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Revised predictive equations for salt intrusion modelling in estuaries

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Abstract. For one-dimensional salt intrusion models to be predictive, we need predictive equations to link model parameters to observable hydraulic and geometric variables. The one-dimensional model of Savenije (1993b) made use of predictive equations for the Van der Burgh coefficient K and the dispersion at the seaward boundary D_0. Here we have improved these equations by using an expanded database, including new previously un-surveyed estuaries. Furthermore, we derived a revised predictive equation for the dispersion at tidal average condition and with the boundary situated at the well identifiable inflection point where the estuary changes from wave-dominated to tide-dominated geometry. We used 89 salinity profiles in 30 estuaries (including seven recently studied estuaries in Malaysia), and empirically derived a range of equations using various combinations of dimensionless parameters. We split our data in two separated data sets: (1) with more reliable data for calibration, and (2) with less reliable data for validation. The dimensionless parameters that gave the best performance depended on the geometry, tidal strength, friction and the Richardson number. The limitation of the equations is that the friction is generally unknown. In order to overcome this problem, a coupling has been made with the analytical hydraulic model of Cai et al. (2012), which makes use of observed tidal damping and by which the friction can be determined.

1 Introduction

Predictive methods to determine salinity profiles in estuaries can be very useful to water resources managers, particularly when applied to ungauged estuaries where only a minimal amount of data are available. Before any decision is made on collecting detailed field observations, it is useful to obtain a first estimate of the strength and range of the salt intrusion in the area of interest. Such estimate can be made if there are predictive equations available to compute the longitudinal salinity profile along the estuary. With reliable predictive equations, water managers are able to estimate how far salt water intrudes into the river system under different circumstances, and more importantly, how interventions may change this situation.

The one-dimensional salt intrusion model of Savenije (1993b) makes use of the Van der Burgh and dispersion equations to represent the longitudinal variation of the salinity. The Van der Burgh and dispersion coefficient at the ocean boundary are obtained by calibration of the simulated salinity curve to observations. Savenije (1993b) established a predictive equation for each of these parameters, so that the longitudinal salinity distribution could be estimated when data were lacking or to monitor the impact of interventions, such as dredging or fresh water withdrawal. The predictive equations have subsequently been modified and tested by several researchers including Savenije (2005), Nguyen and Savenije (2006), Kuijper and van Rijn (2011) and Shaha and Cho (2009).

In this paper, we shall revisit the predictive equations in the light of new insights on how friction and estuary shape affect tidal mixing by deriving a relationship between several governing parameters, making use of the salinity measurements from 30 estuaries including seven new field observations in previously ungauged estuaries in Malaysia that were sampled through a consistent approach. As a result, we present the fully revised and more accurate predictive equations for

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