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Salt intrusion in an estuarine network, a study with an exploratory model

Huib E. de Swart and Inge van Tongeren
Utrecht University, Inst. of Marine and Atmospheric Research, Physics, Utrecht, Netherlands (h.e.deswart@uu.nl)

Many estuarine systems experience increased salt intrusion, which is harmful for ecology and agriculture and may cause problems for fresh water supply to cities. Some causes of salt intrusion are extraction of fresh water in the upper reaches of the estuary and climate change. Besides, anthropogenic measures, like deepening of channels, are known to have a strong impact on the salt balance.

This contribution focuses on salt intrusion in estuarine networks, which consist of multiple connected channels. The motivation of the study arose from observations in the Yangtze estuary that reveal frequent overspill of salt between its different channels. To understand the underlying physics of such behaviour, an exploratory, width- and tidally averaged model has been developed and analysed. This model describes the competition between export of salt by river flow and import of salt by density-driven flow and horizontal diffusion. Its key new aspect is that it generalises an earlier model MacCready (2004) from a single channel to estuarine networks. The new model calculates the distribution of salt in, and salt exchange between the channels, as well as the distribution of river water over the different channels.

Here, results will be presented for a simplified estuarine network consisting of the South Channel, South Passage and North Passage of the Yangtze Estuary. It will be shown that, for the present-day situation, dry season and spring tide, salt intrusion is larger in the South Passage than in the North Passage. As will be explained, this is mainly due to the different geometry of the two channels. Furthermore, it will be shown that there is slightly more river water transport through the South Passage than through the North Passage, except during high river discharge and neap tide. These results agree with field data and results from numerical studies.

Other results that will be presented are the sensitivity of salinity intrusion length and distribution of river water over the different channels to changes in, respectively, upstream river discharge, tidal currents and human interventions. Specifically, the effects of the creation of a Deepwater Navigation Channel in the North Passage on salt dynamics will be shown and discussed.

Reference:
MacCready, P. 2004. Toward a unified theory of tidally-averaged estuarine salinity structure. Estuaries 27, 561-570.