WP7: Coastal Infrastructure

Progress and ways forward

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Building storylines

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- What would coastal Europe look like in a 4ºC warmer world?

- Focus on different metrics and outcomes:
  - coastal flood risk due to sea-level rise and extreme events
  - direct (economic) impact on coastal critical infrastructure
  - indirect impact on society
  - influence of (mal)adaptation and investments on (coastal) flood risk

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Our first storyline: Storm Xaver (2013)

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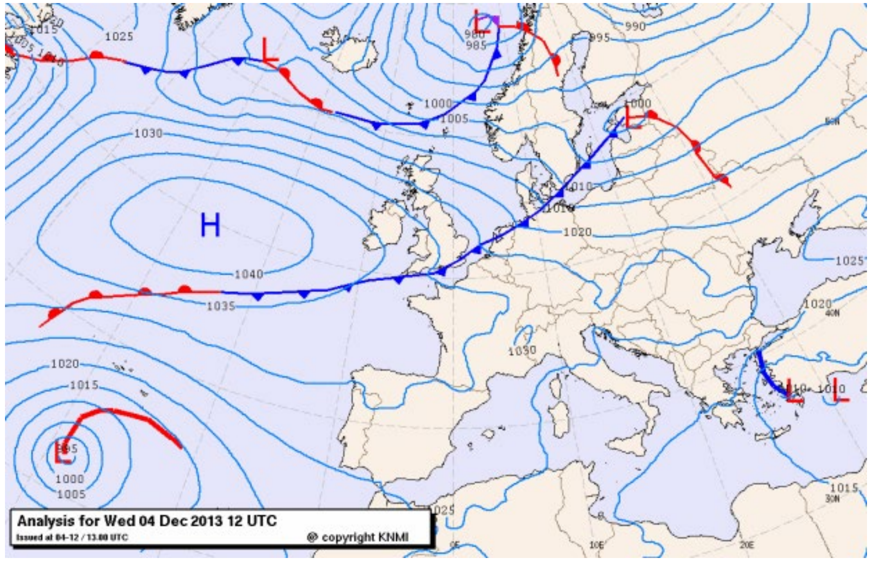
- Storm Xaver was a comparable storm with the 1953 North sea flood event
- Flooding occurred in Ireland, the UK and **Germany**
- But, despite being comparable with 1953 surge levels, luckily in most places the flood defences were strong enough this time!



- **But, what will happen in the future with a rising sea when a storm event like this hits Europe?!**

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Modelling the extreme event: Xaver storm surge

