COMPARATIVE STUDY OF NUMERICAL SIMULATION OF COASTAL FLOODING IN URBAN & ESTUARINE AREAS

J.N. Pan[*], V. Penchev[**], J.S. Zhang[*], F. Penchev[**], M.J. Xiong[*],

D. Dragancheva[***], S. Shukrieva[**], D.T. Wang[*], J.H. Wang[*]

*** NHRI, PR of China**

**** BDCA Bulgaria**

***** BSHC, IMST – BAS, Bulgaria**

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Paper Content

- Background and objective of the study
- Modeled area
- Models and results
- Conclusions

Background and objective of the study

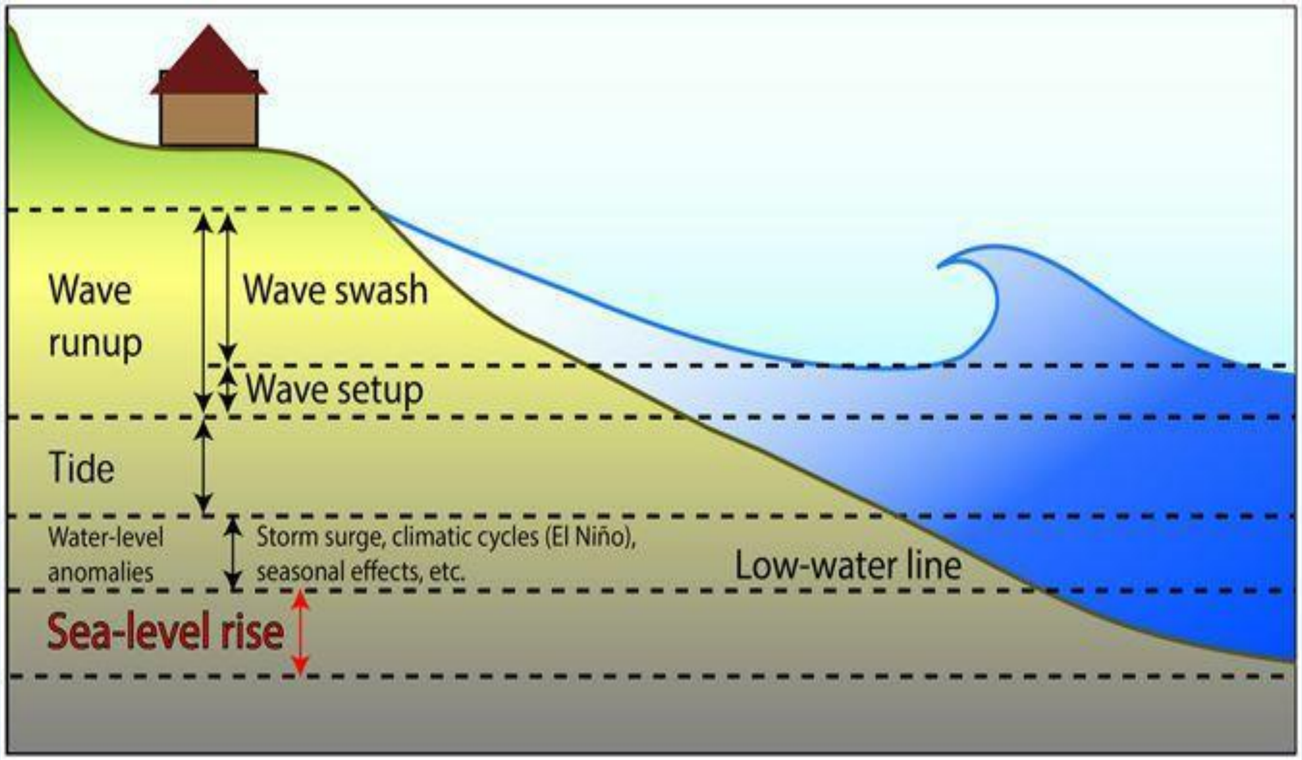
Climate change impact on coastal cities – it change hydrology and hydrodynamics of coastal area, by:

- **High velocity winds**
- **Intensive rainfall, run-off**
- **Increased storm intensity and frequency**
- **Changes to wave size and direction**

The results on coastal zones are:

- ***Coastal floods***
- ***Extensive erosion of beaches***
- ***Impact on marine ecosystems at risk***

Coastal flooding mechanism (sketch diagram)



