Geophysical Research Abstracts
Vol. 18, EGU2016-13948, 2016
EGU General Assembly 2016

Insights into the paleoclimate of the PETM from an ensemble of EMIC simulations

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The Eocene epoch, and in particular, the Paleocene-Eocene Thermal Maximum (PETM) of 55.8 Ma, exhibit several features of particular interest for probing our understanding of the Earth system and carbon cycle. CO_2 levels have not yet been definitively established, but were known to have varied considerably, peaking at up to several times modern values. Temperatures were several degrees higher than in the modern era, and there were periods of relatively rapid warming, with substantial variability in carbon cycle processes. The Eocene is therefore highly relevant for our understanding of the climate of the 21st Century.
Earth system models of intermediate complexity (EMICs), with less detailed simulation of the dynamics of the atmosphere and oceans than general circulation models (GCMs), are sufficiently fast to allow climate modelling over long periods of geological time in comparatively short periods of computer run-time. This speed advantage of EMICs over GCMs permits an "ensemble" of model simulations to be run, allowing statistical analysis of results to be carried out, and allowing the uncertainties in model predictions to be estimated.
Here we apply the EMICs PLASIM-GENIE, and GENIE-1, with an Eocene paleogeography which incorporates the major continental configurations and ocean connections, including a shallow strait linking the Arctic to the Tethys, but with neither the Tasman Gateway nor the Drake Passage yet open. Our two model strategy benefits from the detailed simulation of ocean biogeochemistry in GENIE-1, and the 3D spectral atmospheric dynamics in PLASIM–GENIE, which also provides boundary conditions for the GENIE-1 simulations. Using a 50-member ensemble of 1000-year quasi-equilibrium simulations with PLASIM-GENIE, we investigate the relative contributions of orbital and CO_2 variability on climate and equator-pole temperature gradients. Results from PLASIM-GENIE are used to configure a harmonised ensemble of GENIE-1 simulations, which will be compared with newly obtained geochemical data on ocean oxygenation through the Eocene from the UK NERC RESPIRE project.