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An efficient data assimilation method for high resolution models of ocean circulation

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Mesoscale and sub-mesoscale features such as eddies, fronts, boundary currents and localised upwellings play an important role in ocean dynamics, particularly in the coastal / shelf seas which are characterised by the values of Rossby radius much smaller than in the open ocean. Fine resolution ocean modelling is a ubiquitous practice to resolve such features. Due to inevitable errors,ocean models tend to drift from reality. A process called data assimilation (DA) is a way of keeping a model 'on the tracks' by constantly correcting it with fresh observations (DARC, 2021). Due to their complexity, operational data assimilation systems, such as NEMOVAR, DART or PDAF remained a topic mostly reserved to experts (Carrassi et al, 2018). This study presents a simple and computationally efficient method for DA in a high-resolution 3D ocean model, which is nested into a coarse-resolution good quality data assimilating (parent) model. The method is particularly suitable for localised coastal models which are run by small modelling groups. The method named Data Assimilation with Stochastic-Deterministic Downscaling (SDDA) reduces bias and root mean square errors (RMSE) of the high-resolution model. The basic idea is to assimilate data from the parent model instead of actual observations. In this way, the high-resolution model is physically aware of observations via the parent model. The method allows to avoid a complex process of assimilating the same observations which were already assimilated into the parent model. The method consists of two stages: (1) downscaling the parent model output onto the child model grid using Stochastic-Deterministic Downscaling (Shapiro et al, 2021), and (2) applying a Kalman gain formula to each of the fine grid nodes. The method is illustrated in a synthetic 2D case where the true solution is known, and the high-resolution model forecast (before data assimilation) is simulated by adding various types of errors. The SDDA method reduces the child model bias to the same level as in the parent model and reduces the RMSE typically by a factor of 2 to 5.

References

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