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Interactive comment on "Arctic hydroclimate variability during the last 2000 years – current understanding and research challenges" *by* Hans W. Linderholm et al.

Anonymous Referee #2

Received and published: 11 July 2017

With apologies for the delay in providing this review.

This paper attempts to provide a synthesis of palaeoclimate records spanning the last 2000 years in the Arctic region. In general, the content and subject matter are important and certainly well suited to Climates of the Past. However, prior to publication, I strongly recommend the authors undergo major revisions and resubmit their manuscript for further review.

Major comments

The content of this paper performs two broad functions. The first 23 pages provide a brief background to Arctic climate research, followed by a long review of the techniques

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used to infer past climate variability in the Arctic. The second part of the paper consists of a synthesis of published hydroclimate reconstructions and model hindcasts for the region, spanning the last 2000 years. The paper's title and abstract only refer to the second component (the synthesis), thus the extremely long introductory review comes as some surprise. As a first step, I suggest that the authors consider cutting the paper in half and creating (1) a review of palaeoclimate techniques applied to the Arctic, and (2) a synthesis of the palaeoclimate data. With respect to (1), the authors must carefully consider whether this would represent a valuable addition to the literature beyond the several books and review papers on palaeoclimate techniques. However, in order to meet the objective described in the abstract, this paper needs to be shorter and more focused on the data synthesis.

With respect to the palaeoclimate synthesis, this section warrants a more detailed and systematic approach than is provided in the current manuscript. This systematic approach should include reverting to a more traditional journal article format, with an introduction, methods, results and discussion.

As a minimum, the methods section should provide a clear and detailed description of the process of identifying and screening the published records for the Arctic region, which is not satisfactorily clear. The results section should detail which records were considered, how many were included/excluded and for what reasons. The PAGES 2k network have provided very clear guidelines for this process, and the screening process is described briefly on pages 27-28, however a detailed description and summary is necessary in order for readers to appreciate how comprehensive the search has been. For example, are all records described here included in Ljungqvist et al. (2016)? If not, which additional records were included, and which were excluded?

Furthermore, the approach to deriving the new hydroclimate proxy synthesis, described perfunctorily on page 28, requires a much more detailed description and appraisal as is afforded here. In this respect, I have several questions which are not answered in the manuscript: (1) How was the age uncertainty in these records dealt with when de-

riving averages for the multiple records?; (2) How were the timesteps aligned in order to derive an average of the multiple records? Was this by linear interpolation or another approach? Were the data smoothed in any way, or binned? (3) The synthesis contains records that have an average sample resolution of <50 years, yet the resulting timeseries suggests variability at much higher frequencies – how is this possible? Is the synthesis weighted more heavily towards the annually resolved records? (4) The spatial coverage of records used is uneven, with certain regions being more heavily sampled than others. Of note, for example, are the several Greenland ice core records are included in the synthesis. How does the regional synthesis deal with the bias towards those heavily replicated regions? (5) Finally – I would argue it is misleading to state that the results generated here are 'not a reconstruction'. True, the hydroclimate timeseries isn't calibrated against a particular climate signal, however it is a qualitative reconstruction of relative hydroclimate variability in the Arctic. Generally speaking, given the proliferation of numerical approaches to deriving regional and global syntheses of time-uncertain palaeoclimate records (see for example Anchukaitis and Tierney, 2012, Climate Dynamics), there is considerable un-realised potential in this research that could (and should) be investigated in more detail. If more involved numerical approaches are deemed unsuitable, then some justification as to why must be given.

Related to the review of regional palaeoclimate records, I found the multiple plots of palaeoclimate timeseries (Figures 7-11) quite unhelpful, not least due to the variety of ways the data are plotted (including the use of various graphical styles and time axes being both vertical and horizontal). It would be much more helpful to view a smaller selection of these records in a single figure (maximum two if necessary) on a common timescale in order to assess the Arctic-wide synchronicity or otherwise. It would also be helpful to view the regional synthesis timeseries in comparison with the records from which it was derived, so the reader can get a feel for how certain records have influenced the synthesis.

Parts of the manuscript read well, however I would advise the authors ask a native

English speaker to proof-read the manuscript before resubmission.

Minor comments

Abstract: The abstract describes ‘inadequate proxy data coverage’ (Page 1, Line 37), yet then goes on to call for ‘detailed regional studies, e.g. including field reconstructions’ (P2, L3). How is the latter possible if there’s inadequate data?

Section 2.2.1: I’m not entirely sure this section is necessary for this paper.

P4,L25: the Arctic’s. Errors related to the articles (misuse or non-use of the and/or a) are frequent throughout the manuscript.

P5,L18: ‘there are’, not ‘there is’; ‘phenomenon, which also. . .’

P6,L7: This sentence could be worded better – e.g.

P24,L11: ‘extensive’ -> ‘extensively’

P24, L11: ‘Typically annual precipitation. . . have been the targets’. This is not a complete sentence.

P24, L15: ‘Although potentially. . .’ Also not a complete sentence, and what is meant b the records not being available – not published?

P24, L20: ‘Towards the west’. The spatial context is very vague here – do you mean western Canada?

