Latest Advancements in WOLF Model for Guiding the Resilient Reconstruction in the Vesdre Valley

10th International Meuse Symposium

"Water quantity - Climate change adaptation and resilience"

Speaker - Damien Sansen

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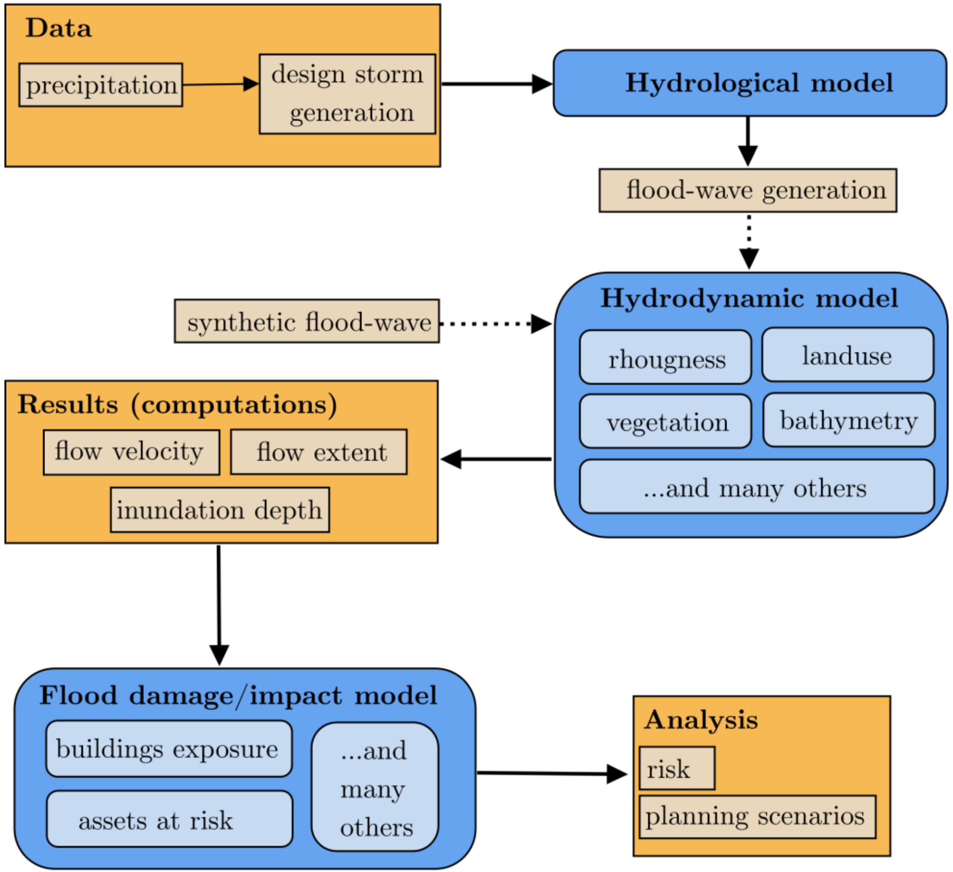
S. Erpicum, M. Pirotton

10/09/2024, Liège (Belgium)

Introduction
WOLF modeling system

WOLF HECE

WOLF HECE | Workflow



WOLF HECE | Workflow

WOLF HECE | **Workflow**

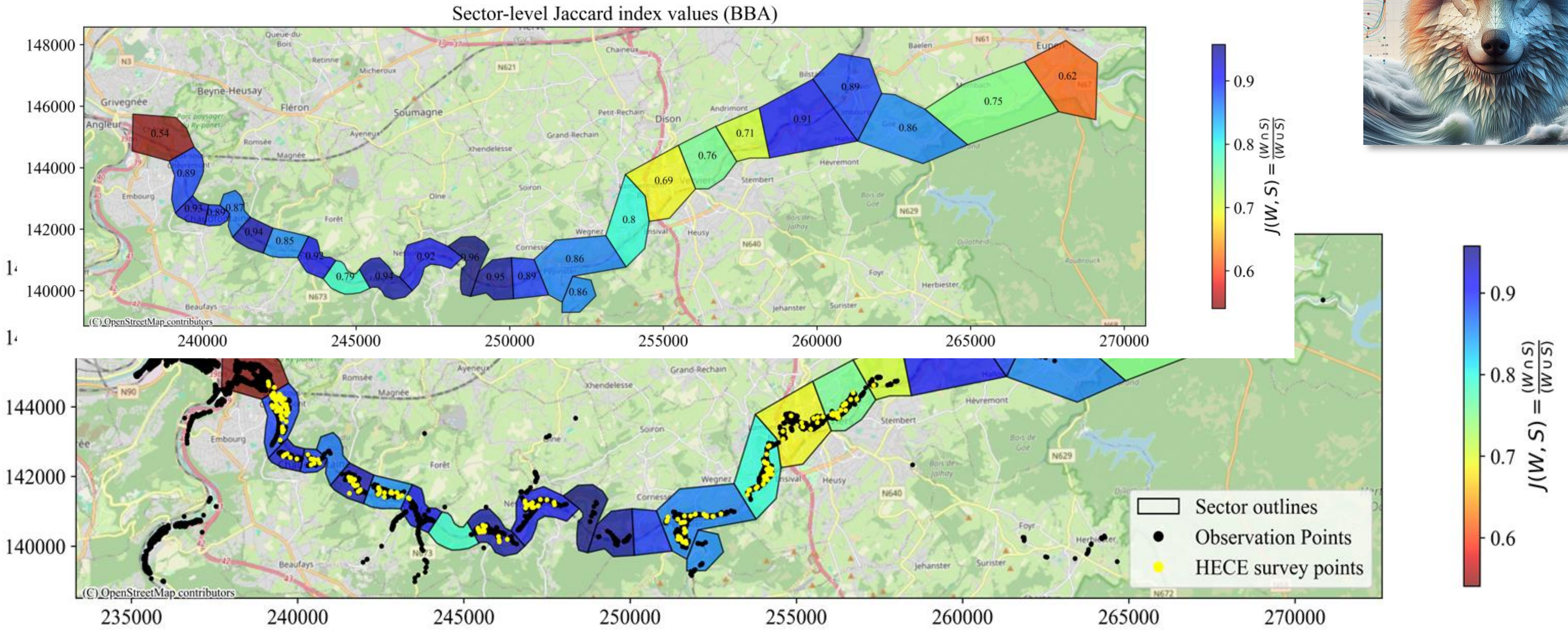
Belgium *(country)*

Vesdre *(river)* catchment

"Does WOLF effectively simulate the 2021 flood event along the Vesdre in terms of **flood extent**, using its hydrodynamic and hydrological components ?"

