RESEARCH CONFERENCES

ESF-FWF Conference in Partnership with LFUI

Mechanisms of Quaternary Climate Change: Stability of warm phases in the past and in the future

Universitätszentrum Obergurgl (Ötz Valley, near Innsbruck) • Austria

06-11 June 2009

Chair: **Carlo Barbante,** University of Venice, I
Co-/Vice-Chair(s): **Hubertus Fischer**, University of Bern, CH

www.esf.org/conferences/09285

With support from
- European Project for Ice Coring in Antarctica

Highlights & Scientific Report

Conference Highlights

Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)

There is an urgent need to predict more accurately how global climate is likely to react to increased emissions of greenhouse gases as a result of human activities. In order to predict the future, it is necessary to determine how global climate has responded during the past to natural variations in forcing factors such as changes in solar input and in the earth's orbital parameters during climatic periods similar to the present.

The most important sources of information about past climate change are derived from palaeoclimatic records such as marine sediments, terrestrial archives and polar ice cores as well as climate model. Those archives are highly complementary, giving a wealth of precious quantitative information on the understanding of the nature and causes of climate variability and change. Hundreds of European scientists are deeply involved in these projects and all of them agree that a better understanding of the past and future climate requires the sharing of results and ideas in common symposia.

In this context our Conference put together renowned scientists in the field of global change and in particular in the field of past climate variability during interglacial periods. It emphasized the novel role of the comparison of the present climate with that of previous interglacial periods, such as MIS 5, 11 and 19, for a better understanding of future scenarios.

The topics treated were timely and relevant, also considering the future implications of the UN COP 15 - Copenhagen Conference (December 2009). The ESF conference, based on the outstanding knowledge acquired in decades of fruitful research programs and thanks to the competence of the speakers, has gone a step further in integrating European and international researchers in the field of palaeoclimatology.

The main outcomes of this conference has been that of exposing a number of young scientists to an up to date topic of paramount importance for the society of tomorrow in a stimulating international environment; this will guarantee the maintenance of a prominent position of Europe in the field of climate research, help educating a new generation of scientists.

The scientific highlights of the ESF-FWF Conference on Mechanisms of Quaternary Climate Change: Stability of Warm Phases in the Past and in the Future can be summarized by

- outstanding presentations on the state-of-the art in palaeoclimate research and related topics. This applies to the extremely high level of panel presentations on wider subjects by world leaders in the field as well as the outstanding poster presentations by young scientists on specific questions in paleoclimatology and especially in the variability of climate during the warm phases.
- a high-level interdisciplinary dialogue between young and senior scientists, which will help to shape the future leaders in paleoclimate research
- the cross-linking of paleoclimatologists from different subdisciplines which has been the ground for close collaboration, especially in Europe.
- the identification of major open questions and research areas to be jointly tackled by European researchers in the future.

X I hereby authorize ESF – and the conference partners to use the information contained in the above section on 'Conference Highlights' in their communication on the scheme.

Scientific Report

Executive Summary

(2 pages max)

The ESF-FWF Conference in partnership with LFUI on **Mechanisms of Quaternary Climate Change: Stability of Warm Phases in the Past and in the Future** has been held in Obergurgl (Ötz Valley, Austria) on 06-11 June 2009. It represented the logical follow up of two conference series on "Polar Regions and Quaternary Climate" that have strongly helped to form new scientists in the field of palaeoclimatology during the last twelve years and represented an ideal forum to follow the outstanding progress in European palaeoclimatology researches over the last decades.

The first conference series was addressed to the formidable results obtained from the high resolution analyses of the EPICA ice cores. Besides representing the forum for ice core researchers, the two conferences represented also the ideal chance to reach out to other scientific communities, such as those of palaeoceanography and climate modeling.

