EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

Exploratory Workshop Scheme

Standing Committee for Life, Earth and Environmental Sciences (LESC)

ESF Exploratory Workshop on

Synoptic-scale climate dynamics over the last millennium: a case study for the MCA-LIA transition

Scientific Report

Kippel (Switzerland), 17-20 May 2009

Convened by:

Valerie Trouet [1], Jan Esper [1], Andy Baker [2] and Eduardo Zorita [3]

[1] Dendro Sciences Unit, Swiss Federal Research Institute WSL, Birmensdorf, Switzerland
[2] School of Geography, Earth and Environmental Sciences, University of Birmingham, United Kingdom
[3] GKKS Research Center, Institute for Coastal Research, Geesthacht, Germany

Co-sponsored by

Oeschger Centre for Climate Change Research

Executive summary

Over recent years, an increasing number of terrestrial and marine proxy data have become available that represent changes in temperature, hydrology, and the thermohaline circulation over the last millennium. The global character of the reconstructed centennial-scale hydroclimatic variability implies forcing by fluctuating global ocean-atmosphere states. The spatial and temporal resolution of the available proxy records, however, is often sparse and limits the possibilities for analyzing the dynamical aspect of climate variability in the past. The synoptic-scale processes driving observed variations in paleoclimate proxy data can be simulated and interpreted using coupled climate models. In addition to this, model simulations can aid in separating externally forced climate signals (e.g. volcanism, solar variability, anthropogenic forcing) from internal climate variability. Relating past variations to twentieth century climate processes can further contribute to a dynamical understanding of natural climate variability and to the development of a dynamical reference frame for the assessment of current and future climatic change.

The main aims of the exploratory workshop were threefold:

1. **To establish state-of-the-art understanding** of synoptic-scale climate dynamics and natural climate variability over the last millennium and the Medieval Climate Anomaly – Little Ice Age (MCA-LIA) transition in particular. A focus on the MCA-LIA transition provided a concrete and well-documented framework for interdisciplinary discussion.
2. **To prioritize research needs and to develop research strategies** for optimizing collaborative efforts between climate modelers, paleoclimatologists, palaeoceanographers, and climate process experts.
3. To lay the foundation for **collaborations** to address primary research needs and strategies.

To reach these goals, we have brought together experts in palaeoclimatology (10) and palaeoceanography (4), climate modelling (8), and climate processes (4). In total, 26 scientists from 8 European countries and the U.S. participated in this three-day ESF exploratory workshop. The workshop was held in the Hotel Lötschberg in Kippel, Switzerland and was convened by Valérie Trouet (WSL, Birmensdorf, CH) and co-convened by Jan Esper (WSL, Birmensdorf, CH), Andy Baker (University of Birmingham, UK), and Eduardo Zorita (GKKS, Hamburg, D). Additional financial support for the workshop was provided by the Oeschger Center for Climate Change Research of the University of Bern.

We aimed at emphasizing the workshop character of this scientific meeting and wanted to facilitate and encourage interdisciplinary discussion and interaction amongst a small group of researchers from different fields of expertise. Therefore, formal presentations were restricted to the first day of the workshop, when four keynote lectures provided a multidisciplinary and in-depth overview of climate dynamics over the last millennium in general and during the MCA-LIA transition in particular (*1. Goal*). **Nick Graham** (climate modeling), **Rob Wilson** (high resolution paleoclimatology), **James Scourse** (paleoceanography), and **David Stephenson** (climate processes) presented in a 45 minute lecture an overview of their field of expertise and its potential

role in understanding low-frequency synoptic-scale climate dynamics. Each lecture was followed by an extensive and cross-disciplinary discussion (approx. 45 min.). Various participants have expressed their appreciation for the high quality of the keynote lectures and the following discussions that served as a solid and comprehensive introduction to the various topics that were discussed later on in the workshop, during the brainstorming sessions.

In addition to the keynote talks, short communications highlighted recently developed data sets (**Dirk Verschuren**, **Fatima Abrantes**, **Ian Hall**, **Ashish Sinha**), applications (**Hugues Goosse, Christoph Raible, Matthew Collins, Stephan Lorenz**), and new insights in potential forcing mechanisms for the MCA-LIA transition (**Eugene Wahl, Eduardo Zorita, Nanne Weber**). The short (10-15 min.) talks during these sessions were also followed by extensive (unlimited) discussion and additional discussion time was provided during the poster session (Day 1) and the excursion (Day 2).

