EGU25-16077
EGU General Assembly 2025

The impact of paleogeographic boundary conditions on early Cenozoic climate simulations

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Studying warm climates of the geological past is essential to improving our understanding of the Earth's climate and carbon cycle under elevated atmospheric CO_2 levels. A major challenge in simulating past climates lies in the accurate reconstruction of the paleogeography – the spatial distribution of land, mountains, oceans, and their bathymetry. However, the impact of paleogeography and its uncertainty on modelled paleoclimates and model-data misfits is poorly quantified. Here, we quantify the impact of paleogeographic boundary conditions on the simulation of early Cenozoic climates (66 to 34 million years ago) using the IPSL-CM5A2 Earth System Model. We performed a series of paleoclimate simulations for key time slices, such as the early and middle Eocene climatic optima (EECO and MECO), using the most recent paleogeographic reconstructions and with varying atmospheric CO_2 concentrations. We tested alternative paleogeographic scenarios, with particular focus on the different reconstructions of the Neo-Tethyan region and the India-Asia collision. In addition, we evaluate the impact of using different global reference frames, including the latest paleomagnetic reference frame of Vaes et al. (2023, Earth-Science Reviews). We show that the choice of reference frame and paleogeographic reconstruction can significantly impact global ocean circulation as well as regional temperature and precipitation patterns. To assess how paleogeography affects model-data comparisons, we compared model predictions against available paleoclimate proxy records. We find that changes in paleogeographic boundary conditions lead to notable differences in the reconstructed position of proxy sites. This may affect interpretations of past climates based on proxy records, such as reconstructions of latitudinal temperature gradients or climate sensitivity calculations. Our findings highlight the importance of paleogeography for paleoclimate modelling, and we discuss how future improvement of paleogeographic reconstructions may contribute to advancing our understanding of past climates and the carbon cycle.