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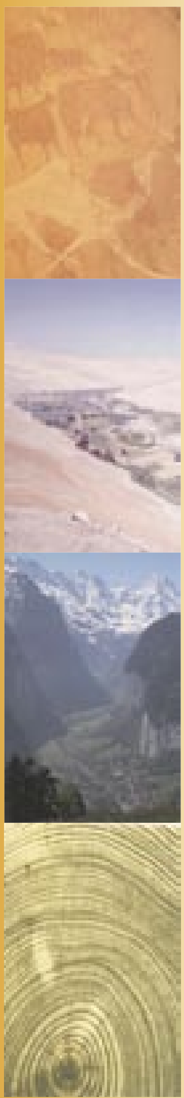
PAGES News
PAST GLOBAL CHANGES

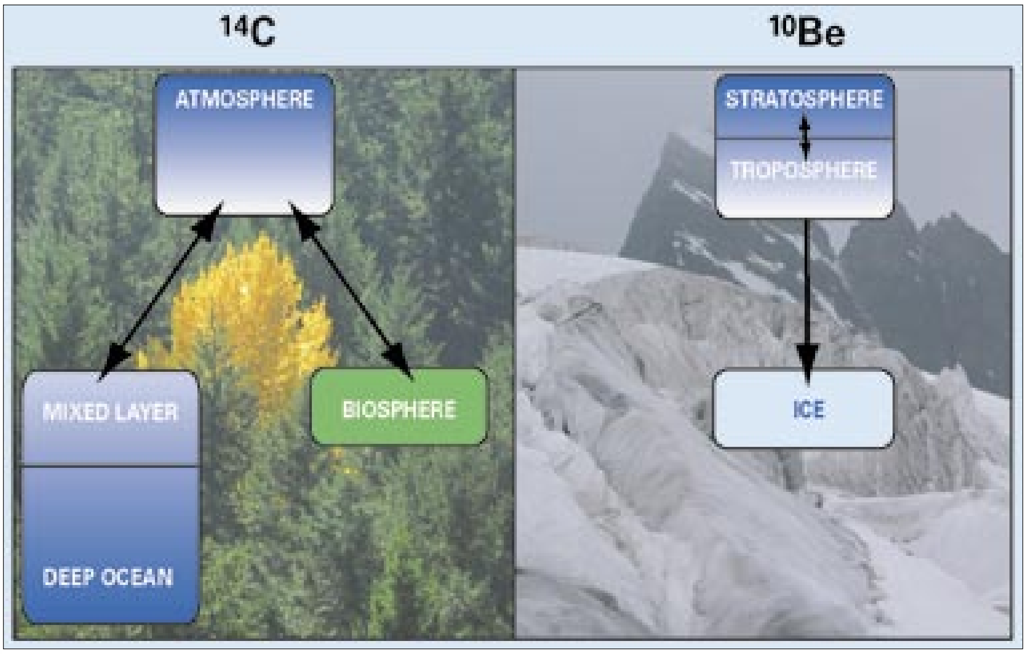
Christoph Kull, Leah Christen and Thorsten Kiefer, Editors

VOL.13, N°1 – APRIL 2005

Future Paleoscience



www.pages-igbp.org



Cosmogenic Nuclides and Dating: Progress is needed!
Comparison of the ^{14}C and the ^{10}Be systems: ^{14}C and ^{10}Be are continuously produced by cosmic rays in the atmosphere. ^{14}C forms $^{14}CO_2$ and starts exchanging with the biosphere and the ocean. ^{10}Be is removed from the atmosphere within about 1 year, mainly by wet precipitation. ^{14}C is archived in tree rings, ^{10}Be in ice cores. Both nuclides reflect changes in the production rate but react differently to climatic changes. This offers a unique opportunity to distinguish between production and system effects. More: page 11.

Contents

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Editorial: Future PAGES

The winds of change have been blowing through PAGES. They have brought about changes in the International Project Office (IPO) team and the Scientific Steering Committee (SSC), and will continue to blow towards new scientific endeavors. As with general trends in global change research, the key word for the future orientation of PAGES is "integration".

PAGES already has a strong record of creating synergy between groups within its community and will now turn its integrative capacities towards building bridges across timescales, that is, integrating paleoenvironmental with present-day research. Some of the partners we need for this can be found on our doorstep, for example, the International Geosphere-Biosphere Programme (see page 6). Present-past integration obviously carries with it huge potential for genuine symbiosis. Present-day science benefits from the temporal extent of paleo-records and their wealth of different scenarios (glacials, greenhouse periods, sea level rises, volcanic events, etc.). Detailed present-day observations of Earth System processes provide a sound basis for paleo-proxies, and for solid and relevant interpretations of the paleo-record. An example of such a "joint venture" is the recent relaunch of the PAGES/CLIVAR intersection (see page 7). As a welcome side-effect, present-past scientific interaction will help to increase the visibility of paleoscience beyond the already famous Greenland and Antarctica ice-core records, with ultimate positive feedbacks on research funding and scientific output. An obvious next level of integration will be to better include the human component in the Earth System. To meet this task, PAGES should be prepared to further open up towards social scientists, archeologists and historians (see page 23). Another logical consequence of highly integrated research across spheres, methods and timescales is the concentration of efforts on regions of particular interest, in order to distribute the huge homework among focused groups. Furthermore, regionalization of research efforts will bring the predictions of global change directly to people's doors (see page 19).

The outlined trends are not inherent to PAGES but rather of general character. The community-driven design of PAGES requires that ideas be passed from you as researchers to the service hubs (IPO and SSC). With free capacity for novel activities and directions, PAGES is at present particularly reliant on your input to fill empty spaces. The perfect occasion for you as a member of the PAGES community to articulate your ideas, and to actively support and shape the future PAGES, is the Open Science Meeting in Beijing in August (see last page). You should definitely not miss this event!

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Polar Regions and Quaternary Climate

ESF EuroConference toward an Integrative View of Climate in Antarctica and Circum-Antarctic Regions

24-29 September 2005, Acquafredda di Maratea, Italy
Chair: Jérôme Chappellaz (LGGE CNRS-UJF, Grenoble, France)
Vice Chair: Carlo Barbante (Venice University, Italy)

One of the big unknowns regarding the climate dynamics in the course of glacial-interglacial cycles and of abrupt events is the role of the Antarctic and the Southern Ocean. The European Project for Ice Coring in Antarctica (EPICA) has provided the climate community with two new ice cores covering more than 200,000 years at Dronning Maud Land (facing the South Atlantic) and about 900,000 years at Dome C (Antarctic Plateau). The new data can now be synthesized but it will be of much higher value if it is viewed in the context of other climate proxy records, current observations, and climate and ice-sheet models. The main goal of the conference will thus be the comparison of the two EPICA ice-core records with records from other climatic archives from Antarctica and circum-Antarctic regions. In addition, reviews of present-day studies in Antarctica and interactions between climate and ice-sheet modeling will stimulate discussions about the most urgent open questions regarding climate and environmental changes in and around Antarctica, leading to a joint strategy for future ice-core investigations.

Further Information: - www.pages-igbp.org/calendar/calendar05.html
- Science: Jérôme Chappellaz (jerome@lgge.obs.ujf-grenoble.fr)
- Organization: Anne-Sophie Gablin (asgablin@esf.org)

Inside PAGES

During the past few months, PAGES has made some major steps towards securing funding for future activities. Discussions about the future direction of PAGES are still ongoing and the launch of PAGES Phase II, alongside IGBP Phase II (see Program News p. 6), is scheduled to take place at PAGES 2nd Open Science Meeting in Beijing, 10-12 August 2005 (www.pages2005.org).

PAGES 2nd OSM:
View the final program at www.pages2005.org/schedule.html. This meeting will be a milestone in the history of PAGES. Do not miss out on being a part of this important event!

PAGES Office:
Having served the PAGES community during the past year with reduced staff and limited resources, the IPO is looking forward to being fully operational again starting April, and to providing the base for PAGES II by the end of August. PAGES new Director, Thorsten Kiefer, will be moving to Bern in April and taking over directorial responsibilities from Acting Director, Christoph Kull.

Christoph will then return to his duties as Science Officer, managing the newsletter, science coordination and networking activities. Leah Christen will continue to coordinate OSM planning and is afterwards looking forward to new science communication challenges arising from PAGES II activities. Selma Ghoneim will continue to be responsible for all financial aspects of PAGES and for ensuring that the IPO runs smoothly. Christian Telepski will be working on the setup and further development of PAGES IT services and a new-look PAGES website.

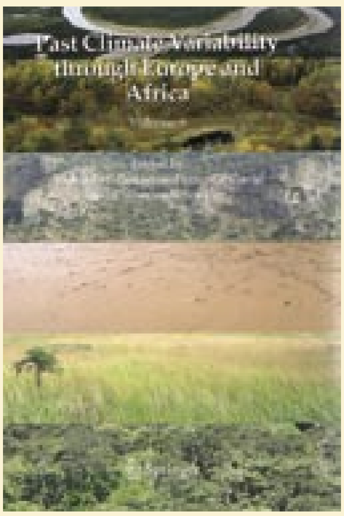
PAGES Newsletter:
The next issue of *PAGES News* will be devoted to the OSM in Beijing. Afterwards, our publication strategy will change somewhat and we will produce thematically open science highlight issues more often. Special issues will also contain a section for open contributions. Consequently, PAGES looks forward to receiving your submissions of science highlights all year round. We also welcome program news, workshop reports and humorous tales from the field. To submit an item, follow the guidelines at www.pages-igbp.org/products/newsletters/instructions.html and contact Christoph if you have any questions (kull@pages.unibe.ch).

National PAGES:
We are pleased to report that our list of National PAGES is growing rapidly, with over 15 countries online. Already successful in the past, this tool will gain importance in the future as we link more and more national networks to the international PAGES community. Go to www.pages-igbp.org/national/national.html for more information on how to link your national activities to PAGES. If your country is not on the list and you would like to help set up national contacts and related web-information, please contact Christoph for further information (kull@pages.unibe.ch).

New on the PAGES Bookshelf:

Past Climate Variability through Europe and Africa

Richard W. Battarbee, Françoise Gasse and Catherine E. Stickley, eds.,
Developments in Paleoenvironmental Research Series, Vol. 6, 2004
Springer, 638 pp., Hardcover, ISBN: 1-4020-2120-8, US$ 159.00 / Euro 120



This book provides a major synthesis of evidence for past climate variability at the regional and continental scale across Europe and Africa. It focuses on two complementary time-scales, the Holocene (approx. the last 11,500 years) and the last glacial-interglacial cycle (approx. the last 130,000 years). An overview of the climate system of the past has never been attempted before on this scale and, as such, the volume represents a benchmark for future research.

It is written by an expert group of climate-change scientists and presents an insight into past climate variability that challenges climatologists who seek to explain climate dynamics of the past, and provides climate modelers with a work of reference for data-model comparison. The book is an advanced but very readable text, essential for all students and scientists interested in global environmental change.

This book represents the PAGES PEP III Synthesis.

Tales from the Field

PAGES IN PATAGONIA

This past January, I was working in southern Patagonia collecting paleomagnetic samples for my current project studying secular variation of the Earth's magnetic field over the past 5 myr. Accompanied by Chris Condit and Matt Gorring, two igneous petrologists, we were sampling Plio-Pleistocene lava flows around the small town of Gobernador Gregores.

The land in Argentina is privately owned, held in large "estancias" (ranches). Due to over-grazing and the decline of a world market for wool, many of these establishments are abandoned or left to a single caretaker. We spent considerable time each day tracking down owners, explaining our project and obtaining permission to collect samples on their land. One morning, we called on Estancia La Angostura, some 50 km from Gregores on a not-so-great dirt road. This estancia was more prosperous than most due to a permanent river in its midst and the fact that they rented rooms to passing travelers.

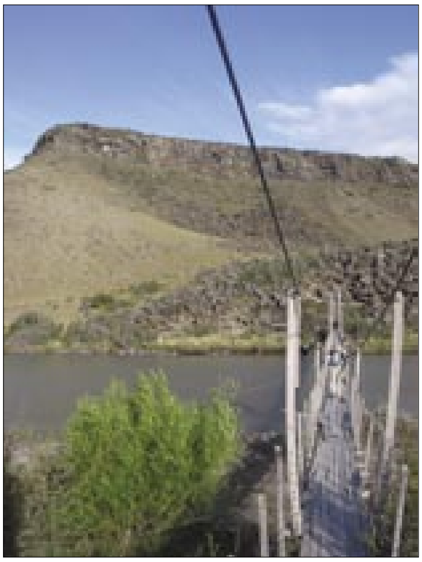


Fig.1: Chris Condit, University of Massachusetts, crossing the Rio Chico, with La Angostura lavas in the background.

