# SO&P

## Simulations, Observations & Palaeoclimatic data: climate variability over the last 500 years


EVK2-CT-2002-00160 SOAP

## Section 5: Executive Summary

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# Section 5: Overall Executive Summary

| Contract no.: | **EVK2–CT2002–00160** | Project period: | **November 2002 to April 2006** |
|---|---|---|---|
| Title: | **SO&P: Simulations, Observations & Palaeoclimatic data: climate variability over the last 500 years** | | |

**Objectives:**

- Provide improved, quantitative reconstructions of the variability of climate over the last five centuries.
- Undertake and analyze climate model (GCM) simulations to quantify the changing influences of natural and anthropogenic climate forcings over this period.
- Establish the reliability of GCM simulations of natural climate variability and sea level change.
- Generate improved estimates of natural and anthropogenic climate variability through the utilisation of simulated and observed/reconstructed climate data.

**Scientific achievements:**

- Development of new approaches to, and demonstration of the value of, integrated data–model analyses for the purpose of understanding climate variability.
- Simulation of the climate of the last 500 or 1000 years with two complementary state-of-the-art ocean-atmosphere general circulation climate models and comprehensive sets of natural and anthropogenic forcing factors.
- Analysis and comparison of the climate model simulations to identify the influence of forcings on global and regional climate, cryosphere, hydrology and sea level.
- The development of new reconstructions of European, tropical, Antarctic and Northern Hemisphere climate (temperature, precipitation, drought and atmospheric circulation) and North Atlantic sea level.
- Development and application of so-called 'pseudo-proxy' methods for the use of climate model simulations to test the potential performance of climate reconstructions and their dependence on statistical methods and the coverage and characteristics of climate proxy data.
- Comparison of climate model output and climate reconstructions to assess the consistency of data and models, and to attempt detection of the effect of natural and anthropogenic forcings on climate. Comparisons have been made for many aspects and regions, including tropical sea surface temperature changes, European temperatures and droughts, Northern Hemisphere temperature changes, and changes in temperature seasonality in Europe and China.

**Main deliverables:**

- New reconstructions of:
    - summer temperatures across western Europe for the last 900 years;
    - temperatures across a large European region for all seasons for the last 500 years;
    - precipitation across a large European region for all seasons for the last 500 years;
    - summer drought severity across the Mediterranean region for the last 650 years;
    - north-western Eurasian regional summer temperatures for the last 2000 years;
    - average tropical annual-mean sea surface temperatures for the last 250 years;
    - summer Antarctic Oscillation index for the last 100 years;
    - Northern Hemisphere temperatures (winter, summer and annual) for the last 600 years;
    - the spatial extent of warming and cooling in the Northern Hemisphere for the last 1200 years; and
    - estimates of relative sea level from the east coast of the North America for the last 500 years or more.
- Climate simulations with two climate models with only natural forcings and with combined natural and anthropogenic forcings:
    - HadCM3 for the last 500 years; and
    - ECHO-G for the last 1000 years.

- A comprehensive website to provide a focus for current and future work of this nature and to provide continuing access to and extensive visualisation of the climate model data and the climate reconstructions.

**Socio-economic relevance and policy implications of the SO&P project:**

This work has clear policy relevance in two areas; first, in assessing the reliability of the climate models that have been used to make projections of our future climate, and second, in determining how unusual twentieth century climate change was in the context of the last 1,000 years.

**Conclusions:**

- The pseudo-proxy evaluations of the potential reliability of Northern Hemisphere temperature reconstructions indicate that many published reconstructions are likely to be affected by bias, in addition to the random error that was already considered in many cases. The bias most likely results in reconstructions having reduced amplitude multi-century temperature variations, but it is not yet possible to determine the magnitude of this bias because it depends upon the reconstruction method, on the characteristics of climate variability, and on the characteristics of the proxy data. In particular, we have demonstrated that explicit statistical descriptions of the errors in the proxy data are needed if reconstruction bias is to be completely avoided. These aspects of SO&P project work have stimulated further research by other groups and by international research bodies such as CLIVAR/PAGES.
- Despite these potential biases, climate reconstructions developed with SO&P support have shown that:
    - it is likely that the Northern Hemisphere is warmer now than at any time for at least 600 years;
    - it is likely that the spatial extent of warmth over Northern Hemisphere land is greater now than at any time for at least 1200 years; and
    - it is very likely that European temperatures have been higher in recent decades than at any other period in at least the last 500 years and that 2003 was by far the hottest summer during that period.
- The climate model simulations indicate that, in the absence of anthropogenic forcings, global-mean temperature would have warmed by only around 0.1°C due to natural forcings, though this result is dependent upon the sensitivity of the climate model. The simulations suggest that anthropogenic forcings may have had a significant impact on climate since the early 19$^{th}$ century (particularly in the tropics). Both the hydrological cycle and cryosphere are also affected by anthropogenic forcings in the model and changes in land-use influence hydrology and spring snow cover.
- This project has established that future work should focus immediately on further understanding the sources of bias and uncertainty in the different reconstructions of past temperature, and the degree to which these can be reduced by the development of improved methods. Improved reconstructions can then be used to continue the testing of climate models that was begun during the SO&P project, and to extend the application of data and models to such issues as constraining the range of climate sensitivity that is compatible with our evidence of past climate change.

**Dissemination of results:**

The SO&P project web site (http://www.cru.uea.ac.uk/cru/projects/soap/) provides access to a wide range of information on the project, including all publicly-available report and data deliverables. Project outputs have also been disseminated via presentations at scientific conferences and around 50 peer-reviewed journal/book papers. Many scientists who have received support from the SO&P project are authors of the forthcoming IPCC Fourth Assessment Report, which cites published results from the SO&P project.

**Keywords:** Climate change, Palaeoclimate, Climate models, General circulation models, Climate signal detection, Climate variability, Climate reconstruction, Tree-rings, Ice cores, Documentary data, Tropical corals, Sea-level rise