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Interactive comment

Interactive comment on "Differing pre-industrial cooling trends between tree-rings and lower-resolution temperature proxies" *by* Lara Klippel et al.

Edward Cook (Referee)

drdendro@ldeo.columbia.edu

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Review of "Differing pre-industrial cooling trends between tree-rings and lower-resolution temperature proxies" by Lara Klippel, Scott St. George, Ulf Büntgen, Paul J. Krusic, Jan Esper

Submitted by: Edward R. Cook

This is a useful paper that illustrates in part some important short-comings of the tree-ring data available from the PAGES 2k database 2.0.0 for the detection of millennial-long temperature trends in total ring widths (TRW). The motivation for this evaluation

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was based on the observation that other temperature-sensitive proxies in the PAGES 2k database show what is interpreted as an orbitally-driven pre-industrial cooling trend over the past 2,000, whereas temperature-sensitive tree-ring data based on ring widths in the same database do not do so. This cooling trend should be found in the Northern Hemisphere (NH) as theory predicts; in the Southern Hemisphere (SH) an opposite warming trend should be found, again based on theory. These expected hemispheric insolation trends are also most strongly expressed in the boreal and austral summers, respectively, with amplification towards the poles (Fig. 3). This should favor the more northerly tree-ring series in the NH because they are principally summer temperature responders, yet a cooling trend is not apparent. Although it is briefly mentioned in the Abstract that the seasonal response could also be ‘annual’ (line 18), it is practically impossible to convincingly argue that tree-ring series anywhere reflect changes in mean annual temperature in their total ring widths. This persistent mythology needs to be laid to rest.

The authors note that there are 415 “temperature-sensitive” tree-ring chronologies in the global PAGES 2k database and proceed to use them to illustrate the lack of a pre-industrial cooling trend in tree-ring series relative to the other temperature proxies (Fig. 2). The 50-year binned composite tree-ring series do have a very slight negative trend, but it is not statistically significant compared to the much larger negative trends found in the other proxies. While this initial comparison sets the stage for the investigations carried out in the rest of the paper, it is somewhat strange because by my calculation (using the 402 NH chronologies noted in Fig. 1a) there are 415-402=13 SH tree-ring series in the 415-chronology total that could have orbitally-driven positive temperature trends in them. Thus, including the 13 SH chronologies in the binned composite (Fig. 2b) likely weakens the chance of finding a statistically significant negative trend in the 402 NH chronologies. Figure 2b should therefore be redone using only the 402 NH chronologies for the binned evaluation of the temperature trend. I do not necessarily expect a change of outcome, but it should be done to be consistent with the argument. On line 60, the reference to “average global tree-ring record” should consequently be changed to “average Northern Hemisphere tree-ring record” as well. Later in the paper it is finally mentioned that the SH tree-ring data were excluded from further analysis (lines 128-129). This should have been mentioned in the beginning, and the SH chronologies immediately excluded, as suggested above.

The lack of a significant negative trend in the tree-ring data (assuming to hold after the SH chronologies are removed) is hypothesized to come from three issues: climate sensitivity, detrending, and spatial distribution. Reasonable arguments for each being a contributor are given and each is tested. The issue of detrending is perhaps the one most dear to my heart because I have spent much of my career studying it. It was therefore with considerable dismay that “the PAGES 2k database contains no information regarding the detrending method used to produce the tree-ring chronologies in its collection . . .” (lines 90-91). Admittedly, the ITRDB holdings are not that much more informative. Even so, this lack of metadata is unfortunate and should be rectified as a matter of PAGES 2k policy. The lack of useful metadata on how the tree-ring series were detrended is why I almost never use tree-ring chronologies directly from the ITRDB. I detrend the raw measurements myself. The majority of my remaining comments will deal mostly with the detrending tests done in the paper.

At the hypothesis testing stage (pg. 5) the original 415 global chronologies were winnowed to a subset of 70 NH tree-ring collections, each at least 800 years long (line 143). It would be useful to have a table in the paper (as an appendix?) that lists these data sets by location, species, length, and modeled climate sensitivity (e.g., maximum correlation with monthly summer temperature), so that others can download the same tree-ring data and repeat the same evaluations on their own. I note that this number (70) is less than that indicated in Fig. 1b (89). Another apparent inconsistency. Regardless, selecting only the longer series for further evaluation is quite sensible because the preservation and detection of a negative pre-industrial temperature trend (if there) will be far easier to accomplish with $\geq$800 year-long series due to issues related to the ‘segment length curse’.