We stopped in at the ranch house and explained to the owner that we were geologists and were interested in sampling the lava flows across the river. He greeted us warmly, invited us in and gave us cold drinks and seats in the dining room. He was very interested in what we were doing and was quite knowledgeable about geology. When we commented on this, he went to a glass-fronted Victorian bookcase and from the bottom shelf proudly produced not one but two copies of a PAGES PEP I report in Spanish. He asked if we were familiar with the project and was quite impressed when I said that not only did I know the project but that the lead author of the main article, Ray Bradley, and I were at the same University. He proudly explained that some people from the project (those working on Lago Cardiel) had stayed with him.

Amazing to be in the middle of nowhere and to discover that those pesky paleoclimatologists had been there already!

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World Data Center for Paleoclimatology update:

The WDC for Paleoclimatology has recently updated its paleoceanography data. The contributed data is available via the web query and map interface at:

www.ncdc.noaa.gov/paleo/paleocean.html

The database now contains 1,434 sites from 260 contributors, and several hundred different variables. PAGES encourages investigators to contribute their recently published data to the database. Information on contributing data can be found at: www.ncdc.noaa.gov/paleo/contrib.html

Comments:
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Further Information:
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In Memory of Dr. Geoffrey Owen Seltzer

The Quaternary science community lost one of its leaders and most influential and enthusiastic participants with the passing of Geoffrey Owen Seltzer on 15 January 2005. Geoff, 45, was at the prime of his career and died after a brave 18-month battle with cancer.

Born in Minneapolis, Minnesota in 1959, Geoff earned his B.A. at Carlton College (1982), and his M.S. (1987) and Ph.D. (1991) at the University of Minnesota. Geoff was a post-doctoral fellow and senior research associate at the Byrd Polar Research Center at Ohio State University and had served on the faculty of the Earth Sciences Department at Syracuse University since 1994. His numerous awards included being named a fellow of the Geological Society of America in 2004.

Geoff's major contributions to the field of Quaternary science included his careful analysis of the climatic significance of paleo-snowlines in the Andes, his novel use of stable isotopes from Lake Junin, Peru to develop a record of regional moisture balance, his leadership in compiling multi-proxy evidence from Lake Titicaca sediments to substantiate early warming of tropical South America at the Last Glacial-Interglacial transition, and his galvanizing efforts to apply surface exposure dating methods to date moraines in Peru and Bolivia. Results of Geoff's research were published in more than 42 papers in journals including *Science*, *Nature*, *Geology*, *Quaternary Research*, and *GSA Bulletin*.

Geoff was blessed with a combination of a keen intellectual insight into many of the key questions that face the Quaternary sciences and an ideal personality for fostering collaborative research efforts with scientists from diverse areas of specialization. He was also very successful at organizing and coordinating large research programs and at obtaining consistent funding for these ventures. These and similar

A photo of Geoff, healthy and full of life, taken by Steve Porter at the Snowline Conference in Scotland in Sept. 2002.

efforts catapulted Geoff into the international limelight and likewise resulted in further collaborative leadership roles. In 1998, he was named leader of the PAGES PEP I Focus, working to compile climate records along a N-S transect through the Americas.

Geoff was very active within PAGES and made many scientific contributions to workshops and conferences, with a special emphasis on PEP I. Geoff recognized that future progress in paleoclimate research must involve a better understanding of atmospheric and oceanic circulation systems. Following on from a PAGES workshop on Hadley Cell dynamics in November 2002, Geoff took on a major leadership role authoring a successful proposal to hold an AGU Chapman conference on tropical-extratropical climatic teleconnections (see Workshop Reports p. 22).

Moreover, working with the PAGES Scientific Steering Committee in Banff in June of 2003, he helped craft the text for an initiative within PAGES on this very topic. The Chapman conference Geoff so carefully planned was held 8-11 February 2005 at the International Pacific Research Center of the University of Hawaii.

One of Geoff's lasting legacies to Quaternary research was his care and mentoring of graduate and undergraduate students. His style was never too overbearing and he expected his students to work very independently. His encouragement was always sincere, as he was. One of the features most widely associated with Geoff was his broad smile. He was a true gentleman and loved to participate in the communal discovery. Geoff always made time for people and truly respected others. His graduate students have gone on to refine research in tropical snowlines, water resources, and paleoclimate reconstructions in South and Central America.

It is with genuine sorrow that we bid farewell to our colleague, friend and mentor. Responses from many others who knew Geoff over the years in various capacities echo our profound sense of loss. Geoff deeply valued his community, and perhaps his greatest legacy to us is the priority he placed on how and with whom he worked. We are reminded in Geoff that life is very short and that adhering to quality over quantity of work is important to success.

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The Pivotal Role of Paleosciences in the New IGBP

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GLOBAL IGBP CHANGE

The EPICA, Vostok and Dome Concordia ice core data from Antarctica have dramatically reinforced a global perspective on the behavior of the Earth's environment. Crucial to this perspective is the increasing awareness of two aspects of Earth System functioning.

Firstly, the Earth itself is a single system within which the biosphere is an active, essential component. This system operates with a regular periodicity, with strong connections between climate and biogeochemical cycling, and within tightly constrained maxima and minima of key environmental parameters.

Secondly, human activities are now so pervasive and profound in their consequences that they affect the Earth at a global scale in complex, interactive and apparently accelerating ways. The effects of human activities are now discernable beyond the limits of natural variability; humans have become a planetary-scale force that has pushed the Earth System beyond its normal "operating range".

The structure of the new, Phase II IGBP research effort mirrors the enhanced scientific emphasis that is being placed on Earth System-level processes and phenomena and on the more detailed dynamics within the Earth System. The Programme is thus built around eight projects: three oriented towards the three major Earth System compartments—land, ocean and atmosphere; three concentrating on the interfaces that transport and transform matter and energy between the three compartments; and two focusing on the changing environment of the planet as a whole, from past through present to the future (Fig. 1).

Understanding global change requires knowledge of the past in order to assess ongoing processes and feedbacks and the sensitivity of various parts of the ocean-atmosphere-land components, and to correctly estimate human impact on this system. This temporal component, especially high-resolution studies of past abrupt change, climate dynamics and regional responses, provides us with the information necessary to better predict our future through modeling.

In essence, past natural experiments in the Earth System, like "messages in a bottle" of climate and hydrologic change preserved in ice cores, tree rings, lake and marine sediments, etc., allow scientists to test the reproducibility of various models to reconstruct past events. For example, greenhouse gas concentrations are rising rapidly and are influencing our climate but are the recent changes observed in the Earth System unprecedented in the past? In this regard, the dynamic perspective and timing of recorded events is critical to unraveling the functioning of the Earth System. How fast did the diverse components change in the past? Where and when did this happen?

These issues are of major importance and interest to all the IGBP projects because they permit an assessment of recent anthropogenically influenced processes with respect to naturally occurring past variations. Sea level, biodiversity, land systems, the cryosphere and atmosphere—all Earth System components provide records of their past behavior. PAGES deals with these past records, integrating all the IGBP projects alongside the project on Analysis, Integration and Modelling of the Earth System (AIMES), and is therefore pivotal to each component of the Programme.

Last but not least, PAGES provides paleo-perspectives on the future sustainability of a habitable planet. As a central IGBP project, it directs its efforts towards providing the IGBP community with regionally significant and globally relevant information on the past behavior of the Earth System, to enable an assessment of the conditions leading to its future sustainability. This requires the integration of records of past changes, as well as systemic analysis and modeling of paleodata, in order to better understand human-climate and ecosystem interactions through time. Of particular focus is the value-added use of biogeochemical proxies in modeling, while exploring ways of assessing

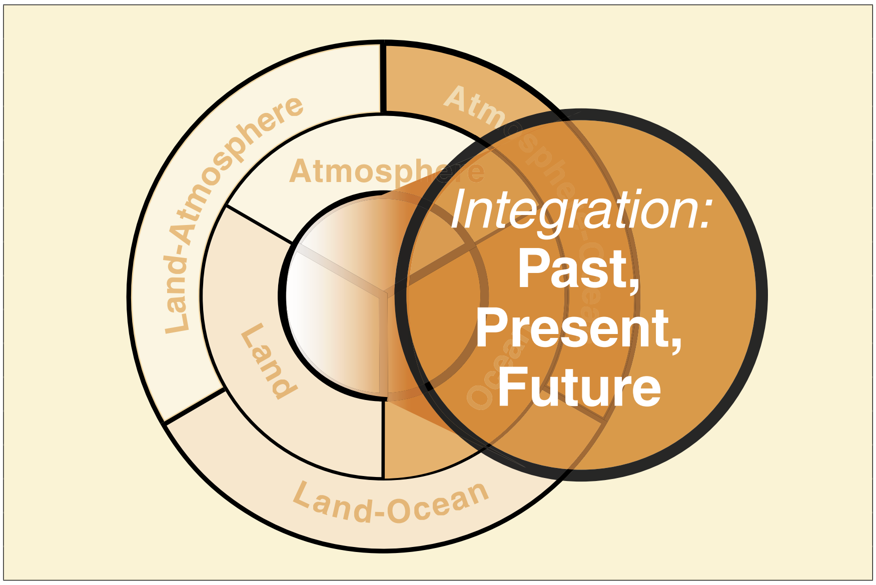

Fig. 1: The new IGBP structure showing PAGES role as the integrating tool.

contemporaneous change on land and in the oceans.

At a macro decision-making level, it is gratifying to see a sign of the further recognition of the role of paleosciences: The 4th Intergovernmental Panel on Climate Change (IPCC) Assessment Report will include a full chapter on paleoclimate. What cannot be overlooked is the transmission of these data products and their implications for policy, educational and societal action through education, networking and outreach at all levels. Here the PAGES website has taken up the challenge of carrying the "message in the bottle" further afield and translating it into more popular knowledge.

The Future of PAGES/CLIVAR Intersection Activities

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The CLIVAR/PAGES Intersection Working Group is jointly sponsored by the PAGES project of the International Geosphere-Biosphere Programme (IGBP) and the Climate Variability and Predictability Programme (CLIVAR) of the World Climate Research Programme (WCRP). It plays an important role in developing and implementing the research agendas of both CLIVAR and PAGES. The group was established in the mid 1990s. Details of its history are recorded in meeting reports and relevant publications archived at: www.clivar.org/organization/pages/index.htm.

A major issue in the past has been communication between the modeling and data communities. The PMIP (Paleoclimate Modeling Intercomparison Project) activities were especially successful, producing a lot of scientific output. Conferences and workshops showed a clear need for such collaborative work in order for modelers to benefit from paleodata to test, calibrate and assess state-of-the-art climate models, and for paleoscientists to be informed about what kind of data is needed to assess the results of climate models.

After successful conference activities in the past, PAGES/CLIVAR seeks to address burning issues in the scientific intersection of the two projects. In November 2004, the newly constituted PAGES/CLIVAR Working Group held its inaugural meeting in Victoria, Canada. The group is lead by Eystein Jansen from PAGES and Andrew Weaver from CLIVAR.

In the future, PAGES/CLIVAR seeks to strengthen its collaboration, while addressing new PAGES- and CLIVAR-related topics with joint IGBP-WCRP activities and revised Terms of References, as follows:

- To promote improved high-resolution, well-dated, quantitative paleoclimate records with seasonal-to-interannual resolution in regions that are of direct relevance to IGBP and WCRP.
- To formulate and promote, in collaboration with PAGES and CLIVAR, a program for analyzing and synthesizing paleoclimate data, in order to reveal evidence of patterns of variability within the climate system over seasonal-to-millennial time scales.
- To promote improved quantitative methods of model-data comparison and evaluation in order to understand the variability present in both the paleoclimate record and the models.
- To promote the use of paleoclimate data to examine issues of climate predictability.
- To coordinate with other modeling activities of relevance to IGBP and WCRP.

Topics for Future Activities will Include:

1. Climate Variability over the Last Few Millennia

Well-dated, high-resolution proxy reconstructions and model simulations incorporating estimates of natural and anthropogenic forcings suggest that late 20th century warming is anomalous in the context of the past 1,000-2,000 years. Significant differences exist, however, between various competing estimates (Fig. 1). Despite progress in recent years, important uncertainties and caveats exist with regard to both empirical reconstructions and model estimates. One important issue relates to the varying seasonality and spatial representativeness of different estimates. PAGES/CLIVAR advocates a paleoclimate reconstruction methodology and data intercomparison project ("PRMDIP") in which various paleoclimate reconstruction methods will be applied to common data sets to elucidate the differences between methods and regions, and where further needs related to the understanding of the past regional variability will be discussed. See also the related Science Highlight by H. Wanner, pages 19-21).

