FURTHER DISCUSSION ON: TREE-RING TEMPERATURE RECONSTRUCTIONS FOR THE PAST MILLENNIUM

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A suite of tree-ring and multi-proxy large-scale temperature reconstructions and analyses have been published over the past decade (**Figure 1**; Jones et al. 1998, Mann et al. 1999, Briffa 2000, Crowley and Lowery 2000, Esper et al. 2002, Cook et al. 2004, Moberg et al. 2005, D'Arrigo et al. 2006, Osborn and Briffa 2006). Virtually all of these studies, despite different methodologies and only partially overlapping data sets, have reached the same conclusion: that recent warming in the Northern Hemisphere appears to have been unprecedented over the past millennium and that this warming is most likely a result of the anthropogenic release of greenhouse gases into the atmosphere. The unusual nature of reconstructed 20th century temperatures is typically robust even if a number of individual series are excluded, and the reconstructions largely fall within each other's respective uncertainty limits.

Several recent opponents of anthropogenically-forced global warming are familiar with statistics but have not personally developed tree-ring or other proxy data or reconstructions themselves. They claim that there are methodological artifacts that could bias, in particular, the Mann et al. (1999) "hockey stick" reconstruction, and by inference, other reconstructions as well. Attempts to refute this claim have been published by several authors (e.g. Mann et al. 2005, Rutherford et al. 2005, Wahl and Ammann in press). However, the methods utilized by the various other studies are often quite different and most are derived in a more straightforward manner than the much-cited "hockey stick" method (Mann et al. 1999). For example, the D'Arrigo et al. (2006) reconstruction was developed using simple averaging of tree-ring records (after accounting for differences in mean and variance over time), followed by linear regression. Care was taken to evaluate the robust nature of the reconstructions developed in this case, rigorously testing for model validity and potential bias. Thus, for the D'Arrigo et al. (2006) study and likely others, there exists no "methodological artifact" which might have biased results in favor of a conclusion of unusual recent large-scale warming. Therefore, we find the concern that there is "some kind of methodological artifact that somehow reverberates throughout nearly all of the reconstructions and that has gone unappreciated by people in the field" to be unfounded.

There has also been accusation of bias in site selection or so-called "cherry picking", in which it has been argued that dendrochronologists only include those sites that show global warming for use in the tree-ring reconstructions. Instead, we maintain that we purposely select those trees and sites which portray low-frequency information. Coherent trends between some tree-ring records are indicative of a common response to large-scale temperature changes. We also pre-screened the tree-ring records used in our reconstruction against individual station records and gridded climate data, to evaluate their more localized response to temperature (D'Arrigo et al. 2006). Only certain types of sites (e.g. due to their ecological characteristics) can provide large-scale temperature information. This is by its very nature a subjective, non-quantifiable process and we make no apologies for selecting these kinds of trees and sites to reconstruct temperature variability. Such a signal can often be readily observed by examining core samples in the field (e.g. increased growth in the 20th century, decreased growth during cold periods of the so-called Little Ice Age, etc), or in tree-ring chronologies even prior to any calibration or modeling with instrumental temperatures.

A number of tree-ring series indicate a divergence between tree growth and temperature at some northern sites in recent decades (e.g. Briffa et al. 1995, Jacoby and D'Arrigo 1995, Briffa et al. 1998, Vaganov et al. 1999, Barber et al. 2000). Theories for the cause (s) of this observed divergence, which may vary from site to site, include decreased temperature sensitivity due to warmer temperatures, drought stress, increased winter snowmelt and ozone effects. This divergence needs to be considered to avoid bias in dendroclimatic reconstructions; however it is not present everywhere. For example, temperature-sensitive elevational treeline sites in Mongolia and the European Alps exhibit dramatic growth increases in recent decades (D'Arrigo et al. 2001, Buntgen et al. 2005). Greater attention to site selection (e.g. avoidance of drought-prone sites) and careful comparison of adjacent sites with regards to their ecological characteristics can help circumvent this problem. As mentioned in the D'Arrigo NRC presentation, Cook et al. (2004) have demonstrated that the divergence appears to be limited to the recent period (after ~1950) and to trees from some northern locations (at some sites within ~55-70°N), and that there is no evidence for a comparable divergence prior to this time (e.g. during the Medieval Warm Period). These observations suggest a unique, anthropogenic cause for the recent divergence and argue very strongly that tree-ring temperature reconstructions for the past millennium should not be called into question based on these recent observations.

In addition to the observations of unusual warming in recent large-scale temperature reconstructions, there is another feature that many of them share, and which appears to be clear evidence for a unique and distinctive fingerprint of anthropogenic change in the recent period. This additional evidence is the striking coherency among the various individual tree-ring records that make up the reconstructions during the recent period, and the much lower coherency during the earlier so-called Medieval Warm Period (D'Arrigo et al. 2006, Osborn and Briffa 2006, Wilson et al. submitted-a). This result strongly suggests that the recent warming is unique and spatially pervasive (Figure 2). Although lower sample size early in the reconstructions may also be a factor, we have taken care to truncate the earlier portions of the tree-ring records used in our reconstructions when replication is low (D'Arrigo et al. 2006). This observation of recent spatial coherency is consistent with the hypothesis of a ubiquitous common forcing (i.e. anthropogenic release of greenhouse gases), that simply did not exist prior to ~ the 19^{th} - 20^{th} centuries.

