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Project Testerep: Numerical Modelling

KU Leuven/UHasselt VSC User Day

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Outline

1. Project Testerep
2. Workflow

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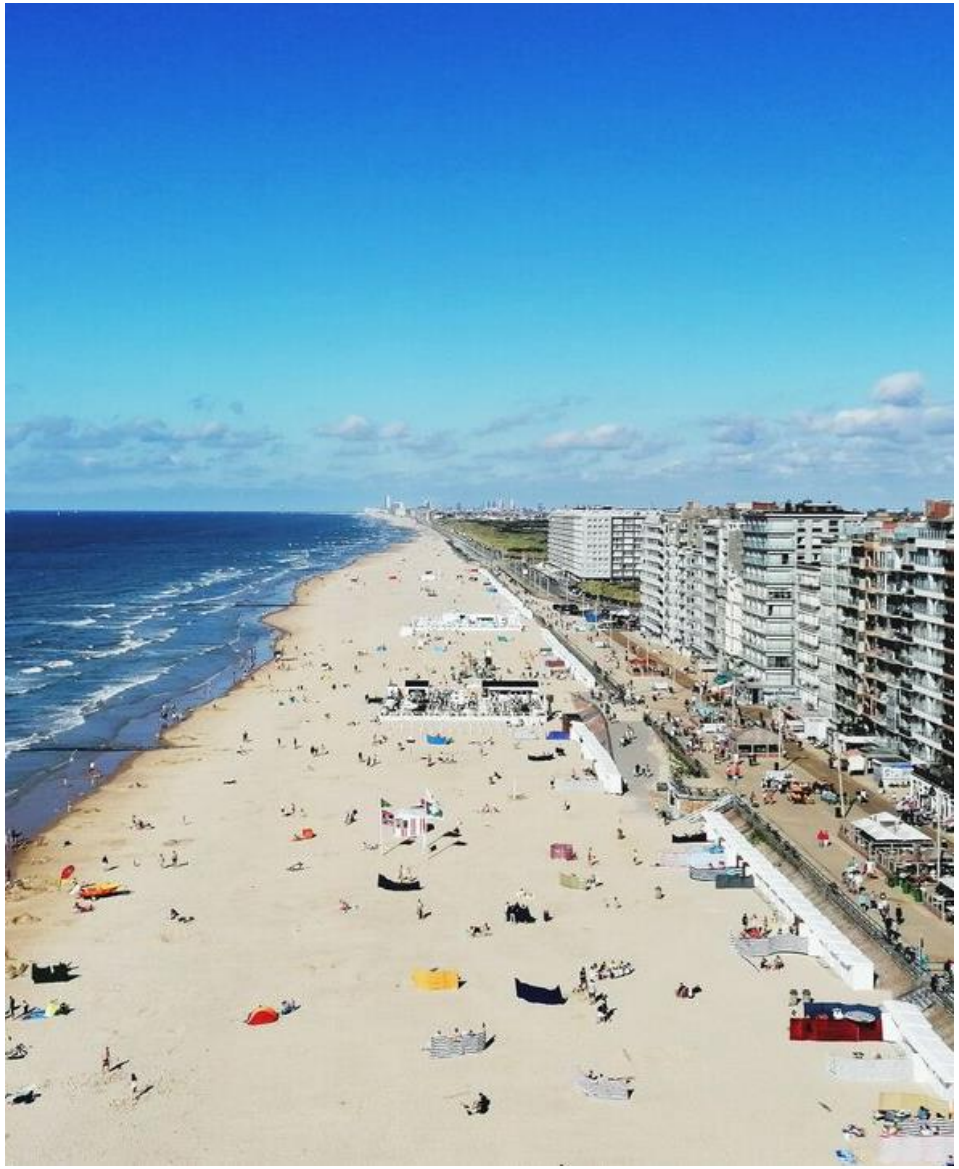
1. Project Testerep

1. Project Testerep

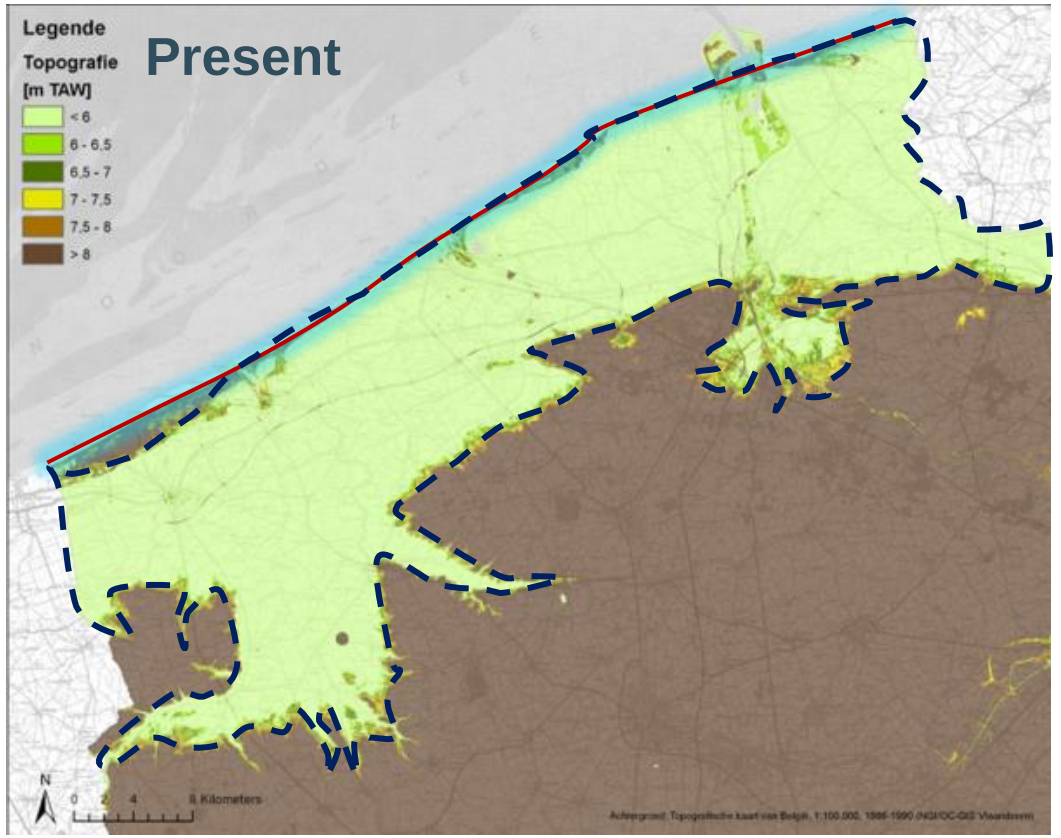
- Belgian coast **today**:
  - 67 km coastline,
  - **Physical stresses** → Tides, waves, winds, and more intense storms, sea level rise.
  - **Human induced stress** → structures, low-lying zone (Mertens et al., 2009),
  - Vulnerability to erosion and flooding of the coast,

How to distinguish human and natural impact?



