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Is there an orbital control on Eocene hyperthermals?

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Here, we use the UK Met Office coupled atmsphere-ocean GCM, HadCM3(L), to elucidate the potential mechanisms behind an astronomical pacing of Early Eocene hyperthermal events.

We carry out extremely long (>3000 years) spinup simulations of the model under Eocene palaeogeographies and various CO_2 simulations. These indicate a threshold in greenhouse gas forcing which controls the mode of ocean circulation. Above 4* pre-industrial prescribed CO_2 levels, the ocean circulation is characterised by weak overturning, and deep water formation at relatively low Northern Hemisphere latitudes. At levels below this threshold, the ocean circulation is vigorous - dominated by a negatively overturning cell driven by deep water formation in Southern Hemisphere high latitudes. The switch on ocean circulation is associated with non-linear large warming in the tropical and sub-tropical Atlantic. This non-linearity is suggested as a potential mechanisms for hyperthermal events: crossing the threshold could lead to large warming of hydrate-rich sediments and additional warming due to released methane.

We then perturb these simulations with idealised extremes in orbital forcing - either high-eccentricity-high-obliquity or low-eccentriciity-low-obliquity, and again run them towards equilibrium. We assess whether the resulting changes in ocean circulation and temperature are sufficient to support the hypothesis that Early Eocene hyperthermals such as the PETM and ELMO were orbitally paced, as has been inferred from the geological record.