

The Millennium project: European climate of the last millennium



M. GAGEN¹, D. MCCARROLL¹ AND S. HICKS²

¹Department of Geography, University of Wales Swansea, UK; d.mcCarroll@swansea.ac.uk

²Institute of Geosciences, University of Oulu, Finland

Millennium is a paleoclimate project funded under the European Union's 6th framework. It was designed by a multidisciplinary consortium of 37 European universities and research institutes and is coordinated by Prof. Danny McCarroll at the University of Wales Swansea, UK. The project aims to address a single question:

- Does the magnitude and rate of 20th Century climate change exceed the natural variability of European climate over the last millennium?

Millennium is developing new proxy-based climate reconstructions from documentary weather records, tree rings, lake sediment cores, peat cores, ice cores, marine sediment cores, and annually banded marine shells. With field sites spread across Europe, reconstructions will be developed at a variety of spatial scales. A modeling component will assess the forcing mechanisms acting upon European climate.

Methodology

There have been many attempts to reconstruct the past climate of the Northern Hemisphere (Esper et al., 2002) and of Europe (Luterbacher et al., 2002), but they produce results that vary, particularly with respect to the longer-term changes. No existing proxy records provide a perfect, unbiased view of past climate, and differences in the way that existing data records have been processed have a strong effect on the reconstructions. Millennium seeks to improve upon this situation with a combination of new proxy records, new analyses of existing records and paleoclimate modeling.

Structure

- Instrumental and documentary archives

Data are being compiled from western, eastern and central Europe, and the Mediterranean. The group is processing derived information into a set of consistent indices expressing variation in temperature and precipitation. Time series are anticipated to be resolved at the monthly level to AD 1500 and at the seasonal level for earlier centuries.

Tree rings

- Paleoclimate information is being extracted from a network of twelve chronologies distributed across Europe from the Iberian Peninsula to the Atlantic margin and polar Arctic. A multi-proxy approach is being used,

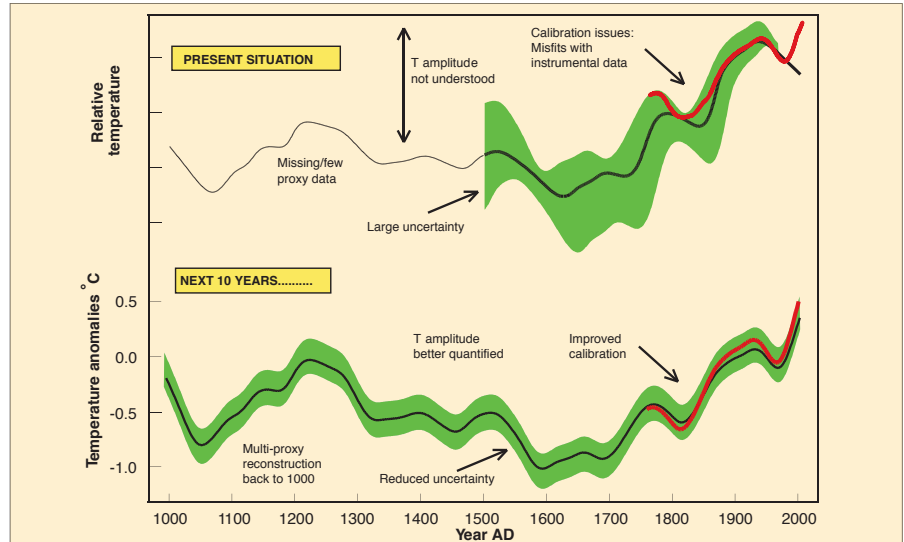


Figure 1: The current limitations of Northern Hemisphere climatology and the advancements into detection and quantitative understanding of European climate variability that Millennium will aim to provide.

including ring widths, wood density, stable isotopes of oxygen, hydrogen and carbon, annual height increment, and needle dynamic data.

- Sediment archives

A multi-proxy approach is being applied to extract paleoclimate information from ice cores, peat deposits and lake sediments. Microfossils, isotope ratios and sediment composition are being analyzed at 11 sites. By carrying out continuous sampling, such that each sample represents as close to annual resolution as it is feasible to obtain, it will be possible to identify short-term abrupt events and pinpoint their date with a high degree of accuracy.

- Marine archives

Sampling has been carried out within Scottish sea lochs and on the North Icelandic Shelf, locations where the rate of sedimentation is high enough to provide a temporal resolution of just a few years. Locations were selected to resolve natural variability in both the position and temperature of the North Atlantic's heat pump. We are also applying dendrochronological methods to the annually banded marine mollusk *Arctica islandica* to provide a novel way to link high-resolution oceanic records with those on land.

- Data analysis and modeling

When empirical reconstructions of climate records, based on regression techniques (e.g. Mann et al., 1999), are compared with numerical simulations of the past millen-

nium, agreement is achieved only for GCMs that produce climate sensitivities at the low end of the range reported by the IPCC (von Storch, 2004). This poses a dilemma as to whether empirically reconstructed climate records based on regression underestimate variability, or whether the GCMs overestimate sensitivity. Millennium's reconstructions are being developed specifically to reduce the artificial loss of variability at multi-decadal to centennial timescales and allow us to address this dilemma.

Revised and new proxy records will be compared to millennial-scale GCM simulations to derive realistic estimates of sensitivities of differing forcing parameters. Version 3 of the coupled Hadley Centre GCM (HadCM3), and its low resolution equivalent (FAMOUS), will be used for long simulations. We are using distributed volunteer computers over the internet, organized through the ClimatePrediction.net project and welcome international scientific collaboration. Further information is available at www.millennium-project.net.

References

- Esper, J., Cook, E.R. and Schweingruber, F.H., 2002: Low-frequency signals in long tree-ring chronologies for reconstructing past temperature variability, *Science*, **295**: 2250-2253.
- Luterbacher, J., Dietrich, D., Xoplaki, E., Grosjean, M. and Wanner, H., 2004: European seasonal and annual temperature variability, trends and extremes since 1500, *Science*, **303**: 1499-1503.
- Mann, M.E., Bradley, R.S. and Hughes, M.K., 1999: Northern Hemisphere temperatures during the past millennium: inferences, uncertainties and limitations, *Geophys. Res. Lett.*, **26**: 759-762.
- von Storch, H., Zorita, E., Jones, J., Dimitriev, Y., González-Rouco, F. and Tett, S., 2004: Reconstructing past climate from noisy data, *Science*, **306**: 679-682, [doi:10.1126/science.1096109](https://doi.org/10.1126/science.1096109).

