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The effect of a flexible hydrological discharge model on the climate of the Middle Miocene

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The Middle Miocene (∼17–14 Myrs ago) climate is characterized by much warmer temperatures and an amplified hydrological cycle with respect to present-day climate. Though it is well known that a change in the global freshwater distribution via the hydrological cycle can impact climate and large scale ocean circulation, most modelling studies encompassing tectonic time scales rather focus on the sensitivity of the climate to orography, ocean gateways, land surface, ice-sheets, and CO_2 changes. Alternatively, here we study the effect of two different kinds of hydrological discharge models and their respective boundary conditions, that are fully implemented in the earth system model COSMOS, on the climate of the Middle Miocene.
The standard hydrological discharge model (HD) of COSMOS requires the information of high spatial resolution orography for the Middle Miocene that is conventionally tuned to present-day conditions, to calculate river routing following the steepest slope of the terrain. Instead, the flexible hydrological discharge model (FHD) calculates river routing by using Middle Miocene orography at identical grid resolution as the atmosphere model and additionally taking the dynamic topography of continental water levels into account.
We find that the anomaly between a climate simulation of the Middle Miocene with COSMOS and HD versus a comparable simulation based on COSMOS and FHD reveals strong differences in the redistribution of freshwater in form of continental discharge from land to the ocean. As a consequence, deep water formation and large scale ocean circulation significantly differ between both model versions, emphasizing the importance of representing a realistic freshwater redistribution from land towards the ocean. We therefore conclude that a more realistic representation of climate states at tectonic time scales necessitates geological constraints on the freshwater redistribution, and changes in the freshwater redistribution may have had a profound impact on the history of global ocean circulation patterns over geological time scales.