Early Cretaceous climate and South Atlantic opening in the Kiel Climate Model (AOGCM)

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Paleoceanographic data for the Early Cretaceous (i.e. Aptian-Albian) greenhouse show large scale perturbations of the global ocean-climate system linked to severe changes in the marine carbon cycle (e.g. Jenkyns, 2010). At the same time the ongoing break-up of Gondwana and the associated 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 (Trabucho-Alexandre et al., 2012; McAnena et al., 2013). Model results underline the importance of the opening South Atlantic, indicating that up to 16% of global carbon burial was deposited in a region covering only 1% of the global ocean surface (McAnena et al., 2013).

Within this project we target the question whether carbon burial in the Cretaceous South Atlantic influenced or even triggered global climate perturbations. In order to asses the timing and magnitude of carbon burial we use a combined approach of physical and biogeochemical modelling which is constrained by a set of new multiproxy geochemical data provided by project partners at the University of Cologne (see abstract of Dummann et al.).

Oceanic gateways, such as the Falkland and Walvis Ridge Gateways in the Cretaceous South Atlantic, excert an important influence on carbon burial in young ocean basins. This is because progressive gateway opening enhances supply and recycling of nutrients to and within the ocean basin and the exchange of water masses across the gateways, thereby controlling the production and preservation of organic matter across the basin.

In order to simulate the evolution of the Falkland Gateway we will use the “Kiel Climate Model” (KCM), a coupled Atmosphere-Ocean General Circulation Model, with different sets of South Atlantic geometry and bathymetry to assess their influence on the oceanic circulation. A box model is then used to generate a transient response of key biogeochemical cycles from the KCM time slices and allow for quantification of carbon burial in the basin at different phases of the opening.

In a first step we use the KCM under Early Cretaecous boundary conditions, representing the Aptian period including a modified geography, a reduced solar constant and a pCO_2 of 1200 ppm (Hong & Lee, 2012). First results for the open South Atlantic set-up show a global mean surface temperature of 23.4 °C, an enhanced hydrological cycle and a significantly stronger horizontal atmospheric circulation. Driven by these atmospheric fields, an intensified oceanic surface circulation in the tropical and subtropical region developed that supported high surface temperatures and low salinities, and a stable stratification of the shallow water column, preventing any deep convection. Modelling suggests that the global meridional overturning circulation was restricted to the upper 2000 m.

References:

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