2. Abrupt Climate Change

Topics considered include ocean dynamics, ice-sheet stability and related modeling studies. PAGES/CLIVAR especially seeks to support and initiate modeling studies of past abrupt climate change events.

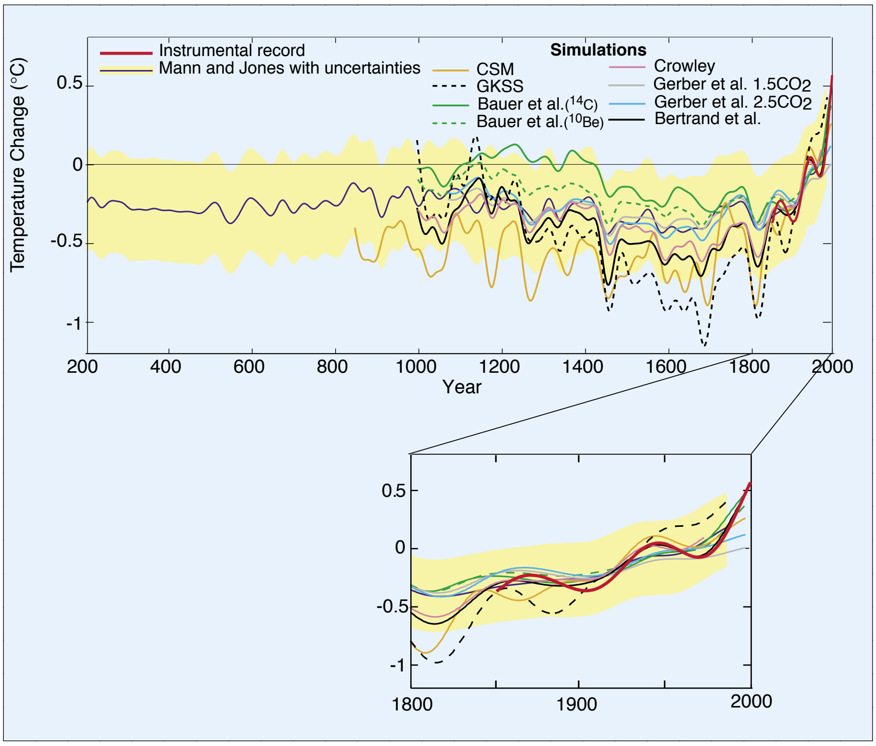

Fig. 1: [Reprinted from Jones and Mann, 2004, Reviews of Geophysics, © American Geophysical Union]. Model-based estimates of northern hemisphere temperature variations over the past two millennia. Shown are 40-year smoothed series. The simulations are based on varying radiative forcing histories employing a hierarchy of models, including 1-D energy based models (Crowley, 2000), 2-D reduced complexity models (Bauer et al, 2003; Bertrand et al, 2002; Gerber et al, 2003), and fully 3-D coupled atmosphere-ocean general circulation models (GKSS, Gonzalez-Rouco et al, 2003; ŒCSM, Ammann et al., submitted). Shown for comparison is the instrumental northern hemisphere record 1856-2003 (Jones et al, 1999) and the proxy-based estimate of Mann and Jones (2003) extended through 1995, with its 95% confidence interval. Models have been aligned vertically so as to have the same mean over the common 1856-1980 period as the instrumental series (which is assigned zero mean during the 1961-1990 reference period).

As a possibility, the 8.2 kyr event might be studied in order to test the ability of the models to simulate the proxy record.

3. Hydrologic, Biospheric, Land-Surface Interactions

PAGES/CLIVAR acknowledges the recent progress made by the PMIP I and PMIP II communities. Comparison of modeling data and related proxy evidence for mid-Holocene paleoenvironments in, e.g., Africa, needs to be extended to further regions and time-slices. PAGES/CLIVAR looks forward to following PMIP activities and will support relevant issues.

4. Tropical-Extratropical Links Including Ocean and Atmospheric Teleconnections

Close interaction is expected between the CLIVAR Southern Ocean Panel and the PAGES IMAGES Southern Ocean Program, in addition to obvious links to the already established science community dealing with these topics. Extension of the workshop series to promote model-data intercomparisons of tropical-extratropical interactions will be supported in order to better understand past and recent climate variability and possible anthropogenic influences. PAGES/CLIVAR will also promote studies in the fields of ENSO, Monsoons, NAO, PDO and IOD.

5. Overarching and Cross-Cutting Implementation Issues

PAGES/CLIVAR will promote and coordinate the forward modeling of proxy data, since these activities have become promising links between the paleo and modeling communities. The website, newsletters and other outreach products will be enhanced in order to involve more scientists in PAGES/CLIVAR activities.

Implementation:

The PAGES/CLIVAR Working Group proposes to address and report on the progress of the relevant issues by means of workshops, special sessions at meetings and special journal issues, and via PAGES and CLIVAR newsletter articles.

At the top of the proposed agenda is the first workshop, to be dedicated to regional variability over the past few millennia. This workshop will compare current approaches for reconstructing past climate variability: Proxy reconstruction methodology and the data intercomparison project (PRMDIP). Contributions from participants in the PRMDIP project modeling experiments would be expected beforehand, so that the workshop could focus on comparing the results of different approaches and focusing on proxy reconstruction methodology.

It is likely that the results of this intercomparison will be published following the meeting. Further information will be available on the PAGES/CLIVAR website: www.clivar.org/organization/pages/index.htm

Contribute:

Is this your field of expertise?

Scientists interested in joining this effort should contact Christoph Kull at the PAGES IPO (kull@pages.unibe.ch) or Zhongwei Yan at the CLIVAR CPO (zxy@soc.soton.ac.uk).

Southern Hemisphere Climate Change: Re-coring Lynch's Crater

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The Atherton Tablelands in tropical NE-Queensland, Australia, contains several good locations that record paleoclimate changes for the southern hemisphere. Lynch's Crater (S17° 21′, E145° 41′) contains the longest peat and lake sediment record, spanning the last ~200,000 years (Kershaw, 1978; Kershaw, 1986). Previous studies were based on a 60-m-long core recovered with a hollow auger drill system. Unfortunately, storage and earlier investigations have left only a few crumbs of the original material.

In the mid 1990s, Peter Kershaw (Monash University, Melbourne) and Chris Turney (Queens University, Belfast) decided to investigate anthropogenic influence and to track volcanic activity, based on material recovered with a Livingston-corer (16 m deep). The work revealed the potential of the site as a record for human arrival in NE-Australia (Turney et al., 2001) and showed its sensitivity to ENSO strength (Turney et al., 2004).

I arrived at James Cook University in Townsville in 2002 and saw the opportunity to move my research focus from tropical peatlands to peatland and lake deposits from the southern hemisphere. Inspired by the earlier work of Peter Kershaw and the latest findings by Chris Turney, we decided to apply for project support to re-core and investigate a complete lake record from Lynch's Crater, so as to extend the initial record. While the applications to the Australian Research Council were pending in 2003, the National Geographic funded drilling with Damien Kelleher and his 4WD truck-mounted drill-rig from the Research School of Earth Sciences at the Australian National University (ANU). We used a hollow auger system that could recover 62-mm-thick core material with both wire-line or rod techniques. Unfortunately, bad weather and the sediment properties only enabled us to recover 20 m with a poorly preserved stratigraphy.

*Fig. 1: **Left**: View from the crater rim south with location of drill site. **Middle**: Core section from the lower part of the core (5,480-5,499 cm depth) with finely laminated lake sediments overlying a graded bed at the bottom. **Right**: ANU drill-rig with hollow auger system in action on site.*

Additional funding from a James Cook University Program Grant was used to return to Lynch's Crater in October 2004 but frustratingly the first hole at a different site produced similar results, despite using a modified drill (a sediment lock-out mechanism using a diaphragm at the end of the head auger and a core catcher). During a relocation of the drill rig closer to the site where the drilling was completed in the 1970s, new ideas about the sediment properties surfaced. We realized that the sediment in the subsurface was not under hydrostatic or hydrologic pressure as previously assumed when sediment shot up the augers but that the auger head was disturbing the sediment in such a way that it drew the water towards the head and liquefied the sediments. We adjusted the system so that the core barrel was at least an auger length in advance of the rotating lead auger in order to avoid liquefaction and pressure build-up around the head. Once these changes were made, we recovered a complete sequence of peat (top 15 m) and laminated lake sediments (including graded beds) to a depth of 64 m.

Multi-proxy analyses such as tephrachronology, palynology, geochemistry, mineralogy, etc., will be carried out by a diverse group of researchers and funding from the following grants: ARC Discovery (Wust, Kershaw, Anderson), ARC QEII (Turney), National Geographic (Turney, Kershaw), JCU PG (Wust, Heimann, Smithers, Ridd), AINSE (Muller).

The following institutions and scientists were engaged in the drilling of Lynch's Crater in 2004:

- Australian National University, Canberra: Damien Kelleher
- Monash University, Melbourne: Peter Kershaw, Susan Rule, Jono Brown
- University of Wollongong: Chris Turney
- Queens University, Belfast: Sarah Davies
- University of Queensland, Brisbane: Patrick Moss
- Florida International University, Miami: William Anderson
- Imperial College, London: Malin Kylander
- James Cook University, Townsville: Raphael Wust, Joanne Muller, Toni Williamson

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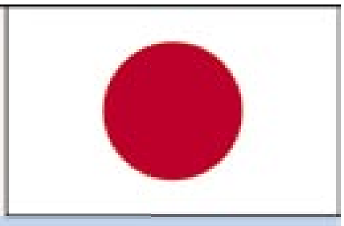
Japan



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Welcome

Japan consists of a long island chain extending more than 2,000 km in the NE-SW direction, surrounded by oceans such as the Pacific to the east, the East China Sea to the southwest, the Japan Sea to the west, and the Okhotsk Sea to the northeast. Japan and its surrounding area have a variety of climate regimes, ranging from subtropical to subarctic. Japan has a long history and abundant historical records on climate in the past. This provides a rare opportunity to conduct paleoclimatic studies on land-ocean interaction, high latitude-low latitude linkage, and paleoclimatic impact on human activities.

National Science Highlight: Proxy PDO signals and recent anthropogenic impact reconstructed from Kamchatkan glacier

Takayuki SHIRAIWA (Institute of Low Temperature Science, Hokkaido University)

The cryosphere in Kamchatka Peninsula, Russian Far East, has been deteriorating since the end of the 19th century. This is evident from various proxy climate records such as changes in mass balances and areas of glaciers, ice-core signals and tree-ring width chronologies. The upper 100 m of a 212 m ice core recovered from a crater glacier covering the summit of Ushkovsky Volcano (3,902 m a.s.l.) showed the climate and atmospheric history over 170 years. There was enrichment of stable oxygen isotopes by an amount of 0.8 per mil from the 19th to the 20th centuries. Fluctuations of the net accumulation rate and the average annual stable oxygen isotope revealed decadal-to-interdecadal oscillations. The two signals showed anti-correlation with the so-called Pacific Decadal Oscillations (PDO) Index, indicating that positive PDO is associated with low snow accumulation and depleted stable oxygen isotope in Kamchatka. The cross Pacific PDO impacts were also detected in the net accumulation time-series in an ice core that we recently obtained at King Col, Mount Logan, Canada. Nitrate ion has been increasing by approx. 100 ppb since the end of the 19th century, which implies accelerated human impact on the atmosphere.

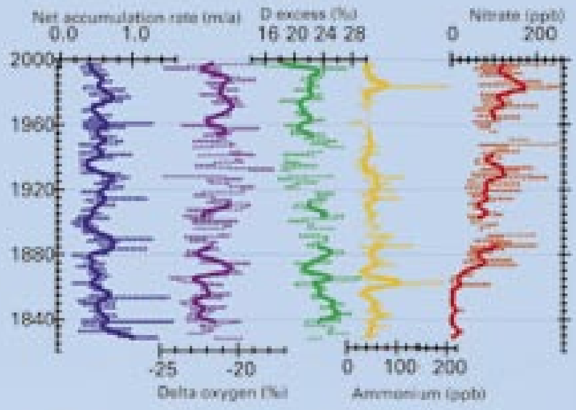

Fig.1: Record of the upper 100 m of a 212 m ice core recovered from Ushkovsky Volcano (3,902 m a.s.l.) showing 170 years of climatic and atmospheric history.

