NEW LEVEE BREACHING SUB-ROUTINE OF LISFLOOD-FP MODEL

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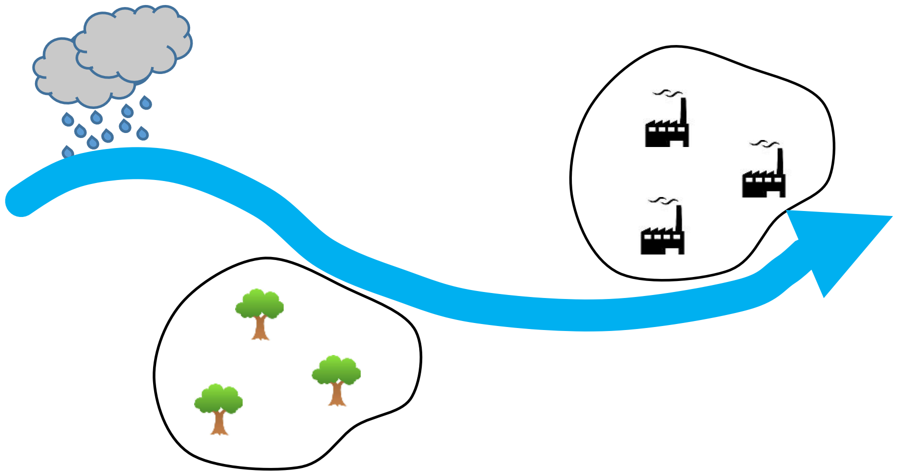
BACKGROUND AND OBJECTIVE

- Levee breach may occur due to hydraulic conditions such as high water loads, durations and velocities, or geotechnical factors that weaken structures (e.g. burrowing animal activities).
- The breach doesn't only bring vast damages, disruptions and fatalities but also changes the overall dynamic of the flood down and upstream from the breach (system behaviour) (van Mierlo et al 2007).
- At the same time, the controlled breaching is one of the flood management strategies to reduce damages downstream (Luke et al 2015).



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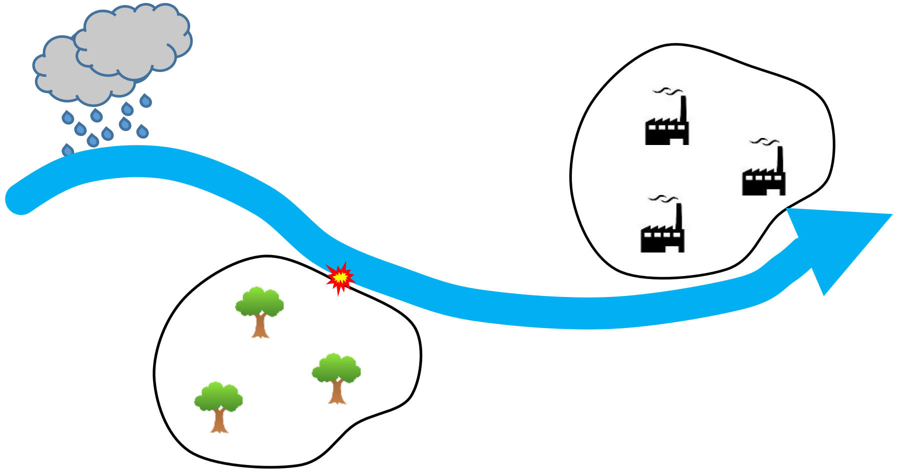

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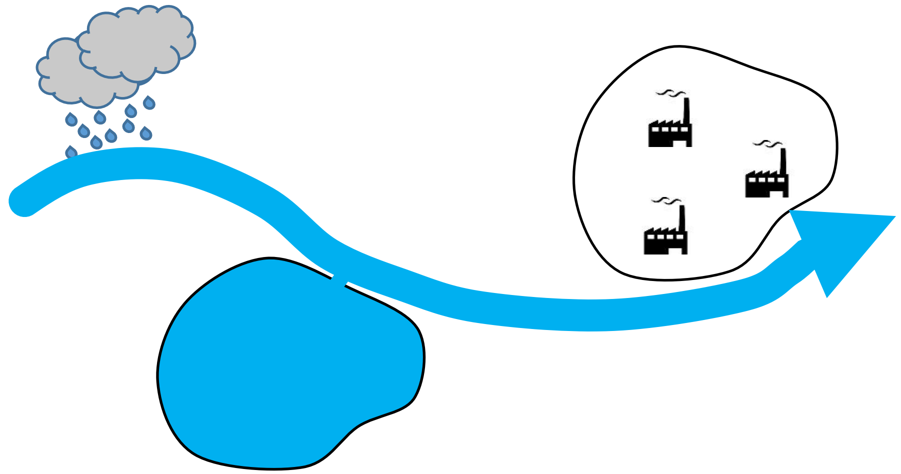

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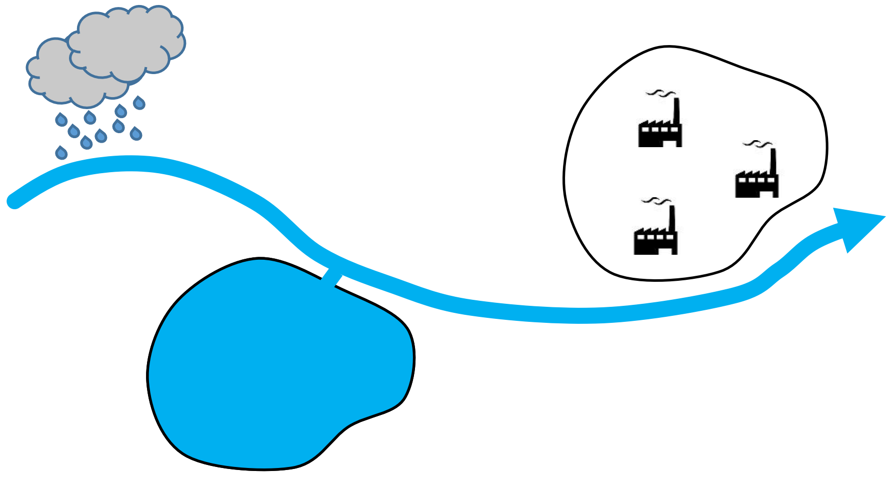