As an ideal continuation, the following second conference series was more addressed to the comparison of ice core records with marine sediments and climate models. It clearly emerged that palaeoclimatology is a fully interdisciplinary research field. The comparative analyses of high resolution ice core records with new exciting records from the marine realm allowed to broaden and intensify the exchange of ideas and to come up with an integrative view on paleoclimatic changes within scientists representing numerous related communities such as past ocean and sea-ice dynamics with a focus on the circum-Antarctic ocean, past climate dynamics in Southern South America and Austral-Asia, climate and tracer-transport modelling, ice sheet dynamics and modelling, and present-day physical and chemical observations in Antarctica.

Following these valuable initiatives the subject of this ESF Conference has been moved toward an emerging topic in the climate research concerning the past and future variability of warm climatic stages during the Quaternary. These warm intervals in the past (which in part were warmer than the Holocene) are of utmost importance to assess the current anthropogenic warming with respect to natural climate variability and to predict the response of the climate system in a warmer future.

It is well known that millennial scale oscillation have occurred over the last 8000 years, resulting in an advance and retreat of mountain glaciers. The causes for this variability are however poorly understood and a deeper knowledge of the problem requires a novel integrated approach through the study of several archives and above all the comparison with previous interglacials.

All the topics that have been initially suggested by the Scientific Committee have been addressed during the Conference with lively discussions about the past, present and future climate changes.

Scientific Content of the Conference

(1 page min.)

- *Summary of the conference sessions focusing on the scientific highlights*
- *Assessment of the results and their potential impact on future research or applications*

The main task of the ESF Conference held in June 2009, was addressed to a **better understanding the past variability of warm climatic stages**. This task has been carried out thanks to the contribution of renowned European and international scientists that have proven to have an outstanding experience in the field, as well the necessary capacity to transfer their enthusiasm to the young generations. About twenty five senior lecturers were present. Ten young scientists were selected by the Scientific Committee to give short talks on their research. This formula was highly appreciated by both early stage and senior scientists, because it gave the possibility to the first to show their results to a highly competent audience and to the latter, to interact with the new generation of scientists with stimulating questions and constructive criticisms.

The Conference was structured on six sessions on different emerging topics in the field of past interglacials. The first session was addressed to comparison between interglacials, with some specific talks on how interglacials are recorded in different climatic archives such as ice cores, marine sediments and terrestrial archives. Once more, the role of orbital parameters and feedback mechanisms emerged as key factors in the regulation of past climate during interglacials.

The second session covered the field of the variability and stability of warm phases. Short-term variability, reconstructed thanks to the high resolution analyses of ice cores and other archives has shown that interglacials are not so stable as initially thought and that regional variations in the climatic archives have to be clearly addressed in order to better understand the variability of the climate systems during these peculiar periods of time.

The problems arising from modelling the climate during warm phases were addressed in the third session, trying to improve the prediction of future scenarios. In particular the response of vegetation dynamics and especially of the carbon cycle dynamics during the present and past interglacials has been discussed. It emerged that implications on these topics must be based on high quality data of atmospheric CO_2 and carbon isotopes as well as on marine archives for carbonate production and palaeoproductivity. Accordingly, one of the highlights of the conference, which fuelled intensive discussions, were the presentations on the first high-precision Holocene isotopic greenhouse gas records, which in the meantime have been published in high ranking journals.

The ice sheets response to interglacial warming and their impact on sea level was the subject of the fourth session of the conference. It emerged that it is difficult to project sea-level rise in response to warming climates by the end of the century, especially because the response of the Greenland and Antarctic ice sheets to warming is not fully understood. The close combination of palaeoclimatic data analyses and modelling efforts will strongly help to put in the right perspective the evolution of present sea level rise.

A modelling session opened the way to the discussion on how and when the present interglacial, the Holocene, will end. Several hypotheses, based on orbital and anthropogenic forcing have been addressed, pointing out that further high spatial and temporal resolution models are needed to better understand the processes that will drive the inception of a new ice age era.

The role of socio-economic aspects and impacts of climate change were finally addressed through specific talks in a dedicated session and open discussions, further amplifying the need of a close collaboration between scientists involved in palaeo data production and analyses and scientists working in the field of impact of climate change at socio-economic level.