***P. Chakraborty**, PhD Student*

WOLF HECE | Workflow



$$\textbf{Jaccard} = \frac{\text{Intersection (A, B)}}{\text{Union (A, B)}}$$

P. Chakraborty, PhD Student

Presentation content

1. Scenarios manager
2. Acceptability manager
3. Further investigations

1. Scenario manager
Efficient way to guide scenarios

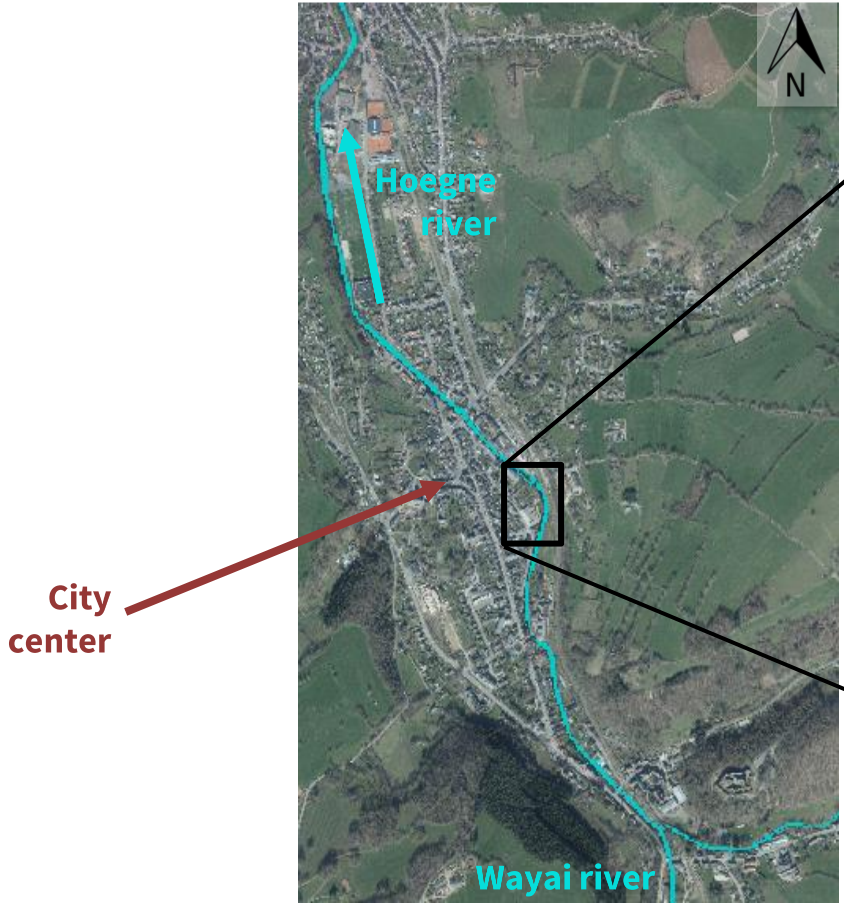
1. Scenario manager | Example on Theux

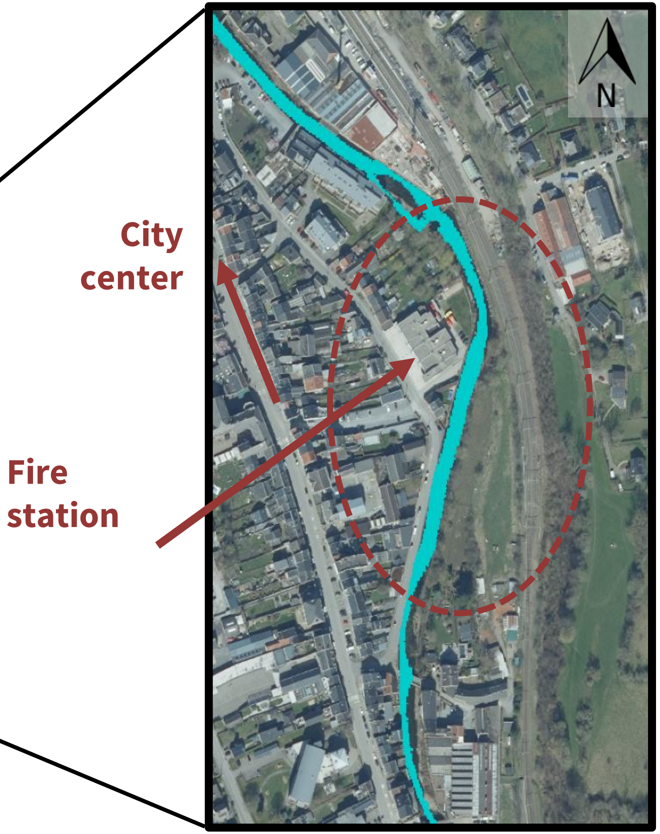
 Belgium *(country)*

 Vesdre *(river)* catchment

 Theux *(municipality)*

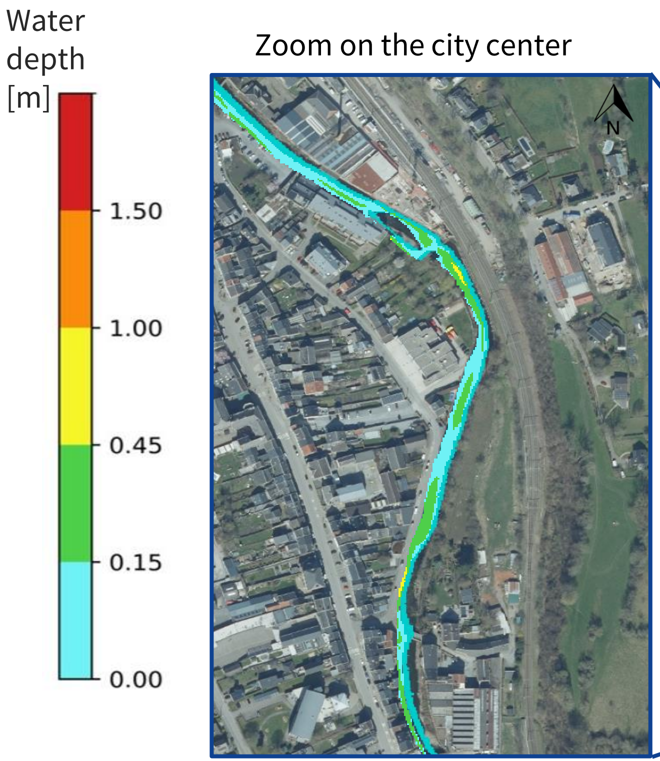
1. Scenario manager | Example on Theux

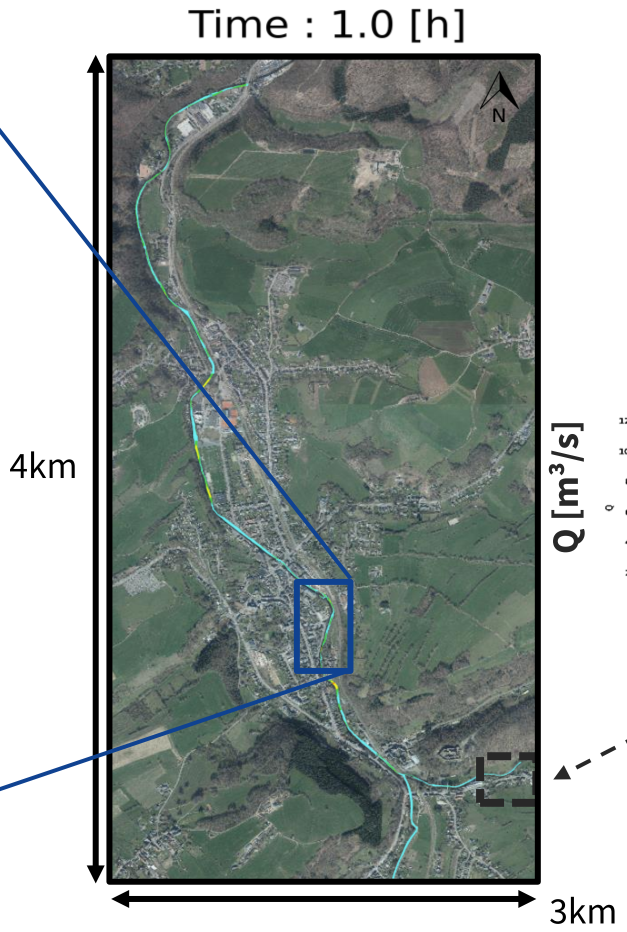


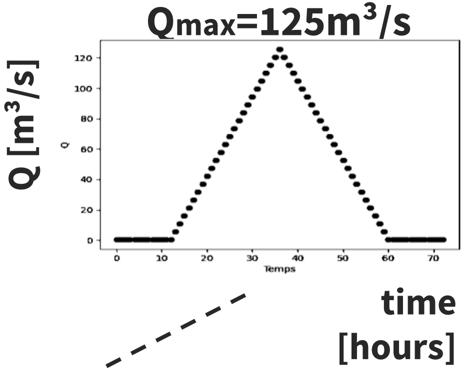


Narrowing of the Hoegne river at the fire station – consequences ?

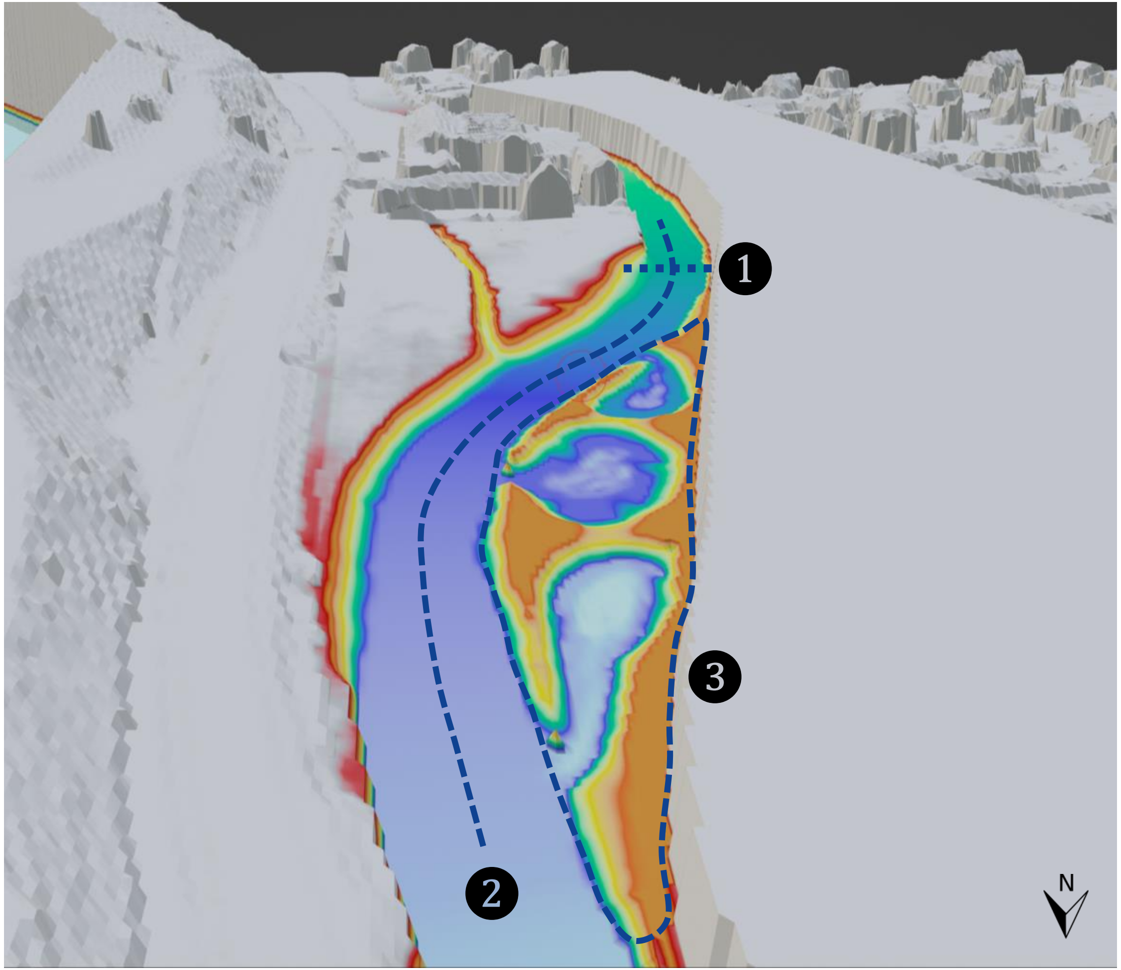
1. Scenario manager | Example on Theux







Weak spot for flood risk !



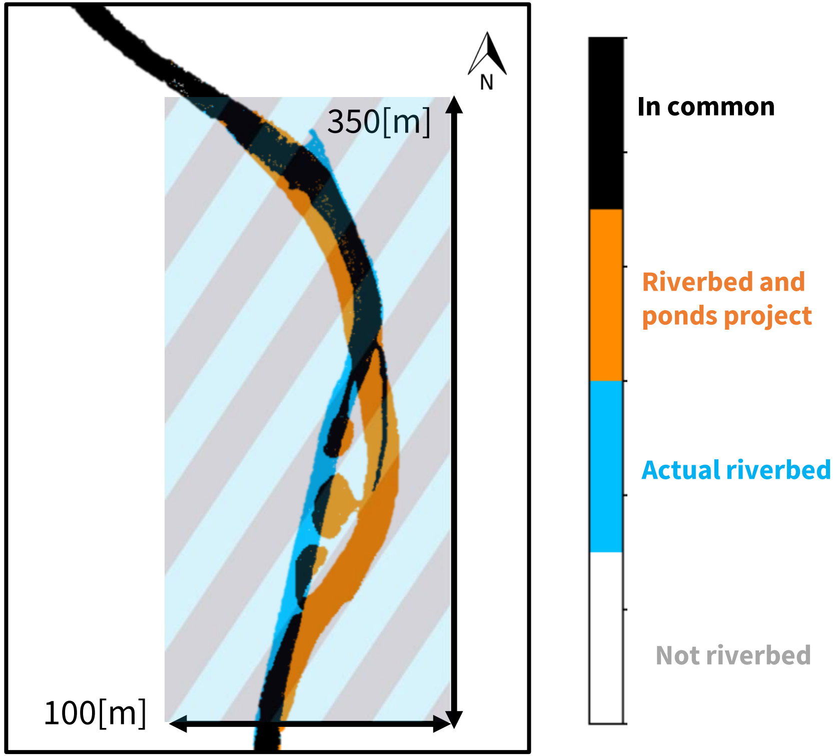
3D view of the NbS studied in Theux, generated with WOLF (ULiège, HECE)

Temporary storage areas (TSAs)

represent a category of soft-engineered NbS that can provide dispersed and small-scale storage throughout a catchment

