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Changes in net primary production in a warming ocean: Examining model projections from coarse resolution to the submesoscale

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Projections from CMIP6 Earth System Models forecast a decline in net primary production (NPP) as the ocean warms up due to climate change. However, for coarse model resolutions of $O(10^5)$ m, there is still roughly a 2-fold disagreement between models for the magnitude and distribution of NPP in the contemporary era [1]. A recent study using the coupled NEMO-LOBSTER ocean physics-biogeochemistry model projected decline in net primary production halving at an eddy-resolving resolution $O(10^3)$ m compared to an eddy-parameterized coarse resolution $O(10^5)$ m in response to ocean warming [2]. In this study, we build on our previous work [3] and simulate changes in biogeochemical parameters using the MITgcm Ocean Physics Model coupled with the Simple Global Ocean Biogeochemistry with Light, Iron, Nutrients and Gas (BLING) Model [4] and examine the reproducibility of the results from the previous study [2].

The ocean physics model in this work uses the hydrostatic primitive equations for an implicit free surface, as described in [5], with a bi-linear equation of state. The simulation domain is a closed basin of size (30 × 30)° with a depth of 4000 m, representing an idealized portion of the North Atlantic Ocean on a spherical polar grid. Analytical profiles of zonal wind, SST forcing and freshwater flux are applied to fluctuate periodically between summer and winter extrema. Temperature and salinity profiles and are initialized using the 2018 World Ocean Atlas reanalyzed climatologies [6]. Monthly atmospheric iron deposition rates are taken from global chemical transport model estimates from a previous work [7]. Biogeochemical tracer concentrations are initialized from interpolated values from MITgcm tutorial experiments [8]. These initial values are spin-up for each resolution until tracer distributions reach equilibrium.

For an ocean warming scenario of +2.8°C over 70 years, roughly corresponding to the SSP8.5 scenario [9], mechanisms for changes in NPP, plankton biomass and nutrient distributions at resolutions of $O(10^5)$ m, $O(10^4)$ m, and $O(10^3)$ m are examined and compared with the previous study [2]. In the future we plan to extend experiments to examine the effect of changing ocean winds and rainfall on ocean biogeochemistry.

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