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Contents

Action list

For climate variability over the last few millennia:

(1) To organize a workshop comparing current approaches – forming a Proxy Reconstruction Methodology and Data Intercomparison Project (PRMDIP).
Mann/Briffa/Schmidt within 18 months (preliminarily planned: March 2006 Switzerland)

(2) To propose/promote possible future approaches and call for more reconstructions of last millennium with high resolution (up to decadal).
Mann/Briffa/Schmidt within 24 months

(3) To work with WGCM, recommending that WGCM give serious consideration to multi model ensembles of last millennium with consistent set of forcing and to make fields available.
Weaver/Jansen after the meeting

(4) To organize/edit a special issue of PAGES Newsletter (December 2005) on forcing.
Masson-Delmotte/Beer/Kull

For abrupt climate change:

(5) To organize a workshop addressing problems of abrupt climatic changes, possibly attached to EGU 2006 Vienna.
Jansen

(6) To coordinate the abrupt climate change workshop outputs so as to lead to a special issue of an international journal.
Weaver

For hydrologic, biospheric, land-surface interactions

(7) To call for synthesis of various studies on hydrologic, biospheric and land-surface interactions through PAGES office.
Jansen/Kull

(8) To write a paper for PAGES News or CLIVAR Exchanges addressing problems in the study of hydrologic, biospheric, land-surface interactions.
Valdes (for September 2005 issue of Exchanges)

(9) To plan a workshop further addressing problems in the studies of hydrologic, biospheric, land-surface interactions and special journal issue down the road.
Weaver/Valdes (within the 5 year vision)

For tropical-extratropical links including ocean and atmospheric teleconnections.

(10) To represent the CLIVAR/PAGES at the AGU Chapman conference in Hawaii February 2005 on this topic and report back to the group.
Masson-Delmotte

(11) To work with the CLIVAR Southern Ocean Panel, to enhance efforts on obtaining records of Antarctic Intermediate Water production (past and present), and to consider a co-sponsored workshop to explore importance of Antarctic Intermediate Water production.
Weaver/Jansen

(12) To work with upcoming PAGES/IMAGES Southern Ocean Program, to see how we can interact and what kind of information we can get from paleo records for intermediate water production in the Southern Hemisphere.
Cortijo

Overarching and crosscutting issues:

(13) To coordinate the forward modeling of proxy data, possibly including a workshop (within the 5-year vision).
Schmidt

(14) To improve PAGES/CLIVAR Website towards becoming fully interactive with data access like BIOME4.
Valdes

(15) To communicate with CLIVAR SSG and PAGES SSC for approval of the revised Terms of Reference resulted from the group discussion at the meeting. Yan/Kull

(16) Message to CLIVAR SSG that crosscutting themes are as important if not more important than individual themes.

(17) Kull will write a piece for the Pages Newsletter (2005/1). Discussing the new program / vision.

(More details for the actions can be found in the Vision Document resulted from this meeting on the website http://www.clivar.org/organization/pages/index.htm)

Background

The CLIVAR/PAGES Intersection Working Group is jointly sponsored by the Past Global Changes (PAGES) project of the International Geosphere-Biosphere Program (IGBP) and the Climate Variability and Predictability (CLIVAR) project of the World Climate Research Programme (WCRP). It plays an important role in developing and implementing the research programmes of both CLIVAR and PAGES. The group was firstly established in the middle of the 1990s. Details of its history are recorded in previous meeting reports and relevant publications archived at http://www.clivar.org/organization/pages/index.htm). The group was reconstituted in 2004 and its Terms of Reference revised (Section 2.3). The current group members are:

Eystein Jansen (co-chair)	Department of Geology, University of Bergen, Norway
Andrew Weaver (co-chair)	School of Earth and Ocean Sciences, University of Victoria, Canada
Juerg Beer	Institute for Environmental Science and Technology (EAWAG), Switzerland
Keith Briffa	Climatic Research Unit, University of East Anglia, UK
Peter Clark	Department of Geosciences, Oregon State University, US
Elsa Cortijo	Lab Sciences du Climat et l'Environnement, Gif-sur-Yvette, France
James Hurrell	National Center of Atmospheric Research, Boulder, US
Michael Mann	Department of Environmental Science, University of Virginia, US
Valerie Masson-Delmotte	Lab. Modelisation du Climat et l'Environment, Gif-sur-Yvette, France
Gavin Schmidt	NASA Centre for Climate System Research, Columbia University, US
Andreas Schmittner	Inst Geowissenschaften, University of Kiel, Germany
Paul Valdes	School of Geographical Sciences, University of Bristol, UK
Weijian Zhou	State Key Lab of Loess and Quaternary Geology, Xi'an, China

Zhongwei Yan (CLIVAR) and Christoph Kull (PAGES) are the contacts at the International Project Offices.

The objective of the 3rd group meeting was to reconstitute the CLIVAR/PAGES Intersection with a new vision concerning integrated projects based on paleo-reconstruction, instrumental data analysis, reanalysis products and modeling, with 2 foci on the last millennium and abrupt climate changes.

1. Introductory Remarks

The third CLIVAR/PAGES (C/P) Intersection Working Group (WG) meeting was held at Oak Bay Beach Hotel, Victoria, Canada during 8-10 November 2004. Prof. Weaver (Co-chair) opened the meeting with a brief introduction to the venue. All participants (Appendix 1) made self-introductions, showing the broad scope of expertise of the group. On behalf of the sponsoring organizations, Drs. Yan and Kull welcomed the attendees and expressed appreciation to Prof. Weaver for hosting the event.

Prof. Jansen (Co-Chair) reviewed the meeting agenda (Appendix 2) and objectives. He expected that the meeting would result in a scoping work plan for the next few years. While the two foci (the last millennium and abrupt climate changes) had been set before the meeting, details remained open for discussion. The participants agreed with the agenda and expectations.

2. The WG role and TORs

This session discussed how the WG contributes to the objectives of CLIVAR and PAGES and reviewed and refined the Terms of Reference accordingly.

2.1. The WG role in PAGES

Dr. Kull presented the PAGES perspective - past and future activities relevant to the WG. PAGES Phase I ran up to 2003, with C/P as one of its 5 foci, where there were 2 themes: PMIP -Paleoclimate Modeling Intercomparison Project and ARTS - Annual Records of Tropical Systems. The progress made under C/P could partly be reflected in a series of workshops/meetings, including:

- Venice meeting 1999: linking modeling-data community,
- Italy - Il Ciocco 2001: abrupt climate change,
- Hadley Cell workshop 2002: merging of P/C scientists,
- Drought workshop 2003: international networking,

- ESF, Spain, 2003: Linking modeling-data community, and
- PMIP meetings

(more details are available through PAGES and CLIVAR web sites).

In the past years, in particular, C/P played a key role in promoting PMIP and in contributing to the IPCC assessments through the paleo chapter.