And modification of the Hoegne riverbed

1. Increased river width
   Give more room to the river
2. Riverbed relocation
   Improve water flow
3. Creation of 'ponds' for storage
   Additional storage during flood event



Area of the ponds (approximation)

- *1 large : 25x35 [m^2]*
- *2 smaller ones : 20x15 [m^2]*

Storage volume of the ponds :

- *4 200 [m^3]*

Total net volume gains (with changes of the riverbed) :

Volume in

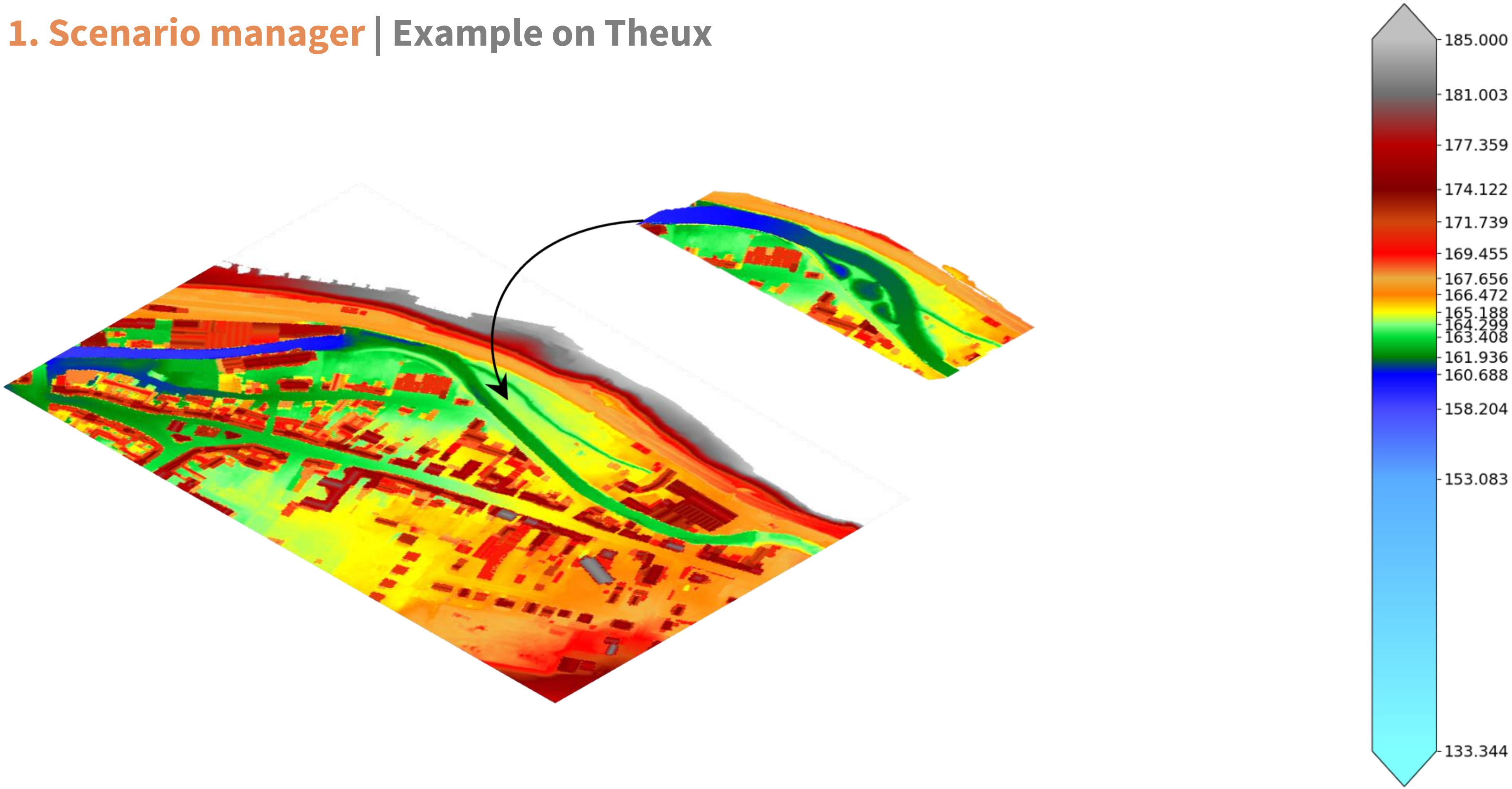
-Without the project : 16 000 [m^3]

-With the project : 28 800 [m^3]

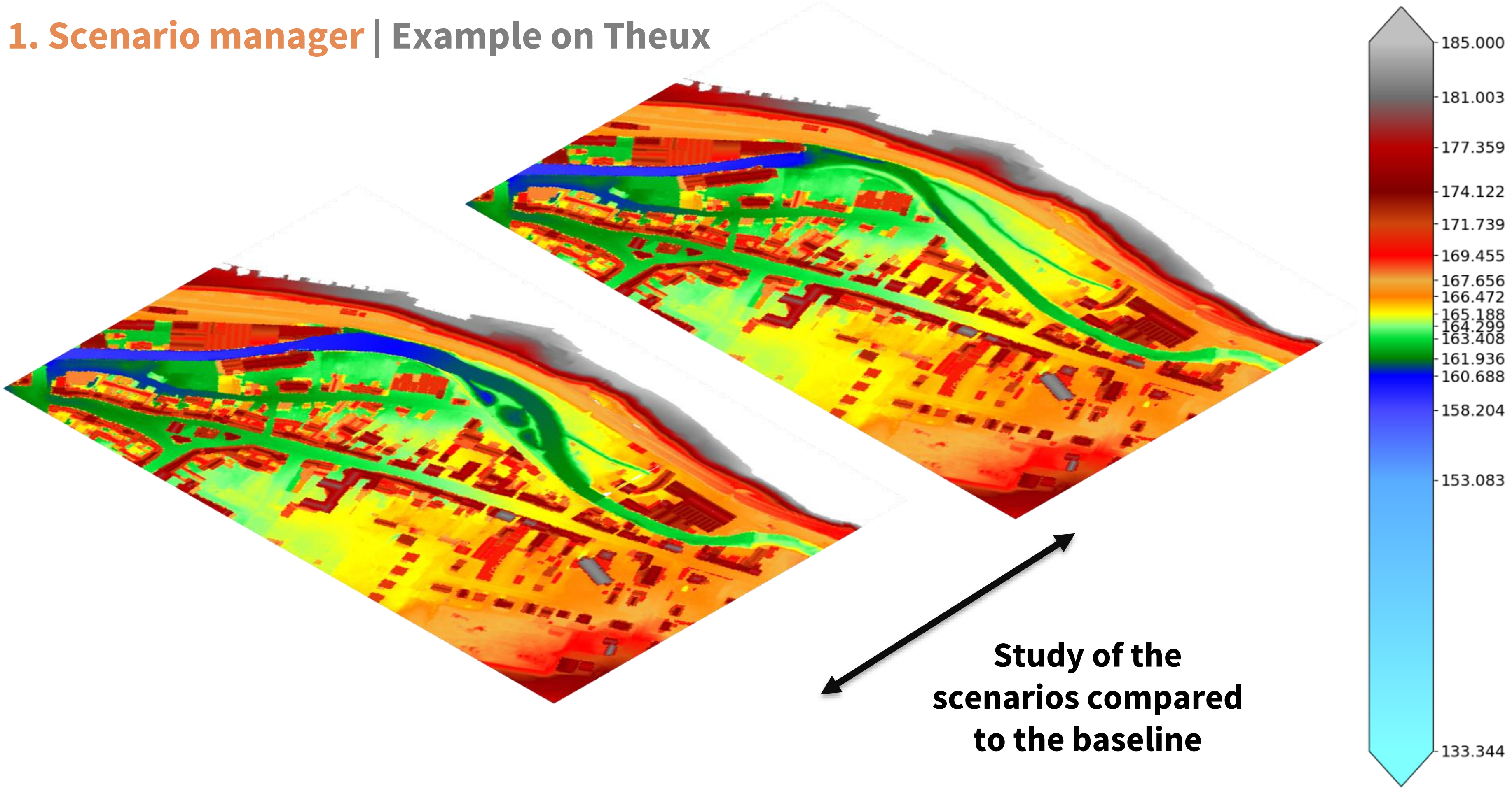
→ Increase of 80%

Efficient ? Need for unsteady simulations

1. Scenario manager | Example on Theux



1. Scenario manager | Example on Theux

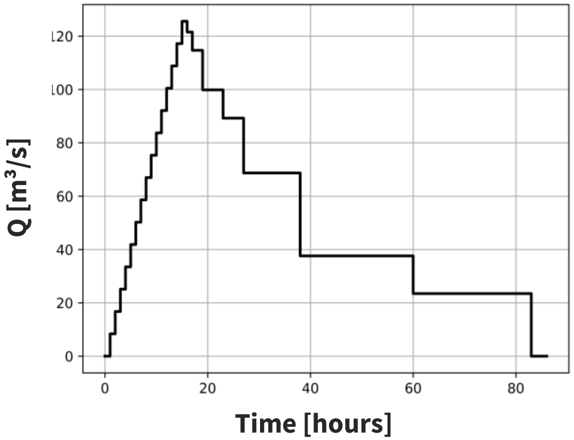


Study of the scenarios compared to the baseline

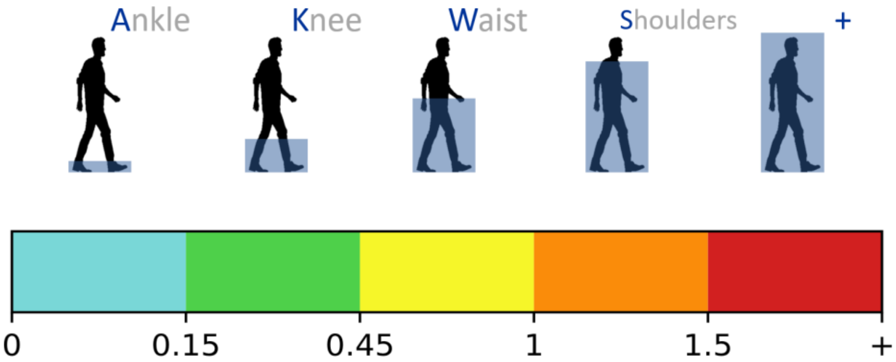
1. Scenario manager | Example on Theux

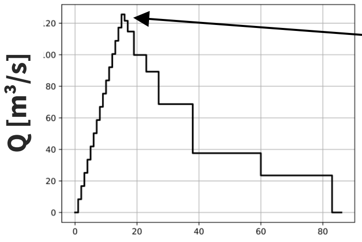
Storage measures: need for an unsteady simulation