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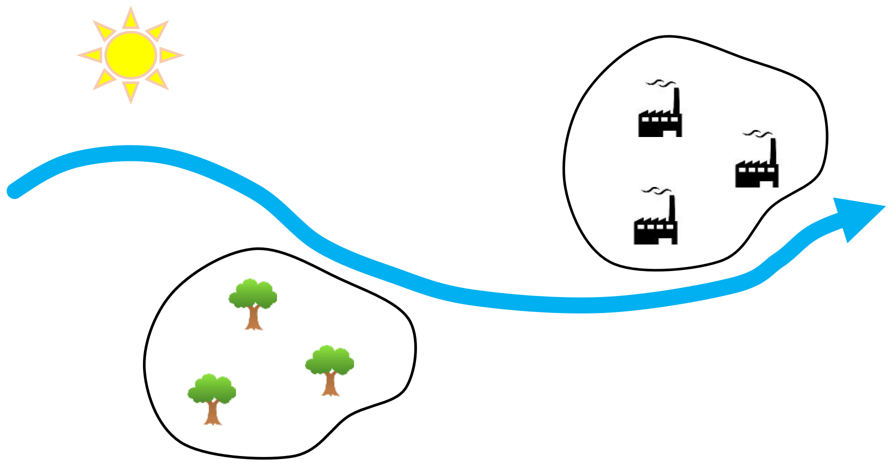


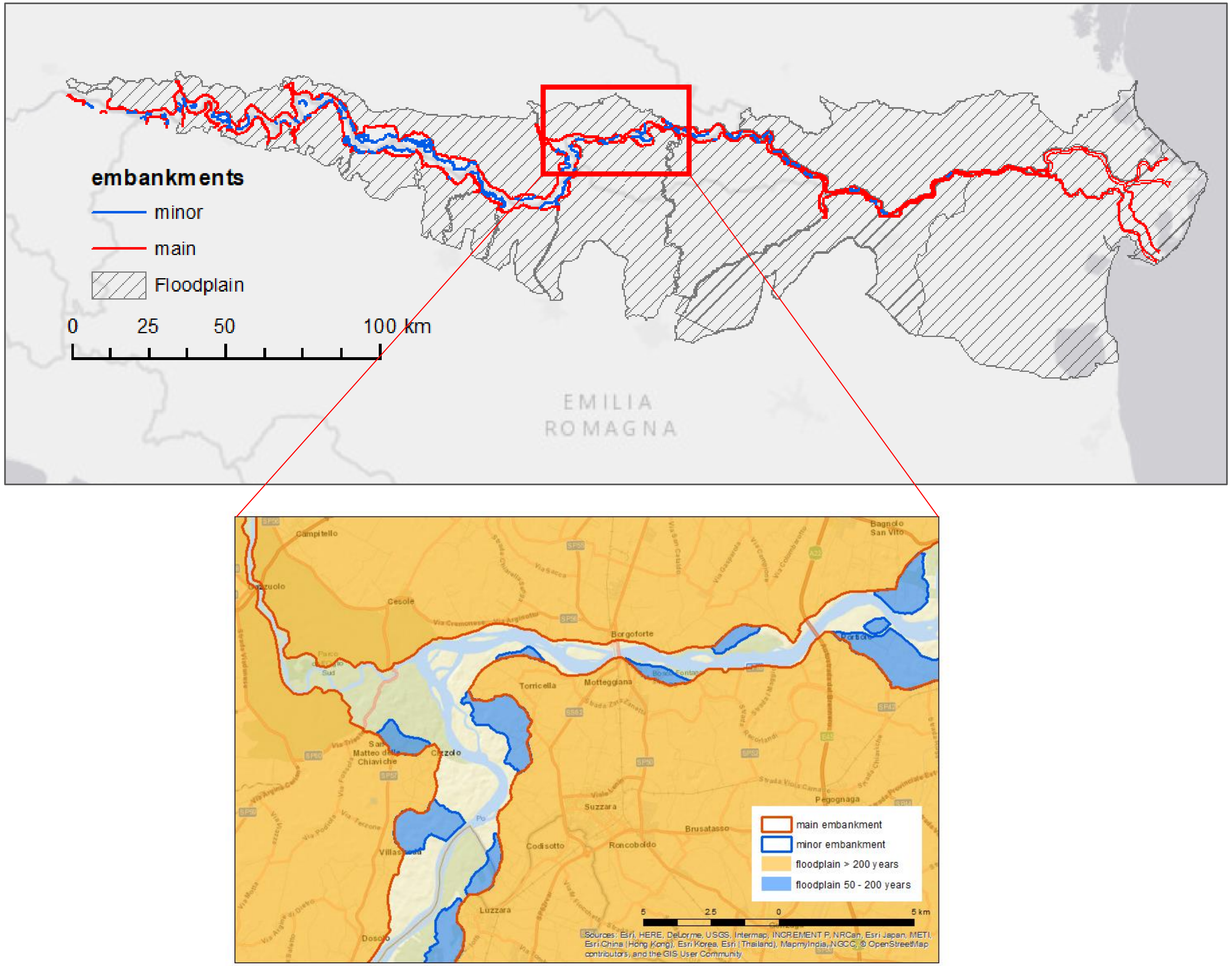
Therefore, our goal is to create a new feature within LISFLOOD-FP (LFP), which would enable non-iterative breaching simulations in fully 2D mode.

Why LISFLOOD-FP?

LISFLOOD-FP is a well-known raster-based low-complexity hydraulic model, which is widely used for large-scale simulations. Its two-dimensional mode is specifically designed to simulate floodplain inundation in a computationally efficient manner over complex topography.

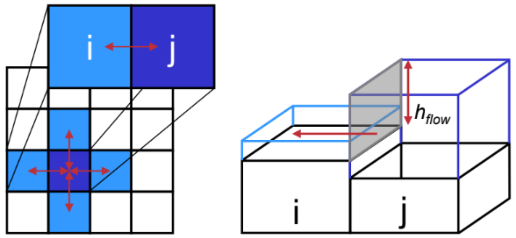
MOTIVATION – Large scale 2D simulations

- Fully 2D simulations on the large scale (river reach ca. 350km long) using LISFLOOD-FP (LFP). Tested on a historical flooding event (Po River, Italy).
- Tests performed using high-resolution LIDAR DEM (2m resolution) aggregated to 30, 50 and 100m showed that 50m resolution is a fair compromise between accuracy of results and computational time.
- Pre-processed DEMs include the actual height and location of the levees, which makes the <u>levee breach option possible</u>.



