Exploring glacial–interglacial variations of the marine carbon isotope record with RECOM-ciso

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Outline

We explore the impact of glacial–interglacial climate variations on the marine carbon-isotope record by means of the sophisticated marine biogeochemistry model RECOM. Different to most other marine carbon cycle models, RECOM does not rely on fixed Redfield ratios for organic soft tissue. Instead, the ratios of C:N and C:Chl in phytoplankton are calculated as a response to light, temperature and nutrient supply, which allows for assessing potential shifts in marine autotroph stochiometry.

Implementation of carbon isotopes

RECOM-ciso considers isotopic fractionation during uptake and dissolution of CO_2, formation and dissolution of biogenic calcite, and photo-synthesis of phytoplankton. In addition, the model accounts for radioactive decay of ^{14}C.
Air-sea exchange of of CO_2 implies kinetic and equilibrium fractionation, modelled following Zhang et al. (1995). Equilibrium fractionation during the formation and dissolution of biogenic calcite is treated according to Romanek et al. (1992). Isotopic fractionation during photosynthesis is parameterized according to Laws et al. (1997), Rau (1994), or Freeman and Hayes (1992). Isotopic fractionation processes are applied to all modelled carbon pools, representing dissolved inorganic and organic carbon, nanophyto-plankton, diatoms, zooplankton, detritus and calcium carbonate. In total, RECOM-ciso considers 37 biogeochemical tracers.

First results

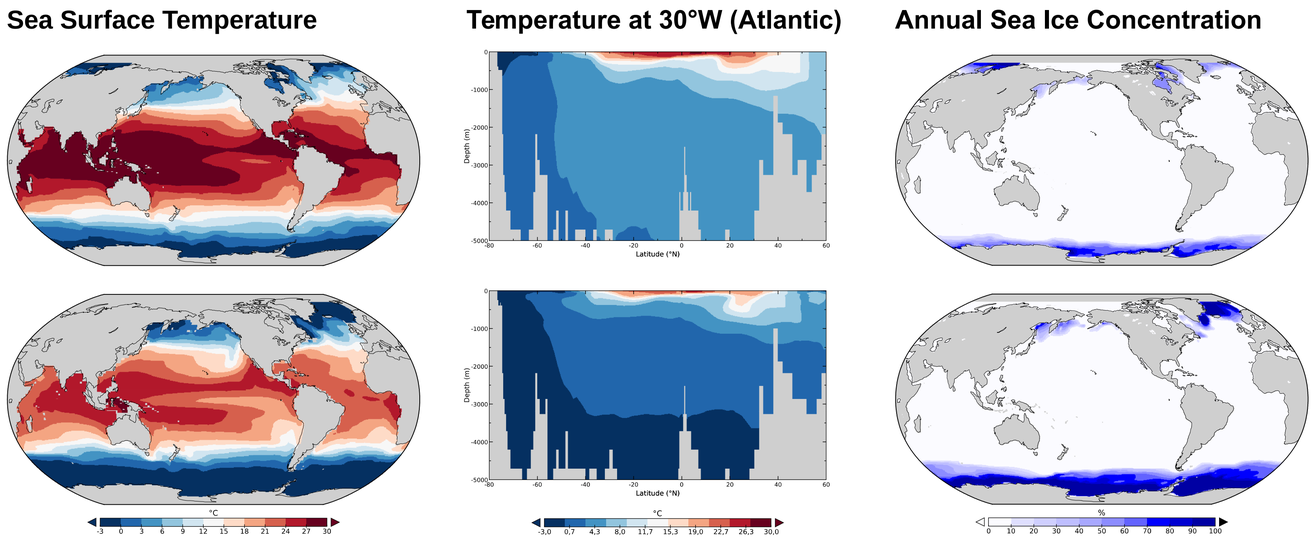
So far, the model has been run over 1000 years. As the equilibration time for ^{14}C is much longer, we focus on $\delta^{13}C$ and the surface ocean. Initial nutrient concentrations have been increased by 3% in the LGM run to account for glacial sea level lowering. Using the same dust input in both simulations, our results do not (yet) capture the potential effects of enhanced iron fertilization during the LGM.

