradation, eutrophication, salinization, and pollution on local ecosystems far exceeds any discernible ecological response to greenhouse gas induced global climate change over the last two centuries.

These are the 'cumulative' rather than systemic changes that not only contribute to changes in atmospheric composition and regional climate, as noted above, but also strongly affect the systems of horizontal transfer at and below the Earth's surface. In this area of study, PAGES' interests overlap with those of BAHC and LOICZ.

One area of activity that has been developed beyond the initial stages is that dealing with human impact on fluvial systems. The LUCIFS (Land Use and Climate Influence on Fluvial Systems) programme has reached the stage of defining a range of carefully chosen case studies worldwide, designed to characterize past changes in hydrology and nutrient regimes in different types of physiographic and human systems which have occurred since the advent of widespread agriculture. The title of this initiative recognizes that human and climate influences interact. There is thus the need both to disentangle them insofar as possible, and to understand the interactions between them. This is especially the case with extreme events since

these are of major significance for human activities, and have dramatically different impacts depending on the type of landscape within which they are expressed.

Tools of the trade

Cutting across the PAGES Foci and Activities are a range of investigational tools that are common to many themes. These require special attention and constant refinement.

Any close comparison between palaeorecords requires that they be dated to a common timescale, so the theme of chronology is of paramount importance. In ideal cases, this can be provided by annual banding of some kind - tree rings, lake sediment 'varves', some ice records and growth increments in corals, to name a few. Examples of banding structure in glacial ice and tree rings are shown in Figure 8. But there are many situations, especially in sediment-based studies, where such precise resolution is not possible, yet the value of the palaeoenvironmental evidence is nonetheless outstanding. New tools for improving chronologies in this type of situation are of extreme importance.

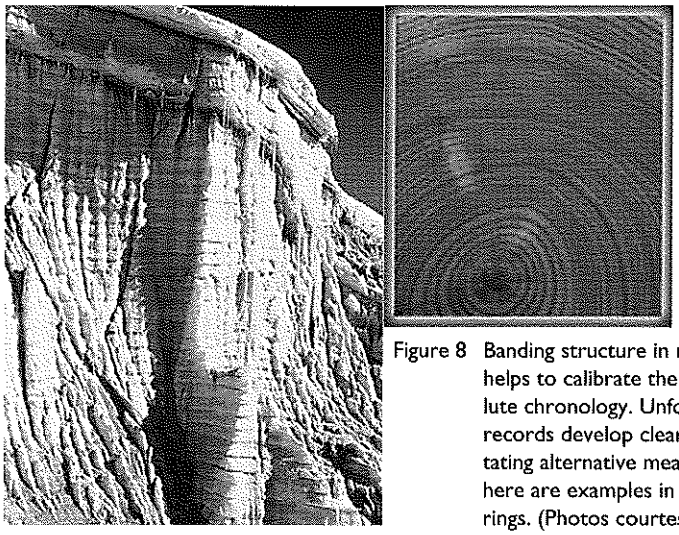


Figure 8 Banding structure in many palaeorecords helps to calibrate the record to an absolute chronology. Unfortunately not all records develop clear banding, necessitating alternative means of dating. Shown here are examples in glacial ice and tree rings. (Photos courtesy of L. Thompson and G. Wellington)

Volcanic tephras

One of the most exciting recent developments has been the use of volcanic tephra as time stratigraphic markers, the subject of the Volcanic Influences on Palaeoclimate (VIP) programme. Icelandic tephras, for example, are quite widespread in Western European continental records as well as a variety of marine records. Moreover, the particles can be fingerprinted geochemically on the basis of extremely small samples. Tephras are of growing interest especially since, in some cases, their presence correlates with distinctive sulphate peaks in ice cores and anomalous growth intervals in tree ring sequences. Thus, in addition to contributing to the chronology of the sites where they are deposited, they can form part of the framework for increasing our understanding of the role of volcanic aerosols in climate forcing. Careful study of volcanic events of the past may help shed light on how volcanic, and indeed anthropogenic, aerosols could interact with future climate change.

Isotope studies

Isotope studies have long been a cornerstone of PAGES science. Their role in Earth system science has been significantly enhanced through the strong impetus given to the Global Network for Isotopes in Precipitation (GNIP) coordinated by IAEA in Vienna. Some examples of isotope records as calibration tools across a range of palaeorecords are shown in Figure 9. Along-

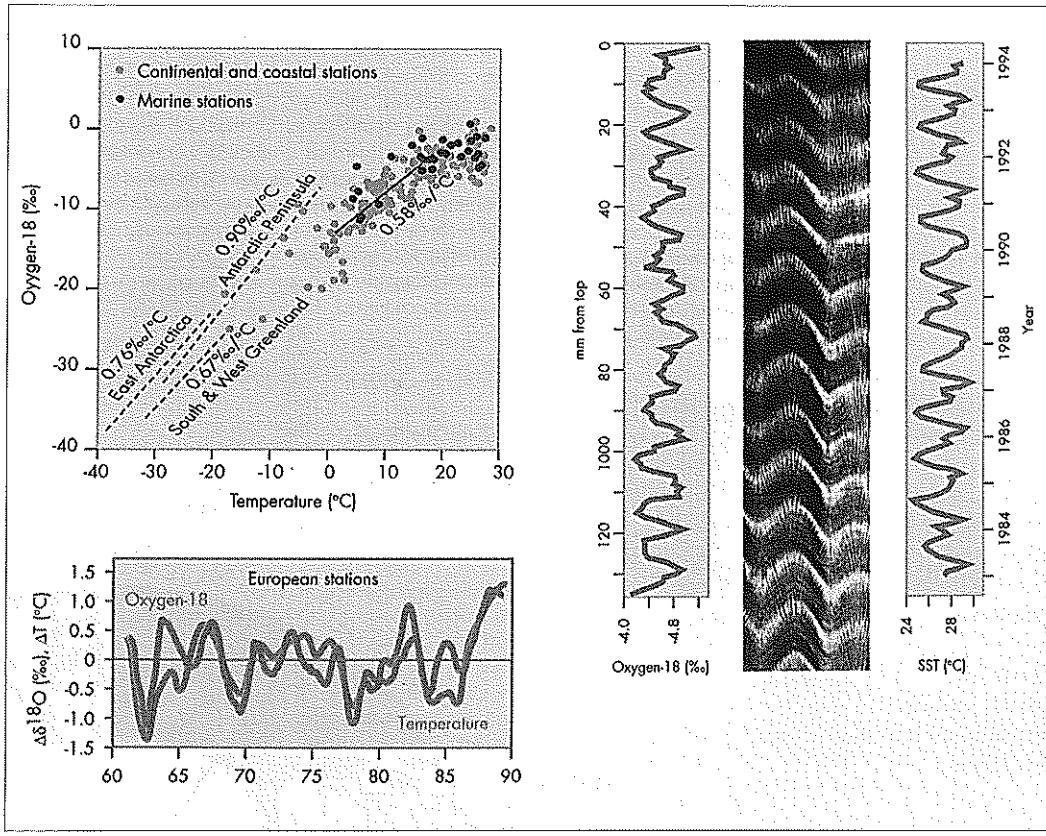


Figure 9 Quantitative calibration of palaeorecords is of paramount importance. Stable isotope signatures provide one of the most effective methods. These graphs, taken from Schotterer et.al. 1996, (Global Network for Isotopes in Precipitation) show (top left) various calibration functions for $\delta^{18}O$ against temperature for different parts of the world, (bottom left) a time-series correlation between $\delta^{18}O$ variations in selected European monitoring stations and deviations from mean annual temperature, and (right) comparison between $\delta^{18}O$ variations in an annually banded coral and measured sea surface temperature over a twelve-year period.

side the continuing GNIP initiative, PAGES is developing a special project designed to improve the basis for interpreting stable isotope records in a range of continental palaeoarchives, including lake sediments, speleothems, tree rings and ice cores. This initiative will pay due regard both to the physical and atmospheric processes controlling the generation of climate-linked stable isotope signatures such as $\delta^{18}O$, as well as to the geochemical and biological influences that regulate isotopic fractionation.