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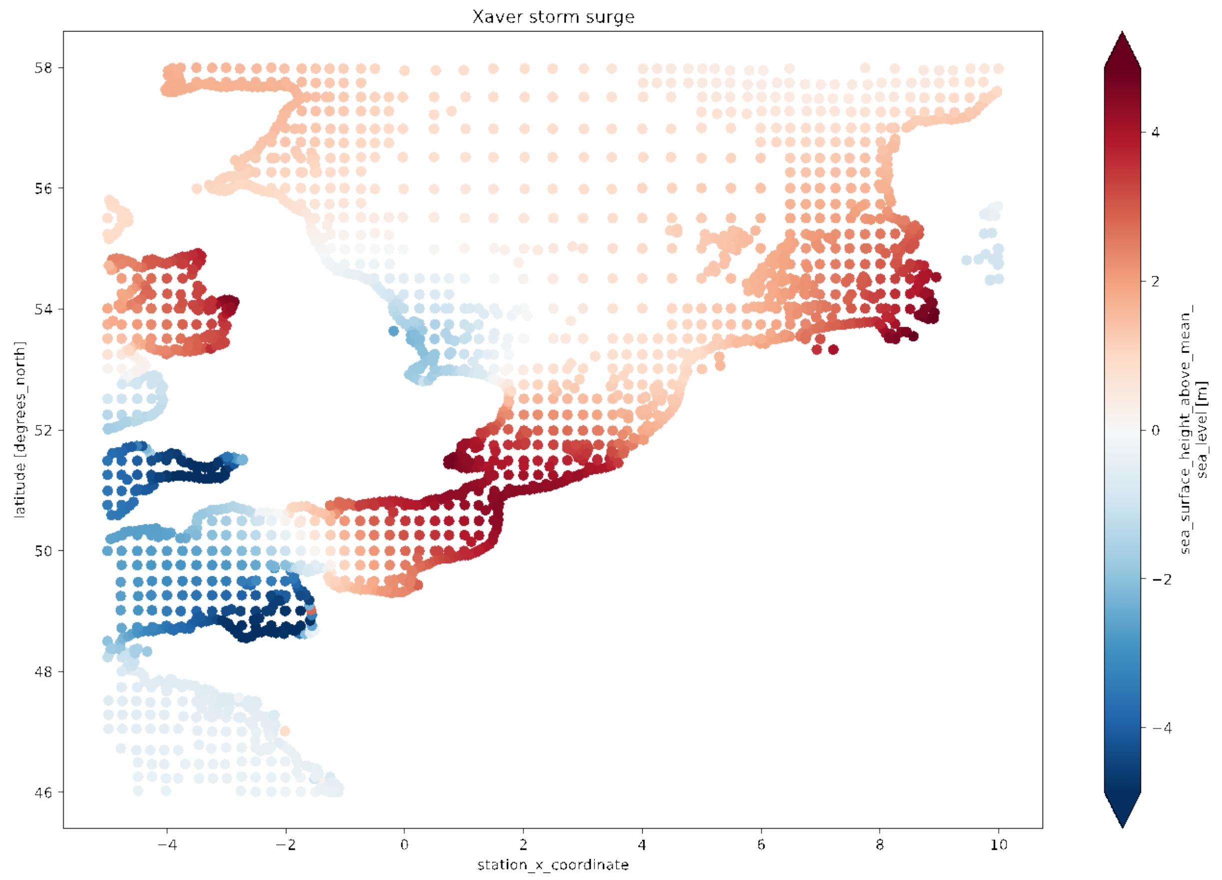

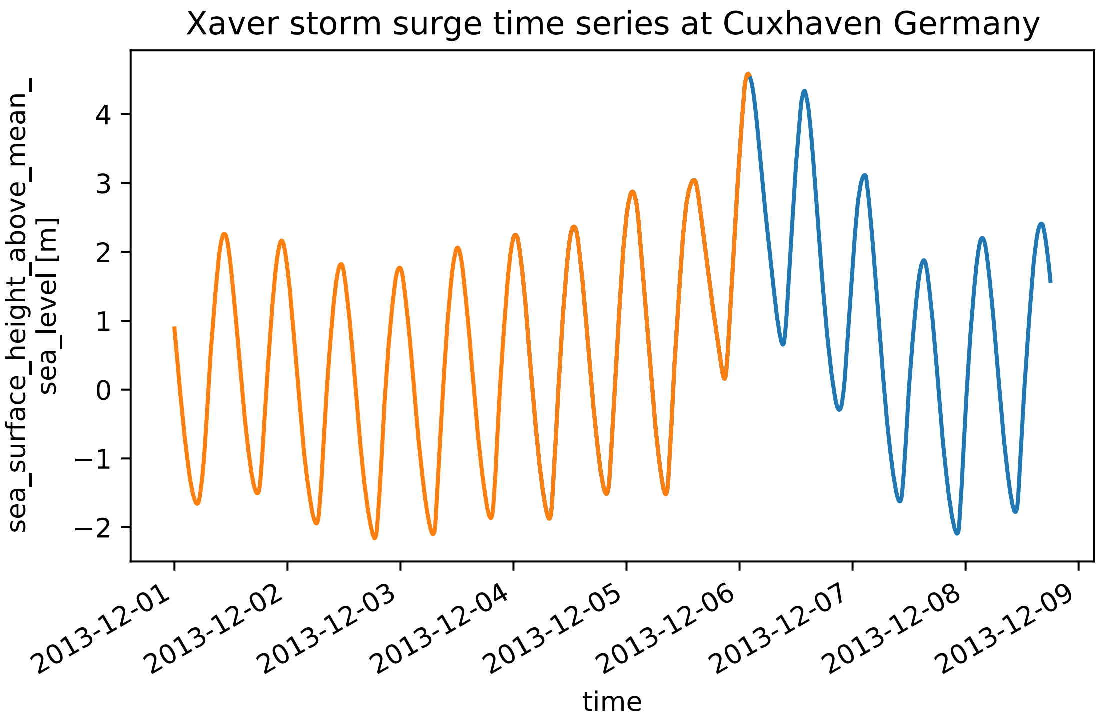

Return period between 25 and 100 years
Data from the Global Tide and Surge Model at the Climate Data Store

