

Phase-resolved wave modelling at the Baltic harbours and shores

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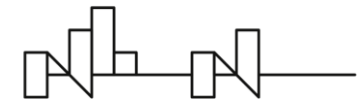
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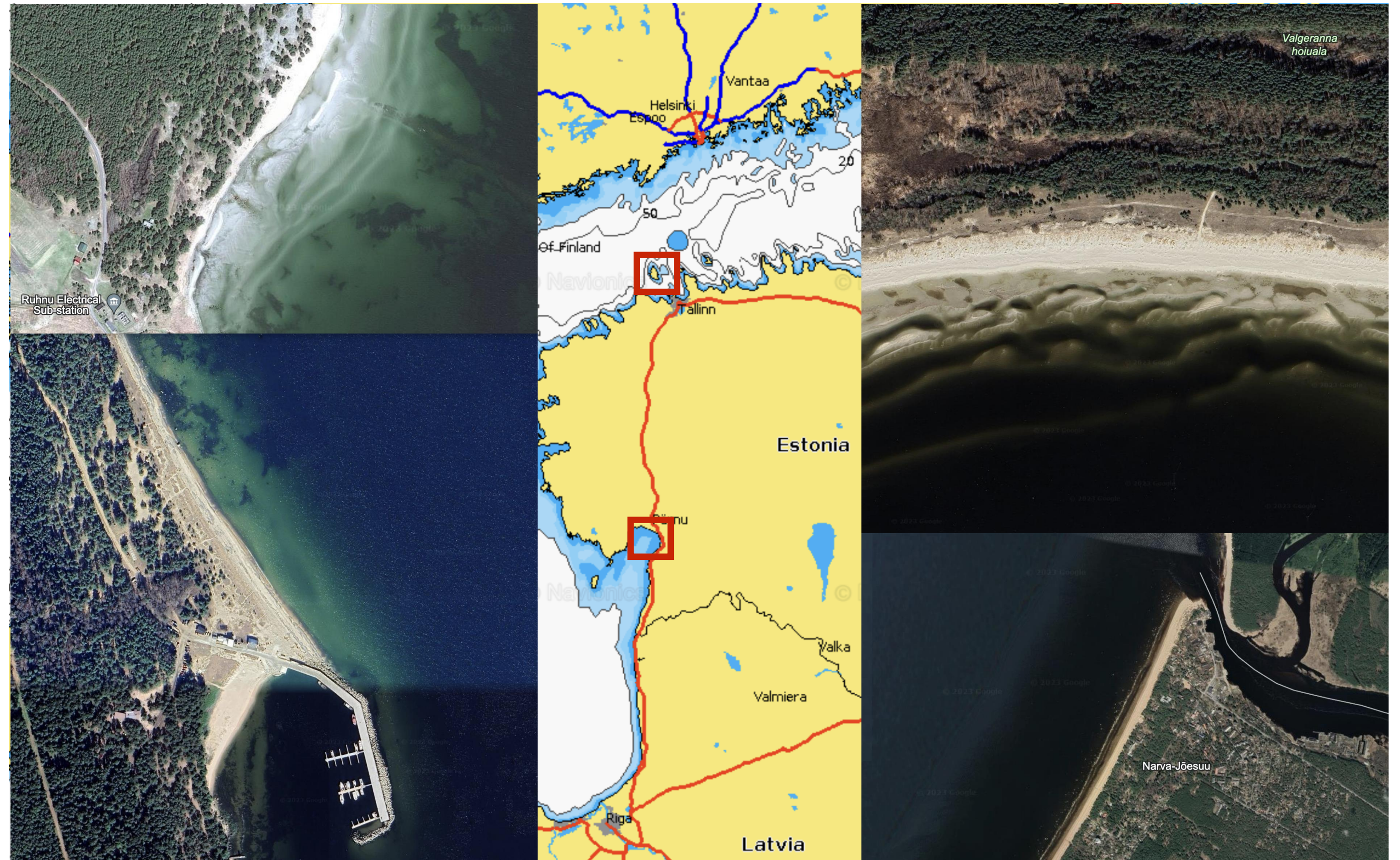
TAL
TECH

Iceland
Liechtenstein
Norway grants



Baltic harbours

- Large water bodies at the Gulf of Finland and the Gulf of Riga
- Long fetch for wind wave generation
- Intermediate to deep water around 50 m
- Sandy coastlines, challenges of erosion and dredging

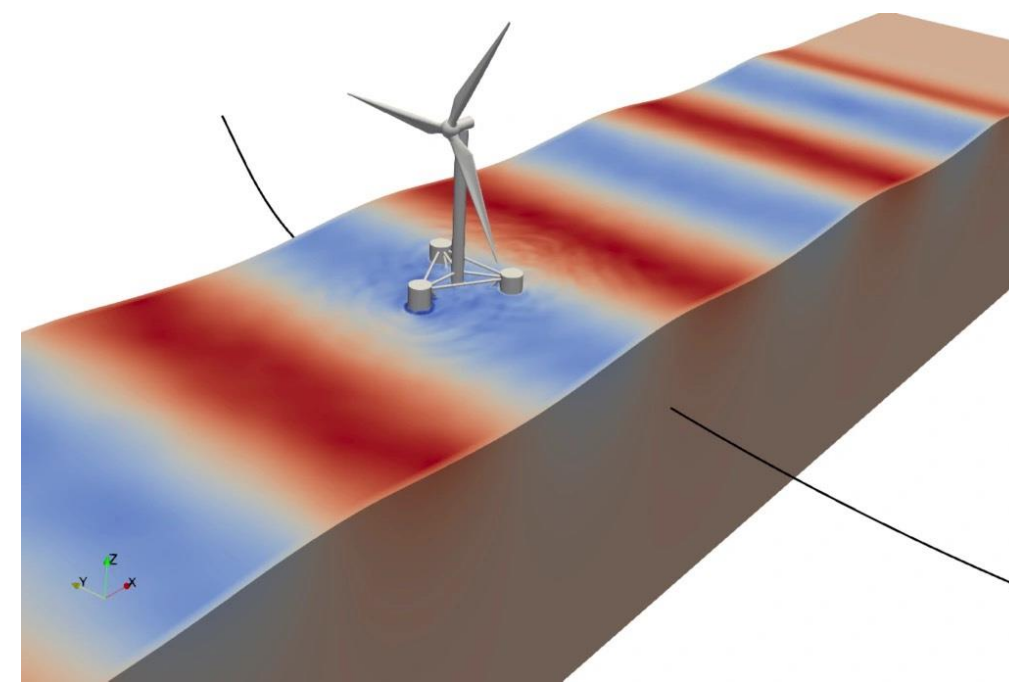


Baltic harbours

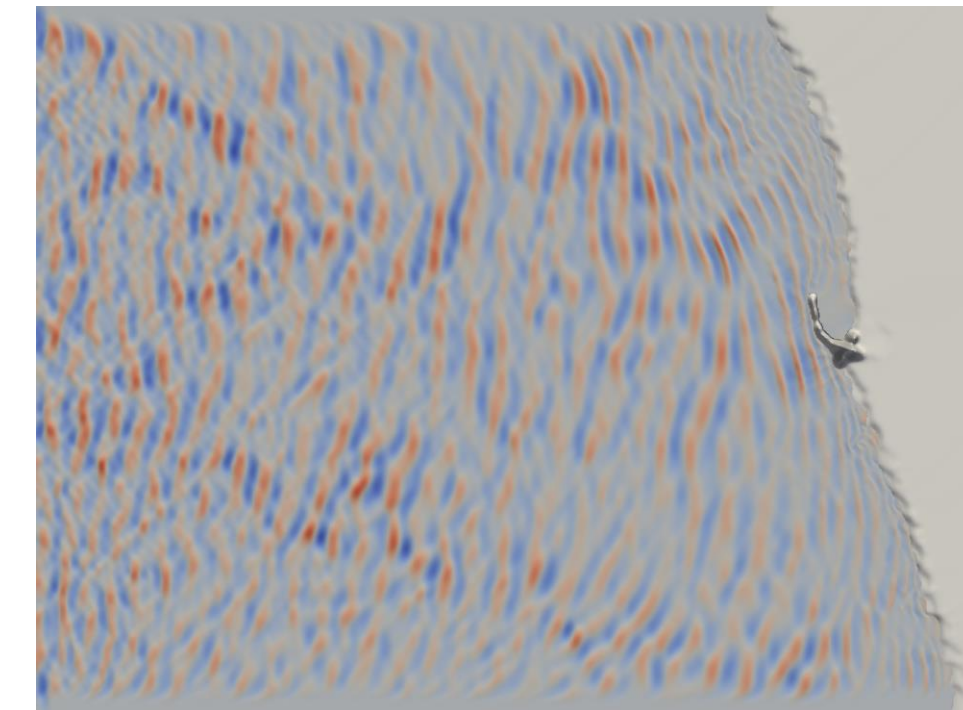
REEF3D

Open-Source Hydrodynamics

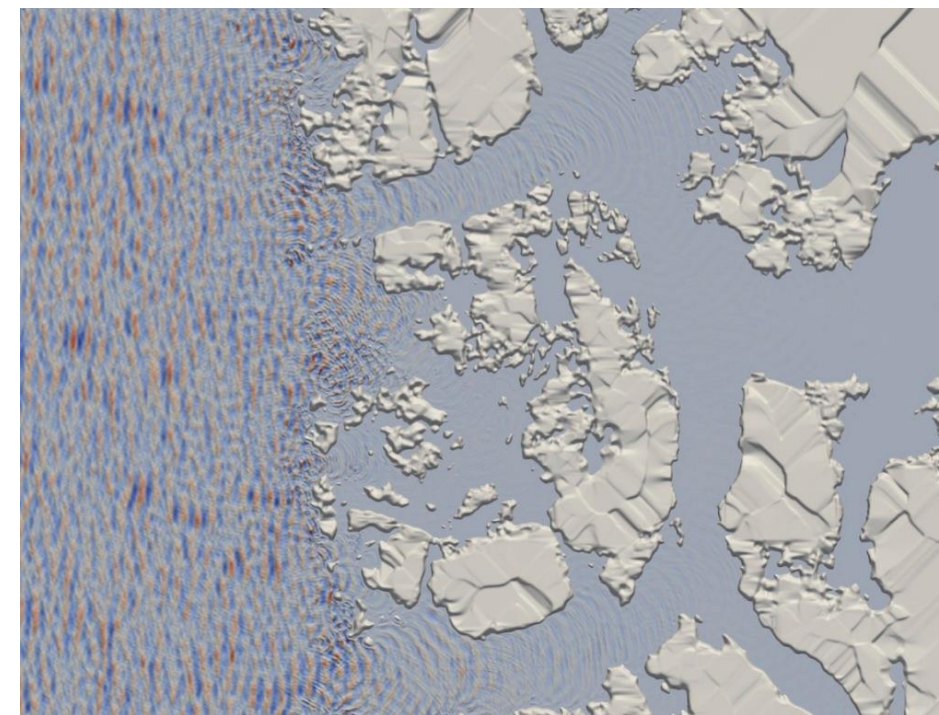
- Born in NTNU, Trondheim, Norway
- Multiscale:
Offshore | Coastal | Nearfield
- Multiphysics:
Hydraulic | Coastal | Offshore
- Open-source:
www.reef3d.com
<https://github.com/REEF3D>