From documents to deep cores

PAGES does not limit itself to unwritten records! Part of the key to establishing the extent to which trace-gas forcing or natural, for example solar or volcanic, forcing is responsible for the most recent patterns of global climate change lies in written documents that can be used to extend the instrumental record back in time. Here, the overriding need is for common and objective procedures designed to quantify climate inferences drawn from documentary evidence. PAGES plans to play a leading role in this area of research in the near future.

At the opposite end of the PAGES time frame, the reconstruction of climate variability and ecosystem response on the timescale of glacial/interglacial cycles, there is a need for long cores from continental sediment sequences that span at least the last two hundred thousand years. This is a technically challenging enterprise, though high quality results of major significance for global change research are the guaranteed reward when the sites are carefully chosen and adequate pilot surveys are carried out in advance. Through participation in the International Continental Drilling programme, PAGES is targeting sites within each of the PEP Transects and the first stages of study at top priority sites are already under way.

Putting it all together

PAGES derives its distinctive identity from prioritizing the study of those aspects of past global change that contribute crucially to our understanding of Earth system function on human time-scales and to our capacity to improve the quality of any assessment of future climate changes and their impacts. Even with this strongly focused research agenda, the range of tasks to which PAGES is committed is broad and diverse. The challenge of synthesizing the results is a daunting one. Full documentation of all the PAGES activities will soon be available through publication of the 'PAGES Status Report and Implementation Plan', now complete and due for publication early in 1998.

To some degree, the structure of PAGES includes built-in patterns of coordination. Some of these, like PEP I, are already at the stage where preliminary synthesis can be attempted (see box on page 7). Beyond these, the PAGES Open Science Meeting to be held in London April 20 - 23, 1998, will provide an over-arching compilation of PAGES science and of its significance for the future (see box on opposite page).

In parallel with presentational syntheses at meetings and in the publications that grow out of them, PAGES shares responsibility for the WDC-A Palaeoclimate Data Base which can be accessed via NGDC in Boulder Colorado http://www.ngdc.noaa.gov/wdc/wdca/wdca-paleo.html or http://www.ngdc.noaa.gov/paleo/paleo.html. This data repository constitutes a major global resource and a long term PAGES legacy of growing value. Efforts are underway to ensure that the facility meets the data needs of all PAGES research. A data workshop in February 1998 will be an important stepping-stone in this direction.

As the PAGES science programme gains momentum, so does the obligation to communicate the results to a wider audience and to accept a role in education and capacity building. Some recent educational initiatives are noted in the accompanying box below.

All the above is a measure of the maturation of the PAGES research agenda. It is also a tribute to the ground-breaking leadership of PAGES in its early days, notably through the insight and vision of Hans Oeschger and those colleagues who laid the foundations of the project within the IGBP framework almost ten years ago.

Keith Alverson, Scientific Assistant,
Frank Oldfield, Executive Director
PAGES IPO, Bärenplatz 2, CH-3011 Bern, Switzerland
http://www.pages.unibe.ch/

A Capacity Building Role

An important and growing educational role is beginning to develop within the scope of PAGES activities. One example is the Nyanza project on the shores of Lake Tanganyika. There, university undergraduate students from the United States and young African researchers will study tropical lake science in a summer programme for each of the next five years. Lake Tanganyika is one of the great East African rift lakes, a system of lakes which comprises one of the most scientifically important and fastest changing tropical lake systems in the world. The project fulfills part of the training mission of the International Decade of East African Lakes (IDEAL) programme, one of the Tasks within the PEP III transect.

PAGES is also very closely involved in the upcoming Advanced Study Course Program to be held in the Environmental Change Research Center, University College London funded by the Environment and Climate Program of the European Union. The theme of the course, which is expected to attract an international enrolment of approximately 25 graduate students, will be 'Holocene Climate Reconstruction.'

In the somewhat longer term, the PAGES IPO plans to develop a suite of educational materials for widespread distribution and to play a more proactive role in capacity building in nations where PAGES science is less fully developed.

Past Global Changes and Their Significance for the Future

IGBP PAGES Open Science Meeting

The meeting will be organized around invited plenary presentations and high-profile poster sessions. The poster sessions will be focused on the recent scientific results of PAGES activities, and the plenary presentations will focus on:

1. The full range of climate system variability
2. Climatic forcing
3. Climate system processes
4. Modelling the climate system
5. Biotic responses to climate change
6. Human consequences of climate change

The Meeting will open with registration and a reception on the evening of April 19, 1998, followed by the first lecture and poster sessions on April 20 from 8:30 am onwards. The closing sessions will be during the afternoon of April 23.

In view of the massive response to the call for abstracts, the venue has been changed to the Senate House of the University of London. This includes a lecture theatre for 500 people. It also means that participation in the meeting is open to a much larger number of scientists whether or not they intend to present posters.

The list of invited speakers is as follows: Richard Alley, Zhisheng An, Edouard Bard, Rick Battarbee, Juerg Beer, Ed Boyle, Ray Bradley, Keith Briffa, Paul Colinvaux, Elsa Cortijo, Anne De Vernal, Peter DeMenocal, Mike Gagan, Francoise Gasse, Sandy Harrison, Sylvie Joussaume, Jean Jouzel, Jim Knox, Suki Manabe, Vera Markgraf, Bruno Messerli, Jonathan Overpeck, Tom Pedersen, Colin Prentice, Dominique Raynaud, David Rind, Thomas Stocker, Lonnie Thompson and Greg Zielinski.

All oral presentations are by invitation and in plenary sessions and this section of the programme is now complete. The deadline for acceptance of additional *poster* abstracts is January 20, 1998. An Abstract Volume will be compiled from mid-January onwards.

The proposed fees, including the cost of the volume of abstracts, are:

Full registration fee: £100 (US$150)
Student registration fee: £35 (US$50)

For further information:
PAGES International Project Office
email: pages@pages.unibe.ch
web: http://www.pages.unibe.ch/
tel: +41 31 312 31 33
fax: +41 31 312 31 68

PAGES Projects and Project Leaders

FOCUS 1 Global Palaeoclimate and Environmental Variability

(PANASH)	
Palaeoclimate of the Northern and Southern Hemispheres	R. Bradley (USA)
Activity 1 **Pole-Equator -Pole (PEP) I: The Americas Transect**	V. Markgraf (USA)
Activity 2 **PEP II: The Austral-Asian Transect**	T.S. Liu (China), J. Dodson (Austrailia)
Task 1 (BDP)Baikal Drilling Project	D. Williams (USA)
Task 2 (HIPP)Himalayan Interdisciplinary Palaeoclimate Project	C. Wake (USA)
Activity 3 **PEP III: Afro-European Transect**	F. Gasse (France), R. Battarbee (UK)
Task1 (IDEAL) International Decade of East African Lakes	E. Odada (Kenya), T. Johnson (USA)
Task 2 (PM-II) Palaeomonsoons II	S. Kroepelin (Germany)
Activity 4 **(IMAGES)**	
International Marine Global Change Study (w/SCOR)	L. Labeyrie (France)
Activity 5 **PAGES-CLIVAR Intersection**	J. Overpeck (USA), J-C. Duplessy (France)
Task 1 (ARTS) Annual Records of Tropical Systems	J. Cole (USA)

FOCUS 2 Palaeoclimate and Environmental Variability in Polar Regions

Activity 1 **Arctic Programmes**	
Task 1 (CAPE) CircumArctic Palaeo-environments	G. Miller (USA)
Task 2 (NAD) Nansen Arctic Drilling	L. Johnson (USA)
Task 3 (GISP 2) Greenland Ice Sheet Project (USA)	P. Mayewski (USA)
(GRIP) Greenland Ice Sheet Project (Europe)	B. Stauffer (Switzerland)
Task 4 (ICAPP) International Circum-Arctic Paleoclimate Programme	R. Koerner (Canada) G. Zielinski (USA)
Activity 2 **Antarctic Programmes** (w/ SCAR)	
Task 1 (ITASE) International Trans-Antarctic Scientific Expedition	P. Mayewski (USA)
Task 2 (ANTIME) Antarctic Ice Margin Evolution	I. Goodwin (Austrailia)
Activity 3 **Bi-Polar Programmes**	
Task 1 (PICE) Palaeoenvironments from Ice Cores	D. Raynaud (France)

