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Estimating estuarine salt intrusion using an analytical and a full hydrodynamic simulation – a comparison for the Ma Estuary

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Salt intrusion is the most acute problem for irrigation water quality in coastal regions during dry seasons. The use of numerical hydrodynamic models is widespread and has become the prevailing approach to simulate the salinity distribution in an estuary. Despite its power to estimate both spatial and temporal salinity variations along the estuary, this approach also has its drawbacks. The high computational cost and the need for detailed hydrological, bathymetric and tidal datasets, put some limits on the usability in particular case studies. In poor data environments, analytical salt intrusion models are more widely used as they require less data and have a further reduction of the computational effort. There are few studies however where a more comprehensive comparison is made between the performance of a numerical hydrodynamic and an analytical model. In this research the multi-channel Ma Estuary in Vietnam is considered as a case study. Both the analytical and the hydrodynamic simulation approaches have been applied and were found capable to mimic the longitudinal salt distribution along the estuary.

The data to construct the MIKE11 model include observations provided by a network of fixed hydrological stations and the cross-section measurements along the estuary. The analytic model is developed in parallel but based on information obtained from the hydrological network only (typical for poor data environment). Note that the two convergence length parameters of this simplified model are usually extracted from topography data including cross-sectional area and width along the estuary. Furthermore, freshwater discharge data are needed but these are gauged further upstream outside of the tidal region and unable to reflect the individual flows entering the multi-channel estuary. In order to tackle the poor data environment limitations, a new approach was needed to calibrate the two estuary geometry parameters of the parsimonious salt intrusion model. Compared to the values based on a field survey for the estuary, the calibrated cross-sectional convergence length values are in very high agreement. By assuming a linear relation between inverses of the individual flows entering the estuary and inverses of the sum of flows gauged further upstream, the individual flows can be assessed. Evaluation on the modeling approaches at high water slack shows that the two modeling approaches have similar results. They explain salinity distribution along the Ma Estuary reasonably well with Nash–Sutcliffe efficiency values at gauging stations along the estuary of 0.50 or higher. These performances demonstrate the predictive power of the simplified salt intrusion model and of the proposed parameter/input estimation approach, even with the poorer data.