COMPOSITE MODELLING APPROACH TO STUDY COMPOUND FLOODING IN COASTAL AREAS

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Paper Content

- **INTRODUCTION** *(about the opportunities and strengths of composite modelling and the objective of the present study)*
- **CASE STUDY I: Asparuhovo-Karantina coastal area (Black Sea, Bulgaria)**
- **CASE STUDY II: Protective dike at Beilun coast (CHINA)**
- **CONCLUSIONS**

INTRODUCTION (and objective of the study)

"Composite Modelling" – one modern approach that skillfully integrates physical modelling, numerical simulations, and verification with field measurement data, to improve modelling and achieve a reliable forecast of inundation in floodplain areas at different scenarios of the initial conditions.

Each element of composite modelling can complement others and add value to the entire study, with different modeling tools being used for each type of modeling (for example, different software programs for numerical modeling of processes).

INTRODUCTION (and objective of the study)

<u>The objective of the study</u> - test two approaches of composite modeling and respectively the using of two numerical tools for numerical simulation of coastal flooding in urban and estuarine area in <u>coastal region of Bulgaria,</u> and overtopping of coastal dike under combined effect of storm surge and waves in <u>coastal region of China</u>.

CASE STUDY I: Asparuhovo-Karantina coastal area (Black Sea, Bulgaria)

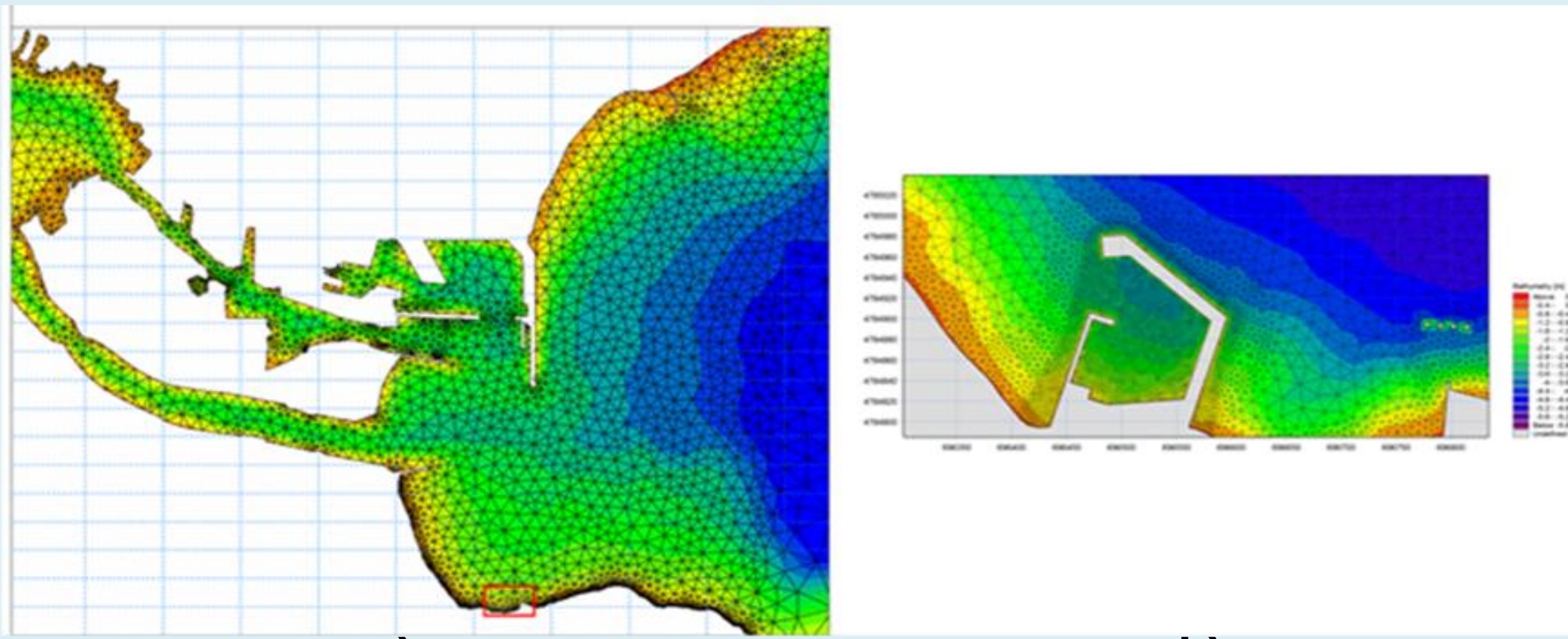
Case Study Area near Varna, Bulgaria

CASE STUDY I: Asparuhovo-Karantina coastal area (Black Sea, Bulgaria)