Dr. Kull informed the group that a bid to one of PAGES' main funders, US National Science Foundation, was in process, to extend funding to 2009, for the new phase of PAGES. The PAGES SSC (Kenya 2004) recommended 4 C/P topics for Phase II:

- Regional Variability (the past 1000 to 4000 years)
- Tropical - Extratropical Teleconnections
- Extreme Events - Rates of Change
- Modeling vs Observation (PMIIP – PMIP 2nd phase)

Details of these topics remained open for discussion. For example, it remained unclear what extreme events and tropical-extratropical teleconnections exactly mean; collaboration between AIMES (GAIM) and PAGES needed to be further developed. Nevertheless, some activities were under way. For instance, PAGES had launched the project of Predicting Greenhouse Gases back to 700kyrs; endorsed (jointly with CLIVAR and others) the PMIIP Workshop in 2005 and prepared for a C/P poster session at the 2nd PAGES Open Science Meeting, Beijing, August 2005. In addition, a web-based data system had been established at the PAGES Project Office.

During discussion, it was felt that there was a need to involve more PAGES scientists in PMIP studies. Prof. Valdes commented that the main requirement the PAGES community could help meet was data input. However, a challenge remains on how to carry out the model-data synthesis.

Prof. Briffa commented that PAGES should learn some lessons from its first phase. For years it had called for collaboration to reconstruct paleo forcings for climate change study. The same statements were still repeated for the new phase of PAGES. This might be partly due to lack of PAGES funds for projects (Dr. Schmidt). For instance, there is special funding under CLIVAR but not PAGES in Canada (Prof. Weaver). It was recognized that international programming usually does not provide funds directly for research but for coordination and scoping meetings. Prof. Valdes took SOLAS as an example, which has no funds for research but attracts scientists and then national funds through focused programming.

Prof. Weaver concluded that the WG should work to provide overarching guidance promoting funding opportunities at international and national levels. He suggested the organization of special issues of international journals (e.g., one of the Journal of Climate for C/P at the PAGES OSM 2005) as a means of contributing to the science. Prof. Jansen informed the group that some EU projects were under way, which might address some C/P issues.

2.2. The WG role in CLIVAR

Dr. Yan briefed the group on how CLIVAR is organized and recommendations from the CLIVAR SSG resulting from its recent annual meetings.

CLIVAR is a part of the WCRP, which has an overall objective - to determine to what extent climate can be predicted and the extent of human influence on climate. Dr. Yan explained that the WCRP had been focused on physical aspects of climate, but kept increasingly interested in the others (e.g., biogeochemical) in recent years. In particular, as he mentioned during later discussions, the CLIVAR SSG had encouraged relevant panels/groups to be actively involved in the studies of carbon cycle in the Earth system, as a contribution to the emerging Earth System Studies promoted by the Earth System Science Partnership (ESSP).

CLIVAR is planned to run up to 2013, with 4 specific objectives:

- To describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in cooperation with other relevant climate-research and observing programmes.

- To extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets
- To extend the range and accuracy of seasonal to interannual climate prediction through the development of global coupled predictive models.
- To understand and predict the response of the climate system to increases of radiatively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

C/P may contribute to some aspects of each of these objectives, while it obviously plays a key role in the 2nd.

At its recent meeting (June 2004, Baltimore), the CLIVAR SSG called for focusing more clearly on 4 crosscutting themes

- ENSO
- Monsoons
- Decadal modes of variability and thermohaline circulation
- Anthropogenic climate change (ACC)

All panels/groups would be asked to report on their contributions in these 4 areas.

The SSG would see data management to be made explicit in the TORs of each panel/group and would review progress against panel and working group TORs via a self-assessment process.

The SSG recognized insufficient cross-panel links and global integration and therefore asked each panel/group to report on its interactions with others as part of its annual report to the SSG. For C/P, cross-panel linkage was partly through a paleo representative at each of the other panels/groups. Currently there were paleo representatives at the Atlantic, VACS and Southern Ocean Panels, who were expected to help to facilitate cooperation with C/P. It was recognized that C/P has strong link to the WGCM through coupled modeling and PMIP activities. C/P is also liable to have a linkage with the ETCCDMI with regard to climate change detection and indices.

During discussion, it was felt that C/P could undoubtedly make contributions to the study of decadal to centennial variability in association with thermohaline circulation and ACC. The existing links to some panels/groups were appreciated, but links to the others (e.g., WGSIP and AAMP) remained questionable unless these panels/groups extend their remit beyond their current agenda.

At the end of his talk, Dr. Yan reminded the group that there was a 1st joint issue of a PAGES-CLIVAR Newsletter in March 2000, highlighting the beginning of the collaboration between the two communities. It would be beneficial to organize a 2nd joint issue to address some specific advances in the field promoted by C/P.

2.3. Revised Terms of Reference (TORs)

All members had been asked before the meeting to consider in advance the original TORs and determine whether or not modification was needed. The discussions about the TORs took place not only within this session but throughout the meeting, which eventually resulted in the revised TORs, as summarized in Table 1. The revision would be forwarded to CLIVAR SSG and PAGES for approval after the meeting (relevant to actions 15-17).

Table 1. Revisions of TORs made by the newly reconstituted group

	Original	***Revised***	***Justifications***
1	To formulate and promote, in collaboration with PAGES and CLIVAR, a programme of paleoclimatic reconstruction providing long-term records of quantitative paleoclimatic data with seasonal to interannual resolution in areas which are of direct relevance to IGBP and WCRP (i.e., monsoon and ENSO regions, the North Atlantic, and areas of the globe with possible hydrologic predictability).	To promote improved high resolution, well-dated, quantitative paleoclimate records with seasonal to interannual resolution in regions, which are of direct relevance to IGBP and WCRP.	• The Panel wished to let the specific foci come in the Vision document and plan, rather than TOR, since formulations in original TOR do not cover all relevant foci of PAGES/CLIVAR. • The aspect of formulating a Programme is related to TOR item 2, as the most appropriate program of action is the synthesis of data to provide products for data model intercomparisons.
2	To formulate and promote, in collaboration with PAGES and CLIVAR, a programme for collecting, analyzing and integrating paleoclimatic data in order to reveal evidence of patterns of variability within the climate system over seasonal to century time scales.	To formulate and promote, in collaboration with PAGES and CLIVAR, a programme for analyzing and synthesizing paleoclimatic data in order to reveal evidence of patterns of variability within the climate system over seasonal to millennial time scales.	• Data synthesis is a better way of describing the activities, e.g. regional syntheses, appropriate for data-model intercomparisons. • Fundamental to ´climate change detection and attributions studies is the necessity of obtaining an estimate of background natural variability. Long time series of proxy data are needed from the last millennium in order to facilitate comparisons with long model experiments (forced and unforced). • In addition, millennial timescale variability is often associated with discussions of abrupt climate change. We do not want to exclude analyzing the possibilities of future abrupt events that may be associated with millennial variability.
3	To formulate and promote the use of paleoclimatic data in evaluating predictive physical climate models, as well as the use of inverse models, to understand the variability present in the paleoclimatic and paleoceanographic record, and to cooperate with other modeling activities of relevance to PAGES and CLIVAR	To promote improved quantitative methods of model-data comparison and evaluation in order to understand the variability present in both the paleoclimatic record and the models.	• Improved wording, e.g., removing 'inverse' in original TOR as it is not suitable; paralleling data-model • Separating 'other' modeling to TOR5
4		To promote the use of paleoclimate data to examine issues of climate predictability.	• Relevant to the last part of original TOR1
5		To coordinate with other modeling activities of relevance to IGBP and WCRP.	• Separated from original TOR3

3. Review of scientific advances

This session reviewed major progresses and problems in paleoclimate studies and relevant international/regional projects, which foster ideas for developing the C/P Intersection.