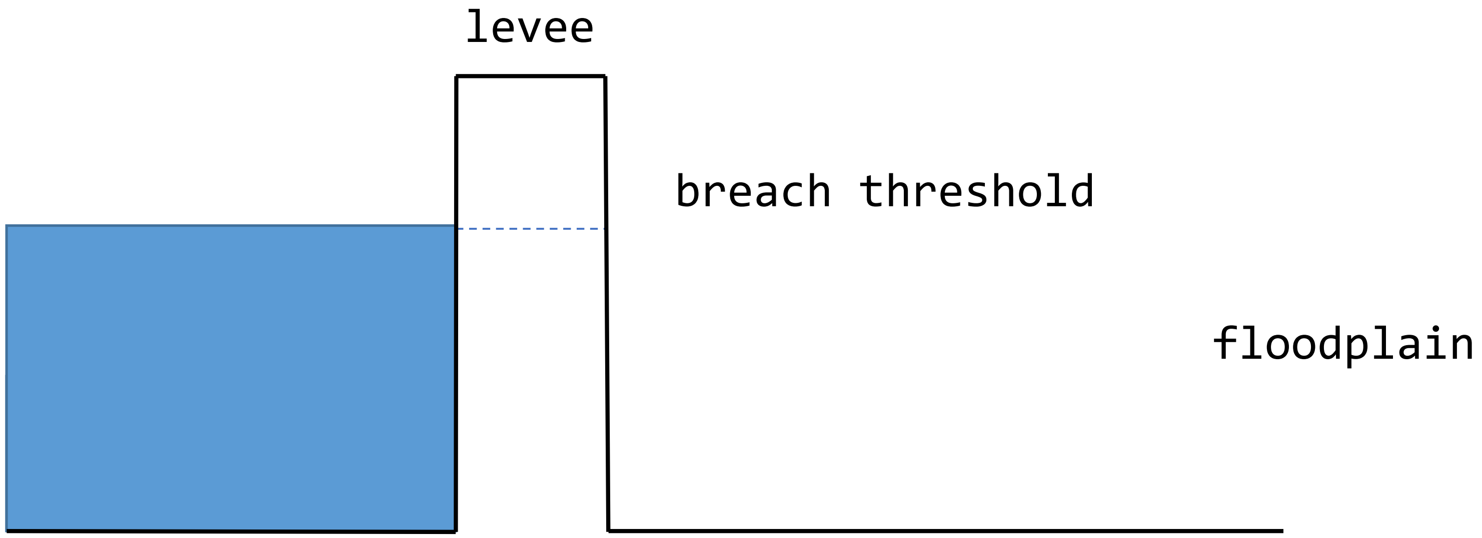
METHODS

LFP is a raster-based model (computational mesh is of the same resolution as the input terrain model´s resolution). 2D floodplain flow is calculated using inertial formulation of the shallow water equations.



Bates et al (2010)

1. Levee height has to be represented in the LFP terrain (GIS pre-processing).
2. Possible breach locations need to be specified in the assisting file.
3. Breach parameters (freeboard, duration, breach depth, modular limit).
4. The flow through the breached cell is calculated with the weir equation.



$$Q = CLH^{1.5}$$

C – weir flow coefficient
L – breach breadth
H – energy head upstream

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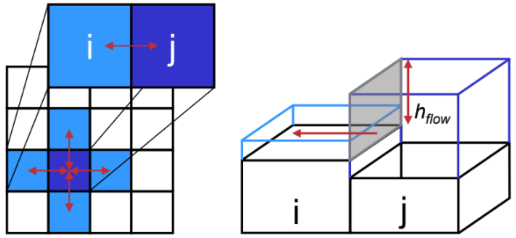

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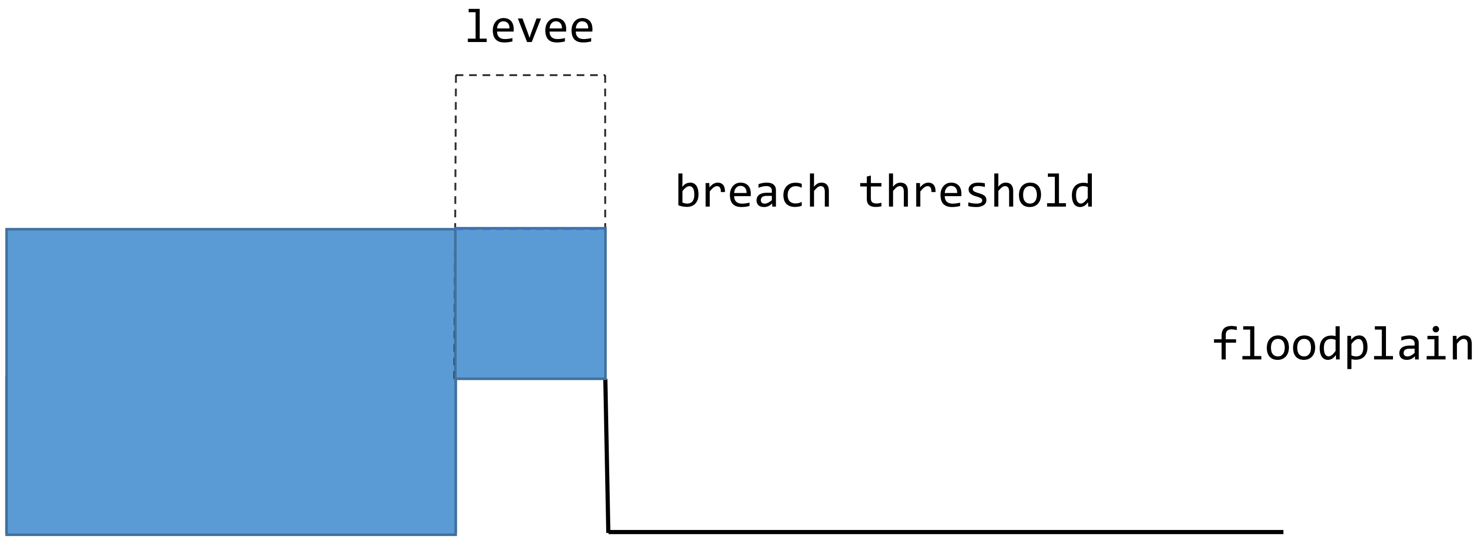