Numerical modelling by MIKE 21:

- ➢ **MIKE 21 SW (Spectral waves)**
- ➢ **MIKE 21 BW (Boussinesq Waves)**
- ➢ **MIKE FLOOD**

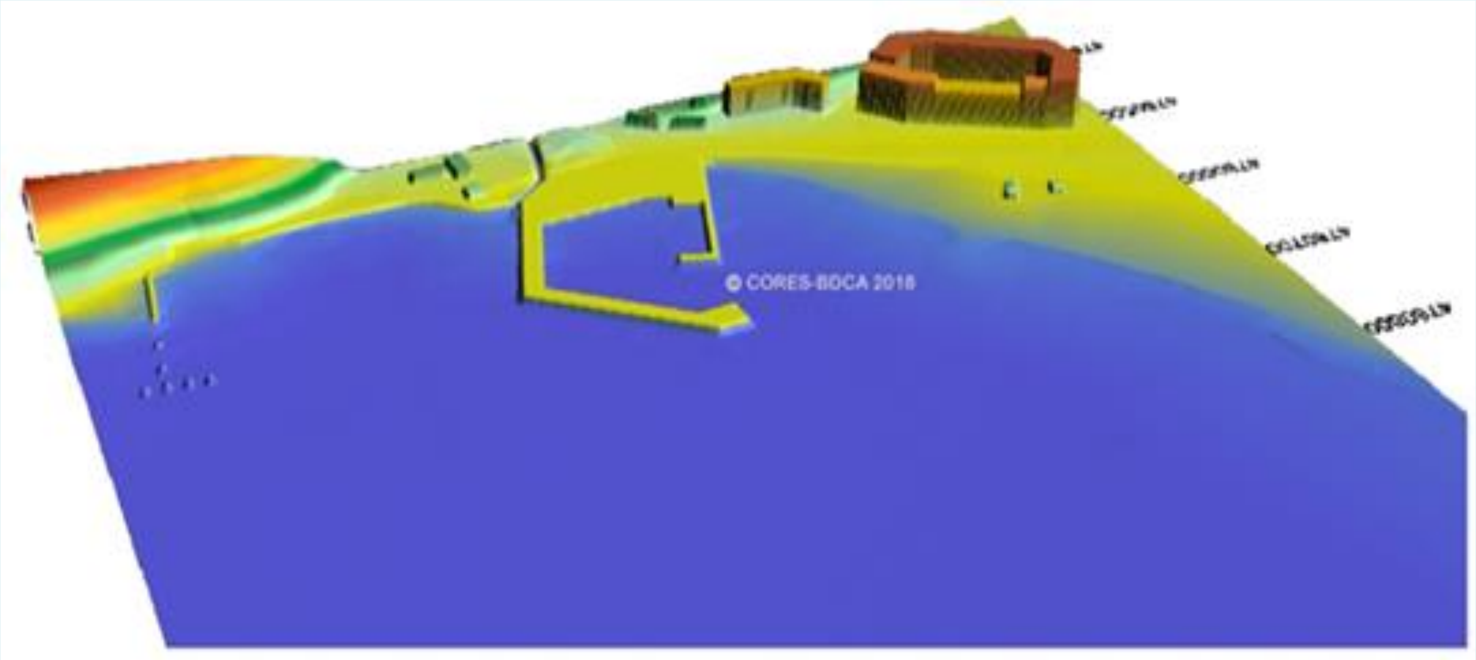
CASE STUDY I: Asparuhovo-Karantina coastal area (Black Sea, Bulgaria)



a) b)

Unstructured flexible mesh for MIKE SW simulations:
a) Varna bay - regional scale; b) Asparuhovo beach area and fishing harbor Karantina – local scale

CASE STUDY I: Asparuhovo-Karantina coastal area



3D Visualization of the Digital Elevation Model (DEM) of the Asparuhovo beach and residential area, including sea bathymetry, sand beach, terrain, roads, buildings, fishing harbor and a small river