There is a great deal of additional, even overwhelming, evidence for unusual recent anthropogenic warming on a hemispheric to global scale. This evidence includes output from various types of climate models (e.g. Jones and Mann 2004). There are also other proxies that show undisputable evidence of unusual, even unprecedented warming. These include observations of the melting of tropical glaciers (Thompson et al. 2000), and a tropical reconstruction of sea surface temperatures based on coral records (Wilson et al. submitted-b). Both of these latter examples indicate distinctive and unusual recent warmth from the relatively stable tropics. There are many other examples as well.

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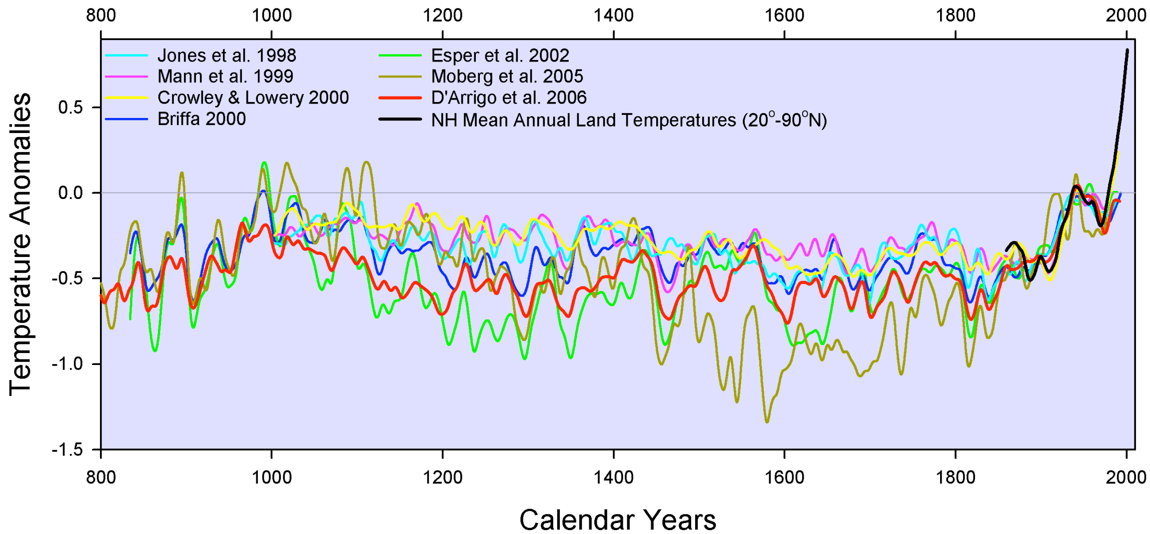

Figure 1. Comparison of NH temperature reconstructions. The smoothed reconstructions were scaled to the smoothed instrumental NH temperature series over the period 1859–1976.

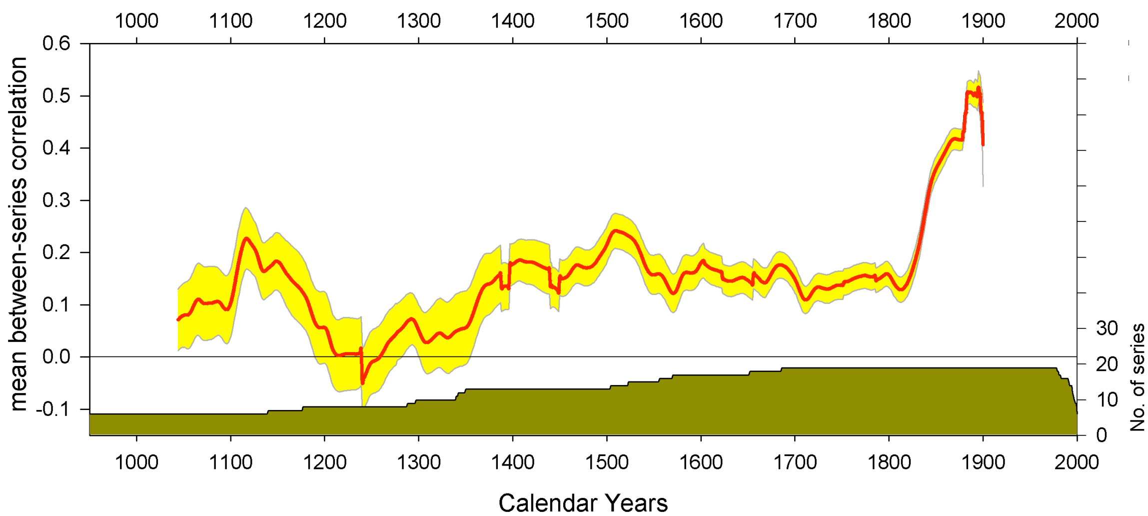

Figure 2. Running 201-year mean between series correlation time-series (with 1 standard error envelope) and histogram denoting the number of series for each data-set through time. Calculated using the 19 tree-ring composite series utilized in D'Arrigo et al. (2006). The RBAR values are centered around the central year of each 201-year window and were calculated for the periods replicated by a minimum of 6 series. This plot illustrates the unusually strong coherency of the recent period.