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FUTURE CHANGES IN THE ARCTIC OCEAN BIOGEOCHEMISTRY IN CMIP5 PROJECTIONS WITH MPI-ESM

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The Arctic Ocean undergoes rapid changes due to global climate change and ocean acidification. Intercomparison studies reveal that although all models project large shifts in the carbon cycle of the Arctic Ocean, the intermodel spread in the degree of changes is quite large as well[1,2]. We will present projections of future climate change in the Arctic Ocean calculated within the 5th Phase of the Coupled Model Intercomparison Project (CMIP5) with the Max Planck Institute's Earth system model (MPI-ESM)[3]. CMIP5 experiments examined here include a historical run covering the period 1850-2005 and three future climate change scenarios referred to as extended concentration pathways (ECPs) running from the year 2006 until 2300. These ECPs follow the standard RCP scenarios in terms of the achieved radiative forcing of 8.5, 4.5, and 2.6 W m^{-2} by the end of the 21st century with simple stabilization assumptions for the atmospheric CO_2 concentrations made onwards. Such extended future climate change projections ran only in the low resolution model version (LR) of MPI-ESM driven by prescribed atmospheric CO_2 concentrations[3]. The oceanic biogeochemistry component of MPI-ESM is the model HAMOCC[4] which runs as a subroutine of the OGCM MPIOM. The horizontal resolution of the oceanic component of MPI-ESM-LR is about 1.5°. Due to grid configuration of MPIOM with the North Pole located over Greenland, the spatial resolution in the Arctic Ocean varies between 15 and 65 km.

The model HAMOCC simulates inorganic carbon chemistry and uses an extended NPZD-type description of marine biology in which phytoplankton and zooplankton dynamics depend on temperature, solar radiation, and co-limiting nutrients (phosphate, nitrate, iron, silicate). HAMOCC uses one phytoplankton type for primary production but separates two types of planktonic shell materials (opal and calcium carbonate shells, respectively), which are exported from the euphotic zone with different sinking rates. Additionally, formation and dissolution of sediments is simulated in the model.

Our results show that under continued climate warming, surface temperature on Arctic shelves rises by up to 10 °C by 2100 and by up to 15 °C by 2300, respectively, under ECP8.5 scenario. Also bottom ocean temperature increases by up to 14 °C by the end of the simulation. Such an unprecedented warming regionally cause sea ice to disappear almost completely all year round. A decrease in salinity by 2100 is projected as a result of sea ice melting, whereas by the year 2300 however, the trend reverses and there is a strong increase in salinity. As a result of warming and ice retreat, our model projects an increase in primary production and export fluxes despite decreasing nitrate concentration. The increase in export production in turn leads to an accumulation of organic matter in the upper sediments. Seawater pH is projected to drop by up to 0.5 by 2100 and by 0.7 by 2300, respectively, in ECP8.5 scenario. We show that our projections of changes in ocean acidification and primary production are due to interplay of changes in biogeochemical processes, ocean thermal state, and circulation.

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