CASE STUDY I: Asparuhovo-Karantina coastal area

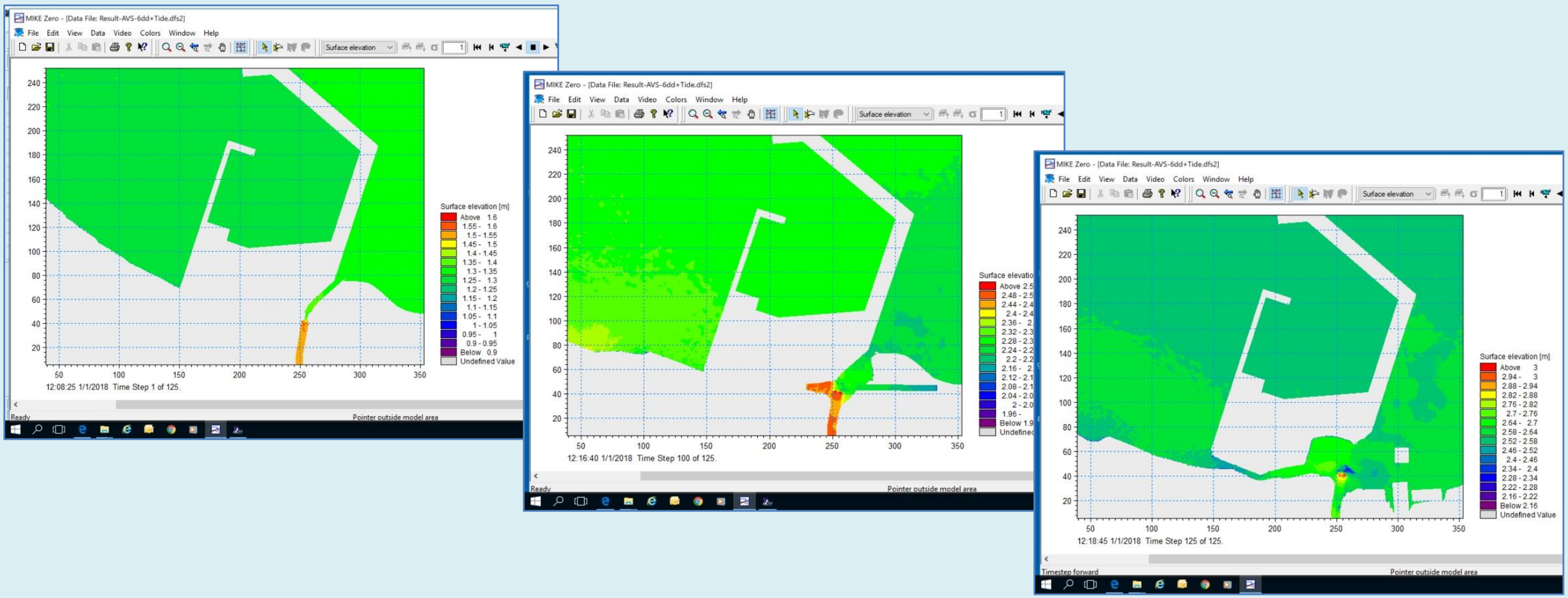


Illustration results of tests by MIKE FLOOD model of compound coastal & fluvial flooding in Asparuhovo - Karantina area

(Sea level rise by storm surge and water coming from the small river)

CASE STUDY I: Asparuhovo-Karantina coastal area

Conclusions:

- **The results obtained by MIKE 21 (SW, BM, MIKE FLOOD) numerical modeling of compound flooding (combination of rising sea level and river overflow) in case area (Bulgaria) are in good correspondence with the provided statistical & field observation data.**

- **This approach of composite modelling *(numerical modelling with field data to build high resolution DEM and statistical & field observation data to "optimization" of numerical model)* can be used to develop coastal flood protection projects.**

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CASE STUDY II: Protective dyke at Beilun coast (CHINA)

