

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

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Klein et al report a comparison of sea-ice anomalies reconstructed from dinocyst assemblages and estimated from climate models for the mid-Holocene. Using a no-change reference state, they conclude that the climate models have little or no skill.

The uncertainty of the reconstructions is estimated at 11%, which is ignored when model skill is estimated. Hence the test of model skill is not fair; even a perfect model might appear to have low skill because it cannot match the reconstructions' errors. Methods to incorporate reconstruction uncertainty into estimates of model skill were developed by Hargreaves et al (2013).

With the methods of Hargreaves et al (2013), skill is “undefined if either the model or

C3323

the reference agrees more closely with the data than the data errors indicate should be possible.” Curiously, the dinocyst reconstructions are more similar to both the no-change reference state and the models than expected given their uncertainty. This leads to a paradox. On the one hand, it can be demonstrated that the uncertainties of the dinocyst-inferred sea-ice reconstructions are larger than that believed by de Vernal et al (2013), perhaps by a factor of two, because of uneven sampling of the environmental gradient (Telford and Birks, 2011), spatial autocorrelation (Telford and Birks, 2005), and partial sampling of the dinocysts' niches. On the other hand, the similarity between the reconstructions and the models or reference state can only be explained if the reconstruction uncertainty is over-estimated.

I can think of three factors that might explain the lower than expected reconstruction uncertainty. First, the uncertainty is the uncertainty of a single estimate, but Klein et al's mid-Holocene reconstruction is the mean of several such estimates spanning the period 6 ± 0.5 ka. If some of the error on the individual estimates is independent, then the uncertainty on the mean will be smaller than expected. How much smaller is difficult to predict, as one would expect some of the uncertainty to be due to site-specific factors that is shared between estimates. Secondly, any site-specific error that remains constant between the mid-Holocene and the PI is removed when anomalies are calculated (whereas other errors in the mid-Holocene and PI reconstructions are added in quadrature). Thirdly, uncertainty is not constant along the sea-ice gradient, rather it is low (perhaps even zero) in some regions remote from the ice margin, and high within the area affected by sea-ice. It may that some sites, for example site 14 off north Scotland, are sufficiently far from the ice margin to have low uncertainty.

These issues highlight the difficulties and importance of quantifying the uncertainty in palaeoclimate reconstructions. Given these difficulties, I would argue that it is premature to conclude that the models have no skill. Rather, questions should be asked about whether the spatially heterogeneous sea-ice reconstructions are physically plausible.

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C3324

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