

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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We would like to thank very much the second reviewer for his/her suggestions on discussing more detail to the proposed winter warming mechanisms and comparing with the other model-data comparison studies. As replied to Eduardo Zorita, we will add an additional discussion part devoted to these issues with more illustrations.

Major comments

1. Please refer to reply to first comment by Eduardo Zorita.

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2. The model uncertainty is addressed in our reply to major comment 4 by review 1.

3. In Gladstone et al 2005 paper, the results from the PMIP2-OA models show no significant change both in mean climate change and interannual variability. However, in the mean DJF SLP change there is a tendency toward an increased meridional gradient in mean SLP, both in PMIP2-OA model (their Figure.1) and PMIP2-OAV model (Figure.7). This change in meridional gradient is obvious not only over the Atlantic region but also in north Eurasia and north America. It implies that the increased atmospheric meridional heat transport may be responsible for the high latitude warmth. Note that the area of focus in our paper(s) is the entire high latitude region north of 60°N. Therefore, in the revised manuscript we will focus on the change in atmospheric meridional heat transport rather than change in NAO.

4. In the case of HadCM and MIROC, the very high CF values for winter is due to the inconsistency concerning the 'warm center' between the models and reconstructions. Winter warmth is seen over north Eurasia and north Scandinavia in the reconstructions, while in HadCM and MIROC there are lower winter temperature in 6ka over these regions. As suggested by the reviewer, the SLP pattern shows more zonal structure in the two models; the warm anomaly is located too much to the south (around 45N) to be able to affect the high latitudes. We will include some discussions in the revised manuscript concerning the reason why some models have very high CF values.

5. This question is essentially dealt by in our reply to second comment by Eduardo Zorita. In the revised manuscript we will include the map of change in sea-ice fraction and sea-ice thickness.

6. It is quite possible that changes in ocean circulation play an important role in sea-ice retreat around the Barents Sea and subsequently cause the winter warm over the region. The changes in northward ocean heat transport are very different from model to model. In MRI a significant increase in northward ocean heat transport is found in the North Atlantic Ocean for 6ka compared to 0ka, about 0.01PW. However, in FOAM-

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OA, there is no significant northward heat transport in the 60N north of Atlantic Ocean. It probably due to the polar cutting is not well treated in FOAM ocean model. We intend to include some discussions about this in the revised manuscript.

7.The changes in sea ice, surface albedo and ocean surface heat flux are very similar in FOAM and MRI, which should be mentioned in the text to avoid the suspicious on FOAM results. We will reorganize the illustrations in the revised manuscript. For instance, as suggested by the reviewers, we will show the map of the changes in sea ice fraction, sea ice thickness etc to explain the possible feedback more clearly.

Minor comments

1.We have followed the suggestion and plotted the different color for summer, winter and annual temperature.

2.We have followed the suggestion and overlapped the contour lines over the shading.

3.Modified in the text as suggestion.

4.Modified the text as suggested by first reviewer in minor revision 1.

5.The typo has been corrected.

6.Here the average means the area-average as calculated in figure.3, it is modified in the text.

7.Here we mean due to the very few winter constructions, the models selected by the cost function have the consistent change over the region where reconstructions located, and could be very different in other regions. We have modified the text following the suggestion.

8.We have checked with the original data description in the PMIP database; the unit of sea-ice fraction is %.

Interactive comment on Clim. Past Discuss., 5, 1659, 2009.