Physical modelling framework and climate forcing

RECOM is connected to the ocean general circulation model MITgcm. Longitudinal model resolution is 2.0°, latitudinal resolution varies from 0.38° to 2.0°, and vertical resolution is 30 levels. MITgcm is forced with climatological fields for the Holocene (Wei and Lohmann, 2012) and the Last Glacial Maximum (Zhang et al., 2013), derived in fully coupled climate simulations using the climate model COSMOS. At the moment, we employ Holocene dust fields (Mahowald et al., 2003) only.

Holocene

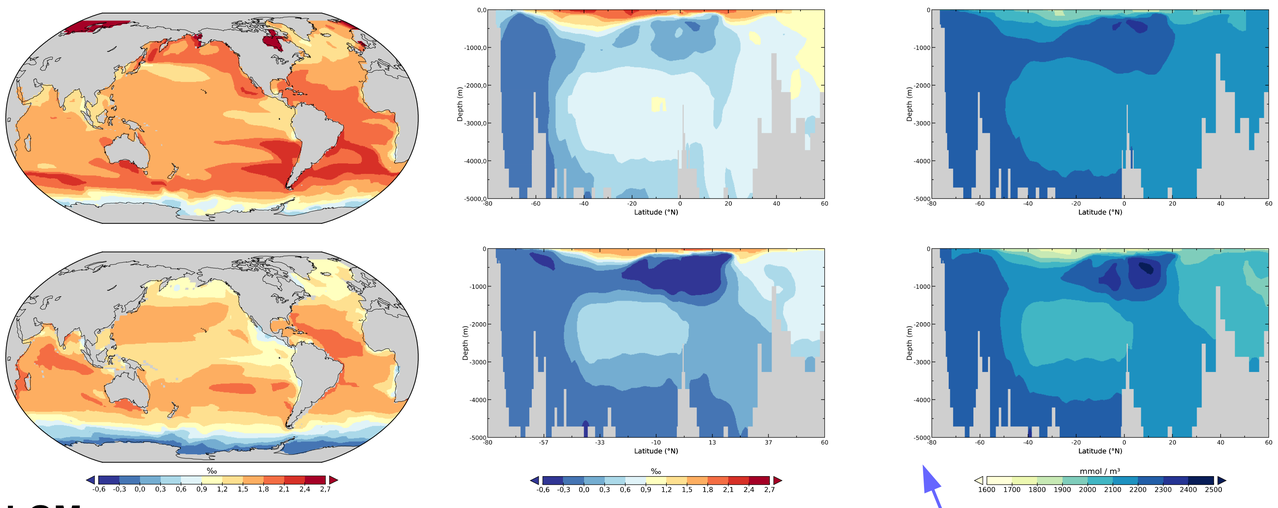
Sea Surface Temperature | **Temperature at 30°W (Atlantic)** | **Annual Sea Ice Concentration**



Last Glacial Maximum (LGM)

Holocene

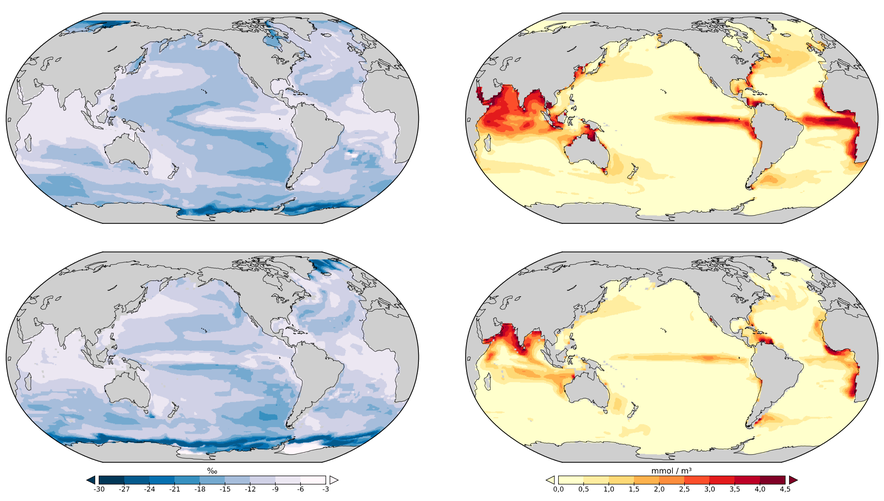
$\delta^{13}C$ of DIC at Surface | **$\delta^{13}C$ of DIC at 30°W (Atlantic)** | **DIC at 30°W**