FOCUS 3 Human Interactions in Past Environmental Changes

Activity 1 **(LUCIFS)**	
Land Use and Climate Impacts on Fluvial Systems	R. Wasson (Austrailia)
Activity 2 **(HITE)**	
Human Impacts on Terrestrial Ecosystems	F. Oldfield (Switzerland)

FOCUS 4 Climate System Sensitivity and Modelling

Activity 1 **Climate Forcing and Feedbacks**	
Task 1 (VIP) Volcanic Influences on Palaeoclimate	J. Beget (USA)
Task 2 Solar Influences	
Task 3 Greenhouse Gases and Aerosol Influences	
Activity 2 **Climate Model - Data Intercomparisons**	
Task 1(PMIP) Palaeoclimate Modelling Intercomparison Project	S. Joussaume (France), K. Taylor (USA)
Task 2 (PMAP)	R. Webb (USA),
Palaeoenvironmental Multiproxy Analysis and Mapping Project	S. Harrison (Sweden)
Task 2a Biome 6000 (w/GAIM/DIS/GCTE)	C. Prentice (Sweden)

FOCUS 5 Cross-Project Analytical and Interpretive Analysis

Activity 1 **Chronological Advances**	J. Pilcher (UK)
Activity 2 **Development of New Proxies**	
Task 1 Isotope Calibration Study	T. Edwards (Canada)
Task 2 Continental Drilling for Palaeoclimate	S. Colman (USA)
Activity 3 **(WDC-A) International Palaeo-Data System**	J. Overpeck (USA)
Activity 4 **(REDIE) Regional, Educational and Infrastructure Efforts (w/ START/IAI)**	

Regional Workshops as a Tool to Build Global Understanding of the Coastal Zone

by P.R. Boudreau, S.V. Smith, F. Wulff, S. Ibarra-Obando and R. Buddemeier

The central and essential objectives of the Land-Ocean Interactions in the Coastal Zone (LOICZ) Core Project are to:

- to determine at global and regional scales the fluxes of the key nutrient elements carbon, nitrogen, and phosphorus, between land, sea and atmosphere through the coastal zone;
- to understand how the coastal zone effects these fluxes through biogeochemical processes; and,
- to understand relationships of these fluxes to human intervention.

One of the earliest activities in the work to achieve these objectives was the writing and publication of the LOICZ Biogeochemical Modelling Guidelines, Gordon *et al.* (1996), and the subsequent establishment of a WWW modelling home page on the internet at: "http://www.nioz.nl/loicz/modelnod.htm". These two publications provide the LOICZ research community with detailed methodologies and examples of the data and analysis required by the project to compile global estimates of carbon, nitrogen and phosphorus (C, N and P) in the world's coastal zones. Experience has shown that, although there may exist much detail data for local sites, much of this information is strongly directed to the local scientific interests of the researchers. The global aims of the LOICZ project require useful methods for taking such detailed information and compiling it in a way that allows comparison and integration into global estimates.

These publications, and the methodologies described, would not have been possible without the active participation of researchers from around the globe. To promote the necessary help and input, LOICZ has convened several workshops on material fluxes in coastal waters at:

- The Centre for Marine and Coastal Studies, University of Malaysia, Penang, Malaysia, November, 1995;
- Nigerian Institute for Ocean and Marine Research (NIOMR), Lagos, Nigeria, November, 1996; and, most recently,
- the Center for Scientific Research and Higher Education of Ensenada (CICESE), Ensenada, Mexico, June, 1997 .

The workshop participants helped initially to develop the LOICZ Guidelines and methodologies for biogeochemical modelling and continue to play an important role in refining and expanding their application. Although each workshop had a regional aspect to it, each has helped to build a broader global view of nutrient flux in marine coastal waters.

The Penang, Malaysia, workshop was one of the first in the series and relied heavily on the researchers from the five SARCS/WOTRO/LOICZ Core Research Sites in Indonesia, Malaysia, the Philippines, Thailand and Vietnam. This work, jointly sponsored by the South East Asian Centre for START (SARCS), the Netherlands Foundation for the Advancement of Tropical Research (WOTRO), and LOICZ, was used to critically review the water, salt and nutrient budgeting approach in different biophysical settings to assess their usefulness in generating comparable data. Although a number of difficulties were identified in some situations, it was generally agreed that the methodologies were useful in taking diverse and detailed data and information for local sites and generating measures that quantify the important processes on regional and global scales. The methodologies provide robust estimates of the quantities of carbon, nitrogen and phosphorus moving into and out of coastal marine systems. They also provide insight into the fate of such nutrients within the systems.

The second workshop in Lagos, Nigeria, co-sponsored by the Joint Global Ocean Flux Study (JGOFS) of the IGBP and SCOR, the Scientific Committee on Oceanic Research (SCOR), and the Intergovern-

Table 1. Mexican ecosystems for which budgets have been developed.

System and State	#	Authors	Latitude N	Longitude W
Estero de Punta Banda, *Baja California*	1	M. Poumian-Tapia,. V. Camacho-Ibar, S. Ibarra-Obando	31° 44'	116° 38'
Bahía San Quintín, *Baja California*	2	V. Camacho-Ibar, J.D. Carriquiry, S.V. Smith.	30° 27'	115° 58'
Bahía San Luis Gonzaga, *Baja California*	3	F. Delgadillo-Hinojosa, J. A. Segovia-Zavala	29° 49'	114° 23'
Estero La Cruz, *Sonora*	4	M. Botello-Ruvalcaba, E. Valdez-Holguín	28° 45'	111° 53'
Bahía Concepción, *Baja California Sur*	5	C. Lechuga-Devéze.	26° 39'	111° 30'
Ensenada de La Paz, *Baja California Sur*	6	C. Lechuga-Devéze.	24° 08'	110° 22'
Bahía de Altata-Ensenada del Pabellón, *Sinaloa*	7	F. Flores-Verdugo, G. de la Lanza-Espino	24° 25'	107° 38'
Teacapan-Agua Brava-Marismas Nacionales, *Sinaloa and Nayarit*	8	G. de la Lanza-Espino, F. Flores-Verdugo F. Wulff	22° 08'	105° 32'
Carretas-Pereyra, *Chiapas*	9	F. Contreras-Espinosa.	15° 27'	93° 10'
Chantuto-Panzacola, *Chiapas*	10	F. Contreras-Espinosa, S. Ibarra-Obando	15° 13'	92° 50'
Laguna Madre, *Tamaulipas*	11	S. Ibarra-Obando, F. Contreras-Espinosa	24° 00'	97° 00'
Laguna de Terminos, *Campeche*	12	E. Gomez-Reyes, A. Vázquez-Botello, J.D. Carriquiry, R. Buddemeier.	18° 40'	91° 35'

P.R. Boudreau

Mexican oyster aquaculturist at work in San Quintin Bay, Baja California, Mexico.

mental Oceanographic Commission (IOC), was convened by the JGOFS/LOICZ Continental Margins Task Team (CMTT) to address material flux in deeper water further off the coast (http://keep.oc.ntu.edu.tw/cmtt). In this situation, where the flow of water and materials is not as physically constrained as in coastal lagoons and estuaries, a number of new approaches were required to implement the budgeting methods advocated by LOICZ. This work continued at a CMTT workshop held in October, 1997.

The most recent workshop focused on Mexican coastal lagoon systems. It was held at the Center for Scientific Research and Higher Education of Ensenada (CICESE), Mexico, on June 2-3 1997.

Coastal lagoons along the 12,000 km shoreline of Mexico are numerous, diverse, and well-studied. They are also subject to extremely varied degrees and kinds of human pressure due to direct uses and indirect insults. Considerable scientific information exists for many of these systems, and the bibliographic information has been well summarized. A workshop in the region seemed likely to yield several useful budgets, to generate interest in the region in developing additional budgets, and perhaps to provide a formula for generating regional budgets elsewhere that would usefully contribute to the LOICZ world-wide database and analysis.

