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Simulation-based approaches for quantitative observing system design

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The North Atlantic Ocean circulation is the result of a range of physical processes, from large-scale gyre circulation (subtropical and subpolar), associated Ekman transports, fluctuations of the gyre boundaries, westward intensification that gives rise to the Gulf Stream, watermass transformation at high latitudes along continental boundaries and in the interior, complex ("return") flows at depth, Arctic sub-Arctic exchanges, efficient communication between the tropics and mid-to-high latitude through wave propagation along eastern boundaries, westward traveling Rossby waves, geostrophic eddies, and submesoscale processes, to name but a few. Interactions with the atmosphere and topography set crucial boundary conditions on the flow. For historical reasons, much of that circulation has been subsumed under a metric called the Atlantic Meridional Overturning Circulation (AMOC), which provides a heavily space (and time)-averaged depiction of the circulation.
Understanding the role that the different elements, which make up the circulation, play, has involved a diverse and heterogeneous stream of observations (satellite and in-situ), which, taken together constitute a sparse, eclectic observing system. Arguably, a rigorous way to combine the knowledge reservoir offered by the available, yet incomplete observations with the knowledge reservoir that is encapsulated in the governing equations of motion, rendered in the form of numerical models, is through formal ocean state and parameter estimation. The adjoint-based effort pursued by the Estimating the Circulation and Climate of the Ocean (ECCO) consortium has produced state estimates that have provided valuable insights into the AMOC in a number of studies. Beyond the use of the adjoint for state estimation, the tool has proven powerful in causal, dynamical attribution studies of subtropical and subpolar North (and South) Atlantic MOC. Furthermore, use of the adjoint and Hessian are enabling rigorous studies of quantitative observing system design within the framework of uncertainty quantification.
This talk provides an overview of how the adjoint-based modeling framework has supported studies of AMOC variability and observing system design. It is meant to set the stage for more detailed presentations these subjects.

Topic

Future AMOC observing –outlining a roadmap

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