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Understanding Surface Temperature Variability during the Pliocene

Alan Haywood (1), Stephen Hunter (1), Harry Dowsett (2), Caroline Prescott (1), and Aisling Dolan (1)
(1) University of Leeds, School of Earth and Environment, Leeds, United Kingdom (earamh@leeds.ac.uk), (2) Eastern Geology & Paleoclimate Science Center, US Geological Survey, Reston, Virginia, USA

Surface temperatures during the Pliocene have often been characterised as being warm and relatively stable. The link between Milankovitch cycles, insolation and global ice volume (as demonstrated by the magnitude of negative and positive benthic oxygen isotope excursions), appears to have been weaker in the Pliocene compared to the Pleistocene. However, the marine benthic oxygen isotope record may over represent the signal of temperature change from the high latitudes. Away from ice sheet regions, where stronger ice sheet/sea-ice albedo feedbacks are expected in response to changes in insolation, the magnitude of surface temperature variability due to Milankovitch cycles would have been the same, or very similar, in the Pliocene (compared to the Quaternary).

Pleistocene and Holocene surface temperatures have not been generalised in the same way as the Pliocene and studies concentrate on reconstructing, modelling and understanding discrete climate events, as well as critical climate transitions. It is appreciated that whilst an event, or events, may have a similar signature in terms of the magnitude of any benthic oxygen isotope (or ice core) excursion, they may still display unique surface temperature characteristics that distinguish one glacial or interglacial from another. This realisation has been possible due to the number of high resolution surface temperature records available. Compared to the Quaternary there are relatively few high-resolution surface temperature records to help constrain the nature of local to regional Pliocene surface temperature variability, although new records are emerging quickly. Regardless of this, our current understanding of Pliocene surface temperature variability at a regional as well as global scale is still emerging.

Here we use Hadley Centre Coupled Climate Model version 3 (HadCM3) to explore the nature of Pliocene surface temperature variability and to explore the premise that individual benthic oxygen isotope events in the Pliocene will have unique characteristics of surface temperature change caused just by variations in insolation. Firstly, we focus our attention on intervals within the mid Pliocene Warm Period (3.3 to 3 million years ago) that are characterised by negative benthic isotope excursions, and therefore are presumed to represent relatively warm "interglacial-like" events (specifically Marine Isotope Stages K1, KM5c, G17 and KM3). Secondly, we also present results from the first fully transient simulation using a full complexity climate model (FAMOUS) for the interval between the "glacial" event M2 and "interglacial" event KM3. We demonstrate how comparing model simulations that capture the effects of orbital variability with newly generated high resolution proxy records of surface temperature change can alter our current understanding of where (geographically) models perform well or poorly compared to data.

We conclude that even when considering orbital forcing alone, discrete climate events in the Pliocene were indeed characterised by unique regional signals of surface temperature change, and that broad generalisations concerning Pliocene surface temperature patterns are at best incomplete.