LGM

Holocene

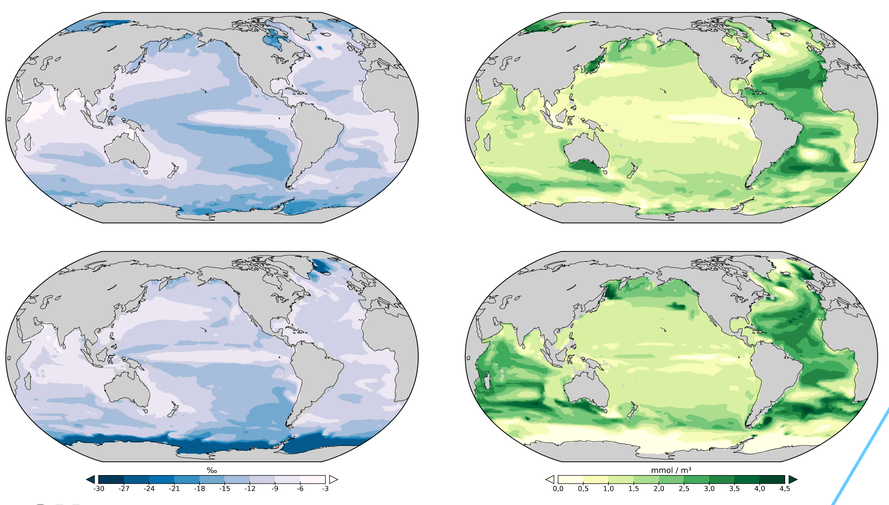
$\delta^{13}C$ of Zooplankton at Surface | **Zooplankton Concentration**