After the excursion on day 2, three key questions were formulated on which the brainstorm sessions were then focused:

1. **How do we define the 'transition' and what is its (spatiotemporal) nature?**
2. **Where are the key areas and where are the gaps for collecting new proxy data?**
3. **Is it possible to formulate a dynamical concept that is consistent with hypotheses based on proxy data and can it be connected to natural climate variability? If there is an agreement, how do we quantify it?**

This session provided a concrete platform for argumentation of primary research needs and the development of research strategies (*2. Goal*). The group of participants was split in four mixed groups of 6 to 7 persons to achieve optimal interaction and exchange of ideas between the different communities. The four groups discussed one or several of the key topics during the session and vivid discussions continued over dinner and beyond. The outcome of these discussions was reported to the whole group on Day 3 (see also **Scientific Content** section).

The proposed research needs/strategies were considered in more detail and more concretely during a conclusive discussion (*3. Goal*). Additionally, future collaborations, avenues for joint research, and follow-up activities were discussed (see also **Outcome** section). The presentation (and personal conversations) of ESF representative **Hefin Jones** was pivotal in this respect, since it identified a number of concrete funding opportunities. All participants agreed that there is an urgent need for the establishment of a long-term research consortium involving the four communities brought together during this workshop.

Scientific Content

1. Synoptic-scale climate dynamics over the last millennium and the MCA-LIA transition: overview

In a first keynote lecture, **Nick Graham** presented process modelling as a means of combining proxy data and climate models. Based on (physical and biological) process models, pseudo-physical conditions can be derived from climate model output data. The pseudo-proxy data resulting from this process can be compared with real proxy data and can provide new insights in and quantitative information about natural modes of climate variability.
Proxy Surrogate Reconstruction (PSR) is a multi-variate, multi-proxy, nearest-neighbour analog method that is based on proxy-model 'similarity'. It maintains model cross-variable relationships and spatial covariance and conserves inter-proxy temporal covariance and can be used to quantify and describe past climate. The main pitfalls of this method are its lack of model temporal co-variance conservation and the uncertainties that are age model, process knowledge, model, and proxy noise related. Also, maintaining physical units of measure is a challenge when using this method. Despite these restrictions, PSR was successfully applied to reconstruct North Atlantic and European circulation patterns over the last millennium from 3 proxy series (Trouet et al. 2009).

Rob Wilson then talked about the potential and limitations of high-resolution proxy records (and tree-ring records in particular) for studying large-scale synoptic climate dynamics. Important challenges to keep in mind when working with tree ring records include (1) capturing low-frequency information (e.g., through regional curve standardization rather than individual tree-based age-trend removal), (2) changing replication through time, and (3) calibration and the linearity assumption it is based on. Calibration is an even stronger challenge for non-annually resolved proxy records, as well as dating errors. Other points of discussion when studying long-term synoptic-scale climate dynamics include the seasonality of the proxy records, their location (specifically for precipitation proxies), and the temporal stability of dynamical processes and the stationarity assumption linked to it. Rob also presented some concrete examples of tree ring records that capture the MCA-LIA transition and the limitations of these records: a summer temperature record from the Canadian Rockies (Luckman and Wilson 2005), Northern Hemisphere temperature composites, and the millennium-long winter NAO record (Trouet et al. 2009).

A marine perspective on the MCA-LIA transition was presented in the keynote lecture by **James Scourse**. He discussed palaeoceanographic evidence, mainly from the North Atlantic region, showing an enhanced Atlantic Meridional Overturning Circulation (AMOC) during the MCA and a weakening during the LIA. Several studies show regional coherence between terrestrial and

oceanographic MCA-LIA changes and suggest a strong link between oceanic circulation and atmospheric processes on centennial time scales. AMOC variability can generate a cross-equatorial SST gradient and changes in ITCZ position and can thus function as an amplifier of internal climatic oscillations or as an amplifier of external forcings (Lund et al. 2006). Some questions remain open, including potential lag/lead relations between marine and terrestrial systems and the value of interannual NAO variability as an analogue for centennial-scale ocean-climate interactions (Lund and Curry 2004).

