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Augmentation of box inverse models using float velocity measurements

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Since the World Ocean Circulation Experiment, box inverse models have been routinely used to quantify the large-scale ocean circulation from hydrographic measurements. These models provide a formal framework in which to investigate the consistency between observations, basic ocean dynamics and prior knowledge of the flow, in a way that allows oceanographers to obtain an optimal estimate of the unknown reference velocities and other basic parameters of the circulation, such as mixing terms. However, like many other inverse problems, box inverse models are inherently underdetermined, which makes the estimated reference velocities suspect. In principle, we can reduce the underdetermined character of the inverse models by adding extra constraints obtained from independent data sources, which might include satellite observations or in situ velocity measurements (an approach often referred to as "eclectic” inverse modelling).

Autonomous Argo floats now provide in situ velocity measurements at mid-depth across the global ocean. While Argo float data appear to be a natural choice as a velocity constraint, they pose a number of challenges for inverse models. Float velocities are Lagrangian measurements that rarely coincide geographically with the hydrographic sections used to build box inverse models. In addition, Argo float velocities represent time averages over 10 days, and this 10-day averaging scale is not guaranteed to be a good match to the time scales that best describe geostrophic velocities in hydrographic sections. Taking these factors into account, we present a strategy that elegantly exploits the common mathematical formalism of inverse modelling and objective mapping to incorporate direct velocity measurements and their error statistics into box inverse models. We demonstrate the skill of this strategy using a test case with eddy-permitting general circulation model output.