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Assessment of strategies for an adaptive sediment management in the Elbe estuary

IMMERSE, 2nd Transnational Estuary Exchange (TEEL)

Online, 24th of November 2020

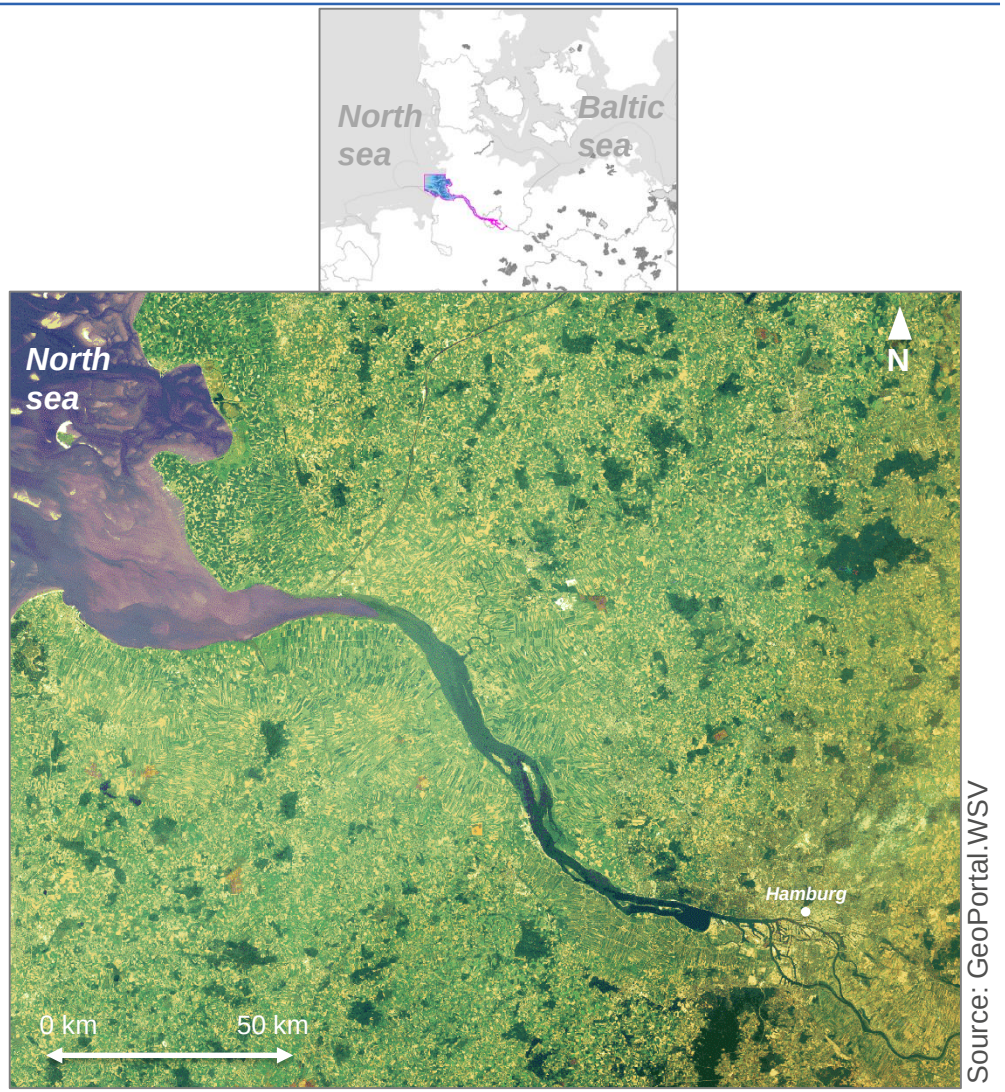
Elbe Estuary

largest estuary in Germany

- Most **important shipping route** for international maritime traffic in Germany
- **Intensively used** by industry, agriculture, power stations, fishery, recreation and tourism
- Shore areas of the estuary **densely populated**
- Areas prone **to storm surge**
- **Valuable habitats** protected by European environmental laws

The challenge

Sustainably and cost-effectively managing while preserving or improving the functions of the estuarine system