The panel presentations and poster session were efficiently supported by discussion groups on specific topics, where both young and senior scientists actively participated. The high level of interaction was especially reflected in ad hoc gatherings of small groups in the evening to deepen specific science issues or to prepare joint publications. The conference has being held at the end of the International Polar Year, thus further amplifying the role of Europe scientific community in the understanding of the Earth climate system through the observation of polar regions.

Forward Look

(1 page min.)

- *Assessment of the results*
- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

A Forward Look Plenary Discussion has been organised at the end of the Conference with the aim to develop a vision on how climate sciences will evolve in the coming years. Both early stage career researchers and senior scientists actively participated on this panel.

Based on a scenario of how the research field in palaeoclimatology will evolve, on the needs of the scientific community, and on Europe's strength and weaknesses, the Conference Scientific Committee presented a strategy aimed at structuring future coordinated research actions and developments at the European level.
Several Scientific questions have been raised during the discussion, and they may help for better addressing the future researches in this field:

- What determines the timing of terminations
- What determines the strength and duration of each interglacial
- What happened at the Mid Brunhes transition
- How well do we know climate forcings and feedbacks?
- How well do we understand millennial to multiannual variability?
- What large scale ocean/atmosphere circulation patterns dominate the variability on these time scales and how will they change in the past and in the future?
- Can we explain past changes in atmospheric composition?
- How can palaeoclimate data constrain ice sheet models during past interglacials ?
- How well can we predict sea level rise in the future?
- How long will be the Holocene ?
- What can be provided to IPCC Fifth Assessment Report ?
- How can climate scientists better interact with policy makers ?

One of the most up to date issues regarded sea level change and its modeling during interglacials. Sea level changes aren't well constrained in the last IPCC report, where there are big uncertainties. No climate model is available to work at this level, because there would be the need of higher resolution and new modules to deal with dynamics such as the effect of grounding rocks and glacial dynamics. On the other side very little is known about the contribution of small glaciers to global sea level rise; as an example in the Tibetan plateau many glaciers strongly retreated in many valleys during the last decades. We need to assume that they'll all eventually disappear, however, these glaciers are crucial for maintaining water supplies and water storage, leaving the possibility of increased flooding and environmental damage.

Another hot issue that was intensely debated is related to the duration of the present interglacial, the Holocene. Do we have another analogous event in the past on which to

test, at least in part, current prediction models? As clearly emerged from the discussion, a true analogue probably doesn't exist so we can't extrapolate directly from the past. We would need more modelling to explain the processes of all interglacials and use that approach to tackle the natural and climate changed Holocene of the future. The increased resolution and complexity of the models would require a new generation of supercomputers. Future climate models would hopefully rely on better and larger data set, where low and high latitude data are included.

Another problem that has been recognized for quite some time but is still not sufficiently addressed is the improved merging of past climate observations and climate models. Forward modeling of paleoproxies in the models is one possibility. Vice versa the distillation of large-scale climate modes and teleconnection patterns (that can be resolved in climate models and that control large parts of the variance in climate parameters) using syntheses of climate archives will be a hot topic in the coming decade.

This opened the discussion to the long lasting issue of the synchronization of terrestrial, marine and ice records, in order to have different archives on the same age scale. Dating by using absolute method is strongly recommended, whenever possible.

Another key aspect is given by future orbital forcing, since it is well known that there will be very little eccentricity forcing in the next ~100ka so precession will greatly affect insolation and CO_2 and other greenhouse gases (GG) will play an even larger role on the climate of the future Holocene for perhaps hundreds of kyr. In this respect we have to take into account that current CO_2 concentrations have taken us out of the Quaternary CO_2 range. The last occasion when GG concentrations were equivalent to 450 ppmv was about 40 My ago with no ice sheets.

