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Storm surge modelling by Delft3D FM – a case study in Shanghai area

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Background

East China Sea is one of the largest marginal seas in the western North Pacific Ocean, and is noted for high levels of primary productivity and for the tremendous extent of river runoff into the sea, notably from the Yangtze River (Ichikawa & Beardsley, 2002). It has the flattest and widest continental shelf in the world, which is bounded to the north by a line running northeast from the northern edge of the Yangtze mouth to the southeastern tip of Korea, to the east of the Ryukyu islands chain and Kyushu, to the south by Taiwan, and to the west by the east coast of the mainland of China. Runoff, tides, winds, the continental-shelf currents and topography are the main controls on hydrodynamic processes in the Yangtze Estuary.

Research Objective

To set up a hydrodynamic model and examine tides and storm surge during typhoon period in Yangtze Estuary and adjacent area.

Model set-up

Storm surge model

Computational unstructured grid

Typhoon model

Spatial varying air pressure and wind fields were constructed using the parametric cyclone model by Holland (1980). The pressure fields are given by:

\[ \frac{\Delta P}{P_n} = k_1 \exp \left( - \frac{R_m}{R_{WMC}} \right) \]

Where \( \Delta P \) is the air pressure at radius \( r \), \( P_n \) is the central pressure, \( P_m \) is the ambient pressure, \( R_{WMC} \) is the radius of maximum wind (RWM), and it is the hurricane shape parameter, which can be estimated by empirical relationships or taken as constant. In this study, \( P_n = 1013.25 \text{mbar}, R_{WMC} = 1.563. \)

In case of no RWM data in the track information, the relation of Tagaki and Wu (2016) is used to estimate this as shown in Fig. 3. The behaviour of typhoon Winnie in 1997 and Typhoon Fitow in 2013 was hindcast using typhoon data from JMA and JWTC, respectively. Since PVTM Sea data for typhoon Fitow in 2013. The wind fields are given by:

\[ V = \frac{1}{2} C_d \frac{\rho_{air} W^2}{\rho_{water}} \]

Where \( V \) is the maximum wind speed, \( \rho_{air} \) is the air density, \( \rho_{water} \) is the water density.

Boundary conditions

Shallow topography adjacent to the river mouth causes denser co-phase lines and a reduction in the velocity of the tidal wave. In the Yellow Sea, the tide rotates with two nodal points, with the southern node having a dominant influence on the northern Yangtze Estuary. The boundary conditions were taken from the Yellow Sea Model (P.K. Tonnon, 2006). The storm surge could be more accurately modelled if the effect of waves is incorporated.

Validation for Typhoon Winnie in 1997

Validation for Typhoon Fitow in 2013

Results

Conclusions

• Currently, the hydrodynamic model to examine the tide and storm surge have been set up, calibrated, and validated.
• Bathymetry data and bottom roughness affect the model results significantly; updated annual bathymetry data is required in the study area if they are available.
• The storm surge could be more accurately modelled if the effect of waves is incorporated.

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