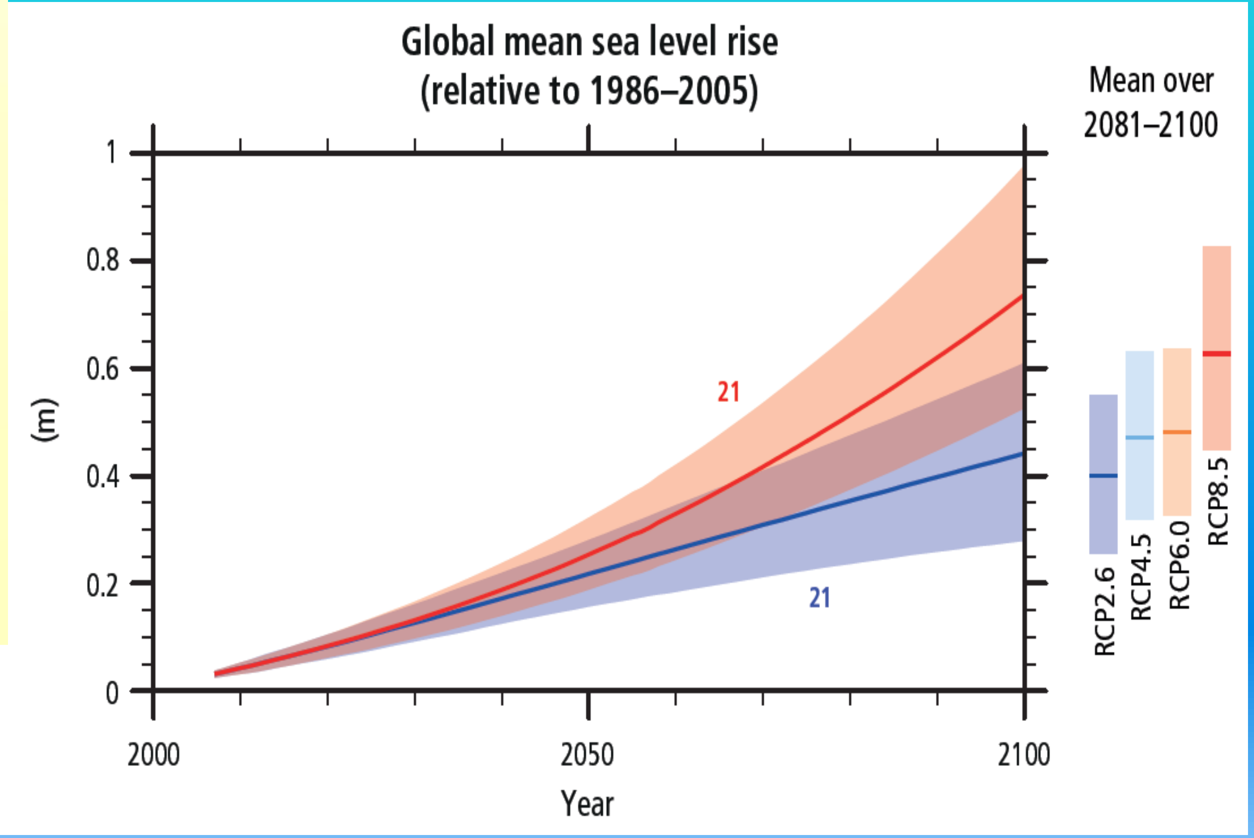
The two major factors acting on SLR are:

- Ice Melt (more water, more mass)
- Heat (Thermal Expansion – more volume)

Background and objective of the study

Sea-Level Rise (SLR)

Global mean **SLR** from 2006 to 2100 as determined by multi-model simulations (*5th Assessment Report of the Intergovernmental Panel on Climate Change (AR5 / IPCC*)



Basic milestones
needed to solve the problem of urban flooding
in coastal and estuarine areas

- ✓ Providing of comprehensive set of **data**
- ✓ Determination of **worst scenarios** including climate change (sea level rise; increased probability of storms)
- ✓ Combine **various modelling tools** to verify climate change aspects
- ✓ **Calibration / Verification** of numerical models is needed

Object of this study is to test two approaches for numerical simulation of coastal flooding in urban & estuarine area using two different numerical tools:

- **MIKE21/MIKE FLOOD** ***developed by DHI (Danish Hydraulic Institute)***
- **SWASH** ***developed by NHRI (Nanjing Hydraulic Research Institute), China***

