Geophysical Research Abstracts
Vol. 15, EGU2013-929, 2013
EGU General Assembly 2013

The Sea Ice Albedo Effect: Improving Polar Amplification in Model Simulations of the mid-Pliocene

Fergus Howell (1), Alan Haywood (1), Jane Francis (1), Bridget Wade (1), Steven Pickering (1), and Harry Dowsett (2)

(1) School of Earth and Environment, University of Leeds, Earth and Environment, Leeds, United Kingdom, (2) US Geological Survey, Reston, Virginia, USA

Climatological reconstructions of the mid-Pliocene warm period (3.29 - 2.97 Ma) indicate that global mean temperatures were approximately 3°C higher than present day, with a warming of up to 10°C in the Arctic and North Atlantic. However, general circulation model (GCM) simulations of this time period have failed to reproduce this high-latitude warming. Whilst these discrepancies could be related to uncertainties in the interpretation of the proxy data, it is also worth considering whether factors in the model performance could be contributing to the disagreement.

Sea ice exerts a large influence over the climate in high latitudes in the Northern Hemisphere, so it is crucial that GCMs can represent sea ice processes proficiently. One of the most important processes related to sea ice is the albedo feedback, as it can enhance a warming or cooling perturbation to the climate. Recent studies of sea ice albedo, focusing in particular on first year ice, and the effects of melt ponds, hint that the standard minimum albedo values used in GCMs could be too high.

The minimum sea ice albedo value in a GCM is often used as a tuning parameter, in order to compensate for deficiencies elsewhere in the model that produce anomalously low or high levels of sea ice. However, this tuning is done for modern day climate, and may not be appropriate for a climate which is substantially different to the present. In a warmer than present climate such as the mid-Pliocene, it is likely that a greater proportion of the ice in summer is first year ice, which has a lower average albedo than multi-year ice due to a lower mean thickness, and the melt pond coverage being higher.

To investigate the full effects of changes to maximum and minimum albedo values on mid-Pliocene simulations, 24 different simulations were run using HadCM3. Each had a different combination of minimum and maximum albedo settings, with the minimum ranging from 0.2 to 0.7, and the maximum from 0.5 to 0.9 (both with intervals of 0.1). Each simulation was run initially for 200 years, and a selection were continued for a further 300 and 1000 years. A subset were also run with pre-industrial boundary conditions, to compare the results with observational data sets.

For simulations with reduced minimum albedo, mean annual surface air temperatures north of 70°N show an average increase of $2 - 3$°C in comparison to the standard run, with warming as high as 6°C in some areas. This suggests that changes to the minimum sea ice albedo in the models could make a large contribution to achieving the polar amplification that mid-Pliocene simulations currently fail to obtain. The strengths of the effects on the sea surface temperatures, as well as the pre-industrial simulations, are also presented.