Reference: *Global Environmental Research* Vol. **6(1)**, 19-30, 2002

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Radiocarbon in Tree Rings: A Unique Treasure of Information

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The radiocarbon dating method is by far the most important technique for dating the past 50,000 years. It is based on the assumption that the atmospheric $^{14}C/^{12}C$ ratio was constant at all times due to the equilibrium between production and decay of ^{14}C (half-life: 5,730 y). Living organic matter is in constant contact with the atmosphere and therefore contains the same $^{14}C/^{12}C$ ratio. At the time of death, the organic matter is decoupled from the atmosphere and the $^{14}C/^{12}C$ ratio begins to decrease according to the law of radioactive decay.

However, it is now clear that the assumption of a constant $^{14}C/^{12}C$ ratio is not quite correct and that this ratio deviates by up to 20% from the value of 1950. This corresponds to an age difference of about 1,500 years. Several leading radiocarbon laboratories made a joint effort to determine the past deviations of the atmospheric $^{14}C/^{12}C$ ratio by analyzing dendrochronologically dated tree rings all the way back to 12,000 years before 1950 (Stuiver et al., 1998). This decadal $\Delta^{14}C$ record is shown in figure 1 and provides the base for calibrating the radiocarbon ages. Although the observed deviations cause problems in dating, they nevertheless provide a wealth of unique information on the history of the production of cosmogenic radionuclides and the global carbon system.

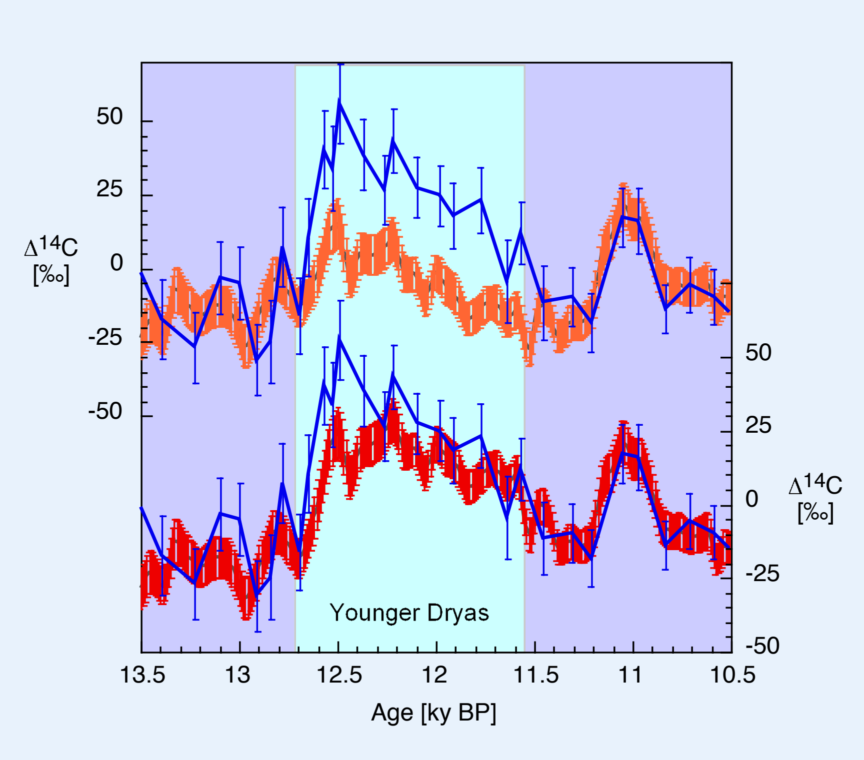

Fig. 2: Comparison of the measured $\Delta^{14}C$ from tree rings with the calculated $\Delta^{14}C$ derived from ^{10}Be in the GISP2 ice core (Muscheler et al., 2000). The agreement during the Younger Dryas is poor (upper set). An agreement can only be obtained by additionally reducing the global deep-water formation (lower set).

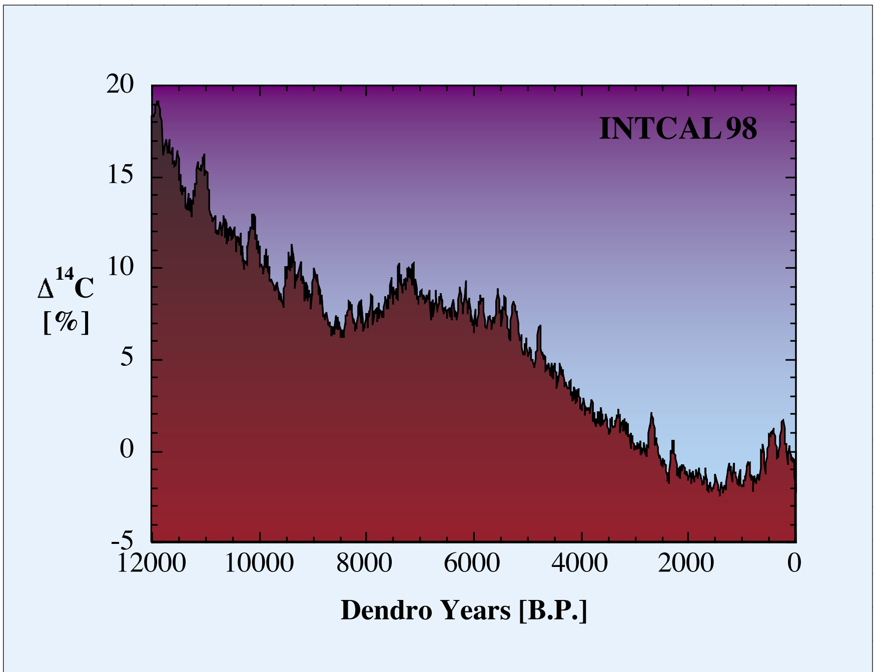

Fig. 1: Deviations of the atmospheric $^{14}C/^{12}C$ ratio from a standard value for the past 12,000 years (0 is 1950) as derived from tree rings (Stuiver et al., 1998).

^{14}C, as well as other cosmogenic radionuclides (^{10}Be, ^{36}Cl), are produced by the interaction of cosmic rays with the atoms of the atmosphere. After production, ^{14}C forms $^{14}CO_2$ and begins to exchange with the biosphere and the ocean (see cover). Interpretation of the observed $\Delta^{14}C$ changes is not straightforward. Changes in $\Delta^{14}C$ can be caused either by changes in the production rate (due to changes in solar activity and geomagnetic field intensity) or the carbon cycle (due to changes in size and exchange fluxes between the reservoirs). The situation is further complicated by the fact that the atmospheric $^{14}C/^{12}C$ ratio determined at a specific time not only reflects the momentary production rate and system conditions but also 'remembers' to some extent earlier changes stored in the

Fig. 3: Example of a fossil Kauri tree excavated in a swamp in New Zealand.

large reservoirs. Without further information, it is a priori impossible to decide whether an observed ^{14}C change is caused by solar activity, geomagnetism or ocean circulation.

One way to gain additional information is to compare the $\Delta^{14}C$ record with ^{10}Be records from ice cores (see cover). ^{10}Be is produced in a very similar way to ^{14}C but its geochemical behavior is completely different. As a result of the large reservoir sizes and the relatively small exchange fluxes between them, the mean residence times of ^{14}C are quite long and range from 8 years in the atmosphere to more than 1,000 years in the deep ocean. This leads to a considerable attenuation of the amplitudes of production changes and to phase lags (Siegenthaler et al., 1980). On the other hand, the mean atmospheric residence time of ^{10}Be is only about 1 year and, therefore, ^{10}Be directly reflects production changes on decadal or longer time scales without any significant attenuation or phase lag. To compare ^{14}C with ^{10}Be, the ^{10}Be record first has to be turned into $\Delta^{14}C$ by means of a carbon cycle model that accounts for the different reservoirs and the exchange processes between them. In figure 2, such a comparison is made for the Younger Dryas (13,000-11,500 BP) (Muscheler et al., 2000). The tree-ring based $\Delta^{14}C$ (solid blue line) agrees well with the calculated $\Delta^{14}C$ based on ^{10}Be from Greenland ice, except for the Younger Dryas period (Fig. 2, upper set). However, if, in addition, the global deep-water formation is reduced in the model by some 30%, the agreement is considerably improved for this period (Fig. 2, lower set) (Muscheler et al., 2000).

This example shows the potential of this technique. The results obtained so far show that during the Holocene period (Fig. 1), $\Delta^{14}C$ can be explained to a very large extent by a combination of solar and geomagnetic modulation. The short-term peaks are mainly due to periods of reduced solar activity (Maunder Minimum type events) while the long-term trend is mainly the result of changes in the geomagnetic dipole moment. There is no evidence of significant ^{14}C changes caused by the global ocean circulation or other system effects during the past 12,000 years.

However, the last glacial, which was characterized by large and abrupt climate changes, shows clear indications of considerable changes in the carbon cycle. To investigate these changes, an extension of the high-precision tree-ring calibration curve is indispensable. There are already a considerable number of $\Delta^{14}C$ reconstructions in various archives (sea and lake sediments, stalagmites). However, a high-precision, high-resolution atmospheric $^{14}C/^{12}C$ record covering the period 12,000-50,000 BP is still missing.

Existing chronologies based, for example, on German oak trees, cannot be extended into the glacial period because there were no oak trees in Germany at the time. An excellent opportunity to cover the glacial period is offered by the Kauri trees in New Zealand (Buckley et al., 2000). Kauri trees have been growing in New Zealand for at least the past 50,000 years and are quite easily found in swampy areas (Fig. 3).

An extension of the tree-ring calibration curve to 50,000 years is not only fundamental to the radiocarbon dating technique, in combination with other radionuclides it also provides unique information on solar variability, paleomagnetism, the carbon cycle in general, and the ocean circulation in particular.

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Fluvial Record of Late Pleistocene and Holocene Geomorphic Change in Northern Tunisia – Global, Regional or Local Climatic Causes?

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Geomorphical-sedimentological approaches with high-resolution stratigraphic records round out Quaternary paleoclimatic and paleo-process research. Our investigations focus on Late Pleistocene and Holocene floodplain evolution.

The central Medjerda Valley, Northern Tunisia (Fig. 1) is a tectonic depression zone that has its origin in the orogenesis of the Atlas Mountains. An up to 10 km-wide floodplain has been incised into it by the meandering Medjerda River. The floodplain is filled with Quaternary sediments, the latest of which are of Late Pleistocene and Holocene age. The floodplain sedimentation allowed the development of predominantly horizontal, well-stratified layer sequences, interrupted by soil-forming processes (Fig. 1).

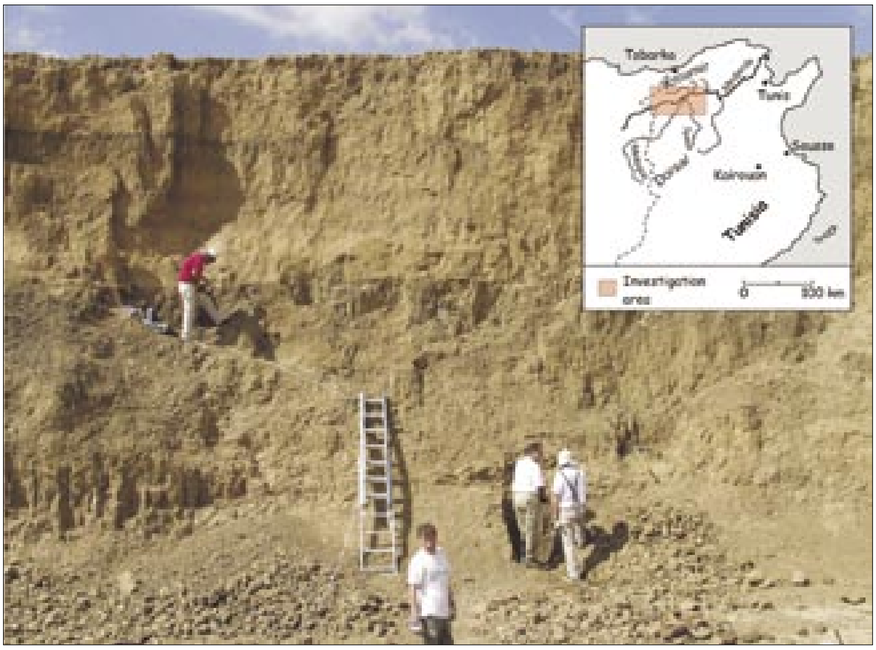

Fig. 1: Area of investigation; excellent exposure conditions allowed detailed sampling.

