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Discussions

# Interactive comment on "Model-data comparison and data assimilation of mid-Holocene Arctic sea-ice concentration" *by* F. Klein et al.

**Anonymous Referee #2**

Received and published: 3 February 2014

General comments:

This manuscript by Klein et al. presents a comparison and integration of model and proxy data on Arctic paleo sea ice coverage - an important and required approach to evaluate and improve the capability of models and proxies to display paleo sea ice conditions. The manuscript is well written and concisely summarises background information on the importance of Arctic sea ice, its paleo variability and the status of climate models simulating paleo sea ice extent. Sea ice concentrations for the Arctic and adjacent seas are simulated for the Mid Holocene (i.e. 6 ka BP $\pm$ 0.5 ka) using the LOVECLIM climate models. The models generate a rather homogenous sea ice cover and - compared to the proxy data - tend to underestimate local differences between regions, which leads the authors to conclude that the skill of the models is low. For

the validation of the models, a proxy reconstruction of Mid Holocene sea ice coverage based upon the distribution of dinoflagellate cysts in 18 sediment cores from different areas in the Arctic Ocean has been used. In a further step, the assimilation of the proxy data into the model simulations enables the assessment of local atmospheric circulation patterns during the Mid Holocene, which highlights the potential benefit of such data assimilations to gain knowledge about changes in the ocean-atmosphere circulation system. While the authors clearly acknowledge the mismatches between proxy- and model-based sea ice reconstructions, I have the feeling that this discussion is somehow biased in favour of the proxy data. Here, a more critical discussion of the proxy data and limitations of this novel quantitative approach is needed. Though I clearly see the merit of this manuscript, I am concerned about the robustness of the (already published) dinocyst data base and suggest that also qualitative (or semi-quantitative) sea ice reconstructions based on non-dinocyst data are taken into account for the evaluation of the models' performance. Some useful references are already provided in section 3.2 but here only discussed referring to the dinocyst reconstructions. Provided that I am not a numerical modeller I leave the evaluation of the modelling component of this manuscript to a climate modelling colleague.

Specific comments:

Assuming that the productivity of dinoflagellates in the Arctic Ocean is highly reduced during winter months (due to the absence of light - which also limits the food availability for heterotrophic dinoflagellates), the expression of reconstructed sea ice cover in terms of annual mean concentrations leaves me puzzled. The meaning and relevance of calculating annual mean sea ice concentrations is not clear to me - in particular with regard to the outstanding seasonal variability in Arctic sea ice cover. The herein adopted approach by de Vernal et al. (2013) to calibrate dinocyst records to annual and not to seasonal means needs to be explained and discussed in more detail. Further, uncertainty in the reconstructed sea ice concentrations is relatively high ($\pm$ 11 %) in comparison to the Mid Holocene-Pre Industrial sea ice concentration anomalies.

Figure 1 shows that only anomalies derived from the two cores (1, 2) in the Chukchi Sea and cores 4 and 5 from the Barrow and Nares Strait exceed the standard error of 11%. This uncertainty in the proxy reconstruction certainly weakens the significance of the model-proxy comparison and the data assimilation approach. Interestingly, the dinocyst record used within this study indicates a higher Mid Holocene sea ice cover in the Chukchi Sea (page 6523, line 1) which contradicts the identification of a significantly reduced sea ice extent and higher sea surface temperatures in the Chukchi Sea at 6 ka by de Vernal et al. (2005; Paleoceanography, DOI: 10.1029/2005PA001157). This inconsistency in the dinocyst approach needs be explained. Further, the study by Anderson et al. (2001) revealing that Alaskan lake temperatures were lower during the Mid Holocene than at present (page 6523, lines 26-29) is not an appropriate reference to support the marine dinocyst data. It is even noted in the manuscript that "the recent period is far from being adequate" to reflect PI conditions which is true as it mainly reflects the current polar amplification of global warming. I also consider the references provided to support the Nares Strait sea ice reconstruction (page 6523, lines 4-10) are not well suited since they refer to sea ice conditions north off Greenland - a completely different setting (governed by different ice drift patterns). Finally, a map of the simulated (seasonal) sea ice cover (extent and concentration) would add value to the manuscript and could serve as a useful reference for further proxy-model studies.

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Interactive comment on Clim. Past Discuss., 9, 6515, 2013.