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Modelling the enigmatic Late Pliocene Glacial Event - Marine Isotope Stage M2

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The Pliocene Epoch (5.2 to 2.58 Ma) and specifically the PRISM interval (3.0 to 3.3 Ma) have frequently been targeted to investigate the nature of warm climates. However, the full range of climate variability within the Pliocene is often overlooked. Although not as dramatic as the glacial and interglacial cycles that typified the Pleistocene, Pliocene records also exhibit climate variability on orbital timescales and intervals which were apparently cooler than modern climate. Marine Isotope Stage (MIS) M2 ($\sim$3.3 Ma) is a globally recognisable positive oxygen isotope excursion (cooling event) that disturbs an otherwise relatively (compared to present-day) warm background climate state.

It remains unclear whether this event corresponds to significant ice sheet build-up in the Northern and Southern Hemisphere. Estimates of sea level for this interval vary, and range from modern values to estimates of 65m sea level fall with respect to present day. Here we implement plausible M2 ice sheet configurations into a coupled atmosphere-ocean climate model (HadCM3) to test the hypothesis that larger-than-modern ice sheet configurations may have existed at M2. Climate model results are compared with available terrestrial data (e.g. biomes, precipitation and warm month temperatures) and marine temperature and oceanographic reconstructions to provide guidance as to which experimental set-up might offer the most compatible reconstruction of global climate during MIS M2.

Whilst the outcomes of our data/model comparisons are not in all cases straight forward to interpret, there is little indication that results from model simulations in which significant ice masses have been prescribed in the Northern Hemisphere are incompatible with high resolution proxy data from the North Atlantic, Northeast Arctic Russia, North Africa and the Southern Ocean. Therefore, our model results do not preclude the possibility of the existence of larger ice masses during M2 in the Northern or Southern Hemisphere. Specifically they are not able to discount the possibility of significant ice masses in the Northern Hemisphere during the M2 event, consistent with a global sea-level fall of between 40 m and 60 m.

Our study highlights the general need for more focused and coordinated data generation in the future to improve the coverage and consistency in proxy records for M2, which will allow these and future M2 sensitivity tests to be interrogated further. Specifically long Pliocene records need to be sampled at high enough resolution to properly resolve the M2 glacial event and assess orbital scale variability through the Pliocene.