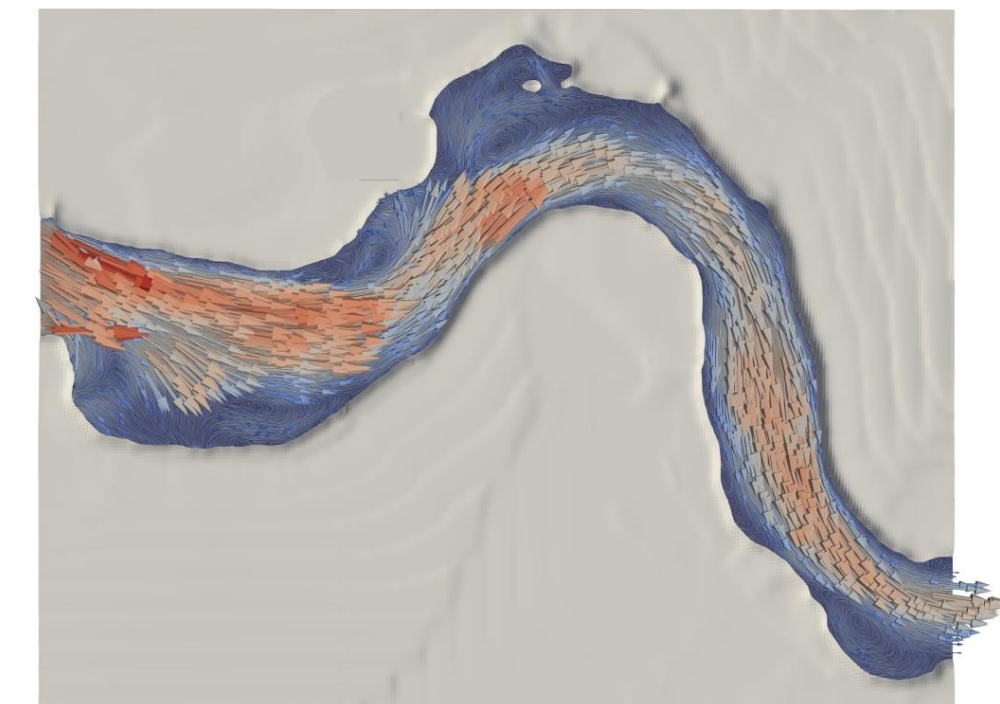
CFD Two-Phase
Navier-Stokes
Equations



NHFLOW Non-
hydrostatic Navier-
Stokes Equations



FNPF Fully Nonlinear
Potential Flow

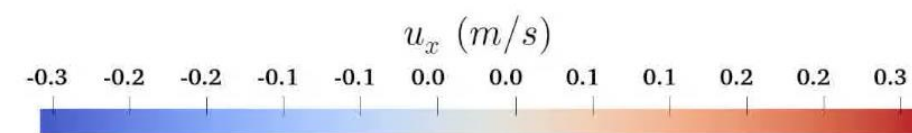
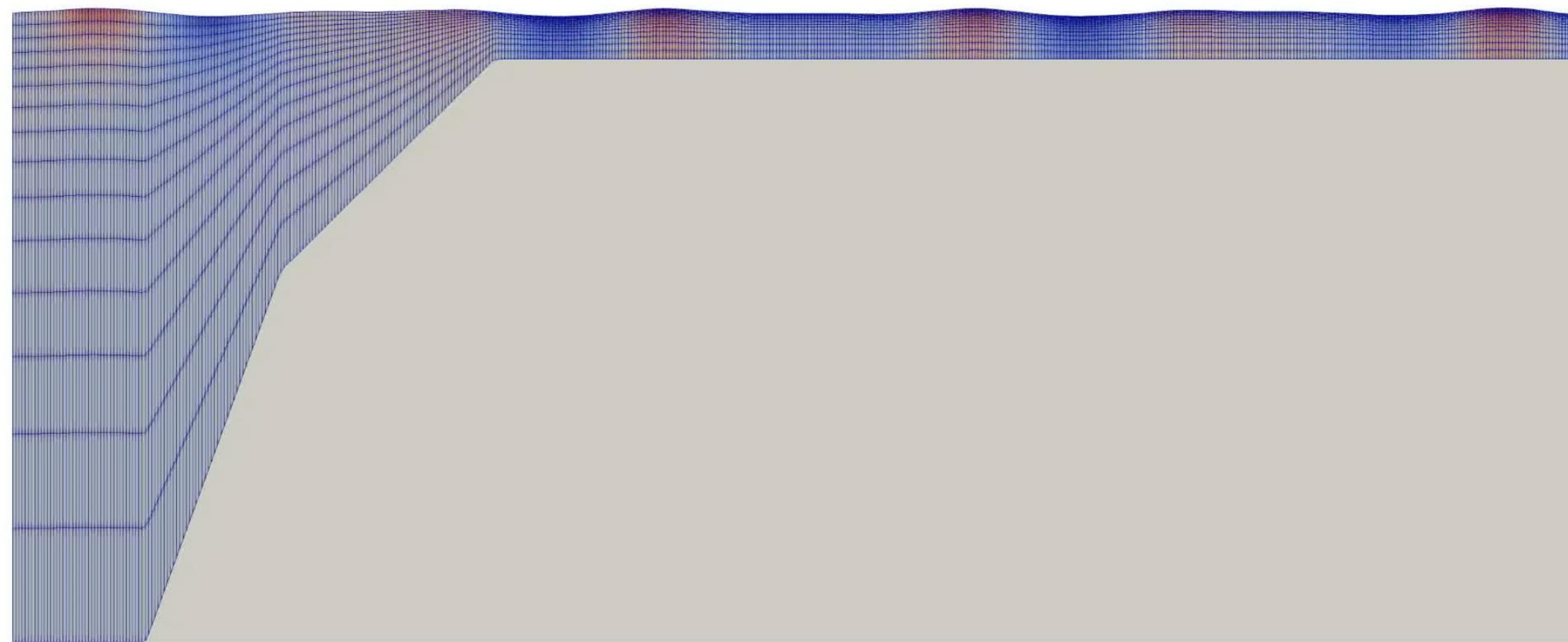


SFLOW Non-
hydrostatic SWE

Baltic harbours

REEF3D : : FNPF

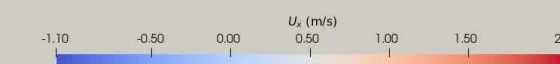
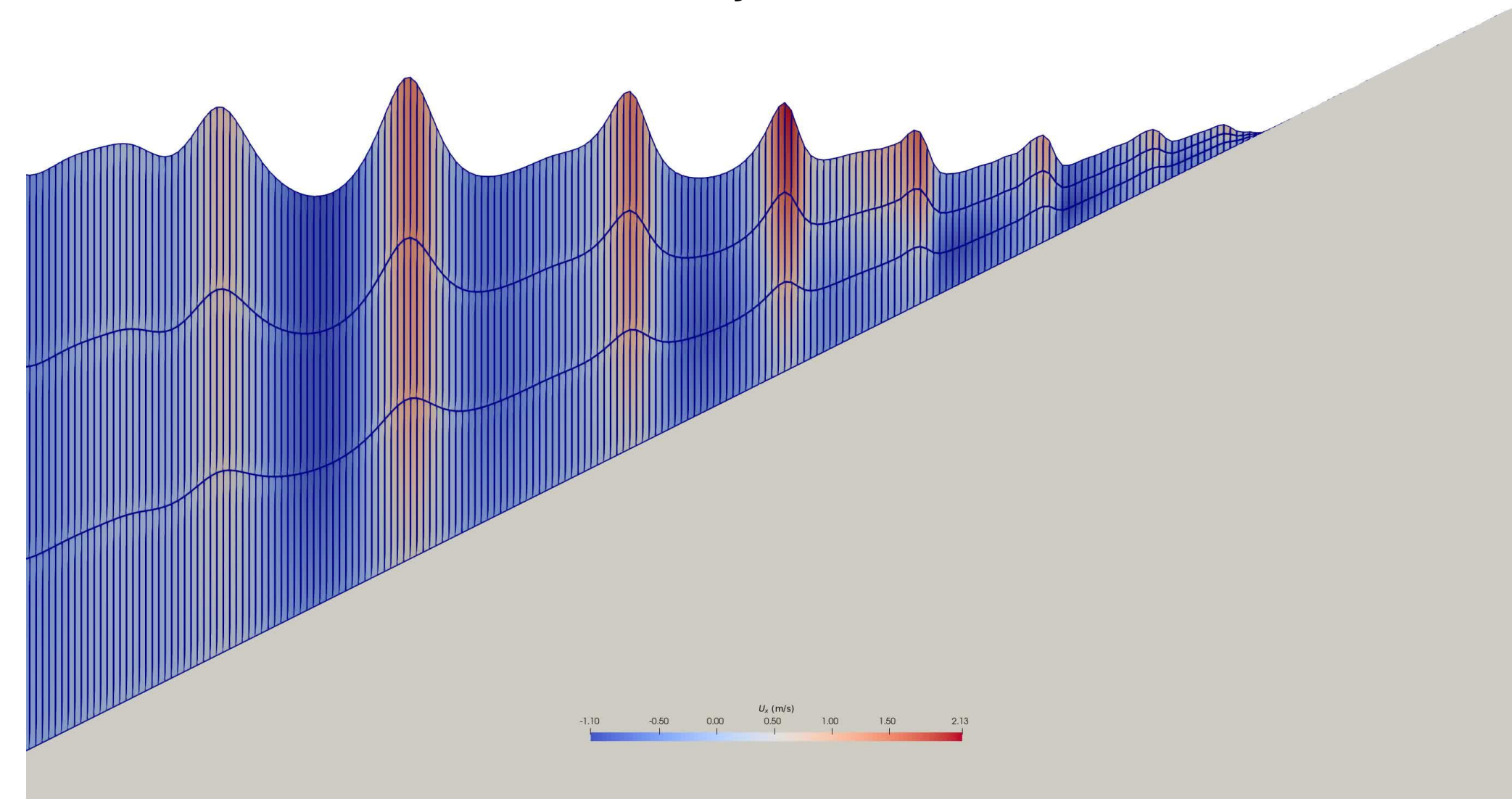
$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2} = 0$$



