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First 2000-year-long temperature reconstructions for individual continents

Past climate change varied remarkably between regions. This is demonstrated in a new study coordinated by the international Past Global Changes (PAGES) project, which reconstructed temperature over the past 1000 to 2000 years. It is the first comprehensive temperature reconstruction on a continental scale. One of its main findings is that a general cooling trend, caused by different factors (e.g. orbital-driven insolation and changes in solar and volcanic activity), was ubiquitous across all continental-scale regions and was reversed by a distinct warm trend beginning at the end of the 19th century.

The scale of this project is impressive. Some 80 researchers from all over the world collaborated on the study, which has just been published in the scientific journal "Nature Geoscience". In one of the widest-ranging efforts yet undertaken to reconstruct climate across the globe, the international author team evaluated data from all continents to track the evolution of temperatures over the past one to two millennia.

This major project was initiated and coordinated by the Past Global Changes (PAGES) organization. PAGES was established in 1991 to facilitate international research into understanding climatic and environmental dynamics by studying the past. The program receives funding mainly from the Swiss and US national science foundations. In 2006, ambitious scientists in the PAGES network decided to organize an initiative to reconstruct the climate of the last 2000 years in unprecedented quality. The first results of the collective effort have now been published. "A key aspect of the consortium effort was to engage regional experts who are intimately familiar with the evidence for past climate changes within their regions," says Heinz Wanner, emeritus professor at the University of Bern and one of the

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original architects of the PAGES 2k Network. "Several mathematical procedures were applied to reconstruct the continental temperature time series and they were compared to assess the extent to which the main conclusions of the study stood up to the different analytical approaches." Previous attempts to reconstruct temperature changes focused on hemispheric or global-scale averages, which are important, but overlook the pronounced regional-scale differences that occur along with global changes, he points out.

Natural climate archives and documentary sources

For the present study, "Continental-scale temperature variability during the last two millennia", the researchers drew up temperature curves for large regions at seven continents, using 511 local temperature records. These were based on the analysis of tree rings, pollen, corals, lake and marine sediments, ice cores and stalagmites as well as historical documents. In most cases the data used were highly resolved, attesting to short-term variations over decades or less, rather than smoothing over centuries. In Africa, there were too few records to accurately determine long-term temperature changes for that continent. Nevertheless, the expansive new dataset will undoubtedly be used in future studies, including for comparisons with the output of climate models used to help project future climate change.

The evolution of temperature across all the continents was noticeably more similar within the hemispheres than between the Northern and Southern Hemisphere. "Distinctive periods, such as the Medieval Warm Period or the Little Ice Age stand out, but do not show a globally uniform pattern," says professor Heinz Wanner. By around 1500 AD temperatures did indeed fall below the long-term mean everywhere. However, in the Arctic, Europe and Asia this temperature drop occurred several decades earlier than in North America and the Southern Hemisphere. These new findings will certainly stimulate vibrant discussions within the research community, Wanner believes.

Long-term cooling trend reversed

The most consistent feature across the regions over the last 2000 years was a long-term cooling trend, which was likely caused by a combination of factors such as an overall increase in volcanic activity, a decrease in solar irradiance, changes in land cover, and slow changes in earth’s orbit. This cooling only came to an end toward the end of the 19th century. The warming during the last century has reversed this long-term cooling, the study found. It remained cold only in Antarctica. An analysis of the average temperatures over 30-year periods indicates that interval from 1971-2000 was probably warmer than any other 30-year period in the last 1400 years.

Cooler 30-year periods between the years 830 and 1910 AD were particularly pronounced during

weak solar activity and strong tropical volcanic eruptions. Both phenomena often occurred simultaneously and led to a drop in the average temperature during five distinct 30- to 90-year intervals between 1251 and 1820. Warming in the 20th century was on average twice as large in the northern continents as it was in the Southern Hemisphere. During the past 2000 years, some regions experienced warmer 30-year intervals than during the late 20th century. For example, in Europe the years between 21 and 80 AD were possibly warmer than the period 1971-2000.

Reference

"Continental-scale temperature variability during the last two millennia", PAGES 2k Consortium, «Continental-scale temperature variability over the last 2000 years», PAGES 2k Consortium, *Nature Geoscience*, in print (doi:10.1038/NGEO1797)

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