

Impact of small bathymetric changes on large-scale hydrodynamics

Robert Hagen, Janina Freund and Frank Kösters



BAW

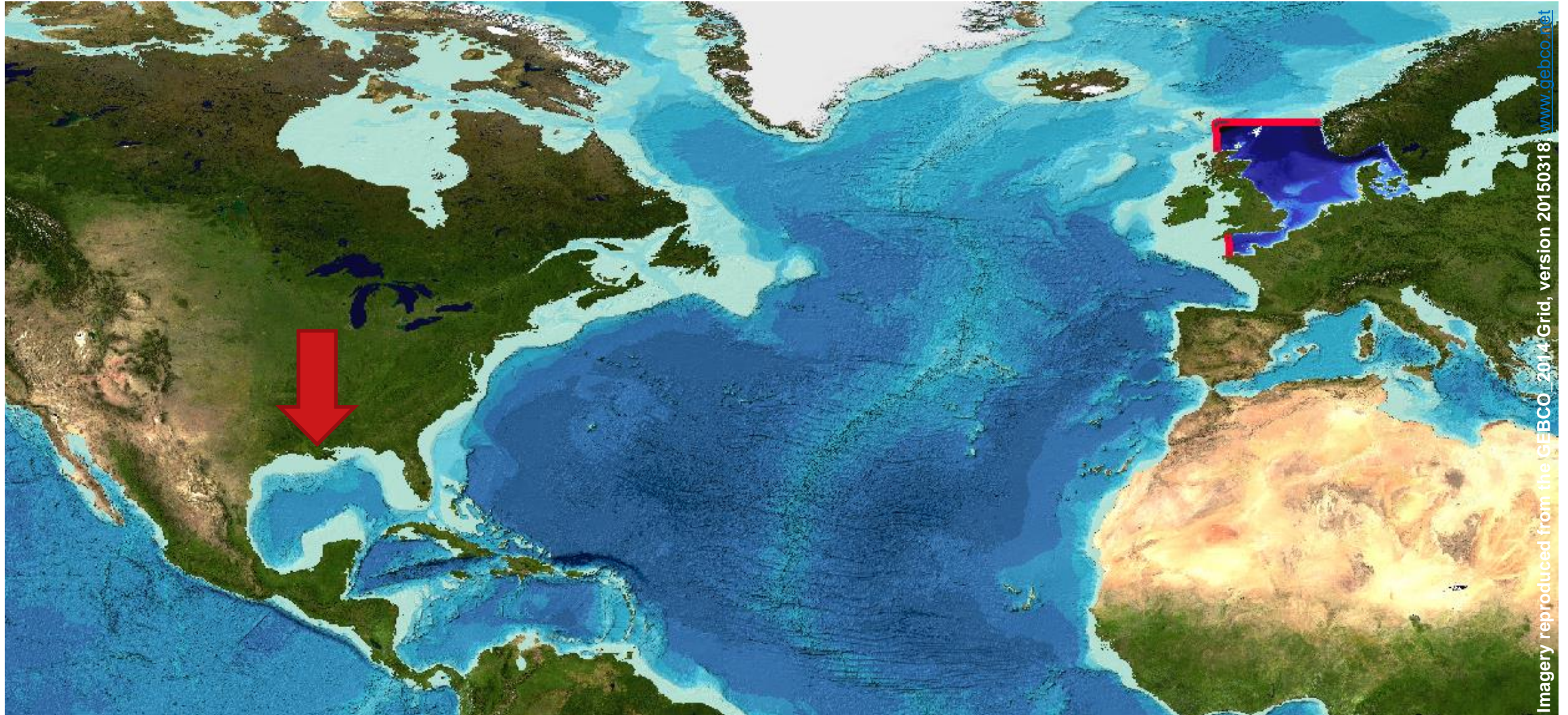
Federal Waterways Engineering
and Research Institute

PECS 2018

Galveston (TX, USA), 10/18/2018

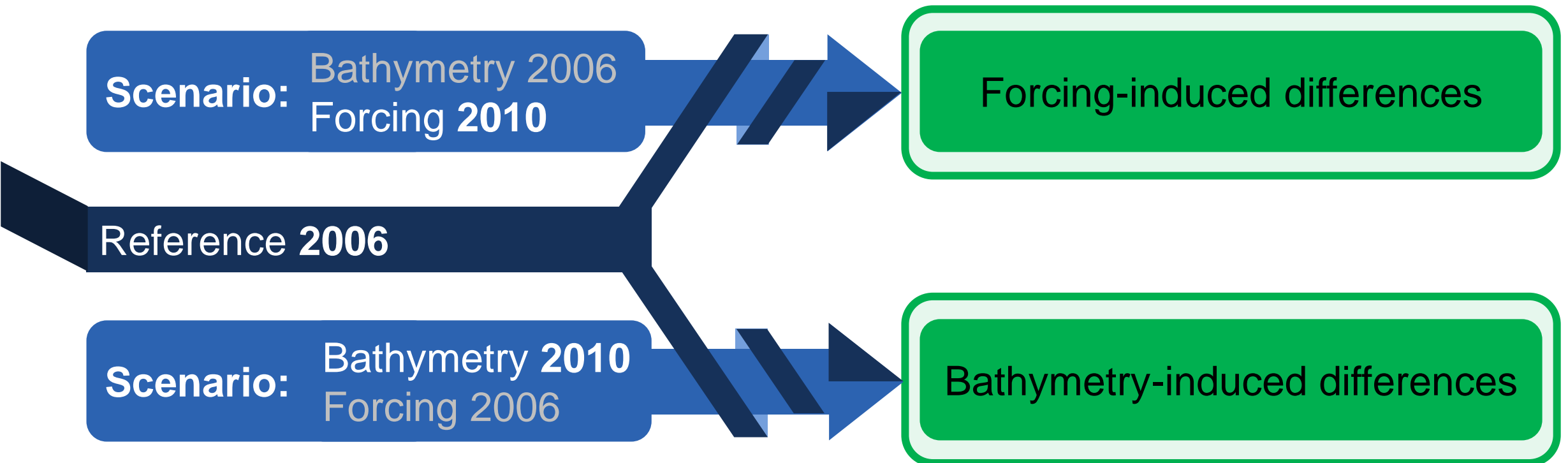
19F2004A

Modeling area



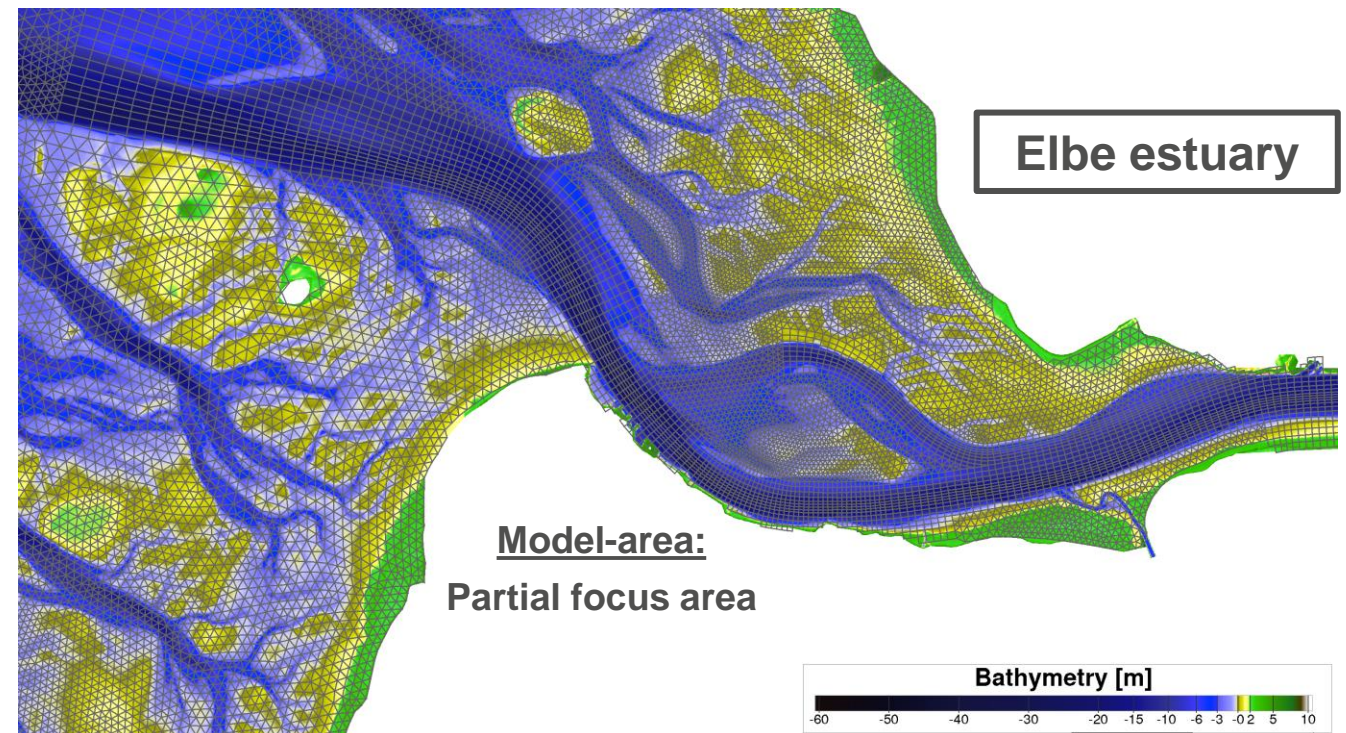
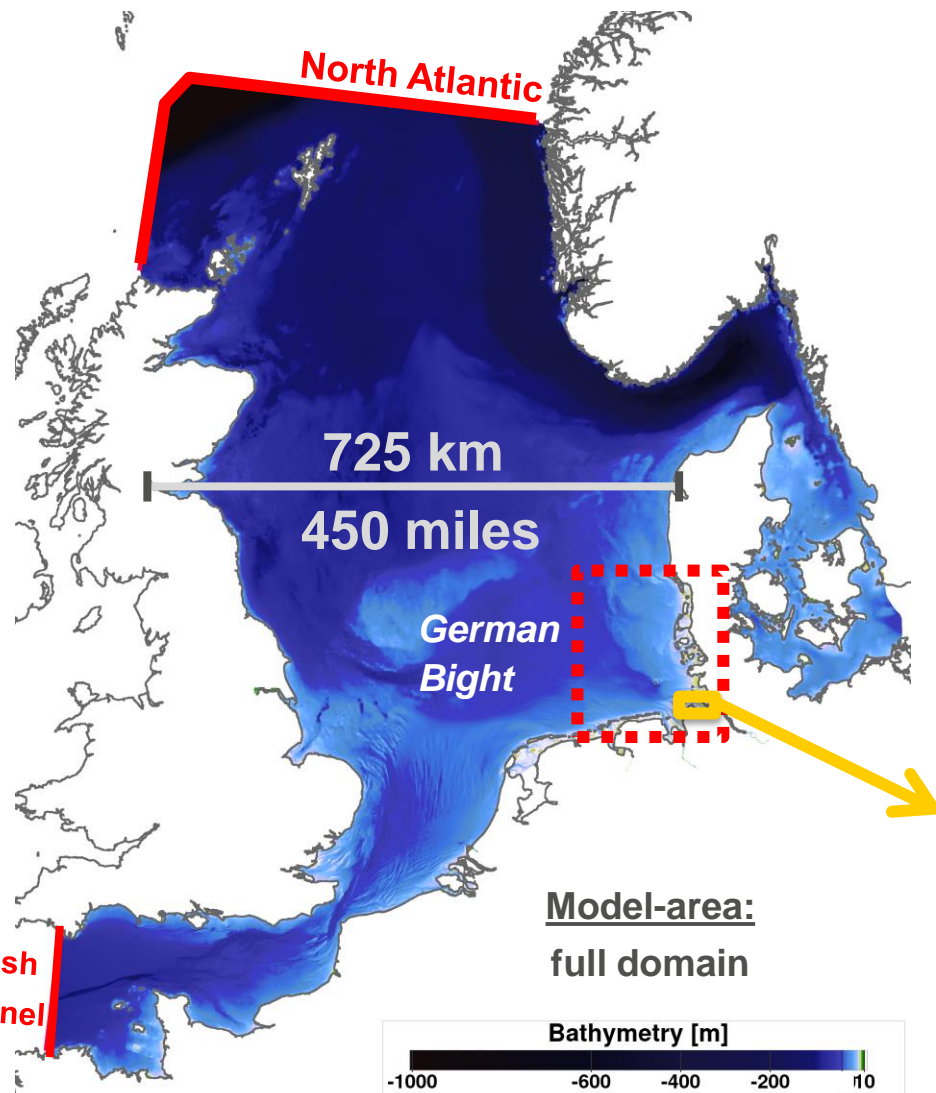
Objective

