Modeling orbital dynamics in early Cenozoic greenhouse climates

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Multiple episodes of abrupt global warming have been recorded in the early Cenozoic geological record. These rapid climatic fluctuations (hyperthermal events) reoccur in a quasi-cyclic pattern, which suggests their onset is closely related to orbital forcing. During hyperthermal events, elevated temperatures coincide with negative carbon isotope excursions and carbonate dissolution, implying that isotopically light carbon was released from a readily exchangeable reservoir. Several sources have been proposed, such as carbon release from the deep ocean [1], terrestrial environment [2], or marine methane hydrates [3,4]. How these would be related to orbital forcing remains inconclusive, despite the strong correlation between the timing of hyperthermal events and 100 kyr and 400 kyr eccentricity cycles.

By modeling the long-term effect of astronomical forcing on Cenozoic greenhouse climate, we explore what parts of the Earth system are most sensitive to insolation changes and what feedback processes might have triggered redistribution of carbon. We use an Earth System Model of Intermediate Complexity (cGENIE) to reconstruct the ice-free conditions of the early Cenozoic and apply time-varying orbital modulation of insolation according to Laskar's astronomical solution (La2004) [5]. Preliminary results suggest that slight changes in insolation associated with eccentricity cycles are insufficient to cause major perturbations in ocean circulation due to the absence of sea ice. Modeled latitudinal humidity and temperature gradients over land show more pronounced changes over orbital cycles. Potentially, slight shifts in zonal climatic patterns caused significant changes in terrestial carbon storage that could act as an important driver or feedback of hyperthermal warming.

[1] Sexton et al. (2011), *Nature* **471**, 349. [2] DeConto, et al. (2012), *Nature* **484**, 87. [3] Dickens (2003), *EPSL* **213**, 169-183. [4] Lunt et al. (2011), *Nat. Geosci* **4**, 775. [5] Laskar et al. (2004), *Astron. Astrophys* **428**, 261-285.