Assessing the global ocean carbon sink with data assimilation

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Abstract

Ocean biogeochemistry models are key tools for estimating global ocean carbon uptake. They represent the major processes of the ocean carbon cycle. However, the simplified process representation, uncertainties in model initialization and in the atmospheric forcing lead to biases and uncertainties in the models' ocean carbon sink estimates. To improve consistency with observation-based estimates, we assimilate data for the period 2010 – 2020 using an ensemble Kalman filter variant (LESTKF) implemented with PDAF in the global ocean biogeochemistry model FESOM2.1-REcoM3. The assimilation of temperature and salinity observations improves the physical state and indirectly influences biogeochemical variables through model processes. To reduce the uncertainty stemming from the ecosystem model, we assimilate biogeochemical observations (sea surface pCO_2, dissolved inorganic carbon, alkalinity, oxygen and nitrate profiles, surface chlorophyll-a). The assimilation of biogeochemical observations directly modifies the air-sea CO_2 flux estimate and the model's interior ocean carbon reservoir. In addition, adjustments to ecosystem variables trigger nonlinear model responses. Globally, the combined regional effects of data assimilation reduce ocean carbon uptake relative to the free-running simulation. This contrasts with the generally higher values reported by prior observation-based estimates of ocean carbon uptake.