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Modelling the extreme event: the flood event (1)

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- OVERVIEW:
  - Using **ANUGA**: Free and **Open Source Software** (FOSS);
  - Developed in **Linux**, but can also run in Windows;
  - Developed by the Australian National University (ANU) and Geoscience Australia (GA)
  - Written by a combination of **Python and C**
  - Can model the impact of hydrological disasters such as dam breaks, riverine flooding, and **coastal flooding**.

- DESCRIPTION:
  - Mathematically, it solves the ***Shallow Water Wave*** equations
    - *Navier-Stokes equations averaged in depth*
  - Finite volume method; Mesh triangular grid representation
  - Robust **wetting/drying** capability (also around structures)
  - Can simulate **hydraulic jumps** (mass and momentum conservation)
    - *Transition from super-critical to sub-critical states*
    - *Important to simulate wave run-up*
  - **Inputs**:
    - *Elevation, water level, bed friction; boundary conditions (Dirichlet, Transmissive, Reflective)*
    - *Optional: rainfall, streamflow, wind-stress or pressure gradients*
  - **Outputs**:
    - *Water surface, bed elevation, depth and horizontal (x-y) momentum.*
    - *Flood extension, depth, duration, and velocity.*

Solving Algorithms

alg	Description
DE0	Uses first order timestepping and a fairly diffusive second order spatial approximation.
DE1	Uses second order timestepping and a much less diffusive second order spatial approximation.
DE2	Uses third order timestepping and the same spatial approximation as DE1
1_5	Uses first order timestepping and similar spatial approximation to DE0.
2_0	Uses second order timestepping and similar spatial approximation to DE1.
2_5	uses third order timestepping and similar spatial approximation to DE1 .

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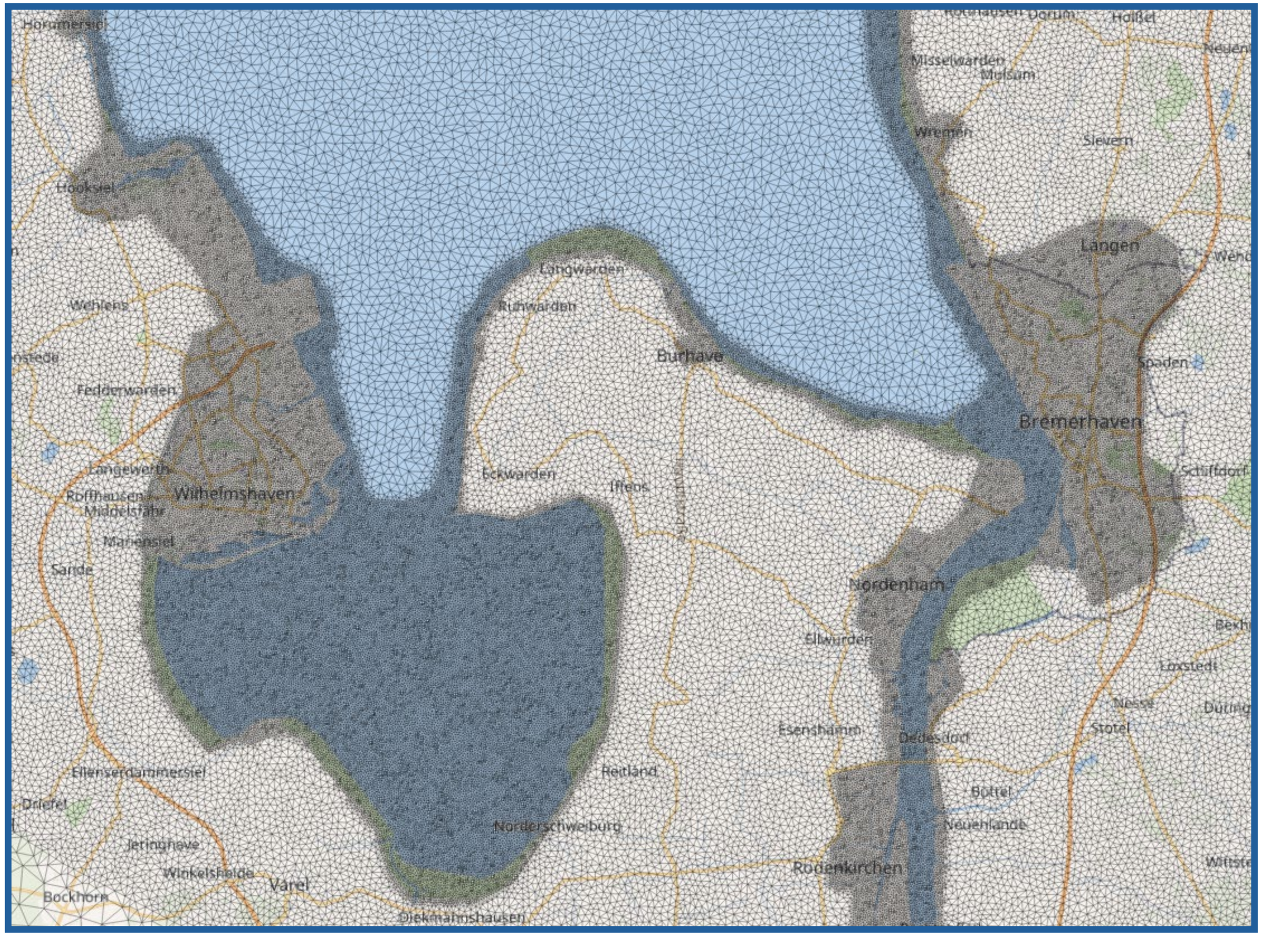
Modelling the extreme event: the flood event (2)