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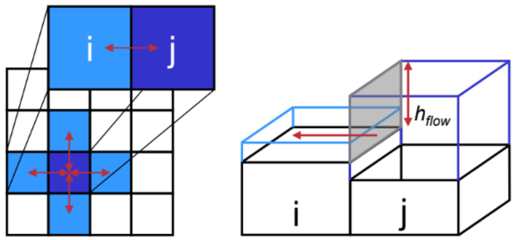

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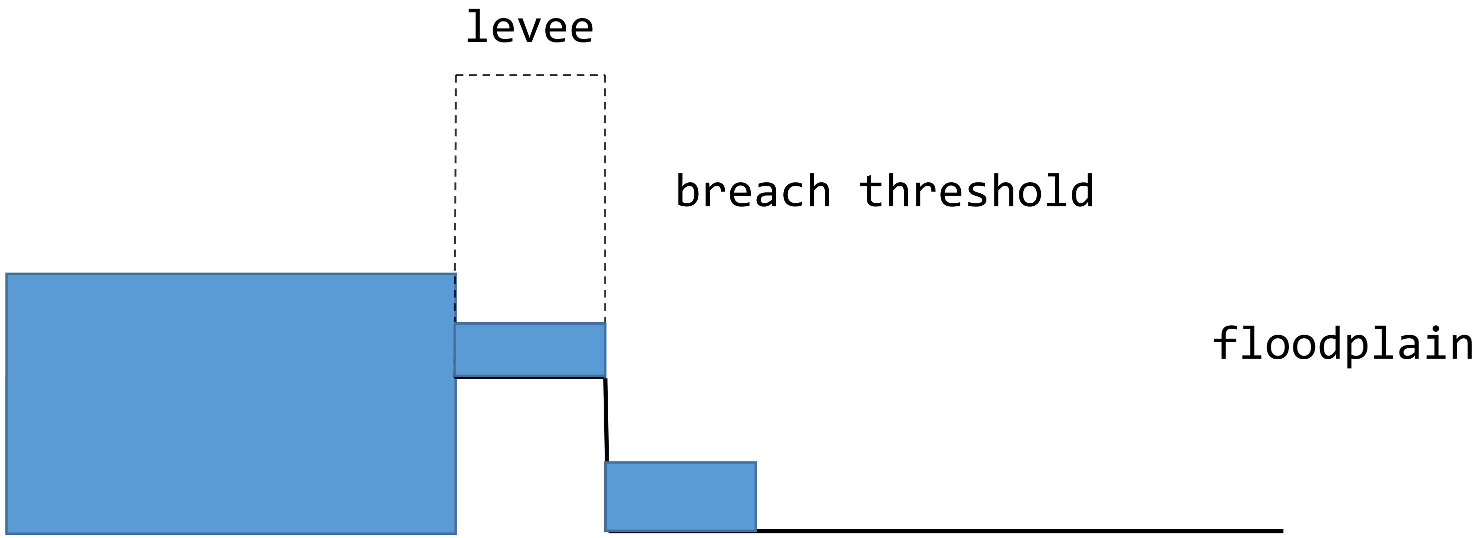

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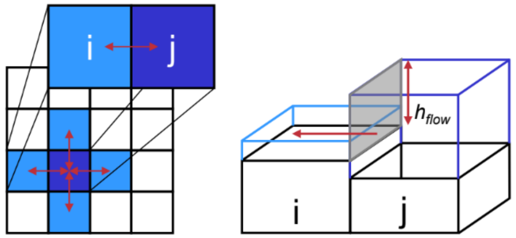

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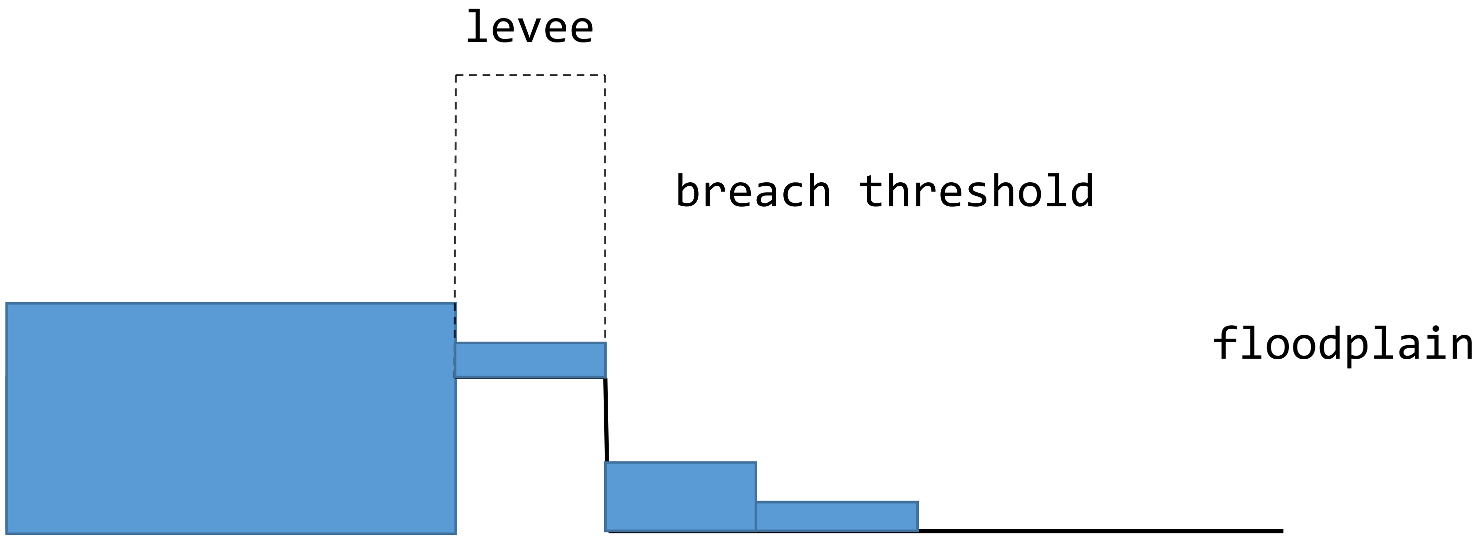