REEF3D : : NHFLOW

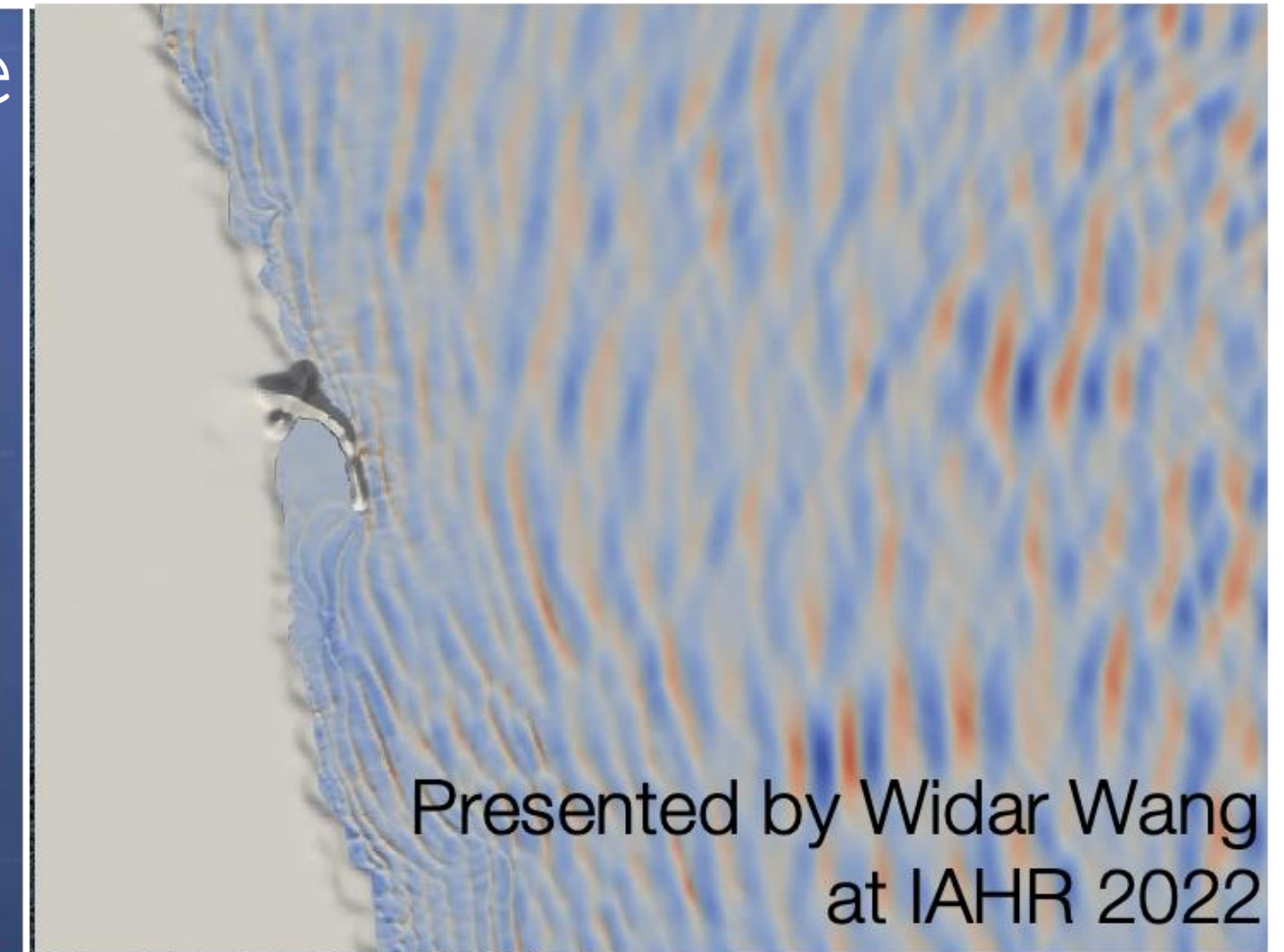
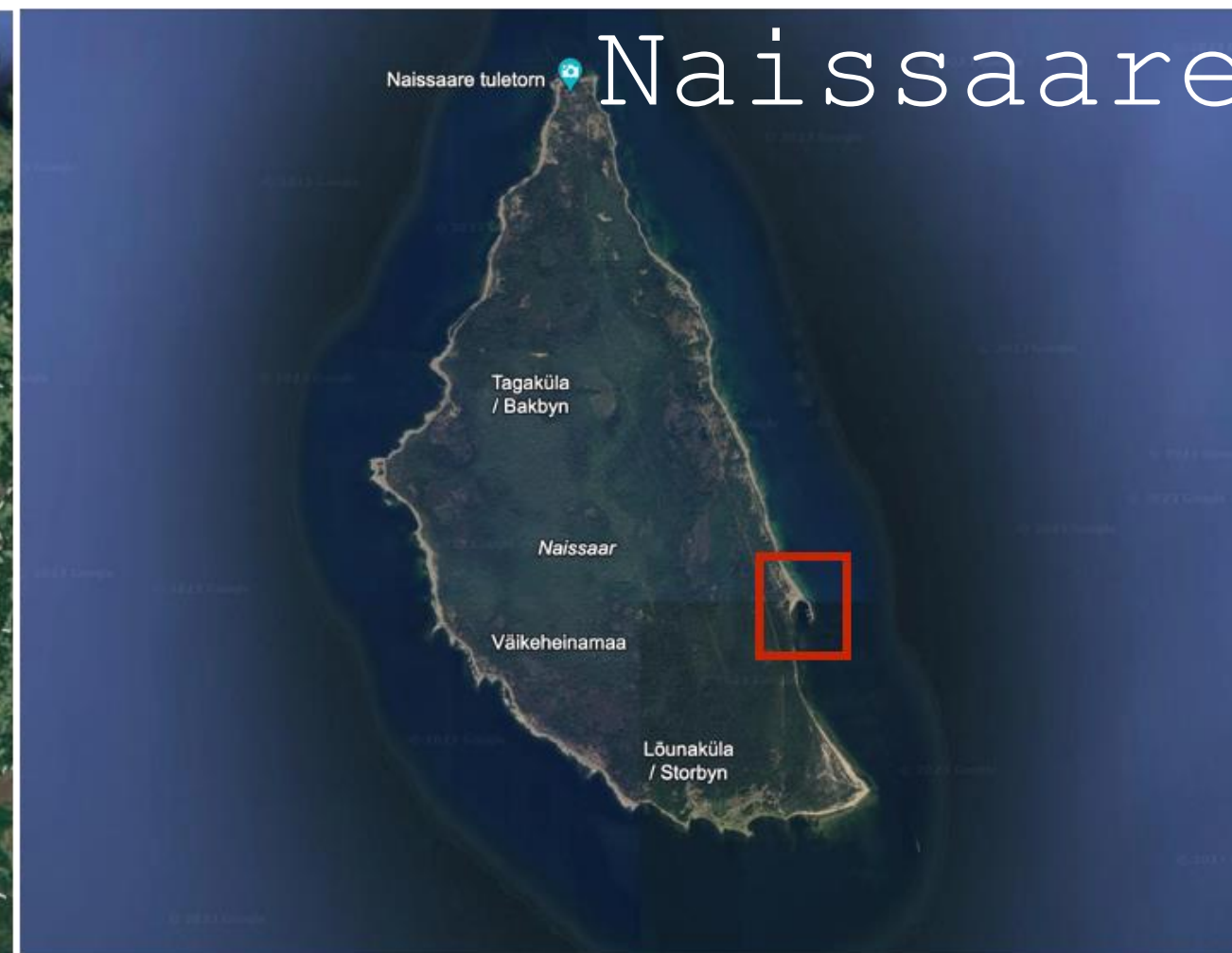
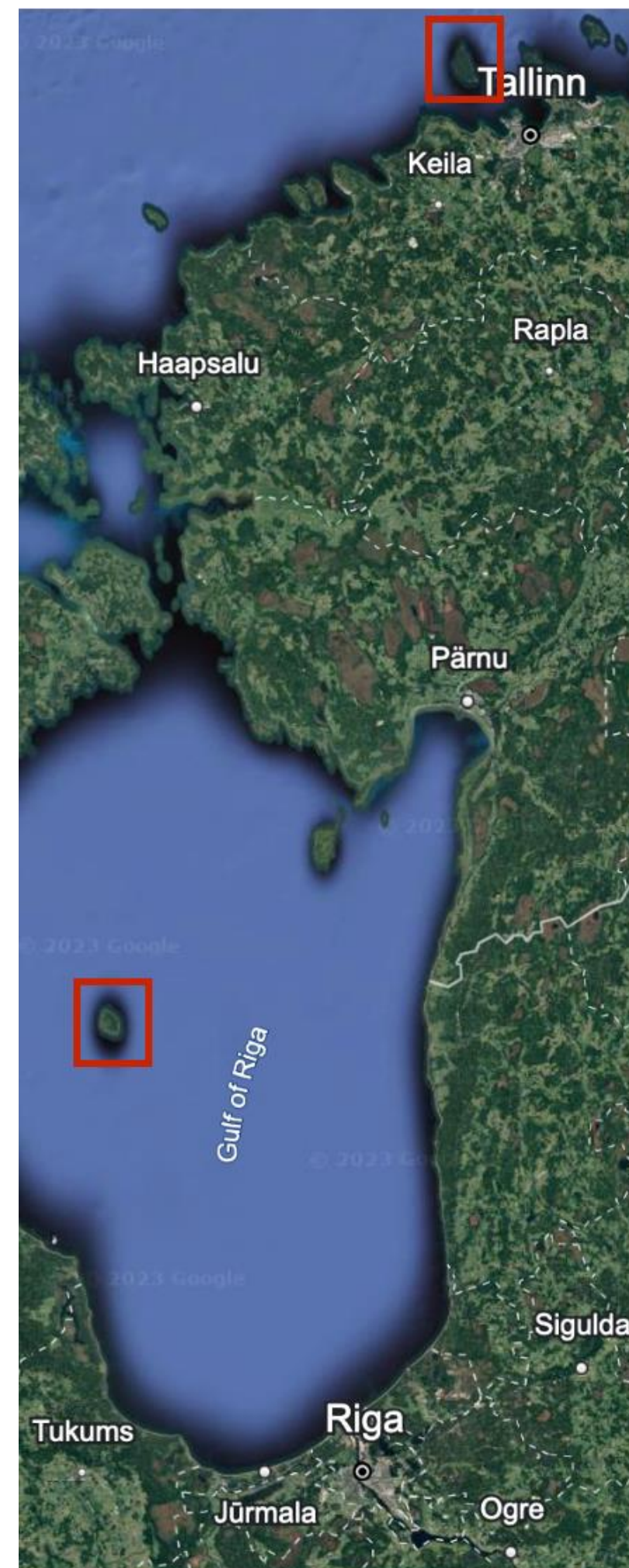
$$\frac{\partial u_i}{\partial x_i} = 0$$