1. Project Testerep

HOW?



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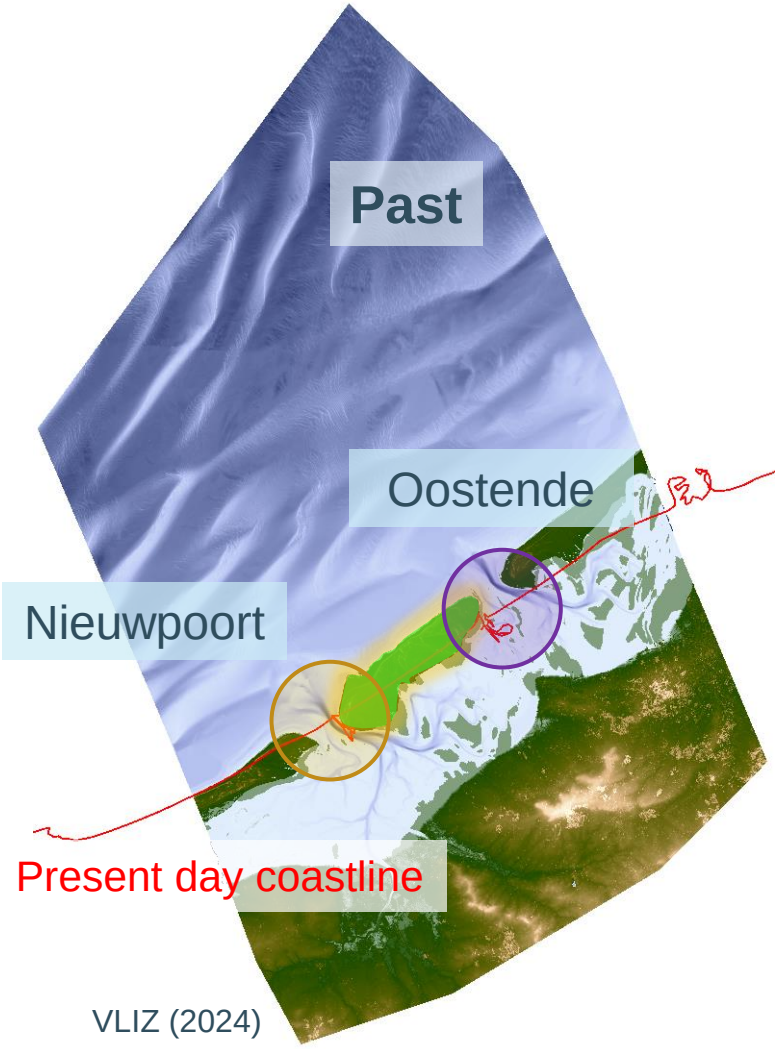
1. Project Testerep



VLIZ (2024)

Intense storms?

Peat extraction?

Subsidence?

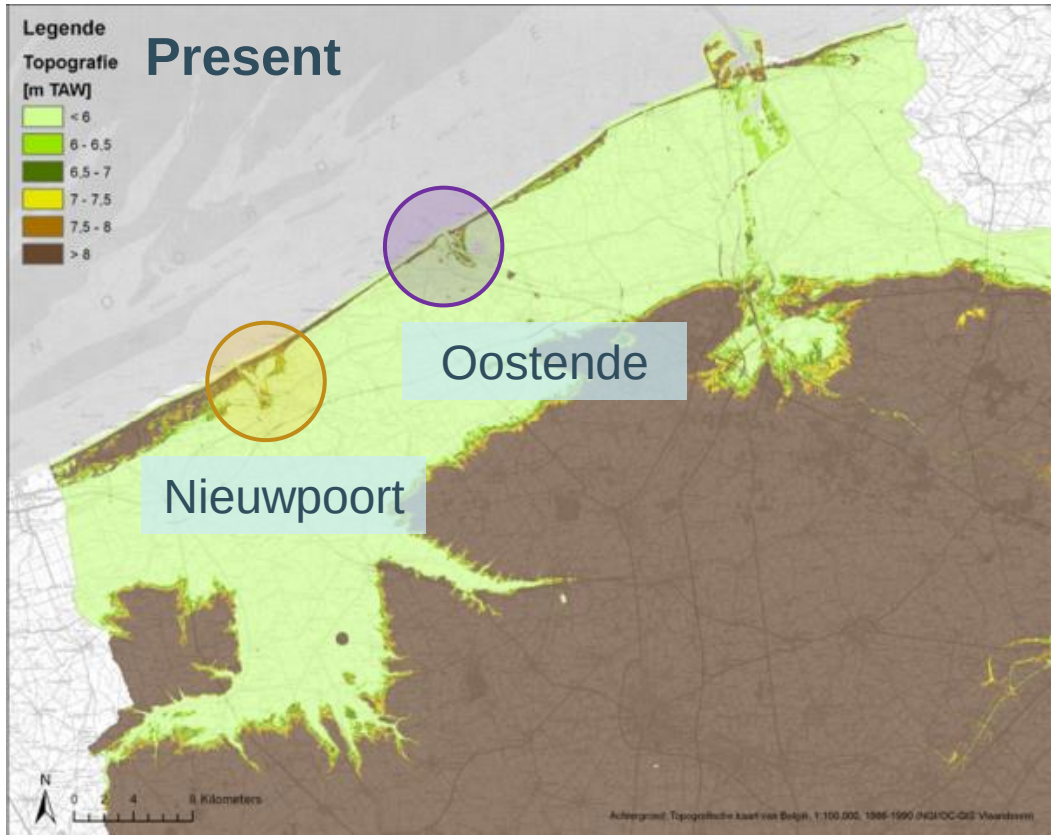
Dams?

HOW?

Climate change?

Dikes?

Dunes?