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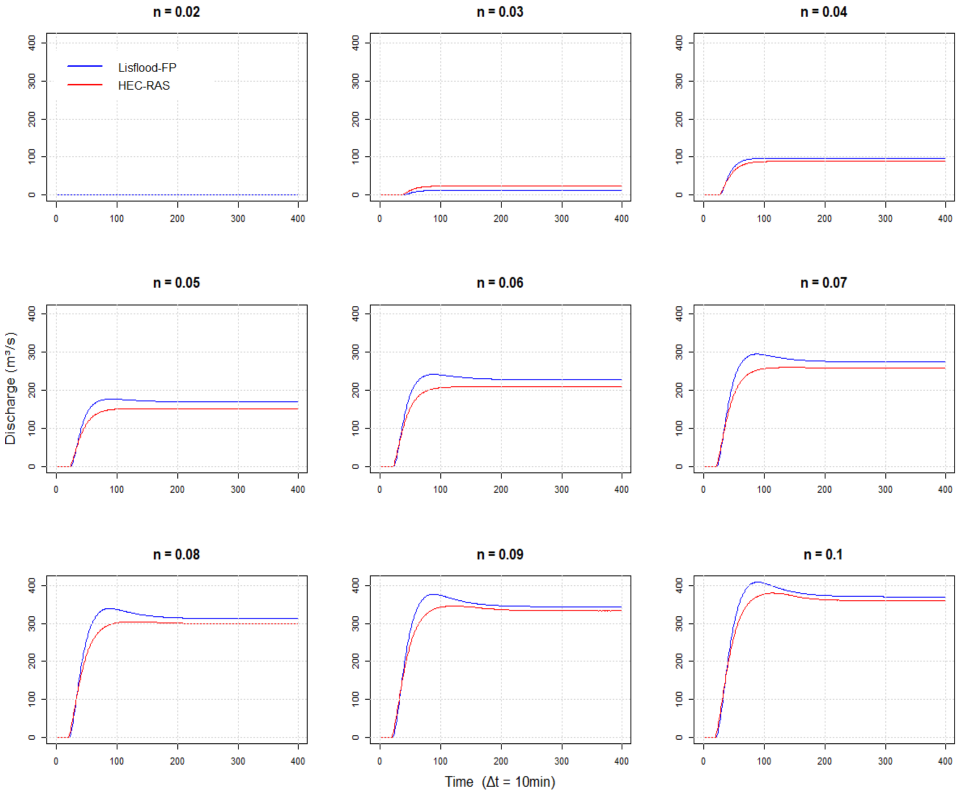
Sub-routine tests

1. Performance comparison of LFP and HEC-RAS 5.0.3. on synthetic data.
2. Sensitivity analysis of the model paramters on the Secchia River flood event (Italy, 2014).
3. Flood extent simulation on the large-scale Polesine flood event (Italy, 1951).

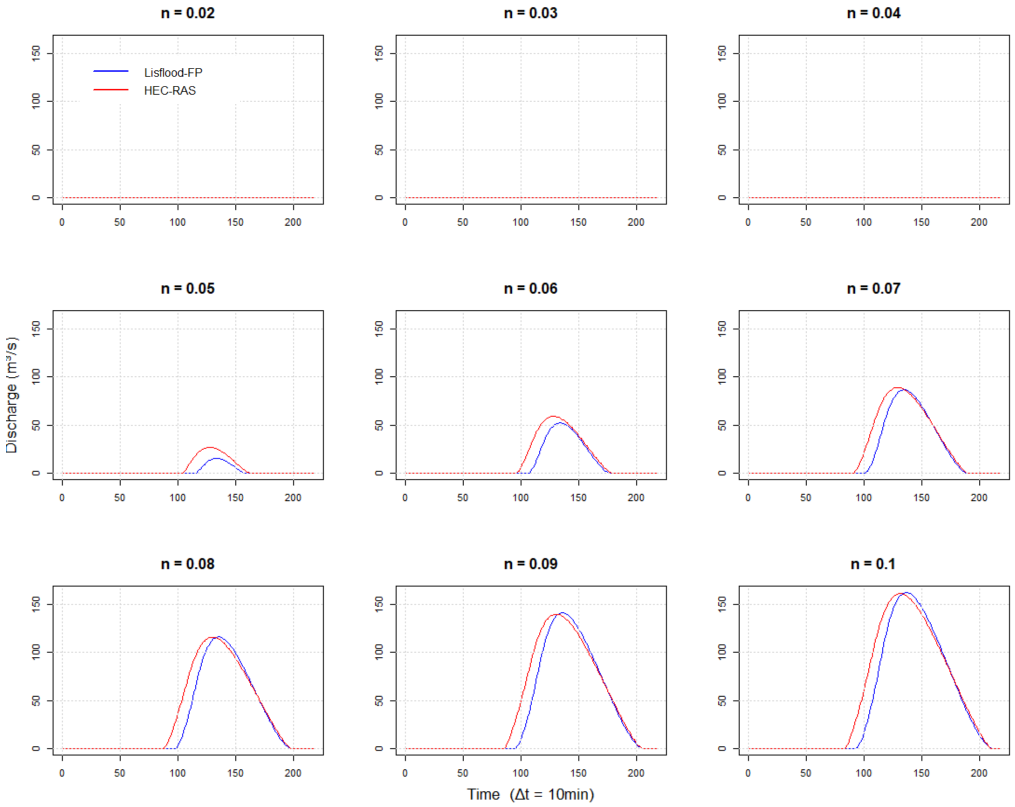
Synthetic simulations

Synthetic DEM and hydrographs to compare the LISFLOOD-FP with HEC-RAS 5.0.3

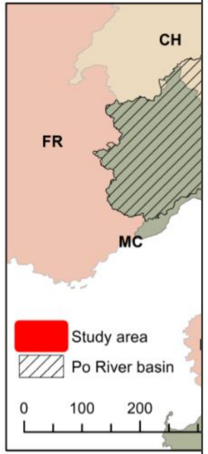
Steady flow conditions
Flow leaving the breach

