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Towards including bottom topography as a control variable in global ocean state estimation

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Numerical solutions of ocean general circulation models are determined by many different parameters. So far, state estimation based on inverse methods, such as that of the ECCO consortium, use surface boundary conditions and, for integrations shorter than the time for barotropic and baroclinic adjustement processes to complete, initial conditions as canonical control variables. Other parameters, for example diffusivities, lateral boundary conditions (free-slip, no-slip, etc.), and bottom topography, are formally assumed to be known. However, it is not clear what their "correct" values in coarse resolution models are. Bottom topography, for example is not known accurately in large regions of the ocean. Even where it is known, its representation on a coarse grid is ambiguous may add numerical artifacts to the ocean model's solution.

The MIT general circulation model (MITgcm) already provides adjoint code with respect to the traditional control variables. Recently, the code has been further developed to include bottom topography as a control variable in exact adjoint computation of the gradient of a variety of scalar objective functions with respect to bottom topography.

With global state estimation in mind, we explore the sensitivity of quantities that are frequently used to describe the state of a global ocean model—such as transport through Drake Passage, magnitude of the meridional overturning circulation, meridonal heat flux in the Southern Ocean, and deviations from climatological data—to small changes in bottom topography on different timescales. This sensitivity is compared to the sensitivity to conventional control variables. Understanding these sensitivities is a prerequisite for conduction model least-square optimizations that are based on adjoint gradient descend algorithms.