Case study area near Beilun sity, China

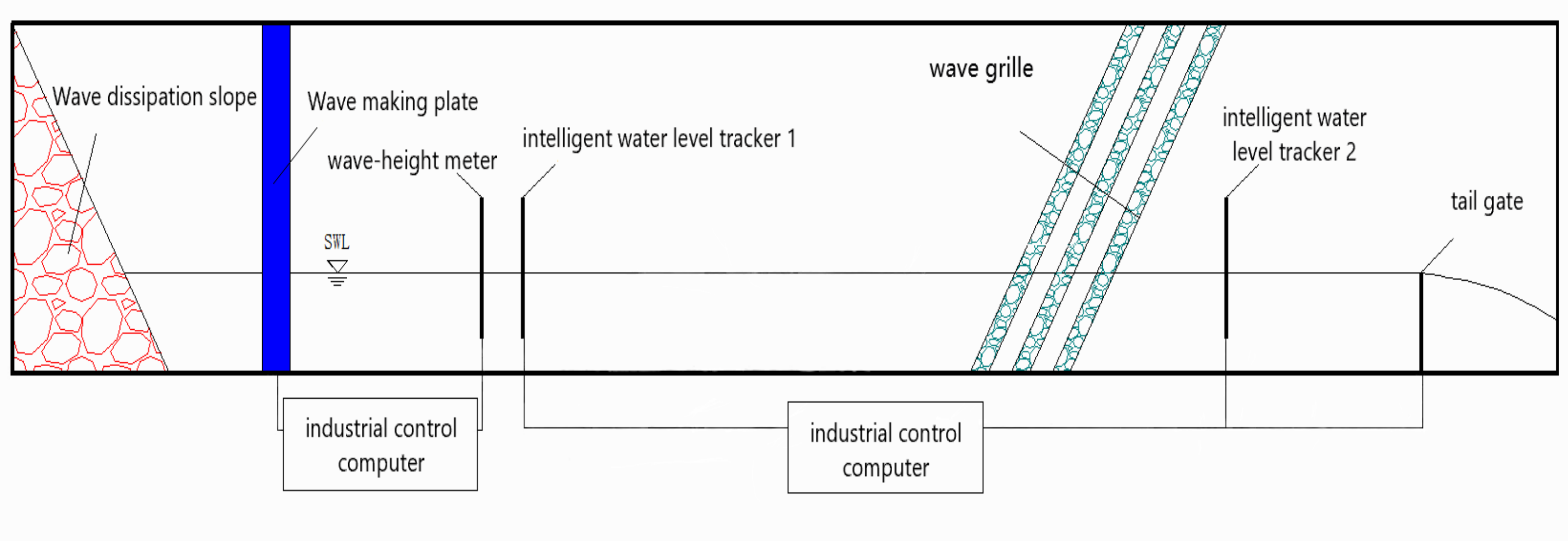
Subject of the study:

To assess the transmission (overtopping of coastal dike under storm surge - combined effect of tidal water level changes and waves).

For this case study, composite modeling was applied using physical model and numerical simulations.

