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The opening of the Drake Passage under idealized conditions

E. Dahms (1,2), F. Lunkeit (2), K. Fraedrich (1,2)

(1) Max Planck Institute for Meteorology, Hamburg, Germany (eileen.dahms@zmaw.de), (2) KlimaCampus, Meteorological Institute, University of Hamburg

The onset of Antarctic glaciation near the Eocene-Oligocene transition (∼34 million years ago) is one of the most prominent climate changes of the history of the Earth. During this climate period, the Antarctic region experienced tectonic, climatic and oceanographic events that led to a geographical isolation and colder conditions. The opening of the Drake Passage between Antarctica and South America allowed the establishment of the Antarctic Circumpolar Current (ACC) and of the Antarctic Polar Front. The impact of different boundary conditions such as the opening of gateways, the change in atmospheric CO_2 or the orbital forcing as causes for a permanent Antarctic Ice Sheet are still under debate. Although model studies have already been performed with GCMs, a clear answer about the importance of the gateway opening in the Southern ocean has not been given. The analysis of different flow regimes of the coupled atmosphere-ocean system during the opening of the Drake Passage can give significant clues for our understanding of climate variability on these geological times scales.
To better understand the effect of the opening of the Drake Passage for the climate of the Antarctic continent, the opening is modelled under idealized conditions, which resemble the set-up of coupled aquaplanet simulations. The model applied in this study is the Planet Simulator, a spectral atmospheric model of intermediate complexity, coupled to the Hamburg Large Scale Geostrophic (LSG) ocean model. The coupling takes place through a mixed layer ocean model, which includes a thermodynamic sea ice model. A relatively coarse resolution and large time steps allow a very long simulation period (20,000 years) to ensure that the model has reached equilibrium. The coupled atmosphere-ocean-sea ice model is run in two set-ups: one simulation with a closed and one with an open Drake Passage. Both include an idealized continent, which covers the south pole up to 60°S and which does not include any topography. The ocean is of uniform depth (5500m) and covers the entire globe northward of 60°S. The only exception is a single-grid-point wide meridional barrier that extends from the north pole to either 60°S (closed Drake Passage simulation) or to 30°S (open Drake Passage simulation). These very idealized set-ups isolate the effect of the opening of the Drake Passage, which is already sufficient to account for a significant cooling of the Antarctic continent.