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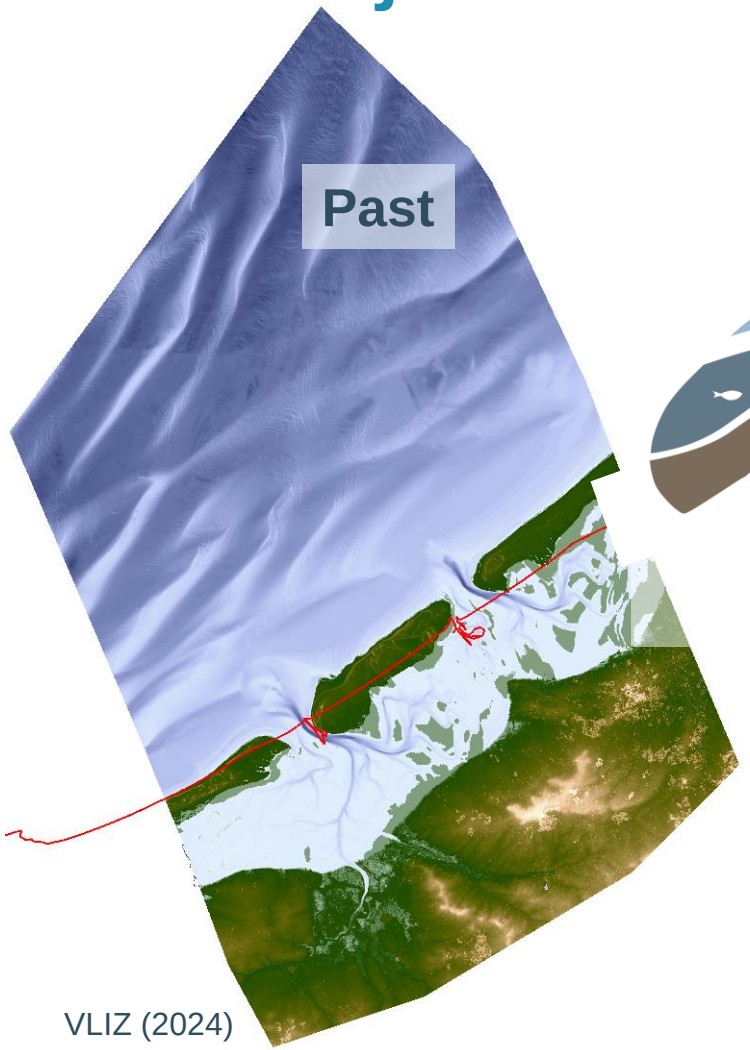
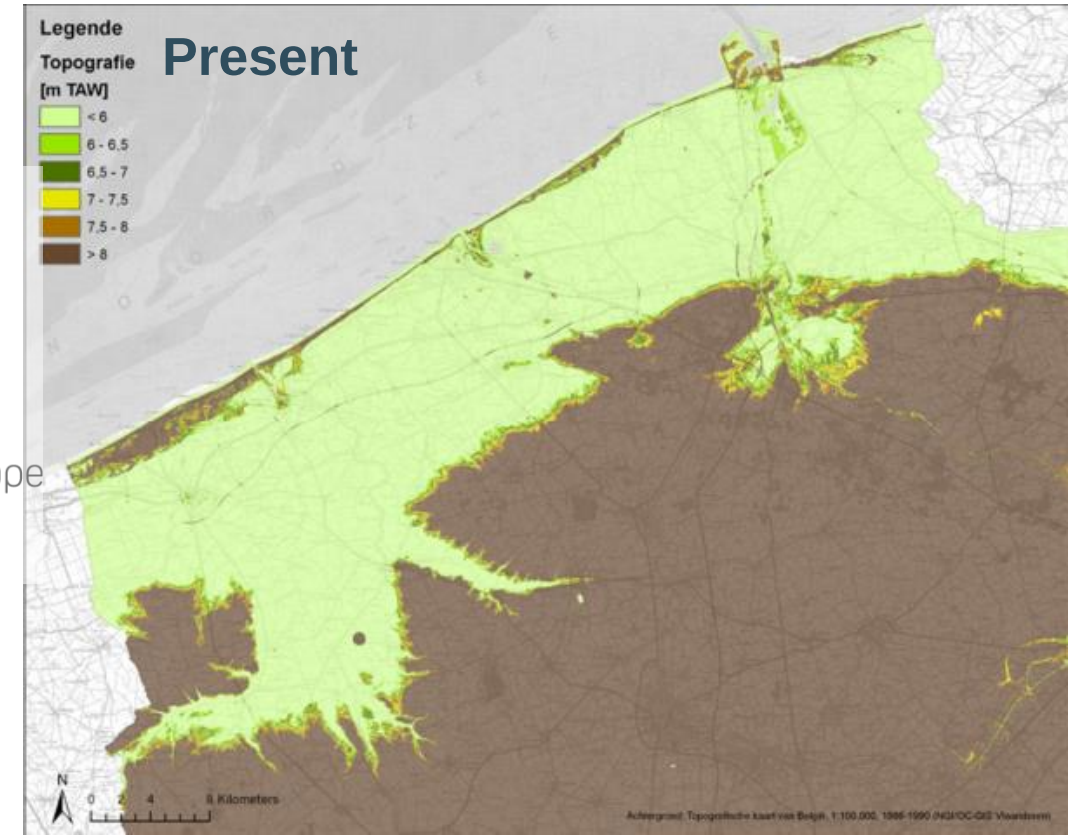
1. Project Testerep



VLIZ (2024)