Modeled area

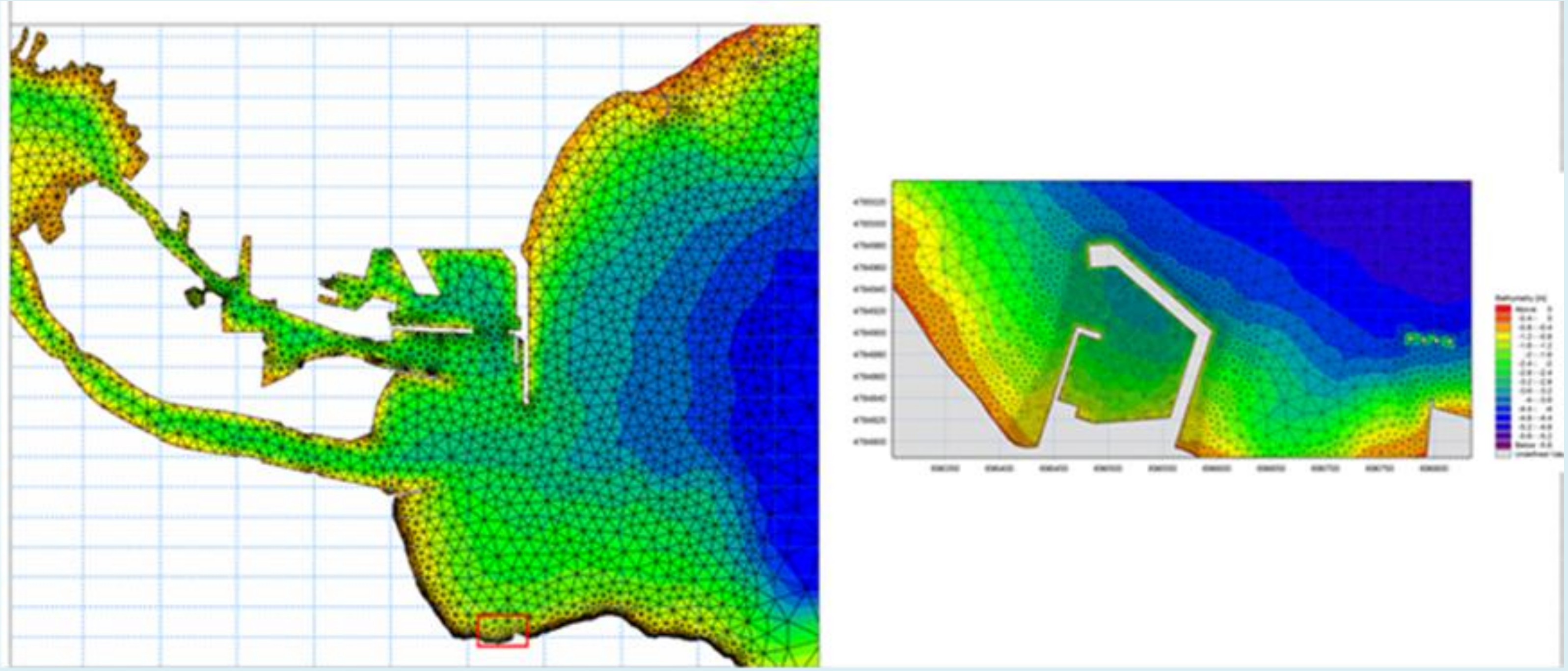
Asparuhovo-Karantina (Varna, Bulgaria)

Models and results

MIKE 21 approach:

- **MIKE 21 SW (Spectral waves) - third generation spectral wind-wave model that simulates the growth, decay and transformation of wind-generated waves and swells in offshore and coastal areas.**
- **MIKE 21 BW (Boussinesq Waves)**