The bulk of the meeting was loosely structured around the different hydrological regimes of the Mexican coastal zones that represent a broad range in environmental situations:

- the arid desert region of Baja California, Baja California Sur, Sinaloa and Sonora;
- the high-runoff region of Nayarit, and Chiapas; and,
- the transition region between the high runoff area of the lower part of the Gulf of Mexico coast and the Yucatan Peninsula, which is dominated by low surface runoff and high groundwater flow.

The Mexican participants came to the workshop very well prepared with data and a good overall understanding of the different systems. Eight budgets were largely completed during the three days of the workshop. Subsequent to the completion of the workshop, four additional budgets were provided and all twelve budgets have been published in a report as well as on the WWW home page of LOICZ (http://www.nioz.nl/loicz/). Table 1 summarizes the lagoon systems which have been budgeted, the authorship and the location for each system.

As was found for the SARCS/WOTRO/LOICZ Core Research Sites, some of the sites modelled required some ingenious modifications of the strict budgeting approach. But within the overall analytical framework, the outputs were consistent. Again, this cooperative work was able to generate quantitative estimates of fluxes that are robust and comparable among the diverse sites. Additional budgets have been proposed and/or are under development other lagoonal systems within Mexico, as a result of this workshop. With such success in these diverse coastal environments, we are confident that global estimates based on these simple budgets are possible.

Work on compiling additional budgets world-wide continues. Led by Steve Smith, Fred Wulff and the LOICZ International Project Office (IPO), over 50 budgets have been compiled for many coastal areas in ranging in latitude from 64°N to 35°S. Most of these have been posted on the World Wide Web Page. Although it is anticipated that detailed analysis of global patterns will not be rigorous until 150 to 200 budgets have been compiled, work has begun on linking these local budgets with more general information on global scales to look for methods of scaling up the results. Of particular interest in the coming months will be the comparison of results from similar, but geographically distant, sites such as have been compiled from Mexico, Africa and South East Asia.

By focusing on directed regional workshops, LOICZ has developed an initial local and regional basis for its continuing work in understanding the important processes that make the world's coastal zones critical to the regulation of the flow of nutrients from the land to the oceans.

The LOICZ Project would like to thank all of the researchers that have so far contributed to this initiative and actively encourage other researchers to become involved. In this way researchers are able to place their individual research efforts in a global context while contributing to the development of a better understanding of the Earth's diverse coastal zones.

Much additional information on LOICZ, and the biogeochemical modelling approach, can be found within the WWW home pages at: "http://www.nioz.nl/loicz/" or from the LOICZ International Project Office (IPO).

Paul R. Boudreau, LOICZ IPO, NIOZ, PO Box 59, 1790 AB Den Burg - Texel, Netherlands. E-mail: loicz@nioz.nl **Stephen V. Smith**, School of Ocean & Earth Science and Technology, University of Hawaii, 1000 Pope Road, Honolulu, HI 96822, USA. E-mail: svsmith@soest.hawaii.edu **Fred Wulff**, Department of Systems Ecology, Stockholm University, S-106 91 Stockholm, Sweden. E-mail: fred@system.ecology.su.se **Silvia Ibarra-Obando**, Division Oceanología, CICESE, PO Box 434843, San Diego, California 92143, USA. E-mail: sibarra@cicese.mx **Robert W. Buddemeier**, Kansas Geological Survey, University of Kansas, 1930 Constant Avenue, Lawrence KS 66047-3720, USA. E-mail: buddrw@kgs.ukans.edu

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Smith, S.V. et.al. 1997. *Comparison of Carbon, Nitrogen and Phosphorus Fluxes in Mexican Coastal Lagoons*. LOICZ/R&S/97-10. Texel: LOICZ, 86pp.

African-GAIM Modelling Workshop

by Berrien Moore and Dork Sahagian

From March 3-12 1997 the African-GAIM Modelling Workshop was held in Mombasa, Kenya, sponsored by the US National Science Foundation (NSF), US National Aeronautical and Space Administration (NASA), US Environmental Protection Agency (EPA), US National Oceanographic and Atmospheric Adminsitration (NOAA), the World Meteorological Association (WMO), START and the African Association of Universities (AAU). The workshop focused on models applicable to Africa in the global context, including terrestrial ecosystem and hydrologic models. Hydrological and ecological models were presented, run by participants in hands-on "laboratory" sessions, and interpreted in terms of African and global applications. Participants developed their own modelling projects during the workshop, to be subsequently expanded at their home institutions as part of broader African global change modelling community. The intent was to include as many younger scientists as possible.

The workshop was directed toward:

- Analyzing key models and data with particular relevance to Africa,
- Interpreting the capability of these models to describe system processes within the region, and validation with field data,
- Building the international modelling and data infrastructures needed to support fully the IPCC process,
- Expanding the capability within Africa to use models focused upon key topics within the overall theme of global change, including
  - the effect of land use change on carbon and nutrient cycling in terrestrial ecosystems, and
  - water cycling and water management.
- Developing model applications to problems associated with land use changes and sustainability of African agricultural and other land use.

Participants divided into two parallel sessions with one focusing on hydrologic models and the other on ecological models. These models were presented by their developers and workshop participants were given hands-on experience in running and manipulating the models and their results. Subsequently, a simple box-modelling program was introduced to give the participants the opportunity to recreate certain aspects of the hydro- and eco- models as well as to create their own models in real time at the workshop. The final phase of the workshop was a team effort by groups of participants to develop a project or pose a tractable problem for collaborative research in the months following the workshop. These included some which represented extension of existing African IGBP programmes as well as new projects which were formulated at the workshop. The presentations of the participants highlighted the fact that there is a great deal of research expertise throughout Africa. There are also numerous international research programs being conducted throughout Africa, some within the auspices of IGBP.

A special session was held for discussion of issues impacting the African global change research community. Of these, two issues emerged as primary- resources, and human impacts. It was clear from the start of the workshop that in many institutions throughout Africa, there are insufficient resources to conduct the research needed to support an African modelling community. In particular, even the most basic computing facilities are often lacking. It was

Participants at the African-GAIM Modelling Workshop.

determined that this problem could best be solved in the context of active research projects. In the course of collaborative funded research, the necessary resources for modelling projects would become available. The workshop participants are formulating research projects in the months following the workshop. The second issue was the importance of human impacts of global change to the African research community. In most regions in Africa, there is considerable concern regarding the ability of current and projected food production systems to provide sufficiently for the growing population in the face of changing and variable climate conditions. A significant aspect of the workshop was to prepare the participants to return to their home institutions with the modelling exposure that will enable them to help build a stronger, more integrated African modelling community. In addition, the participants will act as a knowledge base for further education and capacity building within the African universities and research community in the coming years.

The African-GAIM Modelling Workshop was a first step in augmenting the African global change modelling community. In considering future workshops, it was agreed by the participants that while the format for this first activity was an appropriate beginning, the next gathering should be based on the presentation of concrete results from modelling projects which emerged from the workshop. The participants will keep in contact with each other and with GAIM in the meantime throughout the development, funding and implementation of their projects.

Berrien Moore III and Dork Sahagian, gaim Task Force Office, Institute for the Study of the Earth, Oceans and Space, University of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, USA. E-mail: gaim@unh.edu

The IGBP-DIS Regional Satellite Fire Data Compilation

The IGBP-DIS Office has developed, under the guidance of the IGBP-DIS Fire Working Group, a Regional Satellite Fire Data Compilation which is now available to the scientific community, both in the form of a CD-ROM and from the World Wide Web IGBP-DIS home page (http://www.meteo.fr/cnrm/igbp/).