Testerep

5000 years of Flemish Seascape



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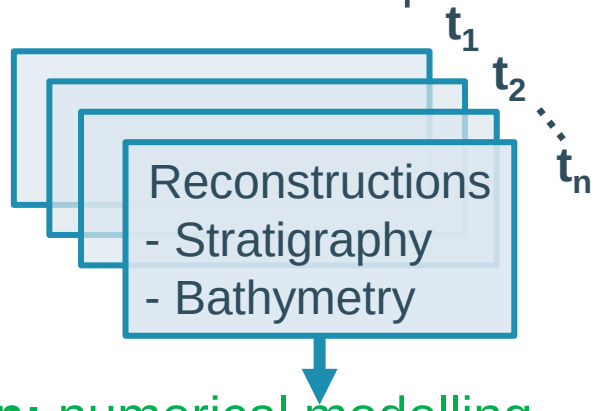
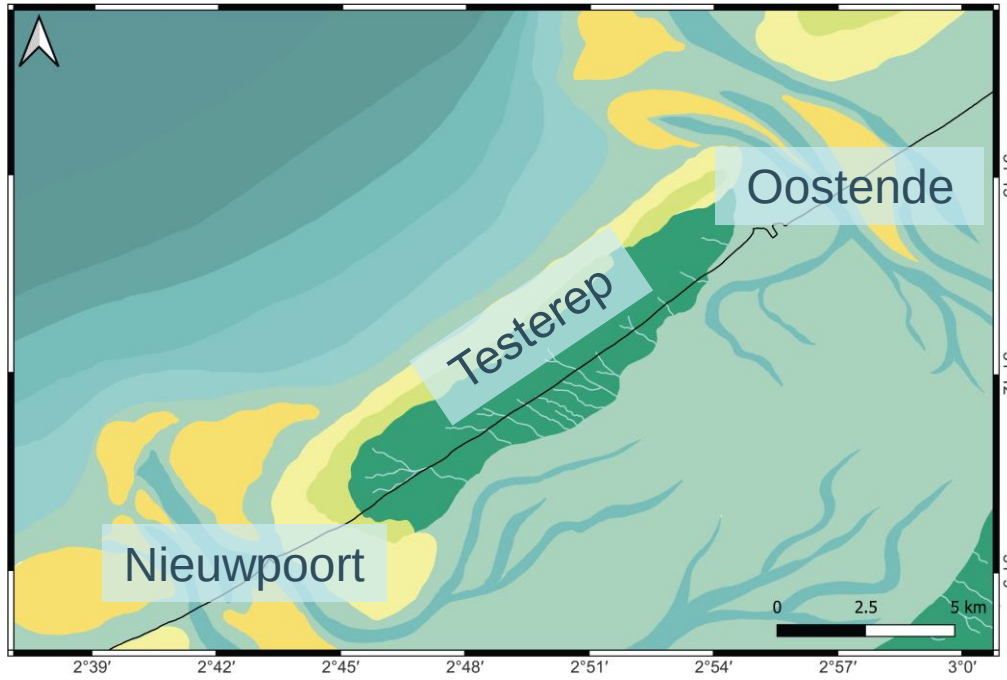
1. Project Testerep

- Project Testerep:
  - **VLIZ (geology):** offshore surveys
  - **VUB (archeology):** onshore surveys
  - Data collection → data interpretation



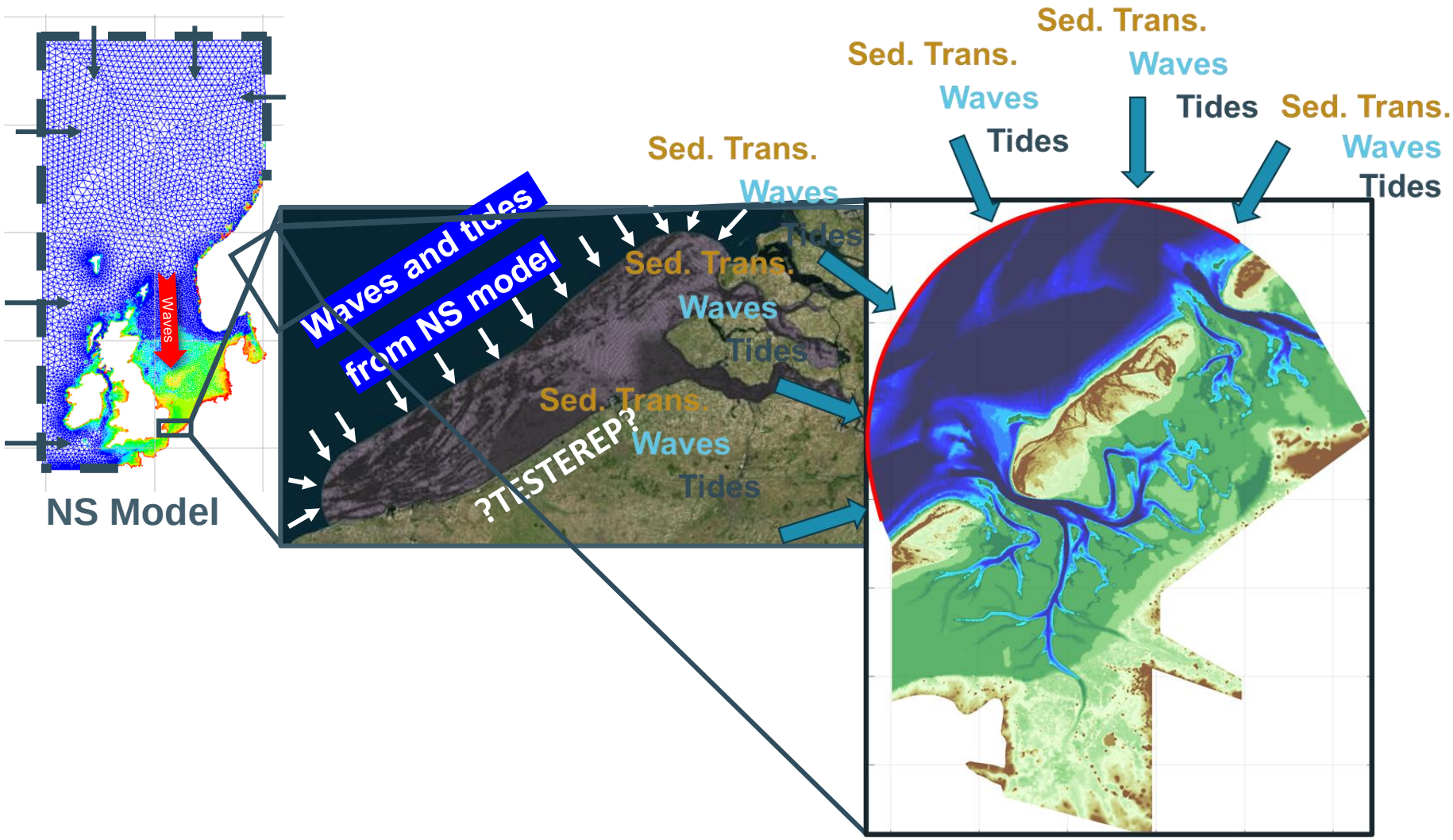
  - **KU Leuven:** numerical modelling



VLIZ (2024)

- **<u>Learning from the past → integration to present plans</u>**

2. Modelling Procedure



North Sea Model (NSM)

TPXO9 → TIDES

WAVES ← *ERA5*

Belgian Coast Model (BCM)