- TRIANGULAR MESH:
  - Five different areas considered for specific precision:

1) *High resolution areas*
   - *Dykes & urban*
   - *Area of ~ 4.000 m²*
2) *Lowlands*
   - *Land areas under 10m*
   - *Area of ~ 23.000 m²*
3) *Highlands*
   - *Land areas above 10m*
   - *Area of ~ 400.000 m²*
4) *Coast*
   - *Coastal areas*
   - *Area of ~ 40.000 m²*
5) *Sea*
   - *Open sea areas*
   - *Area of ~ 180.000 m²*

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Modelling the extreme event: the flood event (3)

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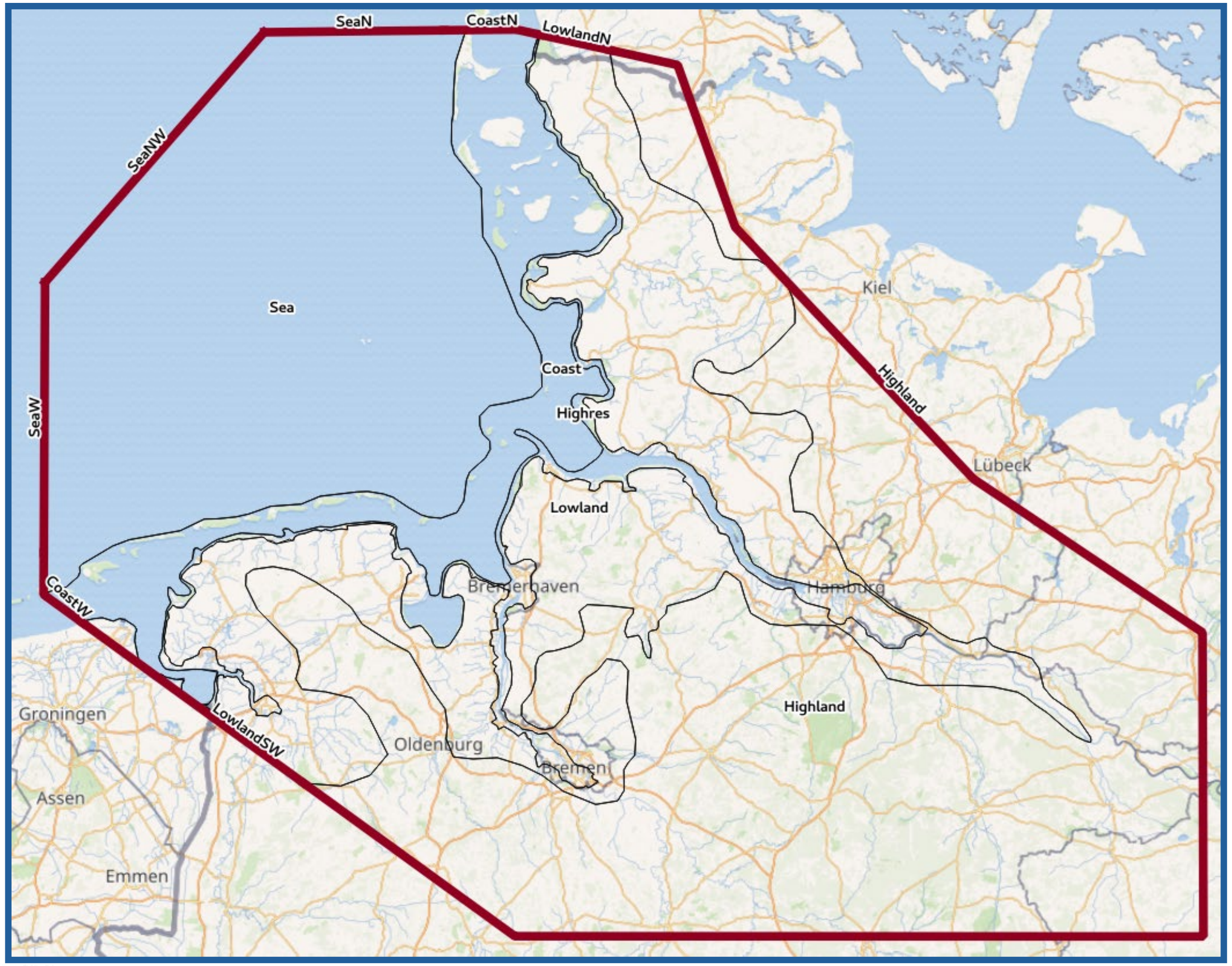