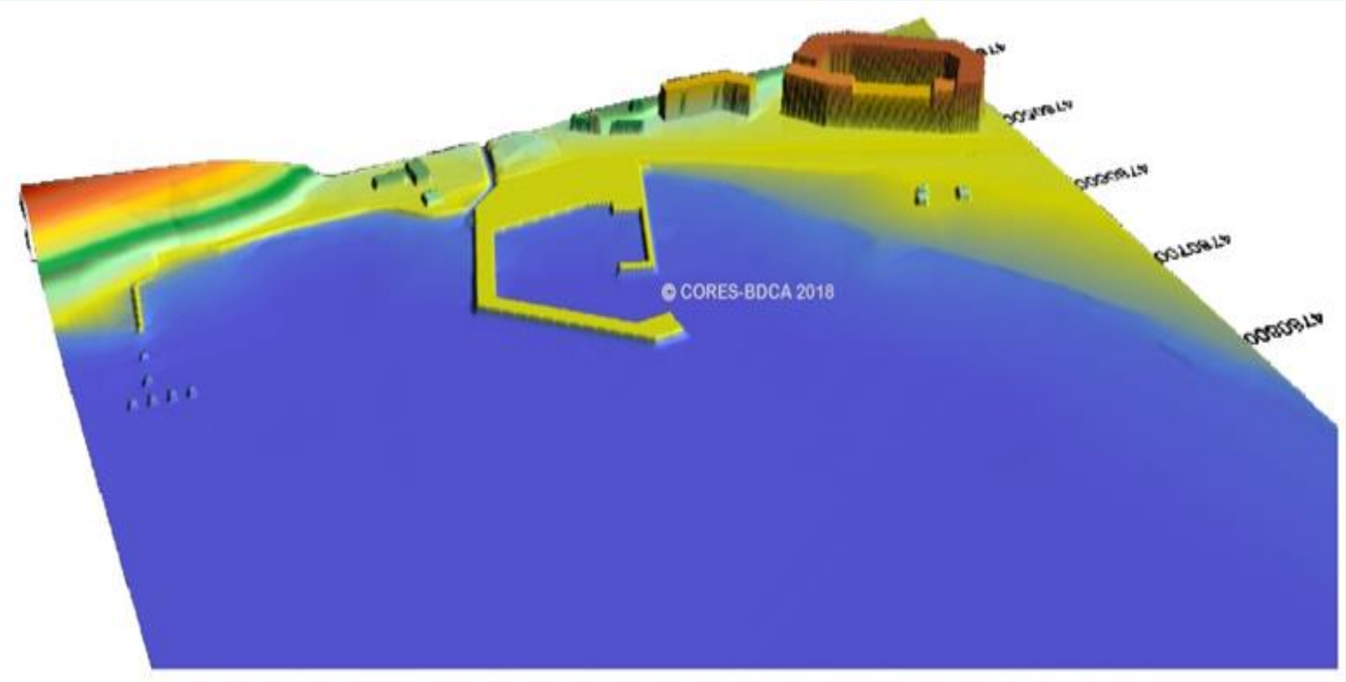
Models and results



Unstructured flexible mesh for MIKE SW simulations:

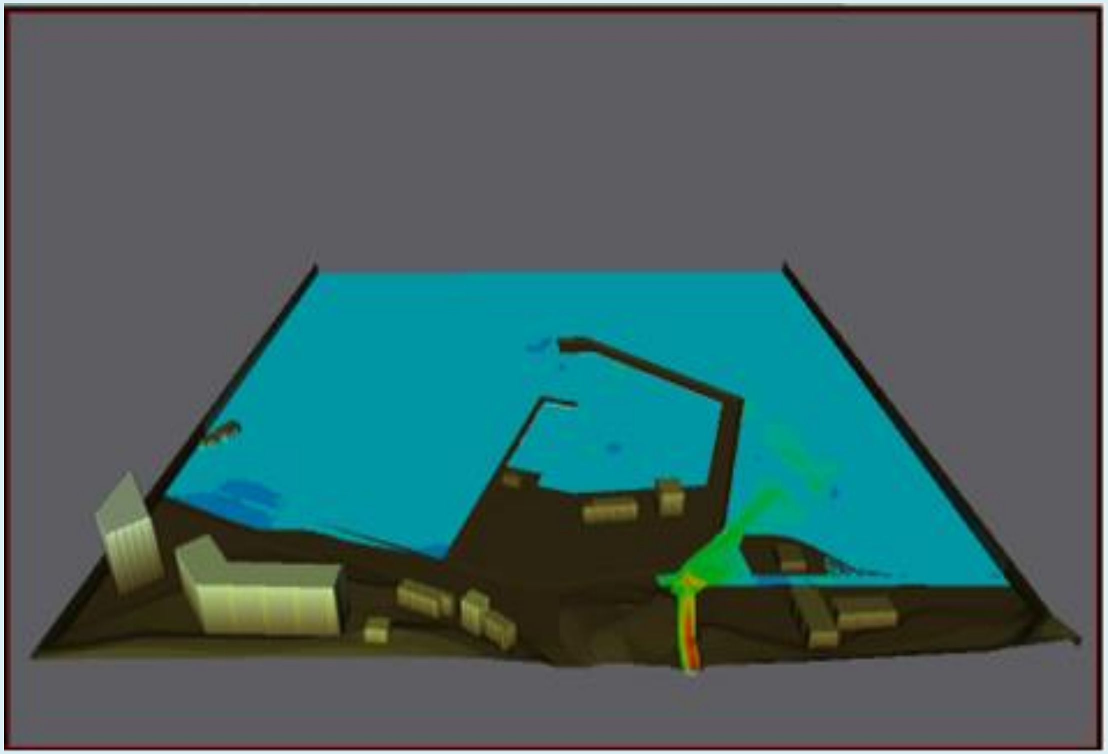
a) Varna bay; b) Asparuhovo beach area and fishing harbor Karantina

