Clim. Past Discuss.,
doi:10.5194/cp-2017-29-RC2, 2017

Climate of the Past Discussions

Interactive comment on "Spatio-temporal variability of Arctic summer temperatures over the past two millennia: an overview of the last major climate anomalies" *by* Johannes P. Werner et al.

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Received and published: 2 May 2017

Werner et al., present a new climate field reconstruction for the terrestrial Arctic (>60N) based on 54 annually-resolved temperature sensitive record. The reconstruction is created using an extended version of the age-uncertain BARCAST methodology presented in Werner and Tingley, 2015, which enables the authors to reconstruct the climate field while accounting for age uncertainty in the uncertain layer counted records (from ice cores and varved sediment). The result is a probabilistic CFR that extends back to 750 AD (although this is inconsistent in the manuscript – see below) and a reconstructed Arctic mean that extends through the Common Era. This represents a major advance, both scientifically, as this is the longest and most data-rich CFR yet de-

veloped for the Arctic, and methodologically, as this is the first full-fledged CFR that I'm aware of that rigorously incorporates age uncertainty. These are both major scientific publications that warrant publication in Climate of the Past.

The authors explore the new reconstruction by examining the 1) predominant trends in the CFR and index reconstruction, 2) reconstructed decades and centuries of extreme warm and cold conditions, and their relative distinctness and 3) evidence for arctic amplification in this reconstruction and a similar reconstruction created for Europe.

The manuscript is also generally well written, methodologies and assumptions are well articulated and the scientific importance of the results is generally well handled. The figures are also of professional quality, although I do include comments where I believe they could be improved in several instances.

Despite the high-impact science presented here, and the professional presentation, I have a number of concerns that I believed must be addressed before publication. My primary concern is the remarkable finding by the authors of widespread and significant warming trends throughout Greenland and Eastern Canada. These are presented clearly in figure 4a. First – this is an instance where the temporal extent of the CFR is confusing, as the trend map is presented as linear trends from 1-1850 CE, not 750-1850 CE. The larger concern, however, is that the origin of these warming trends is mysterious, in that they're not supported by the data. I've attached maps of the trends in annually resolved records north of 60N in the PAGES 2k v2.0.0 database, for records that extend from 1, 750, and 1000 CE to 1850 CE. Although, as the authors note, the trends in the datasets are relatively weak comparative to the interannual variability, most of the records demonstrate significant cooling trends over those intervals, and the rest show insignificant cooling trends. There essentially no evidence in the datasets for warming trends in Greenland and Eastern Greenland.

Given this – this result in the CFR is particularly interesting, and I'm keen to understand why this is occurring. I wonder about the possibility that in fitting the model parameters

described on line 182 to each record based on the instrumental data, that the direction of the linear proxy-climate relationship is inverted in the Greenland records relative to how the data were interpreted by the original authors. Regardless of whether or not this is the cause of the warming trends, including the key parameters in tables A1 and A2 would be helpful to the reader. Also regardless, this CFR/data discrepancy and its cause must be discussed by the authors. To this end, I suggest that the trends of the proxy records be added to figure 4a to make this comparison clear.

Until this concern is resolved, it's hard to evaluate the significance of the epoch analysis and arctic-wide trend comparisons, as its possible that they might change. For example, if the discrepancy in Greenland trends is resolved, the overall cooling trend in the reconstruction will likely increase towards significance, and towards previous estimates.

Regarding the third major scientific topic – that of Arctic observation, I have some bigger picture questions. Primarily – given the methodologies used here, where the parameters that scale proxy data to climate are fit for each record (in the Arctic) or record type (in Europe) relative to their fit with instrumental data – is it possible to learn anything substantial about Arctic amplification in the past? In other words, doesn't the parameter fitting essentially force the apparent amplitude of Arctic change to be greater than lower latitude change because the same phenomenon is observed in the instrumental data, which are used to estimate the temperature scaling for each record? Maybe I've missed something, but my suspicion is that random data run the this approach would also reveal Arctic Amplification (AA) just do to the way the parameters in the model are estimated.

Despite the argument above, there may be good evidence that I am misunderstanding something here given that the Arctic data in Figure 8 do not follow this pattern; although the European data do (increase variability with latitude) as expected. My understanding is that this is due to the inability to directly compare the Arctic and European results, although I aslo don't understand why they cannot be compared directly. If this is indeed

the case, I'd appreciate a much fuller understanding of why they cannot be compared.

Also in this section is the discussion of lagged response of peak (and minimum) temperature in the Arctic relative to Europe, presented in Figure 9. I think it's hazardous to make this assertion, as I don't think there's any evidence that the Arctic warming observed ca. 1000 AD is at all related to the warming in Europe ca. 950 AD, especially given that the European warm intervals ca. 750 and 1200 CE have no Arctic counterpart, and there's no other evidence that medieval climate in the two regions are connected.

