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Improving water levels forecast in the gironde estuary using data assimilation on a 2D numerical model : correction of time-dependent boundary conditions through a truncated karhunen-loève decomposition within an ensemble kalman filter

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In the context of the development and implementation of data assimilation techniques in Gironde estuary for flood forecasting, a Telemac 2D model is used to calculate water depths and velocity fields at each node of an unstructured mesh. Upstream, the model boundaries are respectively La Réole and Pessac on the Garonne and Dordogne rivers. The maritime boundary is 32 km off the mouth of Gironde estuary, located in Verdon. This model, which contains 7351 nodes and 12838 finite elements, does not take into account overflows. It was calibrated over 4 non-overflowing events and validated over 6 overflowing events.

Uncertainty in hydraulic parameters as well as fluvial and maritime boundary conditions are quantified and reduced in this study. It is assumed that time-varying functional uncertainty in boundary conditions is well approximated by a Gaussian Process characterized by an autocorrelation function and an associated correlation length scale. The coefficients of the truncated Karhunen-Loève decomposition of this process are further considered in the control vector, together with the friction coefficients and wind influence factor, of Global Sensitivity Analysis based on variances decomposition to quantify uncertainty and an Ensemble Kalman Filter to reduce uncertainty. The performance of the data assimilation strategy in terms of control vector composition, length and cycling of the data assimilation window, size of the ensemble and mesh, was assessed on synthetical and real experiments.

It was shown that uncertainty in water level predominantly stems from uncertainty in the maritime boundary condition and the friction coefficient in the mouth and in the central part of the estuary. Synthetical experiments showed that data assimilation succeeds in identifying time varying friction following tidal signal, as well as reconstructing the time-dependent maritime forcing even though the KL coefficients identification suffers equifinality. A resampling method based on the persistence of the initial background covariance matrix is used to avoid well-known ensemble collapse in the Ensemble Kalman Filter. Difficulties in estimating the friction parameter of the confluence zone, where the flows are the result of non-linear physical processes, were highlighted. Also, the equifinality problem for identification of the KL coefficients in the boundary conditions was shown to be enhanced, nevertheless, leading to the proper reconstruction of the maritime

forcing and consequently to the expected water level in the estuary. In the real experiment, it was shown that water levels are significantly improved with error smaller than 10cm, along the estuary, except in the upstream sections of the Garonne and Dordogne rivers where model refinement should be improved.

KEY WORDS

2D hydrodynamic simulations, TELEMAC, Gironde Estuary, data assimilation, Ensemble Kalman filter, Karhunen-Loève decomposition, time-dependent forcings