Models and results



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

Models and results

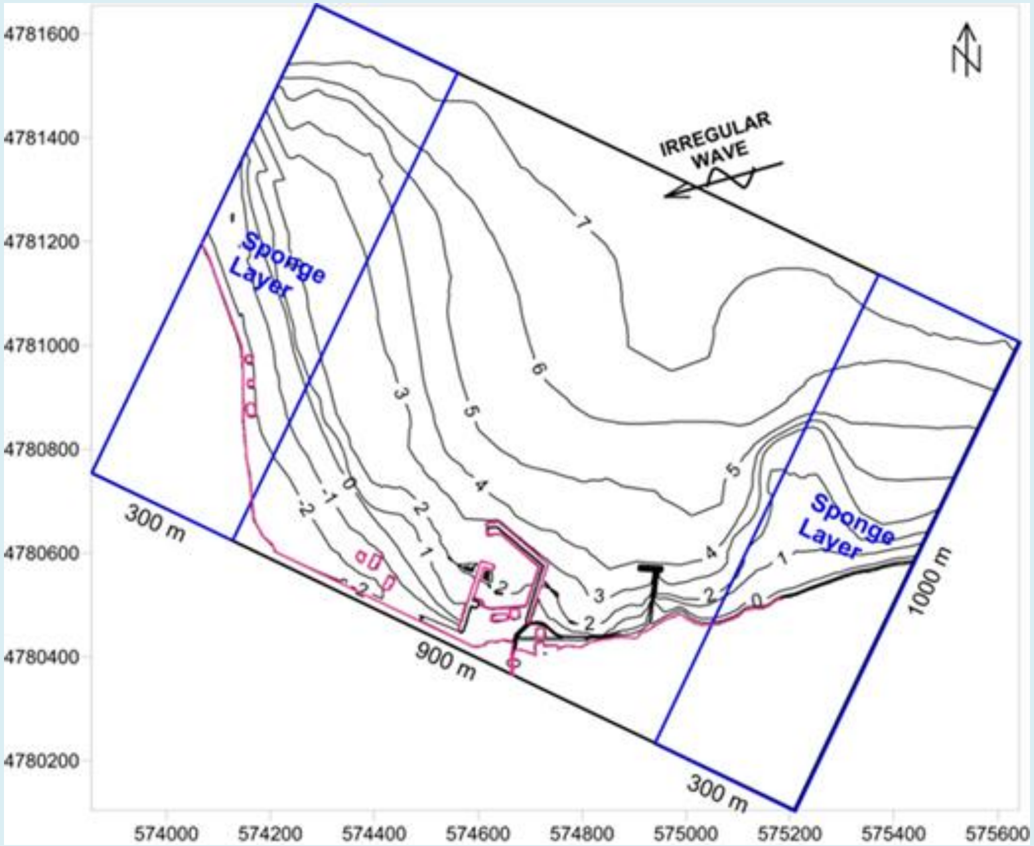


Example results of calibration tests by MIKE FLOOD model of compound coastal & fluvial flooding in Asparuhovo - Karantina area

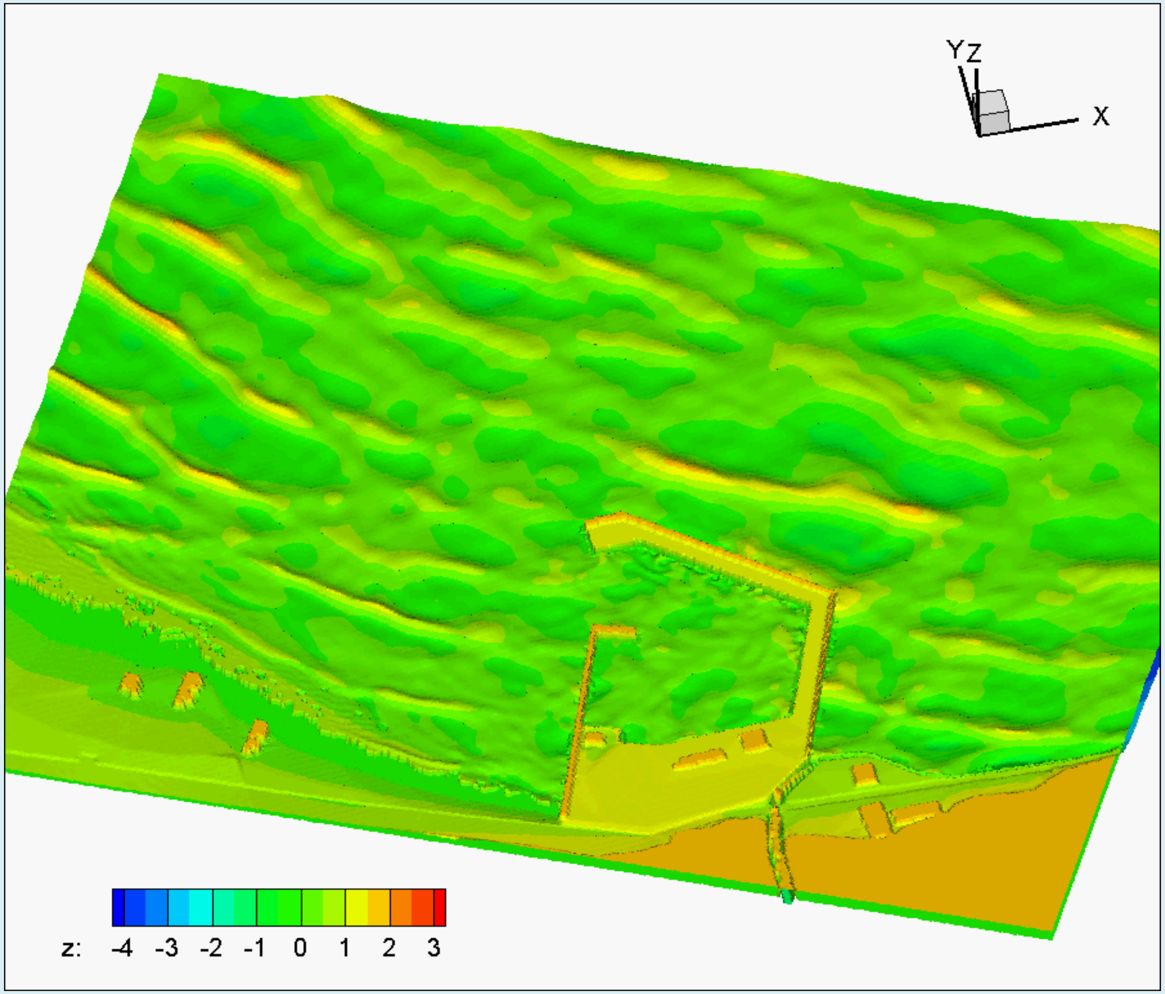
(Sea level rise and water coming from the small river)

