Lagrangian Data Assimilation of Surface Drifters to Support Ocean and Coupled Model Initialization

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The air-sea interface is one of the most physically active interfaces of the Earth’s environments and significantly impacts the dynamics in both the atmosphere and ocean. In this study, we discuss the data assimilation of surface drifters, of which the dynamic motions are highly relevant to the instant change of both surface wind field and underlying ocean flow fields. We intend to take advantage of this relationship and improve the estimation of the model initialization in both ocean and coupled atmosphere-ocean systems.

The assimilation of position data from Lagrangian observing platforms is underdeveloped in operational applications because of two main challenges: 1) nonlinear growth of model and observation error in the Lagrangian trajectories, and 2) the high dimensionality of realistic models. In this study, we first propose an augmented-state Lagrangian data assimilation (LaDA) method that is based on the Local Ensemble Transform Kalman Filter (LETKF). The algorithm is tested with “identical twin” approach of Observing System Simulation Experiments (OSSEs) using the ocean model. Examinations on both of the eddy-permitting and the eddy-resolving Modular Ocean Model of the Geophysical Fluid Dynamics Laboratory (GFDL) are tested, which is intended to update the ocean states (T/S/U/V) at both the surface and at depth by directly assimilating the drifter locations. Results show that with a proper choice of localization radius, the LaDA can outperform conventional assimilation of surface in situ temperature and salinity measurements. The improvements are seen not only in the surface state estimate, but also throughout the ocean column to deep layer. The impacts of localization radius and model error in estimating accuracy of both fluid and drifter states are further investigated. In the second section, we investigate the LaDA within a Strongly Coupled Data Assimilation (SCDA) system using the simplified Modular Arbitrary-Order Ocean-Atmosphere Model (MAOOAM), a three-layer truncated quasi-geostrophic model. Results show that assimilating the surface drifter locations directly is capable of improving not only the ocean states but also the atmosphere states as well. We then compare it to the conventional approach to assimilate the approximated velocities instead of the direct drifter locations and it shows that the assimilating drifter locations outperforms the other approach.