METU CONTRIBUTIONS TO RAPSODI

REVISIONS TO D1, D3, D4

NEW DELIVERABLES, D5 & D6

D1 : Report on existing tools, data, and literature on tsunami impact, loads on structures, failure modes and vulnerability assessment

- Additions, Changes and Comments:

- we are not clear about the following comments from the previous meeting minutes:
  - comment on the relationships between parameters of the presented formulas on tsunami impact and loads, they should be better organized and made clear
  - Reply: As parameters of the tsunami impact loads are already explained one by one in the main text. So no changes are done for the summary table.
  - Discussion on the merits/advantages and disadvantages of each formula that might affect the choice of
    appropriate countermeasures
  - Reply: We are not really sure how to reflect this discussion just by using the literature survey.

- Part 3 - It is added that the tsunami impact loads will be summarized according to FEMA 2016 and will be modified according to Japanese research in 2015.

- Missing / distorted figures and tables are corrected
- Summary and Conclusion part is simplified not to promise for the content of other deliverables, information about what has been done is presented as relation to other deliverables.

D3: Report on the comparison of coastal structures in Europe and Japan

- Additions, Changes and Comments:
- Flood defences against high tides in the Netherlands are included according to the literature provided by Strusinska-Correia and the ones that will be provided by Kaiser are noted to be included
- D3 is revised and the parts including structural mitigation measures (especially the parts 2.2 (Japan-Tsunamis), 4 (Comparative Analysis) and Part 5 (Summary and Concluding Remarks) are moved to D4.
- D3 is focused on types of coastal structures and their functions (tsunami, storm surge, erosion) and comparison of the structures in Japan and Europe.

D4: Report on comparison of mitigation strategies in Europe and Japan

- Additions, Changes and Comments:
- Structural Mitigation Part (Part 2) is revised to include the structural mitigation strategies but general coastal structure information are transferred to D3.
- All the parts are read and checked against possible misinformation
- Parts including structural mitigation are transferred from D3 to the part 2.1 (Japan-Tsunamis) and part 4 Summary and Concluding Remarks
- D4 is now focused only on tsunami mitigation – structural mitigation and non-structural.

D5.Report on computed tsunami parameter values in shallow waters and around structures

Recommended damage metrics

- The **maximum wave elevation** at each grid point, i.e.

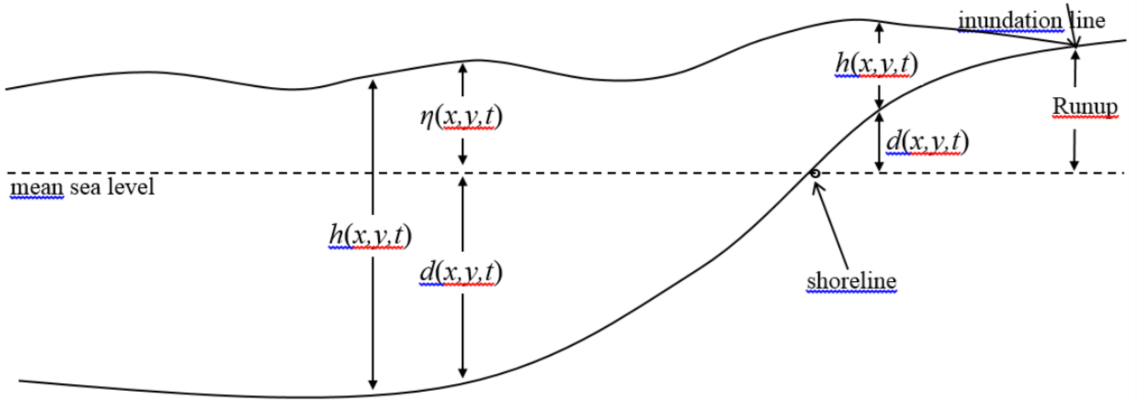
$$\eta_{\max}(x, y) := \max_t \eta(x, y, t)$$

- The **minimum wave elevation** at each grid point, i.e.

$$\eta_{\min}(x, y) := \min_t \eta(x, y, t)$$

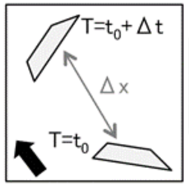
- The **maximum flow depth,** i.e.

$$h_{\max}(x, y) := \max_t h(x, y, t)$$



Schematic representation and basic definitions

Recommended damage metrics



$$v_f = \frac{\Delta x}{\Delta t}$$

Tsunami flow velocity

- The **flow velocity**
  - movement distance of floating objects per unit time

- The **maximum current speed** , i.e.

$$V_{\max}(x,y) := \max_t V(x,y,t) = \max_t \left\{ \sqrt{u^2(x,y,t)+v^2(x,y,t)} \right\}$$

- The **maximum momentum flux**

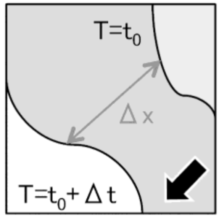
$$M_{\max}(x,y) := \max_t \left\{ h(x,y,t) \cdot V^2(x,y,t) \right\}$$

- The **Froude number**

$$Fr(x,y) := \left\{ \frac{V^2(x,y,t)}{g\, h(x,y,t)} \right\}$$

Recommended damage metrics

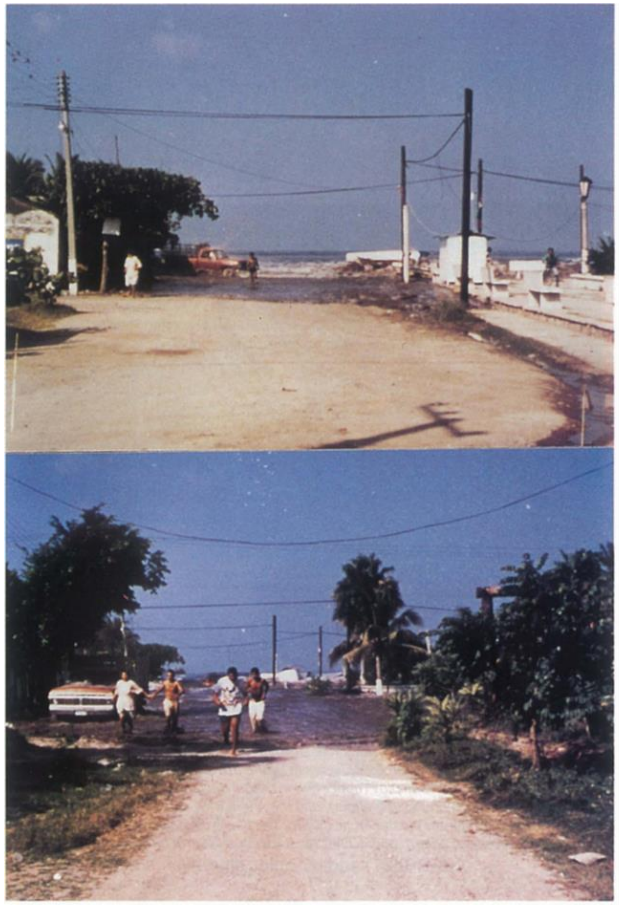
- The **front velocity**
  - The front velocity is calculated by dividing the distance between two tsunami front lines by the time



$$v_p = \frac{\Delta x}{\Delta t}$$

Tsunami front velocity

The wavefront appears slow as it approaches the shoreline, leading to a sense of false security. It is easy to imagine one can outrun it, but tens of seconds or just seconds later (depending on location), the wavefront accelerates rapidly as the main disturbance arrives.



These photos show the wave advancing on La Manzanilla in the southern end of Tenacatita Bay. By the time the lower photo was taken, the water had advanced more than 100 m. Eyewitnesses reported that the wave traveled about as fast as a person could run. After Borerro et al. (1997). [Photo courtesy of Jose Martinez, La Manzanilla]

Numerical Modeling of the Tsunami Currents

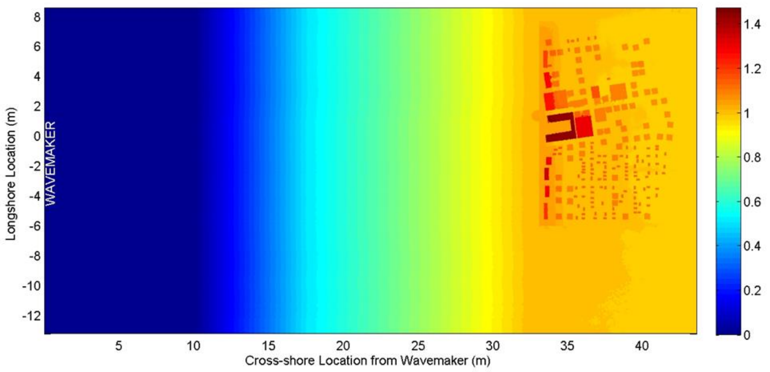
Single long-period wave propagating onto a small-scale model of the town of Seaside, Oregon (Park et al., 2013)

Methodology used in the numerical modeling

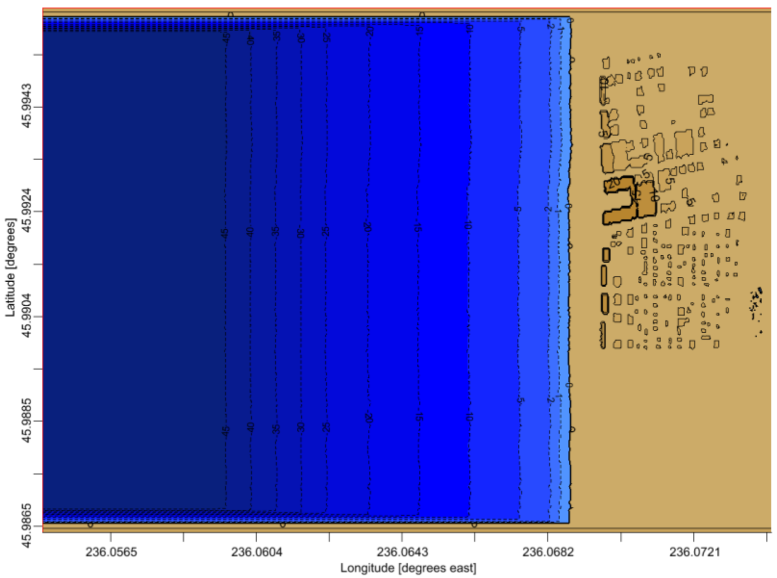
- Method of Splitting Tsunamis (MOST) Model
  - The numerical model developed by Titov and Synolakis (1998, 1995)
  - Validated and verified through Synolakis et al. (2008, 2007)
  - Used to generate propagation database and forecast inundation modeling

- Community Model Interface for Tsunamis (ComMIT)
  - Following the Indian Ocean tsunami of 26 December 2004, the UN established a coordinating group for Indian Ocean Tsunami Warning and Mitigation System (IOTWS)
  - This group recommended the establishment of a web-based community tsunami-flooding model. Hence, ComMIT has been developed by the NOAA Center for Tsunami Research (NCTR).
  - User friendly interface to the MOST model and propagation database
  - Used to generate inundation model

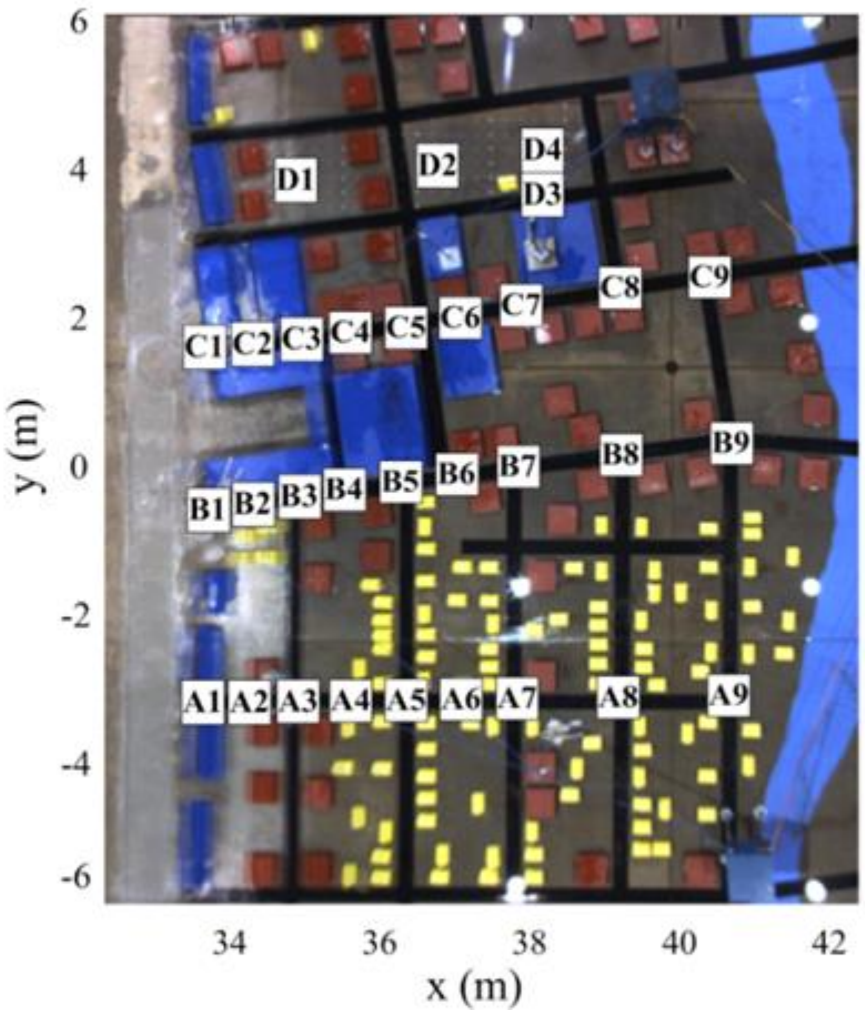
Bathymetry, Model grid Structure, location of wave gauge points and the run parameters