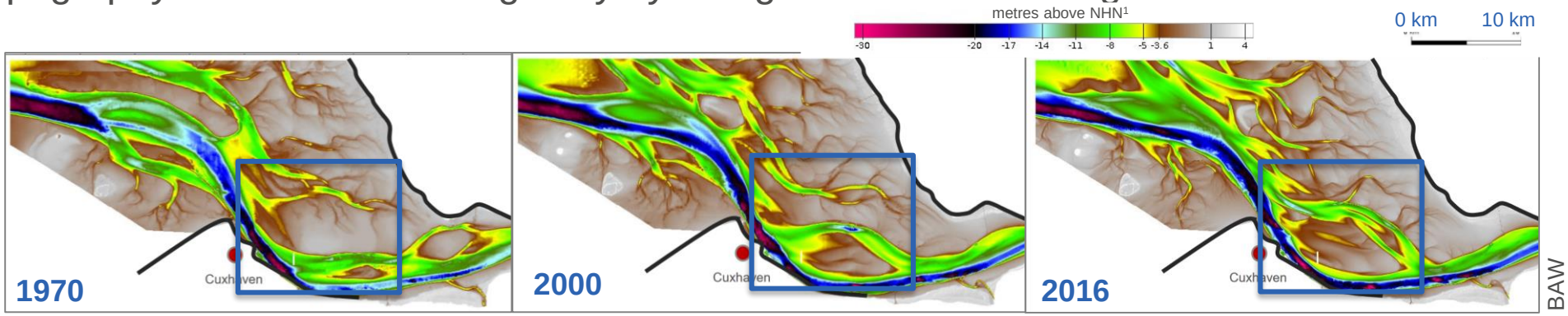


Source: GeoPortal.WSV

Factors influencing the estuary dynamics

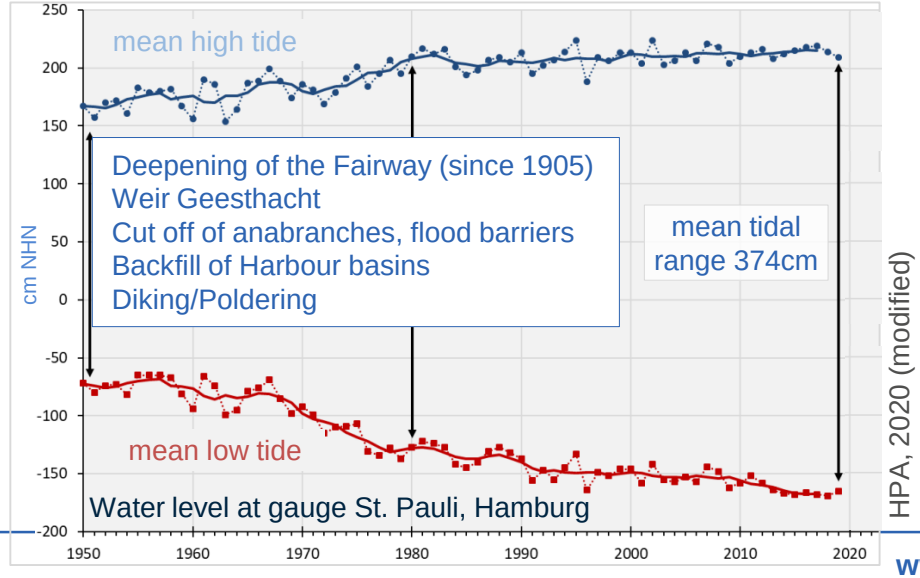
Large-scale morphodynamics at the outer Elbe

- The topography at the mouth changes by hydrological and meteorological events



Anthropogenic interventions

- Waterways adaption and maintenance for shipping
- Storm surge protection



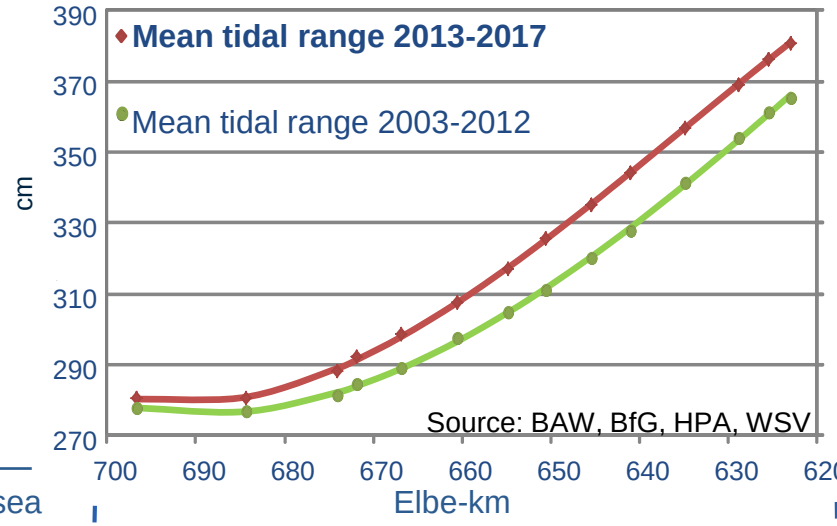
[1]NHN "standard elevation zero", vertical datum used in Germany