- Research with coarse, large-area coastal models implies, that changes in bathymetry result in large scale differences in tidal dynamics (e.g. Jacob et. al., 2015)
- These changes have neither been confirmed with long simulation periods, high-resolution approaches nor have they excluded meteorological influence. Also, calibrated estuaries and high-resolution wetting and drying have been neglected

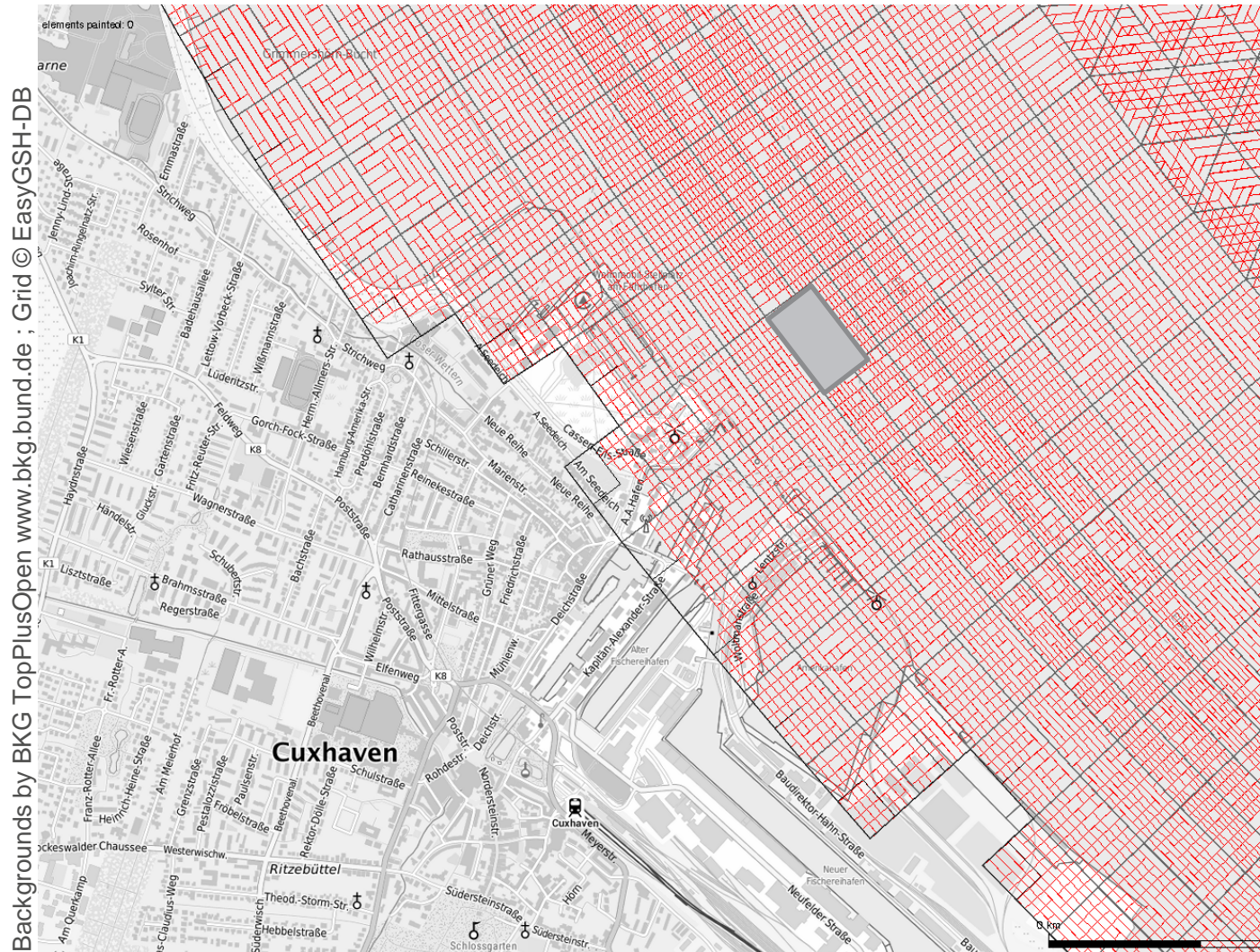


Model Setup

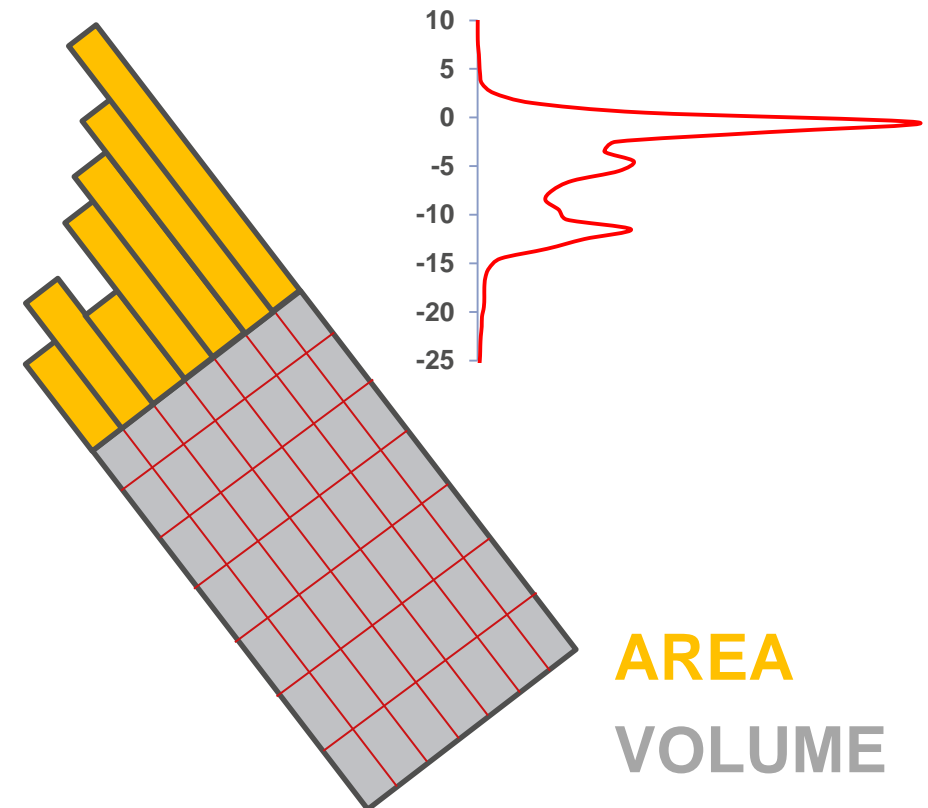
- **Grid resolution** in focus area (German Bight: 30m to 2,000m)
- 3D approach with **focus area**
- **Estuaries included** until tidal weir
- Increased accuracy with **subgrid technology**
- **Goal: 20 year hindcast** (1996-2015) available for download



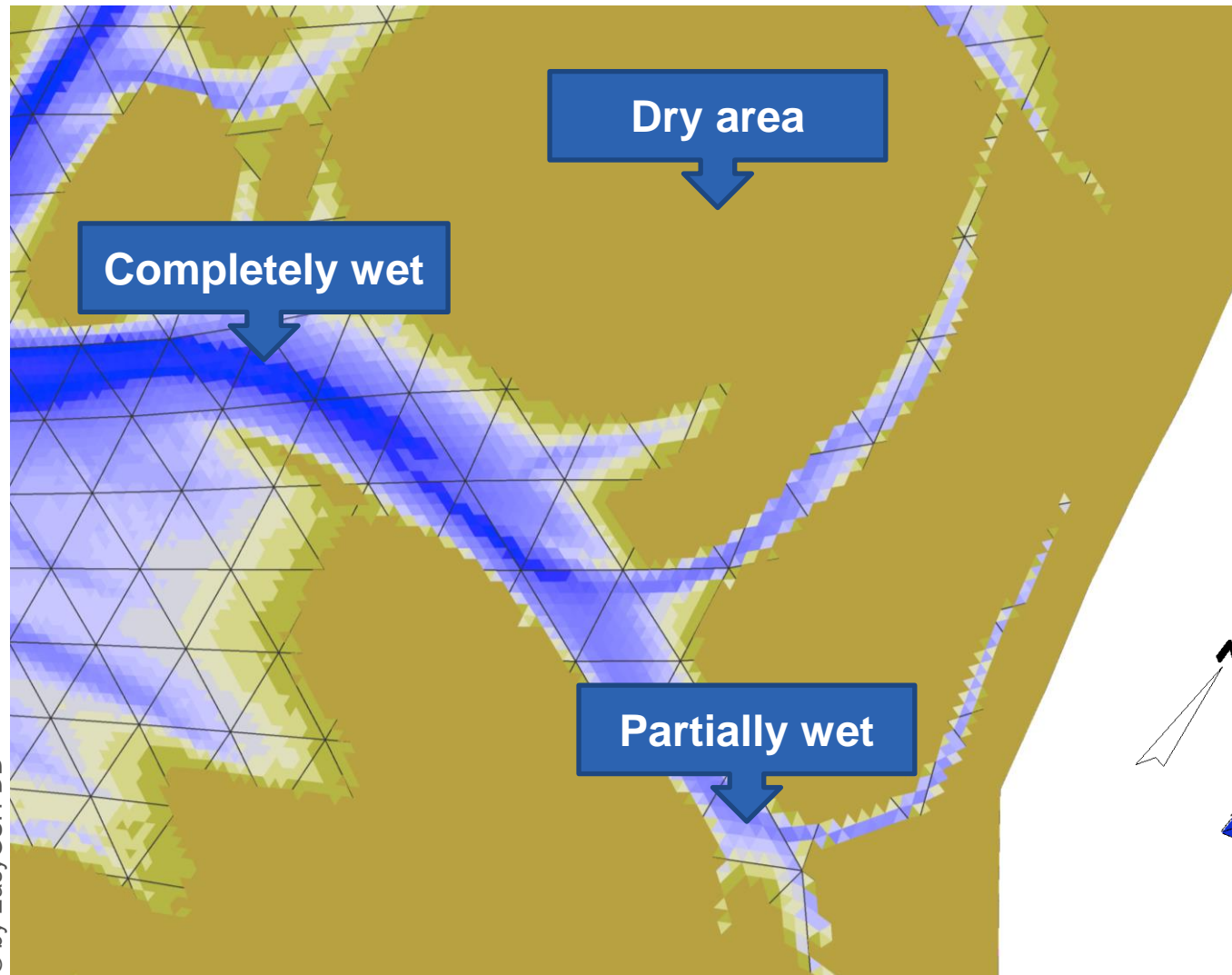
The principle behind subgrid models



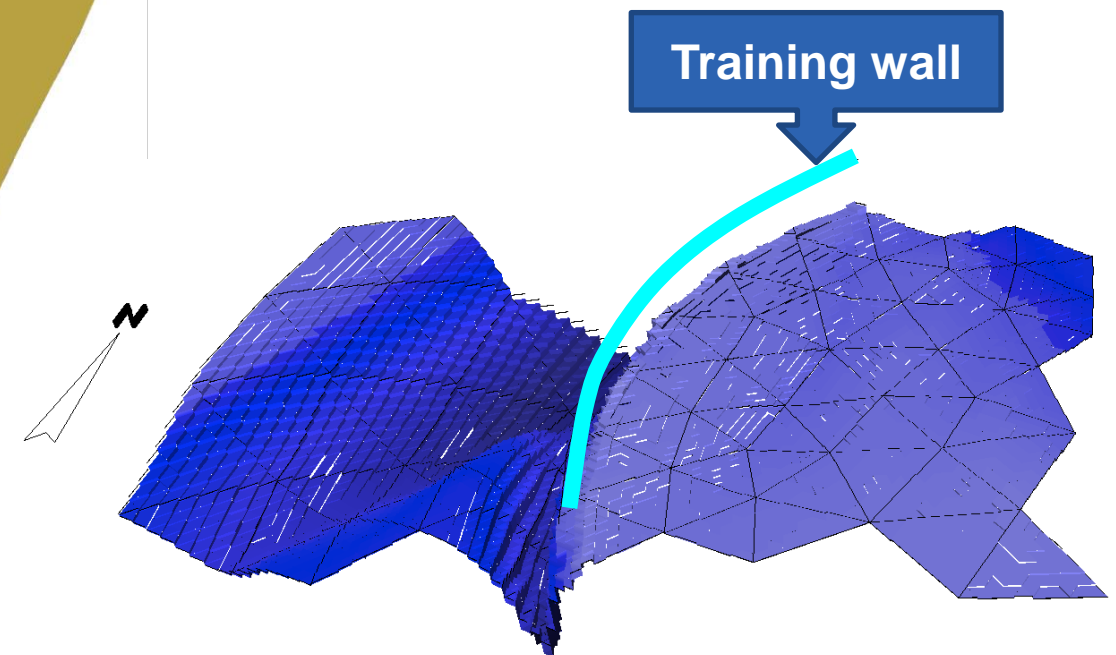
- A **cell** is divided m times
- Subedges receive depths
- The cell has a **depth distribution**