The final keynote speaker was **David Stephenson**, who talked about climate dynamics, statistical modelling of climate variation, and spatial teleconnections and modes. Even a simple statistical model for climate dynamics suggests complex climate variability: non-linear feedbacks in the system can lead to long-term climate variability and complicates the separation of external forcings from natural variations (e.g., 'long memory' in the NAO). Climate variations can be modelled using time series models that aim at providing joint probability distributions and at predicting outliers. Climatic time series can be modelled as the sum of non-stationary (trends and cyclic movements) and stationary (random noise) processes. David made a strong case against using running means to estimate trends and then moved on to discuss climate modes. These provide a parsimonious description of climate variability, but don't necessarily reflect teleconnection structures. More than one mode is often needed to adequately explain regional climate variability (e.g., NAO and EAP for Western Europe).

2. Synoptic-scale climate dynamics over the last millennium and the MCA-LIA transition: brainstorming

The brainstorming sessions on Day 2 were conducted in small, mixed groups and were focused on three key questions.

A. How do we define the MCA-LIA transition and what is its (spatiotemporal) nature?

A number of limitations in the proxy records were discussed that need to be taken into account when defining the transition and its spatiotemporal characteristics:

- ***Temporal resolution***: when deciding on the maximum allowable chronological error, uncertainties need to be taken into account and quantified. Ocean age model uncertainties (e.g. marine reservoir corrections) in particular need to be recognized. **50-yr "bins"** were suggested for determining the transition period per proxy, implying a 2s proxy error of less than 50 years.
- The nature of the transition depends on the ***proxy location*** relative to the dynamic forcing
- and on the ***linearity*** of the proxy (e.g., lake records are often non linear)

- ***seasonality*** of the proxy response (e.g., can proxies record winter climatic conditions?)

In addition to this, it is important to see the MCA-LIA transition in a full **Holocene context** (e.g., 4.2k and 2.7k events). Ocean records (as well as a 3000yr Scotland stalagmite record) show events of similar magnitude, frequency, and persistence over this period. The MCA-LIA transition is unique, however, in that the LIA is unusual at high latitudes, whereas the MCA is unusual at lower latitudes.

Finally, to test the transition, a **change point test** (e.g., Mann Whitney tests) was suggested that compares e.g. 1000-1300 vs 1500-1800 AD averages in climate sensitive regions. Also changes in variance between these periods could be interesting.