TIDES | SED. | WAVES

NESTEREP

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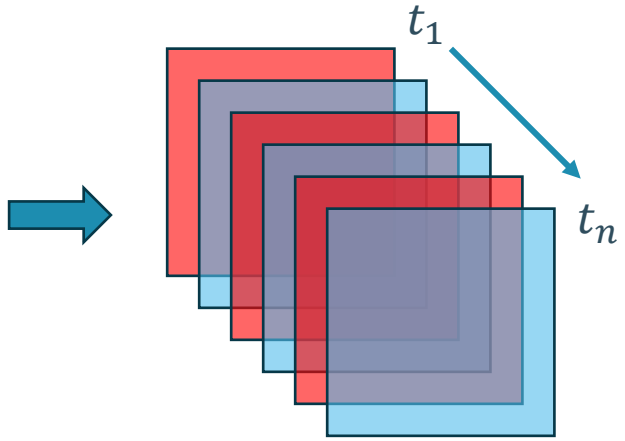
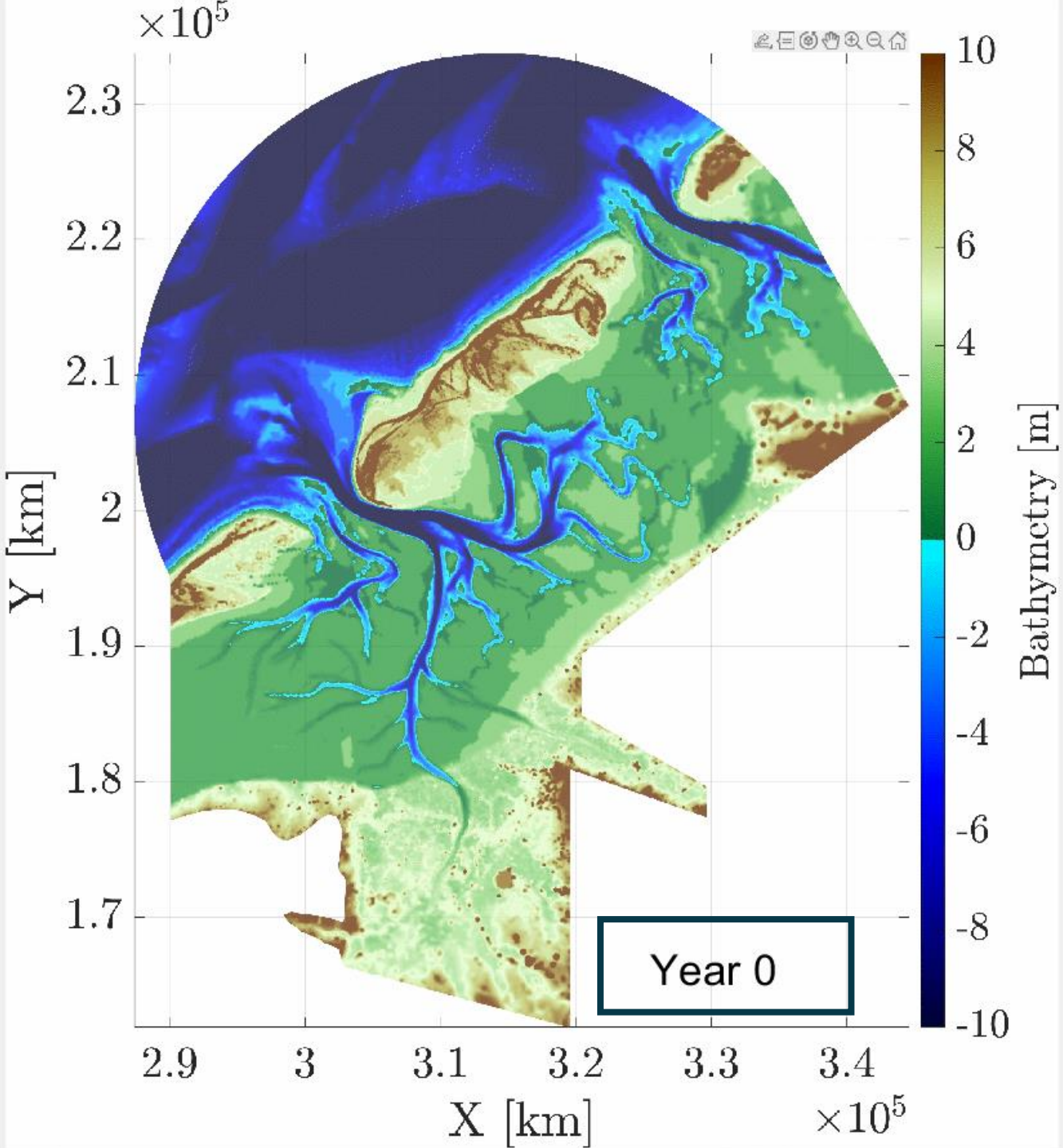
2. Modelling Procedure