3.1. Comparisons of Observed Paleoclimate and Model-Based Studies of Climate Changes Over the Past Two Millennia

Prof. Mann briefed the group on some recent studies of climate change during the last millennia. Proxy reconstructions and model simulations both suggest that late 20th century warmth is anomalous in the context of the past 1000-2000 years. One important source of difference between various alternative proxy-based reconstructions appears to be related to issues of seasonality and spatial representativeness. Methodologies for reconstructing past large-scale temperatures from proxy data have been tested using a long forced simulation of the NCAR CSM 1.4 coupled model. Analyses of synthetic 'proxy' networks produced from the model suggest that existing proxy-based climate reconstructions are likely to yield reliable estimates of past temperature variations within estimated uncertainties. Important differences between estimates of extratropical and full (combined tropical and extratropical) hemispheric mean temperature changes in past centuries appear consistent with seasonal and spatially-specific responses to climate forcing. Forced changes in large-scale atmospheric circulation such as the NAO, and internal dynamics related to El Nino, may play an important role in explaining regional patterns of variability and change in past centuries.

Problems in the methodology of relevant studies were discussed at the meeting. It was noted that more comprehensive coupled models should be applied (Prof. Weaver). However, current CGCMs are even unable to reproduce variability in association with ENSO cycles (Dr. Schmidt). Paleoclimate reconstruction based on specific patterns remains arguable, because patterns are not consistent through time (Dr. Masson-Delmott).

The group recognized that climate variability of the past few millennia be a specific area of focus for C/P. There seemed an agreement that this is an appropriate time frame for attempting to establish the natural variability under boundary conditions (e.g. astronomical configuration and continental ice distribution) that are appropriate to modern-day climate. Emphasis was placed on the examination of alternative statistical methods to paleoclimate reconstruction, a more focused comparison of models and observations, and the promotion of new proxy records of past climate and methods for combining high and low resolution proxy indicators. Pursuing these focus areas, amongst others, in the years ahead seems a productive agenda for the PAGES/CLIVAR intersection.

3.2 Problems in comparing high-resolution climate reconstructions and evidence of forcings

Prof. Briffa started his talk with a summary. He explained why paleo data-model comparison has to be comparing ‘like with like’. On one hand, in paleo reconstructions, there is virtually a random approach to ‘scaling’ (regional, seasonal or timescale biases); on the other hand, in numerical simulations, the forcing histories and implementation are different. As Prof. Briffa pointed out, there tends to be a lack of clear ‘hypothesis’ for gauging the significance of comparison. Scientists need to go beyond saying ‘there is no significant difference’ in data and models. In fact, we might underestimate true uncertainties of model simulations and paleo reconstructions. Many more controlled (systematically planned) simulations are needed in order to understand the differences between paleoclimate histories.

Prof. Briffa emphasized the need to focus on specific ‘targets’ when comparing independent evidence of climate change, when integrating different evidence to provide summary climate histories and when comparing empirical (i.e. observed or reconstructed) evidence of past changes with model estimates, e.g. in the context of climate change detection or model validation exercises. He noted the potential ambiguity that arises in efforts to distinguish data/model differences or rates of climate change when the series or maps being compared are not tightly constrained to optimize the expected similarity and associated confidence levels. Some examples of recent data/model comparisons, based on coupled GCM experiments (including HadCM3 for the last 500 years and ECHAM4-HOPE for the last 1000 years) driven by combinations of natural and anthropogenic forcings, were used to illustrate problems.

In terms of large-scale (hemispheric or global) temperature averages, Prof. Briffa believed that we can do a lot more to elucidate the problem. Tree-ring data are a major contributor to numerous Northern Hemisphere mean temperature histories. The selection of tree-ring data and their statistical processing (to remove internal tree growth bias and to express chronologies in terms of specific climate variables) can affect the apparent amplitude of past climate change. It is not clear that some applications of such processing methods are appropriate as they relate to some published temperature histories.

The group felt there is a need to compare different approaches of paleo reconstructions. A workshop comparing current approaches was proposed, in order to form a Proxy Reconstruction Methodology and Data Intercomparison Project (PRMDIP). Meanwhile, the group agreed to make effort in promoting possible future approaches and more reconstructions of last millennium with high resolution up to decadal (relevant actions 1-2).

3.3. Forward modeling of paleo-proxies for climate change attribution

As Dr. Schmidt noted, the comparison of model output with paleo-data requires different approaches in different circumstances. In the last millennium, where data are high resolution, but signals small, spatial patterns associated with solar and volcanic signals can be extracted using superposed epoch analysis and long-term correlations with supposed forcing functions. These have been usefully and successfully compared with ensemble mean or equilibrium climate model results from versions of the GISS model that include significant stratospheric representation.

It was emphasized that the simplified ocean model used in the GISS model might lead to lack of El Nino-type variability (Prof. Weaver). Arguments were also raised upon how to prescribe volcanic forcing, which may have an effective period from 2-5 years depending on different events (Dr. Schmittner). The group felt that the forcings for climate changes of the last millennia remained as an important issue for further study. A special issue of PAGES Newsletter (or jointly with CLIVAR Exchanges) was suggested to address relevant problems. Later discussions also resulted in a recommendation that the C/P work with WGCM, giving serious consideration to multi model ensembles of last millennium with consistent set of forcing (actions 3-4).

Dr. Schmidt went on to introduce the abrupt climate change at 8.2kyrBP. He noted that, for such an event where there is a strong signal in multiple proxies, it is important that the climate models forward model the proxy data. A recent study included stable water isotopes in a coupled model and successfully compared the results to key isotopic proxies in Greenland and elsewhere. By looking at the sensitivity of cosmogenic isotope deposition in the atmospheric model, the study could also match the variations observed in the ice core concentration of 10Be.

Discussions showed diverse opinions on the forcings of the 8.2k event. Whether or not freshwater discharge was the cause of this event was questioned (Prof. Weaver), though the existence of a cooling signal in the Greenland ice core was quite convincing (Prof. Jansen). Nevertheless, there was consensus that the 8.2k event could be used as a useful test of climate models, due to its radiative forcing conditions being nearer to the modern world.

