Tree-Ring Chronologies and Climate Variability

THE RECENT REPORT BY ESPER *ET AL.* ("Low-frequency signals in long tree-ring chronologies for reconstructing past temperature variability," 22 March, p. 2250) addresses important scientific questions on the spatial scale of past climate periods such as the so-called "Little Ice Age" and "Medieval Warm Period." It also presents a valuable set of data and demonstrates a novel use of a promising technique. As already indicated (*1*), the basis used by Esper *et al.* for comparison with previous studies of Northern Hemisphere (NH) temperature trends over the past millennium (*2–4*) is flawed. For this and other important reasons, the previously established conclusion (*5*) that late 20th century warming appears to be unprecedented over at least the past millennium still stands.

Esper *et al.*, like previous studies (*2–4*), conclude that peak warmth about 1000 years ago was comparable to that of the mid-20th century. However, unlike these previous studies, they did not compare the peak medieval warmth against that of the past few decades, wherein hemispheric temperatures have risen several tenths of a degree Celsius further above mid-20th century levels. Their report is thus not a refutation of the basic finding (*5*) that late 20th century warmth is anomalous in the context of at least the past millennium.

The Esper *et al.* reconstruction exhibits greater century-scale variability than the hemispheric reconstruction of, e.g., Mann *et al.* (*3*), with the greatest differences seen in the level of cooling during the so-called Little Ice Age (17th to 19th centuries). As they indicate, some of these differences may have a geographic basis. Esper *et al.* estimate extratropical (and primarily, warm-season) temperature changes, using an entirely extratropical tree-ring data set. In contrast, the Mann *et al.* reconstruction estimates temperature trends over the full NH, using both extratropical (tree ring, ice core, and historical) and tropical (coral, tree ring, and high-elevation ice core) proxy data and targeting the full NH temperature. Half of the surface area of the NH temperature record estimated by Mann *et al.* lies at latitudes below 30°N, whereas the Esper *et al.* estimate is based entirely on latitudes above 30°N. Tropical surface temperatures are typically less variable than extratropical continental surface temperatures on almost all time scales. For example, Hendy *et al.* (*6*) have shown that there is little if any cooling in a substantial region of the tropical Pacific during the Little Ice Age, and they argue that the main signature of the Little Ice Age is an increase in the poleward temperature gradient. Such inferences are consistent with recently demonstrated dynamical mechanisms for enhanced extratropical continental cooling in the Little Ice Age (*7*). More moderate temperature variations at the scale of the full NH (*2–4*) are consistent with model (*5*) simulations.

Esper *et al.* use the regional curve standardization (RCS) technique in their estimation of temperatures between 800 and 1100 A.D. in spite of the cautions of Cook *et al.* (*8*) and their own injunction that "Successful use of the RCS method generally requires a large number of ring-width series because the method of detrending is not based on any explicit curve-fitting to the individual series…" (p. 2251). Large numbers of samples were used in their study, but not for the period around 1000 A.D. Their supplemental Web fig. 2 (*9*) shows that only 6 of the total of 14 sites cover this period and that the total number of samples used for any one year is between 50 and 70. Dendrochronologists usually take two samples per tree, so their estimate of extratropical NH temperature 1000 years ago is probably based on 25 to 35 trees spread across six locations. They rightly point to the need for more long, well-replicated tree-ring collections covering the period 900 to 1300 A.D.

Rather than refuting past temperature estimates, the Esper *et al.* record underscores the mounting evidence for substantial differences between tropical and extratropical temperature trends in past centuries and the need for more records of millennial length and for a better understanding of the situations under which multicentennial climatic information may be extracted from tree-ring data.

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9. Supplemental material for Esper *et al.* is available on *Science* Online at www.sciencemag.org/cgi/content/full/295/5563/2250/DC1