During its second meeting (Ispra, Italy, 1995), the IGBP-DIS Fire Working Group recognized that there were several existing regional fire data sets, from various satellite sources and different time periods, in various stages of completion and availability amongst the fire remote sensing community. The Working Group recommended that these data sets be compiled and made readily available to the IGBP community. It was agreed that the main objectives for the Data Compilation were as follows:

- Provide easy access to existing satellite fire data sets
- Demonstrate the current capability for regional fire detection and monitoring from satellite
- Provide links to source and derived satellite data sets, as well as links to scientists, facilities, data archives, and bibliography
- Help the user community understand the contributions and limitations of Global Fire Products, including those currently available from the European Space Agency and in development at the Joint Research Centre of the European Commission (JRC)
- Help in laying out the specifications for future fire products and fire sensing systems.

It was agreed that the Data Compilation project would be managed at the IGBP-DIS Office by Martine Michou, with technical guidance from partners at the Space Applications Institute of the JRC, the NASA Goddard Space Flight Center Global Inventory Monitoring and Modelling Studies group, and the Department of Forestry of the Technical University of Lisbon.

Implementation started in early 1997, with a data set solicitation forwarded to about forty different groups of the fire remote sensing community around the world. Overall, more than half of the scientists originally contacted contributed to the Fire Data Compilation, and we are very much indebted to the scientists who prepared their data, and reviewed the Compilation.

Data sets provided consist of pre-fire, active fire and post-fire parameters; the most important pre-fire parameters which can be derived from remotely sensed measurements are those related to the amount and condition of the plant biomass potentially involved in the combustion process. Heat and smoke are the two types of active fire signal that can be detected with the help of remote sensing techniques. This leads to the possibility of quantifying some of the most often requested information items, such as the location and extent of active flame fronts, the timing of fire occurrence, and the fire temperature. As for post-fire parameters, two post-fire signals amenable to detection with remote sensing techniques are considered, charring, i.e. the deposition of a charcoal layer on the burned surface, and formation of a fire-scar. Analysis of these signals permits the quantification of, for instance, the areal extent of burns.

Fire data set satellite sources represented in the Data Compilation include the NOAA Advanced Very High Resolution Radiometer, the DMSP Operational Linescan System, the ERS Along Track Scanning Radiometer and Synthetic Aperture Radar, the GOES Imager, and the LANDSAT Thematic Mapper and MultiSpectral Scanner sensors. Data are available over different regions of the world on all continents. Each data set is accompanied by a documentation that provides the background information needed to assess the usability of the product according to one's needs and objectives. The requested form of acknowledgment for the data set authors is given in the documentation for each data set.

The IGBP-DIS Regional Satellite Data Compilation is accessible from any computer platform (PC, Macintosh or Unix Workstation) equipped with a Word Wide Web browser.

M. Michou and **G. Szejwach**, IGBP-DIS Office, CNRM, 42 avenue Gustave Coriolis, 31057 Toulouse Cedex, France.
E-mail: sec@igbp.cnrm.meteo.fr

People and Events

Executive Officer for LUCC

Xavier Baulies i Bochaca is an ecologist and a cartographer. Since the autumn of 1996 he is also the Executive Officer of the International Project Office of the LUCC (Land Use and Cover Change) project co-sponsored by IGBP and IHDP (International Human Dimensions Programme). His earlier research, at the Barcelona University, was in Plant Ecology and Phytosociology analyzing the distribution of vegetal communities. He has worked on mapping the alpine vegetation of the Catalan Pyrenees by means of satellite imagery and aerial photography through his work in Remote Sensing and Cartography.

From 1987 onwards he was the Head of Thematic Applications of Remote Sensing at ICC (Institut Cartogràfic de Catalunya) until his appointment to the LUCC office. He is an expert in remote sensing and GIS, and has actively participated in initiatives related to land cover mapping in Catalonia, Spain and Europe. He was responsible for a number of experimental and operational projects, as well as the CASI sensor (Compact Airborne Spectrographic Imager) experimental and operational applications (e.g. forestry and agricultural inventories, water pollution and vegetation mapping). He is project coordinator of the CORINE Land Cover project in Spain for the Eastern Iberian Peninsula and Balearic Islands. Prior to that he was the coordinator of land use and cover mapping in Catalonia, and developed specific nomenclatures and methodologies also for Spain. Recently he has been working in the development of expert systems for land cover classification and of geomatic data integration methodologies using Remote Sensing and GIS techniques.

Xavier Baulies

New Chair LOICZ

Since July 1997 Han Lindeboom is the new Chair of the Land-Ocean Interactions in the Coastal Zone (LOICZ) Core Project, a position he has taken over from Edgardo Gomez. A biologist and biochemist by training he started by studying the phosphate cycle of the North Sea and carried out his PhD research on the nitrogen cycle in penguin rookeries off the coast of South Africa.

Since then he has been involved as an ecologist and a toxicologist in projects for the Netherlands government. He is a member of the SCOR Working Group 105 on the Impact of World Fisheries on Marine Ecosystems as well as the ICES working group on Effects of Fisheries, and is the coordinator for the EC project IMPACT II. He has been working at the Netherlands Institute

The Officers at their 10th Meeting in Rio de Janeiro, Brazil

Han Lindeboom

for Sea Research (NIOZ) as Head of the Department of Marine Sciences, dealing with problems like eutrophication, pollution and the effects of fisheries. Presently he heads the Department of Marine Ecology at the same institute. As Chair of the LOICZ SSC he hopes to use his skills to lead the project into the future where the greatest challenge is to bring together research in many diverse scientific fields and geographic regions.

Third Conference of the Parties (COP3) in Kyoto

From 1-10 December, 1997. the Third Conference of the Parties was held in Kyoto, Japan. At the 1992 Rio Earth Summit the Framework Convention on Climate Change was adopted and signed by 154 states. The Convention established a process for responding to climate change over the decades to come and in particular , set up a system whereby governments report information on their national greenhouse gas emissions and climate change strategies. This information is reviewed on a regular basis in order to track the Convention's progress. The Convention entered into force in 1994 and today has close to 170 parties. At the first session of the Conference of the Parties in Berlin, 1995, the Berlin Mandate was established to call on governments to set specific, legally-binding targets and timetables for reducing developed country emissions of greenhouse gases, for adoption at COP3 in Kyoto. The countries involved in the decision process all have different priorities and the challenge for COP3 was to agree on a protocol in Kyoto that could be ratified by the countries.

Professor Tadaki Hirose attended the Conference, representing the IGBP and mostly ICSU. Although COP3 is a very high profile political meeting, the IGBP did want to use the opportunity to release the first Science Report: the Executive Summary Report of the GCTE Synthesis. Many delegates received a copy of the publication and the document was received with great interest.

The discussions leading up to the agreement were very intensive and in some cases quite heated, but the meeting ended with an agreement on CO_2 reduction among the parties, a significant step.

TEACOM Workshop

Under the joint support of APN, START and SSTC (the State Science and Technology Commission of China), an international workshop on Regional Modelling of the "General Monsoons System" in Asia was held in Beijing, China, on October 20-23, 1997, which was hosted by the START Regional Center for Temperate East Asia (TEA). The primary purpose of the workshop was to merge on-going national projects in the region with this regional initiative and to develop international partnerships beyond the region in the form of cooperative research, data and resource sharing, training and capacity building. The workshop was attended by approximately 50 participants from 11 countries. At the workshop 20 leading international scientists and researchers presented their latest research results in the field of Regional Climate Modelling and with a particular emphasis on the General Monsoon System in Asia. Among the scientific issues discussed was a physical-biological-chemical-social coupled monsoon system model, as well as nesting techniques between GCMs and RCMs and the quality of observed data sets used to validate model results. The workshop was very successful and the proceedings of the workshop will be published in January 1998.

At the TEACOM Workshop in Beijing, China

- Congbin Fu

Farewell from Chris Rapley

Much has happened since I took over as IGBP Director in August 1994. All but the most recently approved projects have successfully completed the transition from planning to implementation, whilst the degree of inter-project networking and collaboration has increased beyond recognition. The more mature projects, after five years or so of hard work, are beginning to synthesise significant new insights into the state and behaviour of the Earth system, which add both to our basic understanding and to the foundation of policy-relevant knowledge. The latter is especially important, given the greatly increased expectations of policy makers and funding agencies compared with the mid-1980s when the programme was first established. The recent publication of GCTE's superb synthesis volume provides a compelling example of the extent to which the IGBP now fulfils that role. With the intellectual vibrancy of the programme as lively as ever, and with the relationship to our sister programmes growing yet closer, one can be confident that the IGBP will continue to strengthen and extend its role as a major driving force within Global Change research.