The group was impressed by the forward modeling of proxies and felt that this could be a crosscutting topic for the C/P. The group recommended that Dr. Schmidt take the lead to coordinate relevant studies possibly involving a workshop in coming years (action 13).

3.4. Past abrupt climate changes

Prof. Jansen presented new proxy records from the northern North Atlantic originating from the IMAGES program of PAGES, which has a focus on obtaining open ocean records enabling decadal scale time resolution. Both data sets on abrupt changes during the last deglaciation and data sets on the Holocene period were shown. The results stressed the need to understand the seasonal character of the proxy reconstructions. During the deglaciation it is now possible to mimic the ice core data in terms of resolution. When this is done, it appears as if all significant cooling events in the ice core is mimicked by freshwater anomalies in the ocean, indicating that an intrinsic element of the abrupt changes is a surface water freshening in the North Atlantic and Nordic Seas.

As Prof. Jansen noted, there appears to be an out phase behavior in surface temperature between the tropical Atlantic and the high latitudes, indicating linkages between high and low latitudes, perhaps via variations in the sea ice cover. During the Holocene, there is significant variability on the multi-decadal to centennial time scale, yet it is difficult to find any consistent pacing of this variability. Also in the post glacial period there appears to be strong linkages between low and high latitudes, and both in proxy records and instrumental data a strong correlation between the northward position of the ITCZ and SSTs in the Nordic Seas appears to exist. Both the glacial and Holocene results would indicate that a focus of the C/P on high to low latitude linkages is recommended.

Discussions following Prof. Jansen's talk showed interest in whether the MOC could be implicated in multi-decadal scale variability. For studying the teleconnections between high and low latitudes, need of comprehensive coupled modeling was stressed (Dr. Schmittner). Combined with later further discussions following several relevant talks below, a recommendation for a workshop addressing problems and a special issue of journal emerged (actions 5-6).

3.5. Interglacial warmth and ice sheet stability - a polar perspective of climate change

As Dr. Masson-Delmotte reported, new deep polar ice cores (NorthGRIP, Greenland; Dome C, Antarctica) offer new reconstructions of climate variability on glacial-interglacial time scales. The current climate change context at these polar locations is specific with a weak warming trend in Greenland annual mean temperature and a cooling trend in central east Antarctica annual mean temperature during the last decades, although the Antarctic Peninsula exhibits a large warming trend. Syntheses of Antarctic ice core data for the last millennium and transient modelling with an intermediate complexity climate model (Goosse et al, 2004) suggest that during the last millennium there has been a phase lag of about 150 years between northern hemisphere warmth (in phase with radiative forcing) and southern hemisphere warmth (due to upwelling of slightly warmer deep water masses previously formed in the north Atlantic and the local amplification by sea-ice extent). Greenland ice sheet observations point out to an increasing melt area (Steffen and Huff 2003; Krabill et al 2000). Gregory et al 2004 have raised the concern of future Greenland ice sheet stability showing many climate scenarios with persistent temperature changes 3°C warmer than now over Greenland during the next centuries and argue about a 3°C threshold that may irreversibly destabilise the ice sheet. Cuffey and Marchal (2000) performed simulations of the Greenland ice sheet for the previous interglacial period with idealised temperature forcings, and suggested a possible contribution of the Greenland ice sheet to up to 4 m of sea level increase. Paleoclimatic data may help bring constraints on the Greenland stability issue.

The recent NorthGRIP ice core extends the Greenland climate back to 123 000 years BP (NorthGRIP community members, 2004) and offers a high-resolution climate record of glacial inception. A first order estimates suggests a local temperature change of about 5°C without large change in central Greenland elevation and therefore the data seem to rule out several scenarios of Cuffey and Marchal and suggest a limited contribution of Greenland sea level to previous interglacial sea level increase (possibly 2-3 m out of 4 to 6 m increase). The NorthGRIP record also shows the onset of rapid events during last glacial cycle with the new D-O event 25 taking place a few millennia after common Greenland and Antarctic cooling, with ice sheets about 1/3 of their full glacial extent and with a specific signature (about 1/3 of Greenland $d^{18}O$ change and no Antarctic counter part). The following events mimic rapid events during fully glacial conditions (10 to 16°C temperature change in Greenland, Antarctic counterpart). It is suggested that reorganisations of the atmospheric water cycle taking place during glacial inception may play a key role in the onset of the rapid events, as indicated by deuterium excess fluctuations in ice cores (e.g. Vimeux et al 1999).

Dome C data (EPICA community members, 2004) also suggest a 5°C warming during previous interglacial peak warmth, with a rate of temperature increase of about 1.5°C per 1000 years and no rapid event recorded there. Dome C long climate record points out to a variety of interglacial length and intensity and questions their relationship to orbital parameters and in particular obliquity. A nonlinear response of climate to small obliquity fluctuations is relevant to the basic understanding of climate sensitivity. The sea level increase during the warmest of the previous interglacial period is 4 to 6 m with probably half contribution from West Antarctica and Greenland ice sheets. Although less clearly documented, the large sea level change during stage 11 (2°C warmer than the Holocene in Dome C; sea level increase suggested to be larger than 10 m) suggests that polar ice sheet stability may depend more on the duration of the warm period than its intensity.

Polar ice core temperature reconstructions also provide quantitative constraints in the so-called "polar amplification". Holland et al 2003 showed the dispersion between projections of future climate change as a function of northern hemisphere latitude, and its relation to modern sea ice representation, cloud feedbacks, ocean circulation, and sea-ice changes. Information from ice cores and multiproxy reconstructions of latitudinal temperature changes can provide constraints on "polar amplification" at various time scales (last millennium, Holocene, Last Glacial Maximum) and possibly bring constraints on climate sensitivity. A relevant exercise would be to compile latitudinal temperature changes simulated for future and glacial climates by the same coupled models. A better documentation of Antarctic climate changes at time scales from decades to climatic cycles is a focus of current international projects of the ice core community (International Polar Year traverses; extension of long term records from well selected sites for deep ice cores within the International Programme for Ice Core Science).

Dr. Masson-Delmotte suggested that future research directions should focus on improving reconstructions of Greenland and Antarctic ice sheet accumulation changes using the wealth of indicators from ice cores and new integrated dating methods, because spatial and temporal accumulation changes are major sources of uncertainties in the forcing of ice sheet models. The new climate reconstructions from deep ice cores should be used to force improved ice sheet models taking into account rapid glaciological processes, in order to quantify the sensitivity of polar ice sheets to interglacial warmth and assess our ability to capture their contributions to past sea level changes. The use of water stable isotopes in integrated earth system models is a promising way to progress in this direction and should be encouraged. The same models used to explore the future possible destabilisation of polar ice sheets should therefore be tested against past observed changes such as the previous interglacial period, with a peak warmth about 5°C higher than Holocene levels at both poles, a rate of temperature increase of about 1.5°C per thousand years, a sea level change estimated to be 4 to 6 meters and without abrupt events recorded in Antarctica (Dome C) or Greenland (NorthGRIP).