Methodology

From 1999 to 2002, fieldwork led to the selection and sampling of more than 20 representative key profiles. Field observations and pedological analyses (granulometry, organic matter, $CaCO_3$ content of clay and silt fraction, heavy minerals, thin section analyses) allow us to distinguish five main stratigraphical series. About 60 AMS radiocarbon samples establish a late Quaternary chronology. In several cases, charcoal pieces are remnants of firesites and cultural layers, so we assume we have dated in situ material.

In our investigation, magnetic intensity [mA m^{-1}] and magnetic susceptibility [$K_o = 10^{-6}$ SI units], as well as inclination and declination [°], were recorded. Because of significant similarity with secular variation curves from Sicily (Tanguy et al., 2003), our declination and inclination values give major chronological information about floodplain evolution.

On the basis of chronological findings (paleomagnetics, ^{14}C data, artifacts) and the corresponding sediment thickness of the layers, we can reconstruct a curve for average sedimentation rate. In doing so, the sedimentary conditions between two chronologically well-known marks are regarded as homogeneous. Records of sedimentation rates give detailed information about late Pleistocene and Holocene alluvial history.

Results

Detailed morphostratigraphical fieldwork, paleomagnetics and radiocarbon dates provide a centennial-scale record of Northern Tunisian fluvial sequences (Fig. 2). Alternating sediment texture, sedimentation rates and soil formation within Medjerda overbank deposits indicate short-term fluctuations in late Pleistocene and Holocene fluvial dynamics. Mediterranean river systems show a direct reaction to climatic shifts even of short duration.

Stratigraphically, the base of the synthetic profile is composed of a well-developed, rubefied soil. This soil is formed in a floodplain sediment in which interbedded molluscs give a radiocarbon age of approx. 42.8 ky (uncal). The red soil is covered by fine sedimentation (silty-clayey) at about 13.5 ky cal BP. This sedimentation continues until 12.6 ky cal BP, under climatic conditions similar to modern times (macroremnants of a dated firesite). According to our datings, the Younger Dryas begins at 12.4 ky cal BP and ends about 11.8 ky cal BP. During the Younger Dryas, coarse sediments and gravels were deposited. The onset of the Holocene (11.8 ky cal BP) is marked by fine sedimentation lasting until 6.6 ky cal BP. This is a long period of geomorphic stability, even if sedimentation seems to accelerate at about 8.2 ky cal BP, indicated by the paleomagnetic records of some profiles. At 6.6 ky cal BP, the stable period is interrupted by sedimentation of coarse material. The period that follows is characterized by fine sedimentation in most parts of the floodplain in which a distinct soil is formed (Mid-Holocene Stability).

Around 4.8 ka cal BP, poorly sorted sediments cover the mid-

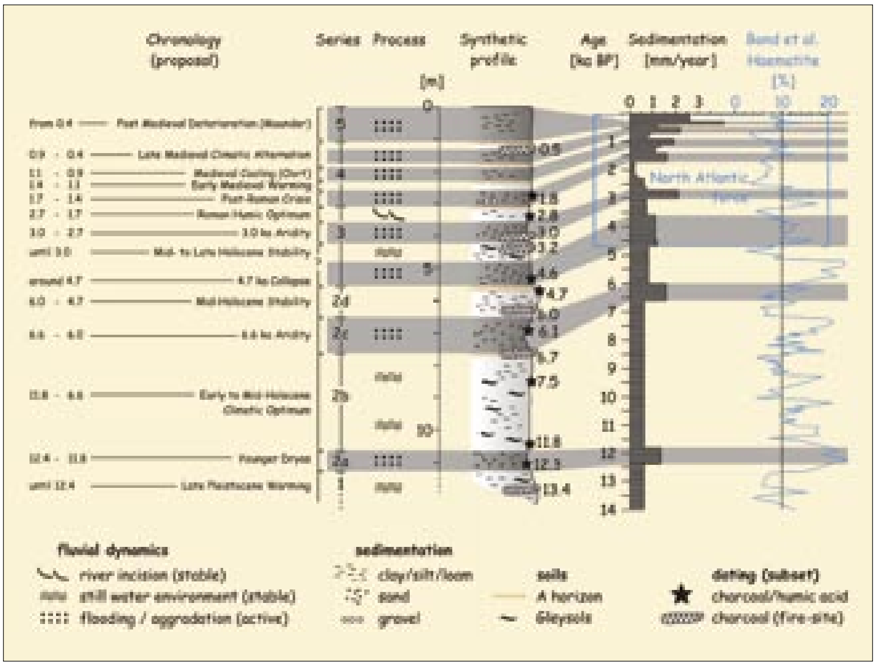

Fig. 2: Synthetic profile of the Medjerda Valley, Northern Tunisia. Chronostratigraphy is based on the analyses of 20 key profiles.

Holocene soil. This indicates an enhancement of morphodynamic processes. Sediments then fine-up until Punic times. After 3.0 ka cal BP, increased morphodynamic processes take place for a short time (dating of two firesites in one exposure). This aggradation of sandy deposits ends about 2.7 ka cal BP. About 2.0 ka cal BP, morphodynamic stability and soil formation may be observed, although the timing of the beginning of soil formation is still unknown. At 1.7 ka cal BP, an accentuated restart of fluvial dynamics takes place. At this time, the morphodynamically stable Punic-Roman period ends and most of the soils are buried under coarse sediments (Post Roman Crisis). Certain sediment strata with ages between 1.2 and 0.8 ka cal BP show humic enrichment due to soil formation. Subsequent minor flooding yields only fine sediments. The top of this sediment-sequence also shows a slight humification. At 0.4 ka cal BP (dating of a firesite), devastating floods occur in the entire Medjerda Basin, leaving thick laminated sediments, referred to as the Youngest Layer.

Conclusions

The Medjerda river system within the semi-arid to sub-humid subtropics of Mediterranean North Tunisia was sensitive to paleoclimatic shifts. Dominant climatic influences were not due to changes in temperature but to shifts in humidity. According to Rohdenburg (1983), geomorphic activity in the subtropics responds to aridification of the climate.

The centennial-scale synthetic profile indicates that:

a) Changes in fluvial dynamics during the late Pleistocene to early Holocene can be assigned to global climatic shifts. Climate changes due to shifts in the North Atlantic deep water formation also seem to be reflected in the central Mediterranean region. However, the paleogeomorphological response of the Younger Dryas appears to be significantly shorter.

b) In the course of the early to mid-Holocene, major shifts in the Medjerda fluvial dynamics correlate with changes in Saharan climate. Brief Saharan aridification around 5 ka corresponds with the 4.7 ka collapse within the Medjerda River system. In contrast, the worldwide documented 8.2 ka EMTH event cannot clearly be deduced from the Medjerda overbank deposits.

c) Medjerda overbank sediments document increased fluvial activity around 6.6 to 6.0 ka. The 6.6 ka event is not well described in other paleoclimatic records. This indicates the possibility of major changes in aridification, even at a regional to local scale.

d) The comparison of mid- to late Holocene sedimentation rates of the Medjerda with the Haematite curve of Bond et al. (2001) reveals a parallel progression of late Holocene North Atlantic coolings and increased alluviation in Mediterranean Tunisia. Short-term periods of geomorphic activity in Northern Tunisia match well with North Atlantic Bond events. The findings indicate a climatic link from the 4.7 ka collapse until today. During the last 2,000 years, climatic optima caused landscape stability regardless of the land-use intensity (Faust et al. 2004). Our findings provide evidence that late Holocene fluvial dynamics in Northern Tunisia were chiefly driven by climate. Anthropogenic impact at most intensified or attenuated the geomorphic processes.

Acknowledgements

We would like to thank the *Deutsche Forschungsgemeinschaft* (DFG) for supporting this project (FA 239/2-1 and FA 239/2-2).

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Tracing Paleoclimatic Signatures in Fossil Woods and Sub-fossil Logs of Kerala, Southwestern India

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Fossil woods and sub-fossil logs, the hard and compact parts of plant remains, are an important source of information on environmental changes of the geological and recent past, as they show detailed cellular structure that can be compared with a modern analogue. Unlike those of older geological periods, Quaternary woods are fossilized as 'fusains', a charcoal-like material, in the lignites and peats or remain undecayed as sub-fossil. Provided they possess annual growth rings, these fossils form a valuable source of climatic data where there is a lack of contemporaneous meteorological records. As growth ring formation is primarily related to climatic conditions, a few of these woods may turn out to be potential species for assessing the pattern of climatic changes in the last few thousand years. Such an application is already gaining importance in paleoclimatic research (Bhattacharyya et al., 1992; Creber and Francis, 1999).

It is estimated that about 25% of the tropical trees in India are known to produce growth rings (Chowdhury, 1964) but climate-controlled growth-ring formation occurs in only a few species. Most of these broad-leaved tropical trees have persisted since the Miocene along the west coast of India (Srivastava and Awasthi, 1996), and, as such, there is great potential for their use in dendroclimatic analysis. Teak *(Tectona grandis)*, Cedrela *(C. angustifolia)* and Toon *(Toona ciliata)* are some of the species with distinct growth rings that have already been exploited for tropical dendroclimatology (Bhatttacharyya and Yadav, 1989; Tomazello et al., 2001). However, new techniques involving stable carbon and oxygen isotopes as indicators for processes underlying tree growth and climate proxies may help when studying tropical trees with indistinct growth rings (Helle and Panferov, 2004; Verheyden et al., 2004). By using such techniques, it may be possible to track climatic signals back to pre-instrumental times. Tree trunks embedded in carbonaceous and silty clays at different stratigraphic levels from several locations along the Kollam-Kodungalloor stretch of the South Kerala sedimentary basin (Fig. 1) are described here, and their importance as potential archives of Late Quaternary environment addressed.

Fig. 1: Landward extension of Kerala-Konkan Basin. The shaded part represents the location of the South Kerala sedimentary basin study area between Kollam and Kodungallur.

There have been a few reports of fossil woods from the Late Quaternary deposits of this stretch of Kerala (Agarwal et al.,1970; Nair et al., in press, Guleria et al., 2004). Rarely, however, are these reports accompanied by any description of the geological settings and taphonomy associated with the fossils. Neither the spatial and temporal distribution, nor the dendroclimatic aspects of these woods have been described so far, despite the fact that the woods have been excavated and used by local inhabitants for many decades. Moreover, except for a few radiocarbon dates, no other details are available, though the woods form potential archives of environmental changes and paleoclimatic signatures.

Large and small trunks of trees, often with their bark and parts of their roots and branches intact, are very common in the seasonal and perennial wetlands. In some cases, the woods are partly carbonized, especially the Late Pleistocene sequences. Holocene logs are generally found with bark and their hard woods intact (Fig. 2a, b). Although these fossil woods are yet to be identified based on anatomical characteristics, data (vernacular/local names) provided by the local inhabitants reveal that at least 13 species of tropical wet evergreen and semi-evergreen forests occur in this region (Table 1). Some of these species have already been reported from the Neogene sediments (Miocene-Pliocene) belonging to the Warkalli Formation, and a few of them are still grown in sacred groves, relicts of the pristine forest that thrived until the Late Pleistocene-Early Holocene in the lowlands of Kerala (Nair et al., in press).

