IMPROVEMENT OF STRATIFIED FLOW FORECASTS IN THE OSAKA BAY USING STEADY STATE KALMAN FILTER

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Abstract

Hydrodynamic models often contain several uncertainties, which can occur at several stages. Model equations may contain errors due to lack of knowledge about the complex physical processes and their interaction. Simplifications often must be made to prevent high computation times. These simplifications will increase the model's uncertainty. Uncertainties in the output of the model can also occur due to incorrect or incomplete input data of the model, such as boundary conditions, meteorological data, and bathymetry. Measurements on the other hand are often sampled with a low spatial and temporal resolution. To reduce those uncertainties in the model output and improve its predictions, a data assimilation technique can be applied. Those techniques combine the model forecast with recent measurement data using the information on the uncertainties in the model and the measurements to give a better estimate of the model output and to significantly improve the success rate of the predictions. The Ensemble Kalman Filter (EnKF) Evensen, (1994) is a generic data assimilation method which is also suited for highly non-linear models. The EnKF was applied for a one dimensional hydrodynamic model and has proven its potential in improving the forecast, El Serafy and Mynett, (2004). However, for three dimensional operational systems as in the case of Osaka Bay, Japan, a full EnKF was computationally too demanding, thus a simplification was a necessity. In the present paper, a Steady State Kalman filter (SSKF) was implemented and applied in combination with a three dimensional Delft3D-Flow system, Lesser et al. (2004), modelling the Osaka Bay, a stratified three-dimensional circulation system. The structure of the uncertainties in the model and the typical correlation scales were assumed

based on those calculated by the EnKF. The aim of the application of SSKF is to improve the daily operational forecasts of salinity and current profiles for engineering activities in this stratified basin. Salinity and velocity components were assimilated for the period of 13-28 of Feb. 2002 on an hourly basis. The results show that the SSKF-hindcast follows the measurements better than the model without assimilation. To quantify the reduction in the error due to assimilation, the percentage reduction is then defined. The overall reduction in the error varies between 29.4%-85.3% for the salinity, 22.2%-73.8% for the north velocity component and 24.0%-71.6% for the east velocity component. The results also show the forecast improvement due to assimilation. The SSKF-forecast are better than those of the model without data assimilation, with the update effect disappearing in time. The forecast improvement occurs within the first 24 hours forecast for the salinity and 20 hours for the north velocity. For the east velocity, this improvement is restricted to the first 6 till 10 hours only due to the effect of the boundary flow forcing on the east velocity component during this period (18^{th} -20^{th} February). The improvement in the forecast of the salinity within the first hours of the forecast is stronger than that in the velocity components.

Finally, this research shows that incorporating recent measurement data through simple data assimilation techniques such as the steady state Kalman filter improves model outputs and forecasting abilities for operational purposes, even in strongly stratified flow systems as Osaka Bay. Further applications for similar operational systems are thus recommended.

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