Deep ocean temperature response to astronomical forcing in the Eocene 'greenhouse'

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Changes in Earth's axial tilt ('obliquity') are known to preferentially influence the intensity of solar insolation received at high latitudes. A large-scale and permanent ice sheet first appeared on Antarctica at the beginning of the Oligocene Epoch, 34 million years (Myr) ago. The concurrence throughout the Oligo-Neogene (last 34 Myr) of a large Antarctic ice sheet with dominance of the obliquity cycle (41 thousand year frequency) in globally distributed palaeoclimate records suggests that high latitude ice sheets may 'amplify' global climate response to regular obliquity forcing. Conversely, it has been hypothesised that the documented absence of large ice sheets during earlier Palaeogene warm 'greenhouse' climates would have led to a damped climate response at the obliquity frequency. Here we test this hypothesis using a new 2.4 Myr-long benthic foraminifer oxygen isotope record through the early to middle Eocene transition. We find that the dominant spectral frequency in our deep sea record is that of obliquity, despite the absence of large high latitude ice sheets. We also observe an Eocene breakdown in the Oligo-Neogene pattern of astronomically paced changes in deep ocean sediment calcium carbonate content and benthic foraminiferal oxygen isotope composition – something that we attribute to the deglaciated early Eocene climate state. Our findings indicate a novel method with which to test for the existence of substantial ice sheets during past greenhouse climates.