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# Climate response to changes in orbital forcing around the first Pliocene Time Slice

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Global annual mean temperatures (MAT) during the mid-Pliocene warm period (~3 to 3.3 Ma) were on average 2 to 3°C higher than the pre-industrial era. This combined with near modern continental configurations, orography and atmospheric $CO_2$ concentrations of 80 to 120 ppmv higher than the pre-industrial; make the mid-Pliocene warm period one of the best intervals in Earth history to investigate the potential long term future response of climate to near future concentrations of atmospheric carbon dioxide.

Existing data/model comparisons for the mid-Pliocene have identified specific regions of concordance and discord between climate models and proxy data. One reason for site-specific disagreement is likely related to the time (warm peak) averaged nature of the mid-Pliocene ocean temperatures provided within existing proxy syntheses. To facilitate improved data/model comparisons in the future new proxy sea surface temperature reconstructions must focus on specific time slices within the Pliocene epoch. Haywood et al. (2013) have identified an initial time slice for environmental reconstruction and climate and environmental modelling centred on Marine Isotope Stage KM5c (3.205 Ma). Critically, this interval displays a very near to modern orbital configuration simplifying the interpretation of proxy data and the experimental design used within climate models. It is also within a warmer period as identified by a negative benthic oxygen isotope excursion of significant duration (thousands of years) in the LR04 stack. Nevertheless, current limitations of chronology and correlation make it likely that new proxy records will be attributable to a time range around the time slice, and may not always represent the time slice specifically. This introduces an element of uncertainty through orbital forcing around the time slice which can be investigated and quantified within a numerical climate modelling framework.

The Hadley Centre Coupled Climate Model Version 3 (HadCM3) has been used to perform a series of orbital forcing sensitivity tests around the identified time slice at MIS KM5c. Simulations every 2 Kyr either side of the time slice to a range +/- 20 kyr have been performed. The model results indicate that +/- 10 kyr either side of the time slice, orbital forcing exerts a less than 1°C change on global MAT. Seasonally, temperature variations exceed this value locally. One exception to this relative stability in climate to modest changes in orbital configuration is seen in the North Atlantic (a region noted for disagreement in existing Pliocene data/model comparisons). Here ocean surface temperature variations of up to 6°C are predicted by the model. These model responses are currently under investigation but appear related to variations in the strength of the Atlantic Meridional Overturning Circulation over relatively short timescales (geologically).

Given that other components of the climate system (ice sheets and vegetation) may also respond to any predicted change in surface temperatures generated through orbital forcing, we have completed additional simulations 10 and 20 kyr either side of the KM5c time slice. These include dynamic predictions of vegetation and therefore facilitate a quantification of the degree to which changing vegetation distributions in response to orbital forcing feedback and influence local climate.