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Efficient Data Assimilation for Accurate Forecasting of Sea-Level Anomalies and Residual Currents using the Singapore Regional Model

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The Singapore Strait is one of the busiest shipping routes in the world with the coastal area being heavily utilized as ports or related industrial facilities with rapid economic development. It is important to provide hydrodynamic information of the water surrounding Singapore for accurate scheduling of harbor facilities, docking and sailing times. The important phenomena in the Singapore Strait include residual (non-tidal) currents which, at times, can dominate the regular flow conditions. It is hypothesized that a major contribution to residual currents results from regional water level variations also known as sea level anomalies (SLA). SLA may occur on different time scales (months, weeks or days) and it is observed that there may be considerable spatial variation within such periods. Towards obtaining reliable forecasts of SLAs and residual currents, the Singapore Regional Model developed in the Delft3D modeling environment has been deployed.

Although capable of yielding reasonably good forecasts, the model is still prone to errors due to parametric uncertainty and low resolution. In order to further improve the quality of the forecasts, it is possible to extract information from the in situ measurements and assimilate it into the model. Such an integration of the observations with the model is known as data assimilation. The present work aims at producing accurate forecasts of SLAs and residual currents by assimilating water level measurements available from observation stations in the region. While the model errors at the observed locations are corrected using error forecasts, the error correction at the unobserved locations of interest is achieved by deploying the Kalman filter. The Kalman filter corrects the model predictions only over one step into the future. Furthermore, the evolution of the model error is highly nonlinear and chaotic. This work proposes to model such errors using local linear models. It further deploys a hybrid scheme for data assimilation which consists of two steps. In the first step, the model errors at the observed locations are predicted using the local linear models. Subsequently, in the second step, the predicted errors are distributed over the remainder of the computational domain using the Kalman filter. The efficacy of this hybrid data assimilation scheme is demonstrated on the Singapore Regional Model.