The accumulation of fossil woods and sub-fossils of large forest trees in huge quantity in the South Kerala coastal plains has considerable significance for inferring the ecology, depositional environment and geological events of the Late Quaternary. It is likely that extensive floods after the transgression might have caused massive destruction of the coastal forests, which in turn buried the

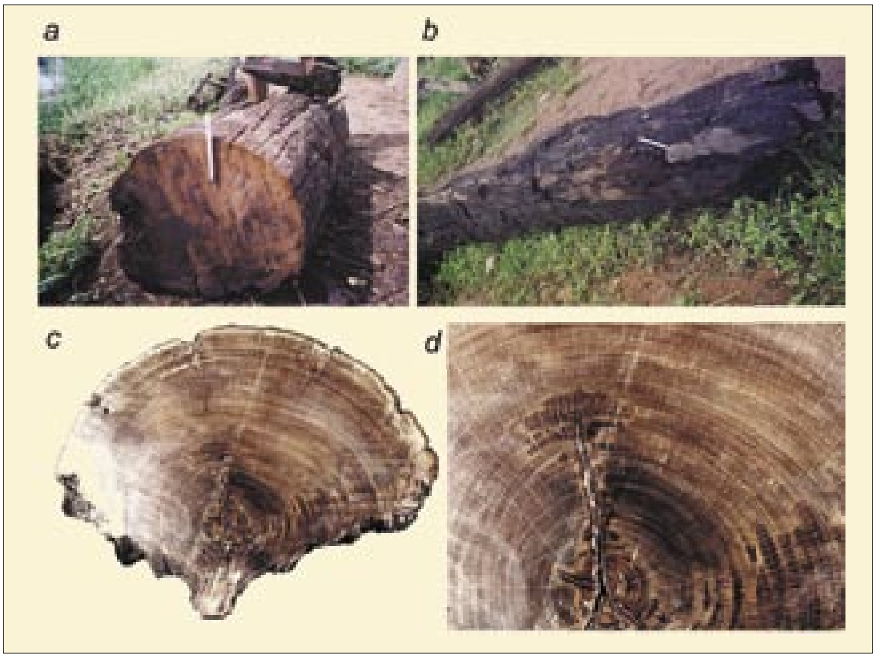

Fig. 2: Fossil wood and subfossil log of Kerala coast: ***a****) Subfossil log excavated from the backwaters of Pathiyoor; Early Holocene.* ***b****) Partially carbonized fossil wood; Early Holocene.* ***c****) Cross section of specimen "a" showing growth-ring pattern.* ***d****) Sector enlarged view of specimen "c" showing closer view of growth rings.*

huge trunks of trees. Evidence for such large-scale floods and scouring in the Early Holocene has been presented recently for monsoon Asia (Kale et al., 2004). There fossils are believed to have accumulated in situ, as many of them possess intact roots and branches and some of them have bark, providing evidence of quick burial. This indicates that these fossils did not drift too far from their place of origin, and hence are of considerable significance in determining the provenance of the vegetation. A profuse growth of wet evergreen and semi-evergreen vegetation comprising many woody species, viz., *Dipterocarpus, Hopea, Shorea, Diospyros, Canarium, Artocarpus, Mangifera, Pterocarpus, Toona, Leea* and *Cullenia* (fossil pollen only) might have been aided by the high Asian Summer Monsoon reported to have been approx. three times greater than the present rate of rainfall.

The area of investigation presently receives annual rainfall ranging from 200 to > 500 cm of which ~70% is from the SW-Monsoon, otherwise known as the Asian Summer Monsoon. Our analyses of the palynodebris and sediment characteristics suggest that there were two periods of abnormally high rainfall, one before the Last Glacial Maximum (LGM) and another during the Early Holocene.

Many of the landforms in the coastal plains and several of the landforms in the hinterland have been shown to contain a partial-to-complete record of the period from the Late Pleistocene to the Holocene. In addition, there are indications that some of these terrains were sub-aerially exposed lands that were thickly forested. As a result of abnormally high rainfall, coupled with tectonics and the antecedent landform characteristics, the trees that grew there were possibly uprooted and buried right there. This would be unique to this area, and therefore calls for detailed and systematic investigation with regard to sub-fossil wood and vegetational history.

As the fossil logs are found in abundance and are incorporated (coalified in varying degrees) into peat or lignite, the cellular details ought to have been preserved in them. The various processes involved in fossilization may

Table 1: List of fossil woods and subfossil logs excavated from the wetlands of Kerala, based on data obtained from the local inhabitants and their potential for dendroclimatological study.
** Fossils known from the Neogene Kerala coast sequence.*

Sr. No.	Vernacular name (Malayalam)	Botanical name	Family	Anatomical features
1.	Anjeli / Aini	**Artocarpus hirsutus* Lamk.	Moraceae	Growth rings indistinct
2.	Plavu	**Artocarpus heterophyllous* Lamk	Moraceae	Growth rings indistinct
3.	Kunthirikkam (Pantham, Thalli)	**Canarium strictum*	Burseraceae	Growth rings indistinct to distinct
4.	Eetty	*Dalbergia latifolia* Roxb.	Fabaceae / Papilionaceae	Initial parenchyma cells; Growth rings fairly distinct
5.	Kambagam	**Hopea parviflora* Bedd.	Dipterocarpaceae	Growth rings indistinct
6.	Elanjhi	*Mimusops elangi* L.	Sapotaceae	Growth rings indistinct
7.	Vengha	*Pterocarpus marsupium* Roxb.	Fabaceae	Growth rings distinct to indistinct
8.	Odal	*Sarcostigma grandis* Wight & Arn.	Icacinaceae	-
9.	Puli	*Tamrindus indica* L.	Caesalpiniaceae	Growth ring distinct to indistinct
10.	Thekku	*Tectona grandis* L.f.	Verbenaceae	Distinct growth rings
11.	Pillamaruthu	**Terminalia paniculata* Roth	Combretaceae	Growth rings indistinct
12.	Agil	*Toona ciliata* Roem.	Meliaceae	Growth rings distinct
13.	Mavu	*Mangifera indica*	Anacardiaceae	Growth rings indistinct

preserve the anatomical details of the wood so well that growth-ring studies may be carried out on them exactly as if they were modern wood. Although conifers in temperate and sub-alpine zones have been exploited for climatic reconstruction, tropical and subtropical trees, with the exception of Teak *(Tectona grandis)*, have been seldom tested. This is due to a lack of information on datable tree rings from the Indian subcontinent. Nevertheless, transverse sections of some of the fossil logs look similar to growth rings, although they are yet to be evaluated microscopically (Fig. 2c, d).

Further excavation and meticulous searching of the fossil woods and sub-fossil logs in the wetlands of Kerala may lead to the identification of additional potential species for dendroclimatic study. Although a few taxa have demonstrated the potential for climatic reconstruction of the historical period, no attempt has been made yet to examine the Holocene or recent past based on tree growth-ring studies. In fact, tree-ring studies of tropical forest species have not often been undertaken, though such studies would be of great significance in terms of investigating global climatic change. There is good scope for paleo-dendroclimatological study in India and what has been discovered so far appears to be only the begining.

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An Upwelling Seesaw in the Atlantic Ocean: Model Results and Paleoceanographic Evidence

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Coastal Upwelling in the Atlantic Ocean

Coastal upwelling regions are important areas of investigation for paleoclimate research because of their high-resolution sedimentary archives and their sensitivity to environmental changes. Understanding the interactions between coastal upwelling zones and climatic conditions is crucial for a proper interpretation of the sedimentary record. In the Atlantic Ocean, the two major coastal upwelling regions are located along the coasts of northwestern (Mauritanian upwelling zone) and southwestern Africa (Benguela-Namibia upwelling system). The strength of African coastal upwelling is a function of the alongshore winds, which in turn are closely tied to the trade-wind systems in both hemispheres. We analyzed the response of the major Atlan-

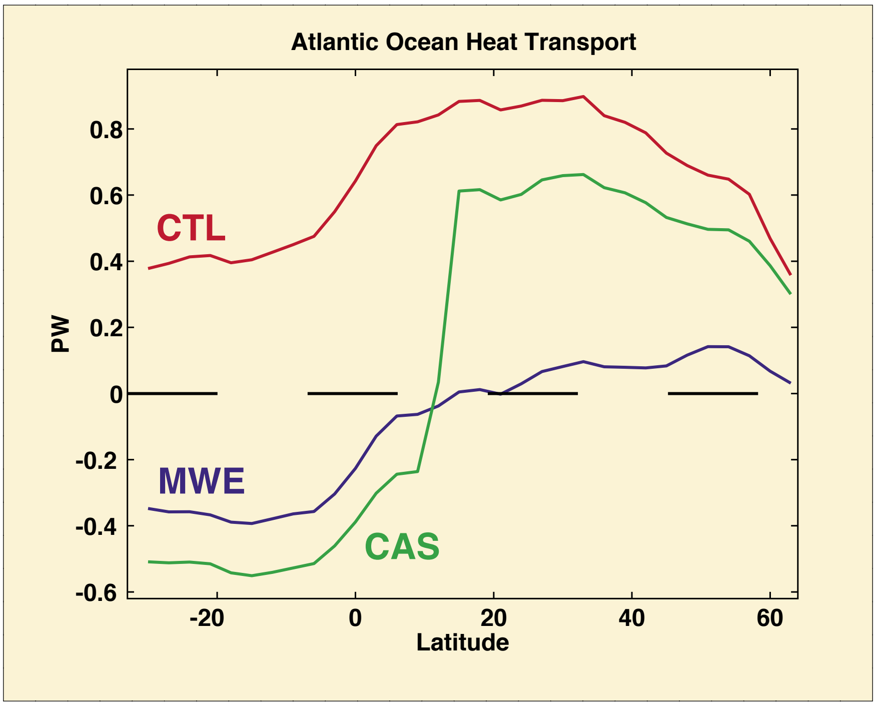

Fig. 1: Northward heat transport in the Atlantic Ocean for experiments CTL (control), MWE (meltwater event) and CAS (Central American Seaway). A reference temperature of 1.3°C has been used in the calculations.

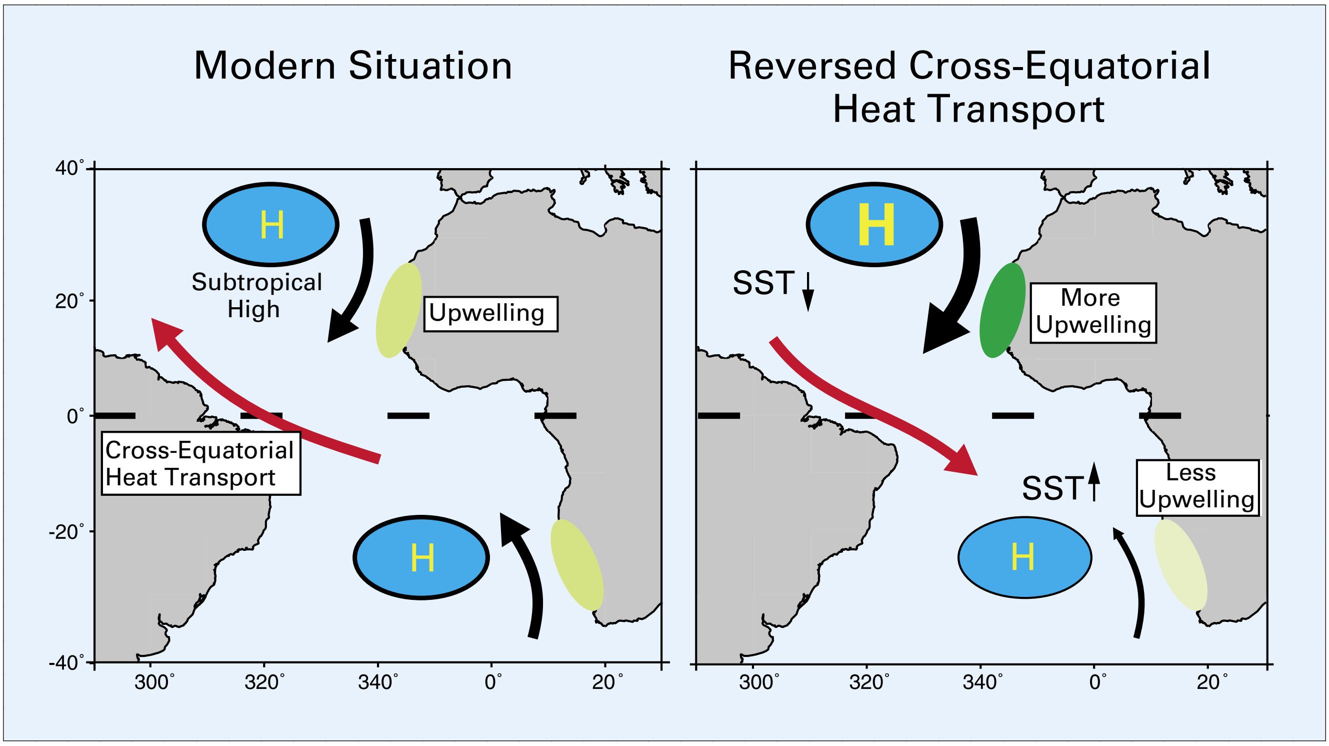

Fig. 2: Schematic of the coastal upwelling seesaw in the Atlantic Ocean. Today, the subtropical highs over the North and South Atlantic are associated with a trade-wind system that promotes upwelling along the coasts of northwestern and southwestern Africa (left panel). A reduced or reversed cross-equatorial oceanic heat transport causes sea-surface temperatures to drop in the North Atlantic and increase in the South Atlantic. The resulting effect on the atmospheric pressure system changes the trade-wind strengths, such that upwelling is intensified along the NW-African coast and weakened off SW-Africa (right panel).

tic coastal upwelling regions to shifts in large-scale oceanic heat transport (Prange and Schulz, 2004). Based on coupled climate model experiments, we suggest an antiphase behavior between the upwelling intensities off northwest and southwest Africa. This teleconnection can be described as a "coastal upwelling seesaw". The state of this upwelling seesaw is controlled by variations in the Atlantic cross-equatorial oceanic heat transport.