Representation of bathymetry in the model scale



Representation of A-, B-, and C-grids in ComMIT (They are obtained at the same coordinates and resolutions (3 m) in the prototype scale)



Location of wave gauges

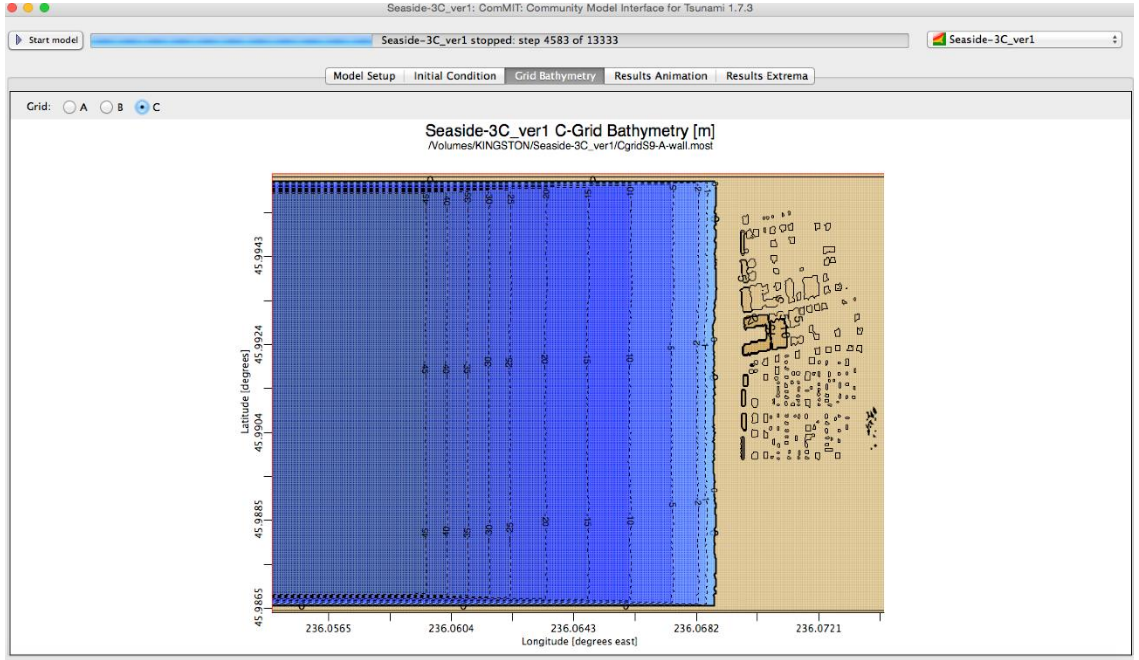
Prototype
to
model scaling

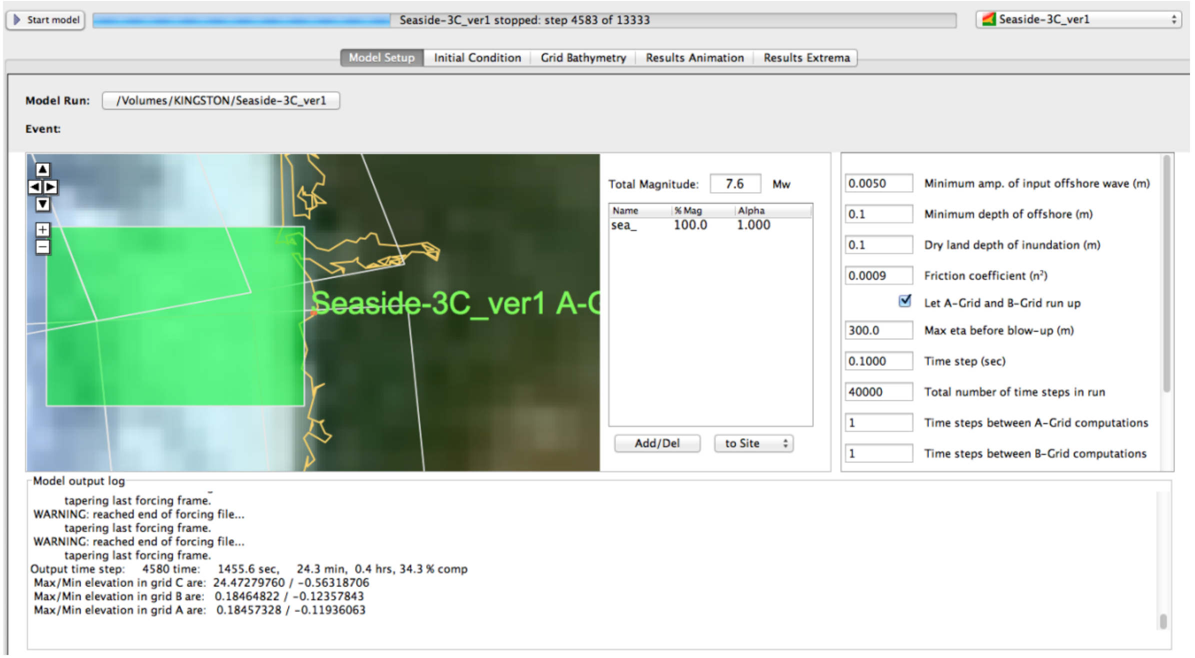
$l_{prototype} = 50\ l_{model}$

0.0050	Minimum amp. of input offshore wave (m)
0.1	Minimum depth of offshore (m)
0.1	Dry land depth of inundation (m)
0.0009	Friction coefficient (n^2)
☑	Let A-Grid and B-Grid run up
300.0	Max eta before blow-up (m)
0.1000	Time step (sec)
40000	Total number of time steps in run
1	Time steps between A-Grid computations
1	Time steps between B-Grid computations
3	Time steps between output steps
0	Time steps before saving first output step
1	Save output every n-th grid point

Run parameters

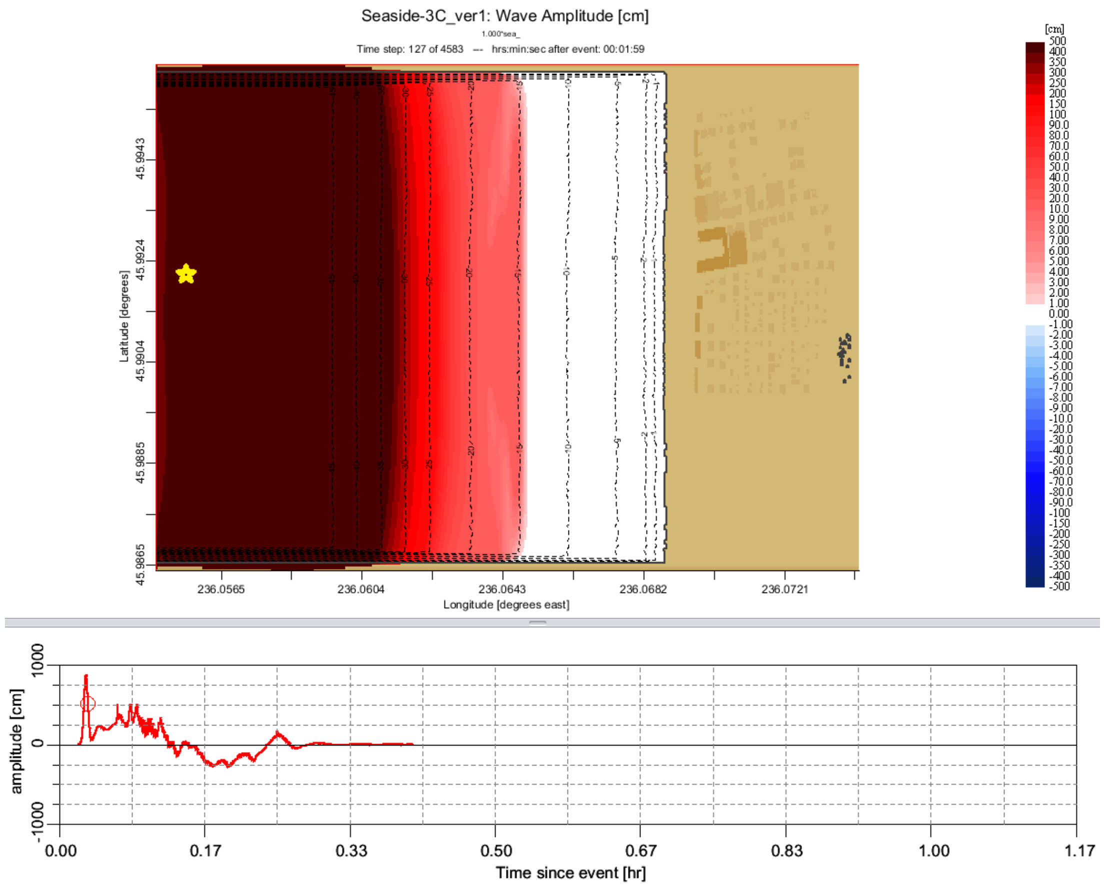
ComMIT model overview



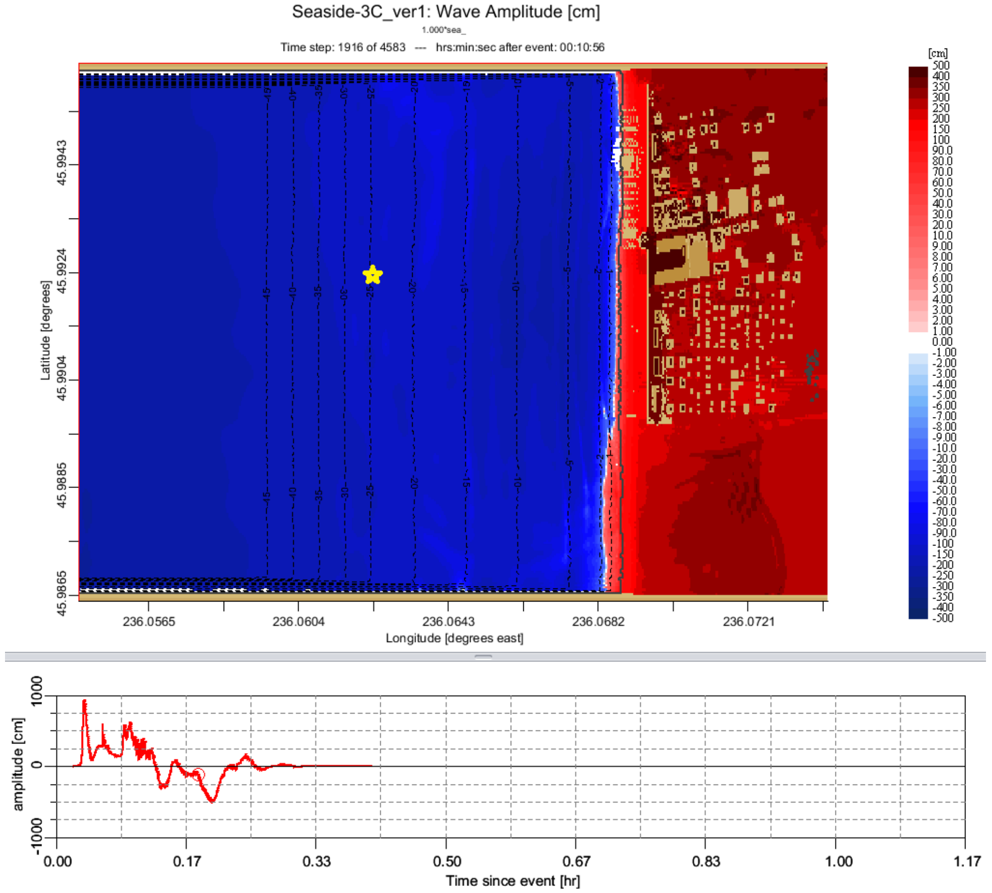


Green rectangle is only used for pointing out to the boundary condition in ComMIT environment.