So it is with mixed feelings that I leave to return to the UK. I will miss the extraordinary array of talented colleagues with whom it has been my privilege to work over the last three years, both within the IGBP and within the many organisations with which we connect. IGBP's success relies heavily on both the generous commitment of voluntary time and effort of the international research community, and on the dedicated efforts of the leaders and staff of the International Project Offices. It has been a pleasure to be part of that process. I will especially miss the team at the Secretariat, who have given me such skilled, enthusiastic, and loyal support. To all of you, I give you my thanks and appreciation.

However, I wish to record a special vote of thanks to the SC-Chair, Peter Liss, who is also stepping down at the end of 1997. Peter's impressive scientific insight, wise diplomacy, good humour, and unfailing commitment have been an example to us all. I wish the new team, Will and Berrien, equal or greater fun and satisfaction.

-Chris Rapley

Liss promises the moon and delivers the Earth to Chris Rapley

Peter Liss Says Farewell

"There is nothing permanent except change"

I have used the above quotation from the Greek philosopher Heraclitus (ca. 500 B.C.) in several talks about the IGBP that I have given over the past four years as Chair of the Scientific Committee. Then it was used to give our endeavours a historical context (and to counteract any tendency to hubris in the programme !). I quote it again now since the IGBP is about to undergo some significant changes in personnel, although I am sure that these will not alter the onward progress of the programme.

At the start of 1998 Berrien Moore will take over from me as Chair of the Scientific Committee, and Chris Rapley will step down as Executive Director, to be replaced by Will Steffen on 1 March. Change in an organisation is both necessary and beneficial, although it is also often feared as being destabilising. In my view this concern will prove to be groundless in the present case since both Berrien and Will are very familiar with the IGBP and are already well known to many people both within and without the programme. The positive benefits of change are the injection of new ideas and enthusiasm, which I know the 'new team' will provide in abundance.

Looking back on my term as Chair, I am struck by how much has been achieved both within and outside the programme. During a period when funds for scientific research have been under great strain in many countries, the work of all programme elements has advanced greatly and there are so many achievements that it impossible to catalogue them all here. At the programme level the Congress held in Bad Münstereifel was a landmark event, with all programme elements meeting together for the first time. Such programme level integration is vital if IGBP as a whole is to be greater than the sum of its parts. I predict a black market developing for places to attend the Second Congress to be held in 1999!

Our relations with our sister programme IHDP and WCRP, as well as with IGFA, are excellent, with a growing recognition of the common task. I am sure this closer working will continue in the coming years; whether it will lead to some form of amalgamation of the three programmes in the future is a matter which I for one will watch with interest.

My lasting feeling as I step down is of all the people I have got to know in the programme and outside it. Most of their efforts are entirely voluntary and it is a fundamental strength of IGBP that it can muster such an array of scientific talent to tackle globally and internationally the research problems of global change. Like me, I suspect they do it because, in spite of its size and complexity, the programme is remarkably responsive to individual effort; long may it continue. I consider it an honour to have served the programme and wish my successor as much pleasure from his efforts as I have experienced.

- Peter Liss

Peter Liss enjoying a relaxed moment during one of his last travels as Chair of the IGBP.

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IGBP Meetings

1998

TBA, Germany

GCTE Focus 1 Workshop: Biosphere-Atmosphere Stable Isotope Network (BASIN) Workshop-II

Jim Ehleringer, GCTE Focus 1 Leader, Department of Biology, University of Utah, Salt Lake City, UT 84112, USA. Fax: (+1-801) 581 4665, E-mail: ehleringer@bioscience.utah.edu

3-7 January, Boston MA, USA

SCOR/LOICZ Working Group (3-5) followed by *SCOR/LOICZ Symposium on Coral Reefs and Environmental Change: Adaptation, Acclimation, or Extinction (6-7)

Robert W. Buddemeier, Kansas Geological Survey, University of Kansas, 1930 Constant Ave., Lawrence, KS 66047, USA. Fax: (+1-785) 864 5317, E-mail: buddrw@kgs.ukans.edu

January/February, TBA

DIS Focus 1: Fire Project Workshop

José Miguel Pereira, D.E.F./I.S.A., Tapada Da Ajuda, 1300 Lisboa, Portugal. Fax: (+351-1) 364 5000. E-mail: jmcpereira@isa.utl.pt or Chris Justice, NASA/GSFC - Code 923, Greenbelt, MD 20771, USA. Fax: (+1-301) 286 1775, E-mail: justice@kratmos.gsfc.nasa.gov

2-6 February, San Quintin Bay, Baja California, Mexico

LOICZ Workshop on Ecological Services and Socio-Economic Sustainability

Silvia Ibarra-Obando, Division Oceanología, CICESE, PO Box 434843, San Diego, CA 92143, USA. Fax: (+52-617) 45254, E-mail: sibarra@cicese.mx

16-20 February, Chiang Mai, Thailand

PAGES Southeast Asian Dendrochronology Workshop

Rosanne D'Arrigo, Tree-Ring Laboratory, Lamont-Doherty Earth Observatory, Palisades, NY 10964, USA. Fax: (+1-914) 365 8152, E-mail: druidrd@ldeo.columbia.edu

17-21 February, Boulder CO, USA

13th SC-IGBP Meeting

IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, 104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: sec@igbp.kva.se

18-21 February, Santa Barbara CA, USA

IGBP-DIS Global Primary Productivity Data Initiative (GPPDI) Development of a consistent worldwide net primary production (NPP) database Work Group 2

Dick Olson, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge TN 37831-6407, USA. Fax: (+1-423) 574 4665, E-mail: rjo@ornl.gov

25-27 February, Toulouse, France

9th IGBP-DIS SSC Meeting

Gérard Szejwach, IGBP-DIS Office, 42 Avenue G. Coriolis, F-31057 France. Fax: (+33-5) 61 07 85 89, E-mail: gerard.szejwach@igbp.cnrm.meteo.fr

2-5 March, Beijing, China

Land-Use Cover Change in Temperate East Asia (LUTEA) Meeting

Dennis Ojima, Fax: (+1-970) 491 1965, E-mail: dennis@nrel.colostate.edu

11 March, Barcelona, Spain

GCTE Focus 4 Time-zero Workshop and Planning Meeting

Elisabeth Huber-Sannwald, GCTE Focus 4 Officer, Department of Ecology, Faculty of Agronomy, University of

Buenos Aires, Av San martin 4453, Buenos Aires 1417, Argentina. Fax: (+54-1) 521 1384, E-mail: huber@ifeva.edu.ar

14-18 March, Barcelona, Spain

*GCTE-LUCC Open Science Conference

Pep Canadell, GCTE Focus 1 Office, Department of Biological Sciences, Stanford University, Stanford, CA 94305, USA. Fax: (+1-415) 723 9253, E-mail: jcanadel@leland.stanford.edu

16-20 March, Heraklion, Crete

*IGAC/GIM and GAIM Worskhop on Inverse Modelling of Global Biogeochemical Cycles

Martin Heimann, Max-Planck-Institut für Meteorologie, Bundesstrasse 55, 20146 Hamburg, Germany. Fax: (+49-40) 41173 298, E-mail: martin.heimann@dkrz.de http://www.gatech.edu/gsc/inverse/overall.web.html

17-20 March, Paris, France

*GLOBEC Open Science Meeting

Elizabeth Gross, SCOR, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, USA. Fax: (+1-410) 516 4019, E-mail: scor@jhu.edu

March/April, TBA

DIS Focus 1: Land Cover validation workshop.

