Tree-Ring Variations over the Western Himalaya: Little Evidence of the Little Ice Age ?

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The Little Ice Age (LIA) is generally believed to have been a widespread phenomenon in the Northern Hemisphere around AD 1450-1850. While there is some consensus for a main phase of LIA from AD 1550-1800 over Europe, there is confusion associated with the use of this term and also considerable uncertainty as to the severity or synchroneity of the various cool events which have been ascribed to it (Briffa et al. 1990). Much of the evidence for LIA has come from documentary historical data and it is only recently that the potential of tree-rings as proxy climatic indicators has been exploited to address this issue. Briffa et al. (1990), using the analysis of a 1,400-year tree-ring record of summer temperatures in Fennoscandia, argue that the LIA is confined to a relatively short period between AD 1570 and 1650. These results have emphasized the probable spatial diversity of climate change, even across Europe through the last millennium (Briffa et al. 1992). With the availability of tree-ring chronologies over other regions across the world, it would be quite interesting to determine whether the spatial extent of LIA-associated climate changes has indeed been limited. The Himalayan region is a case in point.

Several leading tree-ring groups have been active in the Himalayan forest sites over the past two decades, more intensely over the western and central Himalayas. Using a large number of ringwidth and density chronologies of the Himalayan conifers, including *Pinus roxburghii*, *Picea smithiana*, *Cedrus deodara*, and *Abies pindrow*, covering the entire area of western Himalaya, we found that that the summer climate, particularly pre-monsoon (March-April-May) temperature and precipitation strongly influence tree-growth, a feature that cuts across species as well as sites.

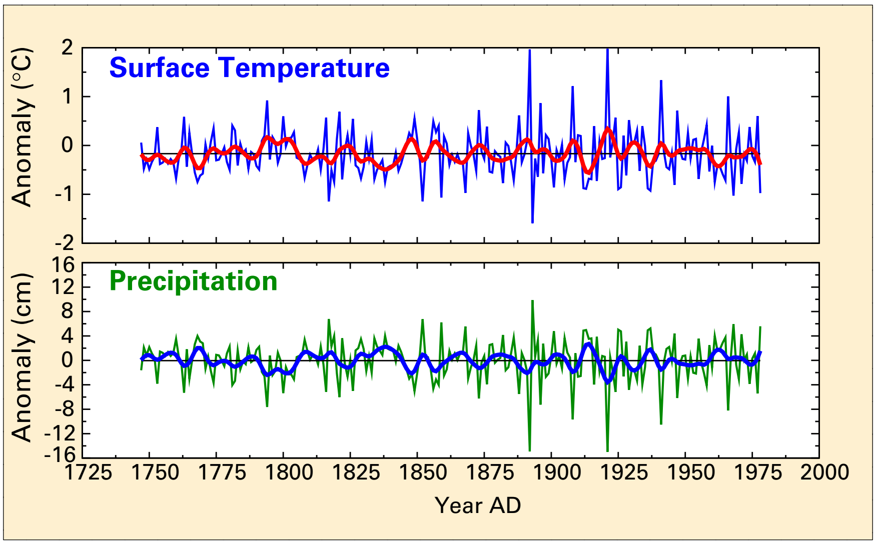

Fig. 1: Reconstructed pre-monsoon (March-April-May) temperature and precipitation anomalies since AD 1747 over the western Himalaya, India, using tree-ring chronology network. Smooth lines are based on cubic-spline-filtered values.

This response is possibly linked to moisture stress conditions during the early phase of the growing season causing growth anomalies in Himalayan conifers.