Modeling results

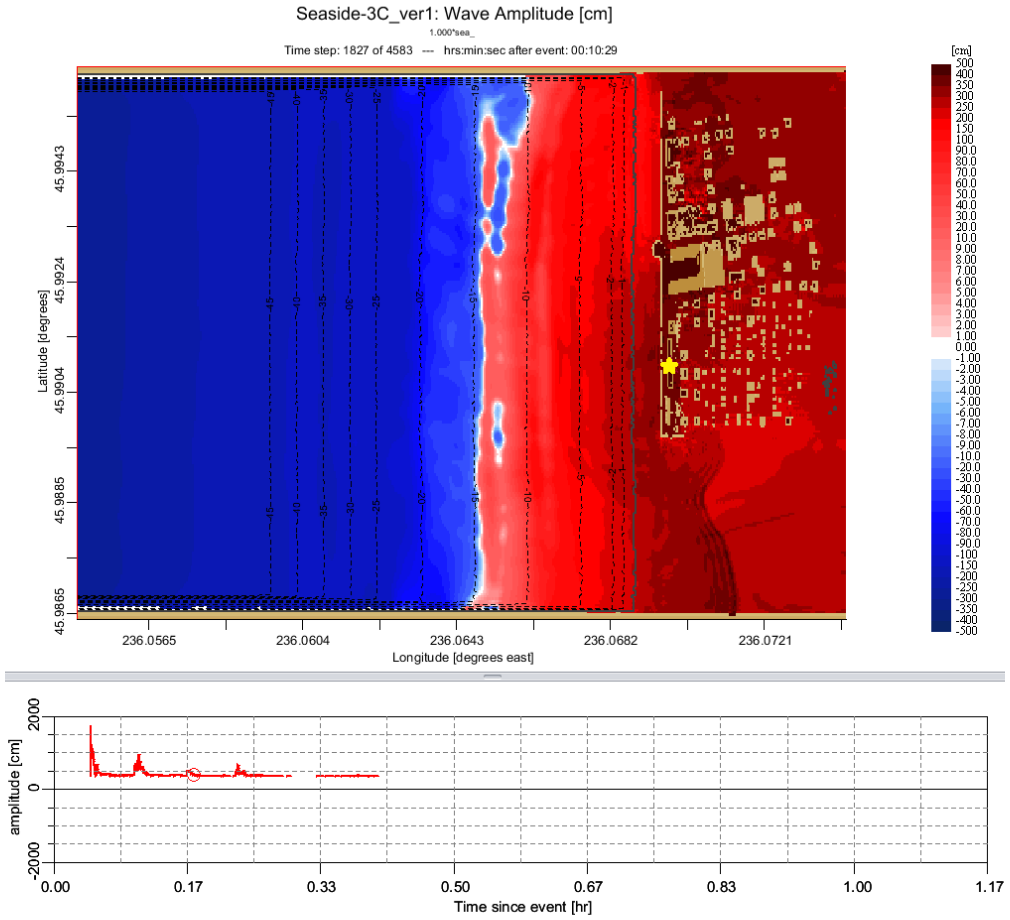


Time series of water surface elevation at the WG1 (yellow star)

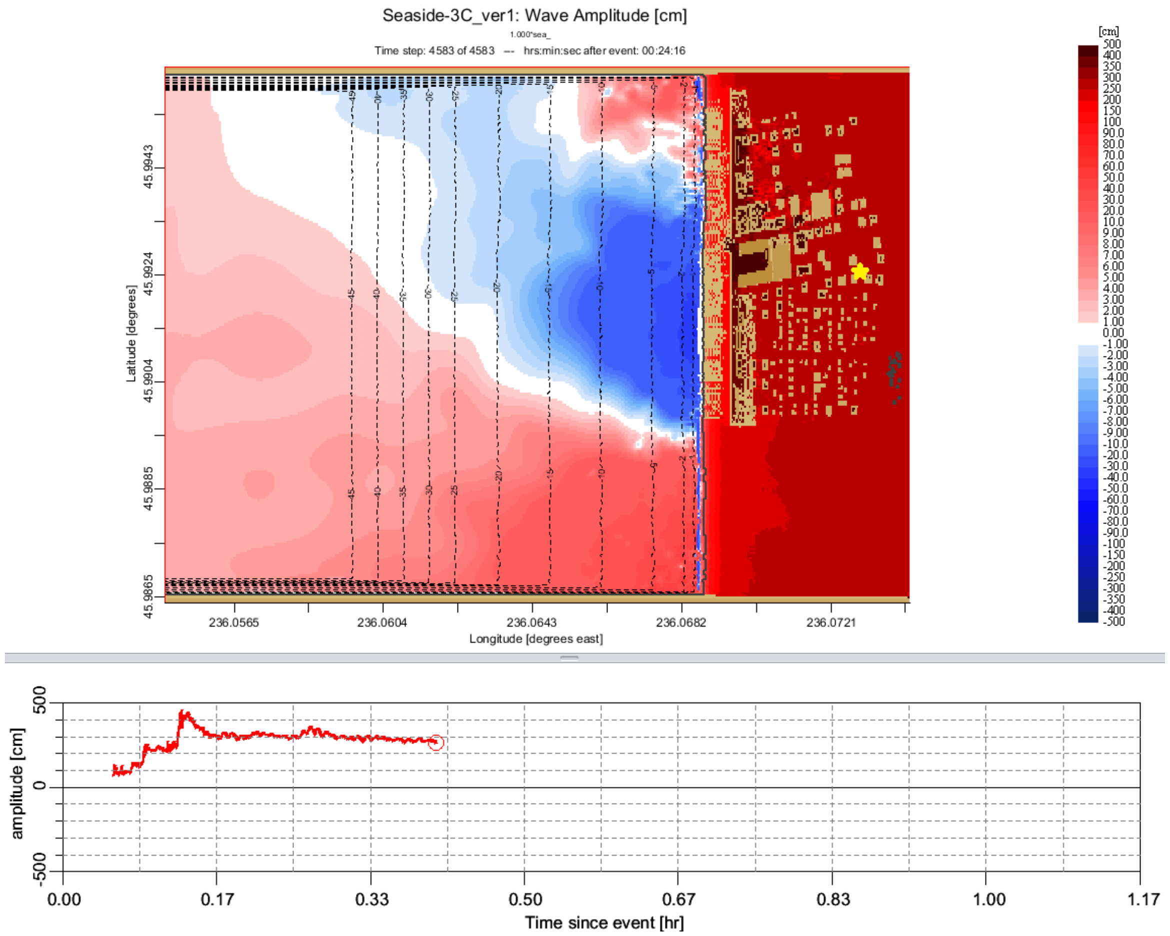


Time series at the WG3 (yellow star)

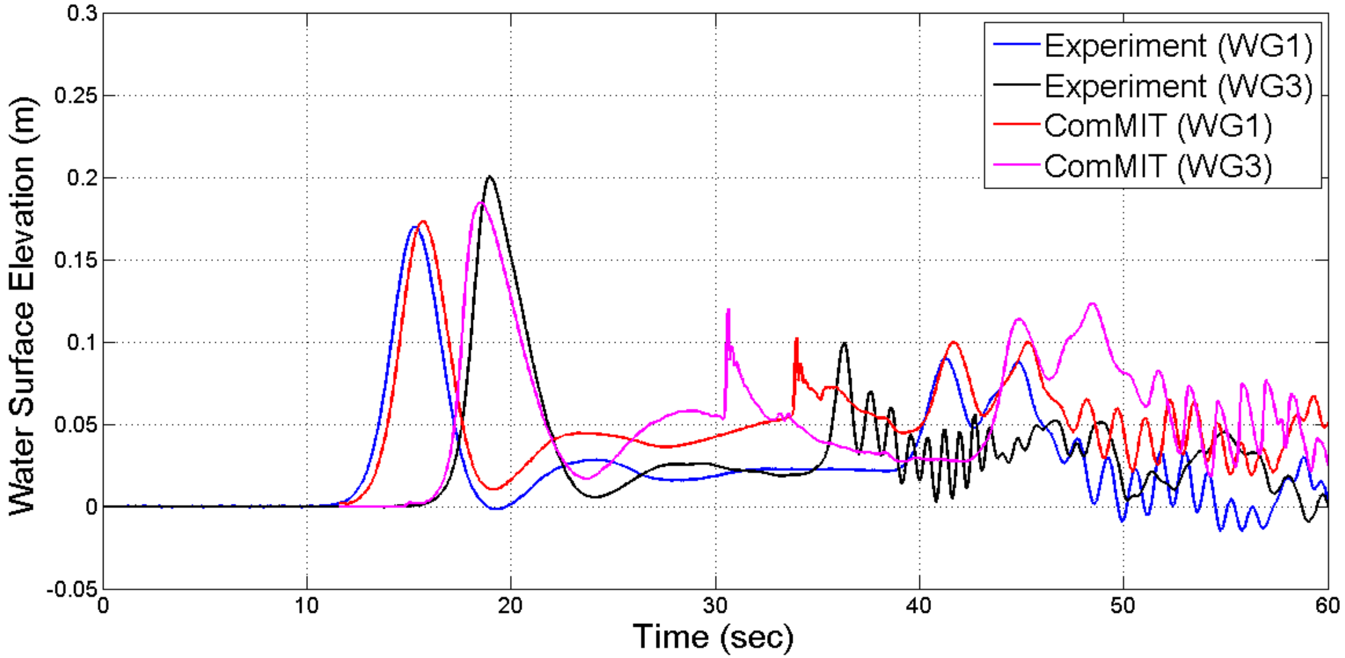
Modeling results



Time series at the WGA1 (yellow star)

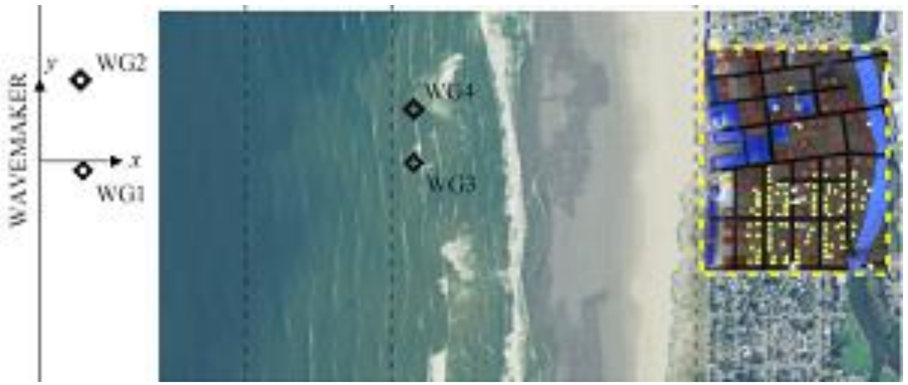


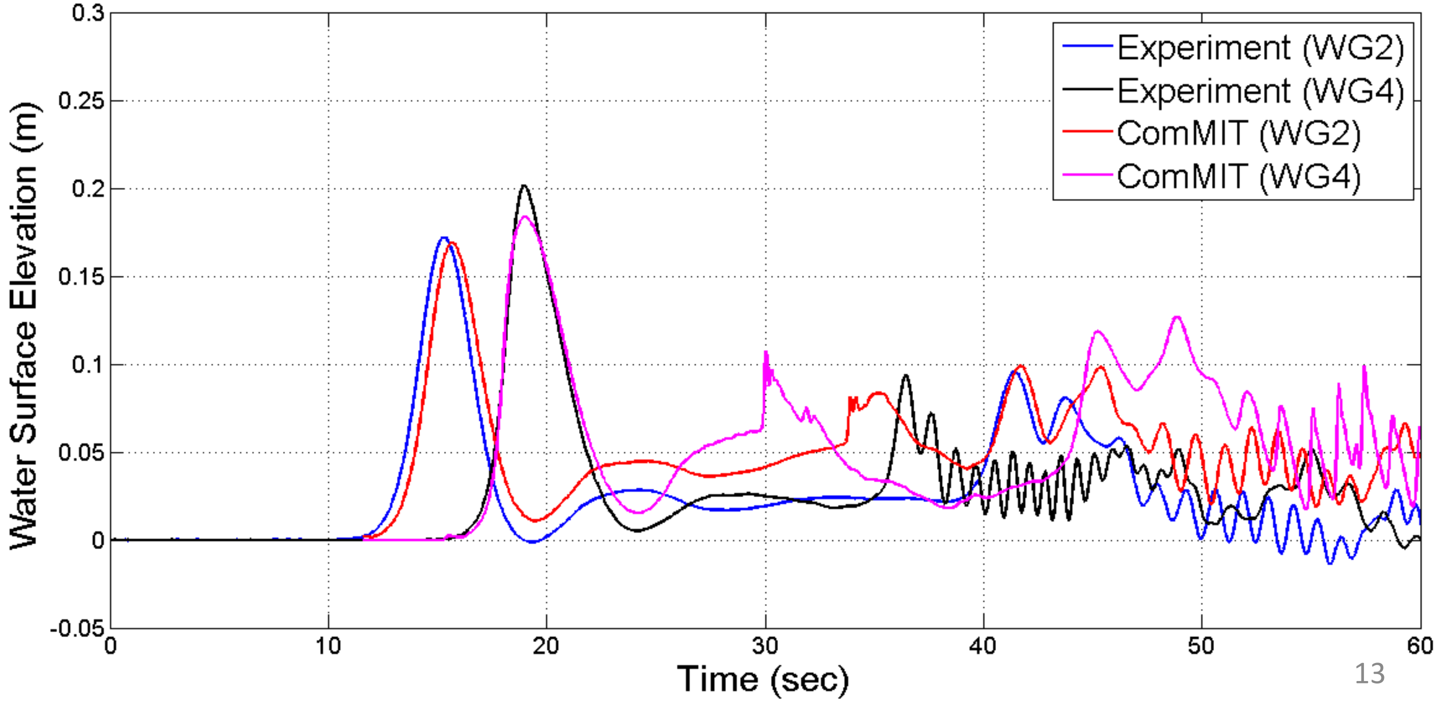
Time series at the WGB9 (yellow star)