3.6 Ice sheets and abrupt climate change

Dr. Clark introduced some episodes of rapid sea level change during the last glaciation (rates up to 40 mm/yr) and their relation to abrupt climate change. They indicate that ice sheet instability has played a key role in the global climate system. During the last deglaciation, partial collapse of one or more Northern Hemisphere ice sheets following hemispheric warming caused a reduction in the Atlantic meridional overturning (AMO), reversing deglacial warming in the north while inducing warming in the tropics and Southern Hemisphere. Subsequent partial collapse of the Antarctic ice sheet following hemispheric warming triggered an increase in the AMO, leading to cooling in the south and warming in the north.

The response of the current Greenland and Antarctic ice sheets to future global warming is of interest because of their possible contribution to global sea level rise. Additionally, because of their location adjacent to sites of intermediate and deep-water formation, these ice sheets may induce changes in ocean circulation through increased freshwater fluxes, with implications for regional-to-global climate change. Recent discoveries in Greenland and Antarctic ice sheet dynamics indicate enhanced ice sheet sensitivity to surface warming, indicating that ice sheets may play a far more important role in future sea level and climate change than previously considered.

Discussions following the talk showed consideration of dating precision, which influences estimation of rate of climate and sea level changes (Dr. Masson-Delmotte). Queries were also raised for possible other mechanisms for abrupt climate changes other than fresh water forcing (Dr.Cortijo).

3.7. Variability of the meridional oceanic circulation under warm climate

As Dr. Cortijo reported, abrupt changes in the Atlantic Meridional Overturning Circulation (AMOC) are better defined and constrained during glacial times. They are linked to the presence of large ice-sheets able to provide the necessary fresh water input to shift from one mode of circulation (active) to another (less active or inactive). Because warm climates are characterized by small ice sheets in the polar areas, the AMOC is more stable and evidence of abrupt change difficult to ascertain.

Recent observations of the ocean temperature and fresh water content show that the ocean is experiencing important changes in these two hydrological parameter. Dickson and co-authors (*Nature*, 2000) have registered a freshening of the deep North Atlantic water from 1965 to 2000. Whether this freshening is part of a natural cycle (link for instance to the North Atlantic Oscillation) or whether it is forced by an anthropogenic influence is still matter of debate. This freshening was also observed in the whole deep Atlantic by Curry and co-authors (*Nature*, 2003), studying all the data available through the water column from 1955 to 1999. In 2001, Hansen et al (Nature) measured the overflow flux of the Norwegian Sea to the North Atlantic Ocean through the Faroes Shetland Bank and estimated a decrease by 0.4 Sv from 1996 to 2000. This decrease, although significant, needs to be confirmed by more measurements in the other passages of this water mass to confirm a slow-down in the overflow.

The study of past interglacial periods can provide more information about the potential changes in the AMOC. But, during the past thousand years, changes in the flux of the AMOC are not a direct measurement. These changes are estimated through the use of proxies, which are more or less constrained. Some proxies estimate the content of the deep ocean water in some nutrients which increase with the distance to the origin of the water mass (Cd/Ca ratio or $d^{13}C$ measured in benthic foraminifera). Some other proxies use the fine terrigeneous fraction of the sediment to follow the intensity of the deep water current (like the sortable silt or the magnetic parameters). These proxies of the deep-water circulation show that the Holocene warm period is punctuated by several oscillations. Some of them have been correlated to major events like the 8.2kyr event recognized in the Greenland ice cores while some others are not well known (Bianchi and McCave, *Nature*, 1999, Oppo et al, *Nature*, 2003, Hall et al, *QSR*, 2004). More recently, measurements of the $^{231}Pa/^{230}Th$ ratio in the sediment have been used to give an estimate of the dynamics of the changes, based on the difference of residence time of the two elements in the water column. Very important results on the rate of the AMOC have been obtained during the last deglaciation by McManus and co-authors (Nature, 2004) showing an almost complete shutdown of the overturning circulation during the Heinrich Event 1 at 16kyrBP. This proxy is very promising albeit the time response seems to constrain its use to relatively long events. Changes in the flux of the AMOC cannot be studied without studying the changes in the sea surface conditions. Proxies of deep temperature in the Barents Sea show clear oscillations during the Holocene. These oscillations, albeit not well understood, could be related to fluctuations in the supplying of warm waters to the Arctic Ocean (Duplessy, unpublished results).

The orbital forcing conditions during the Holocene were not the same as during previous interglacials. The study of Marine Isotopic Stage (MIS) 5e provides other information, particularly on the mode of entering a glacial period: was it an abrupt phenomenon, or a smoothly running event? Recent results of the North GRIP ice core show that the air temperature above Greenland changed very abruptly at the end of the MIS5e (North GRIP community paper, *Nature*, 2004). A similar result has been obtained in 1997 by Adkins and co-authors showing that the end of MIS5e was marked by an abrupt change in the nutrient content of the deep North Atlantic Ocean.

Dr. Cortijo suggested that further research should address two problems in order to provide better constraints on the past climate changes using all these proxies. The first deals with how these proxies are calibrated, particularly in the context of the global warming where modern data show that sea surface and air temperatures started to increase during the last decades. The second is how to develop proxy modeling in order to directly compare the measurements generated by the paleo archives to the equivalent modeled parameter (instead of comparing the proxy data to a physical parameter like temperature or salinity).

During discussion, a common problem in paleo analysis was mentioned that often only some of the fluctuations presented in proxy data series are regarded as ‘signals’, while the others appear to be overlooked (Dr. Schmidt). This makes the proxy records problematic both quantitatively and qualitatively, thus insignificant for testing modeling. Caution should be taken for model-data comparisons in this context.

3.8. PMIP-2 and model-data comparison

Prof. Valdes briefed the group on the Paleoclimate Model Intercomparison Project (PMIP) sponsored by CLIVAR and PAGES. PMIP-1 (Phase I) ran during 1990-2000, aiming at simulating typical period climates such as during the mid-Holocene (6 kBP) and the last Glacial Maximum (21 kBP). The PMIP-1 simulations kept simple but not realistic. PMIP-1 promoted paleo data synthesis (e.g., BIOME 6000; Global Lake status Data Base; LGM tropics and LGM Snowlines), but remained weak in understanding why models are different and in revealing new mechanisms. Since 2002, PMIP Phase 2 has been implemented. The goal is to evaluate coupled atmospheric-ocean-vegetation-GCMs, with an emphasis on more realistic experimental design and analysis of variability as well as mean climates. The results would be submitted to common database before the end of 2004. A project meeting was scheduled in April 2005.

As Prof. Valdes commented, modeling will increasingly focus on transient simulations, uncertainties, high-resolution and increased biogeochemistry. Data studies are therefore expected to reflect more/better synthesis (but not gridded), including transient conditions and variability; 3-dimensional ocean and biogeochemistry proxies. Model-data comparison must be more quantitative and focus on forward modeling of proxies (e.g., isotopes, vegetation, lake level and tree-rings). The chosen paleo time periods/events must have good signal to uncertainty ratios (e.g. monsoons in the Holocene); be suitable for testing processes in the climate system (e.g. rapid changes in THC, transitions in climate system, stability of climate system); and be relevant for future climate change (e.g. carbon cycle, detection/attribution).

