Ensemble-based parameter estimation for improving ocean biogeochemistry in an Earth system model

Improved ocean biogeochemistry (BGC) parameters in Earth System Models can enhance the representation of the global carbon cycle. We aim to demonstrate the potential of parameter estimation (PE) using an ensemble data assimilation method to optimise five key BGC parameters within the Norwegian Earth System Model (NorESM). The optimal BGC parameter values are estimated with an iterative ensemble smoother technique, applied a-posteriori to the error of monthly climatological estimates of nitrate, phosphate and oxygen produced by a coupled reanalysis that assimilates monthly ocean physical observed climatology. Reducing the ocean physics biases while keeping the default parameters (DP) initially reduces BGC state bias in the intermediate depth but deteriorates near the surface, suggesting that the DP are tuned to compensate for physical biases. Globally uniform and spatially varying estimated parameters from the first iteration effectively mitigate the deterioration and reduce BGC errors compared to DP, also for variables not used in the PE (such as C0$_2$ fluxes and primary production). While spatial PE performs superior in specific regions, global PE performs best overall. A second iteration can further improve the performance of global PE for near-surface BGC variables. Finally, we assess the performance of the global estimated parameters in a 30-year coupled reanalysis, assimilating time-varying temperature and salinity observations. It reduces error by 20\%, 18\%, 7\%, and 27\% for phosphate, nitrate, oxygen, and dissolved inorganic carbon, respectively, compared to the default version of NorESM. The proposed PE approach is a promising innovative tool to calibrate ESM in the future.

Tarkeshwar SINGH (Nansen Environmental and Remote Sensing Center, Bergen, Norway), Francois COUNILLON (Nansen Environmental and Remote Sensing Center, Bergen, Norway), Jerry Tjiputra (NORCE Norwegian Research Centre, Bergen, Norway)