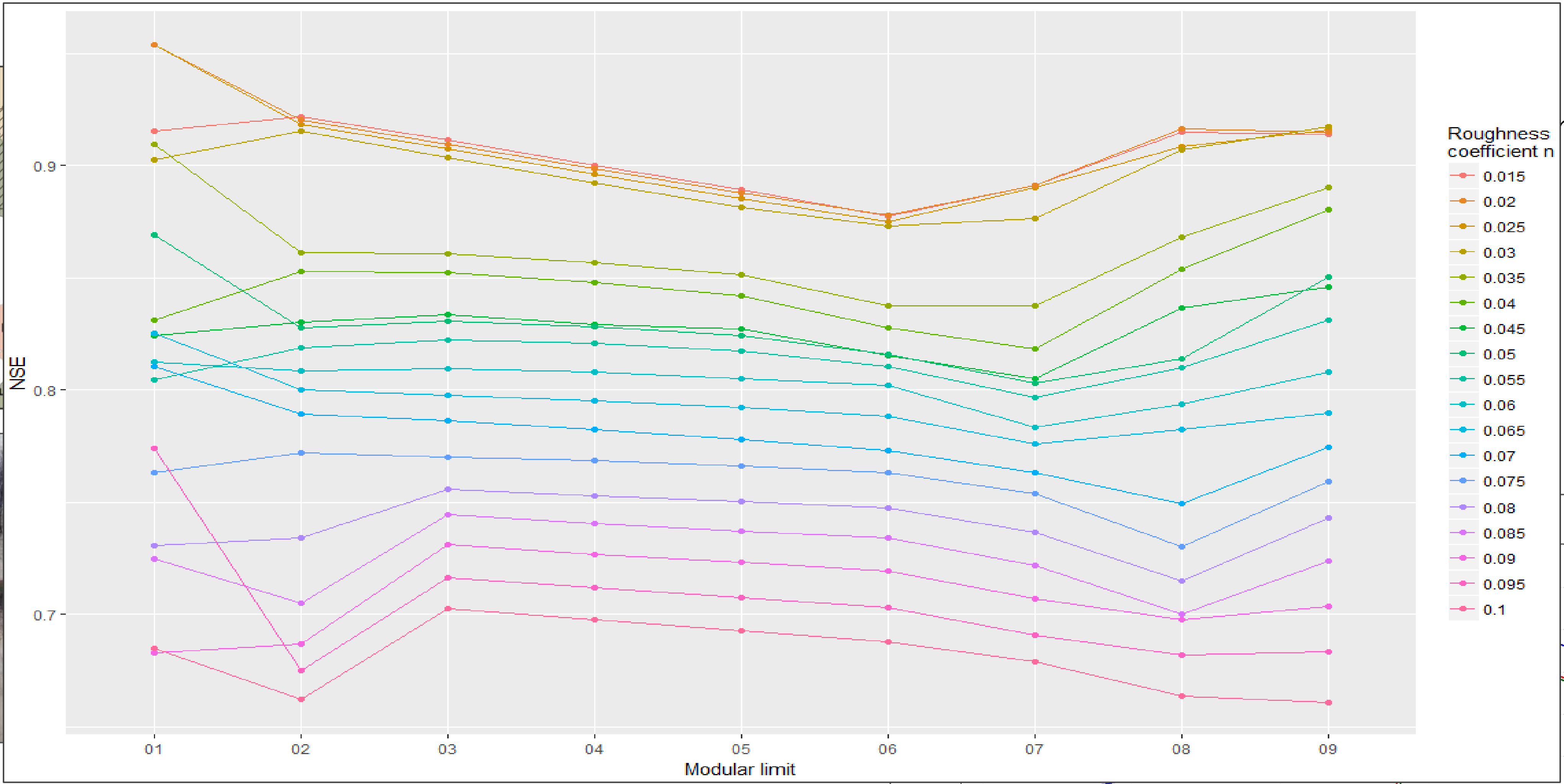


Unsteady flow conditions
Flow leaving the breach

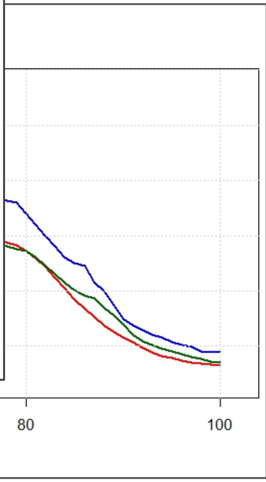


Secchia River flood case