During discussion, Prof. Weaver expressed concern about PMIP-type studies in which models are run under past radiative forcing conditions (e.g., the LGM) and the model output is only selectively compared with proxy data. He questioned how single paleo simulations, without detailed sensitivity analyses and comprehensive model-data comparison, aided increased scientific understanding. There seemed to be an agreement that the group should promote more comprehensive data-model synthesis with a focus on hydrologic, biospheric, land-surface interactions (actions 7-9).

3.9. Using earth system models in conjunction with paleo-reconstructions for the estimation of past climate variability

As Dr. Schmittner pointed out, the paleoceanographic community has created a wealth of data of past climate conditions which can be used to estimate changes in ocean circulation patterns through combination with prognostic climate models. He outlined a simple strategy with three steps: (1) perform different realizations (simulations) of climate states by varying uncertain model parameters (e.g. diffusivities, freshwater budget, etc) or external forcing (greenhouse gas concentrations, topography, etc); (2) calculate objective measure of misfit with paleo data (e.g. correlation, rms error, etc); and (3) determine best estimate as simulation with lowest misfit.

A study of the Atlantic Meridional Overturning (AMO) circulation during the Last Glacial Maximum (LGM) was illustrated as an example. Very different circulation patterns (from 0-25 Sv) were produced and simulated SST, SSS, d14C and d13C distributions were compared with reconstructions. Unanimously, the lowest misfit for each tracer is produced by a simulation with strongly reduced (~50% compared to present day) AMO. In the University of Victoria Earth System Model used for this study, the reason for the reduced overturning is reduced atmospheric water vapor export in the colder glacial climate as opposed to previous speculations, which suggested increased sea ice cover in the North Atlantic.

A second example concerned the response of the marine ecosystem to AMO changes. Model simulations with different marine ecosystem models consistently show a reduction of global productivity if the AMO is reduced. Largest changes occur in the North Atlantic, where the ecosystem collapses if deep-water formation is stopped. Comparison of the simulated patterns of changes in productivity as well as nutrient redistributions are consistent with the paleo record of past AMO changes. It was suggested that a severe decline of the marine ecosystem is likely if the AMO decreases substantially in the future due to anthropogenic global warming as projected by most climate models (IPCC 2001).

In conclusion, the combination of climate models with paleo data provides the possibility to infer past climate states, like e.g. ocean circulation. Models can be compared with the paleo record improving the confidence in the models. Such a comparison can be relevant for future climate change. Dr. Schmittner recommended promoting the inclusion of isotopes and other proxies as prognostic tracers in climate models for improved comparison with the record and the inclusion of marine ecosystem models in Earth System Models as most proxies measured in marine archives are derived from fossil plankton.

The group agreed that careful combinations of proxy data and modeling could improve interpretation of both modeling and data.

3.10. Climate change and carbon cycle during the past 50k years

Dr. Beer reviewed the development of the radiocarbon methodology as a most important dating technique for the past 50kyrs. It was based on the assumption that the atmospheric $^{14}C/^{12}C$ ratio was constant due to equilibrium between production and decay of ^{14}C (half-life: 5730 y). However, the assumption is not correct and in fact that ratio deviates up to 20% from the value of 1950, which leads to an age difference of about 1500 years. To investigate this problem and to establish a correction function several leading radiocarbon laboratories had made a joint effort to determine the past deviations of the atmospheric $^{14}C/^{12}C$ ratio by analyzing dendrochronologically dated tree rings back to 12 000 years before 1950. Although the observed deviations cause difficulties in dating they provide a wealth of unique information on the history of the production of cosmogenic radionuclides and the global carbon system. Observed changes in $D^{14}C$ 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 the size and exchange fluxes between the reservoirs). Without further information it is impossible to disentangle the different potential causes. One way to distinguish between production and system effects is to compare the $D^{14}C$ record with ^{10}Be records from ice cores. To test if an observed change in $D^{14}C$ is due to production or system effects one can compare it with the corresponding ^{10}Be record. If it is a production effect we expect a good agreement, if it is a system effect $D^{14}C$ and ^{10}Be should look differently. Some examples were illustrated to demonstrate the method.

As Dr Beer pointed out, during the last glacial which is characterized by large and abrupt climate changes there are clear indications for considerable changes in the carbon cycle. To investigate these changes an extension of the high precision tree ring calibration curve is strongly required. There are already a considerable number of $D^{14}C$ reconstructions in various archives (sea and lake sediments, stalagmites). However, the optimal archive is tree rings, which record year by year the atmospheric $^{14}C/^{12}C$ ratio. One problem is that chronologies such as that from the German oak is limited to the Holocene period and cannot be extended into the glacial period. An excellent opportunity to cover the glacial period is offered by the Kauri trees in New Zealand. Kauri trees were growing in NZ for at least the past 50 000 and can be found relatively easily in swamps. Dr. Beer stressed that an extension of the calibration curve leads also to a big step forwards in dating. Precise dating is crucial to determine leads and lags between abrupt changes and to establish the rate of changes. In addition, to significantly improve the precision of radiocarbon dating during glacial times, the comparison of $D^{14}C$ with ^{10}Be provides the opportunity to absolutely date ice cores with an unprecedented precision of 10-50 y.

In summary, Dr. Beer anticipated a coordinated international effort to speed up the establishment of high resolution (<10 y) ^{14}C calibration curve based on tree rings (e.g. Kauri) combined with ^{10}Be ice core records that already exist (GRIP, GISP2, Vostok etc.) or are in progress (DML, Dome C). This would provide a powerful tool to study fluctuations in the global carbon cycle (mainly due to ocean circulation), reconstruct changes in solar activity and improve the precision of ^{14}C dating and the time scales of ice cores. To achieve the discussed extension of the calibration within 5-10 years Dr Beer suggested:

- establishing a continuous dendrochronology using for example Kauri trees
- setting up a sample preparation facilities based on existing experienced labs
- setting up a dedicated high precision AMS machine

The group acknowledged that the study of carbon cycle during the last 50k years could not only help improve the knowledge of the dynamical processes in the Earth system, but provide improved dating technique for a long time span interesting to the C/P. It was noted that accurate dating of tree rings remained unsuccessful for long (Prof. Briffa).