Science issues have driven the discussion, and all these outcomes will be relayed to funding agencies and policy makers for future actions, including the Fifth IPCC Assessment Report foreseen for the 2012. Implementation of the recommendations of this Forward Look should also lead to form the new generations of researchers on climate sciences that will allow Europe to maintain its leading position in this field.

- Is there a need for a foresight-type initiative?

During the past twelve years the two Euroconference series on "**Polar Regions and Quaternary Climate**" have greatly and successfully contributed to bring together scientists working in the field of climate change through ice core records with marine and terrestrial palaeoclimatologists. This ESF Conference on Mechanisms of Quaternary Climate Change: Stability of Warm Phases in the Past and in the Future has gone a step forward, integrating researchers working in different aspects of past climate changes with leading scientists in the field of climate modelling and socio-economic aspects of climate change. This Conference has certainly addressed many of the tasks that were initially foreseen, but has raised at the same time new fundamental questions on **modes of variability in the climate system**. Because **there are no other established conferences** on this particular research subject, the launch of a conference in the spirit of the European Science Foundation would be timely and relevant.

The ongoing climate warming requires a detailed understanding of global and regional climate variations and forecasting of their future changes using climate models. These changes pertain not only to the average global warming but also to changes in regional climate, circulation patterns and their temporal variability. To decrease the uncertainty in these model predictions, climate models have to be validated using paleoclimate data as

provided by natural climate archives. Spatially representative climate modes and teleconnection patterns and their temporal variability allow for this validation and represent the vehicles to contrast rather coarsely resolved climate models to point-wise paleoclimate data.

Accordingly, we are proposing to ESF a new conference that is the logical development of the previous one. **Modes of Variability in the Climate System: Past-Present-Future**", this is its title, aims at putting together the world`s most renowned scientists in the field of global change and in particular experts in the current operation of modes in the climate system and their past variability.

Business Meeting Outcomes

- *Election of the Organising Committee of the next conference*
- *Identified Topics*
- *Next Steps*

As stated above, the new proposed ESF Conference will focus on the **mechanisms behind the most important modes and teleconnection patterns in the ocean**, atmosphere and on land at all latitudes and their changes in the past in order to improve predictability of climate variability in the future. This includes past and future changes of modes, climate variability and extremes as well as feedbacks of those changes in climate modes on **biogeochemical cycles** and the **cryosphere** that may lead to amplification of climate changes.

A Scientific Committee is already in place (see below) and the preliminary programme already submitted for evaluation to ESF.

Scientific Committee of the next proposed Conference:
Hubertus Fischer (Chair - University of Bern, Switzerland)
Eric Wolff (Co-Chair - British Antarctic Survey, Cambridge, UK)
Carlo Barbante (University of Venice, Italy)
Valerie Masson Delmotte (CEA Saclay, France)
Thomas Stocker (University of Bern, Switzerland)
Heinz Miller (AWI, Bremerhaven, Germany)
Michael Schulz (University of Bremen, Germany)
Denis Didier Rousseau (Ecole Normale Supérieure, Paris, France)

Atmosphere and Infrastructure

- *The reaction of the participants to the location and the organization, including networking, and any other relevant comments*

We have greatly enjoyed the warm Tyrolean hospitality at the Universitätszentrum Obergurgl (Ötztal, Austria). All the participants appreciated the atmosphere of the infrastructure, typical of a mountain hut. The accommodation and food were also great and format of the conference has allowed a lot of time for informal discussion and exchange of the ideas. The most appreciated features in this respect was the possibility for the early stage career researchers to be in close touch with the world`s most renowned scientists in the field of past global change. This stimulated the discussion and was in the end very productive also for senior scientists. The only **negative practical note** goes to the projector used for the presentations. The light was too faint and some presentations were barely visible. We told this already to the manager of the Universitätszentrum Obergurgl.

We would like finally gratefully acknowledge the support from the European Science

Foundation, the University of Innsbruck and the FWF. We also acknowledge the funding support of the European Project for Ice Coring in Antarctica (EPICA and EPICA-MIS) through the money of the Decartes Prize.