P24, L20: ‘there seems to be’. Use of present tense. In next line, past tense is used. Ensure there’s a consistent approach to tense (ideally use past when discussing past events) throughout.

P24, L23: ‘All show. . .’ What shows? Maybe better link up to previous sentence.

P24, L26: ‘Several’. Be more specific here when reviewing records. How many have been published?

P24, L27: ‘These..’ merge with previous sentence.

P25, L9: ‘A visual inspection. . .’ As described above, it would be preferable to summarise what records exist before identifying those relevant to this synthesis.

P26, L25: By this point, it would be useful to refer to a figure with some data.

P27, L16: ‘variability’ typo

P27, L18: ‘method outlined below’. As described above, it would be better to outline this in a proper methods section.

P28, first paragraph. As above, put this in the methods.

P28, L6: What is meant by ‘even more important’?

P28, L9: What is meant be ‘e.g. tendencies’

P28, L17: ‘This signal is not a signal of precipitations’ This sentence needs some attention.

P28, L22: The value of the Mann-Kendall test is not clear in this context.

P29, L3: Wavelet description. Unless you are using a non-standard wavelet package, I don’t think it’s necessary to provide such detail. That said, wavelet analyses are notoriously susceptible to errors related to unevenly spaced data – was this considered in your analysis?

P29, L16: ‘To minimise the impact of the 1456-1485 CE event’. . . Please provide more justification as to why it was necessary to filter out this event, and on the effects of that decision.

P29, L20: Comparing the North Atlantic and Alaskan records to the ‘global’ analysis, which constitutes both regions. This (as far as I can tell) is a flawed comparison, since surely the North Atlantic subset will be most similar to the global record, since 12 of the 17 constituent records are from the North Atlantic.

P30, paragraph 2. Comparing models with palaeoclimate data. This is a very brief and one-dimensional comparison given the importance of models for future projection. Much more detail should be provided on the similarities/differences and what that means for either the validity of the models or the palaeo- data.

P30, L30. At some point you need to justify why this new synthesis is an improvement on than L16, or indeed why it is necessary beyond L16.

P31, L25: 'Quite flat' – a more scientific term could be used here.

P31, L26-27: I fail to see why the absence of calibration for the new record would have any effect on the trend or variability within the record. The units and range would change, but the pattern would be identical before and after calibration.

P32, L1: 'not fully capturing the observed changes in the latter half of the 20th century'. Have you considered that other (non-climate) anthropogenic activities, such as recovery from acid rain, nutrient deposition or other atmospheric transport of pollutants may have influenced the recent signal in some proxies?

P32, L12: 'this period did possibly undergo'. Mixed up nouns and verbs in this sentence – need to re-word.

P32, L19: The paragraph on seasonal effects would be better merged into the proceeding text and not afforded a separate subheading.

P33, L3: change 'unbalance' -> 'imbalance'

P33, L9: Here you list future recommendations. Why not include these ideas in the bullet points listed below?

P33, L15: Bullet point 1 is two points. Also, by listing all records identified and screened in the results section, you would clearly make the point about data suitability and availability.

P33, L19: 'Proper Arctic2k hydro database. I thought this was the point of this paper?

P33, L23: ‘Field reconstruction’ – I got the feeling from reading this paper that a field reconstruction isn’t really feasible due to a lack of spatial data coverage.

P33, L25: Better collaboration between modellers and palaeo-data collectors is often called for. Can you be more specific as to what the two disciplines could do to improve collaboration?

Tables 1 and 2: Why do we need two tables here? Why not merge? Also, are these all the published records from the Arctic, or just those you could access?

Table 3: this is unnecessary. Just indicate which records are used in table 2.

Figures 1-5. Five figures here is too many. Boil them down to one or 2 most important.

Figures 7-11. See comment above.

Figures 12-13. Merge these figures to 1.

Figure 17. What are the red lines here? Best fit lines? If so, they don’t appear to bisect the data as would be expected. Perhaps there’s an issue?

Figure 18. It would be useful to map z scores, as is the case in the final synthesis. Also, I fear you may be over-interpreting the scale of the yellow-green change in Greenland in Fig. 18a – the range is just 0.2 hydroclimate index units (also explain what that unit actually is).

Figure 20. I’m not sure this figure is necessary.

With respect to the specific editorial guidelines:

Does the paper address relevant scientific questions within the scope of CP? YES

Does the paper present novel concepts, ideas, tools, or data? NO

Are substantial conclusions reached? NO

Are the scientific methods and assumptions valid and clearly outlined? NOT CLEARLY

OUTLINED

Are the results sufficient to support the interpretations and conclusions? NO

Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? NO

Do the authors give proper credit to related work and clearly indicate their own new/original contribution? YES

Does the title clearly reflect the contents of the paper? NO

Does the abstract provide a concise and complete summary? NO

Is the overall presentation well structured and clear? NO

Is the language fluent and precise? COULD BE IMPROVED

Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? N/A

Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? YES - see comments.

Are the number and quality of references appropriate? YES

Is the amount and quality of supplementary material appropriate? YES

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