3.11. Tropical-polar interconnection during the Younger Dryas

As introduced by Prof. Zhou, the Younger Dryas chronozone is recognized in northern high latitude areas as a cold event between 11,000 and 10,000 ^{14}C yrBP (12,900 – 11,600 cal. yrBP) in this context. It manifested itself globally in different ways. Some well-dated stratigraphic sequences together with high-resolution proxy data plots from sites across the arid/semi-arid transition zone in northern China were examined. This climatically sensitive area records a cold/dry Younger Dryas climate punctuated by a brief period of summer monsoon precipitation. Similar climatic sequences have been reported from the Sahel and the equatorial region of Africa. Based on evidence from these sites, among other published data, it was postulated that precipitation during the Younger Dryas was indicative of a low-latitude driving force superimposed on the high latitude cold background. This rain belt rearrangement was probably caused by interaction between cold air advection and summer moisture transport across the tropical Pacific Ocean. Examination of high resolution proxies suggested short-term climate fluctuations indicative of a global teleconnection involving moist air transportation patterns from the tropics to higher latitudes, varying with ENSO and other tropical factors.

Regarding the study of teleconnections between high and low latitudes, Prof. Zhou suggested that the mid latitude transitional zone would be an ideal area. Asian monsoons may be regarded as the linkage between high and low latitudes. In particular, monsoonal China experiences dominant northerly or north-westerly winds in the winter half year associated with the cold air from high latitudes entraining the bulk of the Aeolian dust delivered to the Loess Plateau in mid latitudes, and dominant southerly monsoon currents in the summer half year bringing precipitation inland in mid latitudes from the low latitude oceans, beneficial to the development of paleosol. Therefore the interaction between high and low latitudes will be recorded in sensitive archives such as loess-paleosol sequence, speleothem, lake varve, peat bog, etc. A teleconnection was demonstrated between the Loess Plateau and high latitude areas via westerlies associated with the Siberian High system, postulating strong storm tracks during the Last Glacial Maximum. Some moisture-controlling mechanisms related to atmosphere–ocean coupling might cause rain belt rearrangements, linking tropical and high latitude wind systems.

The group recognized the necessity and potential for improving knowledge of high-low latitude interactions. Discussions throughout the meeting also mentioned relevant activities of other organizations, e.g., AGU Chapman Conference, CLIVAR Southern Ocean Panel and the International Polar Year. Collaborations with these organizations were anticipated (Actions 10-12).

3.12. Abrupt climate change and the stability of the Atlantic thermohaline circulation

Prof. Weaver introduced this topic with an investigation of the variation of North Atlantic Deep Water (NADW) formation over the Last Glacial cycle using the UVic Earth System Climate Model. Equilibrium simulations for the Eemian (125 kyrBP) and the Last Glacial Maximum (LGM--21 kyrBP) both revealed the absence of Labrador Sea Water (LSW) formation although NADW formation still occurs, albeit at a reduced rate relative to the modern times. For the Eemian, the location of convection in the eastern North Atlantic was similar to the present, although it was generally shallower and less extensive. In the case of the LGM, deep convection had moved southward to the western coast of Europe and was much more localized. The inferred inception of a modern-like circulation slightly before 7 kyrBP revealed by proxy reconstructions was not captured by the model unless the melt water forcing from the Laurentide ice sheet was applied in a long transient simulation. This raised questions concerning the applicability of equilibrium simulations in capturing the early Holocene climate. In addition the link was explored between Meltwater pulse 1A (mwp-1A) and the onset of the Bolling-Allerod (Bollerod) event (14,600 yr BP). It was demonstrated that if a large component of mwp-1A occurred in the Southern Hemisphere, the strength of the Atlantic Meridional Overturning (AMO) would increase, thereby warming the North Atlantic region and providing an explanation for the onset of the Bollerod. This finding, together with its associated hysteresis behavior, underlines the significance of the understudied Antarctic Intermediate Water formation in controlling the strength of the AMO.

Prof. Weaver felt that there was still a widespread misunderstanding of the possible consequence of climate change on the AMO, despite the recent IPCC (2001) assessment that "Most models show weakening of the Northern Hemisphere Thermohaline Circulation (THC), which contributes to a reduction of surface warming in the northern North Atlantic. Even in models where the THC weakens, there is still a warming over Europe due to increased greenhouse gases", In particular, he addressed the misconception that a possible consequence of anthropogenic greenhouse gas emissions is: "Global warming will cause the onset of the next ice age". The history from where this misconception arose was documented and it was quantitatively shown how it is impossible for an ice age to ensue as a consequence of global warming. Based on analysis of the paleoclimate record as well as a number of climate model simulations, Prof. Weaver suggested that it is very unlikely that the AMO will cease to be active in the near future; and that a region where intermediate water formation may shut down is in the Labrador Sea, although this has more minor consequences for climate than if deep water formation in the Nordic Seas were to cease.

During discussion, Prof. Weaver further stressed that no coupled model used by IPCC 2001 predicted a collapse of AMO in 21st century. The models that eventually lead to a collapse either need flux adjustments or contain zonal-averaged ocean components. He argued that there was no convincing observational evidence that the 8.2k event involved a significant change in the thermohaline circulation. Discussions showed some disagreement, however. Dr. Schmittner suggested it was not easy to exclude the possibility of the THC shutdown, as some models (e.g., the Hamburg model) did predict this. As to the 8.2k event, some members thought it undeniable as it is reflected in many proxies (Prof. Briffa, Dr. Masson-Delmotte). Dr. Schmidt argued that the P/C should place more focus on climate variability during the Holocene, which is backed by boundary conditions similar to the present. Dr. Clark suggested paying attention to more recent abrupt change events, e.g., around 4.2k and 2.7k. Prof. Jansen commented that although there are still uncertainties about the 8.2k event, it may be a good theme within the C/P vision. Based on the discussions here and throughout the meeting, the group was keen to organize a workshop addressing problems about abrupt climate changes in the past (Actions 5-6).

3.13. IPCC 4AR

The issue was not treated as a separate agenda item as originally planned, but was discussed on occasions throughout the meeting. The possible contributions of the C/P to the IPCC 4AR, Chapter 6 on paleoclimate came up on various occasions. Most of the plans of panel activities have a too distinct time horizon to meet IPCC deadlines for published results. Yet the preparations for the workshop on proxy methodology for the last millennia may be relevant for the IPCC process, and the group will investigate means to provide input from the preparations to the IPCC 4AR.

