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Impact of Improved Ocean Physical State Estimates on Simulated Interannual Air-Sea CO2 Flux Variations

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The ocean carbon cycle undergoes interannual and decadal changes associated with physical variables such as sea surface temperature and salinity, and mixed layer entrainment. But simulation of these variables is uncertain due to errors in physical model numerical methods, initial conditions, parameterizations, and surface forcing. In this paper we explore the potential improvement that we may expect in an ecosystem- biogeochemistry model when the physical state is corrected. We present two experiments. The first, similar to that discussed in Doney et al. (2009a), is a control simulation based on the Community Climate System Model (CCSM-3) ocean Biogeochemical Elemental Cycle (BEC) model for the 20-year period 1985-2004. In the second experiment the model simulation is repeated with certain physical state variables updated based on the Simple Ocean Data Assimilation analysis. Analysis of the results focuses on representation of interannual variations of the surface carbon dioxide partial pressure (pCO2) and air-sea CO2 flux.

Updating of physical variables leads to substantially enhanced interannual variability of surface pCO2 and air-sea CO2 flux, particularly in the mid- and subpolar latitudes. The source of this variability is primarily the increase in mixed layer dissolved inorganic carbon (nDIC) due to enhanced wintertime entrainment associated with increases in mixed layer variability. In addition to increased variability in nDIC, salinity-normalized total alkalinity also shows enhanced variability due to enhanced entrainment. Because variability of winter mixed layer depth is driven by wintertime surface meteorology, updating of the physical variables has the effect of enhancing the connection between variability of the physical climate and variability of surface CO2 flux.