B. Where are the key areas and where are the gaps for collecting new proxy data?

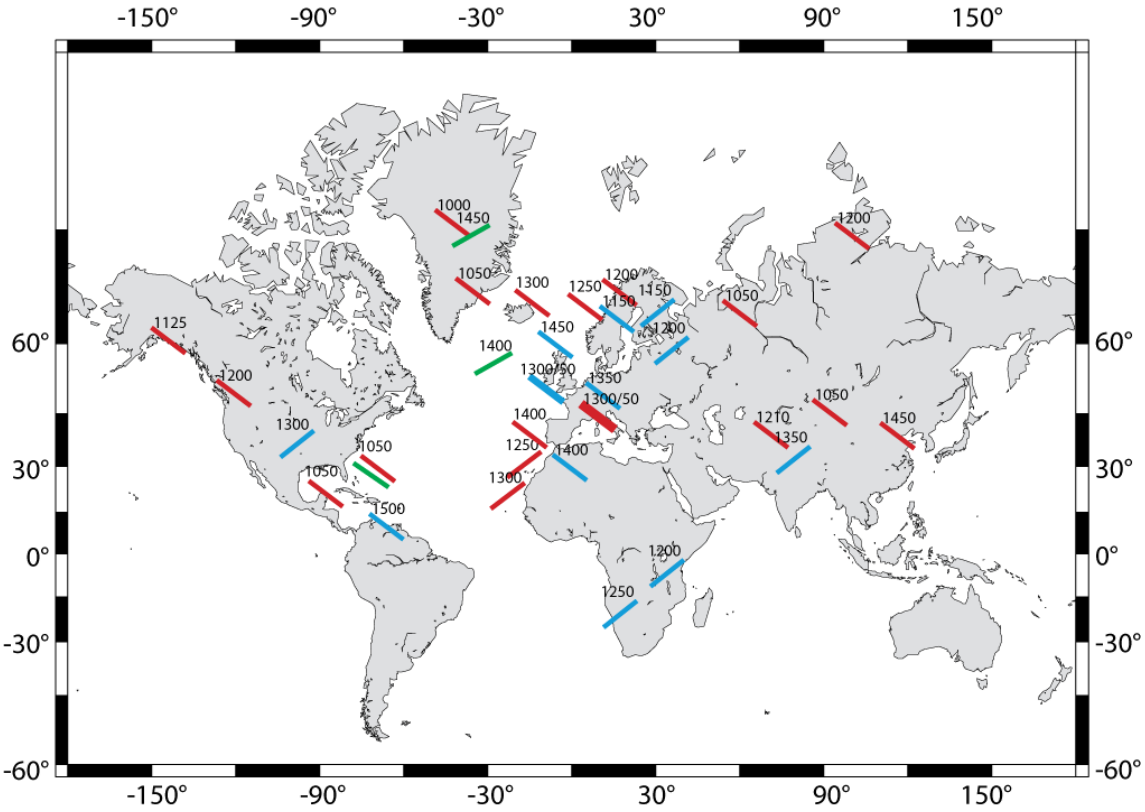

Figure 1: preliminary compilation of proxy records showing the MCA-LIA transition. Different colours represent different climatic or oceanographic variables (red=temperature, blue=precipitation, green=flow). The direction of the MCA-LIA gradient (increase or decrease), as well as the approximate timing of the transition, is provided for each proxy.

A first draft of a **global map** was produced that shows the geographical location of proxies representing the transition and the nature and timing of the transition (Fig. 1). The map illustrates that the global nature of the transition is not spatially or temporally coherent. Based on the

discussion under A, it was suggested that a set of multiple maps is necessary that represent different seasons and different time "bins". Also, a consortium of experts is needed to compile the data and provide good metadata for each proxy. As a first step, 50-year bin maps will be sent around to the workshop participants (or put on the workshop website) for completion. A further step could be to include a MCA-LIA specific proxy database in the NOAA WDC for paleoclimatology (see also Outcome section).

Key regions that are important for understanding global climate dynamics, but where there is a lack of proxy records include:

- the tropical Pacific (E vs. W)
- the Warm Pool region (Indian Ocean vs. Pacific exchange)
- Indian Ocean
- Marine records for southern Africa
- various lobes of the region of NAO influence: Greenland, Florida, Baffin ice caps

Filling these gaps in the spatial proxy picture could potentially help us to test AMOC changes and to map ITCZ shifts and therefore to improve our understanding of the dynamical context.

C. Is it possible to formulate a dynamical concept that is consistent with hypotheses based on proxy data and can it be connected to natural climate variability? If there is an agreement, how do we quantify it?

The idea was proposed to use **natural variability** as the null hypothesis to be tested for the MCA-LIA transition. In this context it is important to avoid over simplistic views and focus on how proxy data can inform climate model predictions. An effort was made to identify the 15 "best" proxies that span the last 1000 years, implying a grading of the quality of the archives (and ultimately a weighting). Many more proxies, however (in the order of magnitude of 30-50) are needed to successfully constrain data assimilation models. Also, a good **process understanding** of proxy responses is necessary to determine acceptance/rejection criteria. Forward modelling of proxies and isotope implemented GCMs can contribute to understanding process responses. It would be interesting to do a MCA-LIA data assimilation model exercise when enough proxy data of high quality are available for this period.
For **quantification** purposes, more probabilistic approaches are needed in the paleosciences, including Bayesian detection and attribution, quantitative fingerprinting, and data assimilation.

OUTCOME (assessment of results, contribution to the future direction of the field)

The last session of the workshop, chaired by Valérie Trouet, was a strategic discussion of the implementation of the scientific output from the workshop in future research strategies. Additionally, future collaborations, avenues for joint research, and follow-up activities were discussed.

In a first round of discussion, individual participants presented personal highlights with respect to the scientific content of the workshop. Recurring topics that were highly appreciated in this workshop included:

- The presentation of new proxy records (e.g., **Ian Hall**'s high resolution sortable silt record of N Atlantic flow) and their compilation (cfr. **James Scourse**'s and **Nick Graham**'s keynote lectures)
- Enhanced communication/interface between modelling and proxy (particularly paleoceanography) communities
- Learning from other areas of climate science, e.g. Bayesian approaches, data assimilation (**Hugues Goosse**)
- Understanding of the natural 'stickiness' vs. external forcing of climate variability (based on **David Stephenson**'s keynote lecture) and its importance for future climate prediction
- Recognition of the complexity of the climate system in general and the MCA-LIA transition in particular
- Recognition of uncertainties in proxy archives, without obsessing over them and thus retaining an optimistic view
- Possibility of integrating ocean data into GCM data assimilation