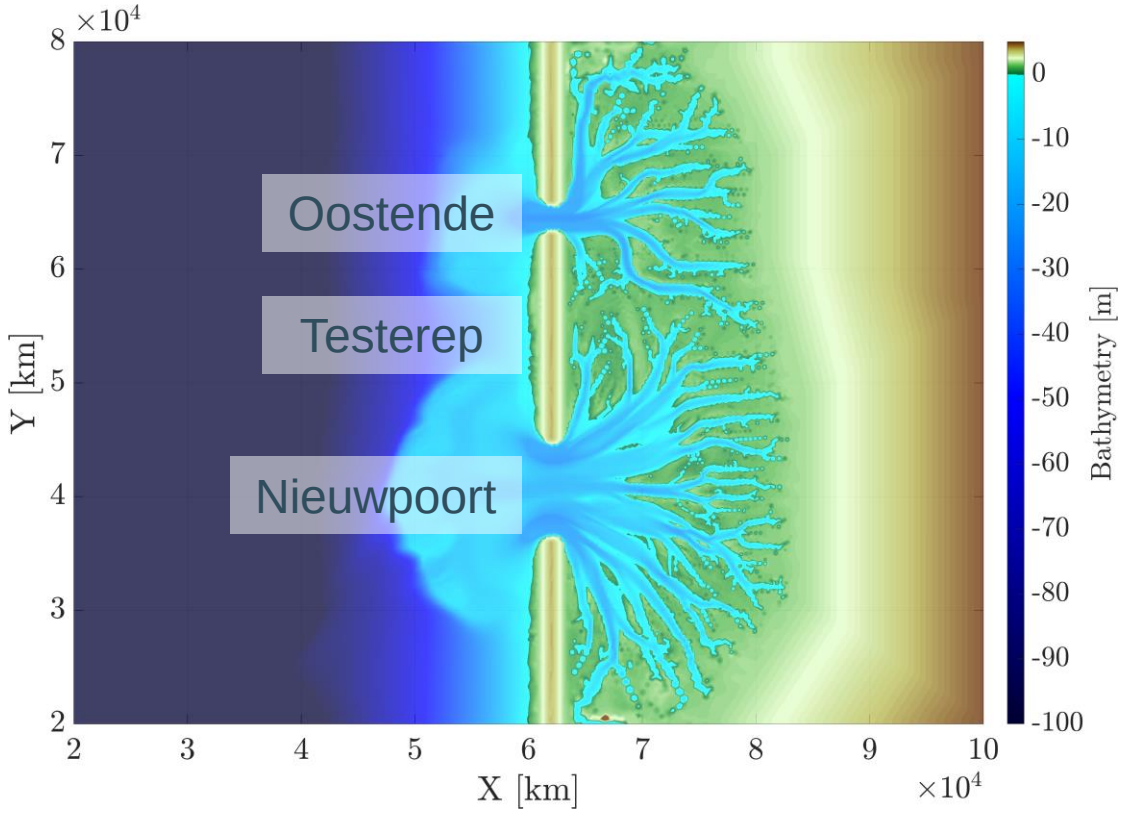
Scenarios



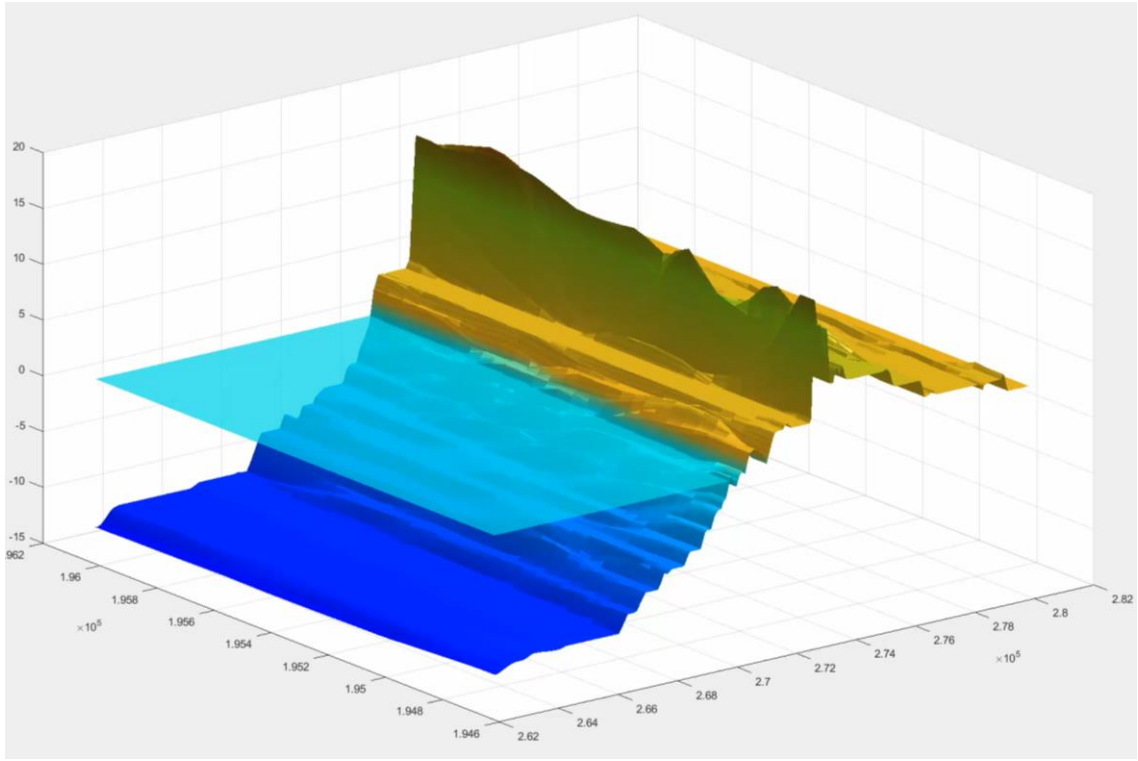
Modelling



2. Modelling Procedure



SBIM – fast assessment of new implementations



XBeach Model – Island response to storms

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2. Workflow

2. Workflow Overview

2. Workflow Overview

- Model: **`TELEMAC-MASCARET/8p4r0-foss-2022b-tmp`**
- Long wave equations for tides,
- Energy equation for waves,
- Advection-diffusion equation for sediment transport,

$$\frac{\partial h}{\partial t} + \boldsymbol{u}\cdot\boldsymbol{\nabla}(h) + h\,div(\boldsymbol{u}) = S_h \qquad \text{continuity,}$$
$$\frac{\partial u}{\partial t} + \boldsymbol{u}\cdot\boldsymbol{\nabla}(u) = -g\frac{\partial Z}{\partial x} + S_x + \frac{1}{h}div(h\,\nu_t\boldsymbol{\nabla}u) \qquad \text{momentum along } x,$$
$$\frac{\partial v}{\partial t} + \boldsymbol{u}\cdot\boldsymbol{\nabla}(v) = -g\frac{\partial Z}{\partial y} + S_y + \frac{1}{h}div(h\,\nu_t\boldsymbol{\nabla}v) \qquad \text{momentum along } y,$$

$$\frac{\partial N}{\partial t} + \frac{\partial(\dot{x}N)}{\partial x} + \frac{\partial(\dot{y}N)}{\partial y} + \frac{\partial(\dot{k}_xN)}{\partial k_x} + \frac{\partial(\dot{k}_yN)}{\partial k_y} = Q(k_x,k_y,x,y,t)$$

$$\frac{\partial hC}{\partial t} + \frac{\partial hUC}{\partial x} + \frac{\partial hVC}{\partial y} = \frac{\partial}{\partial x}\left(h\varepsilon_s\frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(h\varepsilon_s\frac{\partial C}{\partial y}\right) + E - D$$

- Finite element method.