This being the case, I cannot fathom why experiments with (i) 100-year spline detrending (SPL) were carried out. The result is totally predictable with respect to the preservation of multi-centennial to millennial-long trends; they are all removed. Therefore, no negative pre-industrial temperature trend can ever be expected to be detected. Thus, SPL detrending has no relevance to testing the effects of detrending on the presence or absence of the expected negative temperature trend. The use of (ii) negative exponential functions (NEG) gets closer to the issue of preserving multi-centennial to millennial-long variability, so it is useful to experiment with. However, its susceptibility to the 'segment length curse' renders it almost impossible for NEG to preserve a millennial-long cooling trend unless the series being detrended are least millennial in length. This leaves (iii) regional curve standardization (RCS) as the only detrending option that may preserve the negative pre-industrial temperature trend from ring widths being sought. Thus, the authors are right in stating that that this method is the best of the three. Unfortunately, they are also right in stating the tree-ring measurements in the PAGES 2k database are for the most part inadequate for the application of RCS detrending. Besides the datasets not being nearly large enough in general, there are other reasons detailed in Briffa and Melvin (2011) on why use of RCS on inappropriate data sets can lead to the creation of utterly spurious long-term trends. This is because it is rarely appropriate to use RCS on datasets based only on living trees from the same site. Yet, I suspect that this is the case for most of the datasets in the PAGES 2k database. Applying RCS to such datasets can introduce what Briffa and Melvin (2011) call 'modern sample bias' in the form of an artificial positive slope to the final RCS chronology, which is exactly the opposite to what is expected here based on orbital forcing. This being said, the 50-year binned RCS composite may still be useful to evaluate because any 'modern sample bias' in individual chronologies may be attenuated in the large-scale multi-site composite. This is still not optimal, however. On a positive note, I actually find the results shown in Fig. 5 to be encouraging. The 2/3 of the tree-ring chronologies (based on RCS? unclear in the text.) have negative trends up to 1800 CE. Although most are declared not statistically significant, it would be useful to test for the probability that the combined outcome is in fact statistically significant in favor of a cooling trend being there more than by chance alone in 2/3 of the series. This can be easily done using Fisher's combined probability test (https://en.wikipedia.org/wiki/Fisher%27s_method) assuming (quite reasonably here) independence between the individual test outcomes. However, again there appears to be a mismatch in the number of series longer than 800 years declared for use (70) (line 143) and the number indicated in the left-hand bar chart in Fig. 5 (89). The same problem is apparent in the total chronology count (89) shown in Fig. 7b. This inconsistency must be corrected.

The results of the other two tested hypotheses – climate sensitivity and spatial distribution – appear reasonable to me, although it is unclear which version of the chronologies is being used; SPL, NEG, or RCS. This ambiguity must be corrected. I would, however, caution about using chronologies with "mixed climate sensitivity", i.e. a combination of temperature and moisture sensitivity in the ring widths. Published work by Matt Salzer and Andy Bunn show that even at the highest, most temperature limited, elevations in the White Mountains of California it is easy to find bristlecone pine trees that have mixed precipitation/temperature signals in their ring widths. When this occurs, the correlation with summer temperature can be negative, leading to the suggestion here to invert those chronologies to rectify the correlation with temperature (lines 125-126). I am not sure this is a good idea. This form of negative temperature sensitivity is completely different from that for trees with positive temperature sensitivity because the negative correlation with temperature most likely reflects an evapotranspiration demand signal associated with a positive response to soil moisture content and precipitation amount. It is not clear that one should expect this relationship to have the same trend (in inverted form) as that due to the direct effect of summer temperatures on radial growth because this mixed-signal climate response is likely to include the direct effect of changing precipitation amount, which behaves more like a 'white noise' process compared to temperature. At the very least, one might expect the temperature trend expressed in the inverted tree-ring series to be reduced by the effects of a precipitation signal on ring width.

I do not mean to be overly critical of this paper. It should be published after considering my suggestions and comments. It is certainly plausible that TRW cannot provide useful estimates of millennial-long, orbitally-driven, summer temperature changes over the pre-industrial Common Era as Jan Esper would likely argue. There may be biological limitations on ring width that limit both the preservation of such long-term temperature-driven trends and their separability from purely biological trends. If so, even RCS may fail to preserve millennial-long trends due to climate. However, it would be premature to conclude that this is true based on the experiments conducted here. They are very useful, but the PAGES 2k tree-ring database is not sufficient. For RCS detrending, most of the data sets used are inadequate for a variety of reasons. Regardless, the results for tree rings in Fig. 5 are in my opinion actually quite encouraging given the data being evaluated. For this reason, I remain guardedly optimistic that tree-ring chronologies based on TRW will be able to detect an orbitally-driven millennial-long cooling trend in the NH.

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