A number of immediate follow-up actions was suggested, including:

- this **ESF report** on the scientific content of the workshop
- a short report to be published in **EOS or PAGESNews**
- organisation of a **AGU or EGU session** with the theme of this workshop
- An **ESF Research Networking Programme** would allow us to continue our interdisciplinary discussion in an organized and sustainable way, including exchange of young and established scientists and funding for future workshops. The next deadline for proposals is 22nd October 2009, for programs to start from 1st January 2011 onwards. It might be worth looking into (ESF?) funding that starts earlier (and that would allow us to have a follow-up workshop next year).

- Alternatives for an ESF RNP include proposals for a Leverhulme International Network (UK) or COST action.
- Including a **MCA-LIA specific proxy database** in the NOAA WDC for paleoclimatology (**Eugene Wahl** and **Caspar Amman**)
- Presentations, posters, reports, follow-up activities will be posted on a workshop-specific **website** (**Valérie Trouet**)
- Distribution of a participants **email contact list**

FINAL PROGRAMME

Sunday 17 May 2009

Afternoon	*Arrival*
18.00-19.00	*Registration*
19.00	*Dinner, informal (Hotel Lötschberg)*

Monday 18 May 2009 (Day 1)

08.30-08.50 **Welcome and introductions**
Valerie Trouet (WSL, Birmensdorf, CH)

08.50-09.15 **Presentation of the European Science Foundation (ESF)**
T. Hefin Jones (Standing Committee for Life, Earth and Environmental Sciences (LESC))

09.15-10.30 **Untangling the MCA-LIA transition: the role of climate models**
Nicholas Graham (Hydrologic Research Center, San Diego, USA)

Keynote lecture and discussion

10.30-11.00 *Coffee / Tea Break*

11.00-12.30 **Depressing times: estimating Medieval climate from tree rings**
Rob Wilson (University of St Andrews)

Keynote lecture and discussion

12.30-14.00 *Lunch*

14.00-15.30 **Untangling the MCA-LIA transition: the role of palaeoceanography**
James Scourse (Bangor University, Bangor, UK)

Keynote lecture and discussion

15.30-16.00 *Coffee / Tea Break*

16.00-17.30 **Climate dynamics and variations**
David Stephenson (University of Exeter, Exeter, UK)

Keynote lecture and discussion

17.30-18.30 **Recent contributions to the understanding of synoptic-scale climate dynamics on long time-scales: short communications**

Dirk Verschuren: Anti-phased equatorial East African and East Asian monsoon rainfall over the past millennium

Eugene Wahl: Spatial field reconstruction, uncertainty, and detecting a volcanic forcing signal through the uncertainty

18.30-20.00 **Poster session**

and wine reception

20.00 *Dinner*

Tuesday 19 May 2009 (Day 2)

08.30-10.30 **Session 1: Methodological update: short communications**

Hugues Goosse: Towards dynamically consistent reconstructions of past climate changes based on climate model simulations using data assimilation

Christoph Raible: Mid latitude cyclone and blocking statistics during the Maunder Minimum and today

Matthew Collins: Quantifying uncertainty in climate predictions

Stephan Lorenz: Carbon cycle feedback to natural and anthropogenic forcing in ensemble simulations of the Last Millennium using an Earth System Model

Discussion

10.30-11.00 *Coffee / Tea Break*

11.00-13.00 **Session 2: The global character of the MCA-LIA transition: short communications**

Fatima Abrantes: Evolution of Primary Productivity during the Latest Holocene (2,000 yr) off Oporto (Portuguese Margin)

Ian Hall: Surface and deep ocean coupling in the subpolar North Atlantic during the last three millennia

Ashish Sinha: Extreme transient weakening of the Indian Monsoon during the MCA-LIA transition

Discussion

13.00-14.00 *Lunch*

14.00-17.30 **Excursion in the Lötschen Valley**

Ulf Buentgen (WSL, Birmensdorf, CH)

The Lötschen Valley is centrally situated in the Alps, in the canton of Valais in Switzerland. The picturesque valley extends 27 km from the Lötschenlücke (3178 m) at the top of the Langgletscher to the mouth of the valley at Gampel-Steg (630 m). Surrounded by 3000 m high mountains, the valley bottom (1300 m) contains small ancient villages (including Kippel) and the glacial-fed river Lonza. Both the south and northern facing mountain slopes are covered up to about the theoretical maximal treeline (2200 m) by typical subalpine forest consisting of two conifer species, deciduous larch and evergreen spruce. Timber from living trees and historical buildings has been used to reconstruct summer temperatures and larch budmoth populations over the last millennium.

