QUANTIFYING THE EFFICIENCY OF TIDAL EXCHANGE AND SALT DISPERSION IN A HARBOR BASIN

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INTRODUCTION

Desalination contributes to the climate change adaption and increases resilience in all those circumstances in which water scarcity has been exacerbated severely in recent decades. Desalination is the process of removing salt from seawater or brackish water for a range of usage, including drinking. However, desalination produces a by-product, brine (a concentrated salt solution) that must be properly disposed of to avoid adverse impacts on the marine environment. In fact, emergency desalination facilities are popular when a sudden drought happens; it's easy to install and can provide instant drinking water resource, but most of them are installed at harbor areas since there is no time to construct offshore brine outfall pipes, which means brine will be discharged into harbor water directly. In this study, tidal dispersion and the horizontal exchange of water between Kaohsiung Harbor and the surrounding ocean are examined with a three-dimensional high-resolution (the vertical/horizontal grid resolution is 1m/40 m) numerical model. The Port of Kaohsiung is the fifteenth largest container port in the world, and thus plays an important role to economic development. The harbor has two inlets connecting to the sea (indicated as North Boundary and South Boundary in Figure 1) and one fresh river inflow (indicated as River Boundary). There are 97 docks totalling 20.570 meters in length. The strongly varying bathymetry and coastline geometry of the harbor generate complex spatial patterns. In this study, Lagrangian exchange experiments were conducted to demonstrate that tidal currents exchange and mix material near the inlets of the harbor.

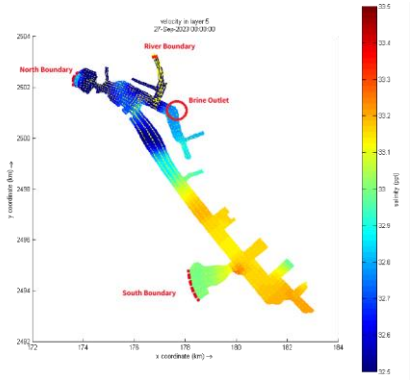
NUMERICAL MODEL

The model used in this work is the Delft3D-Flexible Mesh (Delft3D) modeling suite, developed by Deltares of the Netherlands (http://oss.deltares.nl/web/delft3d/home). This modeling suite includes the widely used hydrodynamic model Delft3D. The tidal constituents in the ocean boundary were provided by the global tidal level forecast of Oregon State University (TPXO9_atlas_v4 data) (Martin et al., 2009). The work contained in this study focuses primarily on the urban area of the Kaohsiung city in the northern harbour and the industry park in the southern harbour.

RESULTS

The salinity distribution in a harbour basin depends on the balance between the river outflow, which is directed seaward, and a dispersive salt flux, which is directed landward. Brine-release simulations from two selected site demonstrate that while the tides efficiently exchange material in the vicinity of the harbour, the nature of salt dispersion from point sources is sensitive to the location of the release. This suggests that high-resolution modeling of salt dispersion from point sources in these regions must be performed explicitly and cannot be parameterized as a plume with conventional Gaussian-spreading in a larger scale flow field. Figure 1 (a) shows when brine was released ($0.23 m^3 s^{-1}$) in the urban area, the salt water accumulated in the inlet entrance due to the relatively small tidal range (the amplitude of M2 tide is approximately 0.16m). The fresh water discharge from the river ($0.54 m^3 s^{-1}$) also play an important role in desalinating the brine. However, when the brine water was released from the industrial park Figure 1 (b), the salt water was accumulated in the southern part of the harbour basin. This tidal mixing zone extends roughly a tidal excursion distance from the inlets and may affect the overall flushing of the harbour.

(a)



(b)

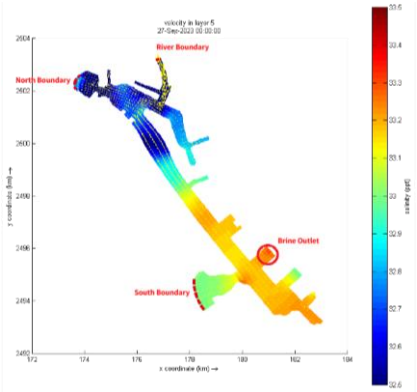


Figure 1 brine-release simulations from two selected site: (a) the urban area (b) the industrial park (shown in the red circle).

REFERENCES

Martin, Paul J., Smith, Scott R., Posey, Pamela G., Dawson, Gretchen M., Riedlinger, Shelley H. (2009): Use of the Oregon State University Tidal Inversion Software (OTIS) to generate improved tidal prediction in the East-Asian seas, Stennis Space Center, MS, 39529-5004.