

Interactive comment on “Northern high-latitude climate change between the mid and late Holocene – Part 1: Proxy data evidence” by H. S. Sundqvist et al.

Anonymous Referee #3

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The authors provide a reconstruction of mid-Holocene temperature change from different proxies for the Northern Hemisphere high latitudes >60N. The paper is intended as a companion to another CPD paper that uses the described reconstruction in a data-model comparison. Probably the most important aspect of the paper that distinguishes itself from earlier reconstructions of mid-Holocene high latitude climate is the specific use of quantitative estimates complete with a description of the associated uncertainty. These include uncertainties related to dating, proxy-climate calibration and digitising from published figures.

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This focus on error estimation is commendable, but full-error accounting is probably an impossible task, and as the authors acknowledge (section 3.6) there are many other sources of uncertainty that they have not been able to consider or quantify. Uncertainty is in the nature of the science and the authors should be congratulated for tackling head-on this often neglected problem, but I wonder whether in focussing on sample/proxy based uncertainties in detail the authors have lost some perspective on other aspects of the problem given the main objective as a large-scale reconstruction for data-model comparison. The other reviewers have discussed in detail the treatment of uncertainty at the sample/site scale in the paper and I agree with much of what they say, however rather than repeat I focus here on the spatial uncertainties which are equally important but somewhat neglected in this study.

This includes the balance between the reconstruction as it is represented at the site scale, and the reconstruction as it is presented at larger spatial scales. The latter is a key element if the authors stated aim of data-model comparison over the Pan-Arctic region is to be achieved. Perhaps the biggest problem in this respect is the small number of sites that the authors base their study on. They present maps of climate anomalies for the Pan-Arctic region north of 60N, but as the authors acknowledge, their data has a strong spatial bias towards the Fennoscandia region. They use only a very limited number of sites to represent other regions, even for summer temperatures for which they have the largest amount of data. This makes meaningful comment about the other regions difficult, both in terms of comparisons with models at the grid-box scale and also in terms of calculating area-average temperatures. Figure 3 shows summary summer temperature anomalies for regions such as 'Siberia' and 'North America' for which they have only a handful of sites to represent these very large regions. Similarly summer, winter and annual temperature anomalies for the entire 'northern high latitudes' are shown in the abstract and conclusion. These are presented with high precision to two decimal places (including the error estimates)!, even though in the extreme case of winter this estimate is based on data from only 7 sites. This suggests both a misleading level of precision, and a poor appreciation of potential spatial variability.

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The authors do not cite any of the previous attempts to reconstruct maps of mid-Holocene temperatures for the regions of interest, and I wonder whether they have fully familiarised themselves with the background to this field of research. From these published studies it should be clear from the temperature variability they show that calculating area-average temperatures for large spatial regions requires a more comprehensive dataset than the authors have collated here. For instance Tarasov et al (1999) show both strong positive and negative anomalies in summer over Siberia. Other studies include Cheddadi et al (1997) and Brewer et al. (2007) for Europe and Sawada et al. (2004) and Viau et al. (2006) for North America, and Wu et al. (2007) for Eurasia. Still others have also specifically focused on the Pan-Arctic region, although in a more semi-quantitative way, such as the CAPE project (CAPE project members 2001). Perhaps it may have been possible for the authors to use some of this additional published data to extend their own analysis? Or alternatively the authors could have created their own analysis since many of these studies are based on freely available pollen data from the European and North American Pollen Databases. These studies and databases include mid-Holocene data from many hundreds of sites more than the authors present.

The authors also use SST reconstructions, but here again the dataset is very small and I am not sure that this is as exhaustive as it could be. They explain that they have taken data from the NOAA data archive, but do not appear to have looked at other data sources such as the PANGAEA data archive, which includes data from the GHOST/MOTIF project. A useful starting point maybe found in appendix 1 of Davis & Brewer (2009), which details many mid-Holocene SST sites for the North Atlantic.

Other issues:

1. The authors do not mention whether or not they took account of post-glacial uplift for Scandinavia between the mid-Holocene and the present day. Changes in relative altitude have been significant in some areas, and may be another source of uncertainty in the climate reconstruction.

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2. The authors use a narrow time-window of 6000±50 yrs to represent the mid-Holocene. This is likely to be inappropriate for PMIP data-model comparisons based on simple orbital forcing because at this temporal resolution the reconstruction (but not the model simulation) will also reflect sub-millennial climate/sample variability. This would be particularly important for the authors study since they are relying on data from relatively few sites. It would be better to take a broader time-slice (such as the more usual 6000±500 yrs) so as to reduce the impact of sub-millennial changes in favour of the broader millennial-scale orbitally driven changes.

Overall I recommend that either the authors need to either restrict their interpretation to the Fennoscandia region for which they appear to have a representative dataset, or else they need to extend their analysis to include more available data from other areas if the study is to be representative of the Pan-Arctic region.

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