Tidal amplification

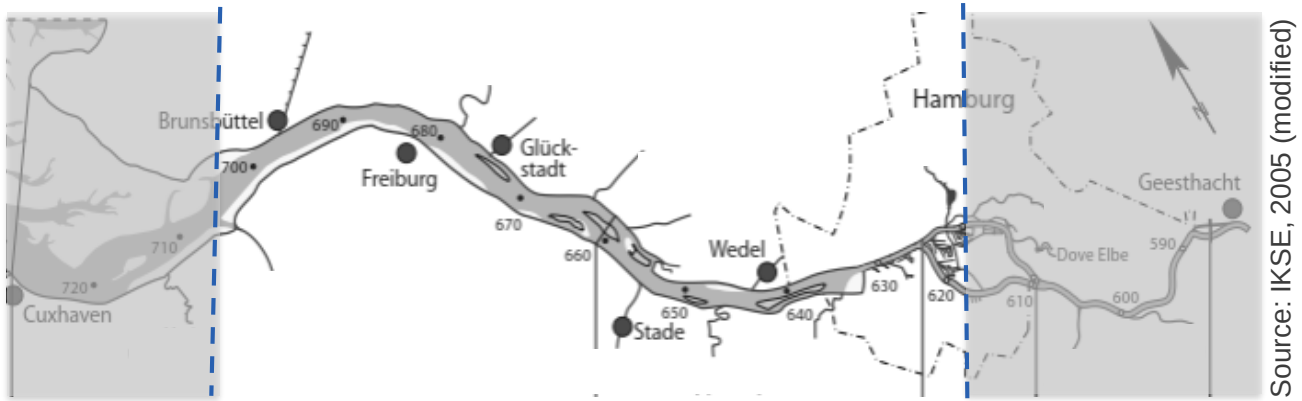
Tidal range increases towards the upper estuary

Tidal range

Energy dissipation



+ 20 cm from 2011 to 2017
at Elbe-km 624 (St. Pauli)



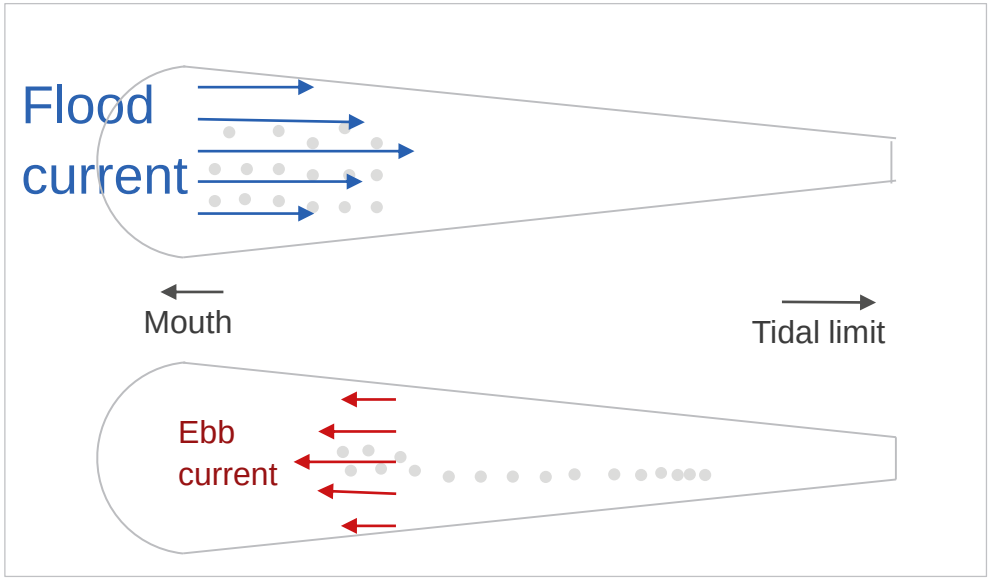
Source: IKSE, 2005 (modified)