No analytical solution → numerical solution

Pre-processing | Simulation file transfer to HPC | Starting the job on HPC | Waiting… | Post-processing on HPC | File transfer to local drive

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2. Workflow Overview

- Input files:
  - Mesh: computational points in space,
  - Boundary condition
  - Fortran files
  - Initial condition
  - Nesting and wind files (large)
  - Steering file

Pre-processing → Simulation file transfer to HPC → Starting the job on HPC → Waiting… → Post-processing on HPC → File transfer to local drive

2. Workflow Overview

- File transfer: Windows subsystem for Linux.
  - rsync

```
rsync -av --append <path_to_the_local_simulation_file>
vsc#####@login.hpc.kuleuven.be:/scratch/leuven/###/vsc#####/
```

- Logging in: via SSH.

```
ssh -i <local_path_to_ssh_keys> vsc#####@login.hpc.kuleuven.be
```

2. Workflow Overview

- Model: **`TELEMAC-MASCARET/8p4r0-foss-2022b-tmp`**
- Available on `wICE`
- Partition: `batch` or `batch_long`
- Number of nodes: 1
- Cores per node: 42
  - After sensitivity analysis, problem specific

2. Workflow Overview

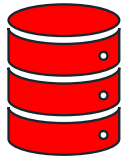
- Post-processing MATLAB (2023b) codes
  - Directly from the same job file

```
#!/bin/bash -l
#SBATCH -M wice
#SBATCH --time=100:00:00
#SBATCH --nodes=1
#SBATCH --ntasks-per-node=42
#SBATCH --partition=batch_long
#SBATCH --mail-type=FAIL,BEGIN,END
#SBATCH --mail-user=
#SBATCH -A lp_testerep
# Set the right environment
# PART 1
# Run TELEMAC
module load TELEMAC-MASCARET/8p4r0-foss-2022b-tmp
runcode.py telemac2d -c ubugfmpich t2d_nesterep.cas
# Post-processing
module load MATLAB/2023b
cd /lustre1/scratch/                 /hpc-matlab/18-hotStartGen/
matlab -nodisplay -r "hotStartGen "/lustre1/scratch/                 /01-scenario1-extensive-tidal-flat-Wadden/02-tide-and-waves/03-v4-nesterep-gmsh/03-mofac/part1/" "RES_NS_coupled_tel.slf" 1 "
matlab -nodisplay -r "hotStartGen "/lustre1/scratch/                 /01-scenario1-extensive-tidal-flat-Wadden/02-tide-and-waves/03-v4-nesterep-gmsh/03-mofac/part1/" "gai_BCG.slf" 1 "
matlab -nodisplay -r "hotStartTimeAdjust "/lustre1/scratch/                 /01-scenario1-extensive-tidal-flat-Wadden/02-tide-and-waves/03-v4-nesterep-gmsh/03-mofac/part1/" "tom-hs-endOf2012.slf" 31620000 "
cd /lustre1/scratch/                 /hpc-matlab/44-initialFinalBathyAnimate/
matlab -nodisplay -r "initialFinalBathy "/lustre1/scratch/                 /01-scenario1-extensive-tidal-flat-Wadden/02-tide-and-waves/03-v4-nesterep-gmsh/03-mofac/part1/" "RES_NS_coupled_tel.slf" "
cd /lustre1/scratch/                 /01-scenario1-extensive-tidal-flat-Wadden/02-tide-and-waves/03-v4-nesterep-gmsh/03-mofac/part1/
cp gai-232000-31122012.slf tel-232000-31122012.slf ../part2/4_Inifiles/
cp tom-232000-31122012.slf ../part2/4_Inifiles/tom-232000-31122012.slf
mv 6_BCGresult ../part2/
```

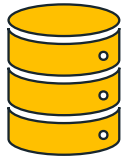
Pre-processing → Simulation file transfer to HPC → **Starting the job on HPC** → Waiting… → Post-processing on HPC → File transfer to local drive

2. Workflow Overview

- $SCRATCH:
  - Running the simulation,
  - Large simulation output files,
- $DATA:
  - Frequently used files (nesting and wind files)
- $HOME: MATLAB codes



Scratch: run TELEMAC



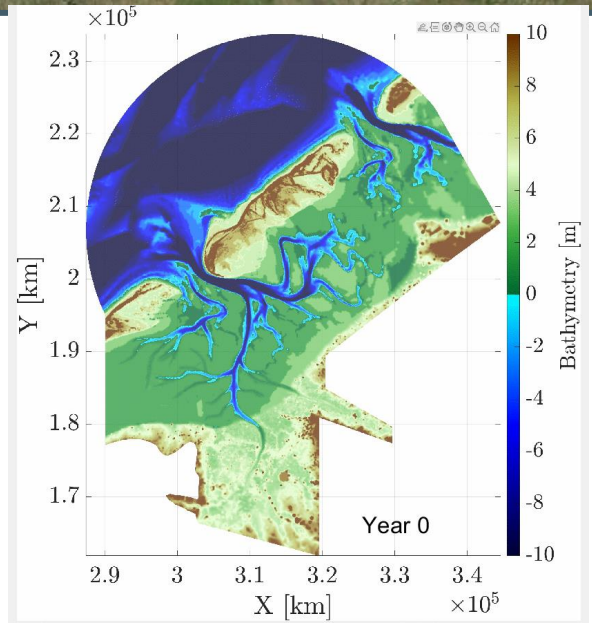
Data: keep FUF

Home: keep post-processing

Pre-processing | Simulation file transfer to HPC | **Starting the job on HPC** | Waiting… | Post-processing on HPC | File transfer to local drive

2. Workflow Overview

- **Real time simulations (higher accuracy) for validation:**
  - Accurate hydro-morphodynamic quantities.
  - One year hydro-morphodynamic modelling ↔ 27 CPU hours
  - Ten years hydro-morphodynamic modelling ↔ 264 CPU hours
- **Morphological acceleration (higher efficiency) for Nesterep:**
  - Only for seabed changes, distorted hydro-morphodynamics.
  - 35 years hydro-morphodynamic modelling ↔ ~~924~~ 42 CPU hours



Pre-processing → Simulation file transfer to HPC → Starting the job on HPC → **Waiting…** → Post-processing on HPC → File transfer to local drive

