Project: **895**
Project title: **GFZ - RECOM**
Project lead: **Maik Thomas**
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In the report period, simulations with the coupled atmosphere-ocean model ECHAM5/MPIOM have been conducted for three time-slices: the early Albian (ca. 110 million years ago, Ma), the Cenomanian-Turonian Boundary (CTB, ca. 93 Ma) and the early Eocene (ca. 55 Ma). The combination of these three time-slices with our simulations of the Pliocene (ca. 5 Ma) and a pre-industrial period (1850 AD), simulated in the years 2012 and 2013, represent the major tectonic events of the opening of the South Atlantic. These simulations are performed in order to compare the modelled ocean currents with sediment thicknesses and sedimentation rates investigated by other projects of the DFG SPP SAMPLE ("South Atlantic Margin Processes and Links with onshore Evolution"). This is one of the three major goals of RECOM.

In the shallow, narrow and enclosed South Atlantic only wind-driven circulation was present. The opening of the South Atlantic to the North Atlantic in the Cenomanian started the influence of North Atlantic Intermediate Water (NAIW) and initiated strong intermediate currents. During the Paleocene the Drake Passage closed, thus inhibiting a proto-Antarctic Circumpolar Current. This continued to affect the ocean circulation in the early Eocene. At this time, the thermohaline circulation was driven by intermediate water formation in the Weddell Sea and the Greenland Sea; deep water was not being formed and the deep ocean thus not ventilated. This changed until the beginning of the Pliocene, when deep water formation in the Greenland, Labrador and Weddell Seas led to a deep convection and ventilated the deep ocean. However, the Atlantic Meridional Overturning Circulation (AMOC) was weaker in the Pliocene than at present-day due to the open Central American Seaway (CAS). Only after the closing of the CAS in the early Pliocene, the AMOC strengthened and the Gulf Stream became as influential on European climate as it is today.

The second goal of RECOM is to study the sensitivity of the ocean circulation to tectonic opening and closing of ocean gateways. Three sensitivity-studies will be performed in 2016.

The third goal of RECOM is to investigate the effect of tidal forcing on the general ocean circulation for these five time-slices. For this purpose, the tidal module by Thomas et al. (2001) was included into MPIOM and the effect of tidal dynamics on ocean and atmosphere circulation was studied for the early Albian, the early Eocene and the pre-industrial period (fig. 1). In the early Albian, tidal forcing causes a reduction of the Global Meridional Overturning Circulation. In the early Eocene, horizontal velocities in the deep ocean are severely enhanced and are increased to 400% the original values in 25% of the deep ocean. This leads to the onset of an overturning circulation in the deep ocean and doubles the strength of the GMOC. In the pre-industrial period, the influence of tidal forcing on ocean currents is small compared to the early Albian and the early Eocene. However, sea ice concentration is decreased by up to 25% in the Weddell Sea. Thereby the heat flux from the ocean to the atmosphere is increased, which causes a raise of the atmospheric 2m-temperature by up to 4°C (fig. 2).

So far, only the effect of altered ocean basin geometry on tidal dynamics has been studied. The effect of long-term evolving orbital configurations on tidal dynamics will be studied in 2016.

Thomas, M., Sündermann, J., Maier-Reimer, E. (2001): Consideration of ocean tides in an OGCM and implications for polar motion. - Geophysical Research Letters, 28, 12, p. 2457-2460. doi:10.1029/2000GL012234