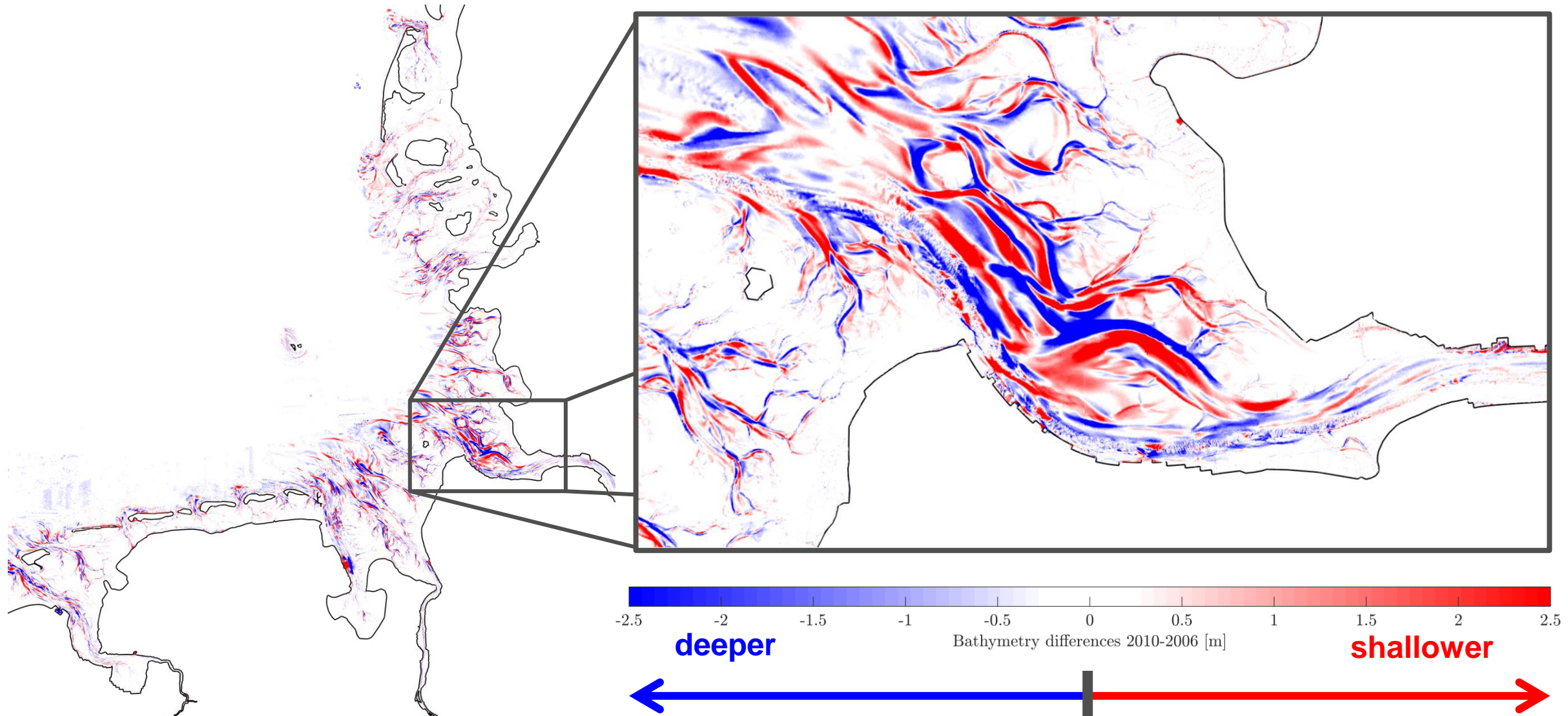
Advanced wetting and drying with subgrid



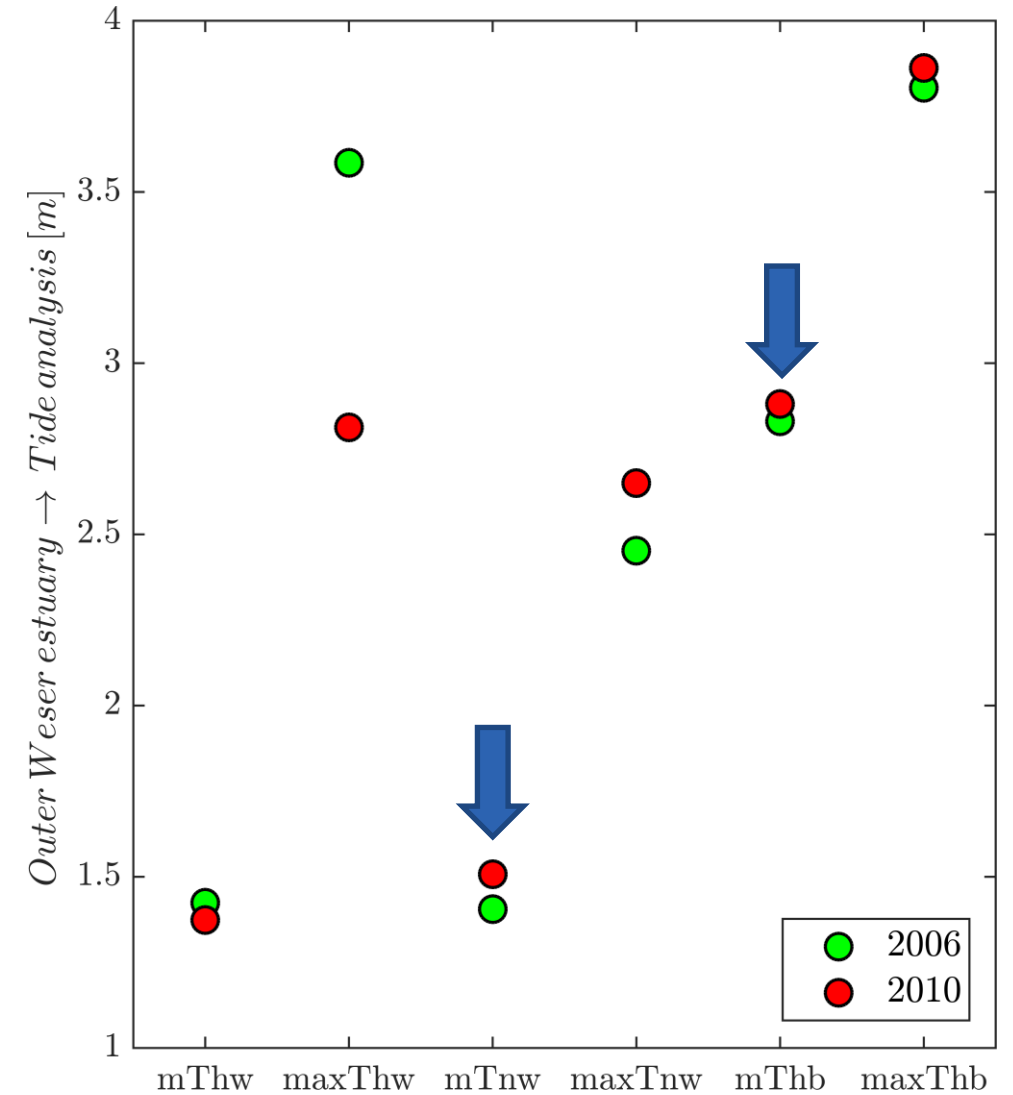
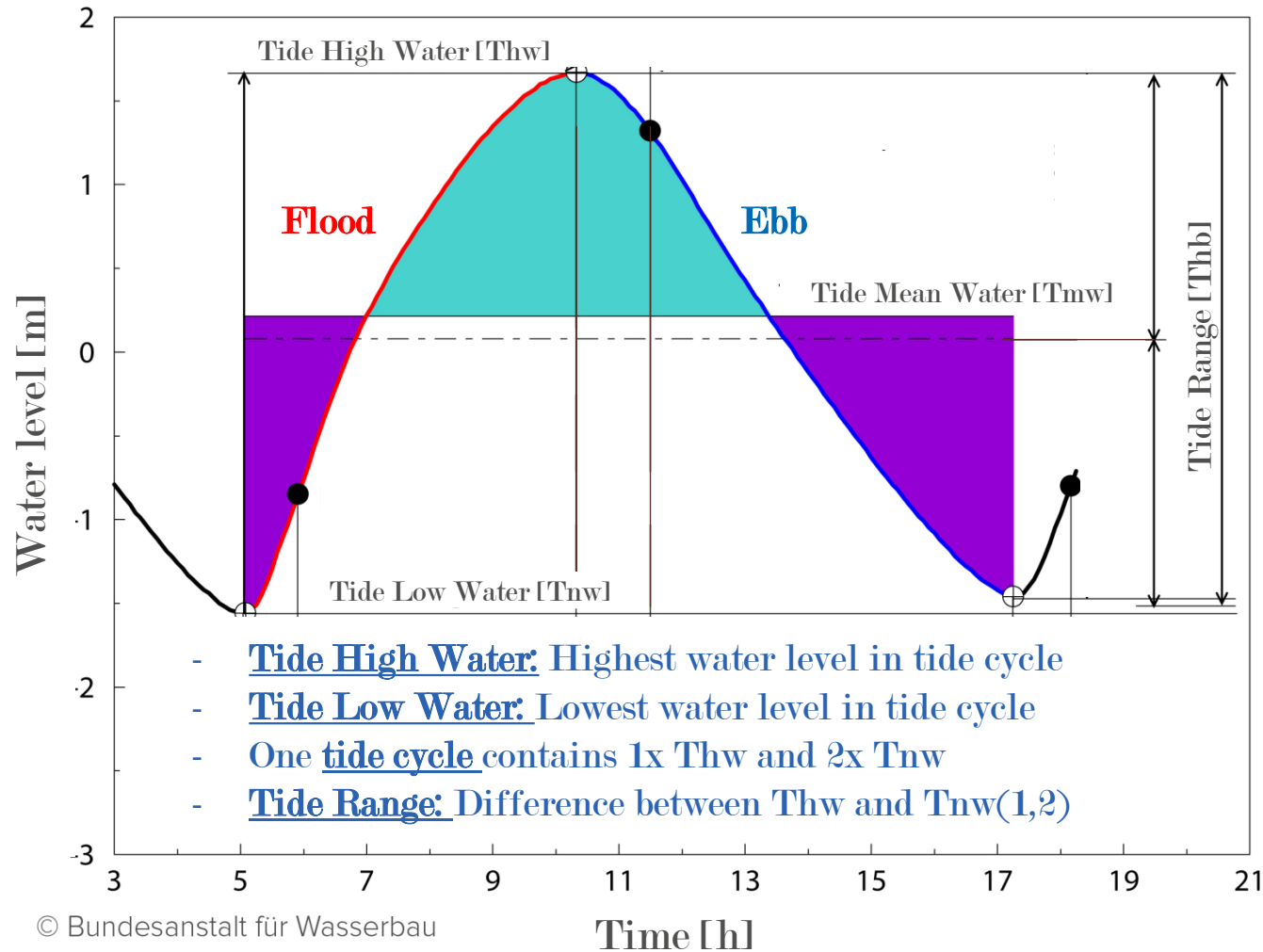
- Cells can be **partially wet**
- Exact representation of **water volume**
- Better representation of **tidal flats**
- Integration of **groins and training walls**
- These are hydraulically efficient