- 25 years return period
- Q_{peak} = 125m^3/s
- Rising limb: 16 h
  Recession limb: 70 h



A look at the evolution of water depth with **AKWS+ color scale**



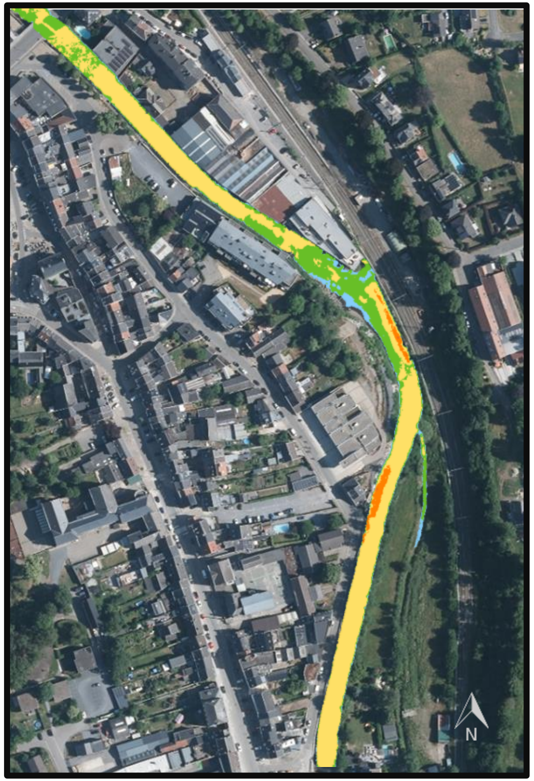


Q_{peak} = 125m³/s (T25)

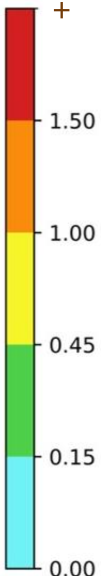
16 h rise,
70 h recession

Time : 1.0 [hours]

Without the TSA



Water depth [m]



With the TSA

1. Scenario manager | Example on Theux

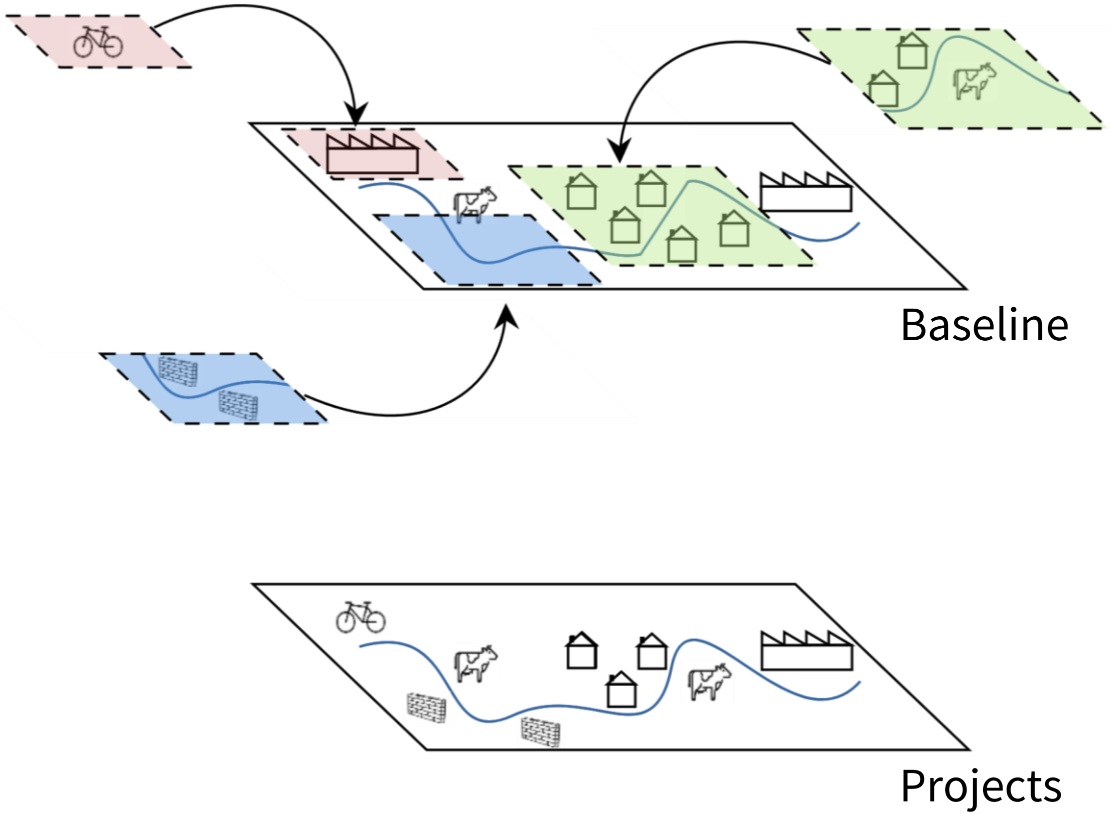
T [years]	25	50	100
Qmax [m³/s]	125.57	162.6	214.8

Time : 1.0 [hours]

1. Scenario manager| A user-friendly tool

A tool to edit **locally** different rasters, allowing to guide project studies and more.

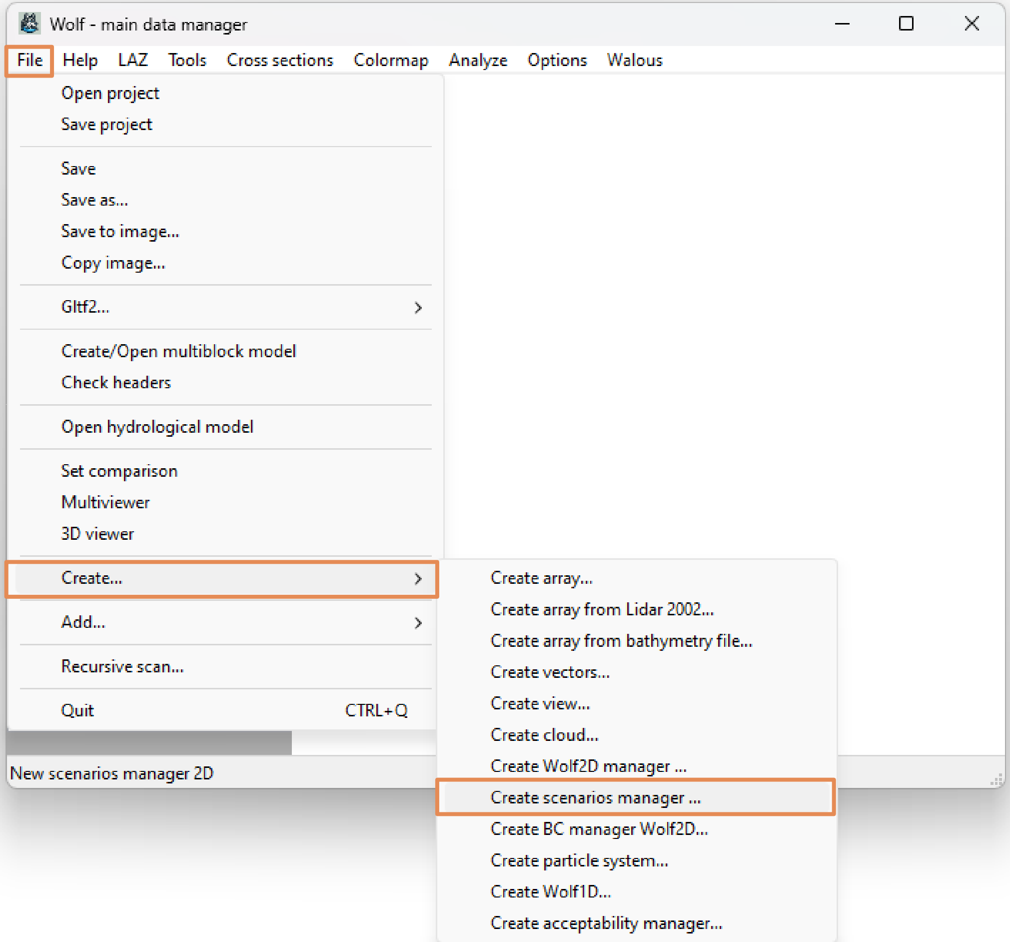
Also applicable for **multiple modifications**, allowing the study of complete design plans.