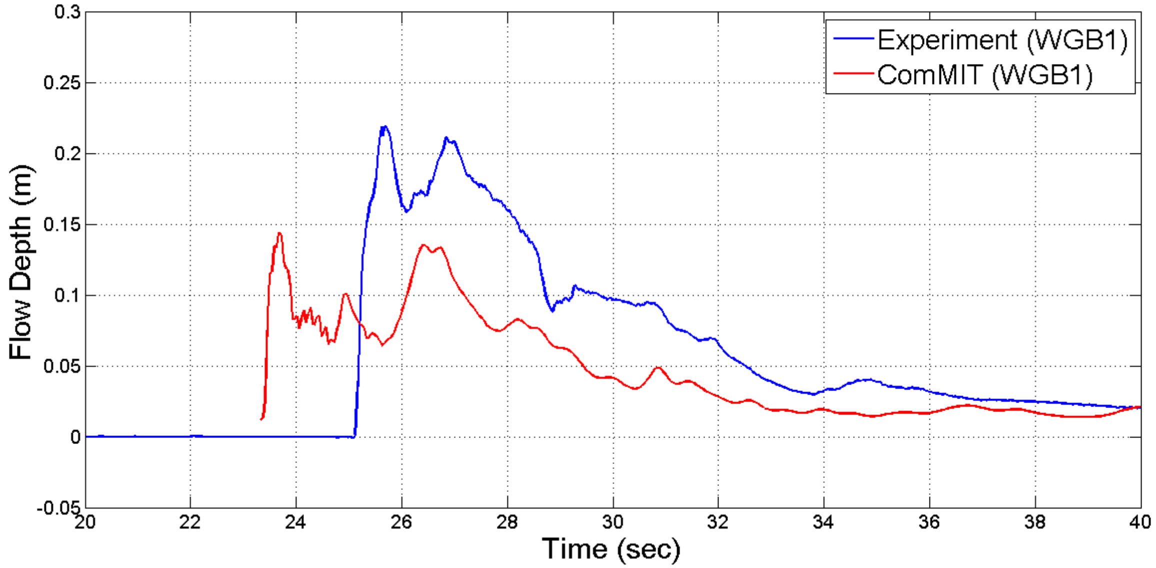
Incident wave comparisons at WG1 and WG3

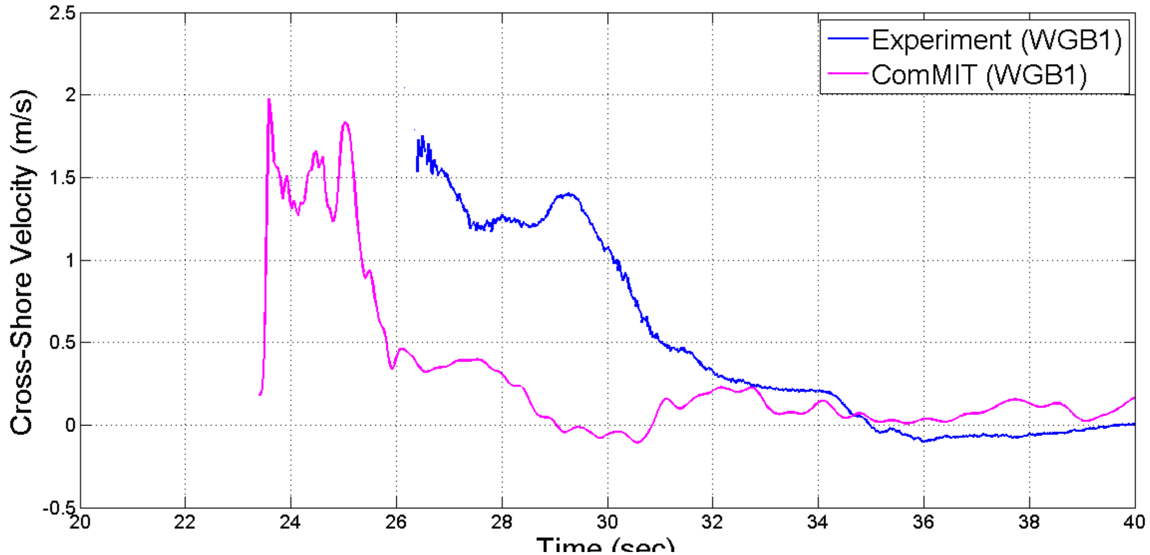
Incident wave comparisons at WG2 and WG4