$$\frac{\partial h u_i}{\partial t} + u_j \frac{\partial h u_i}{\partial x_j} = -\frac{h}{\rho} \frac{\partial p}{\partial x_i} - h g_i$$



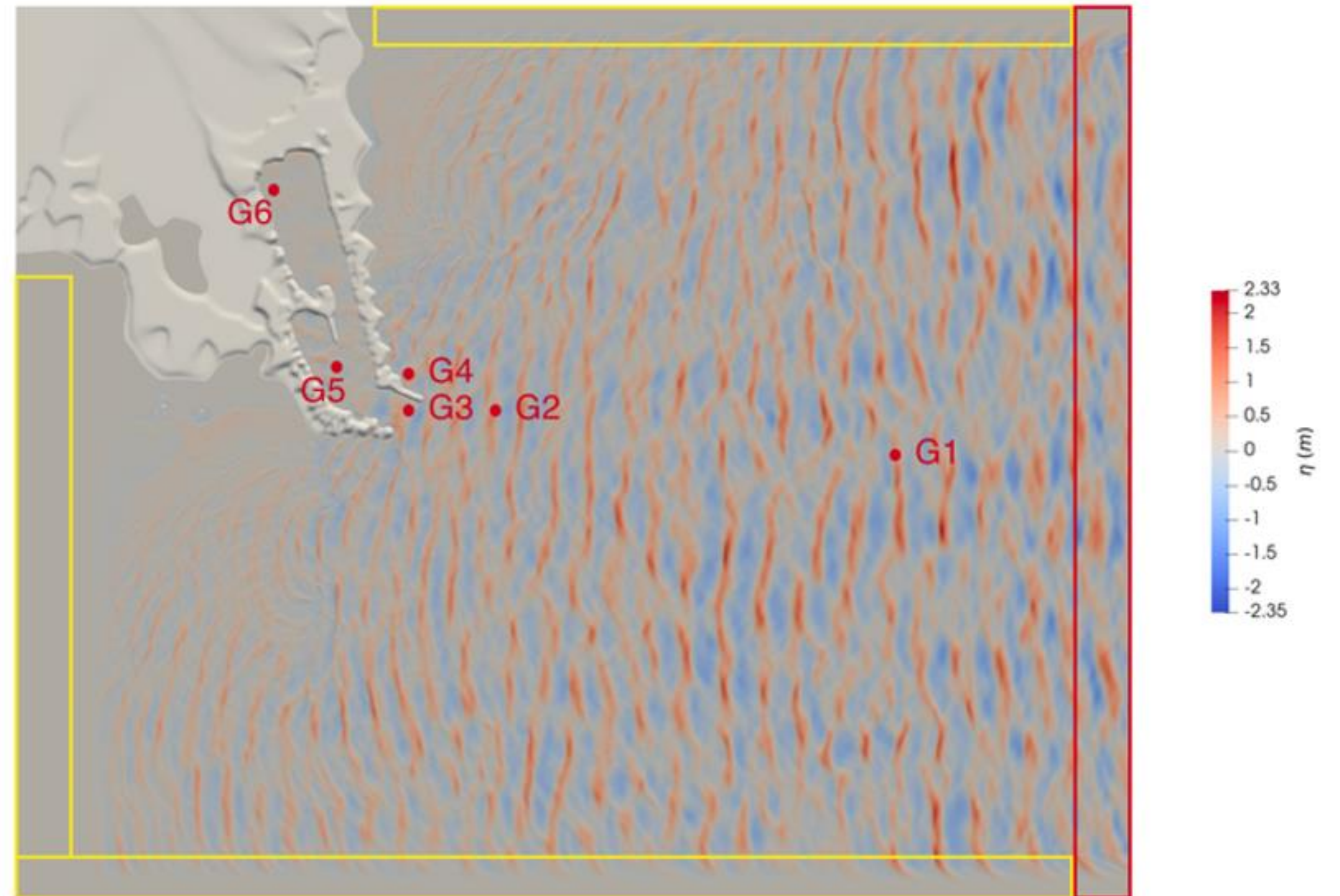
Baltic harbours