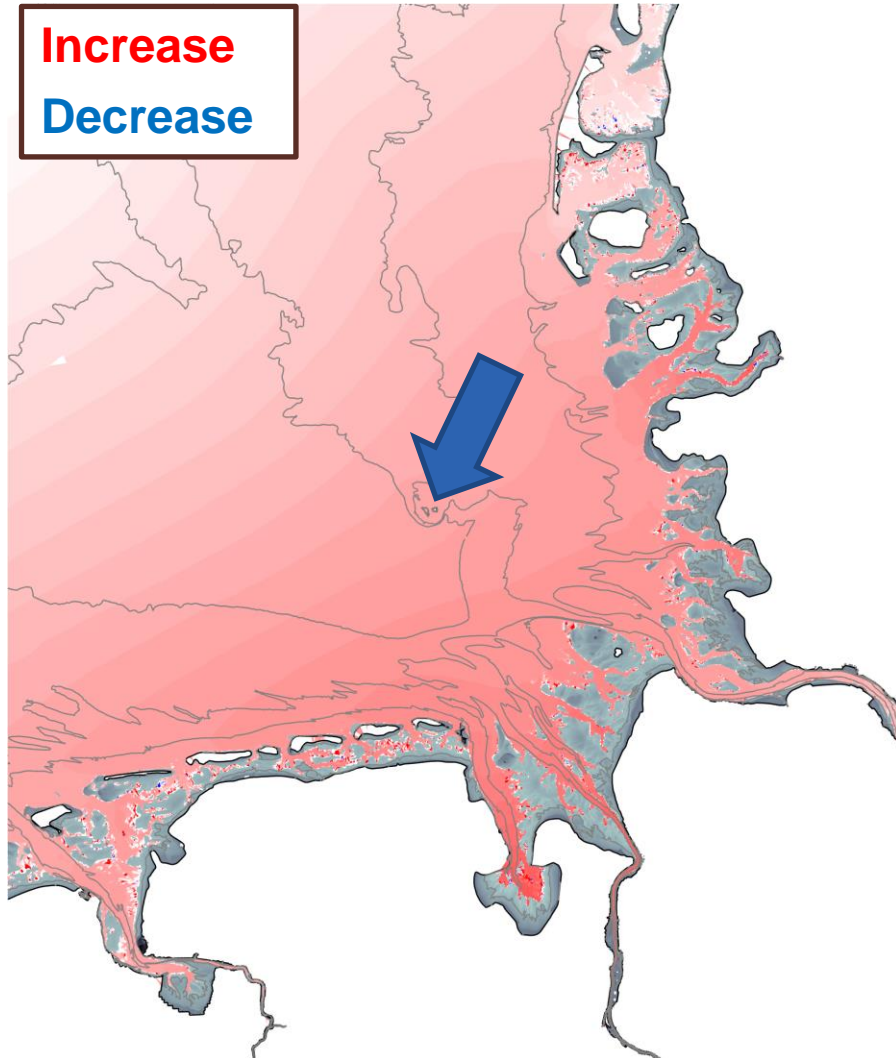
Bathymetry changes in the mouth of the Elbe estuary: 2010 - 2006



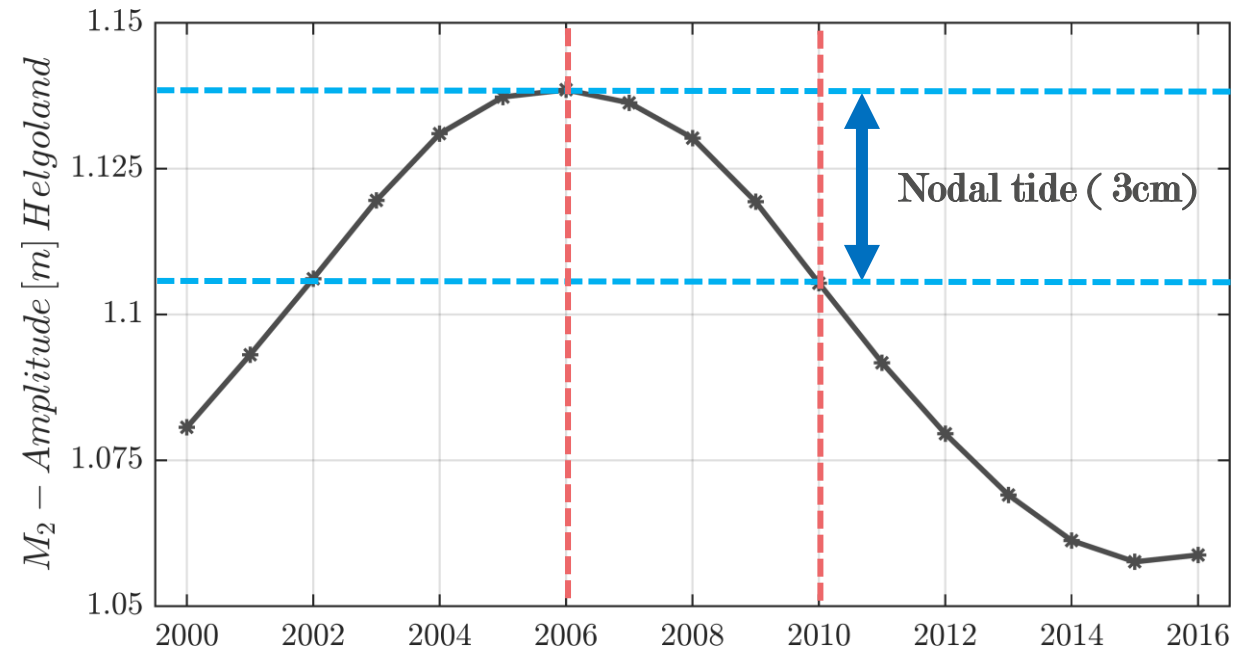
Comparing the forcing of 2006 and 2010



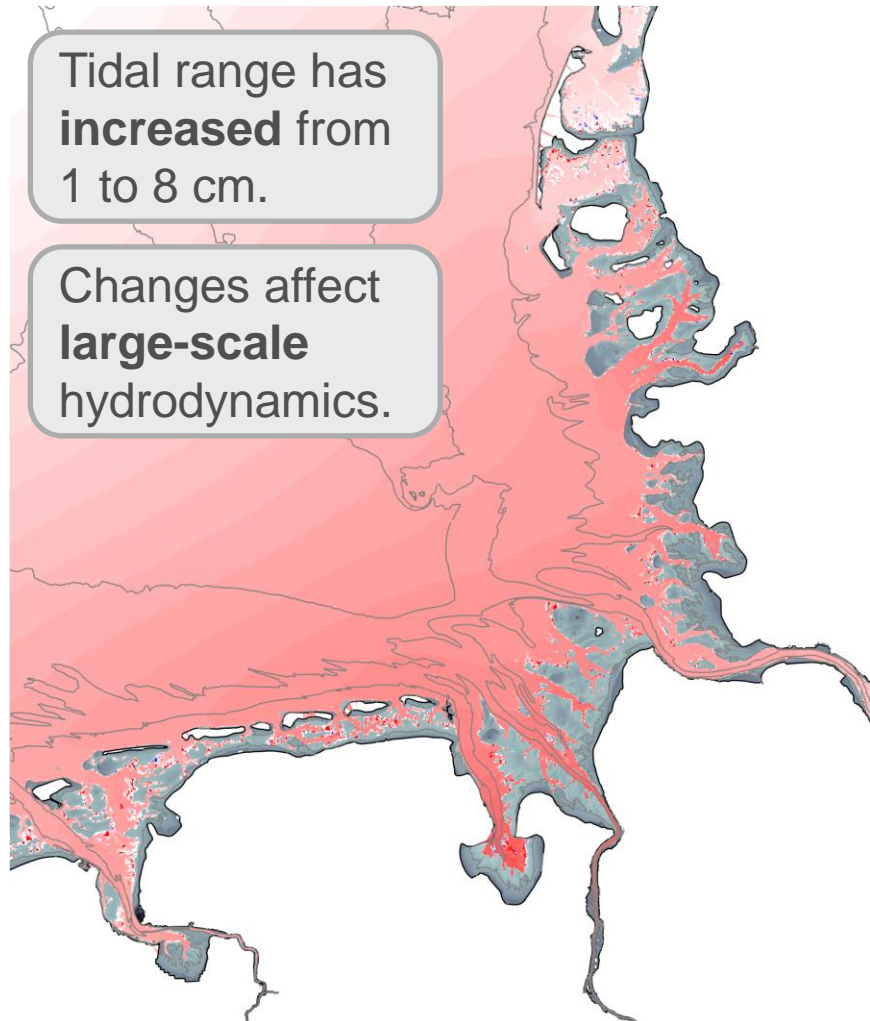
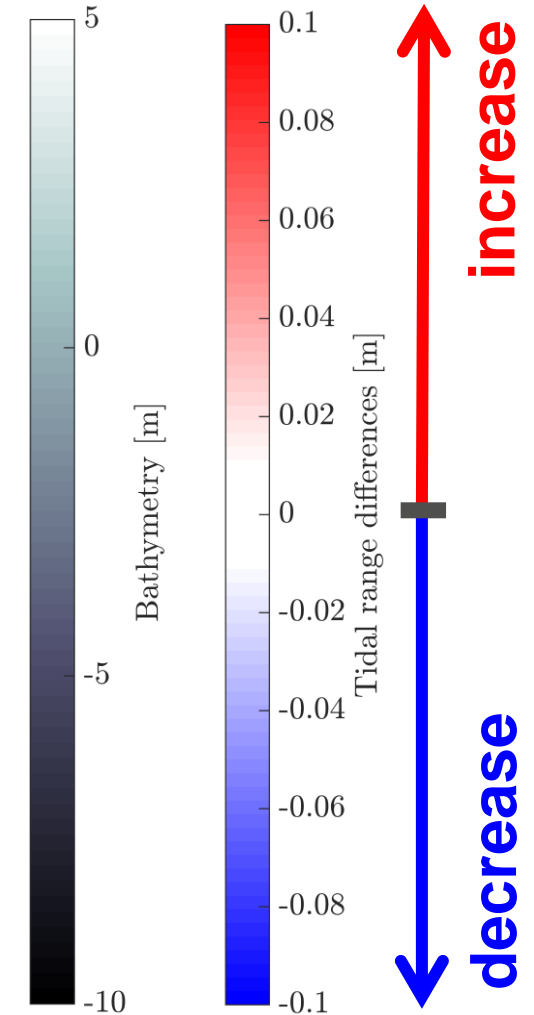
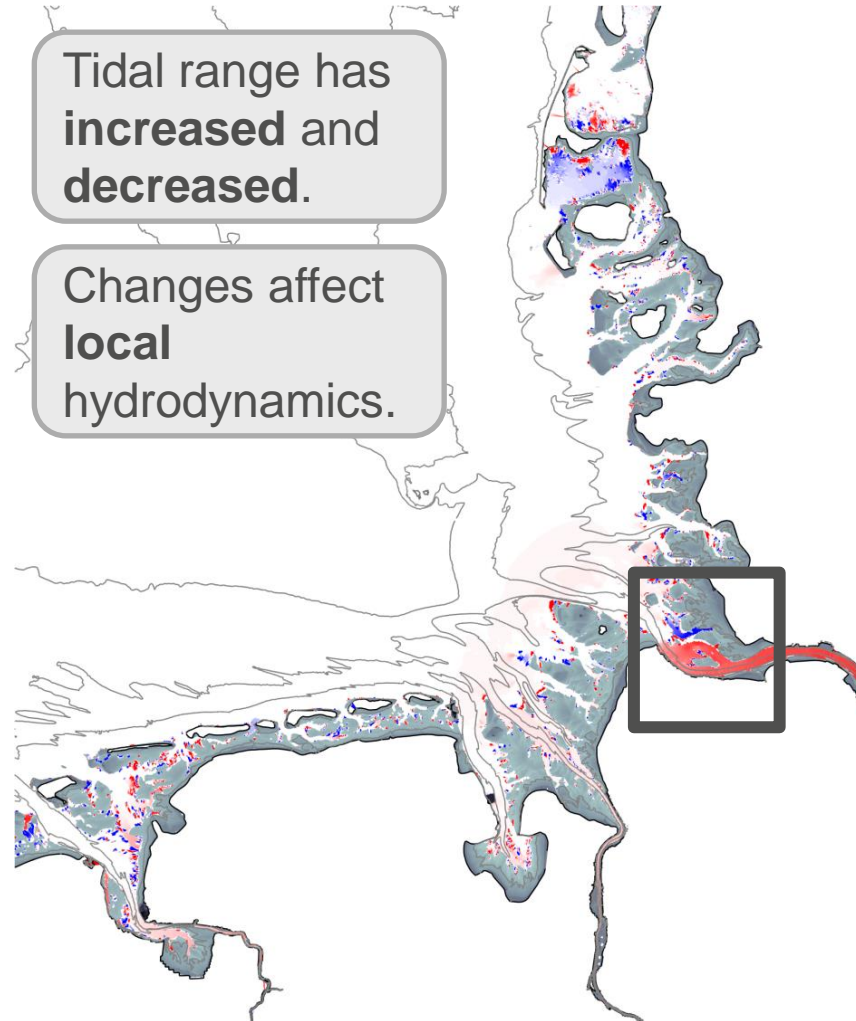
Influence of nodal tide