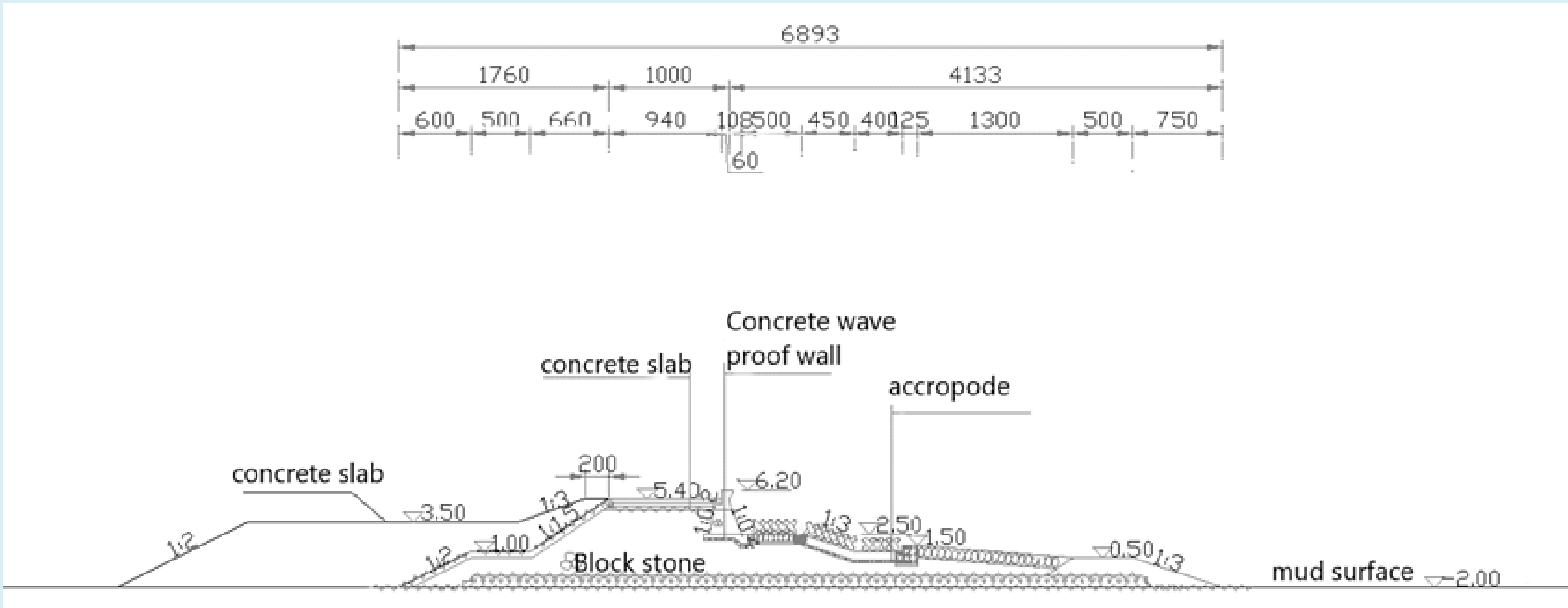
CASE STUDY II: Protective dyke at Beilun coast (CHINA)

<u>Physical modeling</u> – in the long wave flume (175x1,2x1,8) m of *State key laboratory of hydrology-water resource and hydraulic engineering in NHRI (China).*



Scheme of wave flume arrangement

CASE STUDY II: Protective dyke (sea wall) at Beilun coast (CHINA)