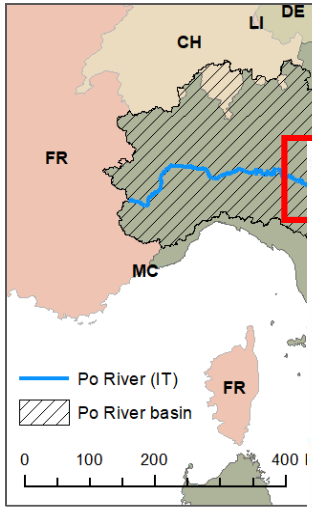


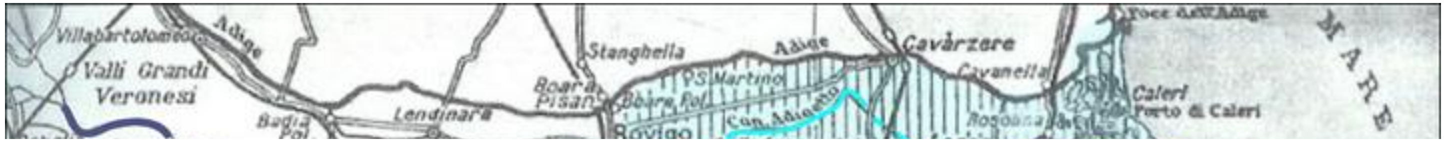


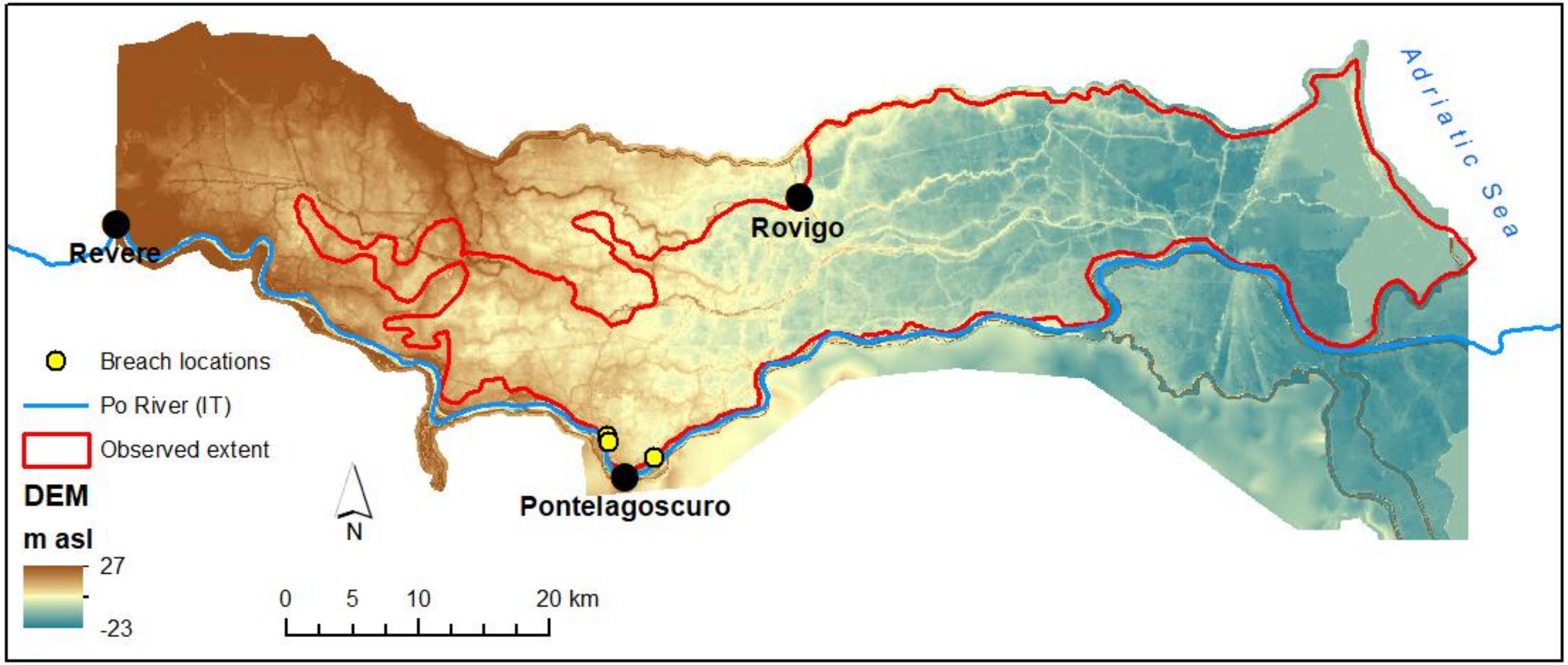
using
nt (NSE)

