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Global Miocene paleobathymetry: implications for paleo-ocean circulation

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Changes in paleobathymetry, especially in the form of opening and closing of strategic oceanic gateways linking large oceanic basins, have caused significant changes in global ocean circulation on geological timescales. Such events are governed by plate tectonics and mantle processes and have been important steps in establishing the modern-day-type thermohaline circulation and have therefore influenced the complex transition from a warm greenhouse to a cold icehouse climate in the Cenozoic time (66 – 0 Ma). In this study, we explore a Miocene (23 – 5 Ma) ocean basin configuration scenario using a new state-of-the-art paleobathymetric reconstruction model for 12 Ma and a numerical ocean general circulation model (MITgcm). The model has 1-degree horizontal resolution and 35 vertical layers. It was run with and without wind forcing and is compared to corresponding runs with present-day bathymetry. We chose the Miocene time as there are few considerable differences in bathymetry with respect to the present-day ocean basin configuration, which are expected to make significant changes in the modelled ocean circulation. The most prominent bathymetric differences between present-day and Mid Miocene are the shallow Greenland-Iceland-Faroe Ridge in the NE Atlantic Ocean that isolates the Nordic Seas from the global ocean circulation, the open Central American Seaway that enables flow between the Pacific and the Atlantic Oceans, and the geometry of the North Pacific Ocean. Our model results show a reduction in the Atlantic Meridional Overturning Circulation and a strengthening of the overturning in the Pacific Ocean in the Mid Miocene compared to the present-day bathymetry runs, both with and without wind forcing. This mode of the ocean circulation, with the Pacific Ocean dominating the global overturning circulation, has been previously proposed for shorter and more recent climate periods such as the last glacial maximum, characterized by the same bathymetry as today, but different atmospheric forcing. In contrast, our new model results suggest that such a mode could have been a stable state in the Miocene due to a different bathymetric configuration. Our results highlight the importance of bathymetric changes for global ocean circulation and climatic changes on geological timescales.