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On the role of long baroclinic Rossby waves in ocean state estimation

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Estimating the variability of the ocean state is an important problem in modern oceanography and climate research. Particularly desirable are dynamically-consistent estimates which are based on the quantitative combination of observations with the equations of motion as represented in an ocean circulation model. This problem usually involves the application of an inverse method and faces at least three main difficulties: the relative paucity of oceanic data, the computational cost of applying inverse methods to ocean state estimation, and the difficulty to understand the solution given the large variety of dynamical phenomena which are commonly represented in ocean models. To understand the solution, simplified models where specific dynamical phenomena can be isolated and studied in detail are needed.

Here we study the specific role of long baroclinic Rossby waves (LBRWs) in the estimation of the time-dependent state of an oceanic subtropical gyre subject to variable atmospheric forcing. Our focus on LBRWs stems from the fact that these waves constitute an important dynamical mechanism for the transient adjustment of the ocean to atmospheric perturbations. In order to isolate the effects of LBRWs in state estimation, we have developed a simplified model of the circulation in a closed rectangular basin on the beta-plane. Various approximations to the equations of motion are made, so that the model admits LBRWs as the only wave solutions. A forward (Kalman) filter and a backward filter are applied to the model to elucidate the role of LBRWs in propagating information from data locations to regions that are void of observations. The results are interpreted in the light of the concept of observability of optimal estimation theory. Analysis of the observability matrix is made to reveal structures of the solution which are accessible to the data and structures which are not.