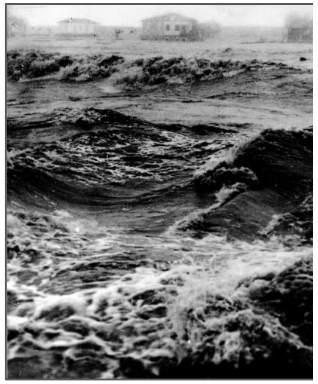


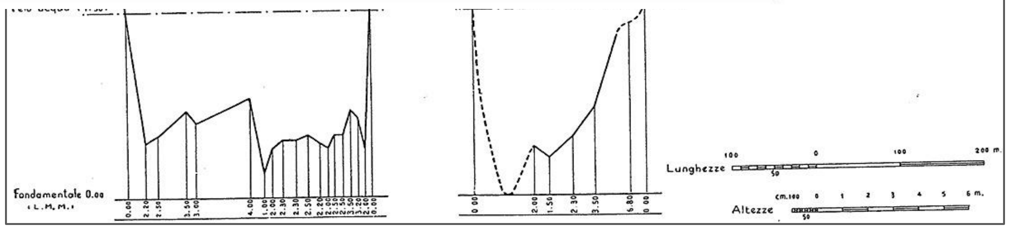
Polesine flood 1951, Po River



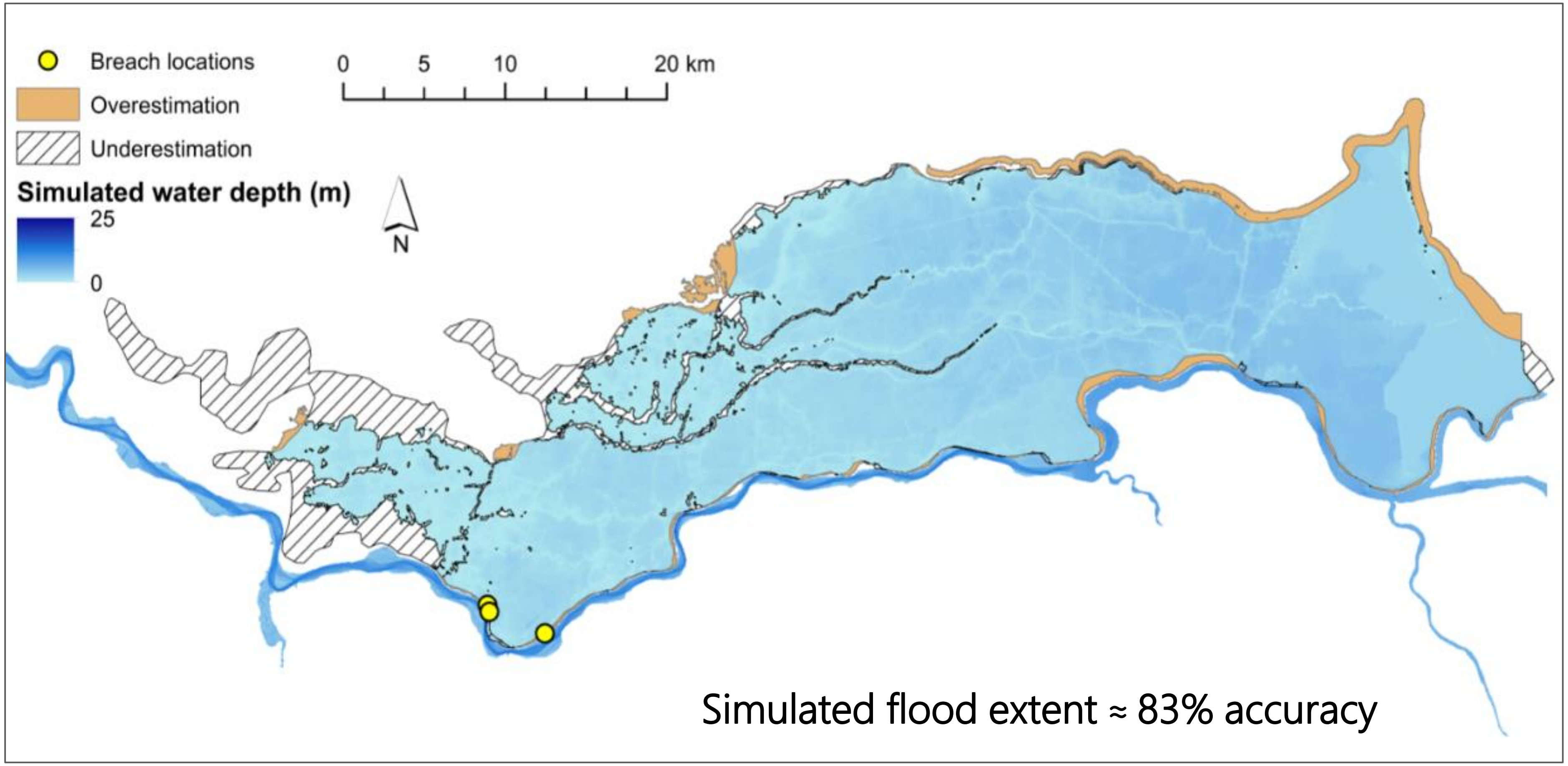








Computational time is 50 minutes of a simulation of 348 hours and over 1,620,000 cells of the input domain with the maximum time step of 5s.



CONCLUSION

1. Synthetic tests showed that the results of LISFLOOD-FP are in a good agreement with HEC-RAS outputs (discharge through the breach) with computational time advantage of LISFLOOD-FP.
2. The tool is not meant to study the breaching phenomenon but preliminary flood risk assessment, emergency planning, etc.
3. Levee breach modelling with LISFLOOD-FP showed the potential to be a tool for various scales, including large-scale flood simulations and production of the envelope of breaching scenarios for various purposes (events reconstruction, system dynamics evaluation, hotspots identification, controlled flooding management, etc.).
4. Can be applied for various geographical regions (including data-scarce areas).

Further work

- Probabilistic levee breaching modelling.
- More parameters for the breach (breach depth progression over time, failure probability).
- Final version production for the code with the application guide.

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THANK YOU

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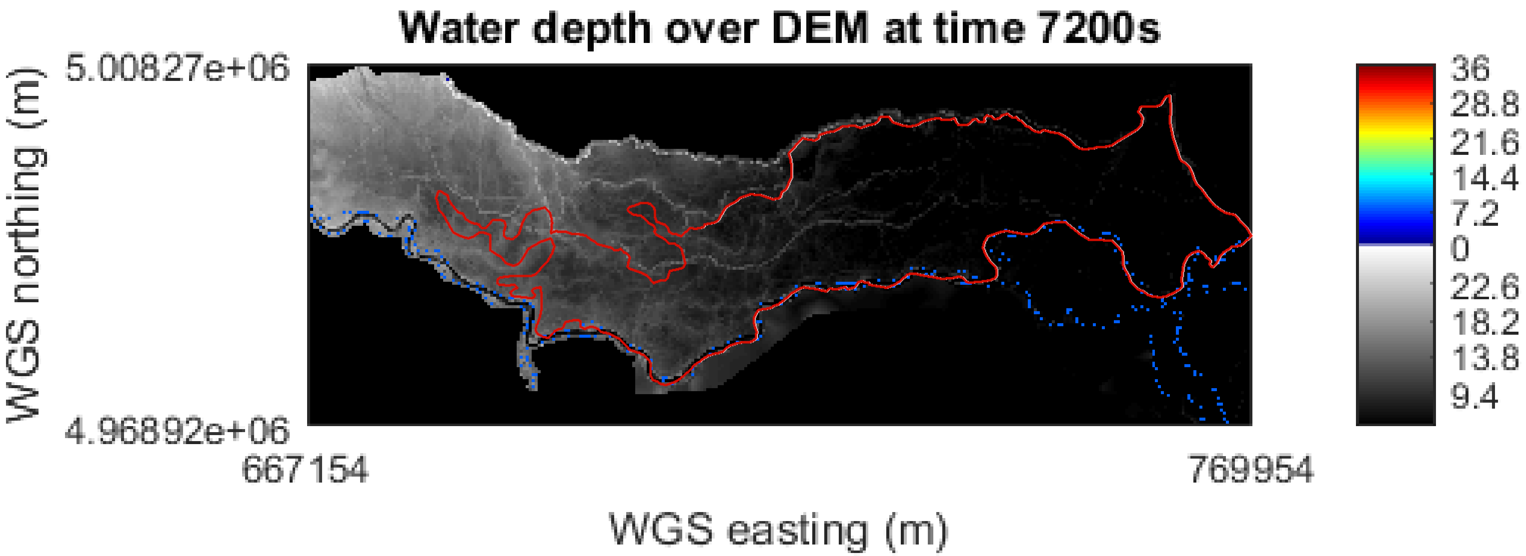

Water depth over DEM at time 7200s
5.00827e+06
4.96892e+06
WGS northing (m)
667154
769954
WGS easting (m)
36
28.8
21.6
14.4
7.2
0
22.6
18.2
13.8
9.4