Unbalanced system

Challenging sedimentmanagement

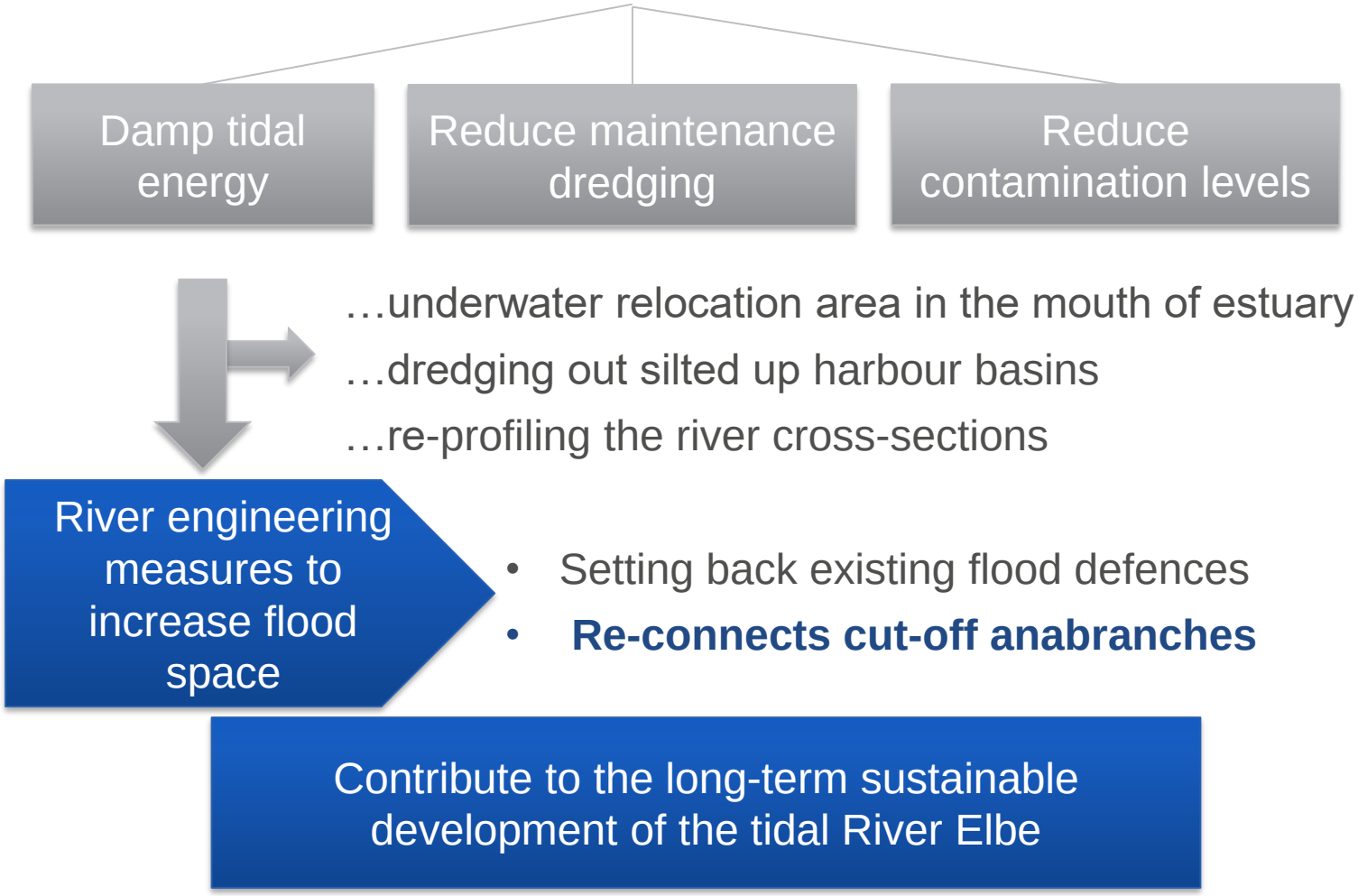
- Insufficient energy dissipation, **tidal amplification**
- Enhanced tide asymmetry : ebb currents are slower than flood currents and poorly transport back suspended load out of the estuary
  -> **tidal pumping**
- Marine sediments mix with **contaminated loads** from up estuary
- Due to climate change: **long periods of low freshwater discharge**, coastal squeeze…

Tidal pumping: upstream sediment transport



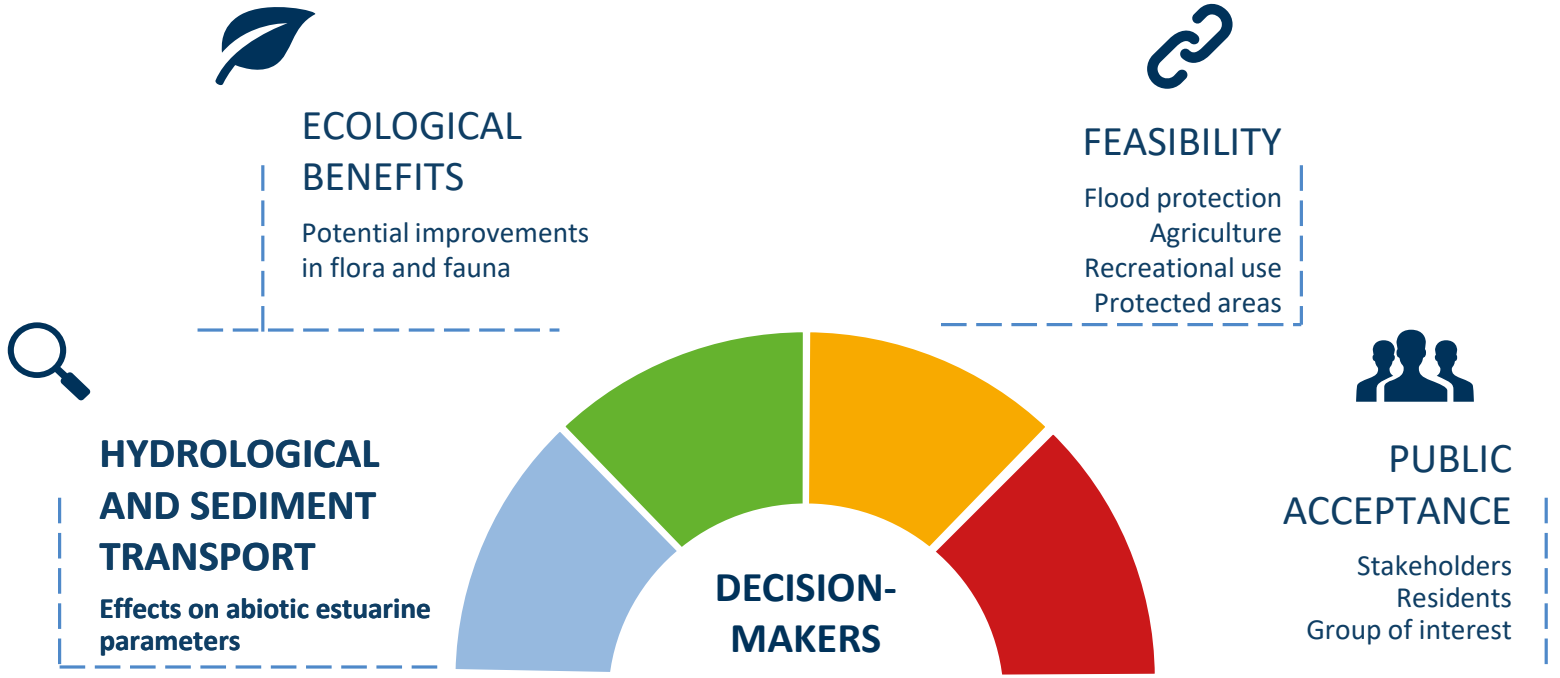
….adaptation of the sediment management strategy