- REEF3D::FNPF
- Effects of breakwaters at harbours

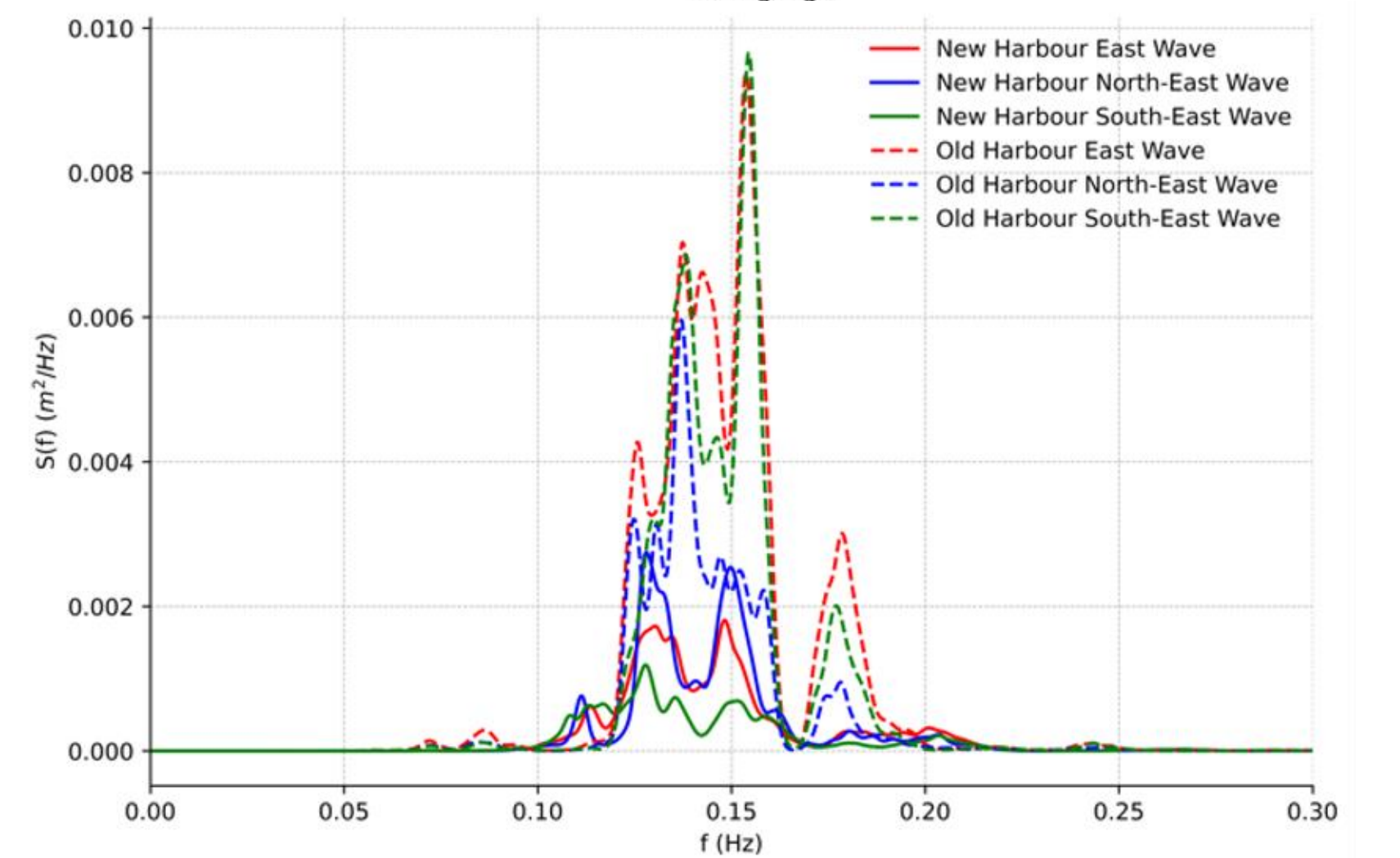
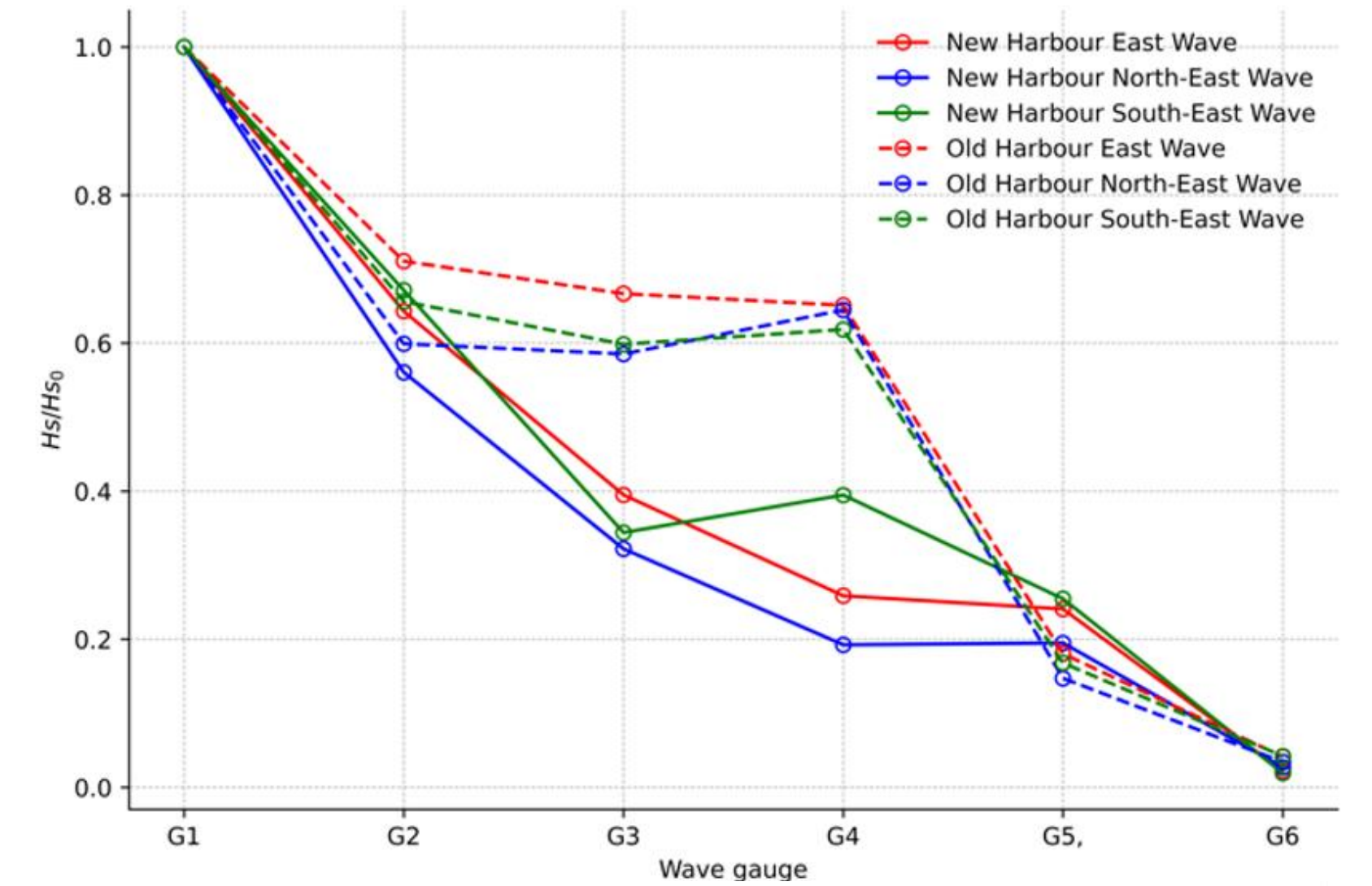
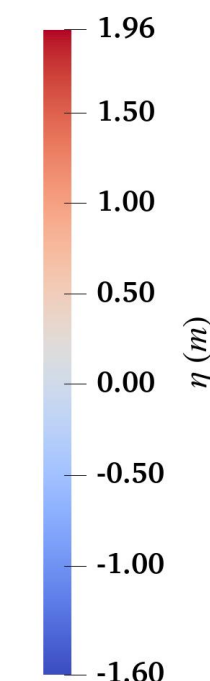
