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Comparison of MERRA-2 and ECCO-v4 ocean surface heat fluxes: Consequences of different forcing feedbacks on ocean circulation and implications for climate data assimilation

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Forcing ocean models with reanalysis data is a common practice in ocean modeling. As part of this practice, prescribed atmospheric state variables and interactive ocean SST are used to calculate fluxes between the ocean and the atmosphere. When forcing an ocean model with reanalysis fields, errors in the reanalysis data, errors in the ocean model and errors in the forcing formulation will generate a different solution compared to other ocean reanalysis solutions (which also have their own errors).
As a first step towards a consistent coupled ocean-atmosphere reanalysis, we compare surface heat fluxes from a state-of-the-art atmospheric reanalysis, the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2), to heat fluxes from a state-of-the-art oceanic reanalysis, the Estimating the Circulation and Climate of the Ocean Version 4, Release 2 (ECCO-v4). Then, we investigate the errors associated with the MITgcm ocean model in its ECCO-v4 ocean reanalysis configuration (1992-2011) when it is forced with MERRA-2 atmospheric reanalysis fields instead of with the ECCO-v4 adjoint optimized ERA-interim state variables. This is done by forcing ECCO-v4 ocean with and without feedbacks from MERRA-2 related to turbulent fluxes of heat and moisture and the outgoing long wave radiation. In addition, we introduce an intermediate forcing method that includes only the feedback from the interactive outgoing long wave radiation.
The resulting ocean circulation is compared with ECCO-v4 reanalysis and in-situ observations. We show that, without feedbacks, imbalances in the energy and the hydrological cycles of MERRA-2 (which are directly related to the fact it was created without interactive ocean) result in considerable SST drifts and a large reduction in sea level. The bulk formulae and interactive outgoing long wave radiation, although providing air-sea feedbacks and reducing model-data misfit, strongly relax the ocean to observed SST and may result in unwanted features such as large change in the water budget. These features have implications in on desired forcing recipe to be used. The results strongly and unambiguously argue for next generation data assimilation climate studies to involve fully coupled systems.