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Understanding the Influence of Retention Basin on Tidal Dynamics in Tidal Estuaries

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Both the tidal motion and suspended sediment concentration (SSC) in tidal embayments and estuaries are influenced by anthropogenic (e.g. deepening) and natural changes. An example of such an estuary is the Ems estuary, situated on the border of the Netherlands and Germany. The mean tidal range towards the end of the Ems estuary has increased from 1.5m in the 1950s to more than 3m in the 1990s while the suspended concentration has increased by a factor 10. To possibly reduce these negative effects, the construction of retention basin(s) (RB) is considered. In this contribution, the influence of location and geometry of RBs on tidal dynamics and SSC is investigated.

For this purpose, a three-dimensional semi-analytic idealized model is developed. This model is an extension of the model proposed by Winant (2007) to arbitrary domain and realistic bathymetry with partial slip boundary condition at the bottom. The sea surface elevation (SSE) is calculated numerically using a finite element method. Next, the three-dimensional velocities are calculated by combining the analytically calculated vertical profiles and the gradients of the SSE which are obtained numerically.

Firstly, the influence of a RB on the tidal dynamics in an infinitely long, rectangular, frictionless estuary is considered. The SSE decreases when the RB is located between a node and a landward antinode, consistent with the work of Alebregtse et al. (2013). Secondly, an estuary of finite length is connected to a sea. By varying the width of the sea, not only the effect of the distance of the RB to the landward end plays a role, but also the distance to the open sea becomes important. Finally, we discuss the influence of a RB on the tidal motion and initial sediment transport, considering the Ems estuary with realistic bathymetry. Results show that the SSE at the landward end of the Ems estuary decreases for all locations of the RBs. This decrease is most pronounced for the RB which is closest to the end of the Ems estuary. Concerning the initial sediment transport, introduction of a RB creates a convergence zone at the location of RB with enhanced along-channel transport seaward and reduced along-channel transport landward of the location of the RB. The intensity of the change in the along-channel transport decreases as the RB is located closer to the landward end. A Similar trend is obtained for cross-channel transport, meaning that the RB will fill more slowly when located closer to the end. The mechanisms resulting in these observed changes, and their sensitivity to the parameters (such as friction, geometry of RBs ,etc) will be discussed in detail.