- Large area variations in deep water result from nodal tide.
- Nodal Tide varies around 3cm between 2010 and 2006
- Meteorology suggests 2006 to be windier, therefore the tidal range is larger in 2010 even though astronomy decreases tidal component amplitudes at the same time.



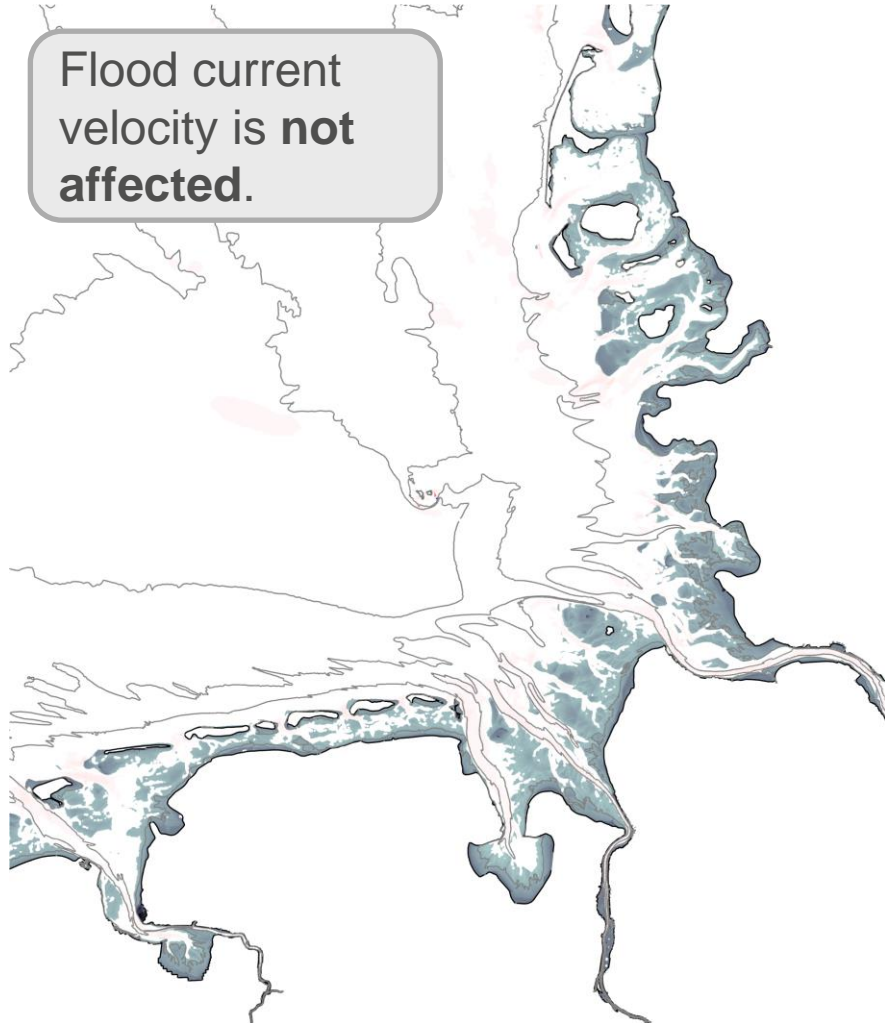
Differences (Tidal range), scenario - reference

 Δ forcing-induced differences Δ bathymetry-induced differences

Differences (Flood current velocity magnitude), scenario - reference

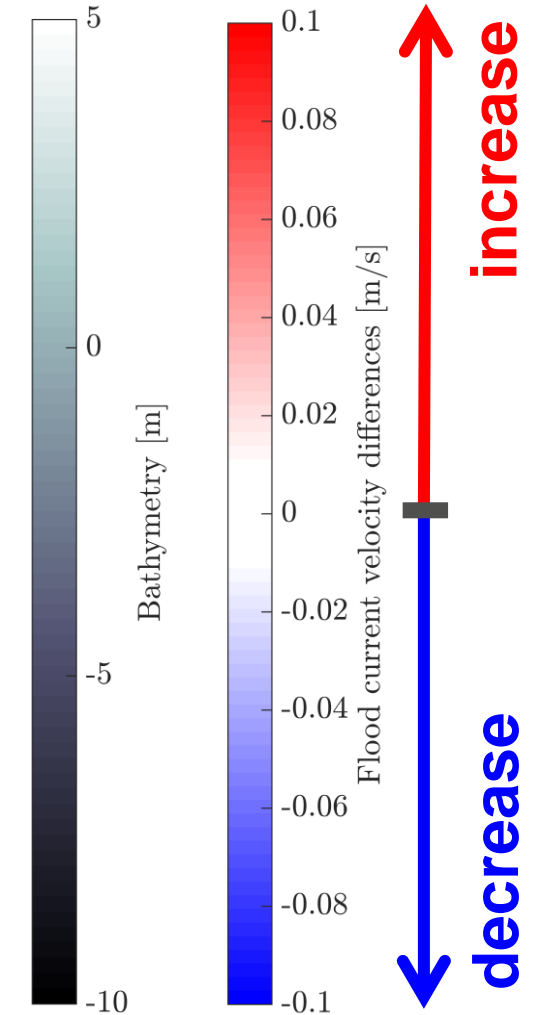
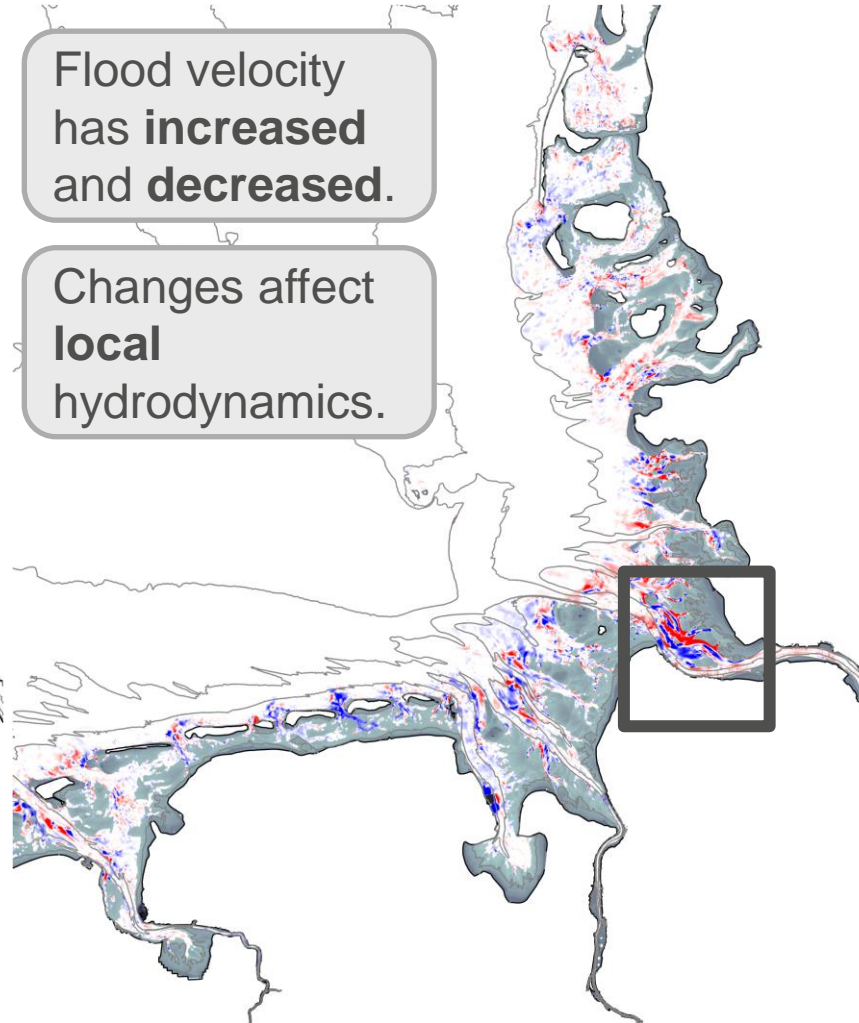
 Δ forcing-induced differences

Flood current velocity is **not affected**.

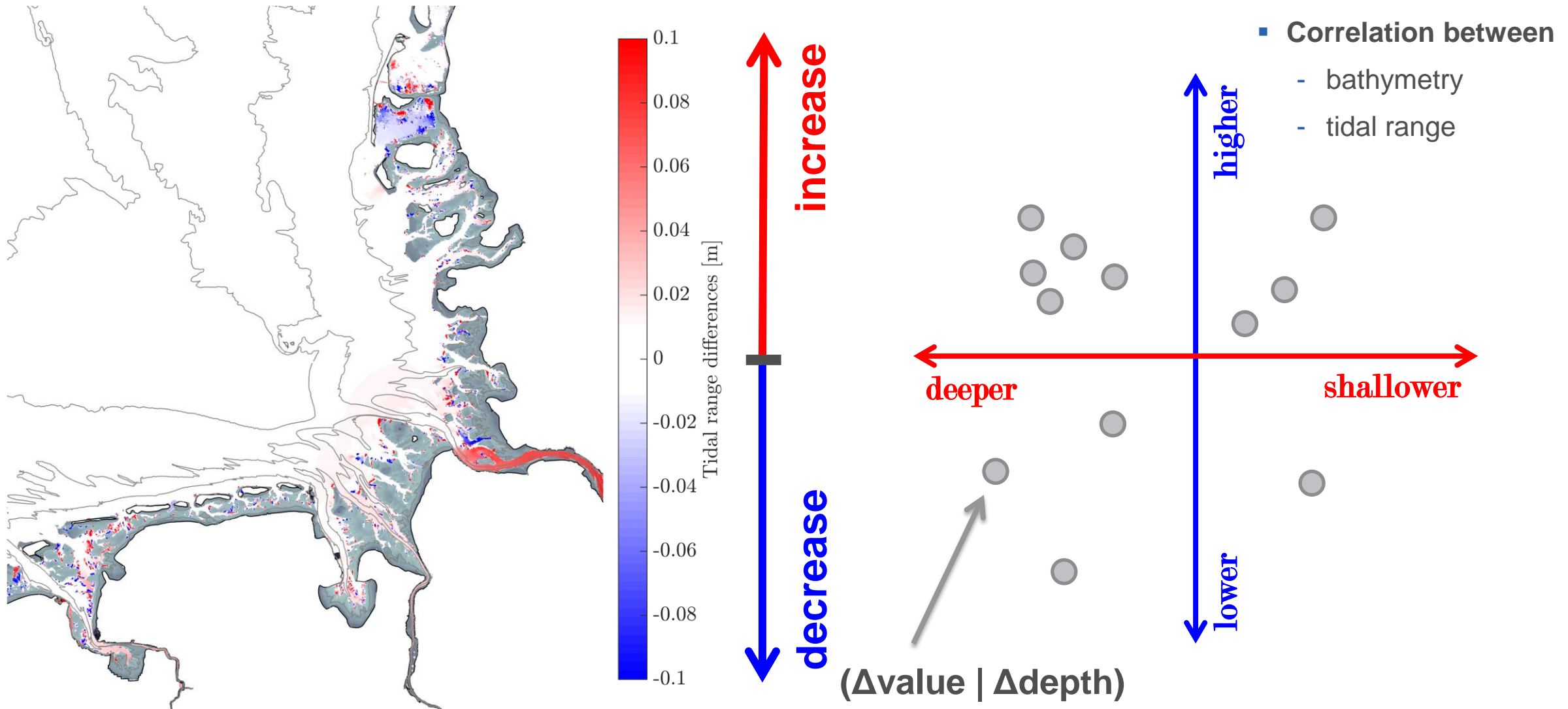
 Δ bathymetry-induced differences

Flood velocity has **increased** and **decreased**.