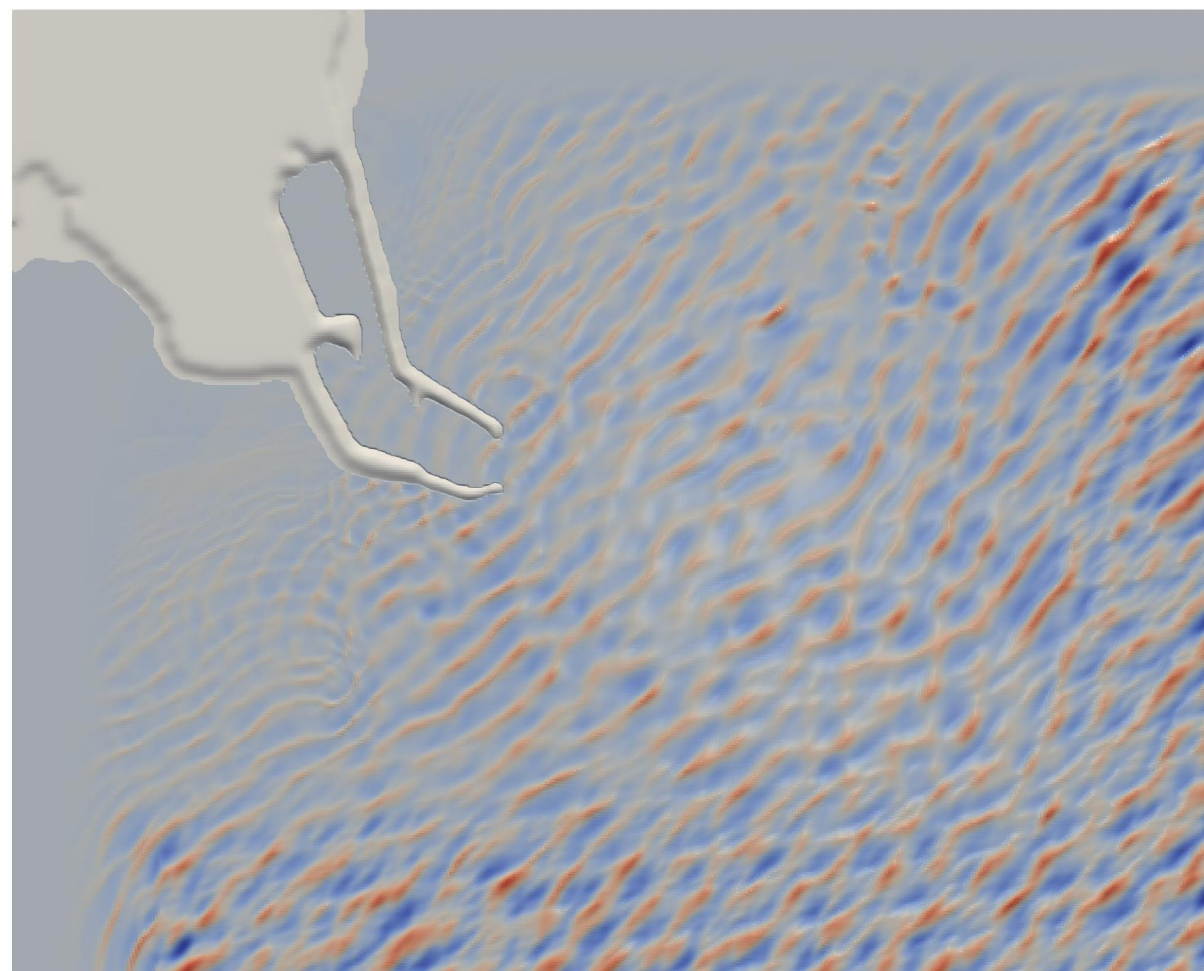
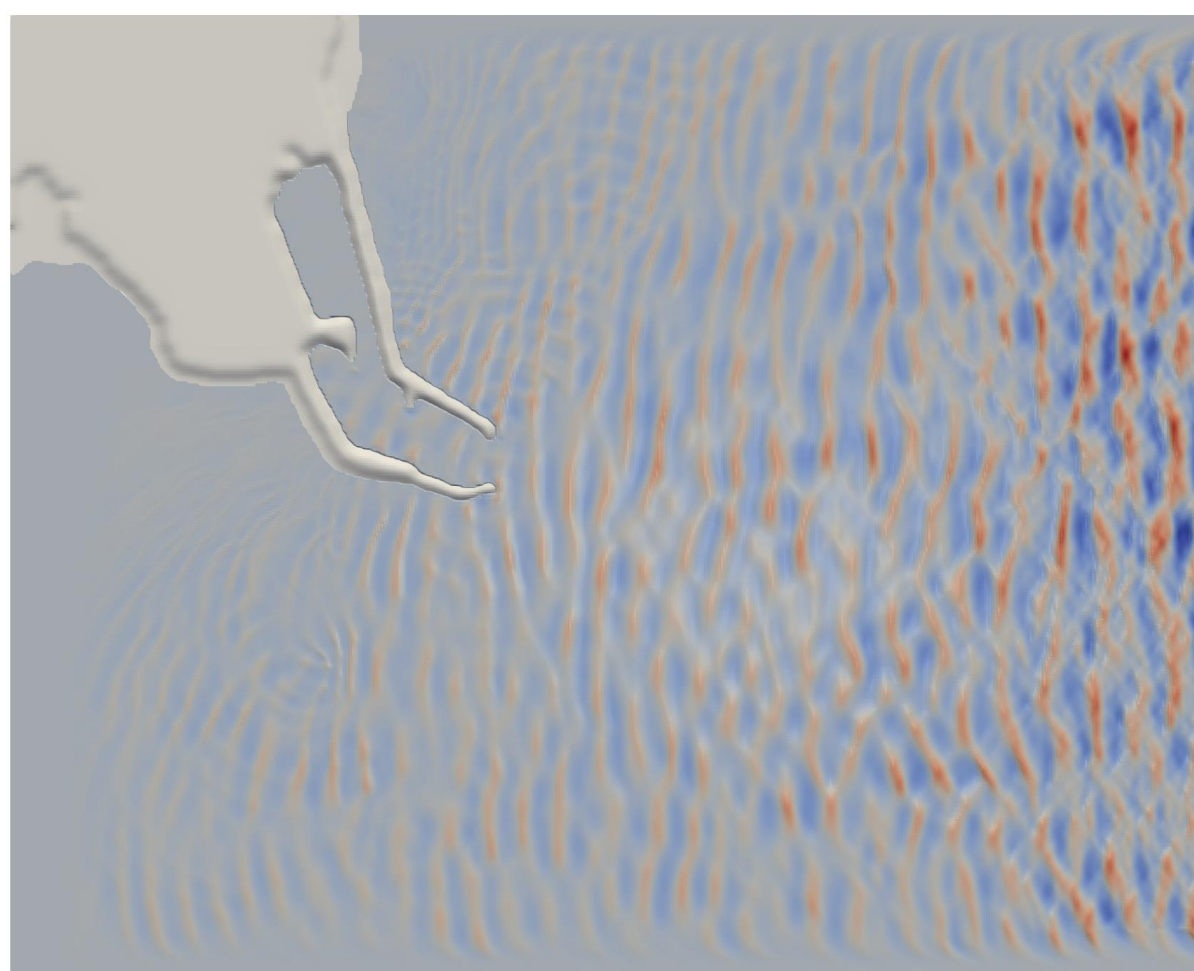
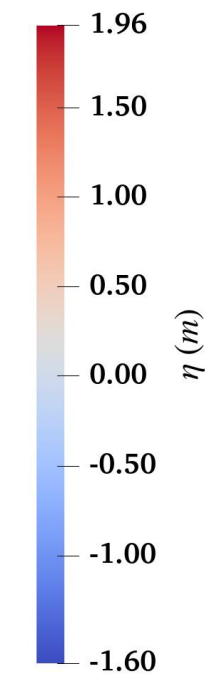
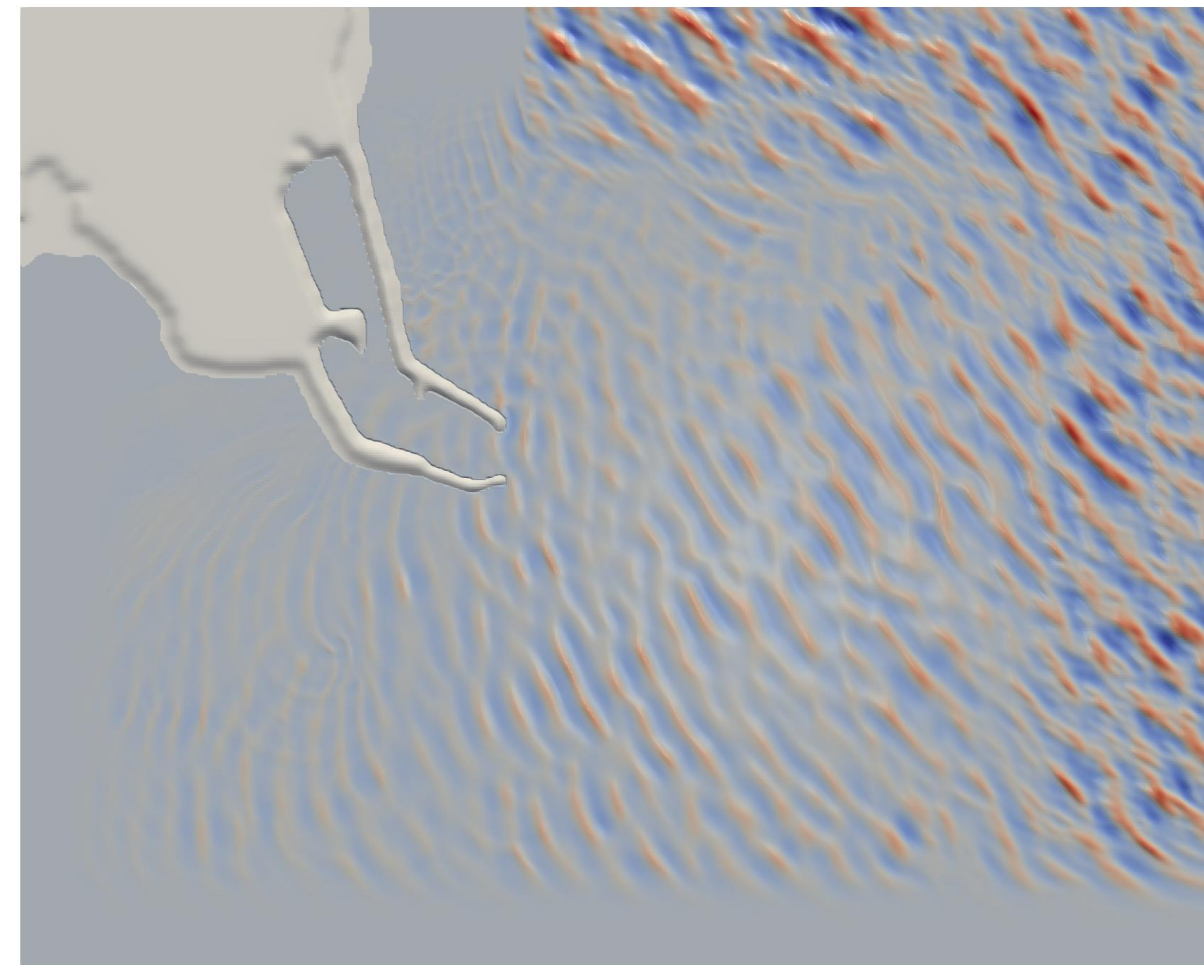
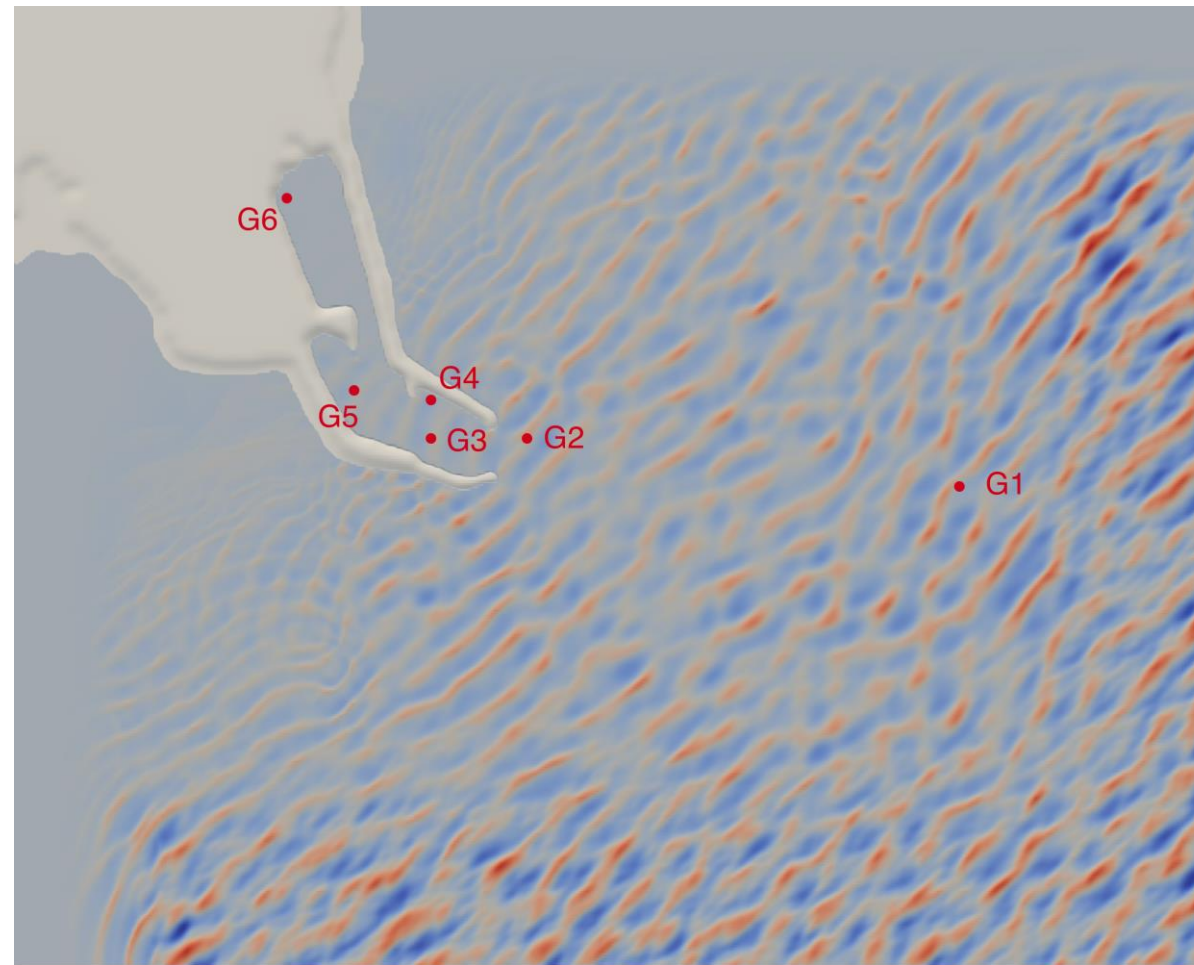