The Coastal Upwelling-Seesaw in a Coupled Climate Model

Substantial reorganizations of the large-scale oceanic circulation (and hence cross-equatorial heat transport) took place several times in the history of the Atlantic Ocean, induced by abrupt changes in thermohaline surface forcing (e.g., Heinrich Events of the last glacial period) or tectonic shifts (e.g., the closure of the Central American Seaway in the Pliocene). In order to study the effect of such processes on Atlantic coastal upwelling dynamics, we performed two sensitivity experiments with the coupled global atmosphere-ocean model ECBILT-CLIO version 3.

The first experiment mimics a glacial meltwater event (experiment MWE): A complete shutdown of North Atlantic Deep Water formation is induced by an anomalous freshwater input to the North Atlantic between 50°N and 70°N. The induced reorganization of the oceanic thermohaline circulation resembles the processes that occurred during Heinrich Events.

In the second experiment, we introduce a Central American Seaway (CAS) with a depth of 700 m. This topographic situation is similar to the paleobathymetric conditions in the late Miocene, somewhere between 12 and 6 million years ago. The CAS gives rise to a transport of tropical water masses from the Pacific into the Atlantic Ocean. The mean total volume transport through the gateway amounts to 14 Sverdrups. Owing to this inflow of relatively fresh water masses into the Atlantic, the formation of North Atlantic Deep Water decreases by about 50% compared to a control run (CTL) with the closed Isthmus of Panama.

Both the meltwater input in experiment MWE and the bathymetric modification of experiment CAS lead to substantial changes in the Atlantic Ocean meridional heat transport (Fig. 1). Most importantly, the heat transport across the equator reverses compared to CTL, causing a redistribution of heat with cooling in the North Atlantic and warming in the South Atlantic. The altered sea-surface temperatures influence atmosphere dynamics; cooling in the North Atlantic intensifies the northern hemispheric subtropical high. In contrast, over the South Atlantic, the subtropical high-pressure cell is weakened by the oceanic warming. The resulting anomalies in wind stress affect the Atlantic coastal upwelling systems through changes in Ekman pumping; the modified trade-wind systems tend to intensify upwelling off northwest Africa, while upwelling in the Benguela-Namibia system is reduced (Fig. 2; Prange and Schulz, 2004).

Paleoceanographic Evidence for an Upwelling-Seesaw Effect During Heinrich Events

Little et al. (1997) analyzed relative abundances of the cold-water planktonic foraminifer Neogloboquadrina pachyderma (left coiling) in sediment cores from the Benguela-Namibia upwelling system over the last 140,000 years. Short periods of low abundance, indicating reduced coastal upwelling, coincide with Heinrich Events. This correlation is particularly striking for Heinrich Events 2 and 4.

For the Mauritanian upwelling zone, high-resolution proxy records for the last 35,000 years were presented by Zhao et al. (2000). A low percentage of the coccolithophorid Florisphaera profunda during Heinrich Event 2 suggests a weak surface water stratification due to enhanced upwelling intensity. Kiefer (1998) estimated primary productivity over the last glacial period from a core located southwest of the Canary Islands, about 450 km off the coast of northwestern Africa. Peaks in paleoproductivity coincide with Heinrich Events 2-5. A possible explanation for these peaks is that an increased amount of nutrient-rich upwelling water was advected from the coast towards the core location.

A Coastal Upwelling-Seesaw in the Pliocene?

Utilizing results from Ocean Drilling Program Site 1084, situated off the coast of Namibia, Marlow et al. (2000) reconstructed the upwelling history from the early Pliocene to the late Pleistocene. Around 4 million years ago, increases in mass accumulation rates of organic carbon, diatom abundance, and the proportion of upwelling species in the diatom assemblage coincide with the final stages of the CAS closure. We hypothesize that the increase in upwelling intensity off Namibia during the Pliocene is attributable to the closure of the CAS, the resulting increase in northward oceanic heat transport (cf. Fig. 1) and the operation of the Atlantic coastal upwelling seesaw. Unfortunately, no unequivocal Pliocene reconstruction exists for the upwelling region off northwestern Africa. For an improved understanding of Pliocene climate processes, future studies should focus on upwelling proxies for the Mauritanian upwelling zone.

Acknowledgments

This research was funded by the Deutsche Forschungsgemeinschaft through the DFG Research Center "Ocean Margins" at the University of Bremen. More information about the ECBILT-CLIO climate model, including a list of references, is available at www.knmi.nl/onderzk/CKO/ecbilt-papers.html.

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Call for a PAGES Initiative on "Past Regional Climate Variability"

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Understanding past environmental variability is a prerequisite for the understanding of future environmental change. If we intend to diagnose, for instance, past climate variability, we have to be aware that a variety of natural and anthropogenic forcing mechanisms, as well as mechanisms inducing internal variability, act together and form a "cocktail" composition that is temporally very variable. The pattern of interaction in figure 1 attempts to document this fact. The upper boxes show how the forcings, together with natural variability, jointly influence the different subsystems of the climate system. As a result of these interactions, a variety of large-scale circulation patterns, modes and regimes are generated. These modes or regimes

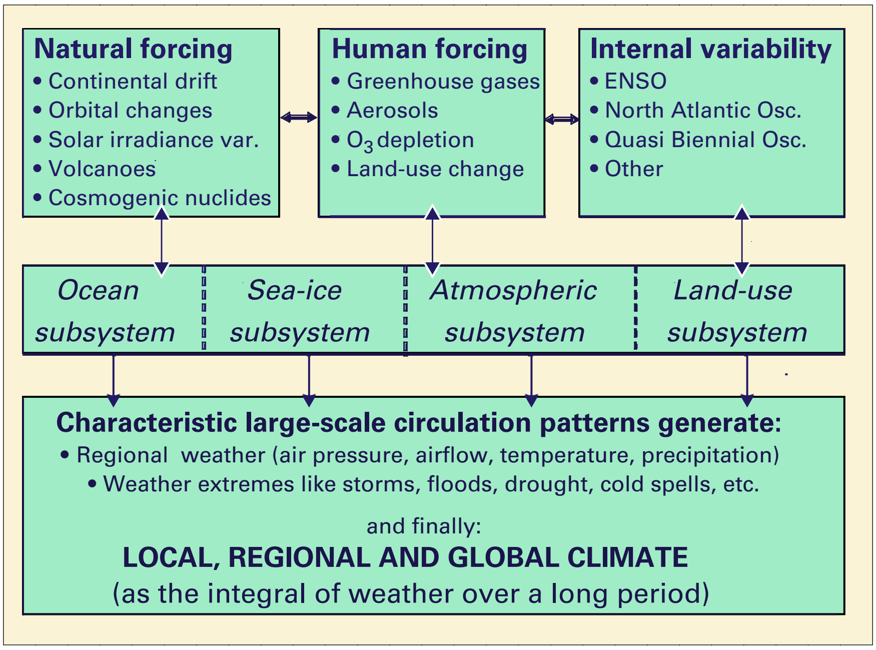

Fig. 1: Pattern of interaction demonstrating how the different natural and anthropogenic forcing factors, together with internal variability, generate local and global climate variability and change.

together cause the generation of mean and extreme local weather. The integral of these local weather phenomena over time and space results in that which we call local, regional and global climate.

The first long-term reconstructions were carried out using a variety of suitable proxy data and were mainly based on a global or hemispheric scale (Mann et al., 1998). Because temperature is directly related to the global energy balance, many studies still concentrate on this variable. In an earlier contribution to *PAGES News*, we already campaigned for the inclusion of other important contributory variables of the climate system, like air pressure and precipitation (Wanner and Luterbacher, 2002). We called it a LOTRED (Long Term Reanalysis and Diagnostics) approach. The basic idea is that the complex dynamical processes leading to past and future climate and environmental change can only be understood if we also acquire insight into the regional dynamics, for example, the cooling of the oceans by strong winds, the deflection of airflow by mountains, or the formation of heavy convective precipitation.

Two other facts have to be kept in mind. Firstly, we must consider that climate variability increases if the investigated area decreases. Secondly, the new generation of coupled climate models delivers simulation data at smaller regional scales (Schär et al., 2004). We therefore need highly resolved reconstructions if we intend to verify long-term past climate runs. In areas like Europe, where dense networks with high-quality natural and documentary archive data are available, multi-proxy reconstructions of temperature on a regional basis with higher temporal resolution (seasonal or monthly) are feasible (Luterbacher et al., 2004). The present multi-proxy database has sufficient quality and density to allow the first 500-year-long reconstruction of continental precipitation fields (Pauling et al., in prep.).

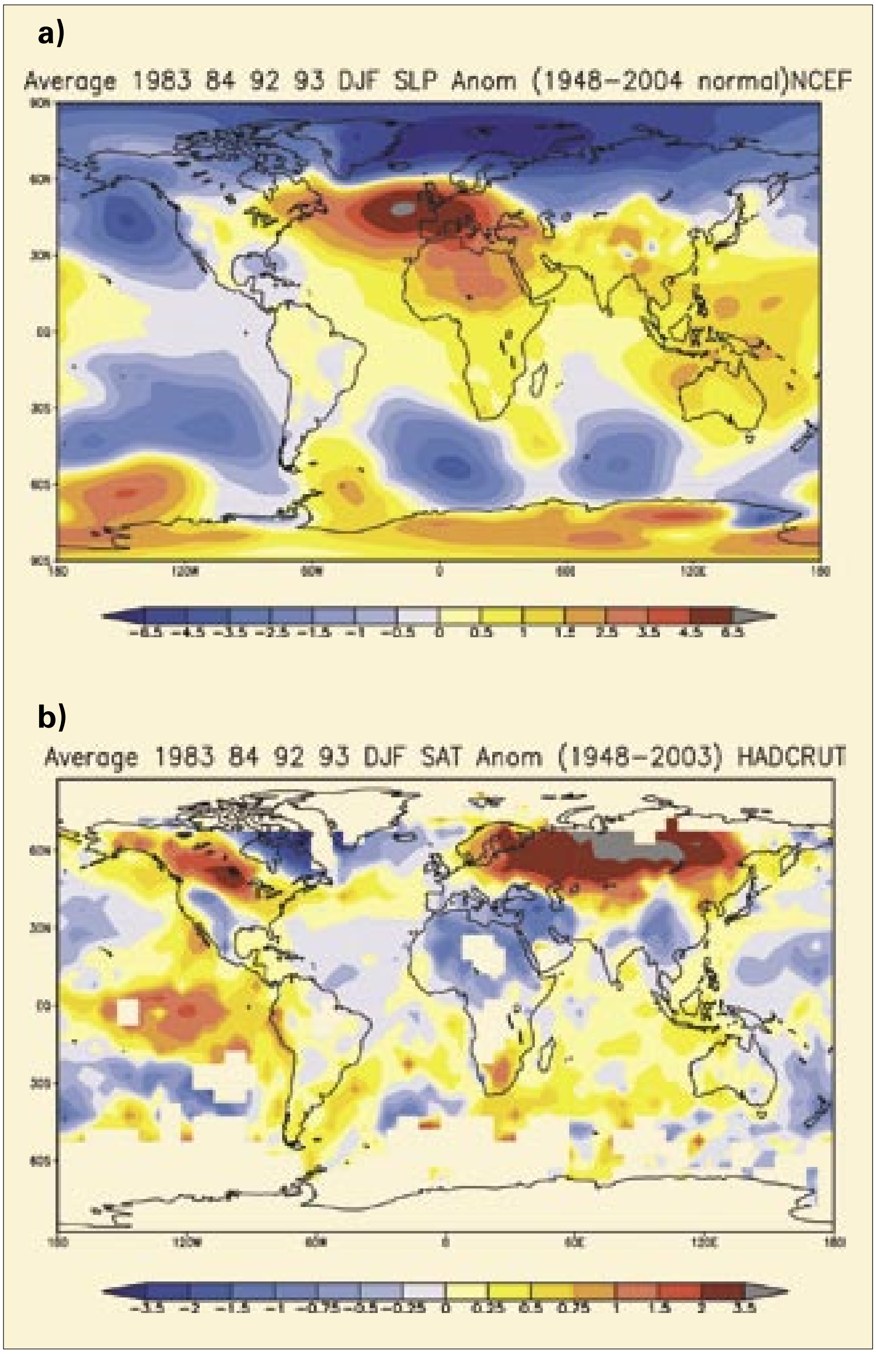

Fig. 2: Influence of the forcing by the El Chichón and Pinatubo eruptions on the global winter (DJF) surface pressure (a) (hPa) and temperature (b) (°C) anomaly fields in the first and second winter after the eruption (analysis by Paul Della Marta, based on NCAR/NCEP data for SLP and HADCRUT2 data for SAT; Kistler et al. 2001, Rayner et al. 2003).

