

## **P 1.2**

### **Paleoclimate Variability and Extreme Events (PALVAREX-3)**

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#### **1. Three research questions of the project**

1. What is the timing of the suggested anomalous drought/wet precipitation patterns, their geographical extent, and their magnitude during the Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA) relative to the 20th century conditions for the North Atlantic/European area?
2. What are the underlying dynamics of extended dry and wet periods in Europe and how are they related to large scale atmosphere and ocean conditions and remote (NAO/AMO and ENSO/PDO, teleconnections) forcing?
3. Is it possible to relate past wet and dry periods in Europe to variations in circulation regimes as recorded by different proxies?

#### **2. Research Summary**

Bradley et al. (2003) point to the fact that the MCA could be more a period with widespread hydrological anomalies from 900 to 1300 AD. Prolonged droughts/wetness affected many parts of the western United States (in particular eastern California and the western Great Basin) and other parts of the world (e.g Mediterranean, Morocco and possibly other parts of Europe), with impacts on society, 'economy' and nature. Prolonged droughts in some areas and exceptional rain events in others suggest that changes in the frequency or persistence of circulation modes (such as ENSO) may account for the climate in some areas. However, the causes of such persistent anomalies remain unknown and need to be investigated. Wet and dry periods in the past centuries suggest that internal variability and external forcings were important to explain observed climate variability over the North Atlantic/European area (e.g. Esper et al. 2007). European precipitation reconstructions back to 1500 were performed recently. Pauling et al. (2006) mainly used land based proxies that are unequally distributed in time and space. Principal component/multiple regression was applied that tended to fit towards mean conditions that did not allow statistical analysis on anomalous dry or wet periods prior to the early 18<sup>th</sup> century. One major aim is to reconstruct past precipitation combining different high and low resolution climate proxies from land and ocean covering the areas of the North Atlantic and European area by applying RegEM and quantil regression methods.

A new challenge in paleoclimatology is to interpret stable isotope ratio time series from hydro-climatic archives in areas with varying contributions of different moisture sources. For the period 1995-2002, trajectory analysis revealed the following humidity source contributions for Alpine precipitation: Atlantic (50%), the Mediterranean (23%), and European land evaporation (21%) (Sodemann, 2007). Variations in circulation patterns during the MCA and LIA may affect these source contributions as indicated by temporal variations of various ice core parameters (stable isotope ratios, deuterium-excess, sea salt and mineral dust concentration) over the last millennium. The potential of these ice core – derived parameters to capture changes in atmospheric circulation and humidity sources will be investigated. The underlying hypothesis is that the deuterium-excess is sensitive to varying contributions of different moisture sources (Atlantic, Mediterranean, land evaporation), whereas the sea salt concentration is related to the strength of the westerlies. Main mineral dust events on the other hand are of Saharan/Sahelian origin and the transport is influenced by the NAO.

### 3. Data and methods

New temporally highly resolved proxies from terrestrial and marine archives will become available within the next 2 years from international projects or personal contacts. For instance, highly resolved speleothems from Turkey, the Middle East and from the central Mediterranean area provide information on the past hydrological cycle (Fleitmann, Bar-Matthews, Silenzi, Montagna, pers. com.). Further, new tree-ring isotopic data (Masson-Delmotte et al. 2005; Treydte et al., 2007) from central Europe and parts of the Mediterranean will be derived by DeTree (P1.3). Existing Fe-exe-flux data at low resolution from the French Massif Central is interpreted as a proxy for rainfall during the growing season (Schettler et al. 2007) will be used as well. New high-resolution information from the same proxies will become available from Ireland (Schettler, pers com). Documentary based information from the Iberian Peninsula resolve anomalous dry and wet periods and floods for more than half a millennium (e.g. Benito et al. 2003). Important precipitation-related information from northwestern and central Europe might be available from EuroClimhist ([www.euroclimhist.com](http://www.euroclimhist.com); Pfister, pers com). During the two NCCR Climate phases the major focus of the ice core research was obtaining suitable cores, analyzing various parameters (Jenk et al. 2007a), dating (Schwermann et al., 2006; Jenk et al. 2007b), and interpretation with respect to temperature variations and air pollution (Schwikowski, 2006; Reithmeier et al., 2006). Within Phase 3 we will build on existing ice core data, but investigate new parameters, which have only recently become available such as deuterium-excess. In order to assess the potential of the new parameters a variety of tools will be applied (spectral methods, e.g., wavelet analysis, PCA and correlation analysis). We will also perform back trajectories analysis over a longer time period using NCEP/Reanalysis and ERA-40 data. The RegEM method was successfully used in the NCCR phase 2 to reconstruct large scale climate fields. We will apply RegEM also within the NCCR Phase 3. Quantil regression, a new method not yet introduced in paleoclimatology will also be tested for multiproxy drought/wetness reconstruction covering the last millennium. The advantage of quantile regression is that it does not fit to the mean values as linear regression based methods, but estimates and conducts inferences, so-called conditional quantile functions. Therefore, a better representation for anomalous dry and wet periods can be expected.

### 4. Milestones and deliverables

#### ***After 18 months:***

- To perform trajectory analysis to investigate potential proxies of atmospheric circulation (deuterium-excess, sea salt and mineral dust concentration) covering the last approximately 60 years
- To select periods of interest concerning the hydrological cycle and test RegEM and quantil regression with data covering the last 500 years.

#### ***After 36 months:***

- To assess the potential of different proxies to capture changes of past circulation and humidity sources;
- To develop indices for past circulation changes;
- To reconstruct spatial patterns of single and extended dry and wet extremes for the last millennium combining climate information from sea and land;
- To better understand the physical processes and large-scale circulation for past changes and anomalous hydrological events;
- To characterize the forcing impact on the past precipitation variability;
- To compare and combine reconstruction and model results;
- To use model output from P1.1 as test-bed for developing reconstruction methods like quantil regression.

## 5. Contribution to the WP1 and collaboration with other NCCR projects and 3<sup>rd</sup> parties

(i) Coordination within WP1 regarding key periods for model-reconstruction comparison. P1.1 provides a test-bed for reconstruction methods (P1.2) and processes, large-scale circulation patterns and teleconnections, explaining past changes and long-term droughts and prolonged wet periods in the hydrological cycle in Europe (P1.3); (ii) Contribute to WP1 with paleoclimate reconstructions from ice cores, including circulation indices which complement tree ring-based reconstructions (P1.3). (iii) Contribute long-term drought records and interaction/comparison with reconstructions at local to regional scale (P1.3); (iv) Collaboration on statistical downscaling (from P2.3) using past modelled (from P1.1) and reconstructed data (from P1.2); (v) Joint research with P2.1 on model comparison using control and possibly past or future simulations with both model systems; (vi) using similar methods but different time windows, the future changes in extremes in the hydrological cycle (P2.3) will be placed in a longer perspective by comparing these with results of P1.2 and P1.1. Another link relates to extreme value statistics that is used both in WP1 and P2.3. Results will be of relevance to authorities and regional organizations as well as to scientific programs and databases dealing with climate change issues and impacts. Examples include: (i) Past Global Changes Program (PAGES), Bern, Switzerland; (ii) MedClivar; (iii) National Geophysical Data Center (NOAA) and (iv) the Intergovernmental Panel on Climate Change (IPCC).

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