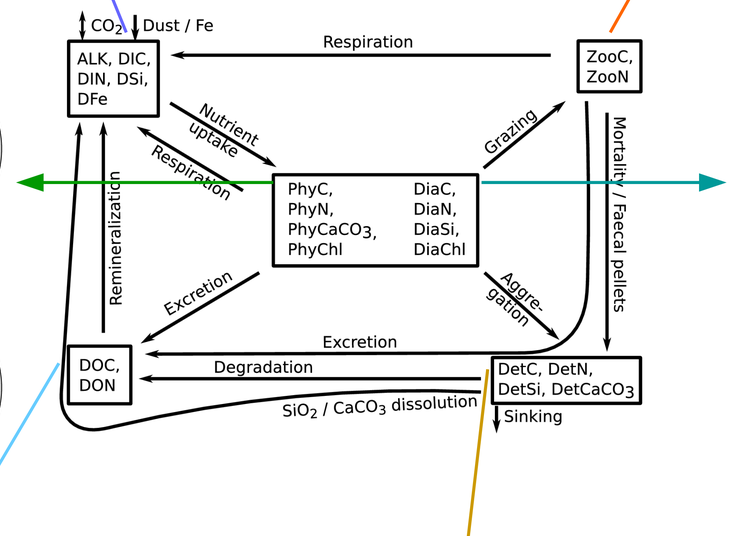
LGM

Holocene

$\delta^{13}C$ of Phytoplankton at Surface | **Phytoplankton Concentration**

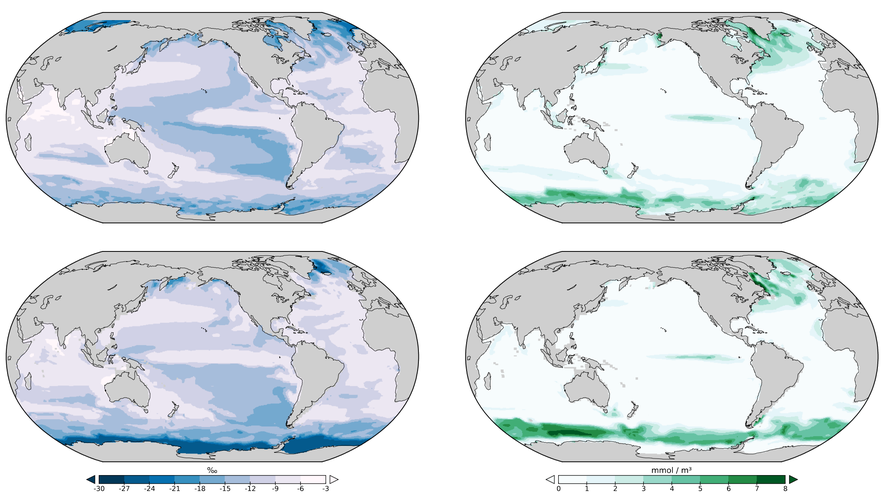


LGM



Holocene

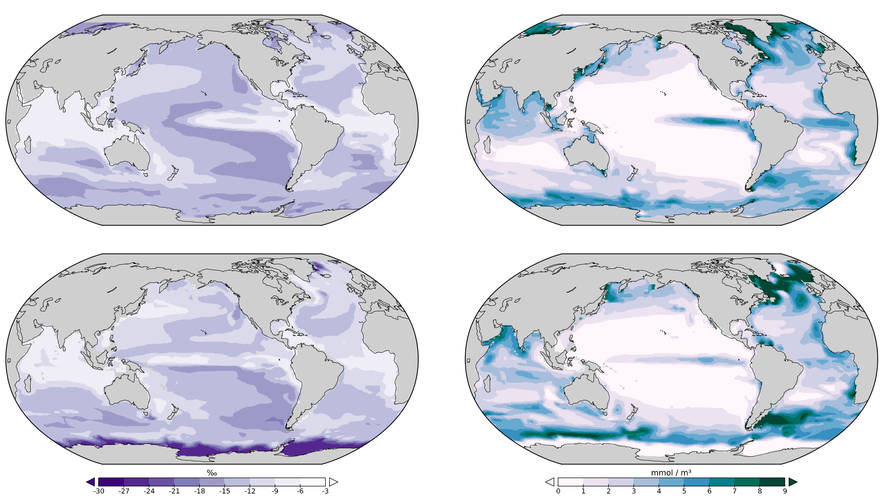
$\delta^{13}C$ of Diatoms at Surface | **Diatom Concentration**



LGM

Holocene

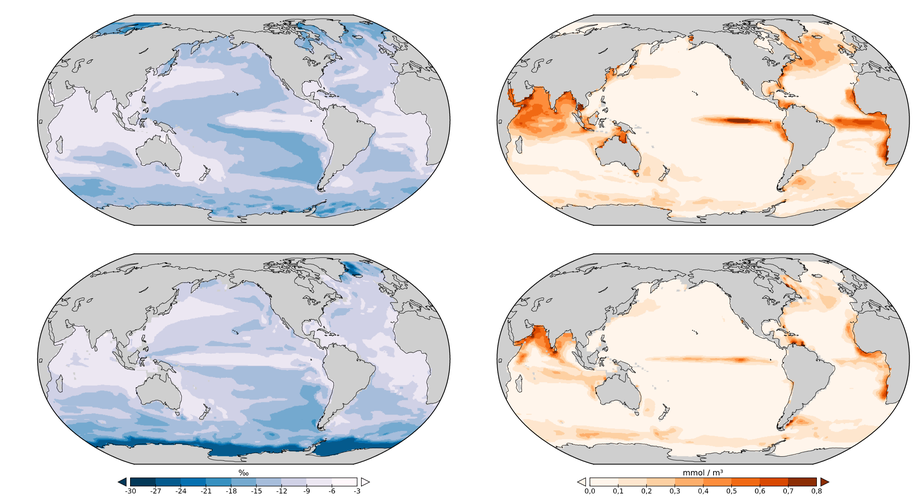
$\delta^{13}C$ of DOC at Surface | **DOC at Surface**



LGM

Holocene

$\delta^{13}C$ of Detritus at Surface | **Detritus Concentration**



LGM

Outlook

The current results mark an intermediate step in model development.
We are going to implement RECOM-ciso into the fully coupled AWI Climate Model, featuring the multi-resolution ocean circulation model FESOM (see below for an impression of its unstructured mesh).