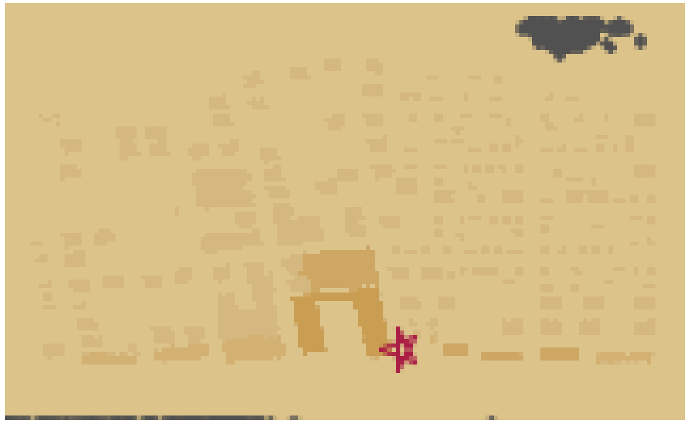


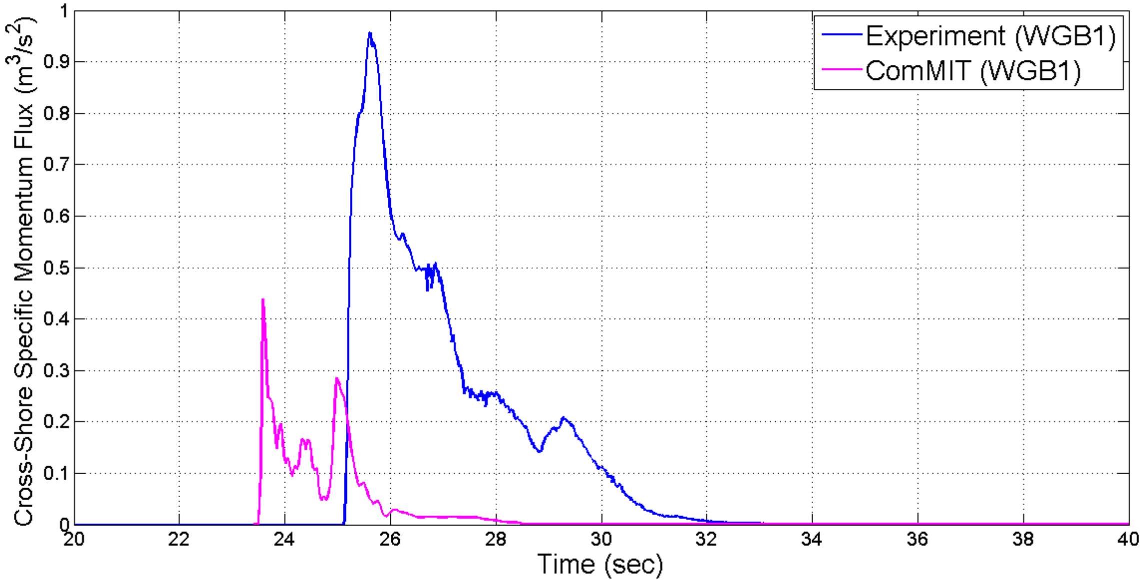


Comparisons at WGB1

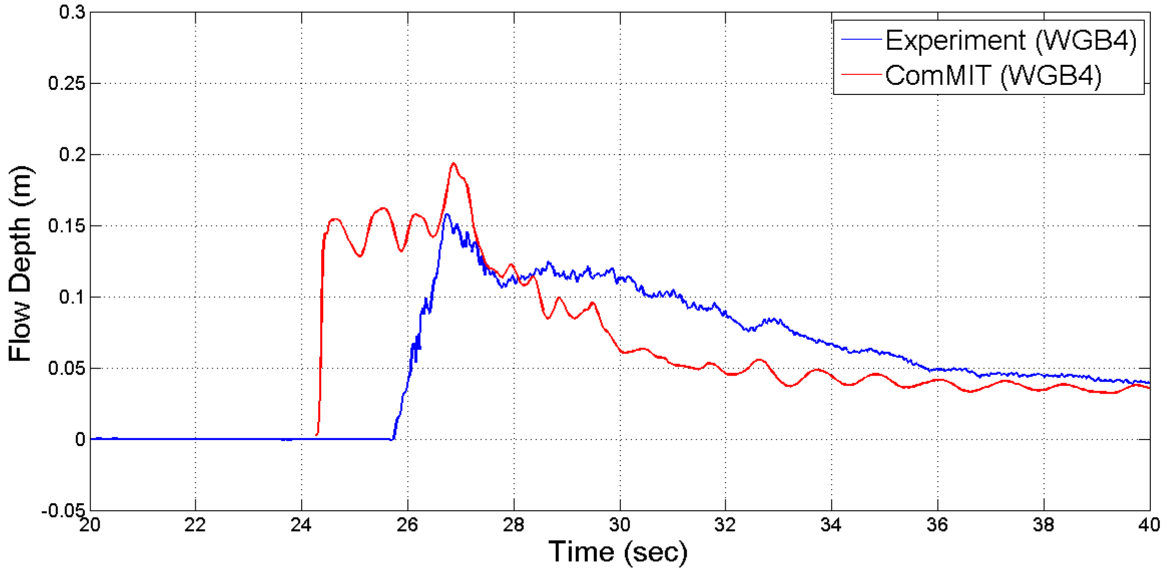


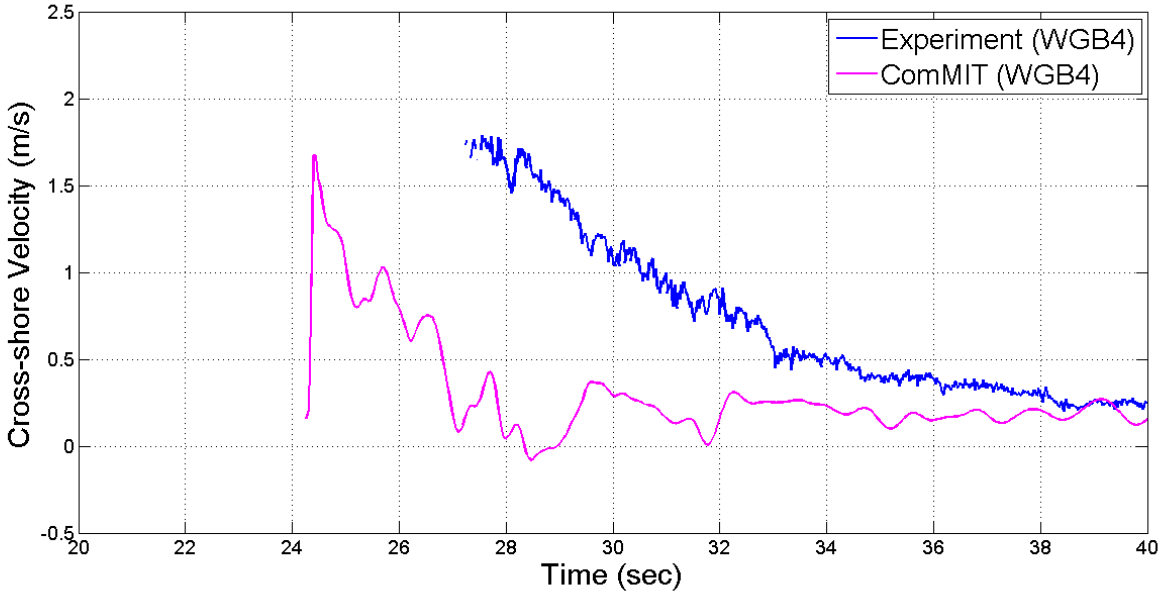


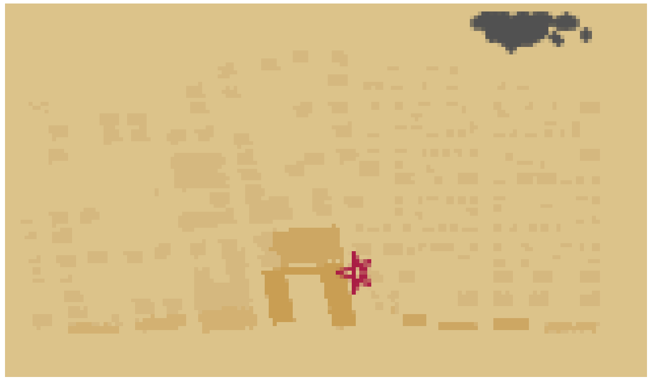


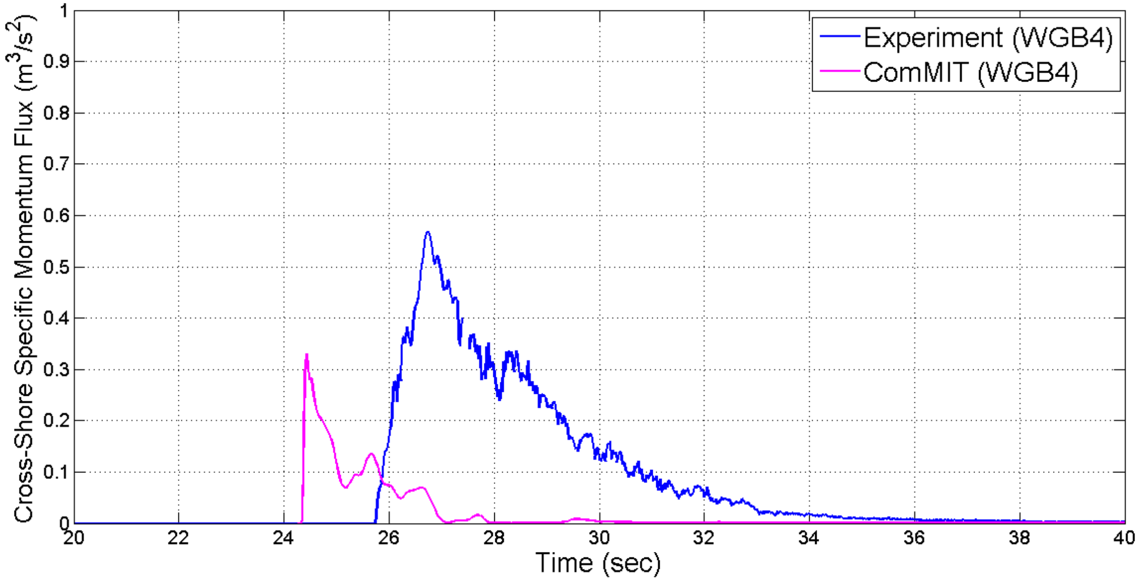


Comparisons at WGB4

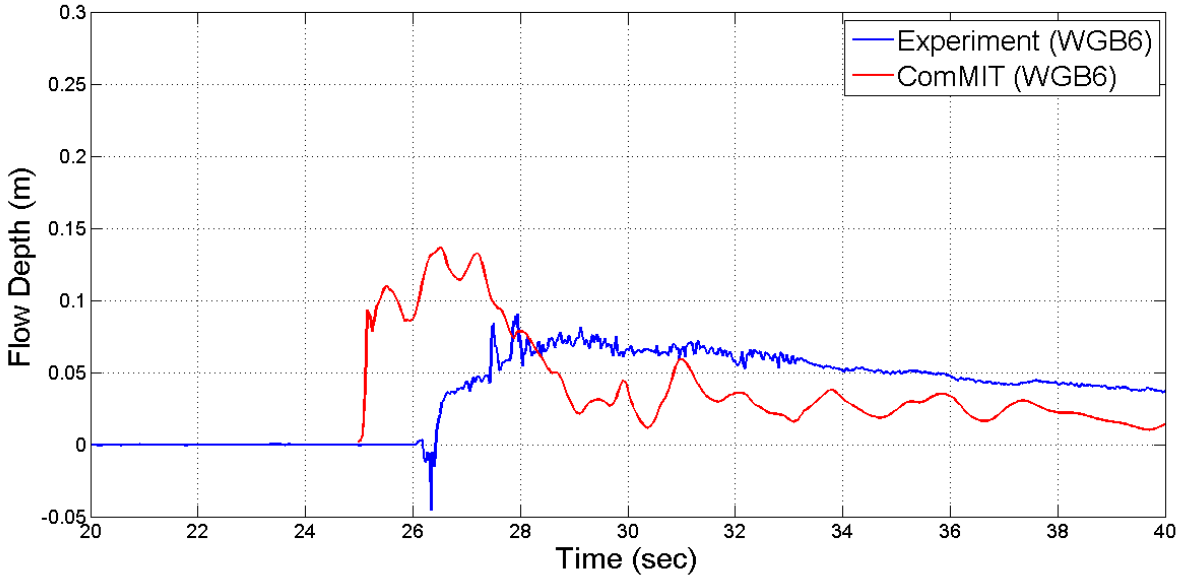


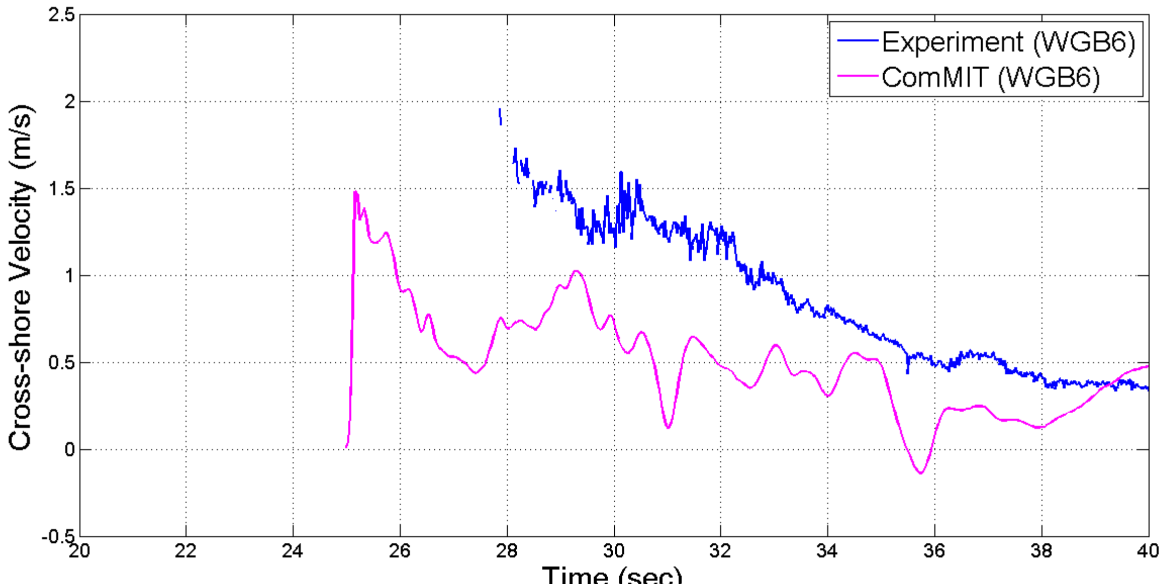


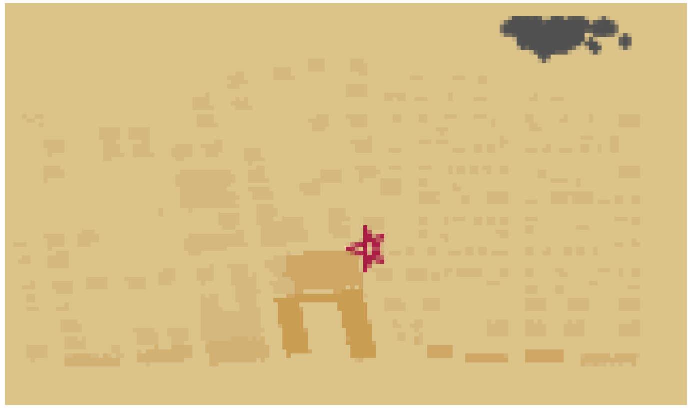


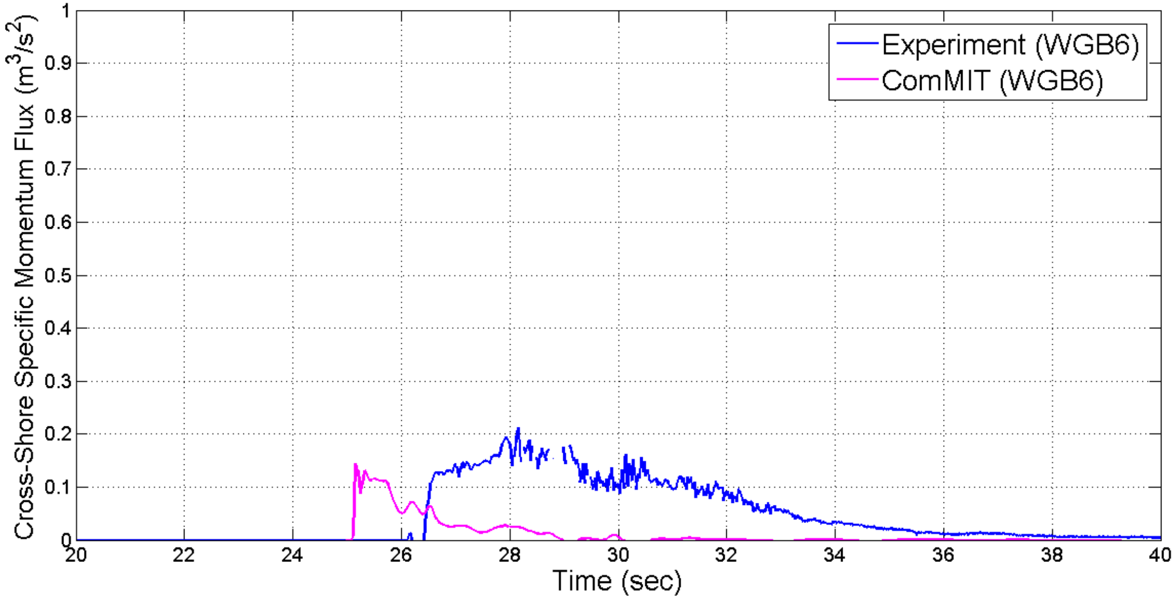


Comparisons at WGB6

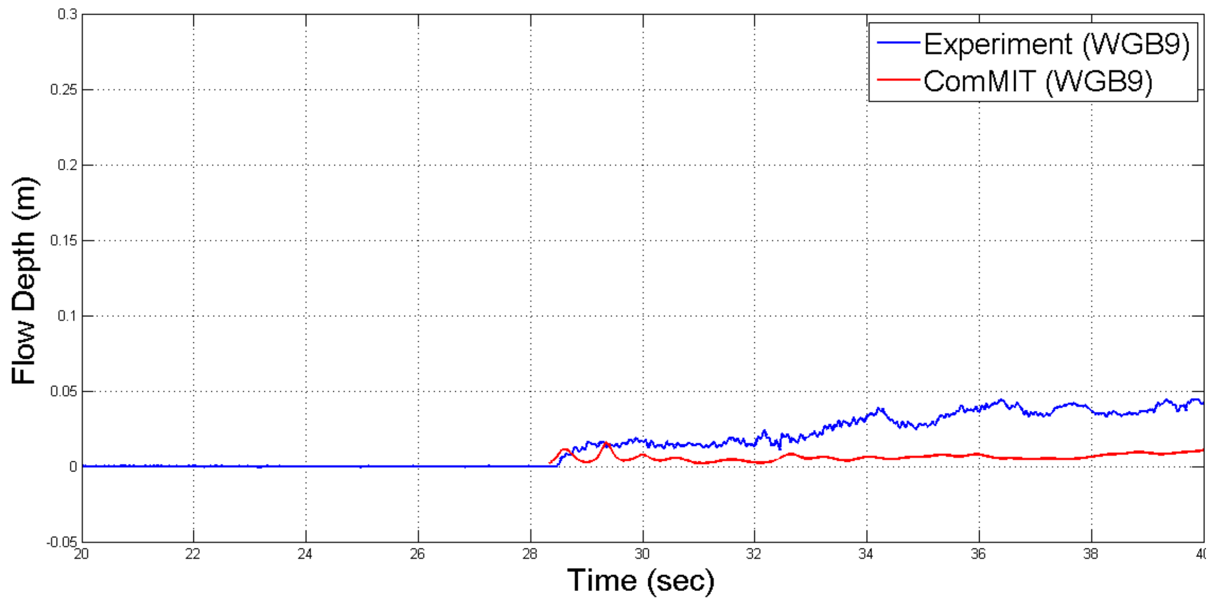


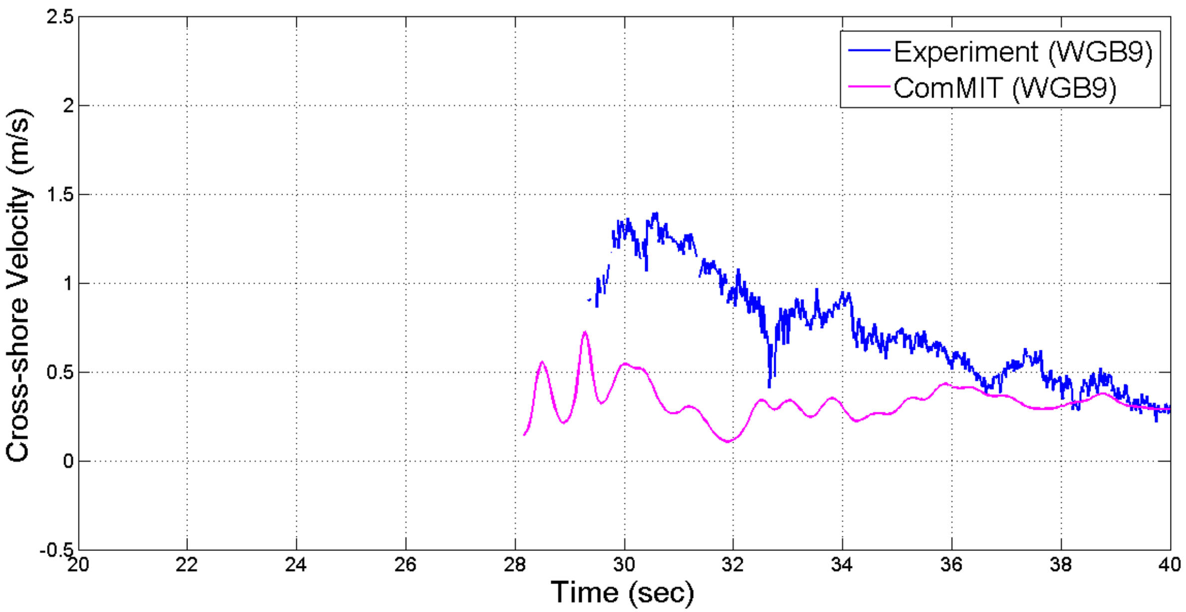


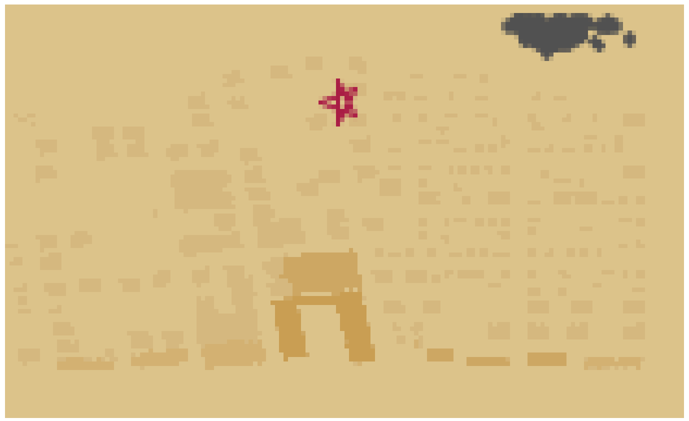


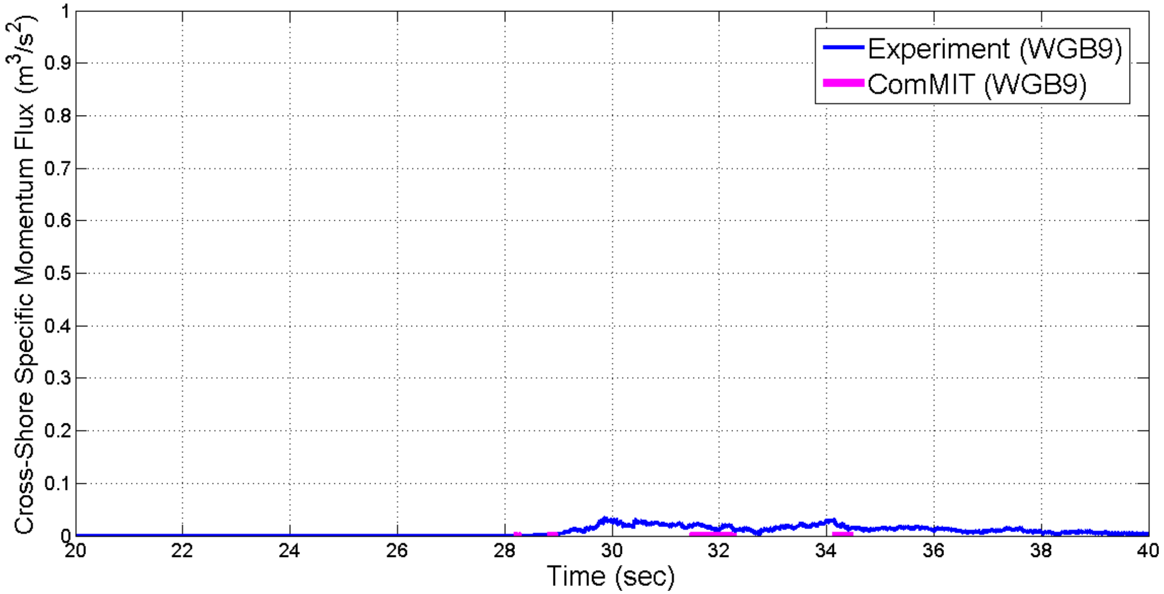


Comparisons at WGB9

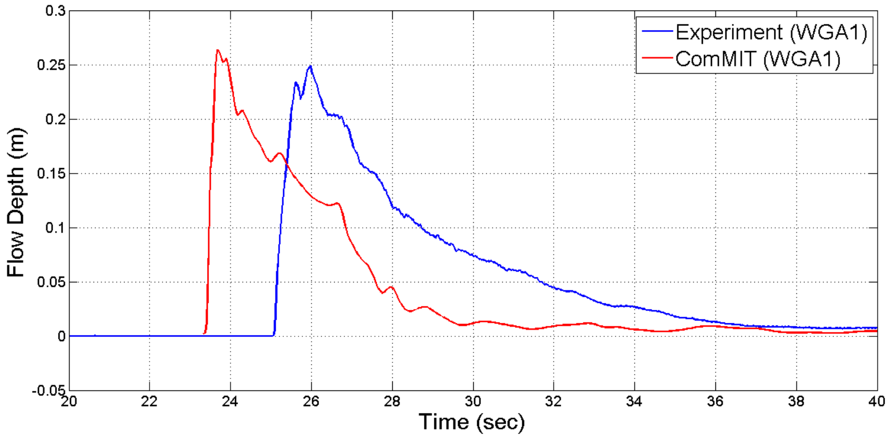