Baltic harbours

- Rhunu
- JONSWAP (3.3)
- $H_s = 2.2m$
- $T_p = 6.3s$
- Mitsuyasu (28)
- 2M cells
- 3.5 h
- 2.5 h @ 128 cores

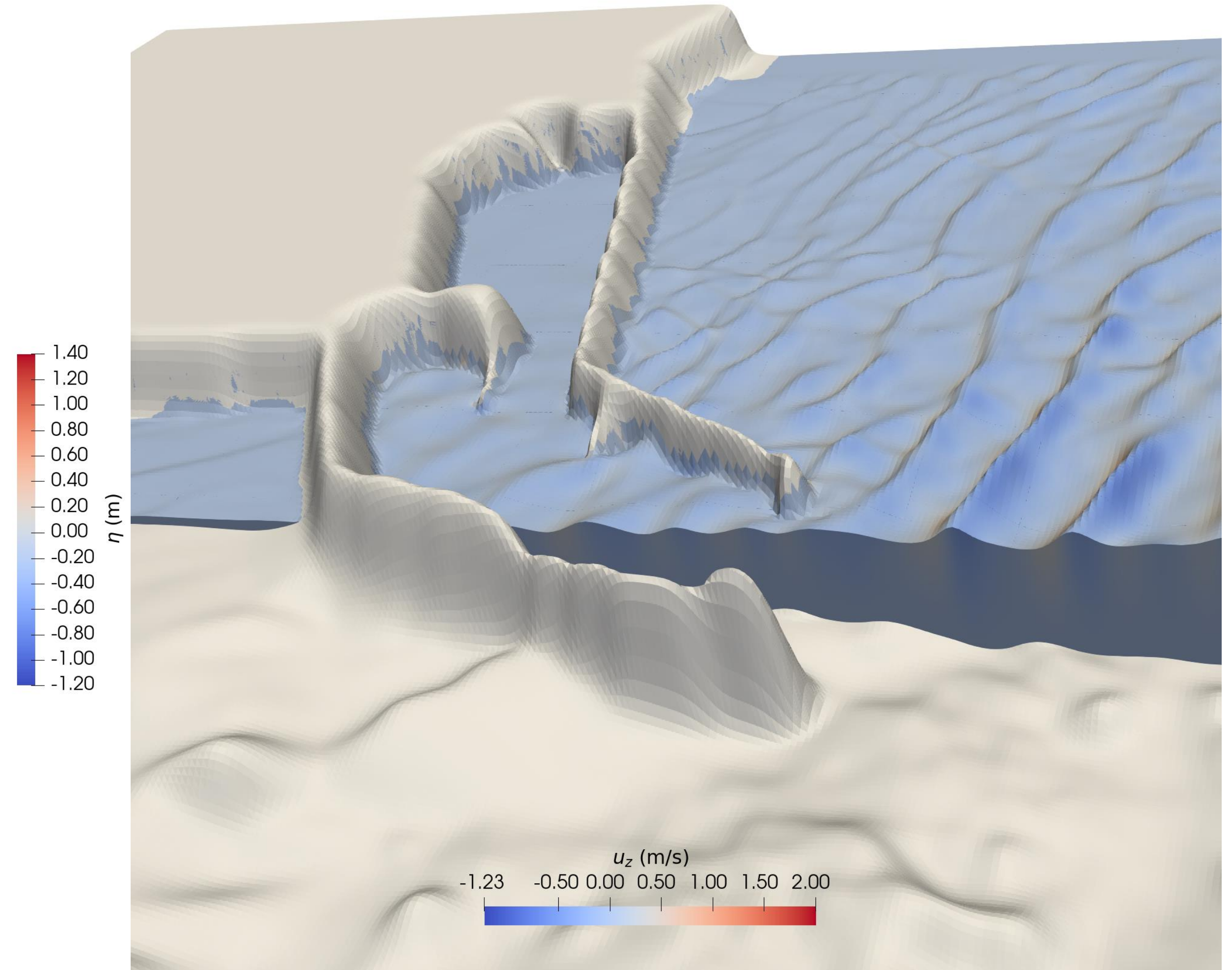
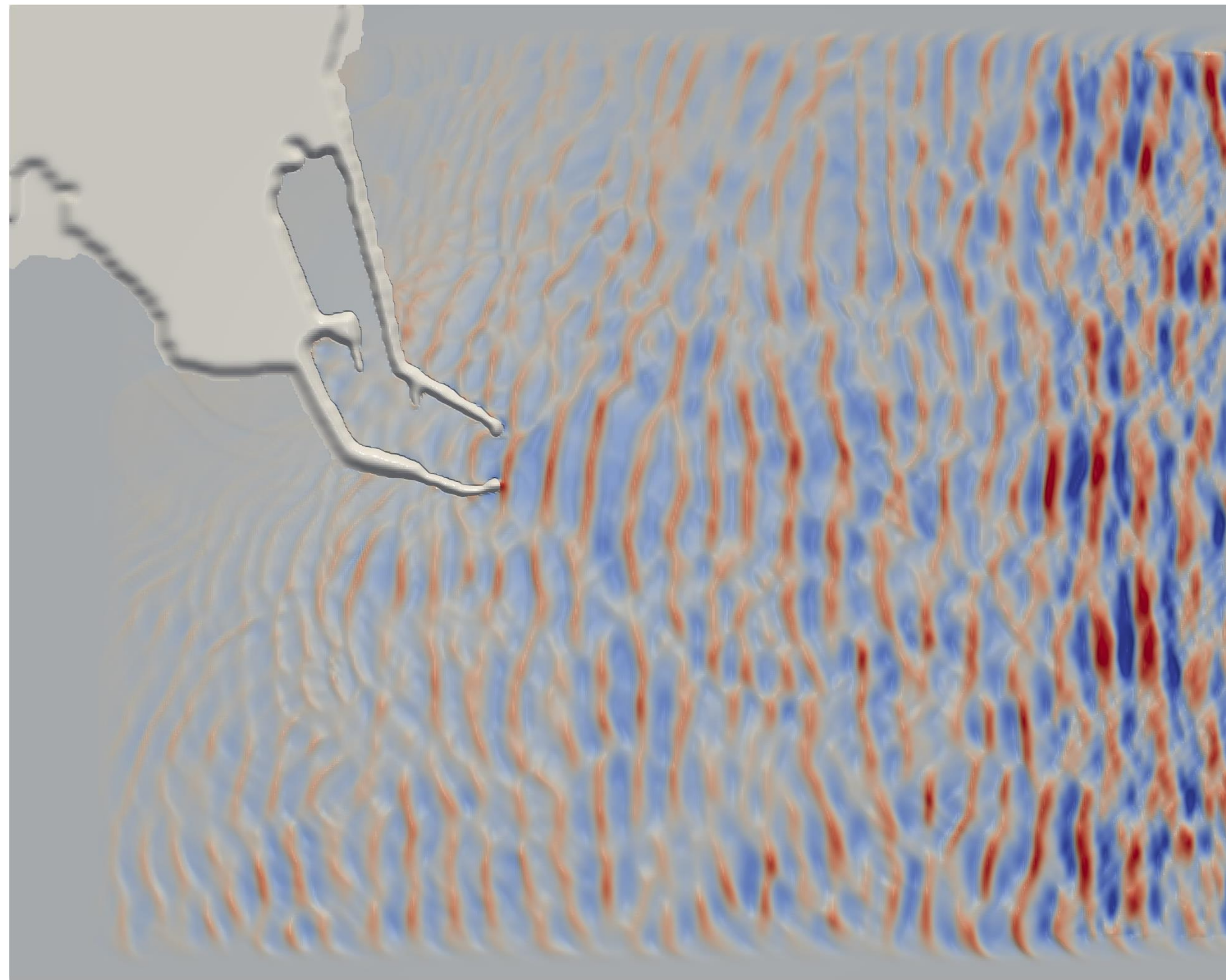


Baltic harbours



Baltic harbours

- REEF3D::NHFLOW



Baltic Shores

- REEF3D::NHFLOW
- Sandy coast
- River entry
- Narva-Jõesuu

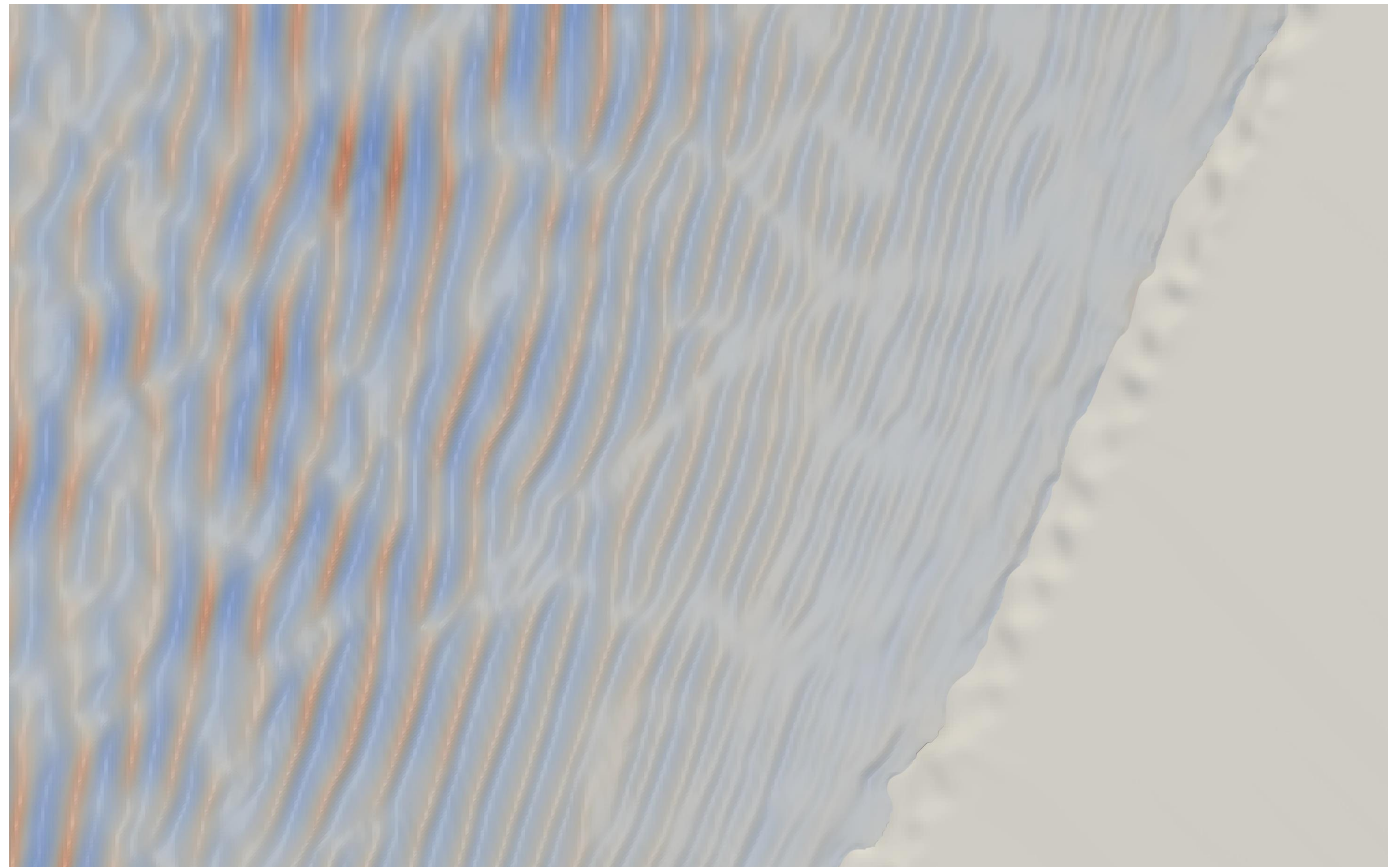
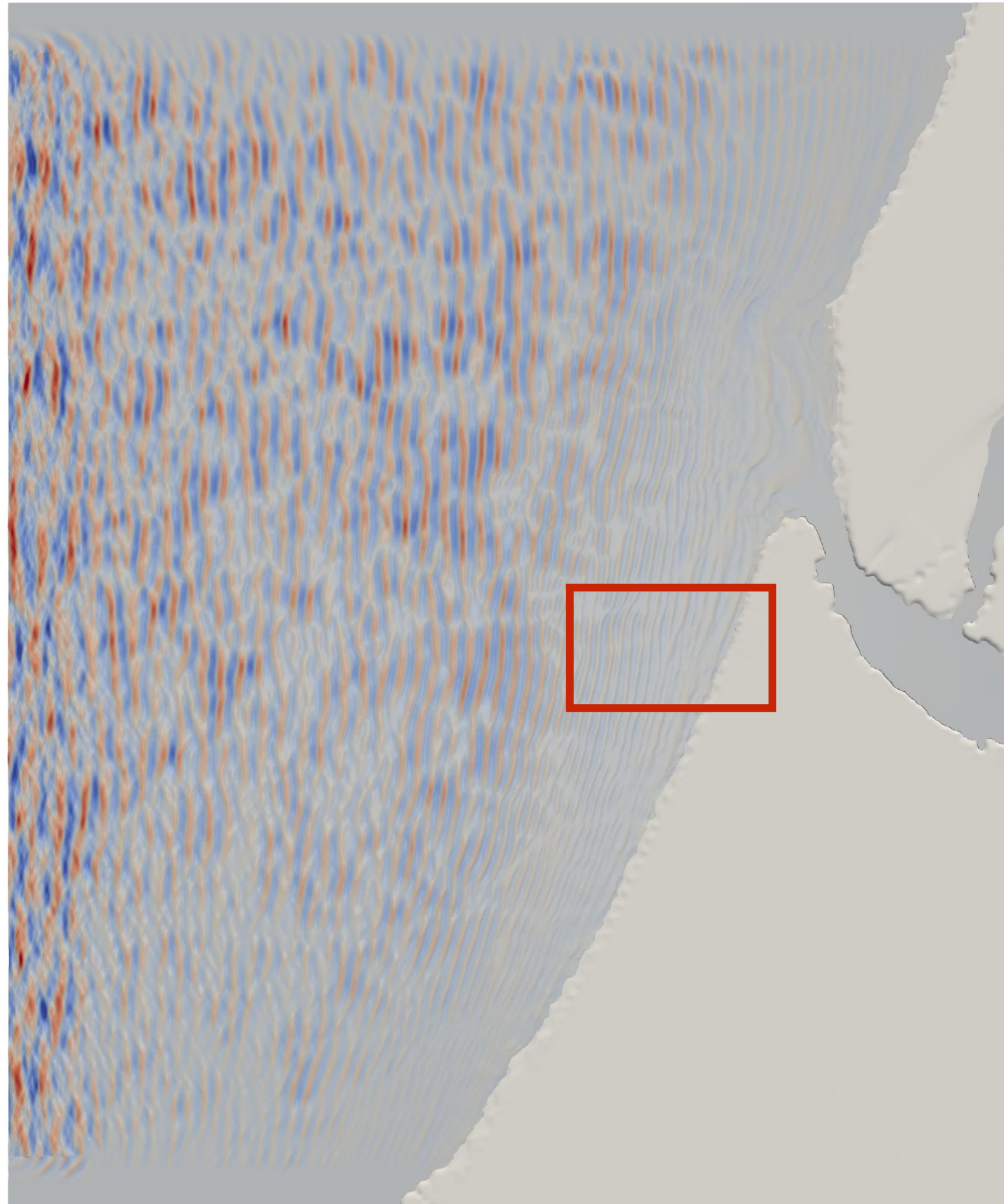