The WSL has started a long-term project in the Lötschen Valley in 2007 to study the influence of climatic change on tree growth. During this excursion we will visit several sites where intra-annual tree growth and temperature are monitored along an elevational gradient. Additionally, we will visit some historical buildings that have functioned as a resource for dendroclimatological research.

17.30-18.00 **Tree-ring studies in the Lötschen Valley**

David Frank (WSL, Birmensdorf, CH)

18.00-20.00 **Brainstorming sessions**

In mixed groups of 6 participants, around the following key questions

1. **How do we define the 'transition' and what is its (spatiotemporal) nature?**
2. **Where are the key areas and where are the gaps for collecting new proxy data?**

3. Is it possible to formulate a dynamical concept that is consistent with hypotheses based on proxy data and can it be connected to natural climate variability? If there is an agreement, how do we quantify it?

Wednesday 20 May 2009 (Day 3)

08.30-9.30	**Session 3: Possible forcing and feedback mechanisms for the MCA-LIA transition**
	Eduardo Zorita: The Medieval Climate Anomaly in the context of long Holocene climate simulations: the role of solar forcing
	Nanne Weber: The role of ocean and atmosphere dynamics in explaining the European Little Ice Age
9.30-11.00	**Summarizing discussion of the brainstorming sessions**
11.00-11.30	*Coffee / Tea Break*
11.30-13.00	**Strategic discussion and closing remarks** *general and practical discussion of research strategies, collaborations, avenues for joint research, and follow-up activities*
13.00-14.00	*Lunch*
14.00	*Departure*

Posters

Andy Baker	Multiple proxies of the climate of the last 1000 yrs from a NW Scotland stalagmite
	Forward modelling stalagmite $d^{18}O$: an example from NW Scotland
Traute Crueger	Artificial tree rings eco-physiologically derived from climate simulations - Assessment of uncertainties of temperature reconstructions from tree rings
David Frank	Climate sensitivity of the Carbon cycle
Jörg Franke	Combining proxy data and model simulations to reconstruct European climate
Stephan Lorenz	The 1258 volcanic eruption
Christoph Raible	Northern Hemisphere teleconnection patterns in ensemble simulation from 1500 to 2100: stability and forcing impacts
Valerie Trouet	Multi-century variability in the PNA circulation pattern reconstructed from tree rings
Dirk Verschuren	Anti-phased equatorial East African and East Asian monsoon rainfall over the past millennium

List of Participants

Convenor:

1. **Valerie TROUET**
Swiss Federal Research Institute WSL
Dendrosciences Unit
Zürcherstrasse 111
8903 Birmensdorf
Switzerland
trouet@wsl.ch

Co-Convenors:

2. **Jan ESPER**
Swiss Federal Research Institute WSL
Dendrosciences Unit
Zürcherstrasse 111
8903 Birmensdorf
Switzerland
esper@wsl.ch

3. **Andy BAKER**
School of Geography
Earth and Environmental Sciences
University of Birmingham
Edgbaston
Birmingham lB15 2TT
United Kingdom
a.baker.2@bham.ac.uk

4. **Eduardo ZORITA**
GKKS Research Center
Institute for Coastal Research
Max Planck Strasse 1
21502 Geesthacht
Germany
eduardo.zorita@gkks.de

ESF Representative:

5. T. Hefin JONES
Cardiff School of Biosciences
Cardiff University
PO Box 915
Cardiff CF10 3US
United Kingdom
jonesth@cardiff.ac.uk

Participants:

6. **Fatima ABRANTES**
Marine Geology Department
INETI
Estrada da Portela Zambujal
Apartado 7586
PT-2721-866 Amadora
Portugal
Fatima.abrantes@ineti.pt

7. **Caspar AMMAN**
NCAR
Climate and Global Dynamics Division
1850 Table Mesa Drive
Boulder, CO 80307-3000
USA
ammann@ucar.edu