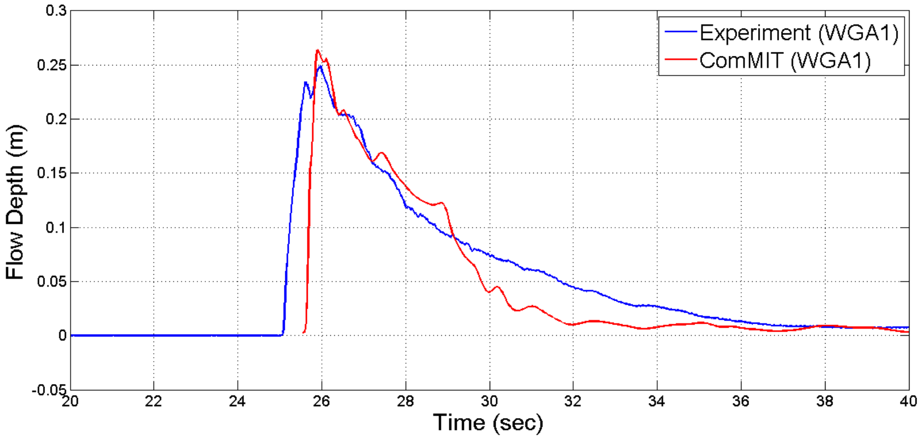




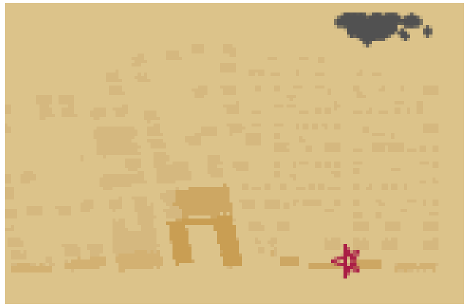


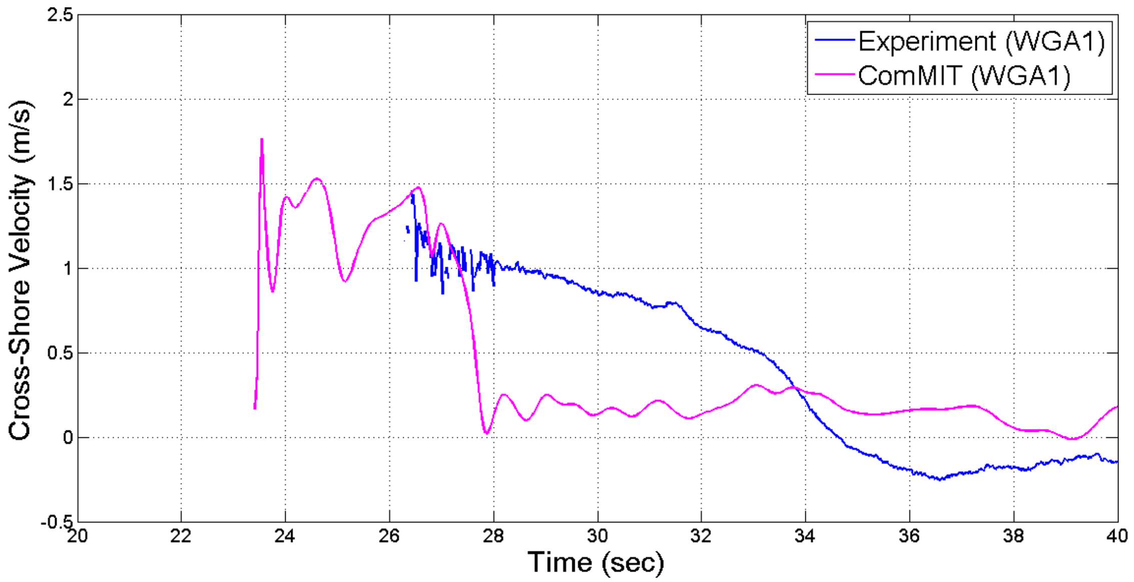
Comparisons at WGA1

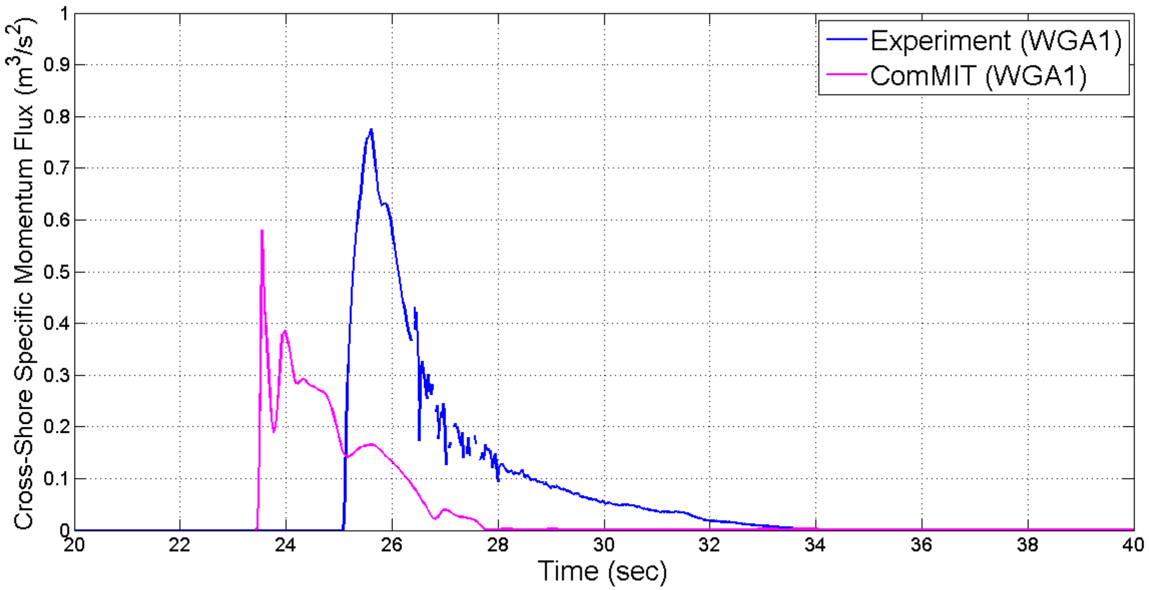




Shifted on time



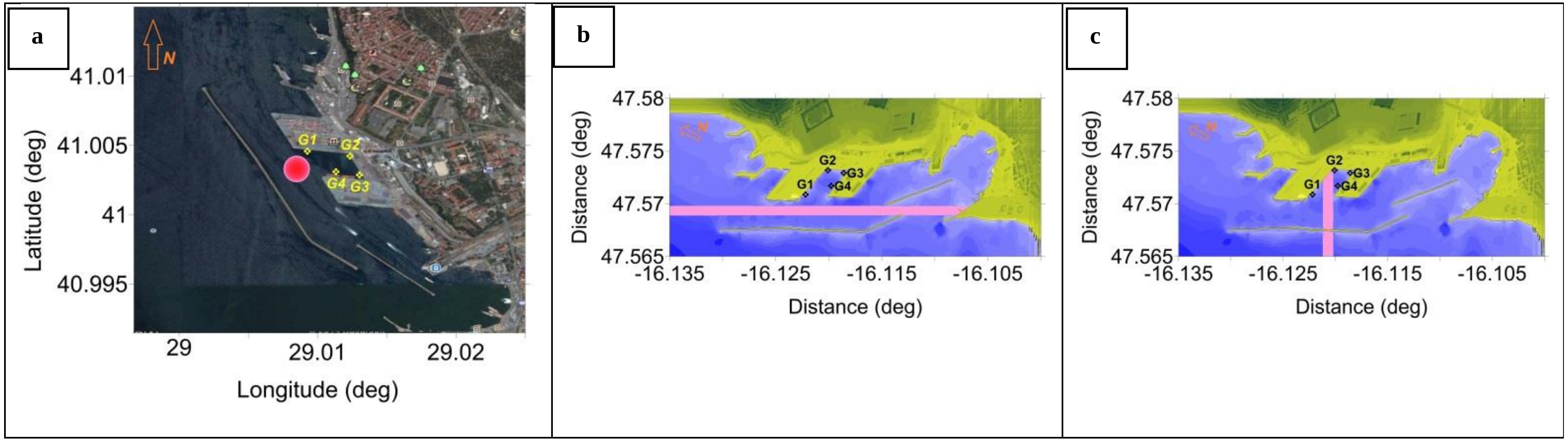




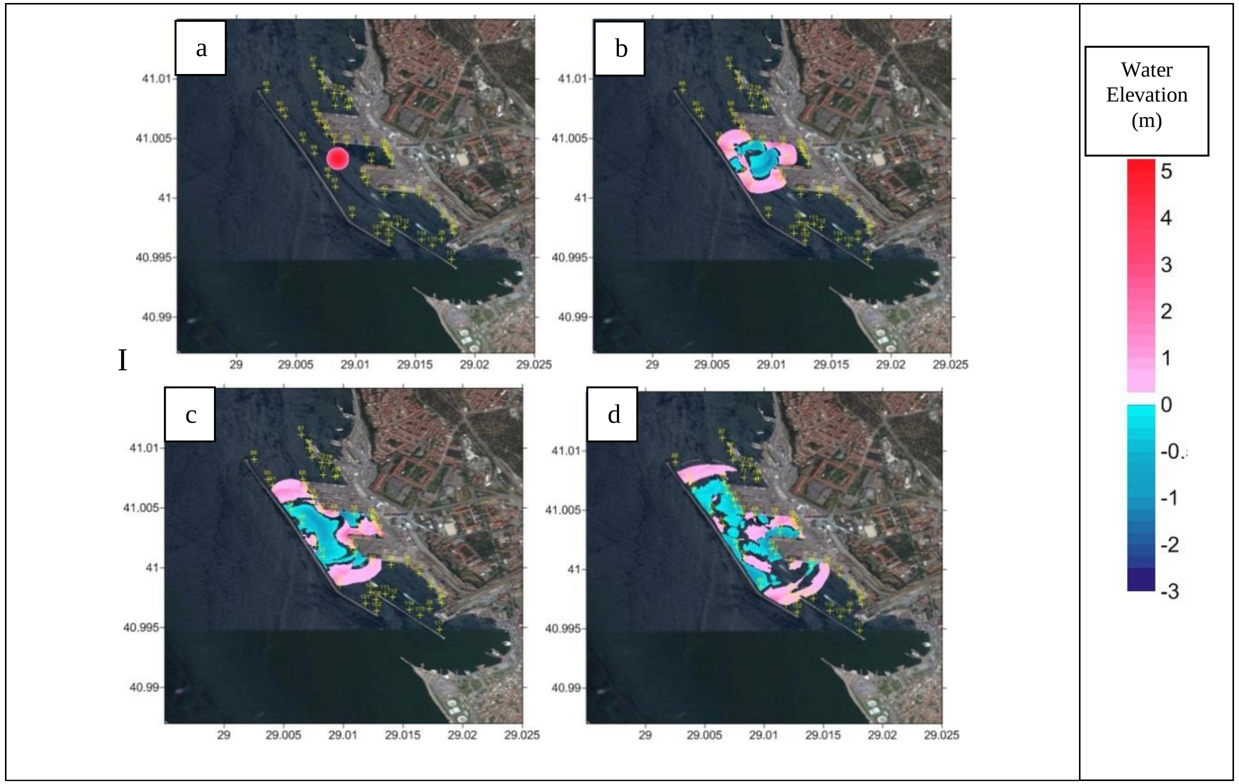
D6: Report on the Tsunamis in ports and harbors

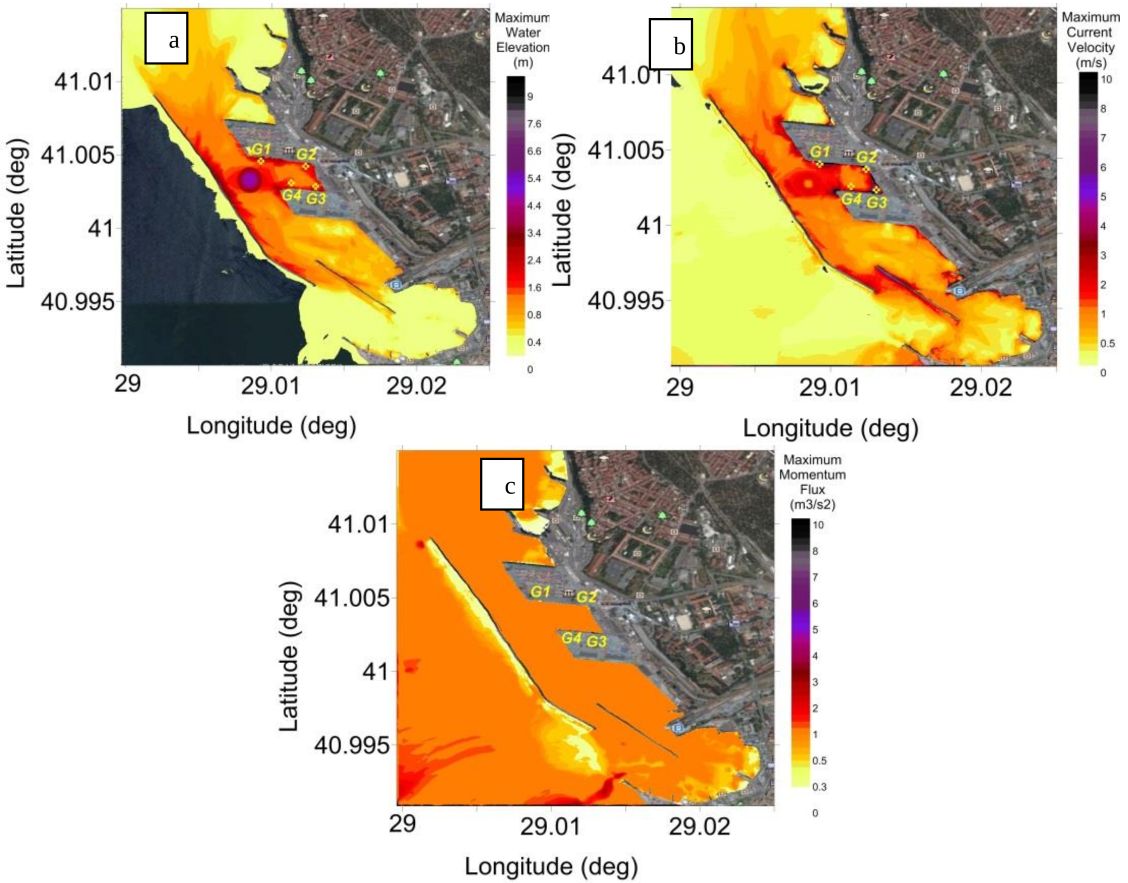
- Information provided in two sections:
  - Direct damages from literature review:
    - Breakwaters: overtopping / no overtopping
    - parting of vessel moorings,
    - manoeuvring movements which are not controlled or transporting unmoored vessels due to tsunami currents,
    - vessels when they are lifted out of water,
    - sediment scouring or deposition due to a tsunami
  - Harbour resonance both literature review and numerical modelling:
    - Amplification of currents, water level and momentum flux

- Case study on Haydarpasa Port focusing on possible increase in tsunami impact due to resonance
- Three different impulses are applied to Haydarpasa Port to calculate the period of free oscillations in Haydarpasa port.
  - i) dome shape circular static source with 5m wave amplitude and 80m diameter (R1),
  - ii) E-W direction, line crested sinusoidal shape time dependent (dynamic) 10 sec period impulse with 1m wave amplitude (R2),
  - iii) S-N direction line crested sinusoidal shape time dependent (dynamic) 10 sec period impulse with 1m wave amplitude (R3).