Pärnu-Valgeranna

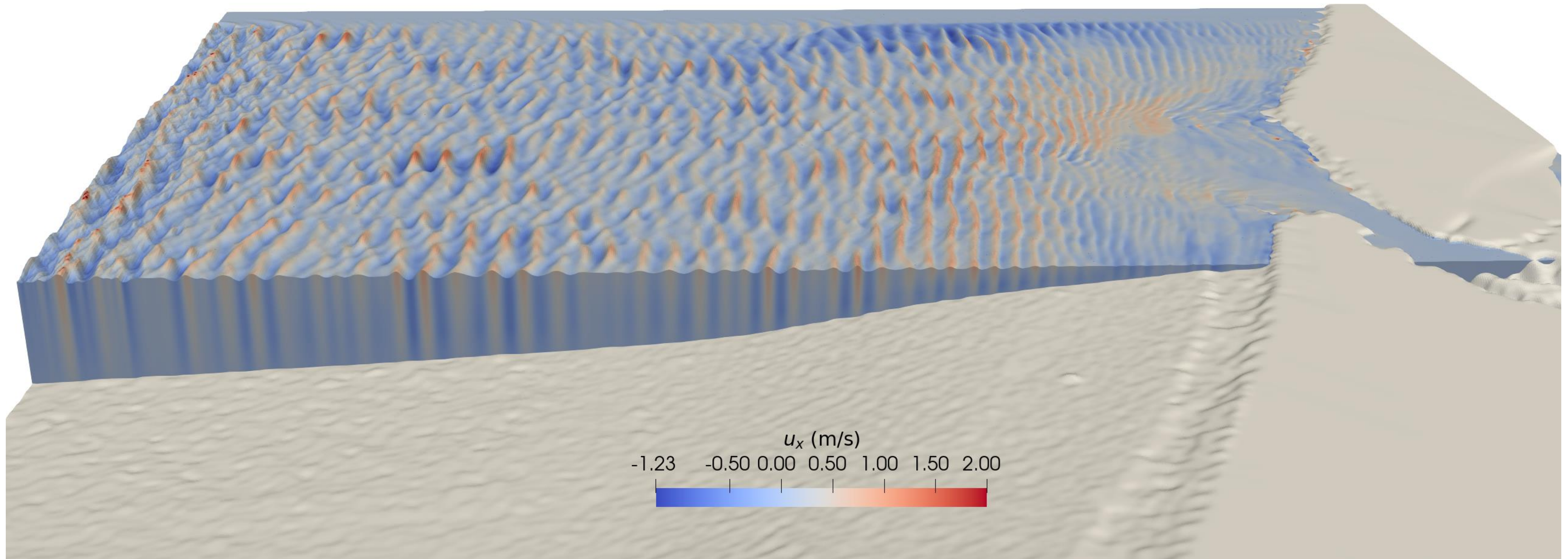


Narva-Jõesuu

Baltic Shores

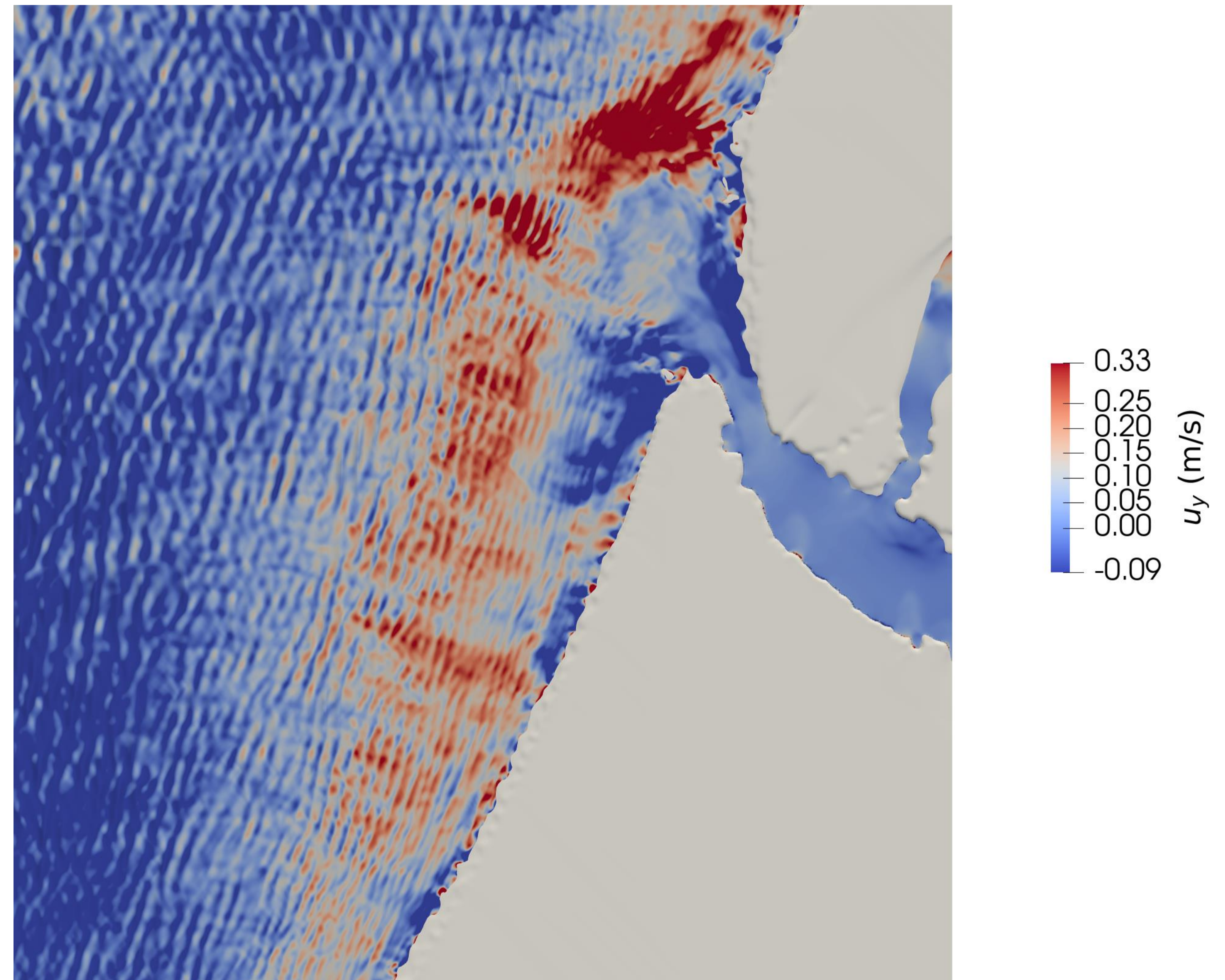


Baltic Shores



Baltic Shores

- Oblique wave
- Wave transformation
- Possible longshore current due to wave
- Wave longshore current interaction with river current



Baltic Harbours & Shores

- REEF3D::NHFLOW
- Wave transformation
- Swash zone
- River current
- Sediment transport



Current breakwater at Narva to be improved (video provided by Rain Mannikus)