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Uncertainty in the changing marine carbon cycle in a future warmer world

Stephanie Dutkiewicz[†]; Jeffery Scott; Andrei Sokolov; Chris Forest
[†] MIT, USA
Leading author: stephd@mit.edu

We use an ensemble approach to examine the uncertainty in key components of the changing carbon cycle in the three dimensional ocean component of an earth system model of intermediate complexity. The ensemble members span different combinations of climate sensitivity, aerosol forcing, and strength of the global ocean vertical mixing and overturning circulation. The ocean biogeochemistry includes the transport of carbon within the ocean, air-sea exchange and explicit representation of the biological pump. We show results from pre-industrial to 2100 for a scenario of green house gas emissions assuming no policy. We find the ensemble provides a wide range of air-sea CO2 uptake (over 2 GtC/y) by 2100, with differing impact on the land-sea partitioning of the anthropogenic carbon sink. The spread in uptake rates is strongly dependent on the ocean circulation strength. In all ensemble members the ocean uptake rate reaches a maximum and plateaus late in the 21st century as warmer waters with high surface carbon content become less capable of taking up additional carbon. We examine the global patterns of these changes and find greatest uncertainty in the Southern Ocean. By 2100 the biological export of carbon to the deep ocean has reduced by a range of 2-12% of current day rates. This reduction in efficiency of biological pump is driven by reduced supply of nutrients to the surface sunlight layers. We examine the range in the global patterns of these changes. We also explore the uncertainty suggested by our ensemble in the acidification of the ocean, in particular examining the difference in the outcropping of the argonite saturation horizon by the 2100 between ensemble members.