Reconstructed pre-monsoon (March-April-May) summer climate of western Himalaya since A.D. 1747 does not show any significant long-term trend over any part of the time series (Fig. 1). While these reconstructions are not long enough to comment with confidence on multi-centennial variability, they would have covered the later part of the LIA had it been of the time span 1450-1850. In such a case, it might be expected that the early part of the tree-ring based reconstructions contain at least the recovery phase from the peak of LIA. However, our studies to date do not indicate any unambiguous signal of the LIA phenomenon over this part of the globe. Other tree-ring based temperature reconstructions over the Himalaya (e.g. Hughes 1992, Yadav et al. 1999) also do not indicate evidence of long-term cooling associated with the LIA period. However, a recent analysis by Cook et al. (2002) based on Nepal tree-ring temperature reconstructions, in which they followed a novel approach to recover some low-frequency variance supposedly lost while detrending the tree-ring chronologies, provides some evidence of the LIA, probably for the first time over the Himalayas. However, they find that the cooling (possibly associated with the LIA) is prominent only in the winter (October-February) temperatures. Most analyses of tree-ring data from the western Himalayan region (of India) do not indicate significant response to winter climate (e.g. Borgaonkar et al. 1994, 1996, 1999, Hughes 1992), making it difficult to detect similar LIA signals. Even the raw tree-ring chronologies do not indicate any perceptible change in tree growth pattern that can be attributed to anomalous cooling conditions contemporaneous with the timing of LIA.

It is evident that the summer climate of the Himalayas as derived from tree-rings, particularly over the western parts during the past few centuries was not much different from the present climate and there is little evidence of cooling associated with the LIA. While this aspect needs further corroboration with more and longer chronologies and also support from other proxy sources, one can possibly surmise that the LIA might have had at best only a weak presence over the Himalayas.

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Fire and Climate History in the Western Americas From Tree Rings

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The usefulness of tree rings in historical climatology derives from their high temporal resolution, exact dating, and sensitivity to precipitation and temperature variables. Another key strength of tree-ring climate proxies is that they can be massively replicated across broad-scale networks encompassing regions, continents, and hemispheres. In addition to influencing the growth of trees, climate variations affect ecological processes, and these processes are also recorded within tree rings. One of the most climatically responsive ecological processes is the occurrence and extent of wildfires. The record of past forest fires is often beautifully preserved within tree-ring sequences as "fire scars" on the lower boles of trees (Fig. 1). By extensively sampling fire-scarred trees in numerous locations, dendroecologists are now assembling broad-scale fire-scar chronology networks (Fig. 2) that are approaching the extent and replication of tree-ring width networks that dendroclimatologists have been assembling since the 1960s.

In combination with calibrated precipitation and temperature reconstructions from tree rings, fire-scar networks help improve our understanding of ecologically-effective climatic change. These records can assist in identifying important changes in regional to global climate patterns, and they can be useful in developing models for forecasting fire hazards in advance of fire seasons. In this brief note I review examples of findings from fire-scar networks in the western Americas. The fire history research community is just beginning to organize and coordinate at the global scale, and there are many new opportunities to collaborate, exchange data, and to analyze paleofire records from new regions.

Fig.1: Fire scars are created on the lower boles of trees by surface fires that injure the growing tissue beneath the bark (cambium), but do not kill the tree. Giant sequoias in the Sierra Nevada, California were repeatedly scarred by surface fires over the past three millennia (Swetnam 1993). By examining cross sections from dead trees, such as the one in the upper photo at Sequoia National Park, we can clearly identify fire scars within the ring sequences (lower photo), and date these fires to the year and season of occurrence. This particular tree had an innermost ring date of 256 BC, and contained more than 80 different fire-scar dates. Composites of fire-scar chronologies from individual trees, and from forest stands, provide time series reflecting fire occurrence and extent across a range of spatial scales.

Regionally Synchronized Fire Events

One of the strongest indications that fire-scar chronologies can reflect climatic variations is the occurrence of synchronized fire-scar events in widely scattered locations, from forest stands to regional scales (Fig. 3A). These regional fire events typically coincided with drought years (Fig. 3B). Similar patterns of fire event synchrony and drought are observed in the 20th century. For example, 1988 and 1989 were severe drought years in the western United States, and enormous areas burned during these years (e.g. the 1988 fires in Yellowstone National Park, and many large fires in the Great Basin and Southwest in 1989). Extensive fires occurred at the global-scale in the El Niño years of 1982-83 and 1997-98 in tropical forests of Indonesia, central Mexico, and the Amazon Basin.

A combination of modern and paleo time series of fire occurrence and weather indicates that high and low fire extent years were often associated with extreme phases of the ENSO (La Niña and El Niño). These patterns were not simply ENSO-related droughts causing high fire occurrence, or wet periods