8. **Lisa BALDINI**
Durham University
Department of Earth Sciences
Science Labs
Durham DH1 3LE
United Kingdom
l.m.baldini@durham.ac.uk

9. **Ileana BLADE**
University of Barcelona
Department of Astronomy and Meteorology
Grand Via de les Corts Catalanes, 585
E-08007 Barcelona
Spain
ileanablade@ub.edu

10. **Matthew COLLINS**
Met Office
Hadley Centre
FitzRoy Road
Exeter EX1 3PB
United Kingdom
matthew.collins@metoffice.gov.uk

11. **Traute CRUEGER**
Max Planck Institute for Meteorology,
Atmosphere in the Earth System
Bundesstrasse 53
D-20146 Hamburg
Germany
traute.crueger@zmaw.de

12. **David FRANK**
Swiss Federal Research Institute WSL
Dendrosciences Unit
Zürcherstrasse 111
8903 Birmensdorf
Switzerland
frank@wsl.ch

13. **Hugues GOOSSE**
Université Catholique de Louvain
Institut d'Astronomie et de Géophysique
B-1348 Louvain-la-Neuve
Belgium
hgs@astr.ucl.ac.be

14. **Nicholas GRAHAM**
Hydrologic Research Center
12780 High Bluff Drive, Suite 250
San Diego, CA 92130-3017
USA
ngraham@hrc-lab.org

15. **Ian HALL**
Cardiff University
School of Earth and Ocean Sciences
Park Place
Cardiff CF10 3YE
United Kingdom
hall@cardiff.ac.uk

16. **Stephan LORENZ**
Max Planck Institute for Meteorology
Ocean in the Earth System
Bundesstrasse 53
D-20146 Hamburg
Germany
stephan.lorenz@zmaw.de

17. **Christoph RAIBLE**
University of Bern
Climate and Environmental Physics,
Physics Institute
Sidlerstrasse 5
CH-3012 Bern
Switzerland
raible@climate.unibe.ch

18. **James SCOURSE**
Bangor University
School of Ocean Sciences
Menai Bridge
Anglesey LL59 5AB
United Kingdom
Oss048@bangor.ac.uk

19. **Marie-Alexandrine SICRE**
CNRS
Laboratoire des Sciences du Climat et de l'Environnement
Ave de la Terrasse
F-91198 Gif-sur-Yvette Cedex
France
marie-alexandrine.sicre@lsce.ipsl.fr
2, Chemin du Cyclotron

20. **Ashish SINHA**
Department of Earth Science
California State University Dominguez Hills
Carson, CA 90747
USA
asinha@usc.edu

21. **David STEPHENSON**
University of Exeter
School of engineering, computing, and mathematics
North Park Road
Exeter EX4 4QF
United Kingdom
D.B.Stephenson@exeter.ac.uk

22. **Dirk VERSCHUREN**
Ghent University
Department of Biology
Ledeganckstraat 35
B-9000 Gent
Belgium
Dirk.verschuren@Ugent.be

23. **Eugene WAHL**
NOAA National Climatic Data Center
325 Broadway
E/CC23
Boulder, CO 80305
USA
Eugene.r.wahl@noaa.gov

24. **Nanne WEBER**
Royal Netherlands Meteorological Institute
Climate Research & Seismology, Climate Analysis
P.O. Box 201
NL-3732 GK de Bilt
Netherlands
weber@knmi.nl

25. **Rob WILSON**
University of St Andrews
School of Geography & Geosciences
North Street
St Andrews, KY16 9AL Fife
United Kingdom
rjsw@st-andrews.ac.uk

Local organizing committee :

26. **Ulf BUENTGEN**
Swiss Federal Research Institute WSL
Dendrosciences Unit
Zürcherstrasse 111
8903 Birmensdorf
Switzerland
buentgen@wsl.ch

27. **Jörg FRANKE**
Swiss Federal Research Institute WSL
Dendrosciences Unit
Zürcherstrasse 111
8903 Birmensdorf
Switzerland
franke@wsl.ch

Statistical information on Participants

Total number of participants: 26 *(not including ESF representative, but including convenors and local organizers)*

By nationality:

Belgium: 2
France: 1
Germany: 3
Netherlands: 1
Portugal: 1
Spain: 1
Switzerland: 6
UK: 7
USA: 4

By gender:

Male: 19
Female: 7 (27%)