Geophysical Research Abstracts
Vol. 18, EGU2016-9186, 2016
EGU General Assembly 2016

The impact of Southern Ocean gateways on the Cenozoic climate evolution

Anna von der Heydt, Jan Viebahn, and Henk Dijkstra

Utrecht University, Institute for Marine and Atmospheric Research Utrecht, Centre for Extreme Matter and Emergent Phenomena, Utrecht, Netherlands (a.s.vonderheydt@uu.nl)

During the Cenozoic period, which covers the last 65 Million (Ma) years, Earth's climate has undergone a major long-term transition from warm "greenhouse" to colder "icehouse" conditions with extensive ice sheets in the polar regions of both hemispheres. On the very long term the gradual cooling may be seen as response to the overall slowly decreasing atmospheric CO_2-concentration due to weathering processes in the Earth System, however, continental geometry has changed considerably over this period and the long-term gradual trend was interrupted, by several rapid transitions as well as periods where temperature and greenhouse gas concentrations seem to be decoupled. The Eocene-Oligocene boundary (∼34 Ma, E/O) and mid-Miocene climatic transition (∼13 Ma, MCT) reflect major phases of Antarctic ice sheet build-up and global climate cooling, while Northern Hemisphere ice sheets developed much later, most likely at the Pliocene-Pleistocene transition (∼2.7Ma). Thresholds in atmospheric CO_2-concentration together with feedback mechanisms related to land ice formation are now among the favoured mechanisms of these climatic transitions, while the long-proposed ocean circulation changes caused by opening of tectonic gateways seem to play a less direct role. The opening of the Southern Ocean gateways, notably the Drake Passage and the Tasman Gateway as well as the northward movement of Australia over this long time period, however, has eventually led to the development of today's strongest ocean current, the Antarctic Circumpolar Current (ACC), playing a major role in the transport properties of the global ocean circulation. The overall state of the global ocean circulation, therefore, preconditions the climate system to dramatic events such as major ice sheet formation.

Here, we present results of a state-of-the art global climate model (CESM) under various continental configurations: (i) present day geometry, (ii) present day geometry with a closed Drake Passage and (iii) a recently developed late Eocene continental configuration. Between the different configurations we find significant differences in heat transport as well as sea surface and deep ocean temperatures around the Antarctic continent. By decomposing the heat transport with respect to different ocean circulation regimes, we reveal the dominant physical processes responsible for the heat transport changes. Moreover, we compare the fully coupled system with the corresponding ocean-only simulations in order to further analyze the interplay between the ocean gateways, sea-ice and atmospheric feedbacks. Finally, for the ocean-only simulations we also compare eddy-resolving spatial resolution with non-eddying resolution to quantify the relevance of resolved mesoscale turbulence on the changes in ocean circulation regimes induced by gateway openings.

In conclusion, we demonstrate that for deciphering the different mechanisms active in the steps of the Cenozoic greenhouse-to-icehouse transition detailed analyses of the pathways of heat in the different climate subsystems are crucial in order to clearly identify the physical processes at work.