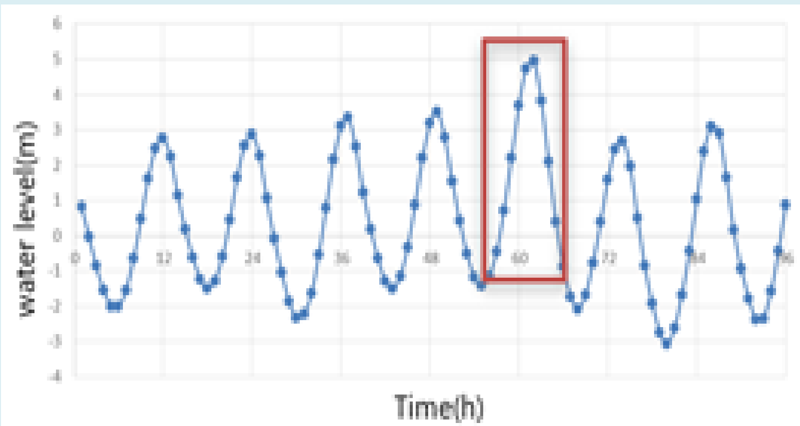


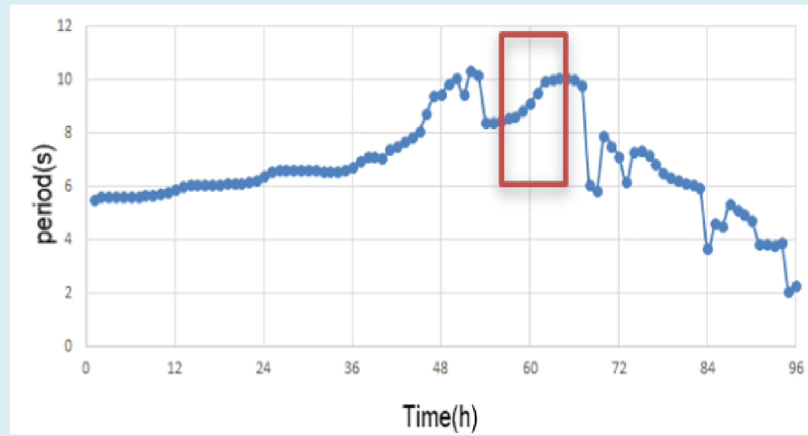
Sea wall cross section in Beilun

Scale of the physical model - 1:16

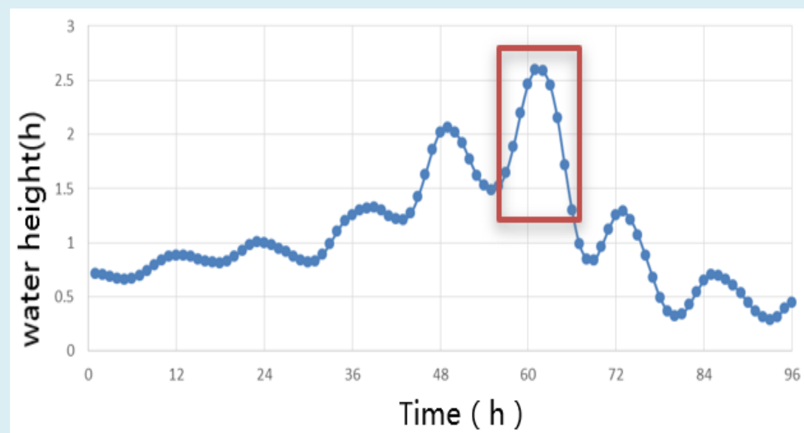
CASE STUDY II: Protective dyke at Beilun coast (CHINA)

Boundary conditions of study was based on Typhoon Winnie (No. 9711), return period 1/100 years, field data for 4 days duration.