Joseph Scepan, University of California, Santa Barbara, Department of Geography, Santa Barbara CA 93106-4060, USA. Fax: (+1-805) 893 3703, E-mail: scepan@geog.ucsb.edu

19-23 April, London, UK

*PAGES Open Science Meeting

Frank Oldfield, PAGES Core Project Office, Bärenplatz 2, 3011 Berne, Switzerland. Fax: (+41-31) 312 3168, E-mail: pages@ubeclu.unibe.ch

29 April-2 May, Adelaide, Australia

8th LOICZ SSC

LOICZ IPO, NIOZ, PO Box 59, 1790 AB Den Burg - Texel, Netherlands. Fax: (+31-222) 369 430, E-mail: loicz@nioz.nl

April/May, Santa Barbara CA, USA

GCTE Activity 4.2 Workshop: Effects of Landscape Complexity on Ecosystem Functioning

Indy Burke, Colorado State University, Department of Forest Sciences, Fort Collins CO 80523, USA. E-mail: indy@artemisia.cfnr.colostate.edu

April/May, Santa Barbara CA, USA

GCTE Focus 4 - Activity 4.1 Workshop: Biodiversity and Ecosystem Functioning

David Tilman, 100 Ecology Building, University of Minnesota, 1897 Upper Buford Circle, St. Paul, MN 55108-6097, USA. E-mail: tilman@cdr.lter.umn.edu

May, TBA, USA

GCTE Focus 1 Workshop: Defining the role of ecosystem warming experiments in addressing future information needs for global change

Lindsey Rustad, Department of Applied Ecology and Environmental Sciences, University of Maine, 5722 Deering Hall, Orono, Maine 04469-5722, USA. Fax: (+1-207) 688 3356, E-mail: rustad@maine.maine.edu

24-29 May, Halifax NS, Canada

*WOCE Conference on Ocean Circulation and Climate

WOCE IPO, Southampton Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, United Kingdom. Fax: (+44-1703) 596 204, E-mail: woceipo@soc.soton.ac.uk http://www.soc.soton.ac.uk/others/woceipo/ipo.html

June/July, Potsdam, Germany

3rd GAIM/DIS/GCTE Workshop on Comparing Global Biogeochemical Models

Wolfgang Cramer, Potsdam Institute for Climate Impact Research, Telegrafenberg, Postfach 601203, 14412 Potsdam, Germany. Fax: (+49-331) 288 2600, E-mail: wolfgang.cramer@pik-potsdam.de

TBA, Potsdam, Germany

GCTE Focus 2 Workshop on Comparison of Forest Patch Models

Dr Harald Bugmann, Potsdam Institute for Climate Impact Research, PO Box 601203, (Telegrafenberg), D-14412 Potsdam, Germany. Fax: (+49-331) 288 2600, E-mail: bugmann@pik-potsdam.de

19-25 August, Seattle WA, USA

*Joint 5th IGAC Scientific Conference and 9th CACGP Symposium on Global Atmospheric Chemistry

Patricia Quinn, NOAA/PMEL/OCRD, Building 3, 7600 Sand Point Way NE, Seattle, WA 98115, USA. Fax: (+1-206) 526 6744, E-mail: quinn@pmel.noaa.gov, WWW: http://saga.pmel.noaa.gov/cacgp98/

20-26 August, Montpellier, France

*GCTE Special Session at International Soil Science Congress

John Ingram, GCTE Focus 3 Officer, Center for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

1-7 September, Nairobi, Kenya

*Fifth Scientific Advisory Council Meeting (SAC V)

IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: sec@igbp.kva.se

28-30 September, Durham NH, USA

9th IPO Executive Officers Meeting

IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: sec@igbp.kva.se

September/October, Nova Scotia, Canada

WMO-IGAC International Cloud Chemistry Modelling Meeting

Andrea Flossman, Université Blaise Pascal - CNRS, Laboratoire de Météorologie Physique, 24 Avenue des Landais, 63177 Aubière Cedes, France. Fax: (033-7) 327 1657, E-mail: flossman@opgc.univ-bpclermont.fr

followed by and linked to:

WCRP-IGAC Workshop on a Comparison of the Performance of Large Scale Models in Simulating Atmospheric Sulfate Aerosols

Leonard A. Barrie, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, ontario M3H 5T4, Canada. Fax: (+1-401) 739 5704, E-mail: len.barrie@ec.gc.ca

October, Beijing, China

TEA Regional Modelling of Monsoon System

Congbin Fu, fax: (+86.10) 6204 5230, E-mail: fcb@ast590.tea.ac.cn

27-31 October, TBA

11th IGBP Officers Meeting

IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden. Fax: (+46-8) 16 64 05, E-mail: sec@igbp.kva.se

1999

TBA, Tennessee, USA

GCTE Focus 1 Workshop: Global change effects on root dynamics

Richard Norby, 1.1.1 Task Leader, Oak Ridge National Laboratory, Building 1059, PO Box 2008, Oak Ridge, TN 37831-6422, USA. Fax: (+1-423) 576 9939, E-mail: rjn@ornl.gov

TBA, USA

GCTE Focus 1 Workshop: A cross-biome synthesis of ecosystem response to global warming

Lindsey Rustad, Department of Applied Ecology and Environmental Sciences, University of Maine, 57212 Deering Hall, Orono, Maine 04469-5722, USA. Fax: (+1-207) 688 3356, E-mail: rustad@maine.maine.edu

20-23 September, Reading, UK

*GCTE Focus 3 Science Conference

John Ingram, GCTE Focus 3 Office, Center for Ecology and Hydrology, McLean Building, Crowmarsh Gifford, Wallingford OX19 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

21-24 August, September, Germany

GCTE Focus 2/3 Workshop on Crop Models and Scaling

John Ingram, GCTE Focus 3 Office, Center for Ecology and Hydrology, McLean Building, Crowmarsh Gifford, Wallingford OX19 8BB, UK. Fax: (+44-1491) 692 313, E-mail: j.ingram@ioh.ac.uk

Publications

IGBP Book Series

IGBP Book Series No.1.

Plant functional types: their relevance to ecosystem properties and global change (1997). Edited by T.M. Smith, H.H. Shugart, F.I. Woodward. Cambridge: CUP, 369pp.

IGBP Report Series

IGBP Report No.41

The Miombo Network: Framework for a Terrestrial Transect Study of Land-Use and Land-Cover Change in the Miombo Ecosystems of Central Africa. (1997). Edited by P.V. Desanker, P.G.H. Frost, C.O. Justice and R.J. Scholes. Stockholm: IGBP, 111pp.

IGBP Report No.42

The Kalahari Transect: Research on Global Change and Sustainable Development in Southern Africa (1997). Edited by R.J. Scholes and D.A.B. Parsons. Stockholm: IGBP, 64pp.

IGBP Report No.43

Predicting Global Change Impacts on Mountain Hydrology and Ecology: Integrated Catchment Hydrology/Altitudinal Gradient Studies. Workshop Report (1997). Edited by A. Becker and H. Bugmann. Stockholm, IGBP, 61pp.

IGBP Science Report Series

IGBP Science No.1

The Terrestrial Biosphere and Global Change: Implications for Natural and Managed Ecosystems - A Synthesis of GCTE and Related Research (1997). Edited by B. Walker and W. Steffen. Stockholm: IGBP, 32pp.

IGBP Secretariat, The Royal Swedish Academy of Sciences, Box 50005, S-104 05 Stockholm, Sweden.

IGBP Programme Elements

BAHC

HAPEX-Sahel (1997). Edited by J.P. Goutorbe, A.J. Dolman, J.H.C. Gash, Y.H. Kerr, T. Lebel, S.D. Prince, J.N.M. Stricker. Amsterdam: Elsevier, 1079pp.

IGBP-DIS

Definition and Implementation of a Global Fire Product Derived from AVHRR Data. 3rd IGBP-DIS Fire Working Group Meeting Report, Toulouse, France,

Earth's Changing Land
GCTE-LUCC Open Science Conference on Global Change
March 14-18, 1998, Barcelona (Spain)

On the 14-18 of March, 1998, GCTE and LUCC will join efforts in Barcelona to hold a large conference on the impacts of global change on the terrestrial biosphere.

