Can 4DVAR effectively correct the mean pycnocline depth in an ocean model?

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Abstract

In a global or regional ocean forecast system, Argo and glider T and S profile data assimilation (DA) aims to change the position of isopycnal surfaces. In the interior ocean, away from frontal regions, the model-data difference in the density structure may be due to the errors in the placement and strength of geostrophic eddies or may suggest an error on a longer horizontal scale, e.g., associated with the vertical misplacement of the thermocline or halocline. Since the model background error covariance has in practice a finite correlation length close to or smaller than the baroclinic Rossby radius of deformation, assimilating the T and S profiles alone results in local correction to the isopycnal depths and sometimes strong spurious geostrophic eddies (Pasmans et al., JGR, 2019). Adding SSH and/or SST to the set of assimilated data reduces this local impact. Is assimilation of in-situ observations, alone or combined with the surface satellite maps, effective at correcting the mean pycnocline level? To answer this question we set up a series of twin experiments in a very idealized configuration. In a rectangular closed domain, the true ocean is at rest (u, v, SSH = 0, horizontally uniform stratification). The Coriolis parameter is constant. The prior model estimate is also the state of rest, but the main pycnocline is lower by 50 m. ROMS 4DVAR is utilized in a sequence of time windows. Can assimilation of synthetic profiles raise the pycnocline? Does adding synthetic SSH, SST and/or SSS observations bring the DA solution to the true state faster?