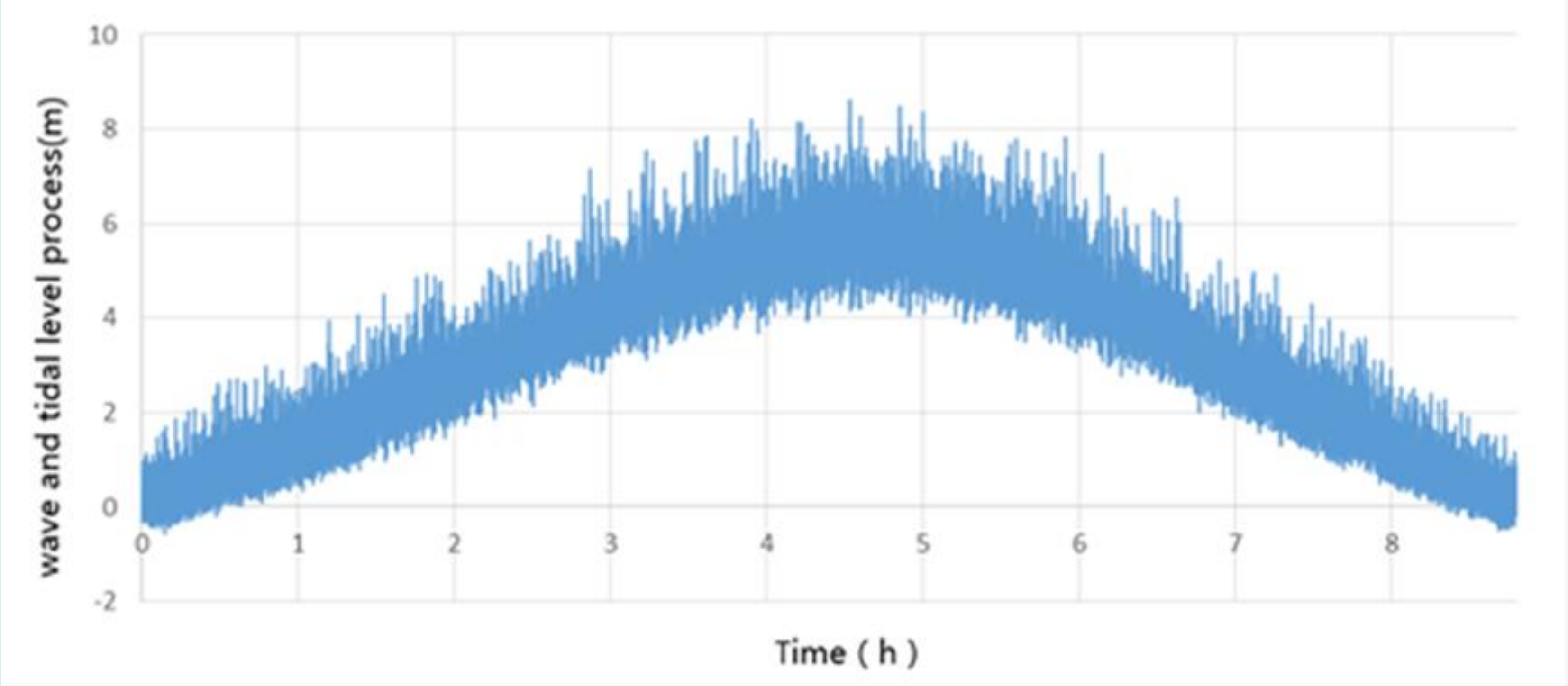


Water level, wave period and
wave height during typhoon Winnie



The <u>**red frame range**</u> is the selected time period (9 hours) for simulation during the model tests.

CASE STUDY II: Protective dyke at Beilun coast (CHINA)



The prototype hydrograph for laboratory simulation of waves + tidal level changes

CASE STUDY II: Protective dyke at Beilun coast (CHINA)

Numerical Modelling by SWASH (v. 5.01)

Parameters:

- Length of numerical model domain - 200 m
- dx = 0.02 m
- One layer in vertical direction (kd<3)
- A Sommerfeld radiation condition and sponge layer - at the downstream end of the numerical domain to minimize the effect of the reflection.
- The automatically changed numerical time step during SWASH calculations to satisfy the Courant–Friedrichs–Lewy (CFL) condition
- A Manning coefficient: n=0.012 s/m1/3

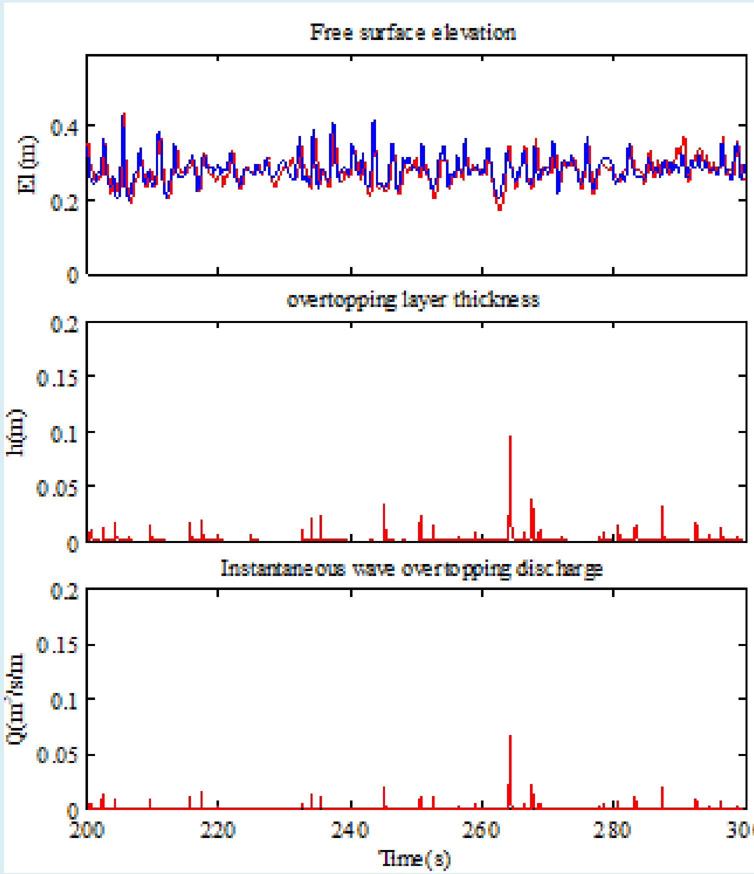
CASE STUDY II: Protective dyke at Beilun coast (CHINA)

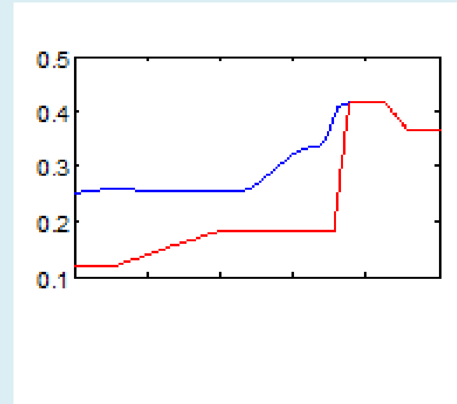
Numerical results - time series of:

