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Modelling Cenozoic ocean paleocirculation states

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While coupled ocean-atmosphere general circulation models are commonly utilised to estimate the paleocirculation state of the ocean for specific episodes in Cenozoic (or earlier) Earth system history, resultant estimates may be biased by particular choices made about the model boundary conditions, such as paleotopographic reconstructions with potentially large uncertainties, or about model parametrisations tailored to be applied in models of more recent climate dynamics. In an attempt to generate a wide array of contingent ocean paleocirculation patterns of Cenozoic climate states, we employ a subset of the Earth system model of intermediate complexity "GENIE-1" consisting of a model representation of the three-dimensional ocean circulation, a thermodynamic-dynamic sea-ice model, and a simplified atmospheric representation. Firstly, we generate large simulation ensembles by subjecting the model to widely-varied transport- and insolation-related model parameters. Secondly, we objectively constrain the resulting ensembles informed by available proxy data of oceanic paleotemperatures and potentially other data-based quantities. The computational efficiency of the model setup is high enough to permit the routine generation of simulation ensembles for a range of topographic configurations of the Cenozoic era, taking into account uncertainties in the reconstruction of particular paleotopographic features, such as inter-basin gateways. As a result, a range of permissible ocean circulation states given our model assumptions can be compiled for each of the temporal snapshots analysed. In subsequent experiments, resultant simulation ensemble subsets can be applied in more comprehensive Earth system model configurations, which allow to further constrain the paleocirculation and to test hypotheses about past long-timescale Earth-system dynamics and their associated uncertainties from the uncertain paleocirculation state(s) of a particular paleoclimatic event or geological age or epoch. As one example of this approach, we present results from an analysis of an ensemble of simulations of the carbon cycle in the early to mid Miocene.