The Estimating the Circulation and Climate of the Ocean (ECCO) "Central Estimate": a Multi-decadal, Coupled Ocean Reanalysis

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Abstract

The Consortium for Estimating the Circulation and Climate of the Ocean (ECCO) has been producing dynamically- and kinematically-consistent global ocean state estimates for nearly two decades. Our current focus is Version 4 of the "Central Estimate", a data-constrained global, 1-degree, coupled ocean, sea-ice, and thermodynamic ice-sheet model that spans the period 1992-present. Our coupled model is made consistent with a diverse in-situ and remotely-sensed ocean, sea-ice, and ice-sheet data in a least-squares sense by iteratively adjusting a set of control parameters using the gradient of an uncertainty-weighted model-data misfit cost function. The cost function gradient is provided by the adjoint of the model (MITgcm).

By construction, ECCO state estimates satisfy the laws of physics and thermodynamics encoded in the numerical model and therefore conserve heat, salt, mass, and momentum. Our philosophy of strict adherence to conservation principles ensures that ECCO reanalyses are useful for investigating the causal origins of observed ocean climate variability. However, because of the enormous scale of the nonlinear optimization problem, strictly obeying conservation laws involves a trade-off with goodness-of-fit; on the whole, ECCO reanalyses are unlikely to reproduce observations as well as ocean reanalyses that allow incremental adjustments to their state vectors through time.

Here we summarize our recent efforts and challenges associated with (i) coupling to the sea-ice and thermodynamic ice-sheet models, (ii) adding novel data constraints such as ocean bottom pressure from GRACE and GRACE-FO, and (iii) increasing the spatial resolution of the state estimation system to achieve eddy-resolving scales.

Keywords: 4DVAR, adjoint, ECCO, state estimation, ocean modelling, coupled models

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