- BOUNDARIES:
  - The Storm Surge event data is simulated by the GTSM – Global Tide and Surge Model
  - Data from GTSM is passed to ANUGA in the form of water level and x-and-y momentum at the "Sea" boundaries:
    - SeaW
    - SeaNW
    - SeaN
  - Simulation is performed for the highest storm tide event, as extracted from GTSM

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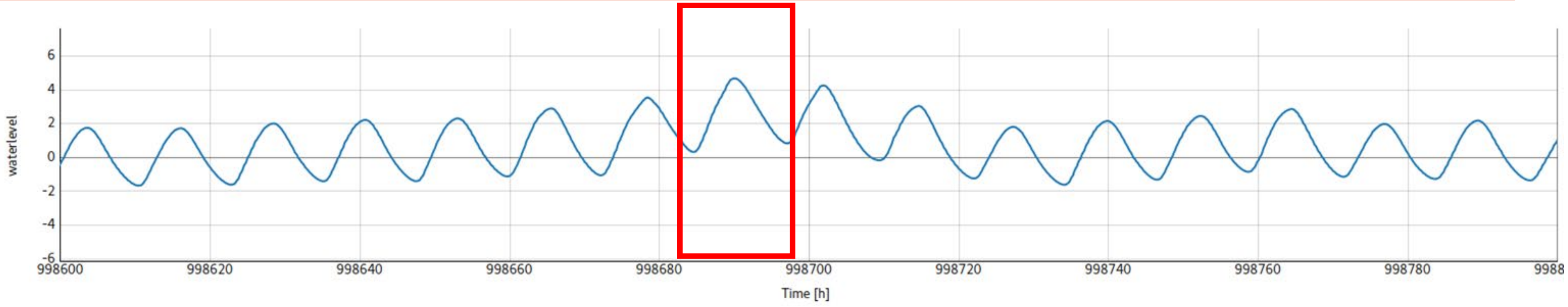
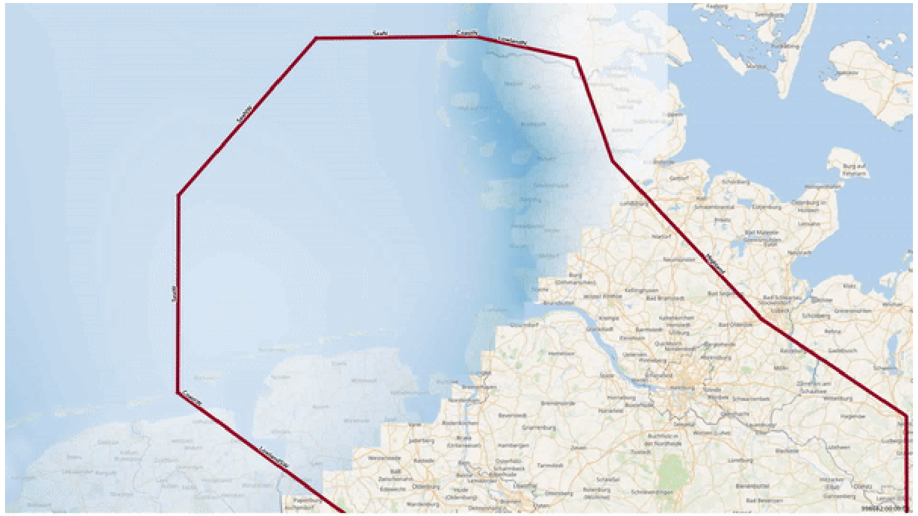
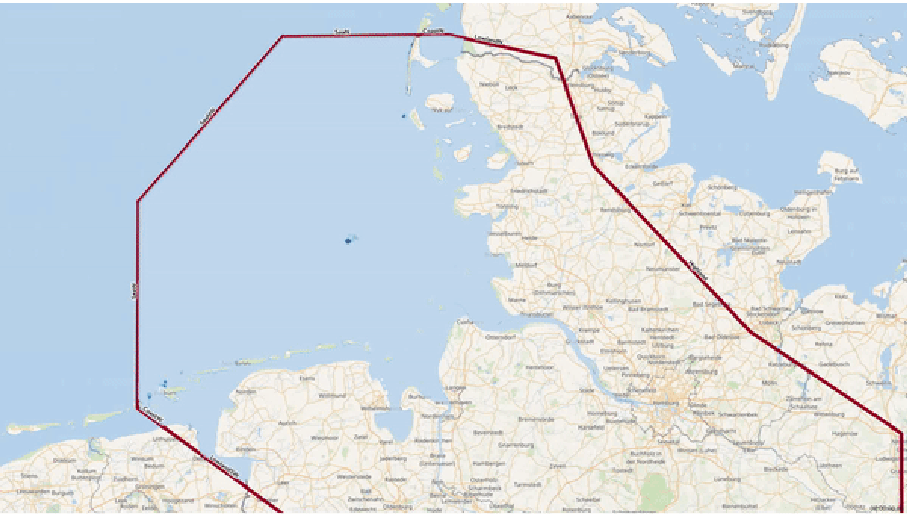
Modelling the extreme event: the flood event (3)