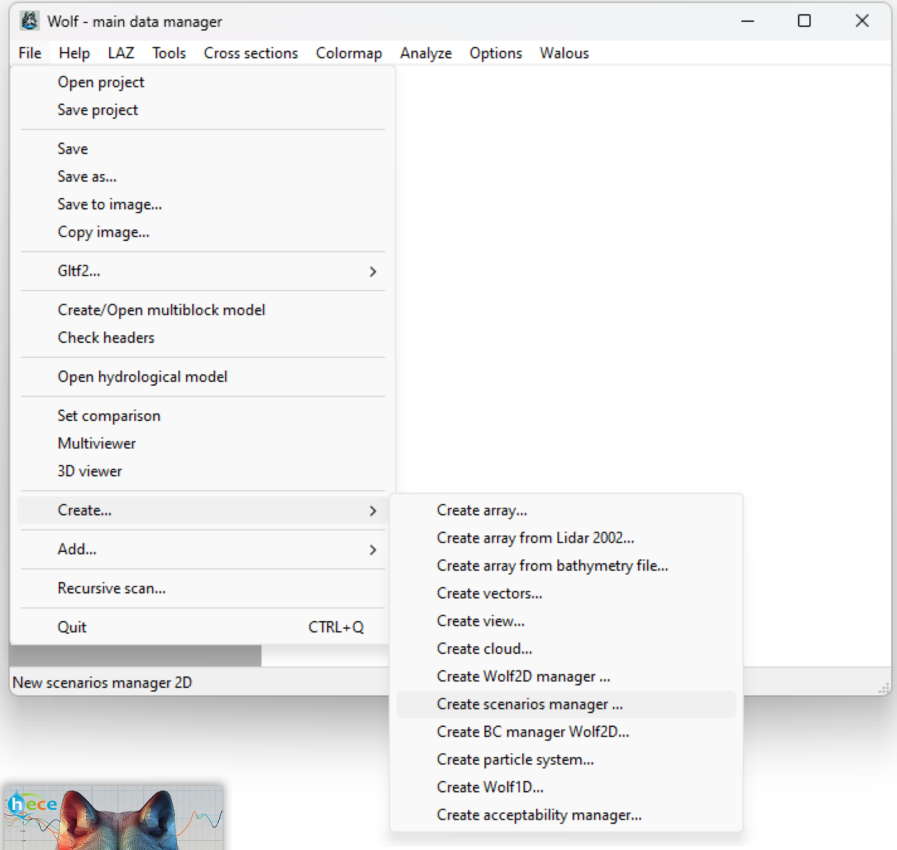


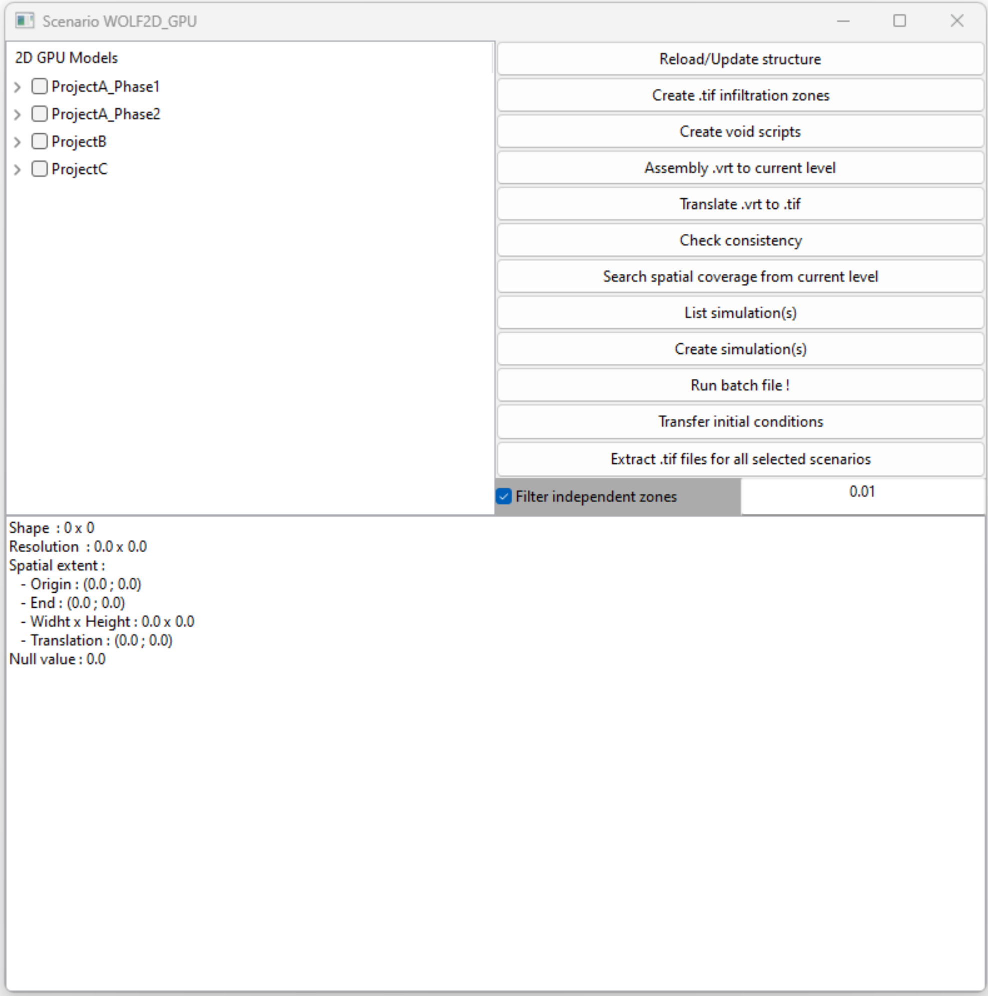
1. Scenario manager| A user-friendly tool

A tool developed in WOLF for local raster editing within a defined area, enabling to guide project studies and more.

Also applicable for multiple modification, allowing the study of complete design plans




Wolf - main data manager
File
Help
LAZ
Tools
Cross sections
Colormap
Analyze
Options
Walous
Open project
Save project
Save
Save as...
Save to image...
Copy image...
Gltf2...
Create/Open multiblock model
Check headers
Open hydrological model
Set comparison
Multiviewer
3D viewer
Create...
Add...
Recursive scan...
Quit
CTRL+Q
New scenarios manager 2D
Create array...
Create array from Lidar 2002...
Create array from bathymetry file...
Create vectors...
Create view...
Create cloud...
Create Wolf2D manager ...
Create scenarios manager ...
Create BC manager Wolf2D...
Create particle system...
Create Wolf1D...
Create acceptability manager...


Scenario WOLF2D_GPU
2D GPU Models
ProjectA_Phase1
ProjectA_Phase2
ProjectB
ProjectC
Reload/Update structure
Create .tif infiltration zones
Create void scripts
Assembly .vrt to current level
Translate .vrt to .tif
Check consistency
Search spatial coverage from current level
List simulation(s)
Create simulation(s)
Run batch file !
Transfer initial conditions
Extract .tif files for all selected scenarios
Filter independent zones
0.01
Shape : 0 x 0
Resolution : 0.0 x 0.0
Spatial extent :
- Origin : (0.0 ; 0.0)
- End : (0.0 ; 0.0)
- Widht x Height : 0.0 x 0.0
- Translation : (0.0 ; 0.0)
Null value : 0.0

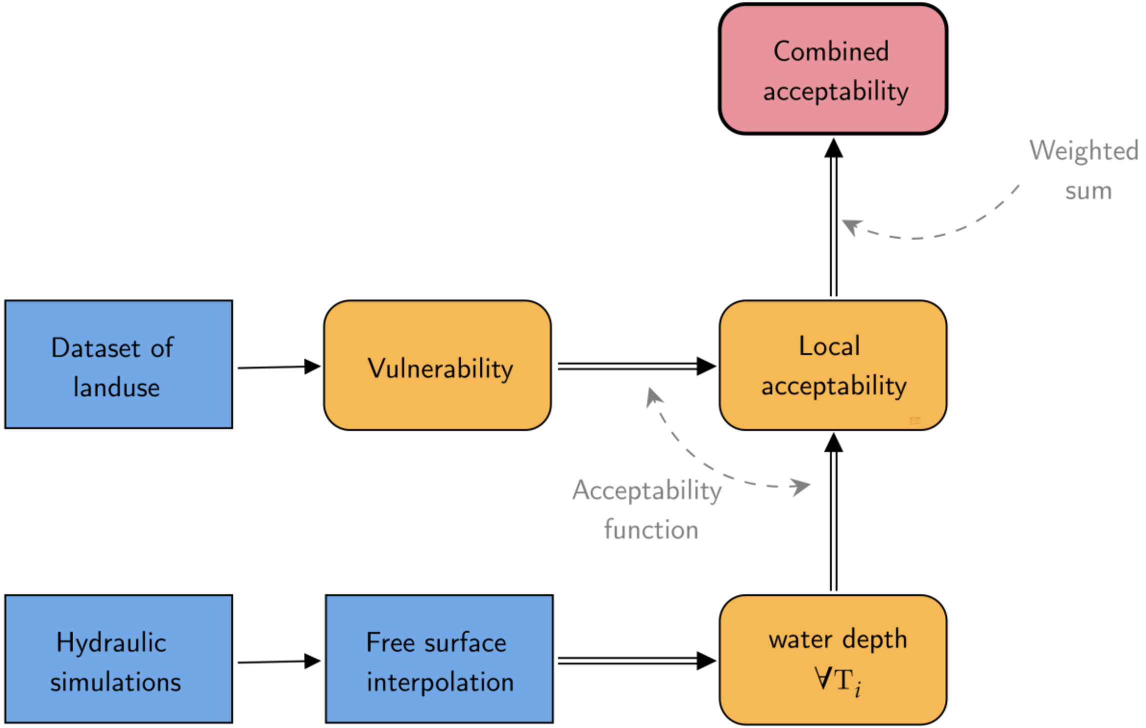

hece

2. Acceptability[1] manager

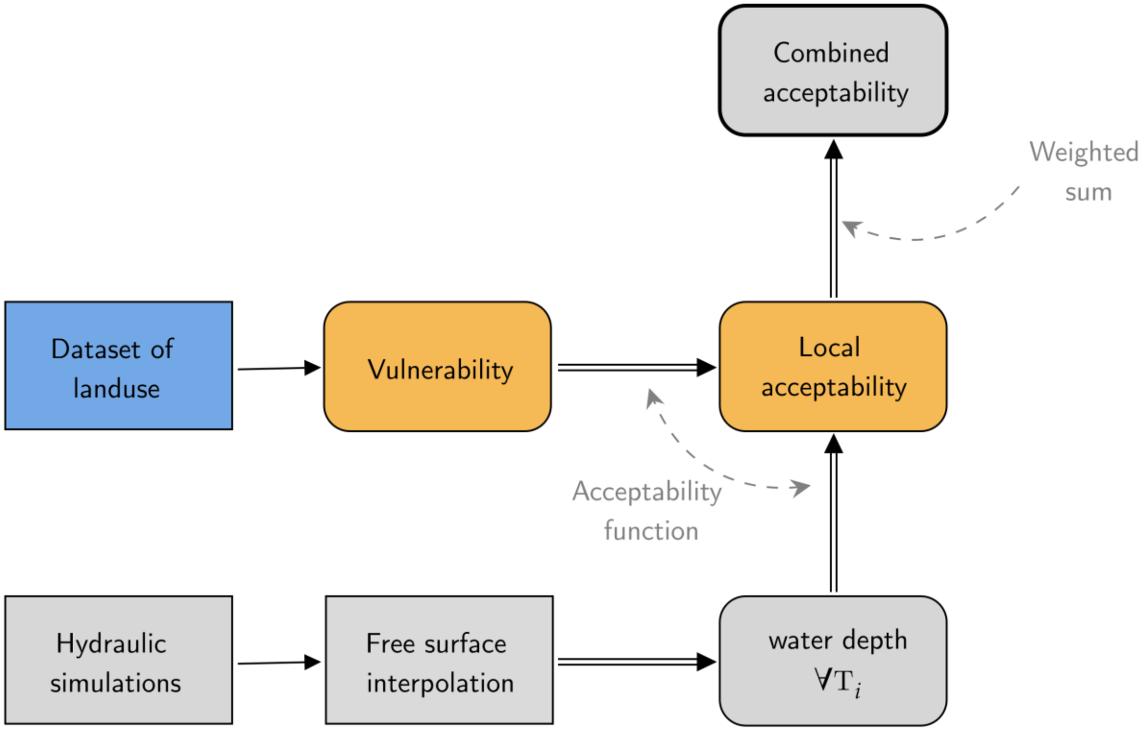
A risk module incorporated in WOLF

[1]First results of the Resilience Working Group led within the framework of the Flood Transversal Group