- ✓overtopping layer thickness, **h(t),**
- ✓overtopping velocity, **u(t)** on top of the wave wall
- ✓overtopping discharge **Q(t)** per unit length

Qualitatively comparison using video images from the physical model:

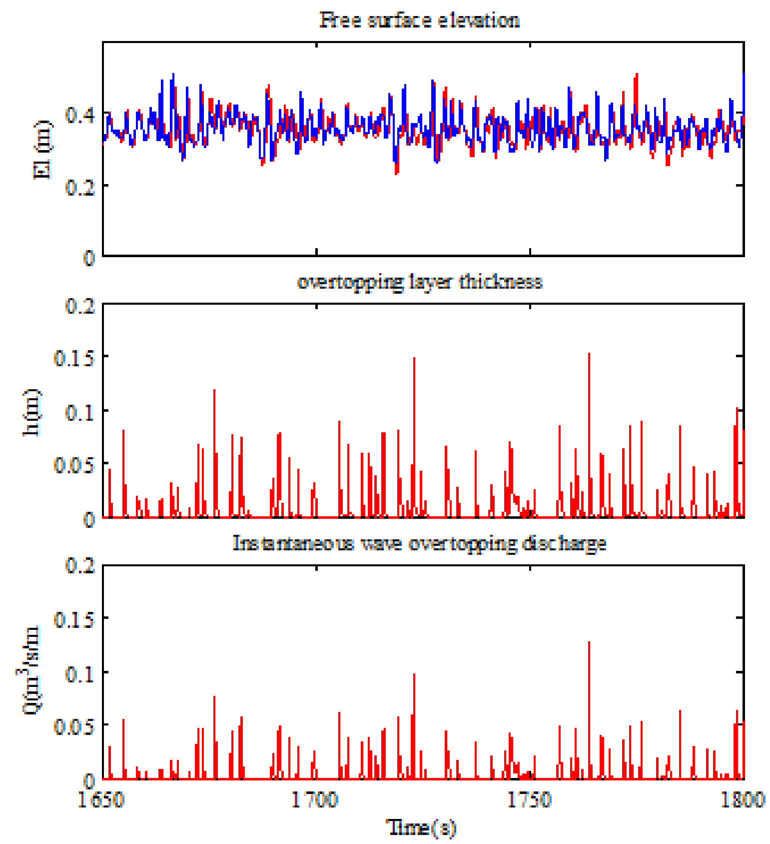
CASE STUDY II: Protective dyke at Beilun coast (CHINA)

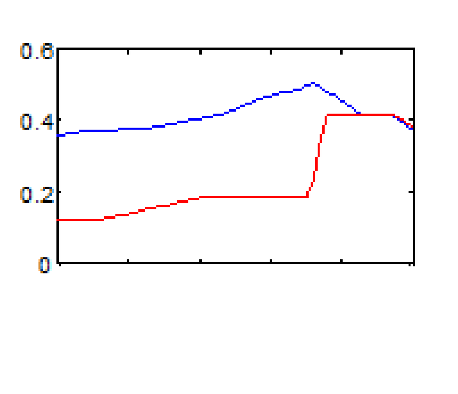




Measured (blue line) and computed (red line) free surface elevation, overtopping layer thickness, instantaneous overtopping discharge at the prototype <u>water level 3.7 m</u>

CASE STUDY II: Protective dyke at Beilun coast (CHINA)





Measured (blue line) and computed (red line) free surface elevation, overtopping layer thickness, instantaneous overtopping discharge at the prototype <u>water level 5.01 m</u>

CASE STUDY II: Protective dyke at Beilun coast (CHINA)

Conclusions:

- **Overtopping of the sea dyke in coastal region in China under compound impact of sea level variation (tide and storm surge) and waves is studied by composite modelling using SWASH numerical model and physical model tests in wave flume;**
- **Numerical results indicated that using a phase resolving numerical model (SWASH) could provide the wave overtopping which compared well with the physical model tests.**

Thank you for your attention