GTSM



ANUGA



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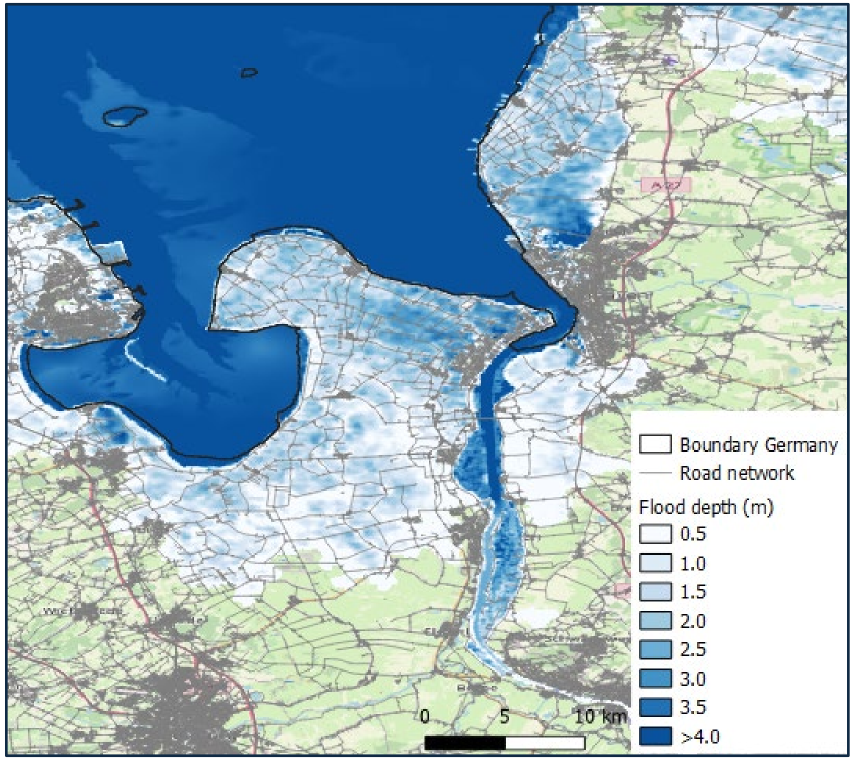
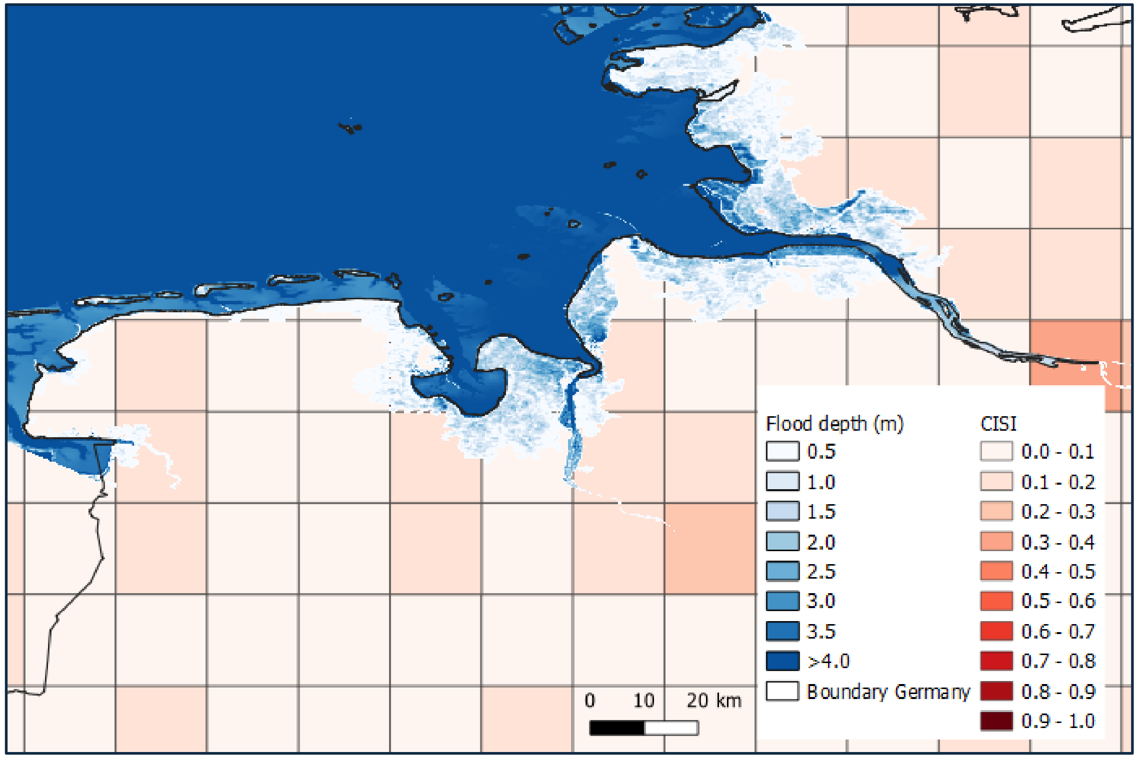
Analyzing the impacts: exposed assets in Germany during storm Xaver



Exposure of roads in Bremerhaven and surroundings



Infrastructure exposure in Northern Germany (CISI resolution of 0.25x0.25 degrees)

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Whats next to develop for other storylines?

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- Storm Ophelia and its counterfactuals (what would happen if the storm would have a slightly different path):
  - Major "issue" with this storm: it is not expected it would actually cause significant flooding along the North Sea coast due to its (fast) speed → could look at wind damages instead of flooding?

- Reduction of sea-ice extent and the impact on trade routes

- **Tagging along with other WPs to assess the impact of coastal infrastructure elsewhere and the link to Europe?**

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