Elbe River Engineering and Sediment Management Concept 2008



Which river engineering measure should be implemented?

- More than 20 river engineering measures depicted potential benefits on the hydrodynamics
- The estuary partnership Forum Tideelbe chose 3 potential river engineering measures for the Elbe aiming **creation of additional flood space in the estuary.** For those, feasibility studies started.



Impact forecast study

Reconnection of the cut-off anabranch Dove Elbe

- Measure aim

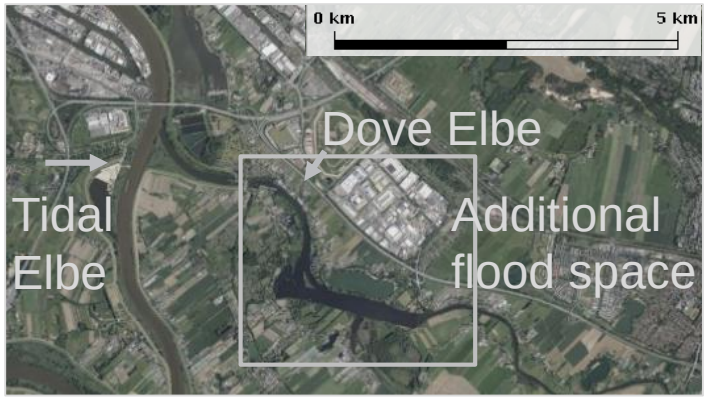
Improve the unbalanced morphological conditions in the estuary

- Mechanism

Enhance the tidal flood space (tidal prism) and **damp tidal energy in the estuary**