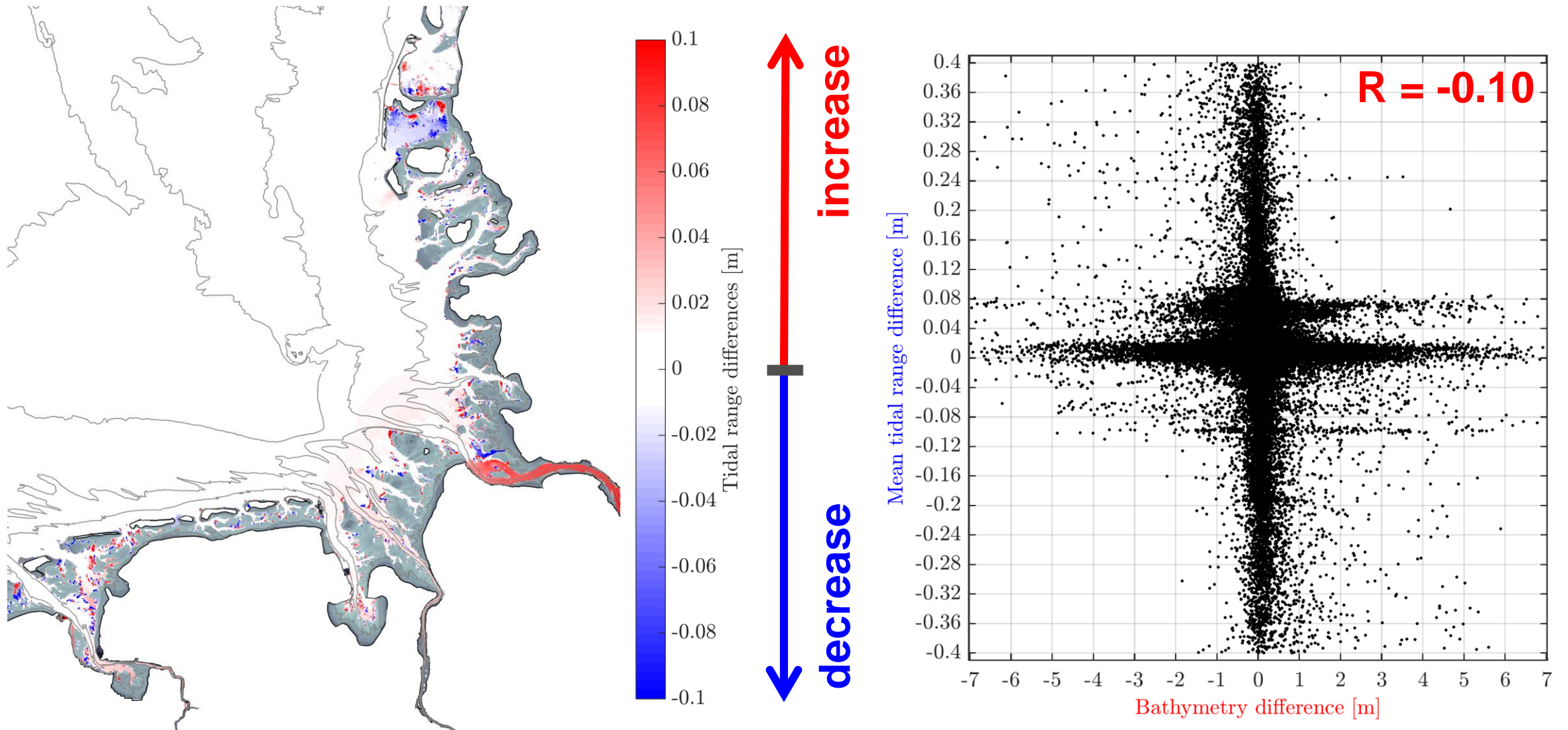
Changes affect **local hydrodynamics**.



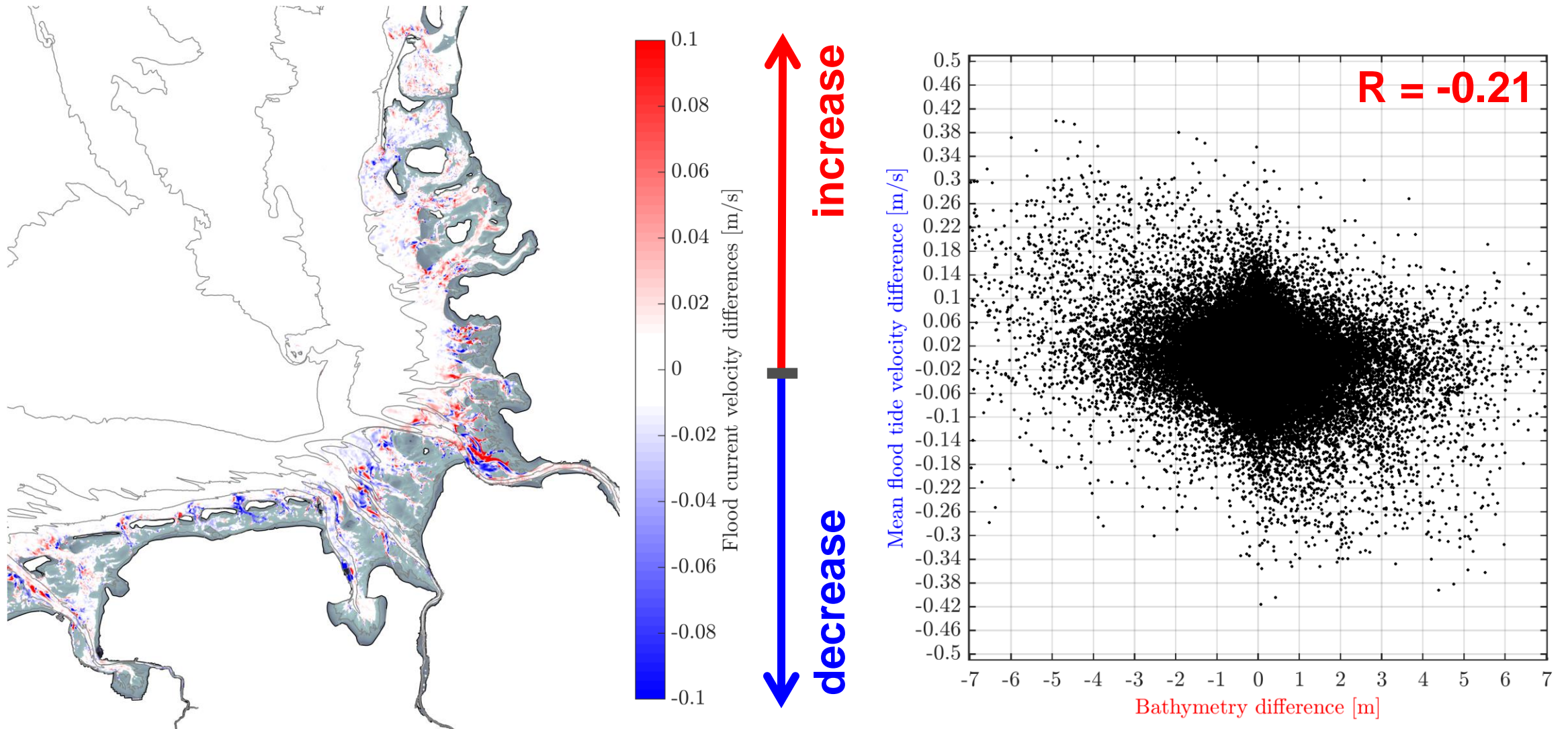
Correlating bathymetry differences with hydrodynamics



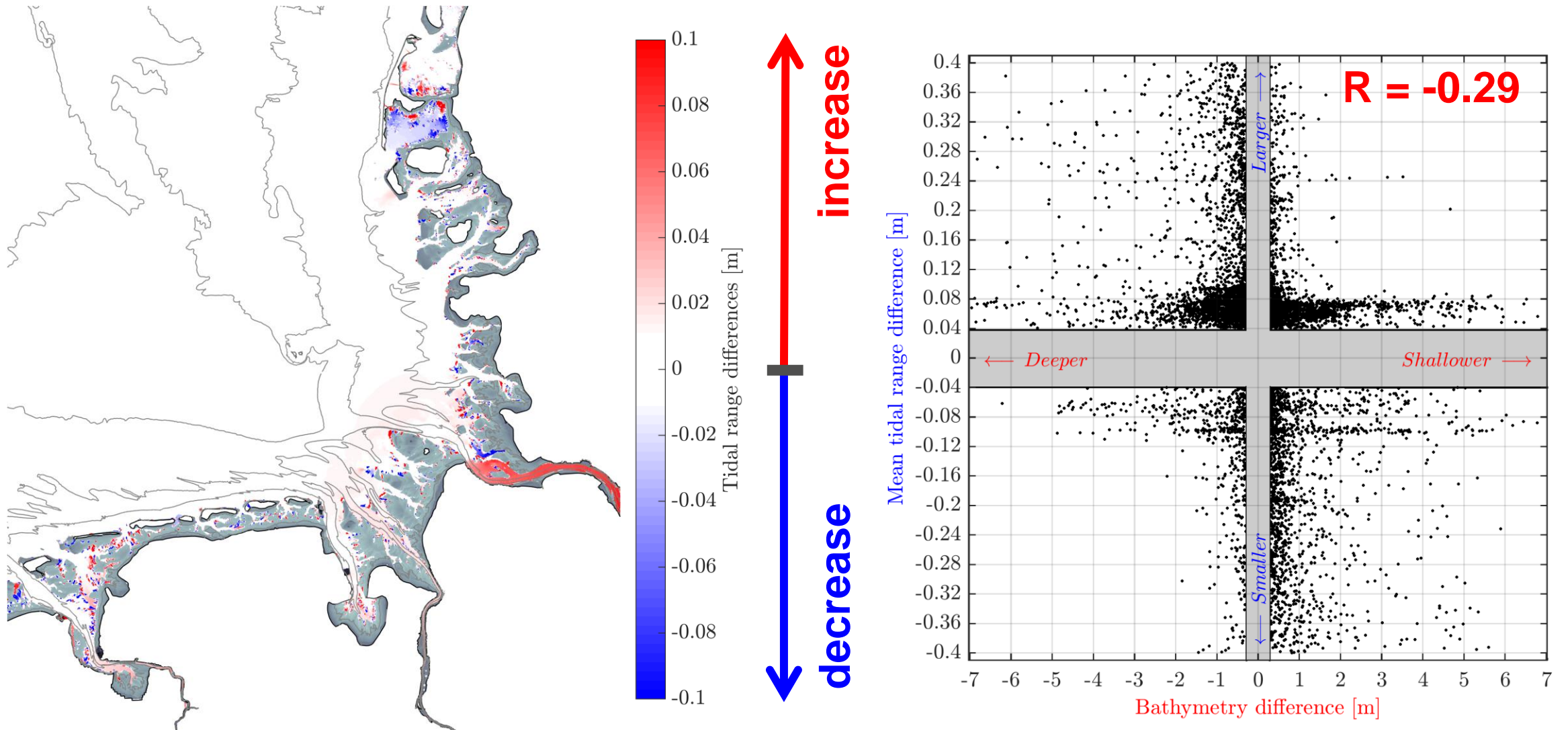
Correlating bathymetry differences with hydrodynamics