The main thrust of the Conference is to bring the global change community together in a common forum:

- to present the latest understanding on global change impacts on the terrestrial biosphere and feedbacks to climate
- to understand the regional implications of global change
- to develop strong links between research community and the policy and resource management sectors
- to meet like-minded colleagues from around the world to discuss scientific progress and possibilities for future collaborations
- to identify future research needs and strategies for "Living with global change"

The main topics of the conference are:

Impacts of Climate and Atmospheric Composition Change on Ecosystem Functioning, and the Implications for the Earth System.

- Social and Ecological Driving Forces of Land Use Change.
- Vegetation/Land Cover Changes at Local, Landscape and Global Scales.
- Global Change Impacts of Agricultural Production, Forestry, Biodiversity, and other Issues of Importance for Human Well-Being
- START Forum on Regional Approach to Global Change Research.
- European Forum on Global Change Research.

For further information, check the confererence homepage at: http://jasper.stanford.edu/GCTE/LUCC/Conference98.html or contact:

Dr. Josep Canadell, GCTE-F1 Project Officer, Department of Biological Sciences, Stanford University, Stanford, CA 94305-5020, USA. tel.: (+1-650) 723 1530, fax: (1-650) 723 9253, email: jcanadel@leland.stanford.edu

13-15 November 1996 (1997), IGBP-DIS Working Paper #17. Edited by J.P. Malingreau and C.O. Justice. Toulouse, IGBP-DIS Office: 35pp.

IGBP-DIS Office, CNRM, 42 Avenue G. Coriolis, 31057 Toulouse Cedex, France.

JGOFS

Joint Global Ocean Flux Study: Publications 1988-1996 (1997). JGOFS Report No.24. Bergen: JGOFS, 92pp.

JGOFS IPO, Center for Studies of Environment and Resources, High Technology Centre, University of Bergen, 5020 Bergen, Norway.

National Research

Colombia

Diversidad Biotica II - Tipos de Vegatacion en Colombia (1997). Edited by J.O. Rangel Ch., P.D. Lowy C., M. Aguilar Puentes. Santafé de Bogotá: Universidad Nacional de Colombia: 436pp.

Germany

World in Transition: the Research Challenge (1997). Berlin, Springer-Verlag: 208pp.

German Advisory Council on Global Change (WBGU), Secretariat at the Alfred-Wegener-Institute for Polar and Marine Research, Columbusstrasse, D-27568 Bremerhaven, Germany.

Ireland

Global Change and the Irish Environment (1997). Edited by J. Sweeney. Dublin, Irish Committee for IGBP/Royal Irish Academy: 170pp.

Irish Committee for IGBP, Royal Irish Academy, Academy house, 19 Dawson Street, Dublin 2, Ireland.

Switzerland

Research on Sustainability and Global Change - Visions in Science Policy by Swiss Researchers (1997). Bern: ProClim, 32pp.

ProClim - Forum for Climate and Global Change, Swiss Academy of Sciences SAS, Bärenplatz 2, 3011 Bern, Switzerland.

UK

Climate change and its impacts: a global perspective. Some recent results from the UK research programme. (1997). London, the Met. Office, 16.pp.

Hadley Centre for Climate Prediction & Research, Meteorological Office, London Rd, Bracknell, Berkshire, RG12 2SY, UK.

USA

The U.S. effort has produced a large number of peer reviewed papers on emissions and related mitigation and adaptation strategies. The papers are available from the U.S. Country Studies Program.

CSMT, 1000 Independence Avenue, SW, PO-63/GP-196, Washington, DC 20585, USA.

Related Organizations

GCOS

In situ Observations for the Global Observing Systems. Development of an integrated strategy and identification of priorities for implementation (1997). Geneva, World Meteorological Organization, 56pp.

GCOS/GTOS Plan for Terrestrial Climate Related Observations - version 2.0 (1997). Geneva, World Meteorological Organization, 136pp.

Global Climate Observing System, c/o WMO, 41, Avenue Giuseppe-Motta, PO Box 2300, 1211 Geneva 2 Switzerland.

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Report 1996 (1997). Andhra Pradesh, ICRISAT: 98pp.

ICRISAT Asia Center, Patancheru 502324, Andhra Pradesh, India.

ISRIC

Bi-Annual Report 1995-1996 (1997). Wageningen, ISRIC, 85pp.

International Soil Reference and Information Centre (ISRIC), PO Box 353, 6700 AJ Wageningen, the Netherlands

WCRP

Stratospheric Processes and their role in Climate. Proceedings of the First SPARC General Assembly, Melbourne, Australia, 2-6 December 1996. Volume I and II (1997). Geneva: WCRP, 672pp.

Joint Planning Staff for WCRP, c/o World Meteorological Organization, Case Postale No. 2300, CH-1211 Geneva 2, Switzerland

Worldwatch Institute

Vital Signs 1997: The Environmental Trends that are Shaping our Future (1997). Edited by L.R. Brown, M. Renner, and C. Flavin. New York, W.W. Norton: 165pp. (ISBN: 0-393-31637-8, price: $12.00)

Worldwatch Institute, 1776 Massachusetts Avenue, NW, Washington, DC 20036, USA.

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Requests for reproduction of articles appearing in this distribution should be addressed to the Editor (E-mail: sheila@igbp.kva.se)

NewsLetter requests and change of address information should be sent to:

IGBP Secretariat
The Royal Swedish Academy of Sciences
Box 50005, S-104 05 Stockholm, Sweden
Tel: (+46-8) 16 64 48
Fax: (+46-8) 16 64 05
E-mail: sec@igbp.kva.se

http://www.igbp.kva.se/

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Data and Information Systems (IGBP-DIS) Project of the International Geosphere-Biosphere Programme (IGBP)

Assistant Data Manager

The Data and Information System (DIS) Project of the International Geosphere and Biosphere Programme (IGBP) is accepting applications for the position of an IGBP Assistant Data Manager to begin in January 1998 (or earlier if feasible) in Toulouse (France) at the IGBP-DIS Office. This position is for one year, with possibly one year extension.

IGBP is an interdisciplinary scientific activity established and sponsored by the International Council of Scientific Unions since 1986. The programme is focused on acquiring basic scientific knowledge about the interactive processes of biology and chemistry of the earth as they relate to Global Change (for information on IGBP plesae access http://www.igbp.kva.se/)

IGBP-DIS was founded in 1992 and is a cross-cutting, data focused activity. It has placed priority on catalyzing the development of data sets of value to multiple IGBP Core Prects, and on ensuring that IGBP data will be properly archived and made accessible to the scientific community at large (for information on IGBP-DIS please access http://www.cnrm.meteo.fr/cnrm/igbp).

IGBP data consist of a very wide range of atmospheric, oceanographic and terrestrial data, from both in situ and remotely sensed instruments, and from a number of modelling activities. The role of Assistant Data Manager will be to assist the IGBP-DIS Data Management and Dissemination Leader in coordinating and overseeing all IGBP data management issues, and more specifically the following ones:

- develop an IGBP dat and information management plan in collaboration with a group of experts representing various IGBP Core Projects;
- implement the feasibility of thsi plan, (1) to a number of IGBP-DIS global data sets and products such as the land cover, the fire and the soil global data sets, in collaboration with international partners, and (2) to a number of IGBP Core Proejct existing and future data sets;
- deal with dat aproviders to facilitate access to satellite and other data by the IGBP community.

The qualified candidate should have a MSc (or equivalent) in earth sciences; a degree in computer sciences would be an assett; experience in management of atmospheric, or oceanographic or terrestrial data; familiarity with international data centers and archives; familiarity with data exchange and transmission issues including national and international standards and formats; experience with data and information protocols, expecially via the Internet; organizational skills; skills in working efficiently with scientists and data managers of many nations and agencies; and excellent oral and written communication skills in the English language.

To apply, send a resume and cover letter to the IGBP-DIS Office, 42 Avenue Gustave Coriolis, 31057 Toulouse Cedex, France. Phone (+33-5) 61 07 85 81, Fax (+33-5) 61 07 85 89, E-mail: sec@igbp.cnrm.meteo.fr

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