Ultimately, given the apparent inability to compare the European and Arctic reconstructions, the potential challenges in looking at AA in such reconstructions, and the challenges in relating temperature variability between the two regions, I'm not sure that this section belongs in the manuscript, because as it currently stands, it raises more questions than it answers.

I suggest that the authors replace this with a different investigation with less complications. I like the idea of comparing the Arctic reconstruction with the European one (but only if they can be directly compared) but limiting the focus to the areas of overlap, or near overlap, would lead to a more interesting discussion, as there the assumption that they should be covarying is much more reasonable.

Overall, this is an exciting study and a well-written paper. After the issues discussed above are satisfactorily resolved, I suggest that it be published in Climate of the Past.

I attached detailed comments in a marked version of the manuscript.

Sincerely, Nick McKay

Please also note the supplement to this comment:
http://www.clim-past-discuss.net/cp-2017-29/cp-2017-29-RC2-supplement.pdf

Interactive comment on Clim. Past Discuss., doi:10.5194/cp-2017-29, 2017.

Normalized.PAGES2kv2.0.0.annual.trends.1-1850

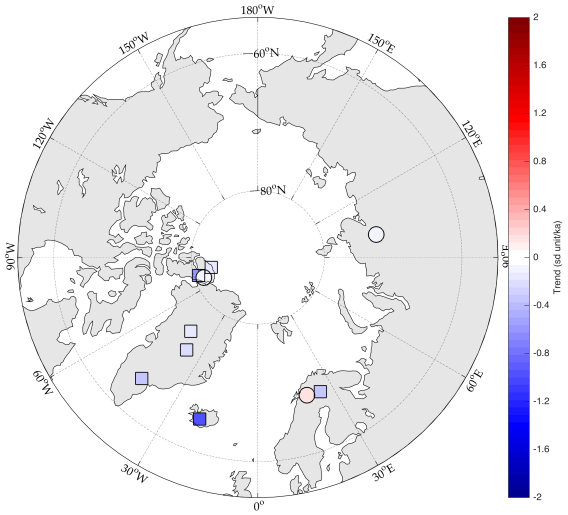

Fig. 1.

Normalized.PAGES2kv2.0.0.annual.trends.750-1850

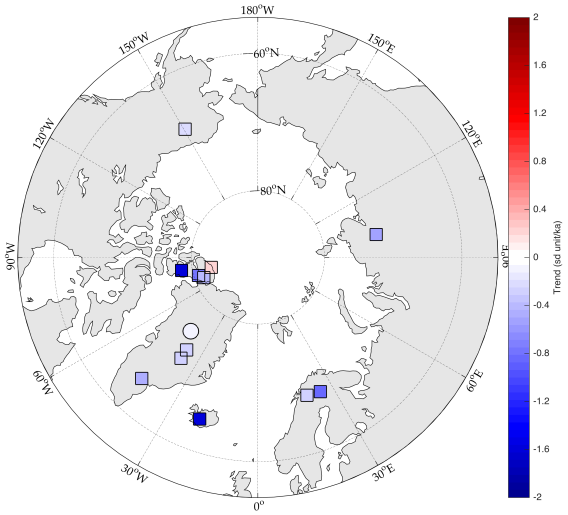

Fig. 2.

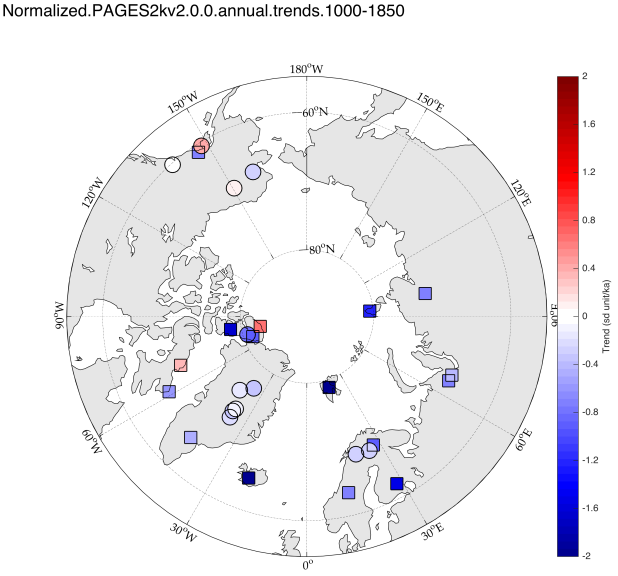
Normalized.PAGES2kv2.0.0.annual.trends.1000-1850
180°W
150°W
150°E
120°W
120°E
90°W
90°E
60°W
60°E
30°W
30°E
0°
60°N
80°N
2
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
Trend (sd unit/ka)

Fig. 3.