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# Early Cretaceous Climate and South Atlantic opening in the Kiel Climate Model

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Paleoceanographic data indicate large scale perturbations of the Aptian-Albian (∼125 to ∼110 Myrs) greenhouse climate associated with severe changes of the marine carbon cycle. At the same time, the ongoing break-up of Gondwana and the related opening of the South Atlantic and Southern Ocean led to the emergence of young ocean basins, characterised by vast shelf areas and limited circulation. Several studies relate these evolving basins and their restricted environments to periods of increased black shale formation and carbon burial with a particular importance of the developing South Atlantic.

We test the hypothesis that the development and destruction of marine carbon sinks in the South Atlantic is controlled by the opening of several key ocean gateways. For this purpose we tigthly combine new geochemical proxy data from several drill sites with a joint physical and biogechemical modelling approach to detect regional changes in carbon sequestration and assess their influence on the global carbon cycle.

In a first step we employ the Kiel Climate Model, a coupled atmosphere-ocean-sea ice general circulation model, under Early Aptian (120 Myrs) boundary conditions, including elevated $pCO_2$ levels of 1200 ppm, a reduced solar constant and changes in the land-sea and vegetation distribution. We investigate the simulated surface climate and large-scale dynamics and test the sensitivity of the ocean circulation to different bathymetries of key stages of the South Atlantic opening.

Due to the large contrast between the applied initial conditions and the Early Cretaceous boundary conditions the adjustments in the global density stratification took nearly 10,000 model years. This was in part caused by a strong vertical salinity gradient induced by large surface freshwater fluxes in the early model years. The gradual build-up of a global overturning circulation only slowly redistributed higher saline waters from deeper levels to the surface, decreasing vertical density gradients. Steady state global mean surface air temperatures are elevated by nearly 10 °C compared to a pre-industrial simulation and reach 23.5 °C. The surface warming is mainly radiatively driven by the higher atmospheric $pCO_2$ levels (∼70% of the warming) and surface albedo changes (∼30% of the warming). Weaker tropical deep convection reduces low-latitude cloud cover compared to the present day and leads to a net cloud-induced small warming in the tropics. The absence of polar ice caps prevents high-latitude atmospheric subsidence resulting in thicker, low-level clouds that reflect incoming shortwave radiation and consequently cool the surface. These cloud radiative feedbacks contribute to maintain low and mid-latitude meridional temperature gradients similar to today. High latitude surface warming is attributable to significantly decreased Antacrtic elevation levels and surface albedo reductions caused by the ice-free polar regions. The simulated Arctic surface climate shows pronounced variability on multi-decadal and multi-centennial time scales associated with periods of drastic reduction in wintertime deep convection and high-latitude heat transport.