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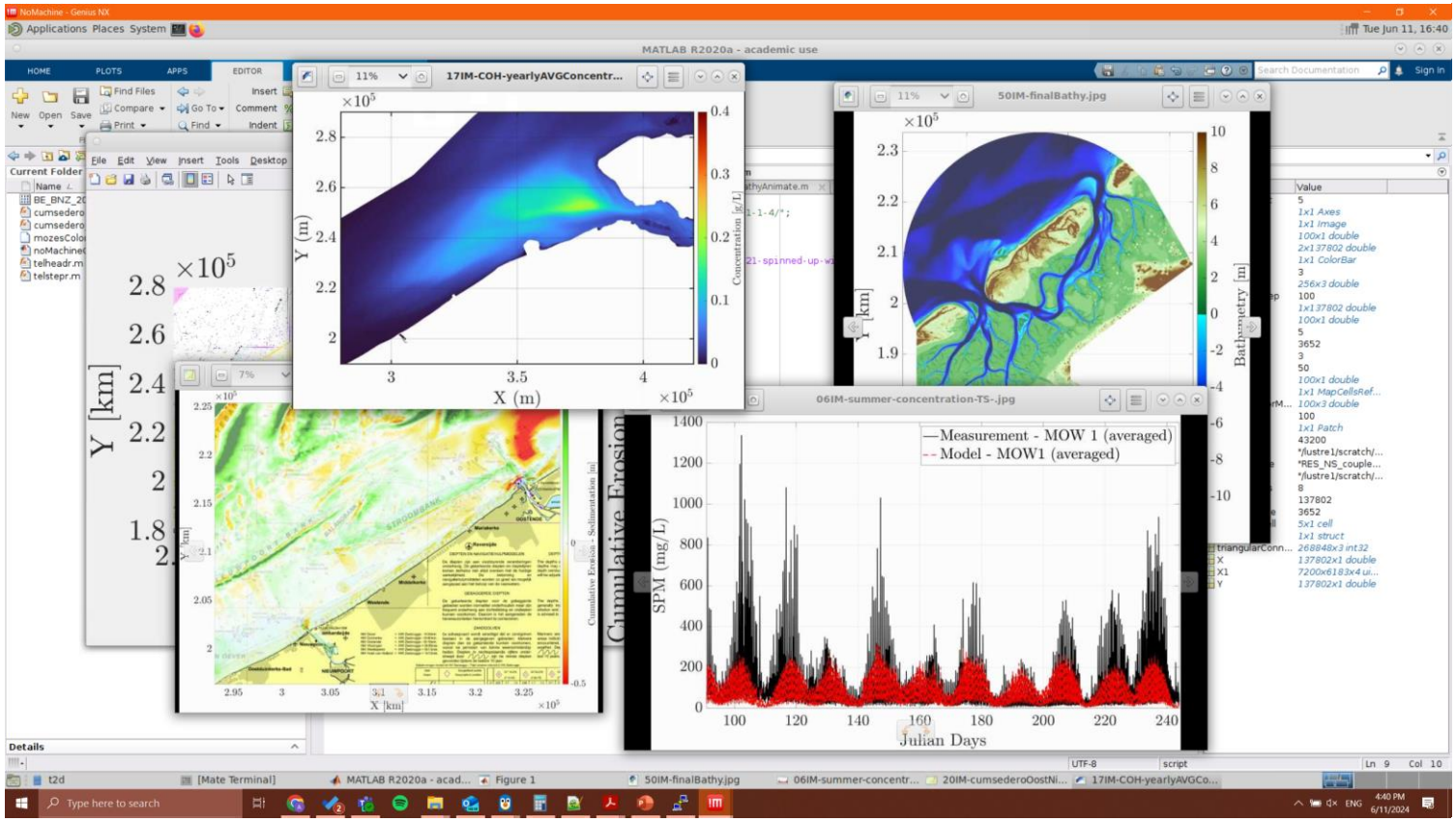
2. Workflow Overview

- Post-processing MATLAB (2023b) codes within the jobfile
- NoMachine
  - Small code corrections
  - Small code runs.
  - Quick result check



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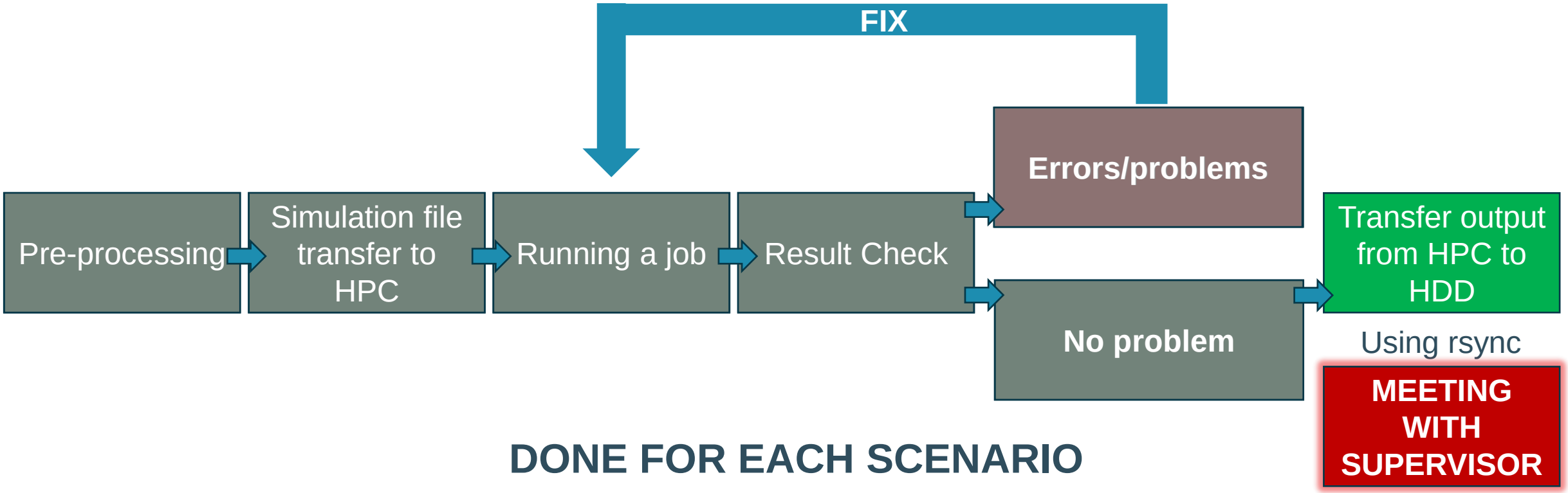
2. Workflow Overview



DONE FOR EACH SCENARIO

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THANK YOU!

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References

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