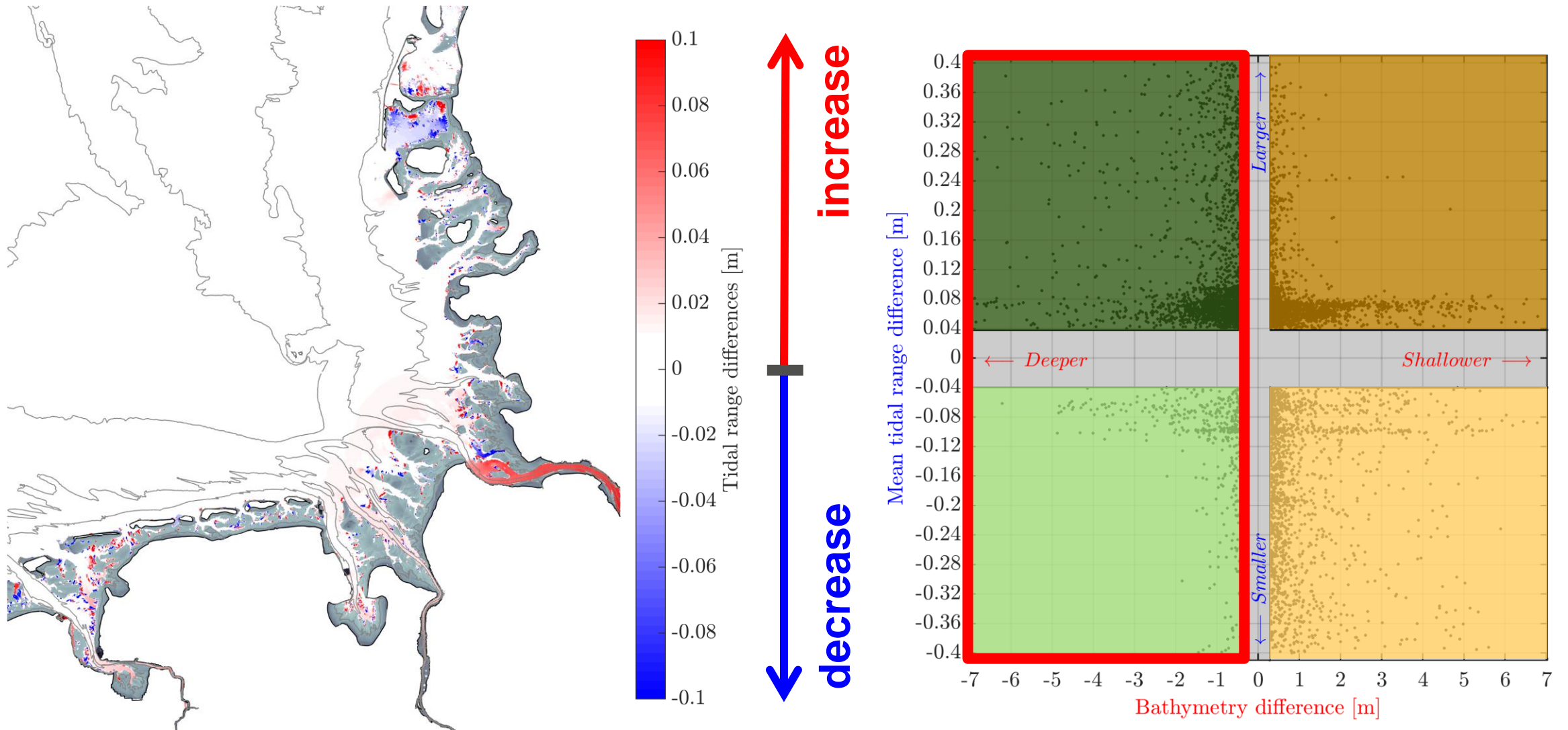
Correlating bathymetry differences with hydrodynamics



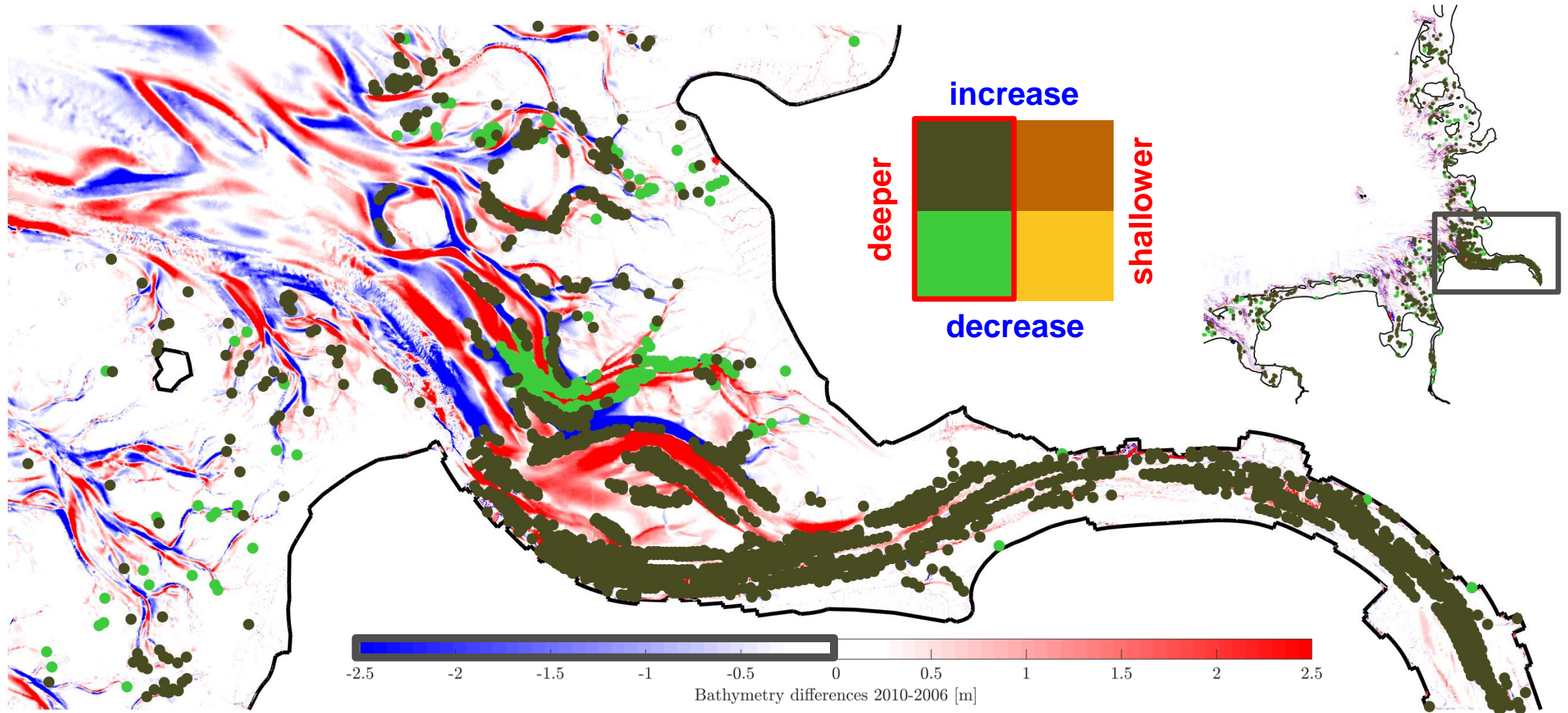
Correlating bathymetry differences with hydrodynamics



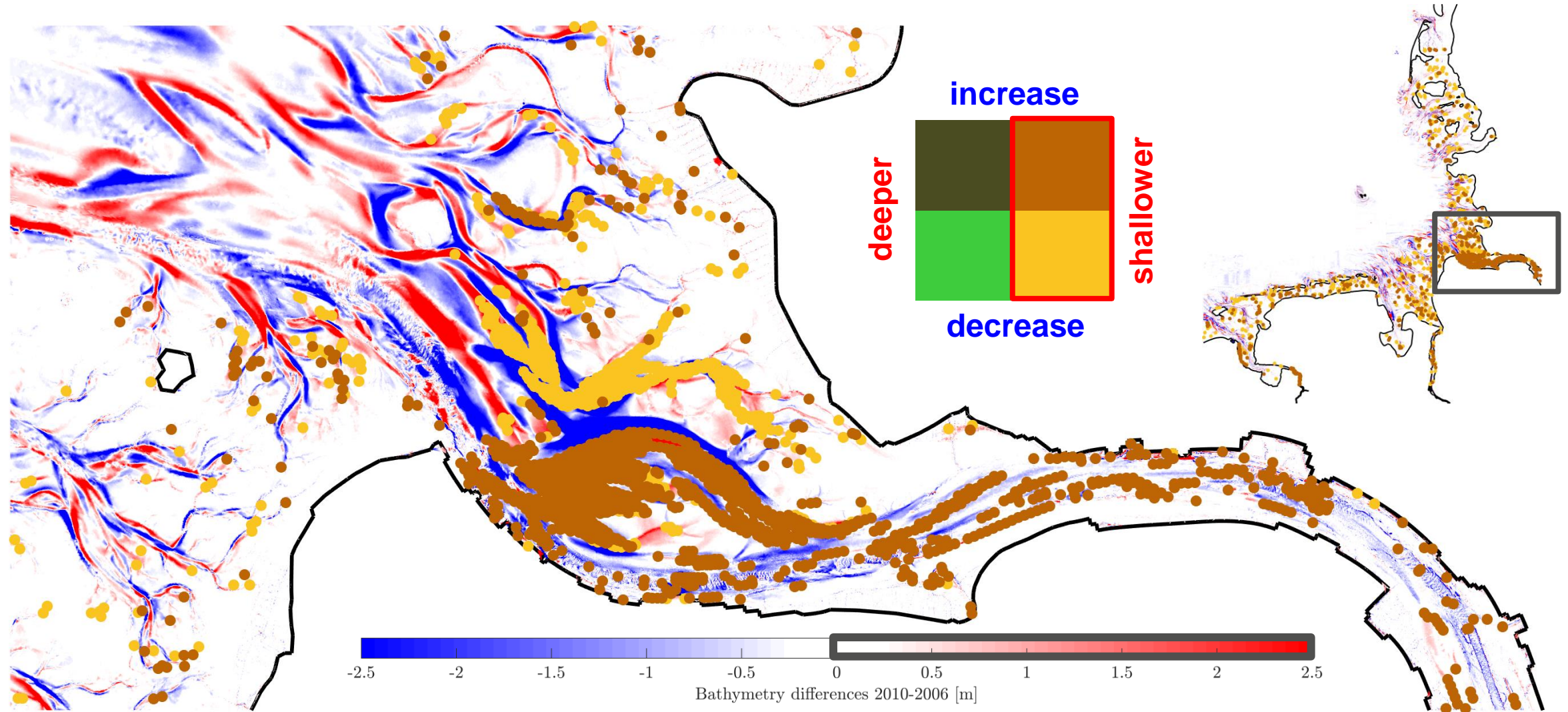
Color-coding differences of bathymetry and hydrodynamics



