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Ocean response to possible southern meltwater pulses during Eocene-Oligocene cooling climate trend: A sensitivity ocean modeling study

Understanding ocean circulation and sea level change in the past (and foreseeable future) is one of the focal points of paleoceanography. Sea level may change due to several primary causes, including the meltdown of the major ice sheets, sea ice melting, and changes in the thermohaline structure of the oceans. The sensitivity of the past ocean circulation to meltwater impacts may have been different from the present-day. We still have only a vague understanding of how ocean basin geography may influence the freshwater impacts in different oceans; the role of geography is important for reconstructing variability of past climates with substantially different land-sea distributions. As freshwater impacts in past geologic eras having different basins configurations may have been different from the present-day pattern, the sensitivity of the ocean circulation to sea surface density impacts and climate change could have been different as well.

We use the Eocene-Oligocene geometry and climate to address the past ocean and sea level long-term internal variability because this time slice provides a substantially different geometry and for a strong sea ice impact that can be seen in the geologic record. The Eocene epoch is crucial as a transition from the warm Cretaceous ocean to cooler oceans that may have been subject to bi-polar millennial-scale oscillations of the deep ocean circulation caused by freshwater pulses of the developing southern cryosphere. In a series of numerical experiments, sea ice melting and sea water freezing around Antarctica were simulated by superimposing freshwater layers over zonally-averaged sea surface salinity. Eocene sea surface temperature and sea surface salinity are specified based on the paleoclimatic record and modeling. In our simulations, the Eocene ocean circulation is indeed sensitive to freshwater impacts in the Southern Hemisphere. There are noticeable sea level changes caused by the restructuring of the deep ocean thermal and haline fields linked to the changes in deep ocean circulation.