Marine carbon cycle reponse to Miocene climate simulations, a model-data comparison

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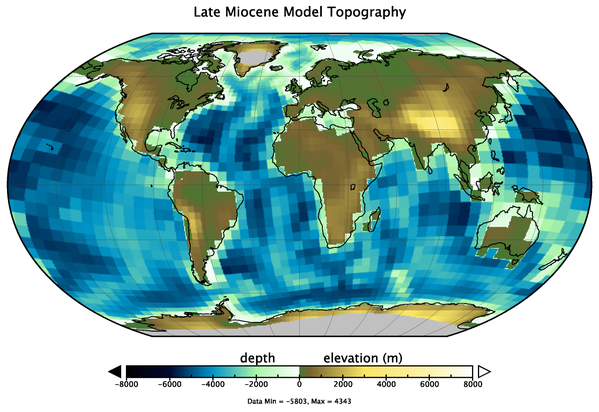
Research outline

We show first results of a modelling sensitivity study in which we investigate the response of the marine carbon cycle to environmental changes typical for the Late Miocene. We employ the outcomes of fully coupled climate simulations to run a coarse-resolution 'offline' model of the marine carbon cycle, aiming to validate the results with marine proxy records and to assess CO_2 reconstructions.

Model setup

- MPIOM ocean circulation model (Marsland et al., 2003)
- HAMOCC5 marine biogeochemistry model, driven by MPIOM (Wetzel et al., 2005)
- nominal resolution: 3.6°x6.0°x23L
- Late Miocene (Tortonian) setup features an openCentral American Seaway, depth = 500 m



- Atmospheric forcing is based on fully coupled climate simulations using ECHAM5 (resolution T31L19) / MPIOM (resolution 1.8°x3.0°x40L) (Knorr et al., submitted)
- CO_2 concentration in ECHAM5: 278 ppm (experiments CTRL, TORT278) or 450 ppm (experiment TORT450)
- Integration time of MPIOM-HAMOCC5 (so far): ~2500 years
- After ~10000 years the simulations shall be continued at the resolution of the fully coupled climate model (1.8°x3.0°x40L)
- Modelled stable carbon isotope distributions are compared with measurements by Quay (2005), Shackleton andHall (1997), and Woodruff and Savin (1989).

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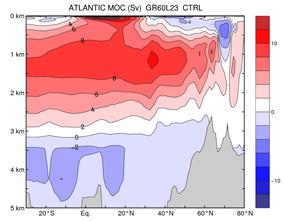
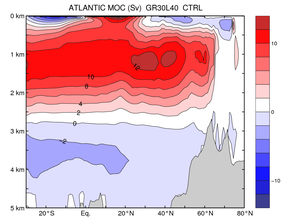
Physical response of the ocean

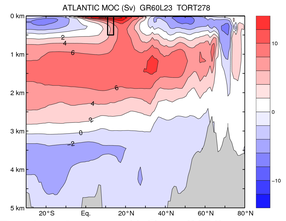
Atlantic meridional overturning circulation



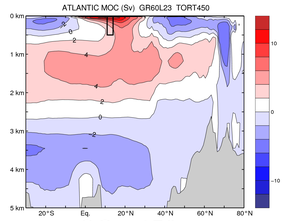
Control run, coarse resolution



resolution = 1.8°x3.0°x40L

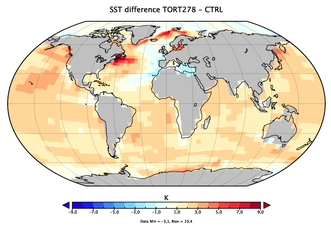


Tortonian, pCO_2=278 ppm

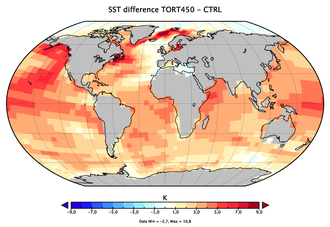


pCO_2=450 ppm

Sea-surface temperature changes



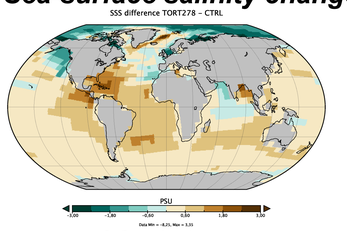
pCO_2=278 ppm
Global *SST* change = ~1.9°C



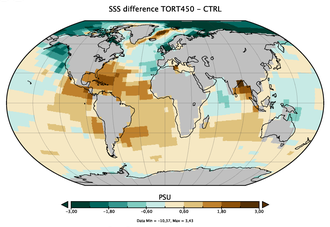
pCO_2=450 ppm
$\langle \Delta SST \rangle$ = ~3.2°C

Despite pronounced warming in TORT450 there is still some sea ice in the Arctic Ocean (of up to ~1.5 m, not shown).

Sea-surface salinity changes



pCO_2=278 ppm

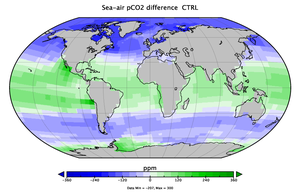


pCO_2=450 ppm

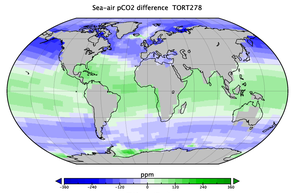
Biogeochemical response of the ocean

Shown are results after 2000 years of model spinup with fixed pCO_2.

Sea-air pCO_2 difference



Control run



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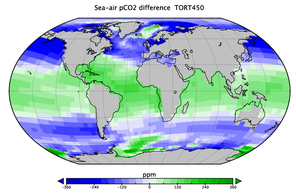
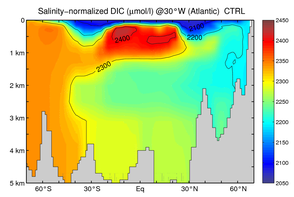
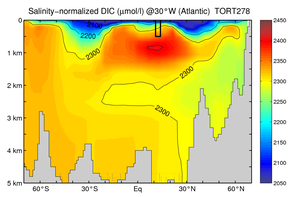


pCO_2=450 ppm

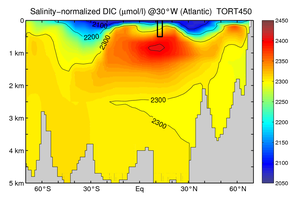
Dissolved inorganic carbon



Control run

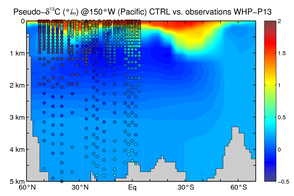


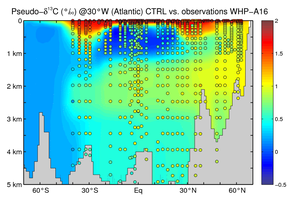
Tortonian, pCO_2=278 ppm



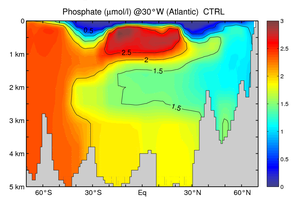
pCO_2=450 ppm

Stable carbon isotopes





Phosphate



$\delta^{13}C$ is currently estimated from phosphate via $\delta^{13}C$ (‰)=1.7028-0.6405×PO_4^{3-} (µmol/kg). Atlantic phosphate is shown for comparison on the right hand side.