2. Acceptability manager| Acceptability workflow



2. Acceptability manager| Acceptability workflow



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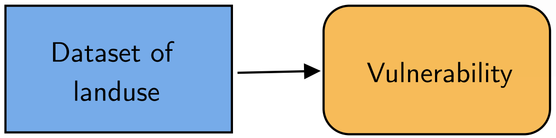
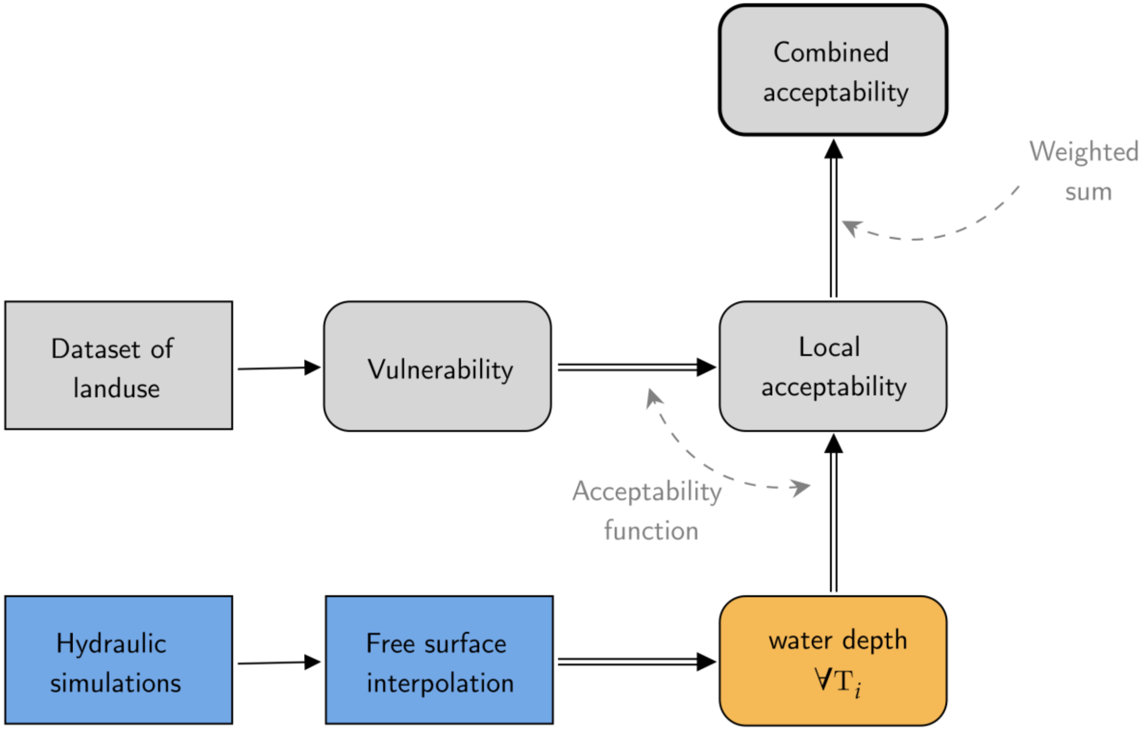


Level	Vulnerability	Criterion
5	Huge	**Examples:** Hospitals, fire stations, civil protection. **Description:** Extreme impact. Severe constraints with high risks; submersion is likely to cause major disruption or damage, requiring extensive mitigation measures.
4	High	**Examples:** Nursing homes, health services, police. **Description:** Significant impact. Submersion leads to considerable constraints, with substantial risks and potential for severe disruption or damage.
3	Moderate	**Examples:** Residential buildings, schools, economic activities. **Description:** Moderate impact. Some constraints are present; submersion may cause noticeable effects but can be managed with standard measures.
2	Low	**Examples:** Recreational areas, storage zones, ports. **Description:** Minimal impact. Limited constraints; submersion poses negligible risk, with manageable effects on functionality and operations.
1	Null	**Examples:** Natural reserves, parks. **Description:** No constraints. Submersion is generally beneficial.

2. Acceptability manager| Acceptability workflow



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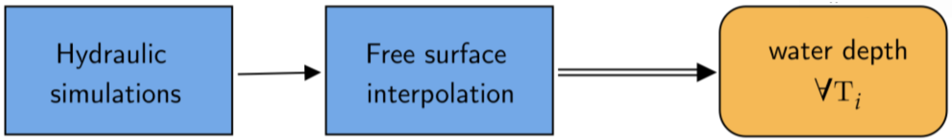
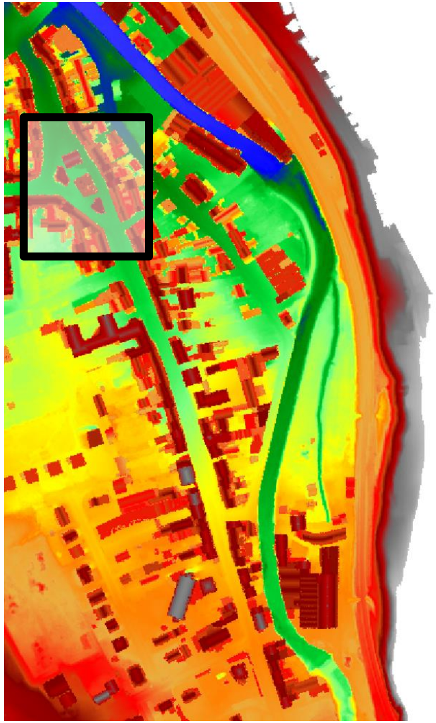
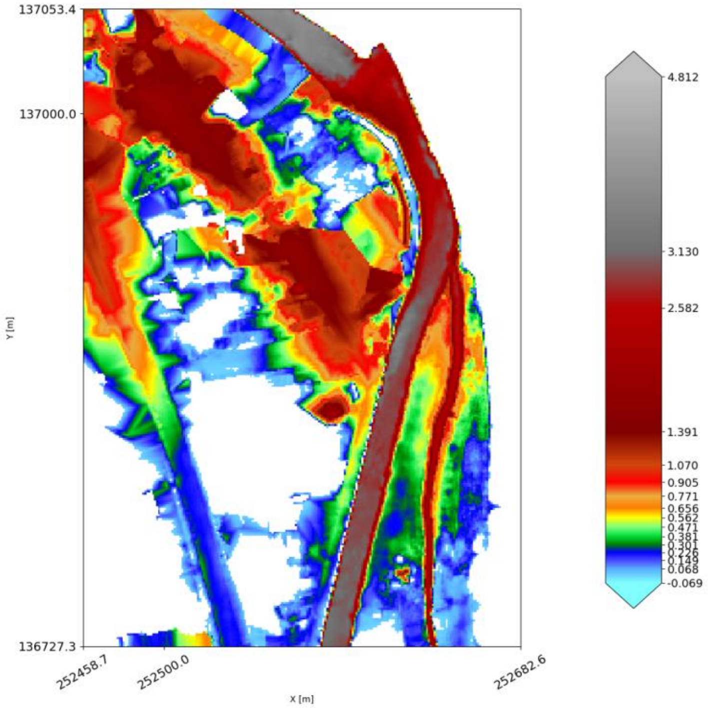


Inputs

- Roughness coefficient
- Boundary conditions
- Topography/ bathymetry

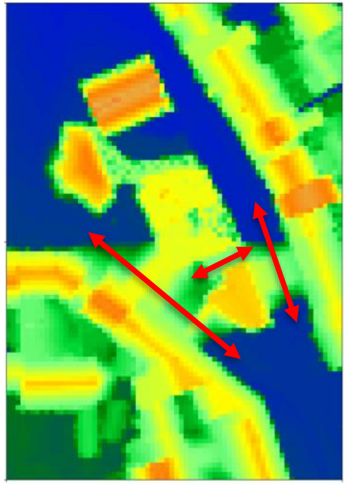




2. Acceptability manager| Note on data treatment (topography)

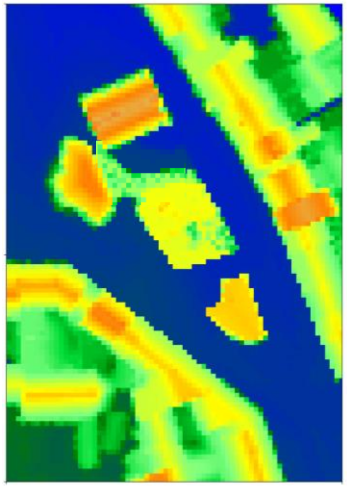
Green LIDAR (2023, 50[cm] resolution) data

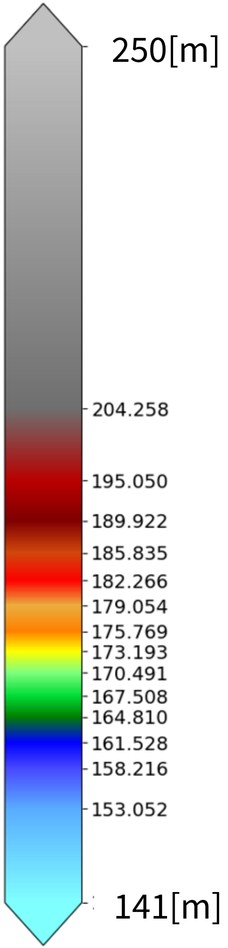
Existence of **interpolation problems**



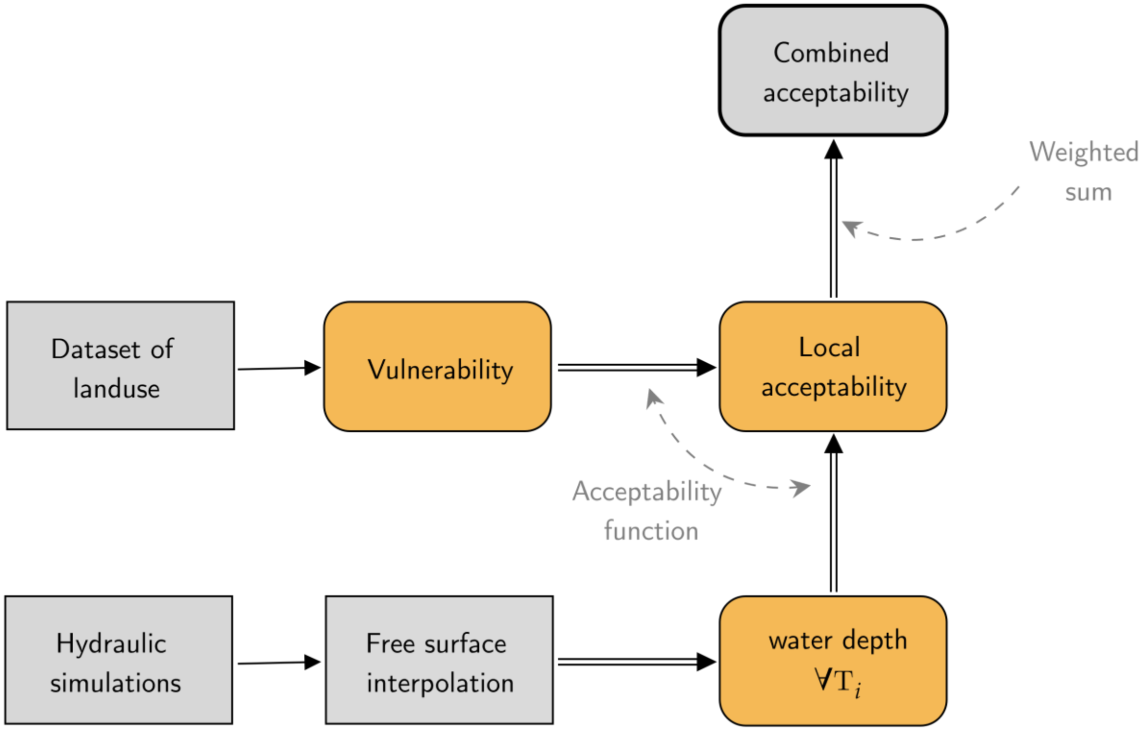
e.g until 7[m] errors at the municipality in Theux