- Expect benefits

Reduce tidal range and **counteract tidal pumping**

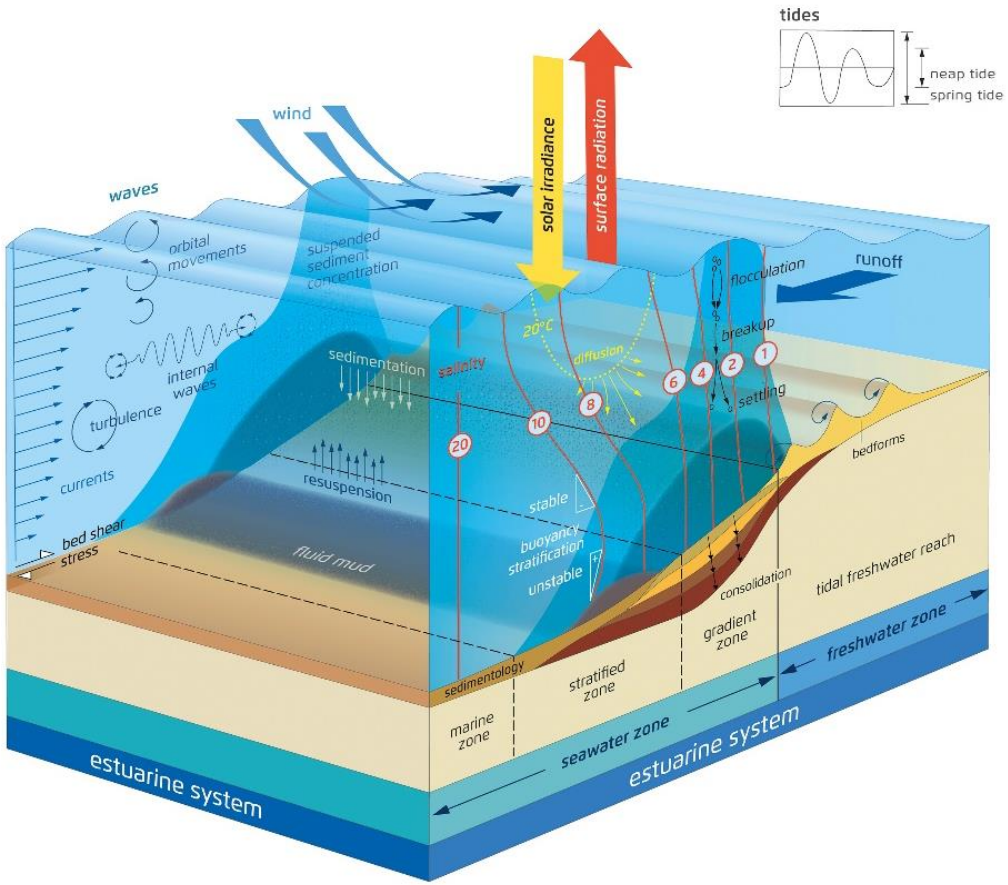


Assessing measure impact
-Modelling physical process in estuaries-

- Impact forecast study based on

  HN-Modell UnTRIM to solve numerically **3D**-differential equations relating to free-surface hydrodynamics

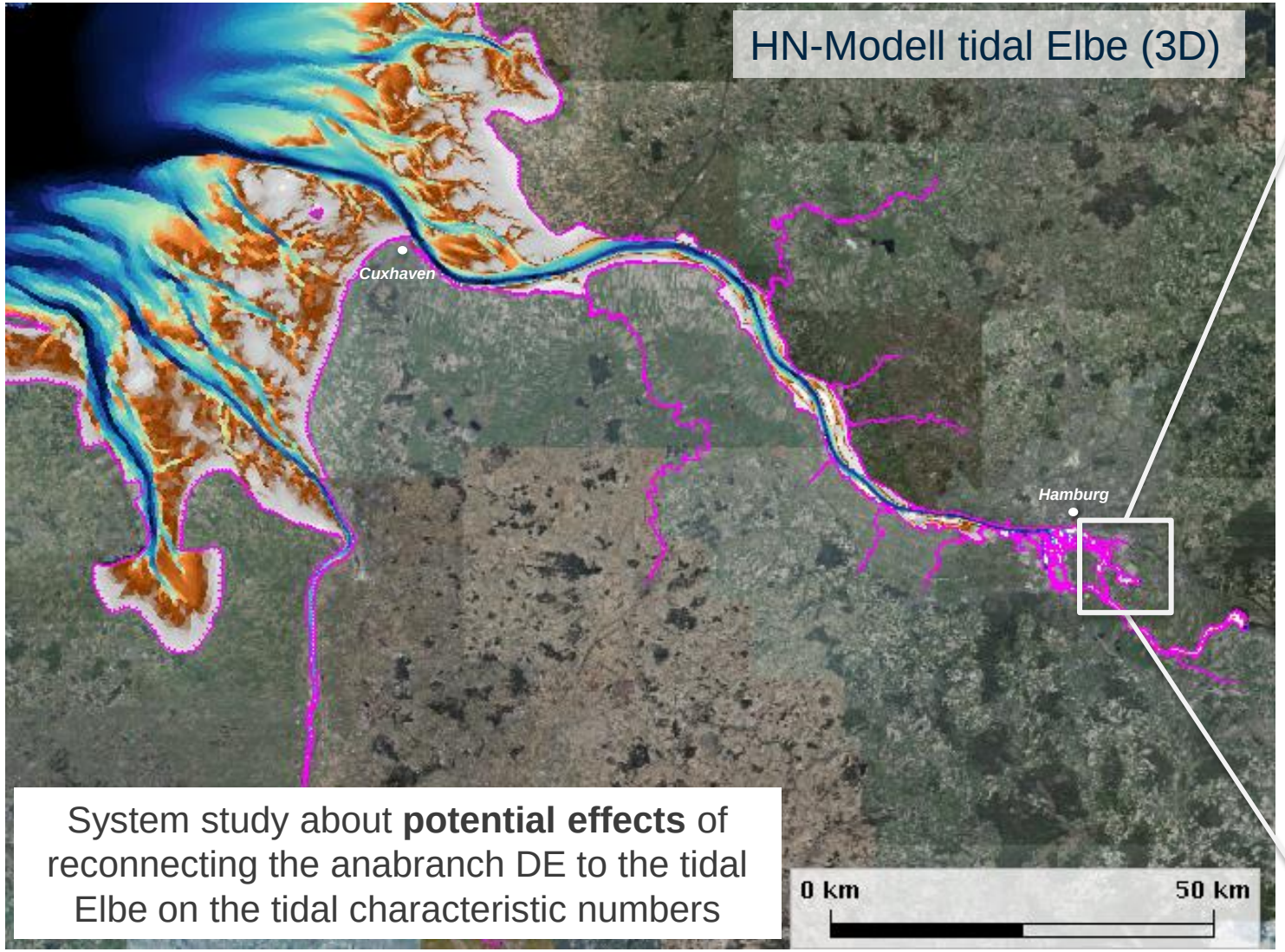
  Morphological model Sedimorph coupled to simulate sediment transport



