Abstract for the 18th Physics of Estuaries and Coastal Seas Conference, 2016

Saltwater intrusion in an idealized estuarine channel network

Maarten van der Vegt[1] and Rinse de Swart[1]

Keywords: estuaries, saltwater intrusion, tides, tidal junction, Delft3D.

Abstract

Many deltas consist of multiple downstream channels, which generally differ in length, depth and width. The freshwater derived from the river is distributed over this channel network and mixes with the salt water from the sea, resulting in saltwater intrusion into the network. In many urbanised, low-lying deltas, saltwater intrusion is becoming an increasingly large problem. Existing studies on estuarine dynamics mostly focused on single-channel estuaries, while the estuarine dynamics in systems consisting of multiple channels received comparatively less attention. In a study by Buschman et al. (2010), it was shown that barotropic tides affect the division of river discharge at a tidal junction. However, they used a depth-averaged model and did not include density effects. Here, the analysis of Buschman et al. (2010) is extended to the baroclinic dynamics. The main objective of this study is to understand and predict how the length of downstream channels affects the saltwater intrusion in an idealized estuarine channel network.

A baroclinic Delft3D model (10 equidistant sigma layers) was setup, representing a very simple estuarine channel network (Figure 1). It was forced by both river discharge and tides. Using the model, the effect of varying the length of one downstream channel on tidal propagation and salinity intrusion in the channel network was investigated (see Figure 1). The results show that with increasing length difference between the two downstream channels, more tidal energy from the shorter channel is transferred to the longer channel. This affects the water level amplitudes and water level gradients in the shorter channel, causing the freshwater discharge to be concentrated in the shorter channel. Furthermore, tides cause a net circulation of water from the long channel to the shorter one. As a result of these processes, salt can easily intrude upstream through the longer channel, causing vast quantities of salt to be transported upstream. The larger the length difference, the more pronounced this effect gets. This results in the counterintuitive phenomenon that for increasing length of one downstream channel, saltwater intrudes further upstream of the junction (Figure 2). As a next step, the analysis will be extended by studying the dependence of saltwater intrusion on the depth of the downstream channels. This will further improve our understanding of saltwater intrusion in estuarine channel networks such as commonly found in low-lying deltas.

References

Buschman, F. A., Hoitink, A. J. F., van der Vegt, M. and P. Hoekstra (2010). Subtidal flow division at a shallow tidal junction. Water resources research, 46, doi:10.1029/2010WR009266

[1] Department of Physical Geography, Faculty of Geosciences, Utrecht University, the Netherlands. M.vandervegt@uu.nl and rinse.deswart@planet.nl

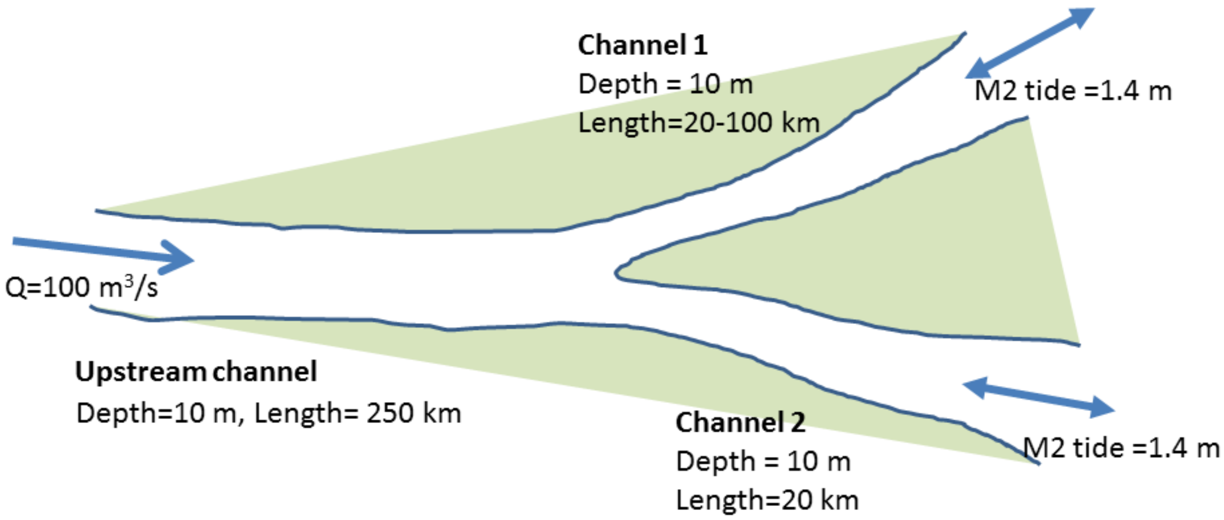

Figure 1. Schematic geometry of idealized estuarine channel network in Delft3D.

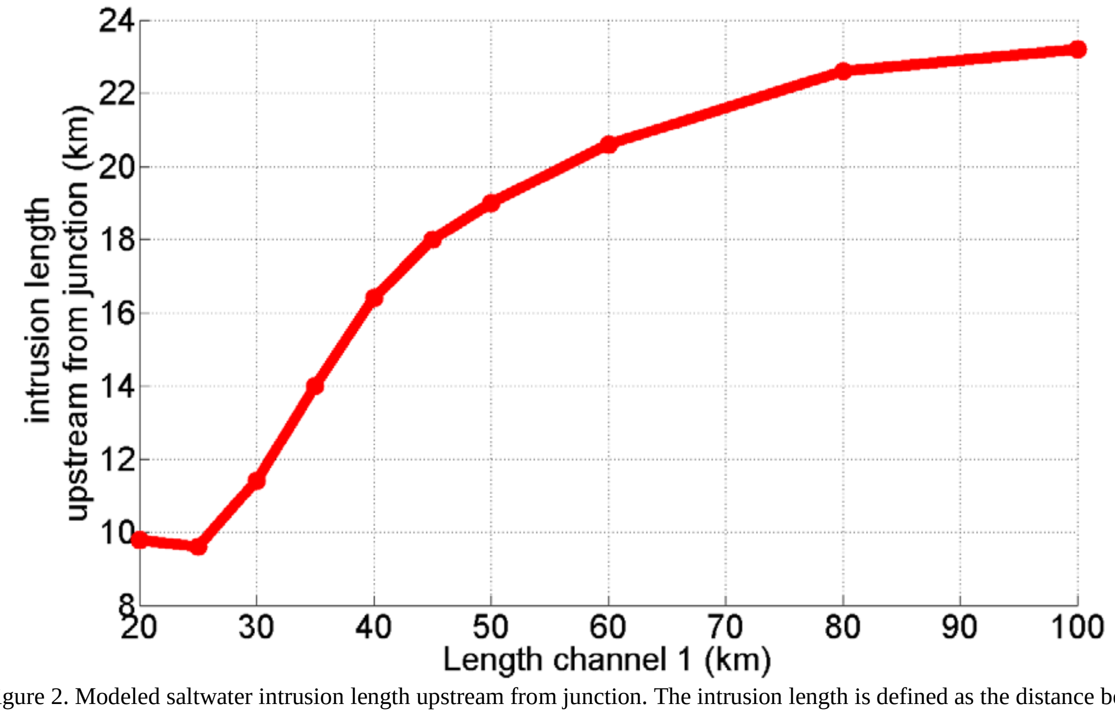

Figure 2. Modeled saltwater intrusion length upstream from junction. The intrusion length is defined as the distance between the tidal junction and the location where the tidally- and cross-sectionally averaged salinity is 1 PSU. Intrusion length is displayed for changing the length of Channel 1, while keeping the length of Channel 2 at 20 km.