Models and results

SWASH approach: wave transformation in coastal area

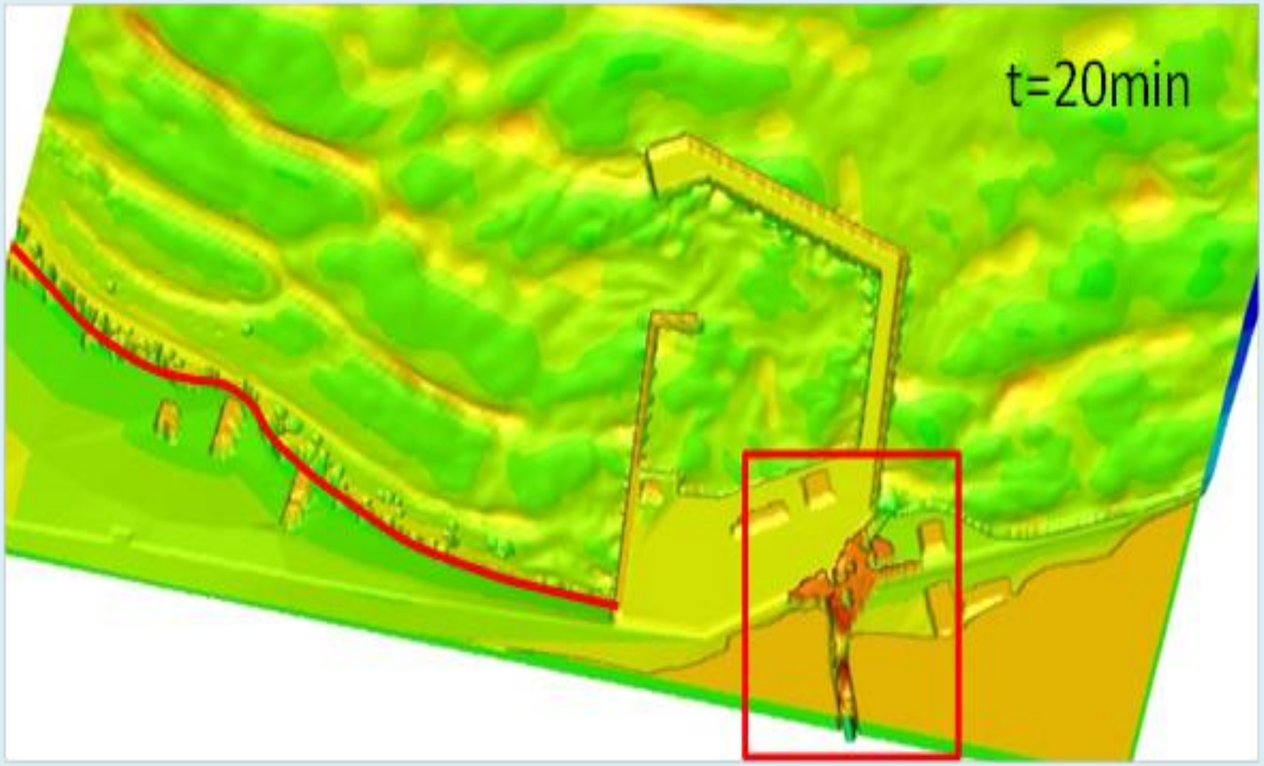


Schematic view of SWASH model domain



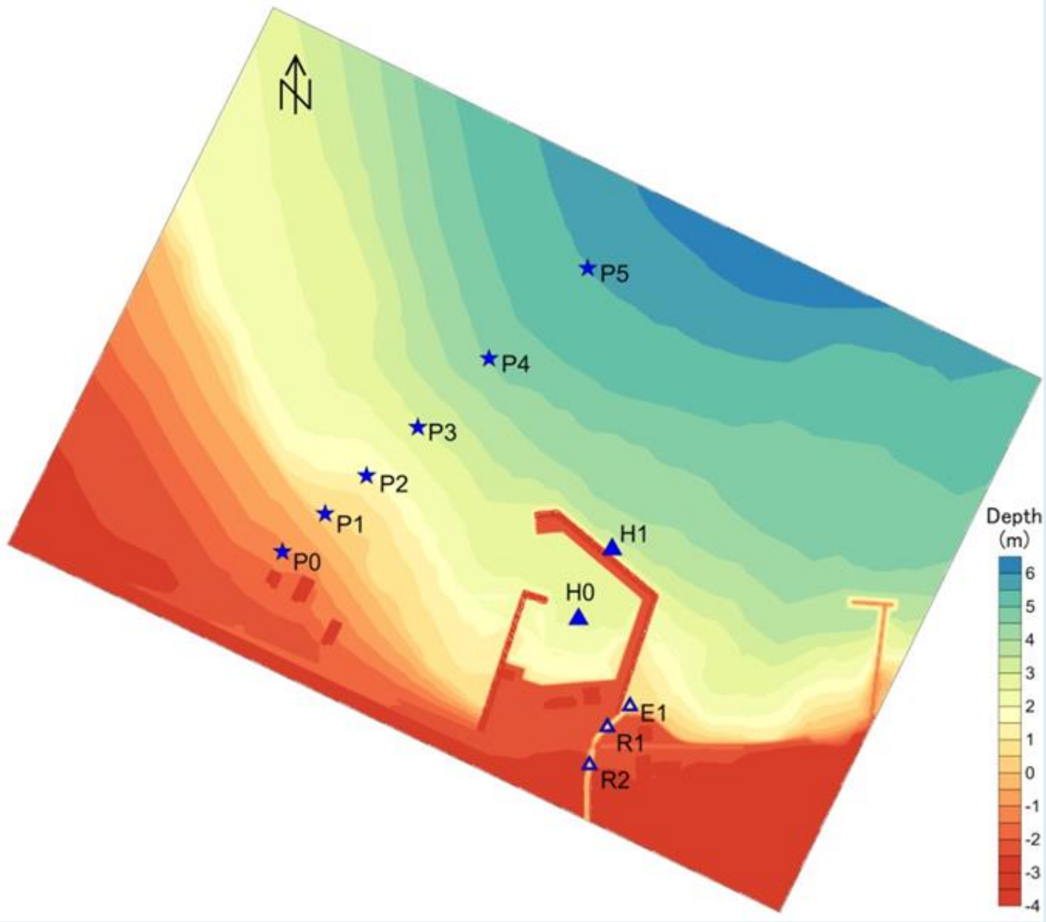
Y
Z
X
z: -4 -3 -2 -1 0 1 2 3

Models and results



Detailed results of flooding by SWASH in Asparuhovo - Karantina coast (after 20 min. simulation period)

Models and results



“Virtual” wave gauges for extracting a time series results, located at initial still water depth of:
P0 (-1.2 m)
P1 (0.5 m)
P2 (1.5 m)
P3 (3.5 m)
P4 (5.0 m)
P5 (6.0 m)

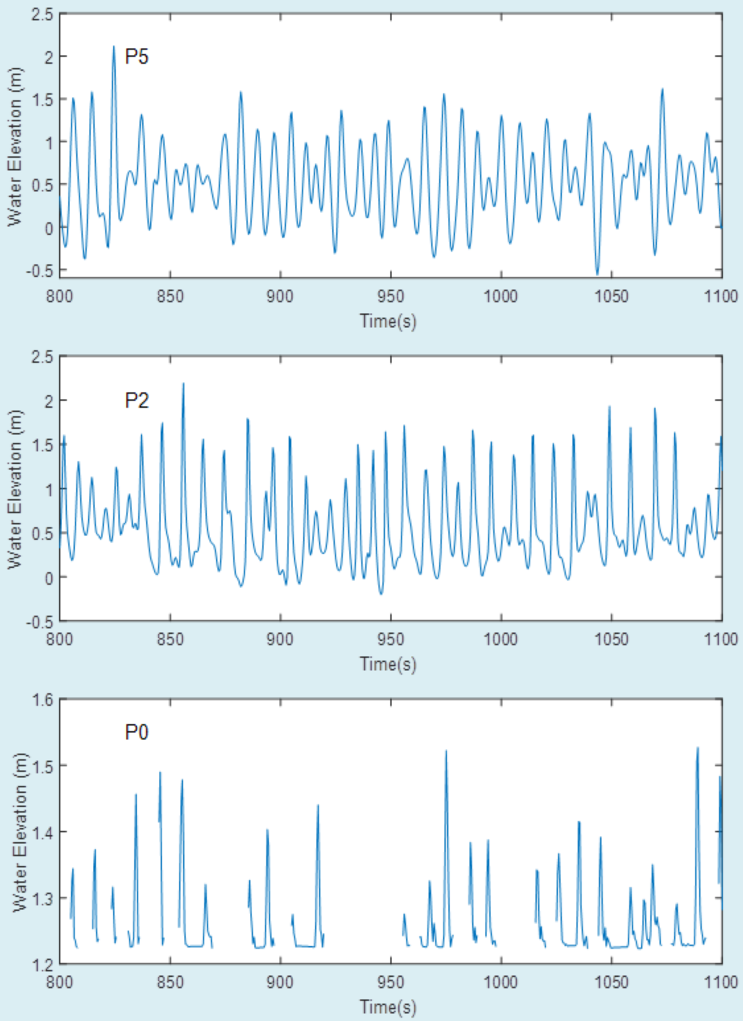
Models and results

Time series at points P5, P2 and P0:

- **In relatively deeper waters larger than 5.0 m.**
- **In shallow water (nonlinearity)**
- **In swash zone (breaking waves, with violent turbulence and rotational flows)**

At the swash zone on the beach, the wave uprush height can reach up to +1.5 m above the still water level.

