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Early Cretaceous South Atlantic opening - modelling the effects of geography, bathymetry and radiative forcing

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Paleoceanographic data indicate large-scale perturbations of the Early Cretaceous global climate system 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 regional marine carbon sinks in the South Atlantic are primarily controlled by the progressive opening of several key oceanic gateways. For this purpose we tightly combine new geochemical proxy data with a joint physical and biogeochemical modelling approach to detect regional changes in ocean circulation and their possible influence on carbon accumulation. In a first step we employ a global atmosphere-ocean general circulation model, the Kiel Climate Model (KCM), with different ocean bathymetries representing key stages of the South Atlantic opening. Varying levels of atmospheric pCO_2 are used to distinguish between geographically and radiatively driven changes.

High atmospheric pCO_2 levels lead to an enhanced hydrological cycle with amplified evaporation over the coastal shelf areas and a subsequent halokinetic circulation with warm and saline intermediate and bottom waters in the South Atlantic. We find a high sensitivity of the South Atlantic and Southern Ocean circulation and water mass stratification to the local basin geometry and gateway depths. These scenarios can be matched to distinctively different environments and magnitudes of carbon burial found in the geochemical data.