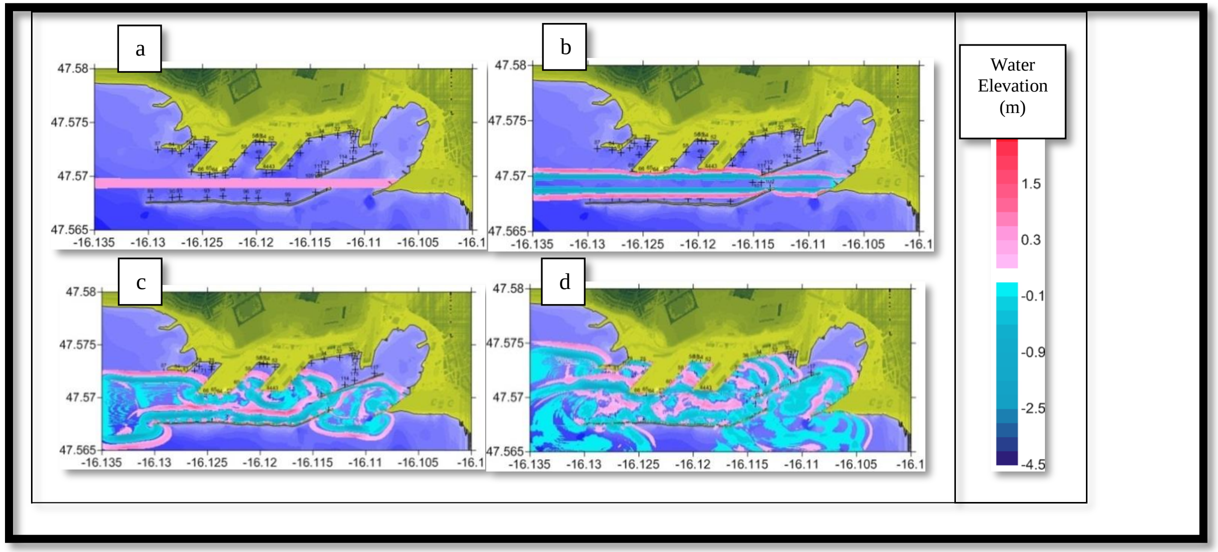


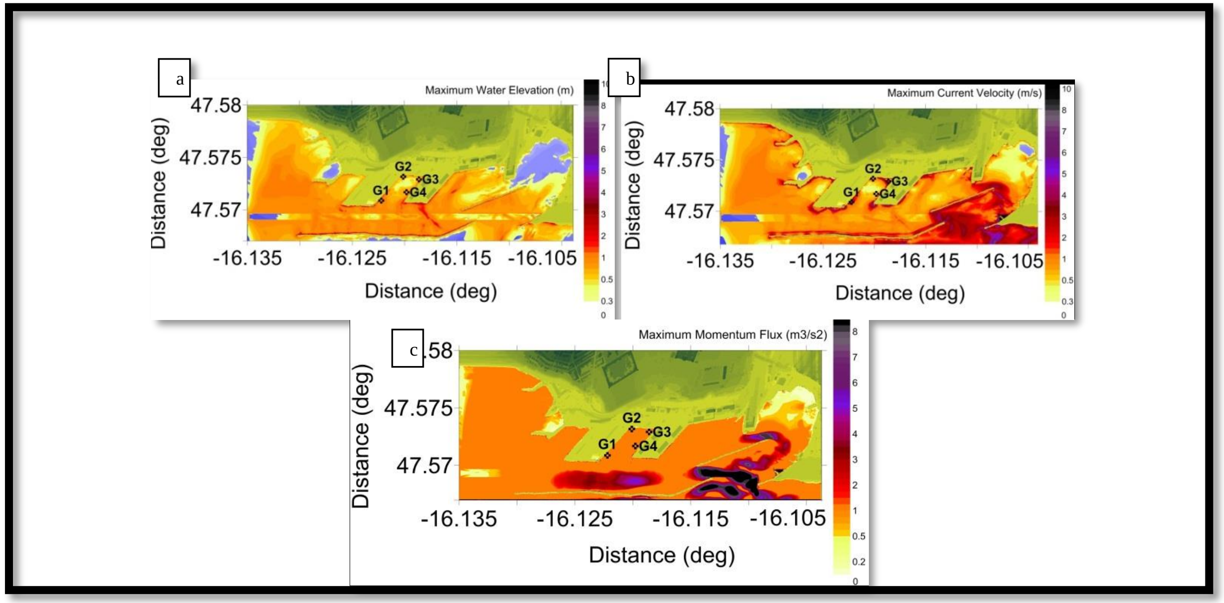
Results for Dome shaped input

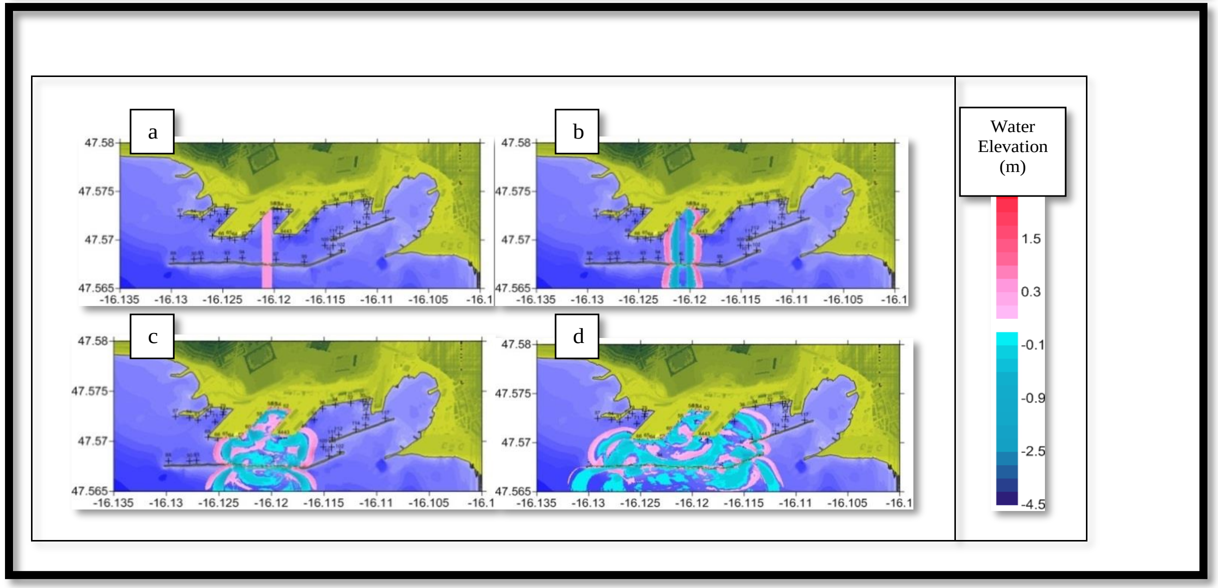


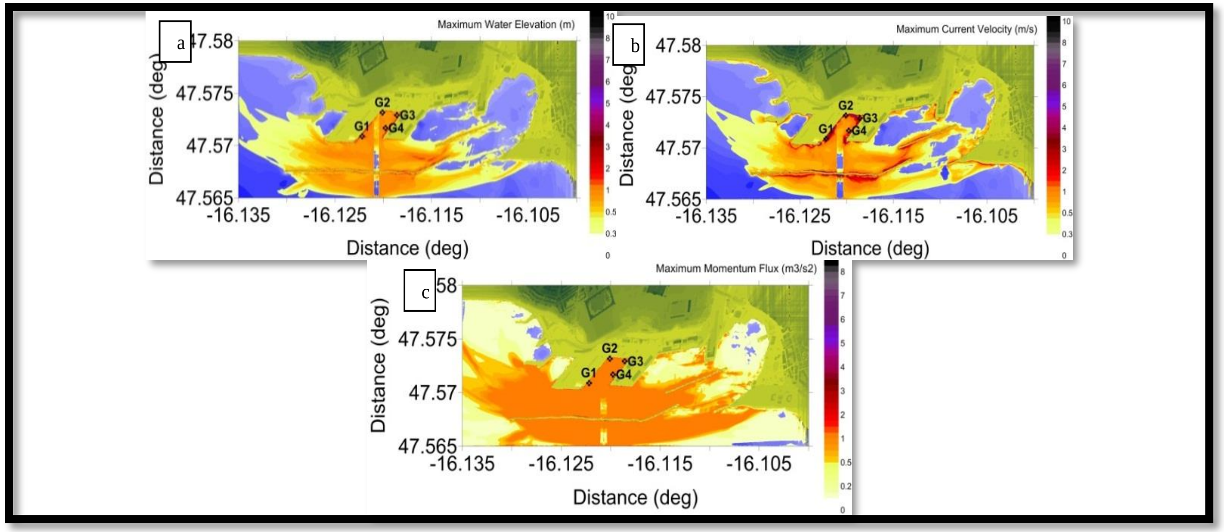


Results for Line impulse in sinusoidal shape

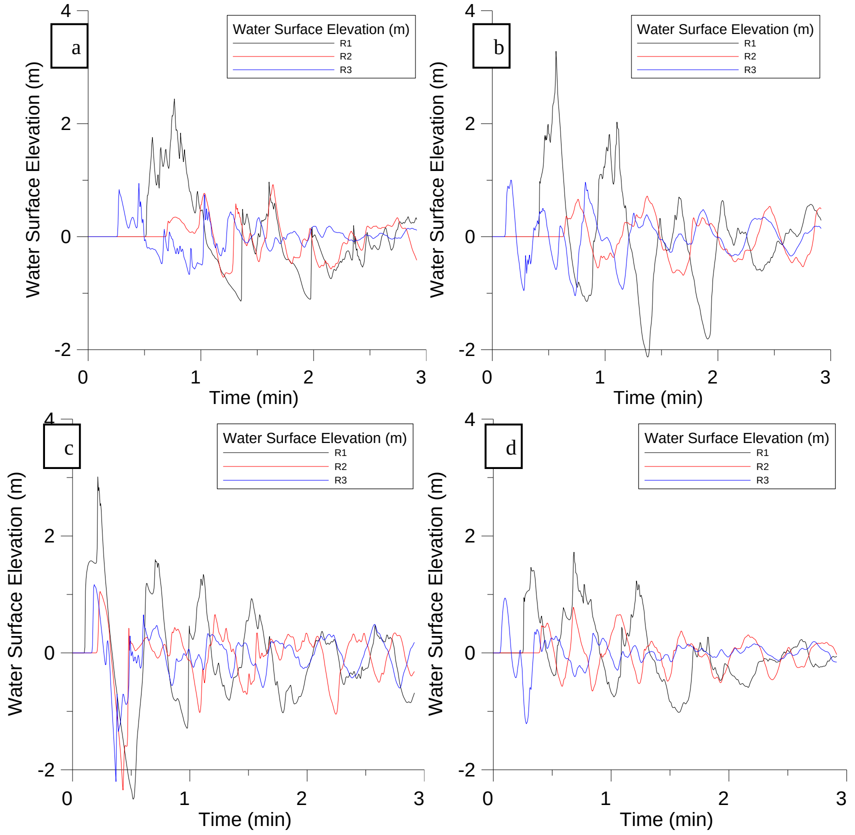


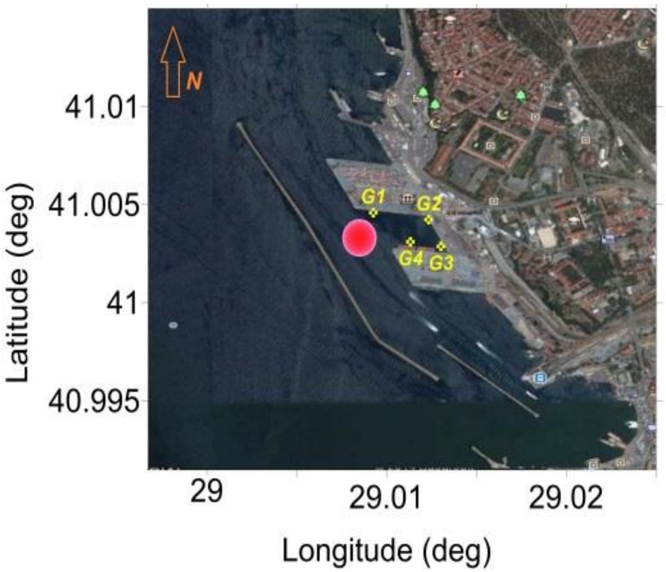


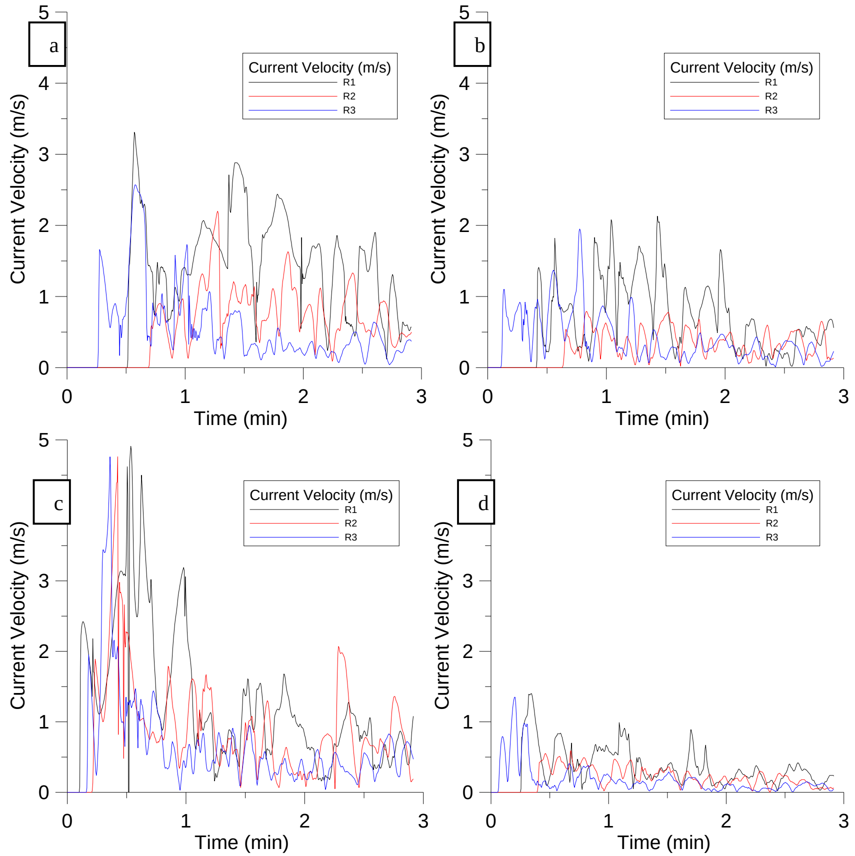




Results – Critical points & Critical processes







Results & Conclusions

Mode no.	*Line impulse parallel to main breakwater*	*Line impulse perpendicular to main breakwater*	*I initially static Gaussian shape uplift of water surface with $100m$ diameter*
1	476.4	1311	1311
2	150	374.4	374.4
3	111.6	218.4	154.2
4	66.6	154.2	114
5	55.2	109.2	67.2
6	45.6	69	54.6
7	40.2	54.6	44.4
8	33.6	44.4	40.2
9	28.2	40.2	33.6
10	25.2	34.2	28.2
11	20.4	28.2	25.8
12	17.4	25.8	20.4
13	16.2	23.4	17.4
14	12	20.4	16.2
15		17.4	12
16		16.2	
17		12	

- Possible recommendations for layout of ports such as regular (e.g. rhombohedral shaped) basins having fully reflective boundaries inside the ports becoming critical points for amplification
- Possible recommendation on calculating and comparing basin resonance to possible tsunami scenarios
- Additional information and comments from partners…