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Assimilation of temperature and salinity profile data in the Norwegian Climate Prediction Model

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Assimilating temperature and salinity profile data is promising to constrain the ocean component of Earth system models for the purpose of seasonal-to-dedacal climate predictions. However, assimilating temperature and salinity profiles that are measured in standard depth coordinate (z-coordinate) into isopycnic coordinate ocean models that are discretised by water densities is challenging. Prior studies (Thacker and Esenkov, 2002; Xie and Zhu, 2010) suggested that converting observations to the model coordinate (i.e. innovations in isopycnic coordinate) performs better than interpolating model state to observation coordinate (i.e. innovations in z-coordinate). This problem is revisited here with the Norwegian Climate Prediction Model, which applies the ensemble Kalman filter (EnKF) into the ocean isopycnic model (MICOM) of the Norwegian Earth System Model. We perform Observing System Simulation Experiments (OSSEs) to compare two schemes (the EnKF-z and EnKF-ρ). In OSSEs, the truth is set to the EN4 objective analyses and observations are perturbations of the truth with white noises. Unlike in previous studies, it is found that EnKF-z outperforms EnKF-ρ for different observed vertical resolution, inhomogeneous sampling (e.g. upper 1000 meter observations only), or lack of salinity measurements. That is mostly because the operator converting observations into isopycnic coordinate is strongly non-linear. We also study the horizontal localisation radius at certain arbitrary grid points. Finally, we perform the EnKF-z with the chosen localisation radius in a realistic framework with NorCPM over a 5-year analysis period. The analysis is validated by different independent datasets.