4. A vision for the future 5 years

Based on presentations and discussions during the previous sessions, the group was able to summarize/develop prioritized lists of subjects that are promising for significant achievements in the near future and that need close collaboration between CLIVAR and PAGES communities. A vision document would be written after the meeting (Appendix 3). A strawman of the vision was developed, with writing assignments as follows:

CLIVAR/PAGES Intersection Panel Vision Document for the next 5 years

1. Introduction (*Weaver/Jansen/Yan/Kull*)
2. Key scientific issues

2.1. Climate variability over the last few millennia (*Mann/Briffa/Masson-Delmotte/Beer/Schmidt*)

2.2. Abrupt climate change (*Clark/Weaver/Schmidt* re: forward modeling)

2.3. Hydrologic, biospheric, land-surface interactions (Valdes/Jansen)

2.4. Tropical-extratropical links including ocean and atmospheric teleconnections (*Schmittner/Masson-Delmotte/Cortijo/Zhou/Weaver*)

3. Key implementation issues

3.1. Climate variability over the last few millennia

   a) Workshop comparing current approaches: Proxy reconstruction methodology and data intercomparison project – PRMDIP – preliminarily planned for spring 2006 in Switzerland (*Mann/Briffa/Schmidt*)
   b) Workshop about possible future approaches proposed for late 2006 to early 2007 (*Mann/Briffa/Schmidt*)
   c) Work with WGCM. CLIVAR-PAGES Intersection recommends WGCM give serious consideration to multi model ensembles of last millennium with consistent set of forcing and to make fields available. (*Weaver, Jansen*)
   d) Special issue of PAGES news on Forcing (*edited by Masson-Delmotte/Beer/Kull*)

3.2. Abrupt climate change
- a) Workshop addressing problem. EGU 2006 Vienna (*Jansen)*
- b) Aim for workshop to lead to special issue. (*Weaver*)

3.3. Hydrologic, biospheric, land-surface interactions
- a) Call for synthesis through PAGES office (*Jansen*/*Kull*)
- b) PAGES/CLIVAR Newsletter (*Valdes)*
- c) Workshop addressing problem and special journal issue down the road (*Weaver*/*Valdes*)

3.4. Tropical-extratropical links including ocean and atmospheric teleconnections.
- a) Report how we fit (placeholder) (*Masson-Delmotte*)
- b) Work with CLIVAR Southern Ocean Panel suggesting important to focus on obtaining records of Antarctic Intermediate Water production (past and present). Consider a co-sponsored workshop to explore importance of Antarctic Intermediate Water production. (*Weaver*/*Jansen*)
- c) Work with upcoming PAGES/IMAGES Southern Ocean program using IPY to facilitate (*Cortijo)*

3.5. Overarching and cross-cutting implementation issues.
- a) Coordinate the forward modeling of proxy data possibly including a workshop (*Schmidt*)
- b) PAGES/CLIVAR Website. move to fully interactive like BIOME4 (*Valdes)*

5. Closing remarks – next meeting

The co-chairs worked together on the last day to check and confirm a list of the post-meeting actions. Some members discussed planning of the next meeting (at lunch), when Dr. Masson-Delmotte offered to host the next group meeting in France. An alternative suggestion was to combine the next group meeting to one of the proposed workshops in 18-24 months, given the tightened funding situations within CLIVAR and PAGES. The issue would be discussed within the group later on.

Communication with CLIVAR SSG and PAGES side were carried out through Drs. Yan and Kull shortly after the meeting, which resulted in a consensus for co-sponsoring the proposed PRMDIP workshop to be held in Switzerland during spring 2006. Considerations of funding for the other workshops were raised.

The C/P group meeting was closed with recognition that it had been an exciting success in terms of bringing together a wide range of experts, facilitating warm and timely discussions upon contemporary issues of paleoclimate study and resulting in a fruitful vision and work plan for the near term.

Appendix 1.

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Appendix 2.

Meeting agenda

CLIVAR/PAGES Intersection Working Group 3rd Meeting
8-10 November 2004
Oak Bay Beach Hotel, Victoria, Canada

Meeting Aims:

- *to reconstitute the CLIVAR/PAGES Intersection with a new vision concerning integrated projects based on paleo-reconstruction, instrumental data analysis, reanalysis products and modeling – as an output, a Science Plan linking WCRP and IGBP will be written, to allow national agencies to target an international project for funding opportunities*

with 2 foci on:

- *the last millennium; and*
- *abrupt climate changes*

Monday 8 Nov 2004

8:30 – 9:00 **1. Introduction**
Welcome (Weaver, 5 mins)
Introductions of members (5 mins)
Review of agenda, expected outcomes (co-chairs, 20 mins)

9:00 – 10:30 **2. WG role in PAGES and CLIVAR**
To discuss how the WG contributes to the mother programmes' objectives; to review/modify the Terms of Reference (see appendix).

The PAGES perspective: past and future activities (Kull/Jansen, 30 mins)
The CLIVAR perspective: links to other CLIVAR activities (Yan, 15 mins)
Discussion on WG's role and Terms of Reference (co-chairs, 45 mins) – *All members are asked to consider in advance the terms of reference as they are now written (see appendix) and determine whether or not they need modification*

10:30 – 11:00 Tea break
3. Review of the past and ongoing projects
To review major progresses in relevant international/regional projects, which foster ideas for developing the C/P Intersection – 20 mins for each presentation followed by 10 mins discussion.

11:00 – 12:30 **3.1. Focus 1 – the last millennium**
Comparisons of Observed Paleoclimate and Model-Based Studies of Climate Changes Over the Past Two Millennia (Mann)
Problems comparing high-resolution climate reconstructions and forcings evidence (Briffa)
Forward modeling of paleo-proxies for climate change attribution (Schmidt)

12:30 – 14:00 Lunch

14:00 – 16:00 **3.2. Focus 2 – abrupt climate change**
Abrupt changes in the past and their relevance to the present global change (Jansen)
Interglacial warmth related to polar ice sheet instability (Masson)
Ice sheets and abrupt climate change (Clark)
Variability of the meridional oceanic circulation under warm climate (Cortijo)

16:00 – 16:30 Tea break

16:30 – 18:30 **3.3. Issues for advancing paleoclimate study**
PMIP-2 and model-data comparison (Valdes)
Using Earth System Models in Conjunction with Paleo-Reconstructions for the Estimation of Past Climate Variability (Schmittner)
Climate change and carbon cycle during the past 50k years (Beer)
Tropical-polar interconnection during the Younger Dryas (Zhou)

Tuesday 9 Nov 2004

8:30 – 9:30	**3.3. Issues for advancing paleoclimate study (cont.)**
	Problems in current paleoclimate study and ways forward (Weaver)
	Discussion or any other business
9:30 – 10:30	**4. Special session for IPCC FAR**
	Brief on the paleo-chapter in IPCC FAR (Jansen)
	Discussion – how to contribute to FAR as a WG (all members)
10:30 – 11:00	Tea break
	5. Developing a new vision of the C/P Intersection and working plan
	To summarize/develop prioritized lists of subjects that are discussed so far and promising for significant achievements in the near future but need close collaboration between CLIVAR and PAGES communities, based on which a vision document will be written.
11:00 – 11:30	Introduction (co-chairs, who will prepare a strawman document with instructive ideas for all to discuss)
11:30 – 12:30	Small group discussions – 1. The last millennium (led by Weaver) 2. Abrupt change (led by Jansen)
12:30 – 14:00	Lunch and group photo
14:00 – 15:30	Summaries of small group discussions / feedbacks 1. Weaver 2. Jansen
15:30 – 16:00	Tea break
16:00 – 17:30	Further discussion on the vision document and writing assignments (all)
19:00 - 20:00	Group dinner at Oak Bay Marina

Wednesday 10 Nov 2004

8:30 – 10:30	AOB
	Action review
10:30 – 11:00	Tea break – end of meeting

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