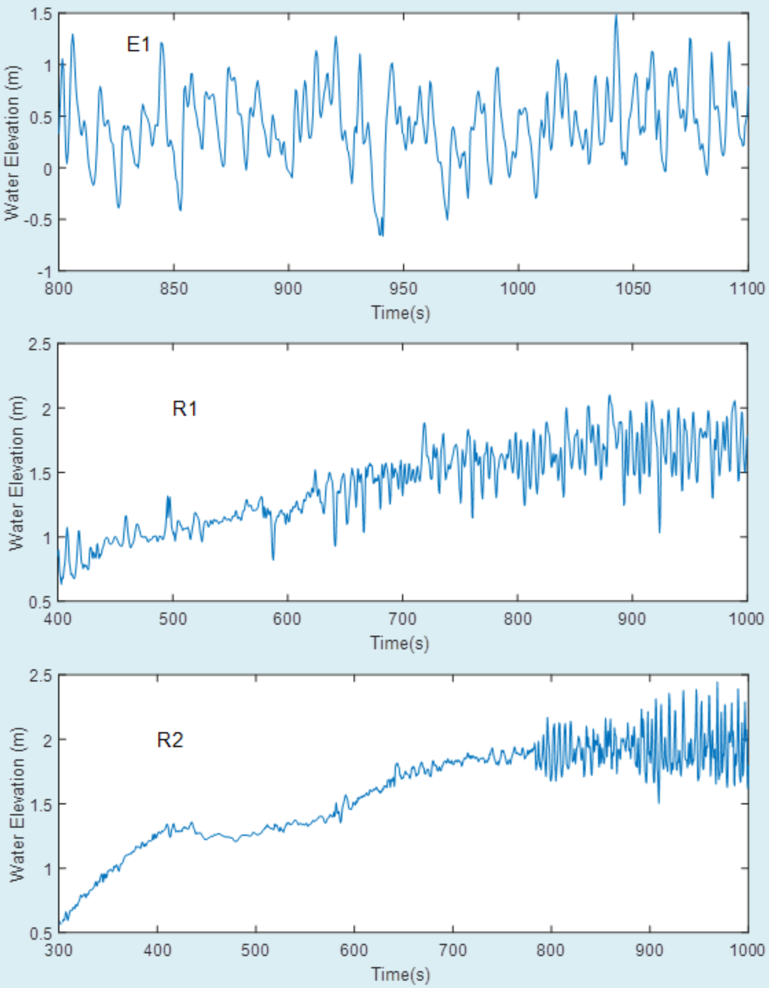
The large waves can aggravate the coastal disaster in the coastal area.



Models and results

Time series at points E1, R1 and R2 in the river:

- The surface elevation at the estuary is controlled by irregular wave motions with slight mean level variations;
- In the upstream river the elevation rises from 0.5 m to 1.7 m at R1 and from 0.5 m to 2.0 m at R2. The rising curves are loaded by short wave vibrations.



Models and results

<u>SWASH model results :</u>

- **Storm surge and wave set-up push the waterline forward 40 meters to the backshore, approaching the front of coastal buildings;**

- **The wave uprush of large waves may aggravate the flooding disaster that can reach to +1.5 m above the still water level on the beach;**

- **Upstream discharges make inland inundations with a flooding area of about 1500 m^2.**

- **Surface elevations in the river is mainly controlled by upstream discharge. The water level in estuary area is mainly affected by the waves in the shore**.

CONCLUSIONS

Two different numerical tools for simulation of flooding and inundation in residential coastal areas has been investigated for a case area of Asparuhovo-Karantina, near Varna, Bulgaria:

- One approach use MIKE21 (SW, BM, MIKE FLOOD) numerical tools for simulation of inundation in areas with complex topography and bathymetry. The obtained results for the case area are in good correspondence with the provided statistical & field observation data;

(reason to use this approach when developing coastal flood protection projects)

- Another approach use SWASH model to simulate compound coastal flood by wave transformation in coastal area;
- The results obtained by the two approaches are comparable. They have demonstrated the applicability of the chosen approaches for forecasting of flood inundation, as well as for flood mapping and flood risk assessment in urbanized coastal and estuarine areas. This encourages authors for further research and improvement of the demonstrated approaches.

Thank you for your attention