Time-Dependent Response of Overturning Circulation to Warming across Eocene hyperthermals

SANDRA KIRTLAND TURNER[1] AND ANDY RIDGWELL[1,2]

[1]Department of Earth Sciences, University of California, Riverside, Riverside, CA 92521, USA
[2]School of Geographical Sciences, University of Bristol, Bristol BS8 1SS, UK

In order to inform projections of the ocean's response to anthropogenic climate change, studies have focused on reconstruction and modeling of the global ocean overturning circulation across both past warm climate states and transient warming episodes, such as the hyperthermal events of the early Eocene epoch. Yet the impact of climatic warming on overturning circulation rates is dependent on the timescale (not just magnitude) of temperature increase. While enhanced stratification is the expected ocean response to abrupt increases in temperature, a sluggish ocean circulation is not a consequence of a persistently warm climate state. Past episodes of climatic warming over a variety of timescales, from millenial-scale warming to orbital-scale trends, provide test cases for reconstructing the time-dependent sensitivity of ocean overturning to increasing global temperature. However, fully exploiting the paleoceanographic record requires that dynamic ocean models include representations of the measured tracers. For the Eocene hyperthermal events in particular, these are mostly passive tracers of the ocean circulation that do not directly record rates of overturning -- making detection of changes in circulation rate (as opposed to changes in global overturning patterns) across these events particularly challenging. Here we use the Earth system model cGENIE to evaluate the response of global ocean circulation to varying rates of temperature change similar to those postulated across the early Eocene hypthermals and demonstrate that a 'sluggish ocean' is only the initial response to warming. We further evaluate changes in modeled volumetric transport through the lens of two common proxies: the carbon isotopic compoisition of dissolved inorganic carbon (reconstructed via benthic foraminiferal carbon isotopes) and the distribution of seafloor sedimentary carbonate content. We demonstrate that changes in the spatial patterns of these variables can be used to elucidate changes in the rate of ocean overturning circulation through a combined data-model approach.