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Climate of the Past Discussions

Interactive comment on "Northern high-latitude climate change between the mid and late Holocene – Part 2: Model-data comparisons" *by* Q. Zhang et al.

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First of all I would like to acknowledge the difficult task of reconciling a whole set of model simulations and proxy-based climate reconstructions, taking into account the uncertainties involved in both type of analyses. This objective is laudable and I think the authors present good and interesting points.

I have two short comments, one related to a possibly minor technical error and one concerning the physical mechanisms related to the warmer high-latitude winters in

spite of the lower winter insolation in the Arctic regions in the Mid-Holocene.

1. I think the equation in page 1671 line 11 is not correct. This equation defines the Cost Function that embodies the mismatch between one climate simulation and the reconstruction, as the ratio between the temperature mismatch squared and the uncertainty in the reconstruction. This uncertainty is given in terms of the standard error sigma. I think the correct factor to normalize the square of temperature differences should be the standard error squared and not the standard error itself. An example can illustrate the contradiction of using the standard error: we can imagine two grid points with available temperature reconstructions; in one of them the temperature mismatch to the model is 1K and the standard error is also 1K. In the other grid point the temperature mismatch is 2 K and the standard error is also 2 K. Logically , both grid-points should contribute equally to the cost function, but following the equation in the paper the second grid point contributes twice as much. The use of of the standard error squared also follows from maximum likelihood arguments.

But perhaps this is just a typo in the equation

2. My second point is related to the question of why Arctic winters are warmer in the Mid Holocene. If I understood properly, the basic argument presented in the manuscript is that the ocean, with its thermal inertia, accumulates more heat during summer due to the enhanced insolation, and this heat is transferred to the atmosphere during winter. This mechanism, though plausible, is not completely clear to me. For instance, one could also argue that due to the lower insolation in winter, the ocean receives less heat, which leads to colder sea-surface temperatures and thicker sea-ice. This, in turn prevent summer temperatures to reach higher values. So we could explain by the ocean thermal inertia colder summers than today, instead of warmer winters than today.

If the oceans were storing heat in summer and setting it free in winter, we should see increased temperatures in the ice-free ocean regions in winter, where the ocean heat flux could freely escape to the atmosphere. But Figure 6 shows that the maximum warming occurs in ocean regions that should be ice covered in winter (for the model MRI) or overall (model FOAM-OAV). In this latter model, ocean regions at mid-latitudes are even colder in winter. The thermal-inertia argument should, however, be applicable also here.

It is difficult to suggest other mechanism but, from Figure 6 alone , it seems that the meridional heat transport by a disturbed atmospheric circulation could be involved - this would explain, at least in the FOAM model, the cool anomalies at mid-latitudes surrounding the warmer Arctic.

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