Correction with tool existing in WOLF

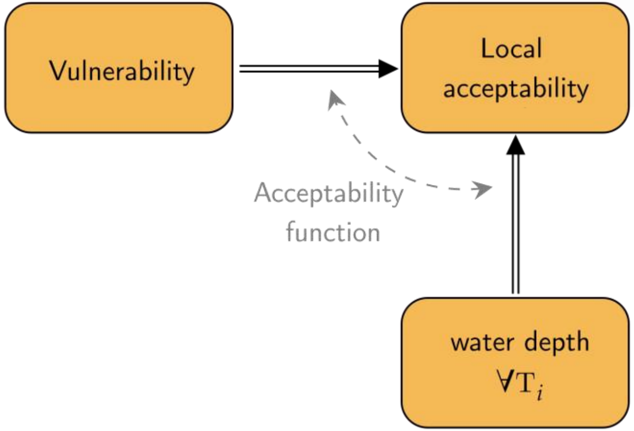




2. Acceptability manager| Acceptability workflow



2. Acceptability manager| Acceptability workflow



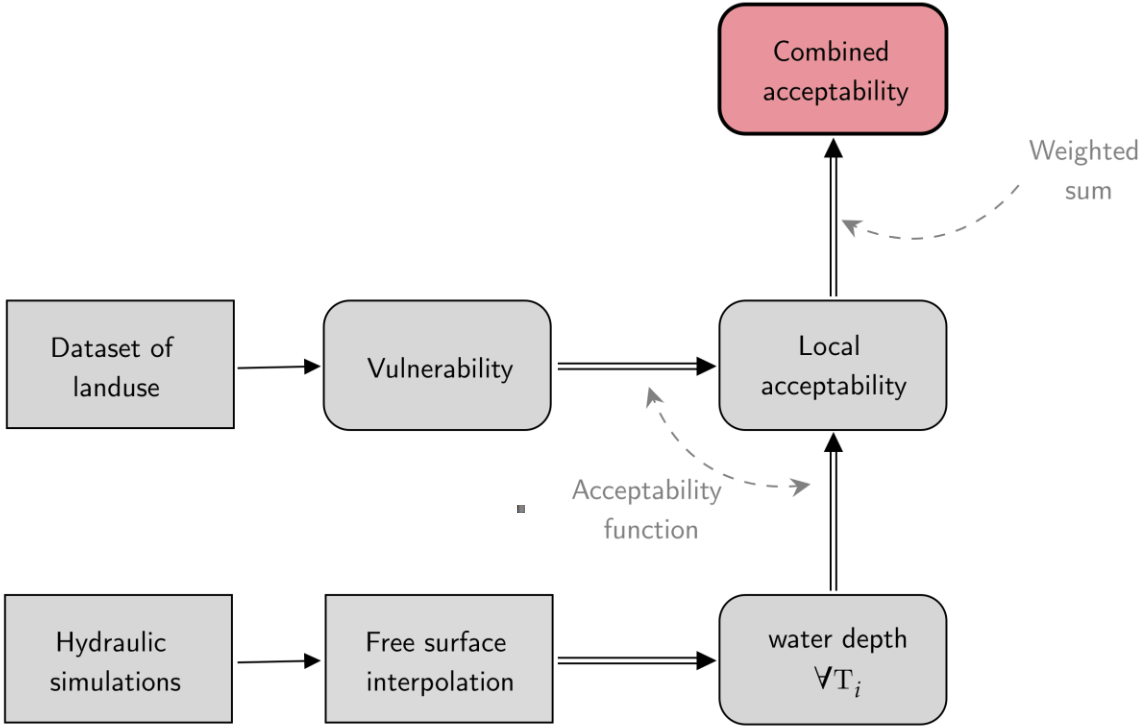
Score	Acceptability
-2	Not acceptable
-1	To be avoided
0	Neutral
1	Favorable
2	Unconstrained

e.g Simplistic local acceptability score example

Vulnerability level X →

T \ wd	wd_0	wd_1	wd_2	wd_3	wd_4
T_a	0	0	-1	-2	-2
T_b	0	0	-1	-2	-2
T_c	0	1	0	-2	-2
T_d	0	1	0	-1	-2
T_e	0	2	1	0	-1

2. Acceptability manager| Acceptability workflow



Combined acceptability

Combined acceptability matrix

$$A^* = \sum_{i=k}^{n} a_i A_i \tag{1}$$

with the normalized weighting coefficients a_i defined in Eqs.(2,3,4) and A_i the local acceptability matrices.

Normalized weighting coefficients

$$a_k = \frac{1}{T_k} + \frac{1}{2}\left(\frac{1}{T_k} - \frac{1}{T_{k+1}}\right) \tag{2}$$

$$a_l = \frac{1}{2}\left(\frac{1}{T_{l-1}} - \frac{1}{T_l}\right) + \frac{1}{2}\left(\frac{1}{T_l} - \frac{1}{T_{l+1}}\right) \tag{3}$$

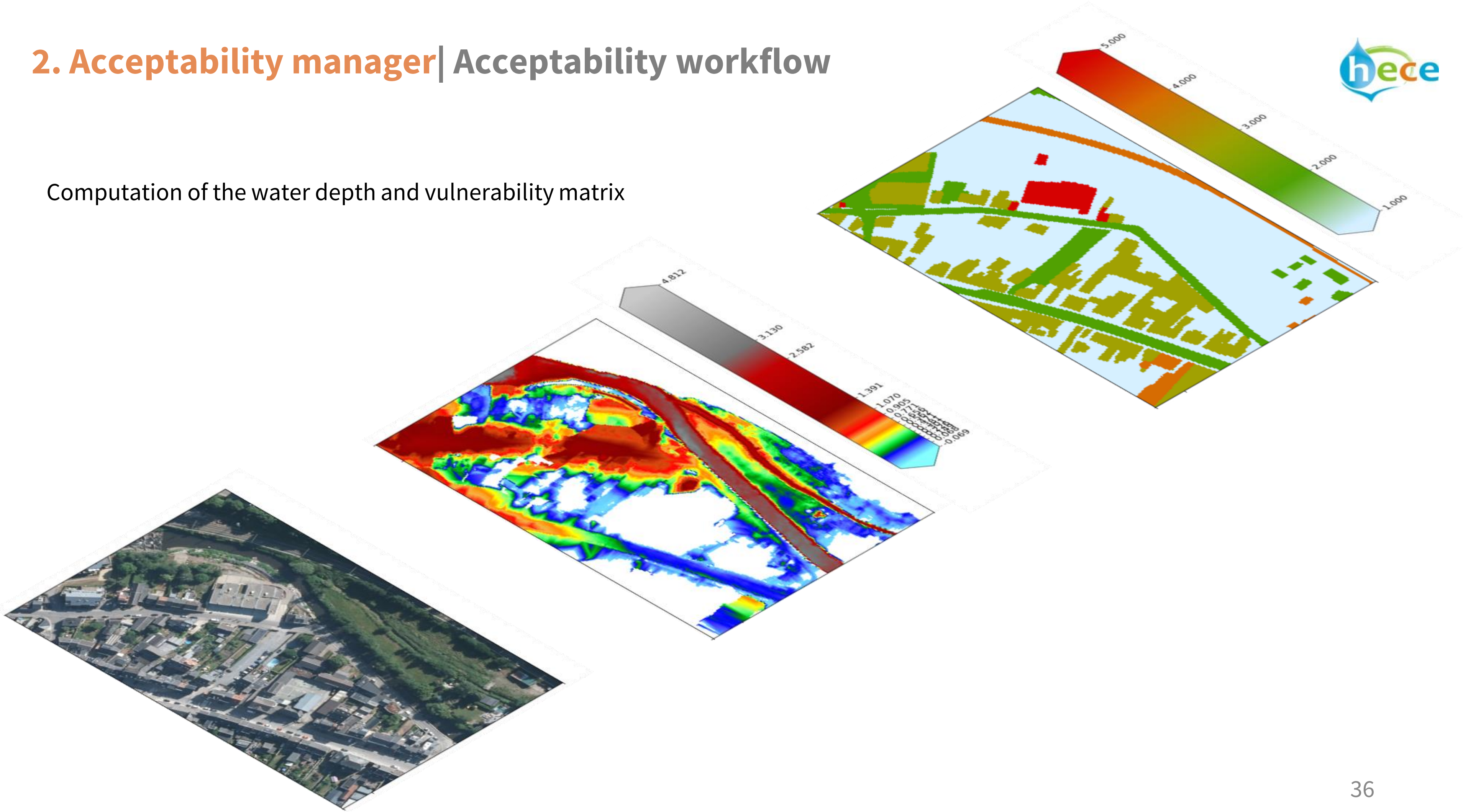
$$a_m = \frac{1}{T_m} + \frac{1}{2}\left(\frac{1}{T_{m-1}} - \frac{1}{T_m}\right) \tag{4}$$

with the subscript k corresponding to the weighting coefficient for the first available return period denoted T_k, m to the last, and l for intermediate elements. The notation +1 (or -1) corresponds to the next (or previous) available return period.

a_2	a_5	a_{15}	a_{25}	a_{50}	a_{100}	a_{1000}
0.65	0.2	0.08	0.04	0.015	0.0095	0.0055