One basic procedure to try to understand how the complex mix of natural and anthropogenic forcings, as well as internal variability, influence climate modes or regimes is to isolate one of these forcing factors that is remarkably strong, and to study the reaction of the climate system. In the case of model simulations, it is rather easy to generate a single specific forcing or to study natural variability under fixed forcing conditions. When using high-resolution reconstructed data, we have to define a period where one of the factors in the uppermost boxes of figure 1 was remarkably pronounced. By studying the anomalies during such periods, we can start to understand the dominating processes. And, indeed, most of these processes cause complex regional patterns. As an example, figure 2 indicates the influence of the forcing of the El Chichón and Pinatubo eruptions on the global winter (DJF)

Table 1: Influence of selected forcings and the two most important natural modes of climate variability in regional climate (SAT: surface air temperature, SST: sea surface temperature).

	Northern hemisphere	Tropics	Southern hemisphere	Timescale	Reaction of ENSO	Reaction of NAO (winter)
Natural forcings:						
Solar irradiance minimum	Warm oceans, cold continents (winter, SATs)	SSTs slightly higher	Southern oceans cooler (SATs)	Decadal to centennial	?	Negative state
Explosive tropical volcanic eruptions	Cold oceans, warm continents (also cool in N. Africa and China in winter)	Positive temperature anomalies in Eastern Pacific (SATs)	Deepening of midlatitude lows	Inter-annual	Can trigger ENSO events	Positive state
Anthropogenic forcings:						
Increasing GHGs and aerosols	Marked warming in all seasons (stronger in northern areas and over land), mainly increasing precipitation amounts	Slight warming (more in central and eastern equatorial Pacific), inconsistent precipitation trends	Warming (inconsistent magnitude), precipitation trend uncertain (exception: positive trend in Antarctic area)	Already decadal	Little change or small increase (uncertain)	Very uncertain (small trend to negative state)
Ozone depletion in polar areas	Similar to southern polar area but more complex processes	?	Cooling of Antarctic stratosphere, higher wind speeds	Decadal	?	Slight trend to positive state (?)
Land use change	Urbanized areas: slight temperature rise Deforested areas: slight temperature decrease	Drier in deforested areas	Similar to northern hemisphere (but smaller because of reduced area)	Decadal to centennial	?	?
Modes of natural variability						
ENSO warm episode	Wet: Florida, Gulf of Mexico Dry: NW India, Hawaii	Wet: Central Pacific, S. India, Uganda and surroundings Dry: Indonesia, Philippines, Central America	Wet: E Argentina, Uruguay Dry: SE Africa, E. Australia – Melanesia	Quasi periodic: 3-7 yrs	—	Negative state is possible
NAO (positive state)	Enhanced westerlies – Warm and moist: N. Eurasia, NE USA, E. Canada Cooler and partly drier: S. Europe and N. Africa, NW Atlantic Ocean	Marked northern hemispheric trades	?	Quasi periodic: 6-10 yrs	?	—
NAO (negative state)	Weaker westerlies – Rather cool and moist: S. Europe and N. Africa Cold and dry: N. Europe, NE USA, E. Canada	Weaker northern hemispheric trades	?	Quasi periodic: 6-10 yrs	?	—

pressure and temperature fields. The pressure distribution (Fig. 2a) not only shows a deepening of the midlatitude lows on both hemispheres but also a positive pressure anomaly southwest of Great Britain. The influence of these anomalies on wintertime heat transport is reflected in the temperature anomaly map (Fig. 2b), for example, in the form of a strongly positive temperature anomaly over Eurasia (Shindell et al., 2004).

Finally, Table 1 gives an overview of a selection of possible regional effects on circulation patterns or surface temperature and precipitation anomalies, generated by typical forcings or by the modulation of the two dominating internal modes of variability listed in figure 1. We hope that this summary will encourage many PAGES scientists to perform more regional reconstruction and modeling studies of climate variability and other environmental issues!

Acknowledgments

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Tropical-Extratropical Climatic Teleconnections: A Long-Term Perspective

Chapman Conference, Honolulu, Hawaii, 8-11 February 2005

Climatic teleconnections link regional variations to global phenomena. An excellent example of this is the impact that variations in El Niño Southern Oscillation (ENSO) have on global climatic anomalies.

The purpose of this conference was to bring together atmospheric scientists, oceanographers and paleoclimatologists in order to provide modern climate scientists with a better understanding of paleoclimate records, and paleoclimatologists with the opportunity to place their records into the larger context of climate processes. Climate periods reconstructed using proxy records from ocean, lake and peat sediments, fossil corals, ice cores, speleothems, paleosols and tree rings included the last millennium, the Quaternary, and the Pliocene-Miocene. Variability on millennial and orbital time scales is apparent in many of these records and they show tropical-extratropical connections but forcings can be different. Millennial variability in tropical SST records corresponds to prominent features in the North Atlantic (e.g. Younger Dryas) but have a muted response in the western tropical Pacific. Well-preserved corals in eastern Indonesia record a cooling event over ~100 years synchronous with the 8.2 ka cold event in the North Atlantic, supporting the role of atmospheric teleconnections in rapidly propagating this signal to the tropics. The paleoclimate record of the Asian summer monsoon winds shows robust teleconnections with ENSO and North Atlantic climate. Antarctic ice cores show variability that may be tied to variability of moisture sources at low latitudes.

Fig. 1: The conference brought together experts in observation, theory and modeling of modern teleconnections, and in analysis of past records of climate variability.

The reports on modern climate using observational diagnostic analysis and modeling results provided a basis for understanding the paleoclimate records. The global heat budget provides strong constraints on the climate system by requiring systematic movement of energy. Latent heating in precipitation dominates the patterns of atmospheric heating and teleconnections. Monsoons are a coupled atmosphere-ocean-land phenomena and are characterized by a strong cross-equatorial pressure gradient. Teleconnections originating from patterns of tropical SST change and variability are sensitive to a change of ENSO variance and to the patterns of warming in the tropical Pacific and Indian Oceans. Oceanic thermohaline circulation was also shown to be important.

The interdisciplinary mix of researchers from eight countries led to lively discussions and provocative questions, and new collaborations have already been forged to study the climate system from a longer-term perspective. Future meetings are being planned to continue to bring paleo-proxy and instrumental data, and climate modeling of the past, present and future to bear on the nature of climate change.

Acknowledgments
This conference was sponsored by the International Pacific Research Center, the US National Science Foundation and PAGES.

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An Overview of the Swiss Contribution to the HITE Project

HITECH Workshop 2004, Zurich, Switzerland, 18 October 2004

Human Impacts on Terrestrial Ecosystems (HITE)—an initiative of IGBP-PAGES—is an international network of projects devoted to the study of ecosystem changes on decadal-to-millennial time scales. The Swiss contribution to HITE comprises a cluster of five projects, the "HITECH-Net", where "CH" stands for *Confoederatio Helvetica*, Latin for "Swiss Federation".

A major HITECH workshop entitled "Using modeling, paleo archives, historical and contemporary information to assess present and future ecosystem dynamics" took place in mid-October 2004 at ETH Zurich. This one-day workshop comprised four keynote lectures, eleven contributed presentations and several posters. Participants were mostly from Switzerland but also included scientists from the UK, Germany, France, Austria and Italy. Presentations were grouped into four chronological sessions, each beginning with a keynote lecture.

The first session focused on long time scales and the early history of human impacts on ecosystems.

Fig. 1: Studying the human impact on terrestrial ecosystems requires an interdisciplinary approach!

B. Ammann (University of Bern) gave an overview of methods and approaches in paleoecology. Subsequent presentations covered topics such as tree migration, impacts of climate and humans on vegetation changes, and reconstruction of historical fire regimes. The second session focused on the historical time scale. M. Bürgi (WSL, Birmensdorf) showed how environmental history and historical ecology extend paleoecological approaches up to the present time. Other presentations focused on past disturbance patterns in forest ecosystems, with an analysis of fire history and ecology. In the afternoon, J. Dearing (HITE Leader, University of Liverpool, UK) presented the Lac d'Annecy project in France, a study of the impact of changes in historical land use and climatic shifts on sediment deposition. Other presentations on linking past with present ecosystem dynamics included approaches using aerial photographs, tree rings and genetic markers. The last session focused on assessing future ecosystem dynamics using modeling. H. Bugmann (Swiss Federal Institute of Technology Zurich) discussed how approaches for evaluating past ecosystem dynamics could be used to project future trajectories of terrestrial systems. Case studies covered predicting future fire regimes and using models of insect outbreaks to derive sustainable management strategies.

The workshop revealed a wealth of approaches and data sources and illustrated the importance of an integrated approach. The need for multi-site studies, meta-analyses and comparative approaches was also recognized.

For more information see: www.wsl.ch/HITECH.

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Past Ecosystem Processes and Human-Environment Interactions

PAGES Focus 5 Conference, Buellton, California 13-18 February 2005

PAGES Focus 5 is composed of three distinct but complementary sub-programs that focus on the human dimensions of environmental change: Human Impacts on Terrestrial Ecosystems (HITE), Land Use and Climate Impacts on Fluvial Systems (LUCIFS) and Human Impacts on Lake Ecosystems (LIMPACS). Program leaders and around 30 scientists representing 14 countries met for 4 days in February to discuss research findings and the future development of the program.

J. Anderson, R. Dikau and H. Bugmann led days dedicated to oral and poster summaries within the sub-programs, and John Dearing led a further day of presentations and discussion about modeling and integration. Talks and posters ranged from modern and historical flooding in the Mississippi catchment, to the causes of eutrophication in Lough Neagh and the sustainability of mangrove forest. M.-J. Gaillard ran a workshop on POLLENDCAL, the calibration of pollen diagrams in terms of land cover. C. Crumley chaired a session on how to enhance links between the social and natural sciences.

Over twelve hours of lively debate identified a number of areas where Focus 5 could be developed, particularly concerning integration and regionalization of research outputs. A new integrative scheme for organizing Focus 5 science was proposed. It emphasizes the synthesis of data and findings from multiple case studies for specific areas of the world. These syntheses will provide the long temporal perspective on the functioning and sustainability of specific regions. A simple matrix of zonal/azonal areas and the degree of previous human impact will provide the basic organizational structure (Fig. 1).

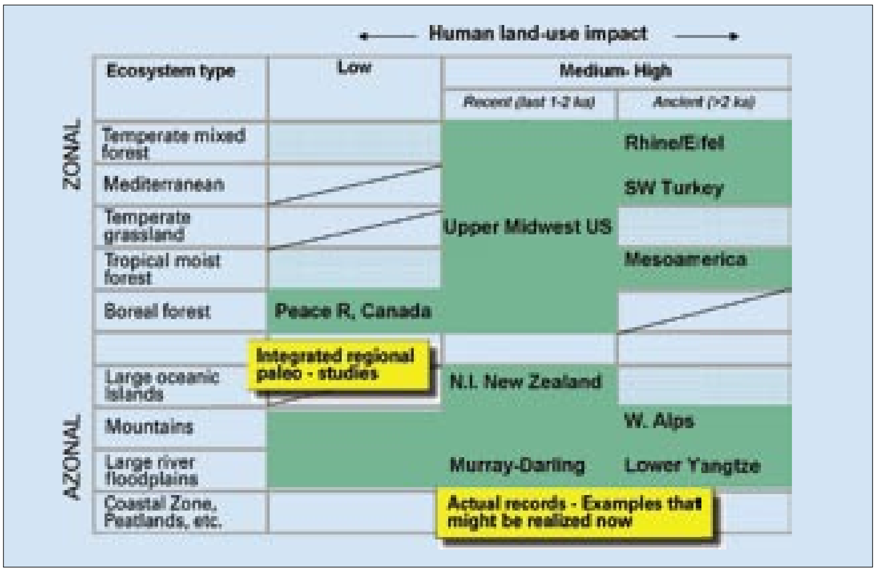

Fig. 1: Proposed matrix for regionalization of global case studies with geographical examples.

In practice, it is likely that regional groups will nominate their work for inclusion, and Focus 5 will encourage syntheses where they are required and new research where none exists. A number of flagship studies combining archives (e.g., sedimentary, documentary, instrumental) will be promoted as demonstration projects. The new scheme will be launched at the PAGES OSM. This meeting was a rare opportunity for Focus 5 scientists to meet as a single group and achieved a great deal, especially in terms of integration. It served to emphasize the diversity of environmental issues and topics that Focus 5 lends itself to, and the clear need to learn from the past in order to understand the present.

Thanks to Isabelle Larocque for organizing the meeting and to all the participants for their full contributions.

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