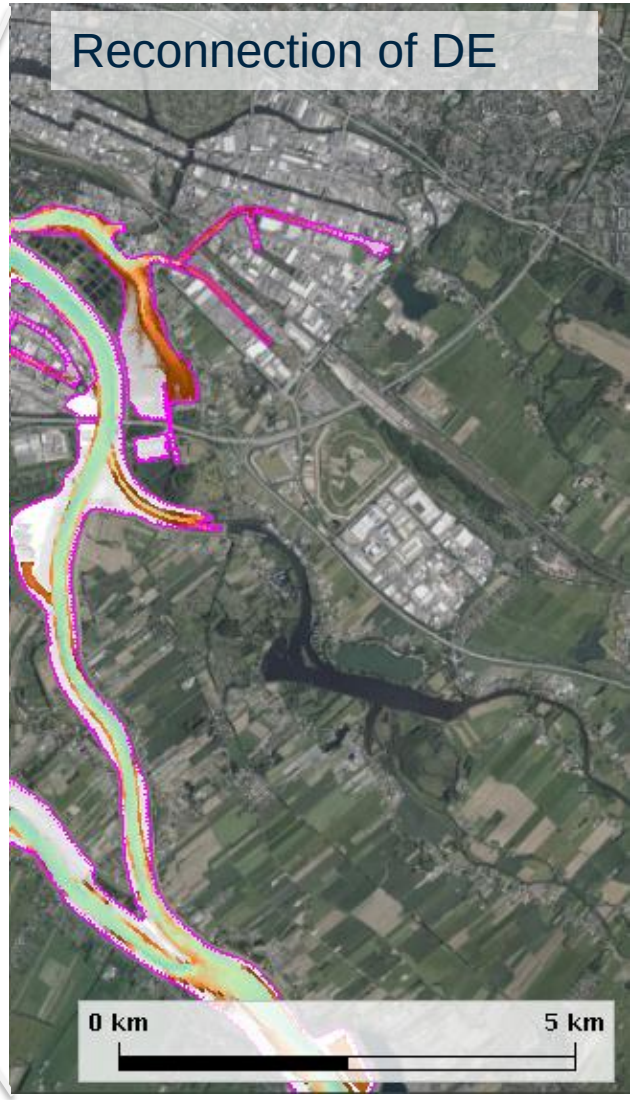
Source: BAW

Effects on hydrology and sediment transport

- 3D numerical modelling -



System study about **potential effects** of reconnecting the anabranch DE to the tidal Elbe on the tidal characteristic numbers



