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Climate of the Past Discussions

Interactive comment on "Northern Hemisphere temperature patterns in the last 12 centuries" *by* F. C. Ljungqvist et al.

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C. Loehle raises a most valid point concerning the importance of considering the effects of different kinds of errors when combining temperature proxy records. Before discussing this important topic we want to remind the reader that our manuscript is about the spatial patterns on centennial time-scales and not another attempt at reconstructing a time-series of past temperature variability in the temporal domain. It is certainly true that peaks of a time-series tend to be "smeared out" because of dating errors. We are familiar with this problem and a brief qualitative discussion of the likely results from this smoothing effect is, for example, given in Ljungqvist (2010) in the context of time-series reconstructions of temperature variability.

This "smoothing out" of peaks is, as C. Loehle notices, only relevant for our study if this

effect is not stable over time but tends to increase back in time. A large temporal bias in the dating error and measurement error distribution would pose a problem for our conclusions about the recent warmth verses the past (e.g., medieval) warmth. However, we are convinced that this problem is not present. In fact, proxy types that do not possess any dating errors (e.g., tree-ring records and documentary historical records) show approximately the same rate and magnitude of change as the proxy types (e.g., lake and sea sediments) that generally do possess dating errors. This is evident from comparing the time-series of the different proxy types shown in Fig. 4A. Concerning dating errors we also want to point out that not all proxy records have the largest dating uncertainties in older times. Many radiocarbon-dated sediment/pollen archives have no dating points in recent centuries and their accumulation time scale towards the top (present) is only assumed to be linear.

It is somewhat another matter concerning measurement errors. Indeed the sample rate for non-annual proxy records is usually higher in recent times. Tree-ring chronologies also tend to be built up of increasingly more individual cores in recent times. On the other hand, other error sources likely increase in form of progressively larger anthropogenic influences from, for example, agricultural activity and commercial logging. This is especially true for lake sediment and pollen records. It is, unfortunately, not possible to quantify the measurement errors and their distribution over time or make any assumption about them, that can be considered robust.

Our conclusion is that the overall bias regarding the magnitude and rate of recent warmth versus the past (e.g., medieval) warmth is insignificant in the overall perspective and that the conclusions are robust despite certain dating and measurement errors. To a certain degree we do quantitatively investigate the impacts of dating and measurement errors by way of the tests of robustness in the Supplement. As stated in the article, these tests reveal that the patterns observed remain after all low-resolution records (mostly identical to those proxies with considerable dating uncertainties) are excluded. This also holds true for the conclusion that the temperature change from the

19th to the 20th century is the largest between any two consecutive centuries in the past 12 centuries.

To summarize, we argue that the dating and measurement errors from the individual proxies do not affect the conclusions about the 20th century warming versus the medieval warming. If, anyway, there should be a certain bias, it is rather an underestimation of the 20th century warming than the medieval warming given that the exactly dated records (e.g., tree-ring records) indicate the highest 20th century values.

References

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