North Atlantic-Arctic circulation controlled by the subsidence history of the Greenland-Scotland Ridge

Background information

During the Eocene/Oligocene interval (42–24 Ma), the subsidence of the Greenland-Scotland Ridge (GSR) from subaerial conditions towards a submarine rise constitutes an active ocean gateway control of North Atlantic-Arctic water exchange. Although the long-term evolution of such ocean gateway development on adjacent ocean water mass characteristics is generally accepted to induce basin-scale reorganizations, the climatic impacts, as well as the associated mechanisms of climate changes remain largely elusive. Here, we investigate the effect of the GSR subsidence with the aid of a fully coupled Earth System Model (ESM) COSMOS (Jungclaus et al., 2006):

Results

Sill depth controls on the Arctic salinity regime

Sea opening evolution in context of the Greenland-Scotland Ridge (GSR) subsidence history. A threshold regime, characterized by semi-enclosed estuarine circulation is identified at ca. 30–40 m of GSR sill depth.

Effect of Arctic seaway opening on the climate

Impact of the Greenland-Scotland Ridge seaway opening on the surface air temperatures (°C, middle panel) and the seasonal cycle of the sea ice in the Northern hemisphere with respect to the mean climatic state (left panel). The GSR seaway opening induces a pronounced warming in the high northern latitudes as well as the removal of perennial sea ice in the Arctic Ocean (right panel).

Conclusions

We find a critical GSR sill depth regime between ca. 30-80 mbsl that forces major reorganizations in the North Atlantic-Arctic circulation associated with extreme salinity, temperature and sea ice changes in the Arctic Ocean. At critical GSR sill depths, atmospheric CO₂ changes also affect the brackish Arctic salinity and circulation regime. Taking uncertainties in timing into account this suggests that after tectonic preconditioning between ca. 36–31.5 Myrs ago, contemporary CO₂ changes modulated the climate and circulation regime in the Arctic Ocean on much shorter millennial timescales towards the establishment of a fully ventilated bidirectional seaway circulation ca. 31.5 Myrs ago.