Sensitivity Analysis of the Atlantic Meridional Overturning Circulation through the POP Tangent Linear and Adjoint Models

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Although many modeling studies are available in the literature showing the highly sensitive dependence of the North Atlantic meridional overturning circulation (AMOC) with regard to modeling parameters and variables, there exist still significant uncertainties in the model configurations such as mixing parameter values and initial and forcing conditions. A full characterization of the AMOC would not be possible with the standard approach of multiple forward integrations using different perturbations of the forcing and initial conditions. We are thus developing the tangent linear (TL) and adjoint (AD) versions of POP ocean model . Based on the automatic differentiation technique, the POP TL and AD models allow a direct computation of the AMOC sensitivity for various modeling variables. Along with the model forcing variables, all of the main prognostic modeling variables, velocity, temperature, pressure, and salinity are included in the forward and backward differentiation process of the POP TL and AD models. Especially, the numerical experiments are more focused on understanding how the fresh water forcing term and initial conditions interplay with the AMOC calculation. A vertical AMOC profile at 26 north latitude with a problem set of 1-degree resolution is used for the sensitivity test runs. In addition to the numerical experiments, detail implementation procedures of the tangent linear and adjoint models are introduced.