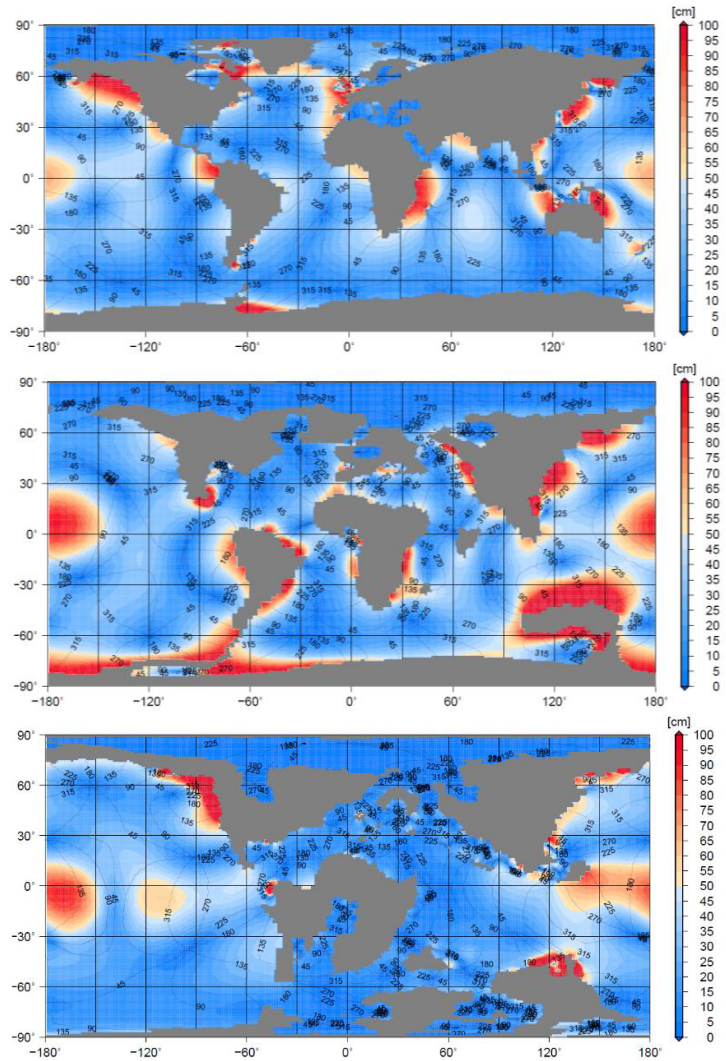

Figure 1: Amplitude (colored contours) and phase (numbered lines in °) of the M_2 partial tide of the pre-industrial period (top), the early Eocene (middle), and the early Albian (bottom).

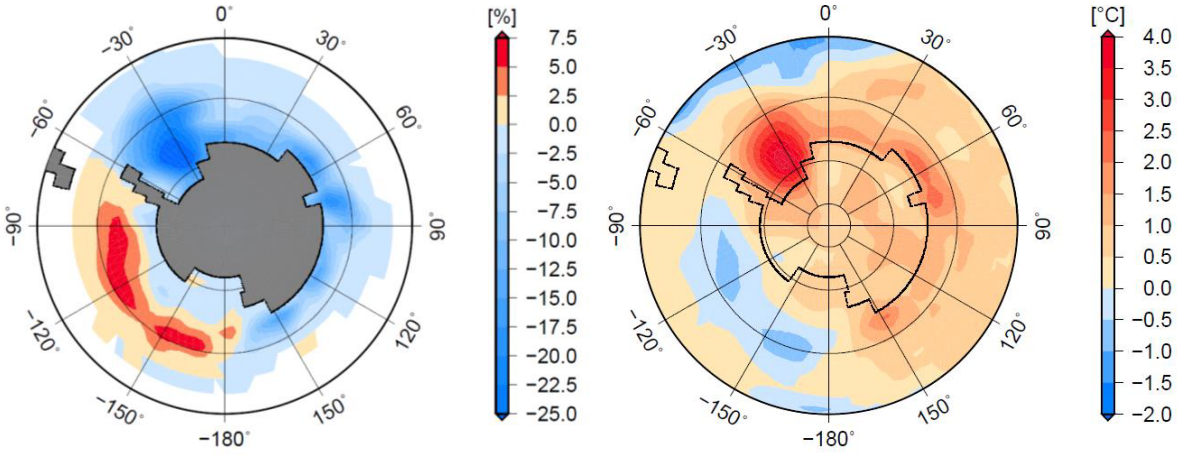

Figure 2: Difference PITIDE-PICTRL of multi-decadal mean sea ice concentration (left) and atmospheric 2m-temperature (right). Positive values indicate an increase in sea ice concentration or 2m-temperature, respectively, when tidal forcing is included into the ocean model. Marked latitudes are 45°, 60°, 75° and 85°.