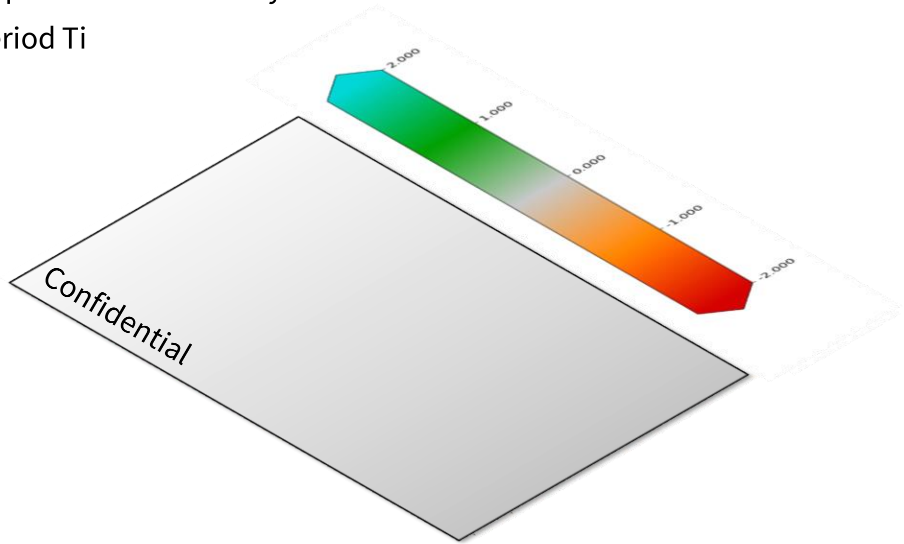
2. Acceptability manager| Acceptability workflow

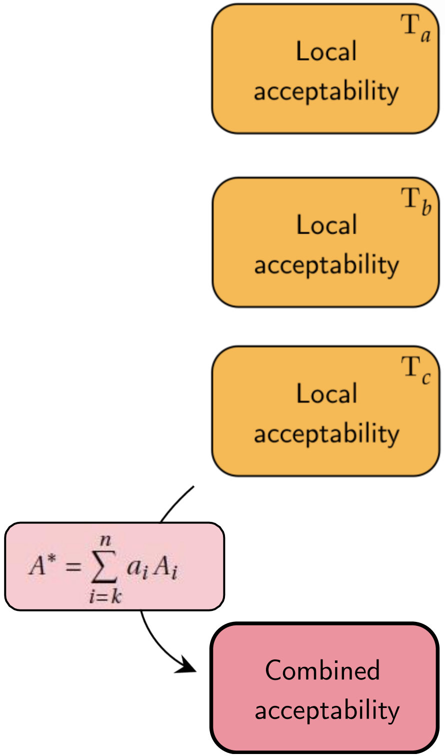
Computation of the water depth and vulnerability matrix



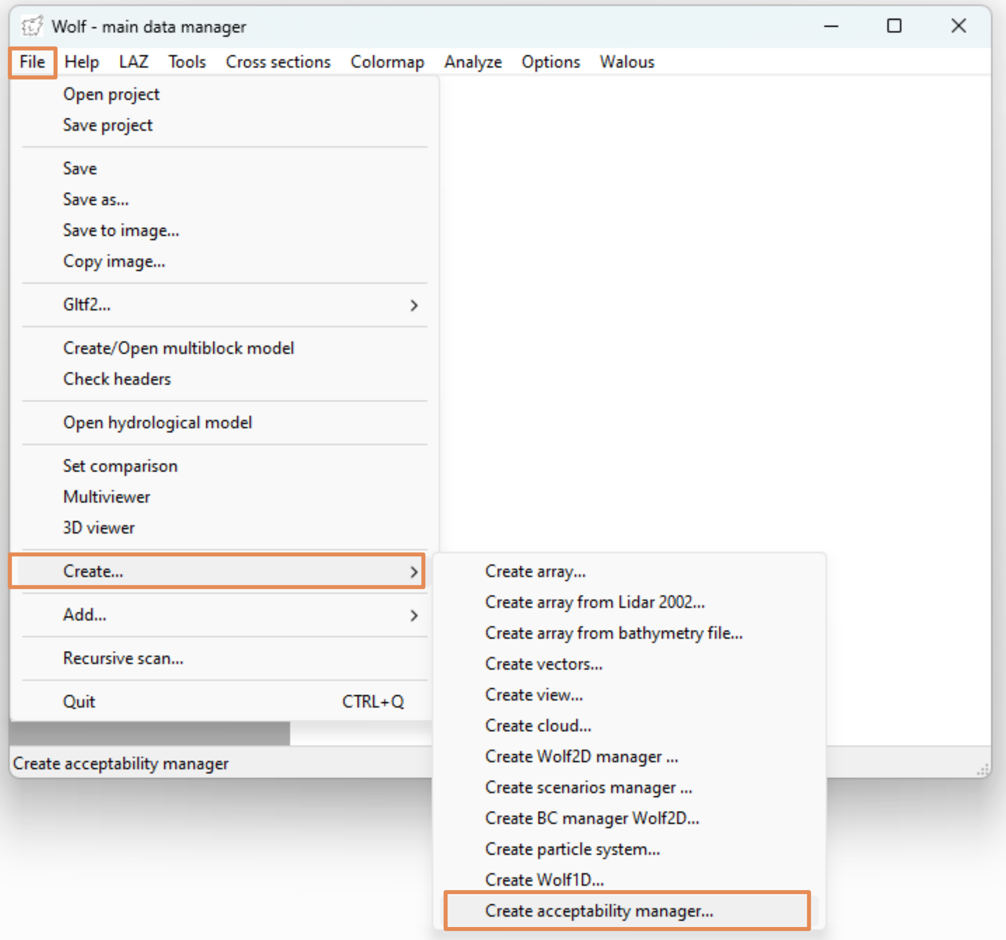
2. Acceptability manager| Acceptability workflow

Computation of the water depth and vulnerability matrix
for each simulated return period Ti





2. Acceptability manager| User-friendly interface



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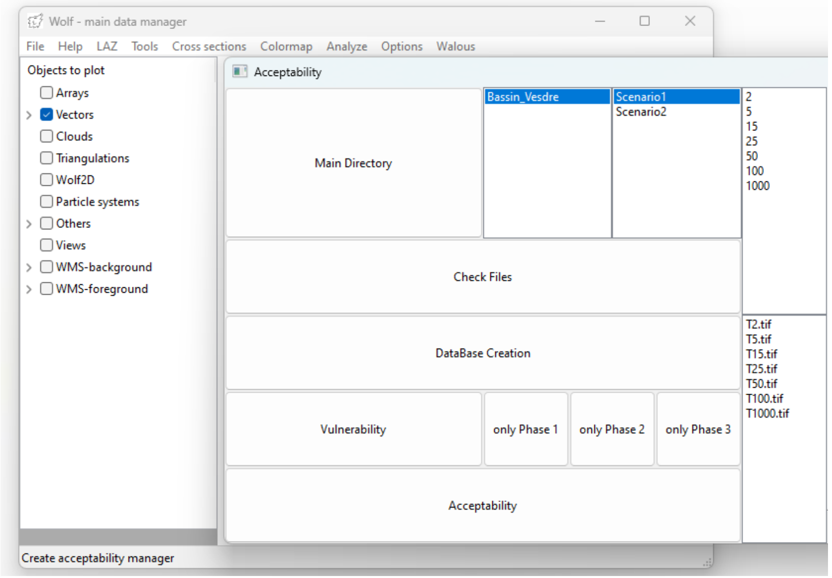
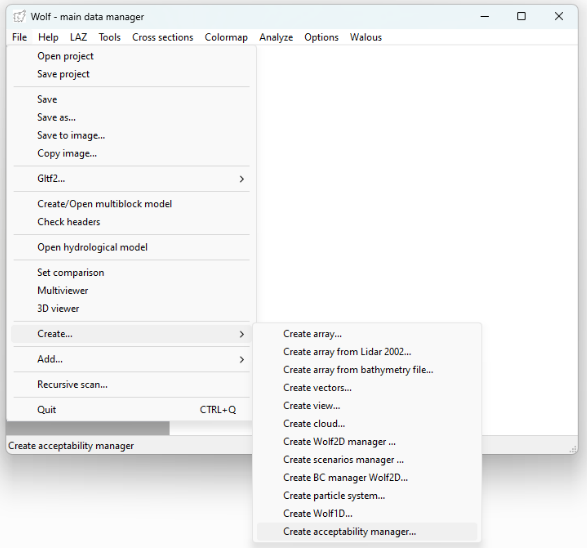
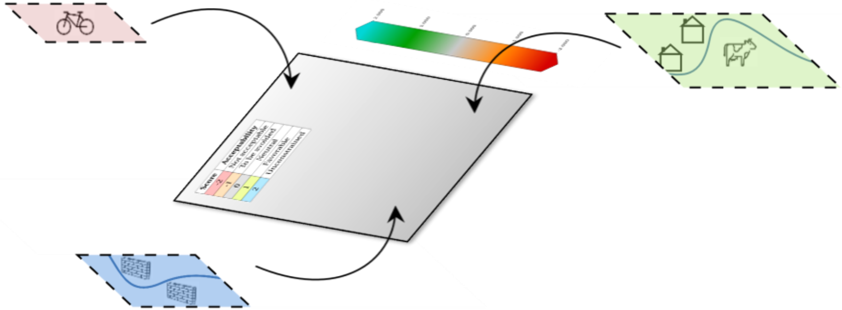




3. Further investigations

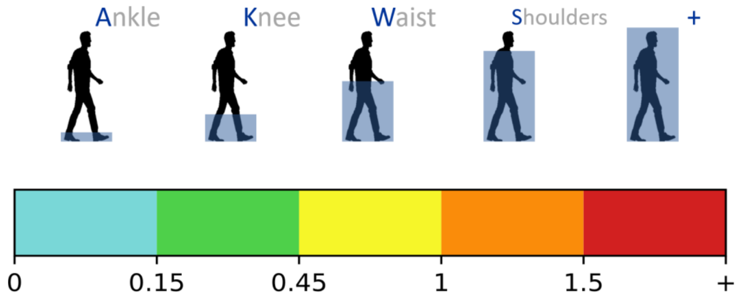
3. Further investigations| Acceptability manager

- Questioning the weighting coefficients;
- In-depth analysis of the Theux case study, and generalization;
- Creation of a technical tool for managing scenarios in terms of acceptability.



Attention must be paid for communicating results.

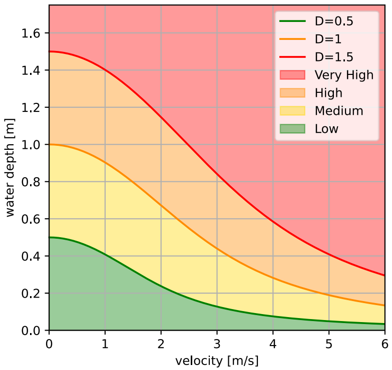
For example, focusing on **pedestrian risks.**



Two examples :

AKWS+ scale

‘**Total depth D**(wd, v) [m]’ which is equivalent height corresponding to the **force** exerted by the water flow



“2D shallow water GPU parallelized scheme for high resolution real-field flood simulations”, R Vacondio et al., River Flow 2014

Thank you for your attention

Other questions ?

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