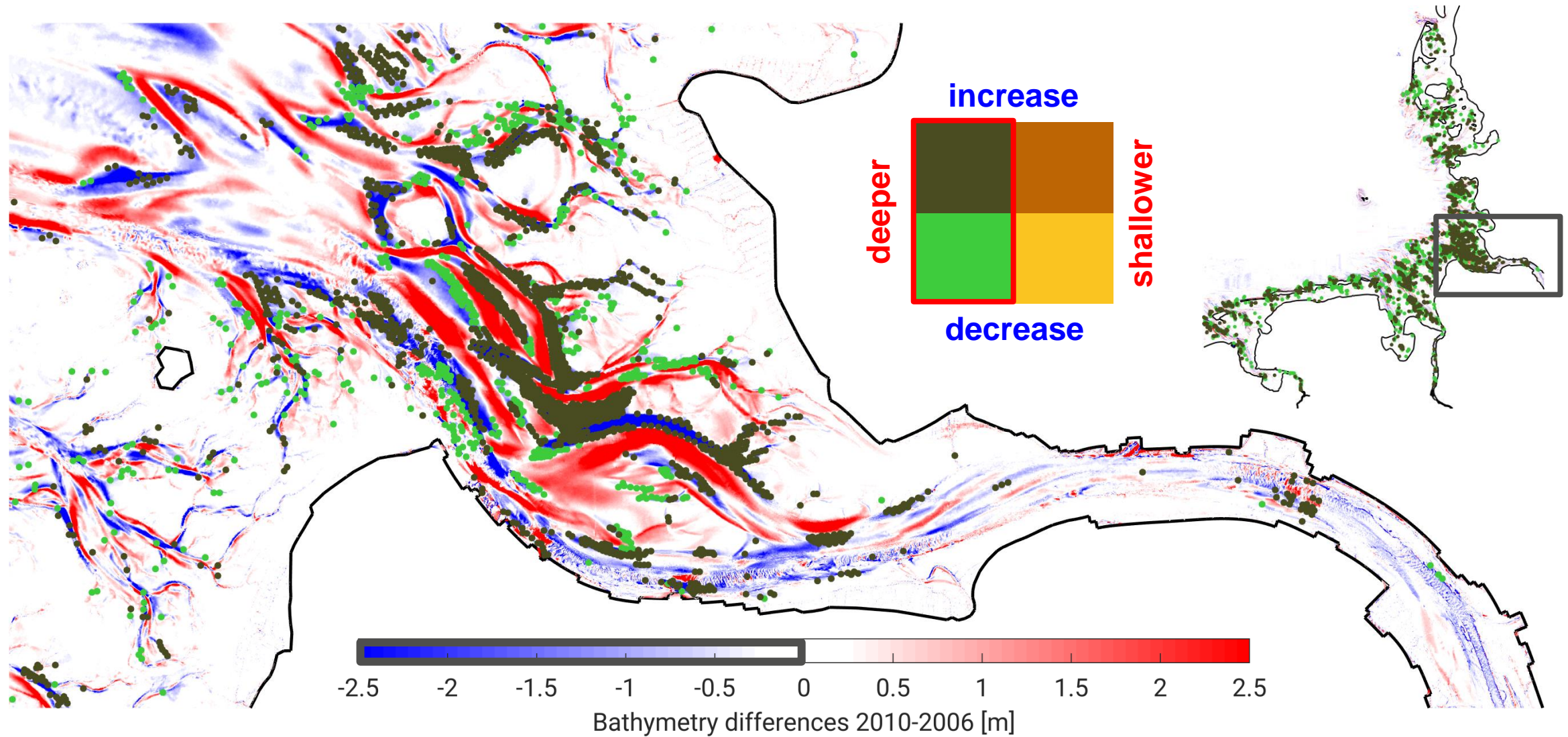
Changes of tidal range due to deepening of bathymetry in the Elbe estuary



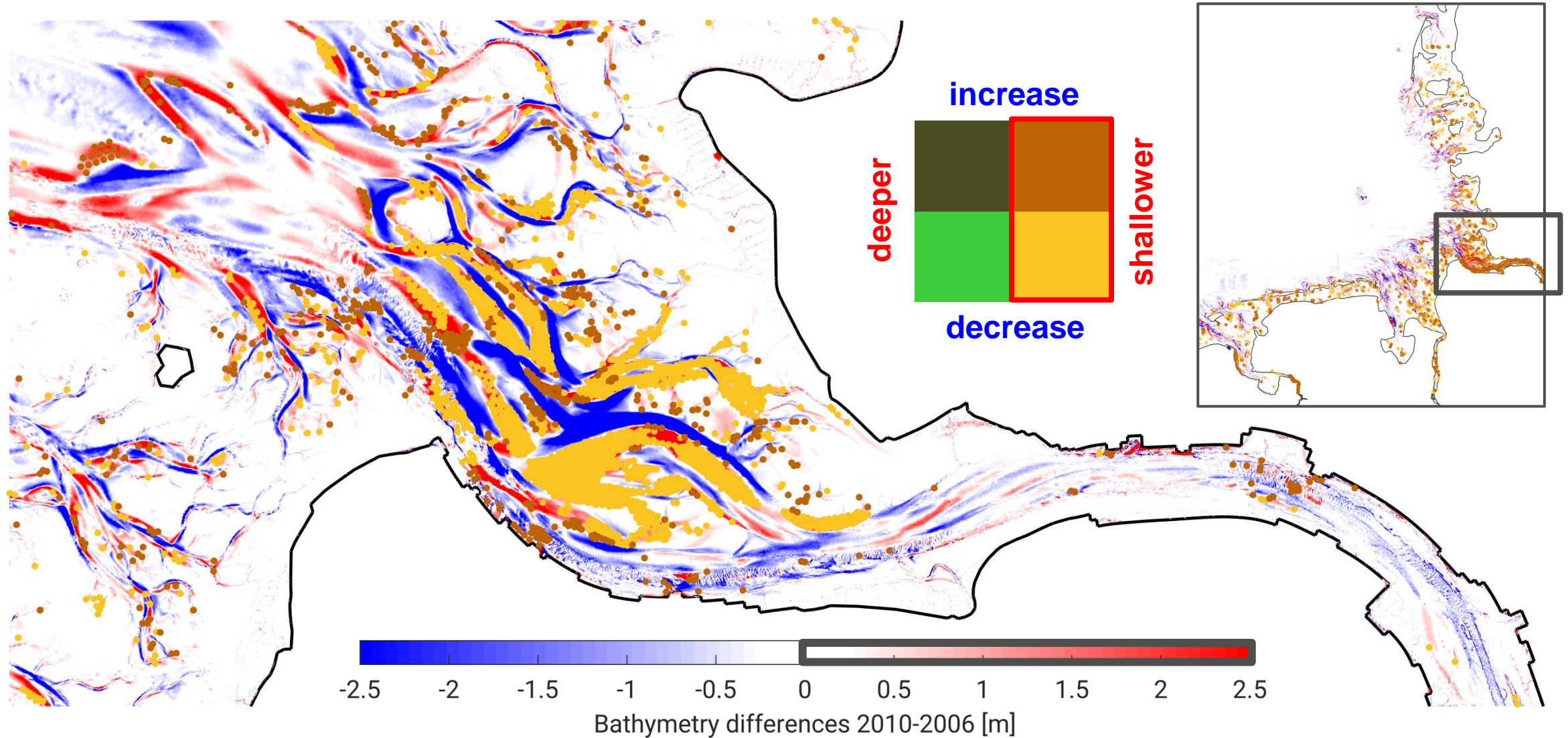
Mean tidal range due to shallower bathymetry in the Elbe estuary



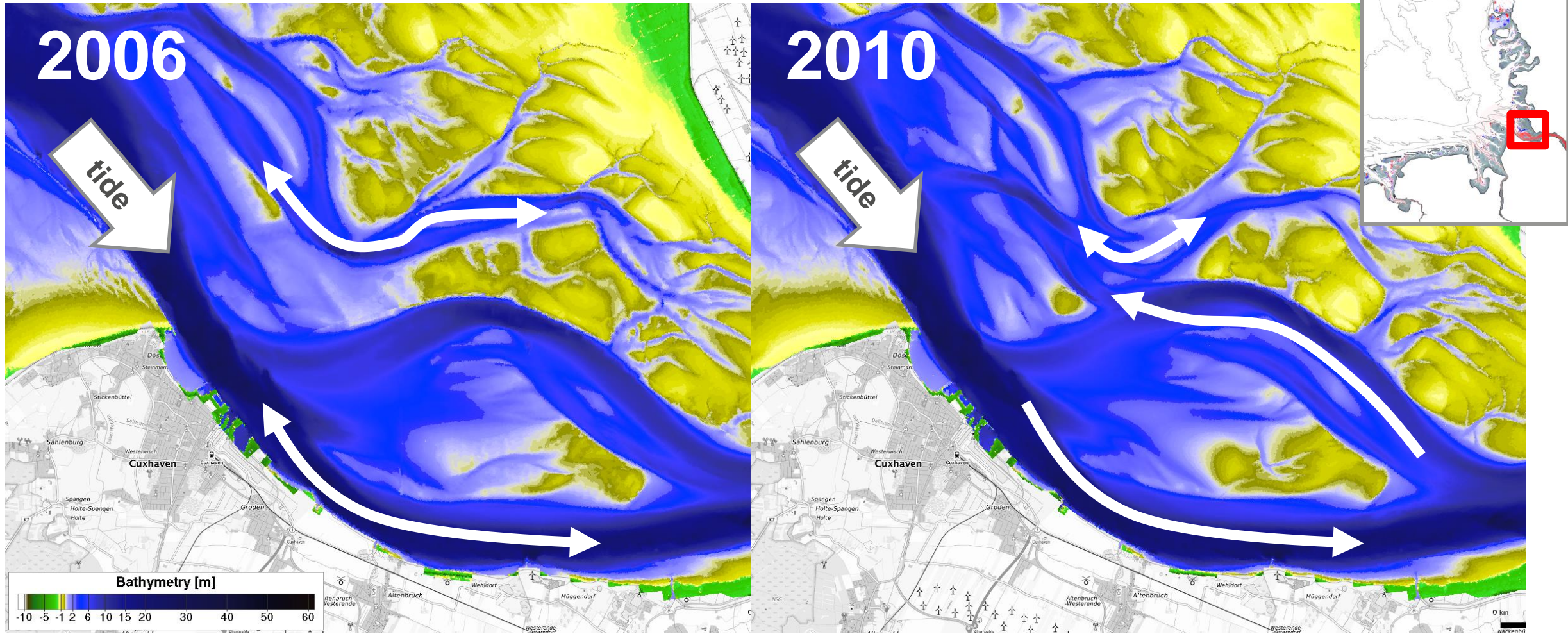
Mean tide velocity due to deepening of bathymetry in the Elbe estuary



Mean tidal velocity due to shallower bathymetry in the Elbe estuary



Bathymetry in the mouth of the Elbe estuary: 2006 and 2010



Background © by BKG TopPlusOpen www.bkg.bund.de

Summary and Outlook

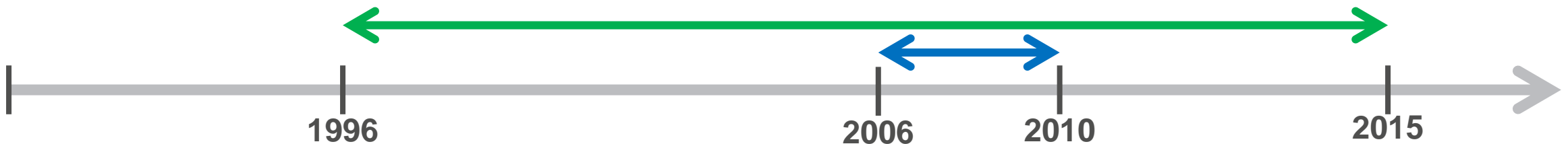
- A North-Sea model with high-resolution in shallow water has been built to reproduce hydrodynamics from 1996 to 2015
- A well calibrated reference run (2006) has been varied with the forcing (scenario 1) and bathymetry (scenario 2) of 2010

Results:

- The **forcing** produced **large-scale differences** in tidal dynamics (by **meteorology**)
- Small-scale **bathymetry variation** produces **local changes** in hydrodynamics
- Direct **correlation** of local hydrodynamics with bathymetry variation is rather **weak**

Outlook and future tasks

- Extend the temporal space to analyze larger bathymetry differences, because large-scale implications were **not found**



References

Web references

- **EasyGSH-DB:** <http://mdi-de.baw.de/easygsh/> ; (bathymetry, sediment and hydrodynamic data available for download)
- **WMS:** TopWebPlus (grey); www.bkg.de ; (available for everyone)
- **WMS:** Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net; (available for everyone)

Other references

- JACOB, B.; STANEV, E. V. and ZHANG, Y. J.: Local and remote response of the North Sea dynamics to morphodynamic changes in the Wadden Sea. In: Ocean Dynamics, Vol. 66, 5, 671-690, doi: 10.1007/s10236-016-0949-8, 2016.