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Salt intrusion in the Pearl River Estuary (China) during the dry season and the onset of the monsoon

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Adequate freshwater supply is vital to support the development of estuaries and deltas throughout the world. However, it is often threatened by saltwater intrusion, which results from the interaction of water and salt dynamics. A better understanding of estuarine dynamics is therefore critical in order to manage the effects of climate change and human interventions on estuarine ecosystem and freshwater resources.

We focus here on a case study in the Pearl River Estuary (South China Sea), a region which has seen some of the most rapid urbanization in human history over the last forty years and which has become the largest contiguous urban region in the world. At present, saltwater intrusion endangers freshwater availability for over 40 million people, especially during the dry season. The Pearl River Estuary presents a complex shape, both in terms of bathymetry and geometry, making salt transport a three-dimensional process. Previous research on this estuary has mostly been limited to the longitudinal variability and non-time dependent forcing. In this study, we present results from a three-dimensional estuarine numerical model in order to unravel the interwoven longitudinal and lateral salt transport processes as well as their transient evolution.

We implemented the FVCOM (Finite Volume Community Ocean Model) to the entire Pearl River Delta using an unstructured grid with a resolution ranging from about 200 km at the open ocean boundary to 20 m in the narrow channels in the upper reaches of the delta (allowing around five points across section). Numerical simulations cover the period from October 2007 to June 2008, thus focusing on the dry season and the onset of the monsoon and providing insight into the transient dynamics of the estuary. The bathymetry is generated from a set of surveys performed in 2008 in order to produce the most accurate representation of the delta at the time of the simulation. The model is forced by water elevation at the open ocean boundary. We specify freshwater inputs using daily measurement data from upstream hydrological stations. The initial and boundary salinity conditions are derived from outputs of the HYCOM model. The model is validated and calibrated against water level and salinity measurements available over the same time period.

Numerical results from a series of numerical simulations presented here provide a detailed picture of the 3D salt dynamics both during time-independent conditions and during transient conditions. Early results show temporal variability at different scales, in particular with a dependence of salt intrusion length on spring-neap cycles. We will also present the influence of various forcing mechanisms, both individually and in conjunction with others. These results will help determine which conditions favour or inhibit the development of salt intrusion, as well as its sensitivity to the changes in those conditions. This knowledge will aid with estuary management and will help in identifying possible alleviating measures.