Effects on hydrology and sediment transport

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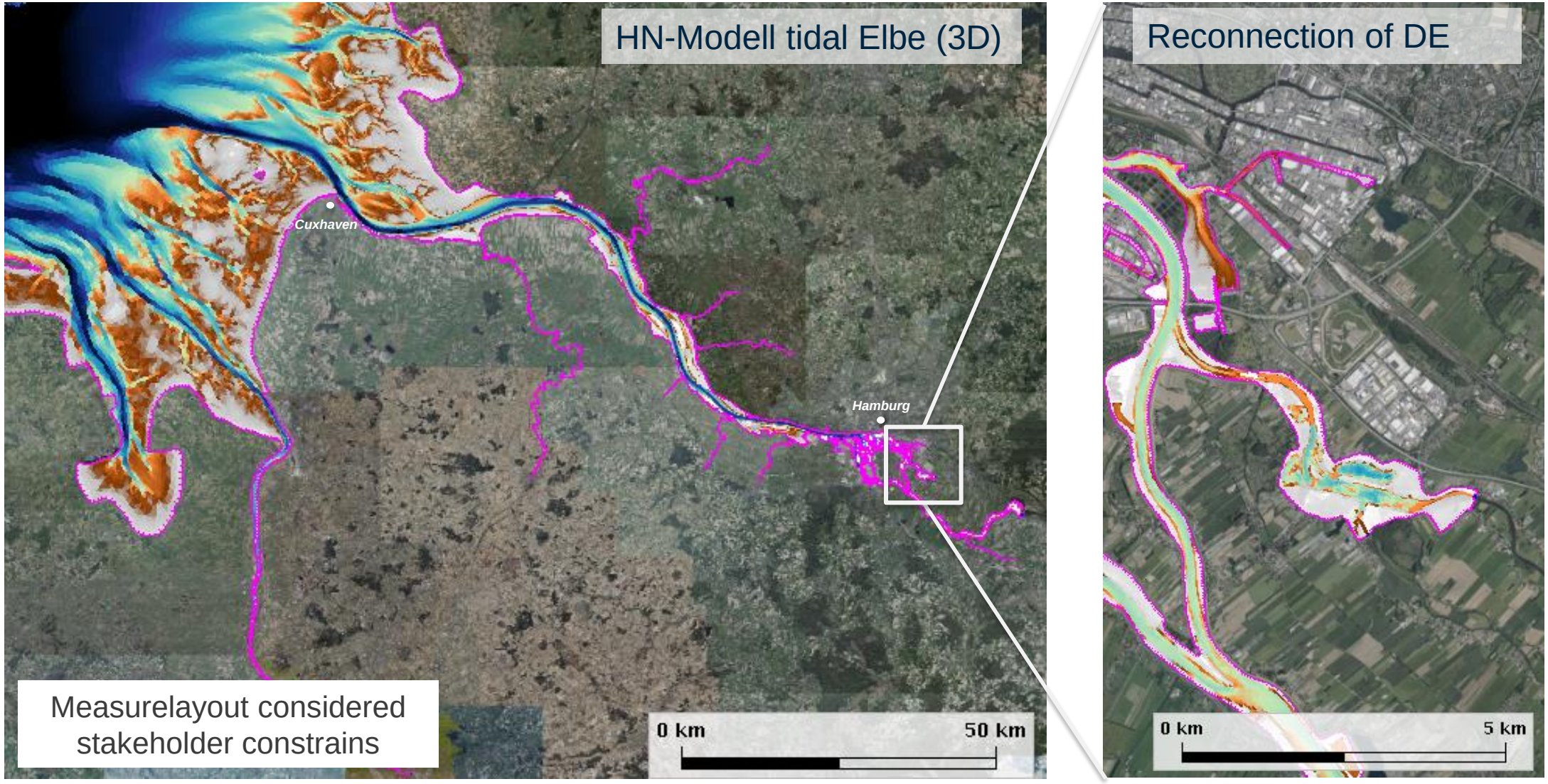
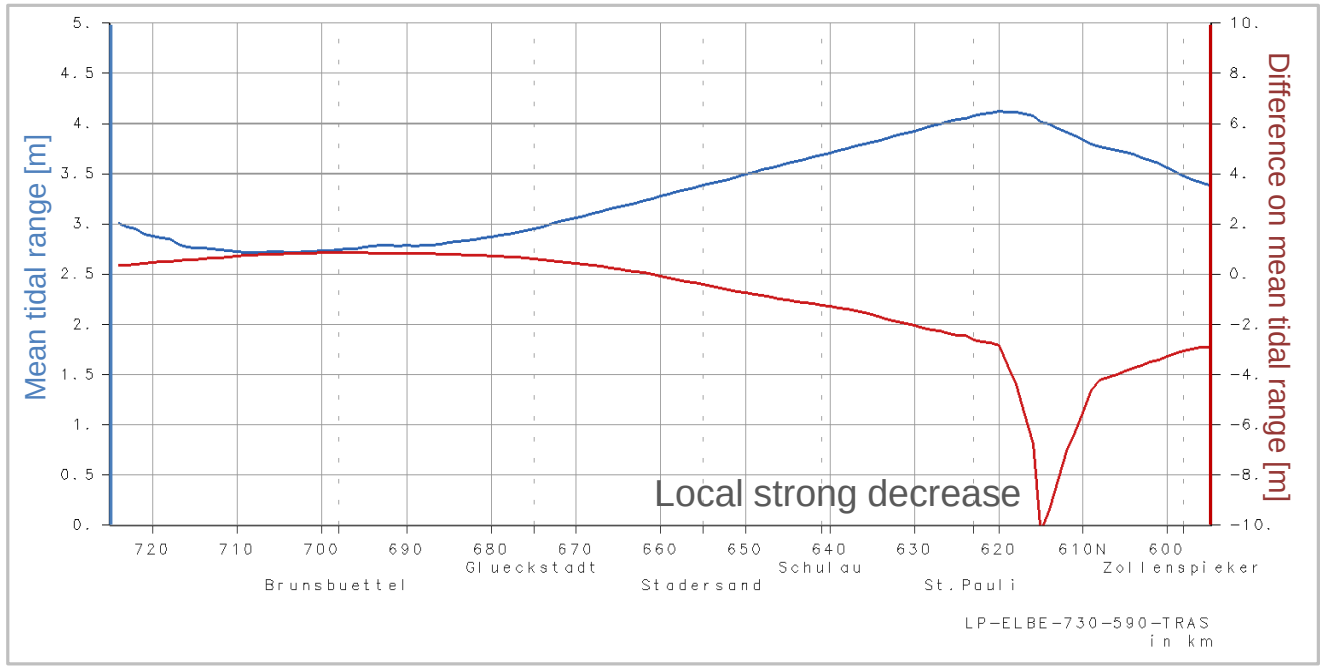


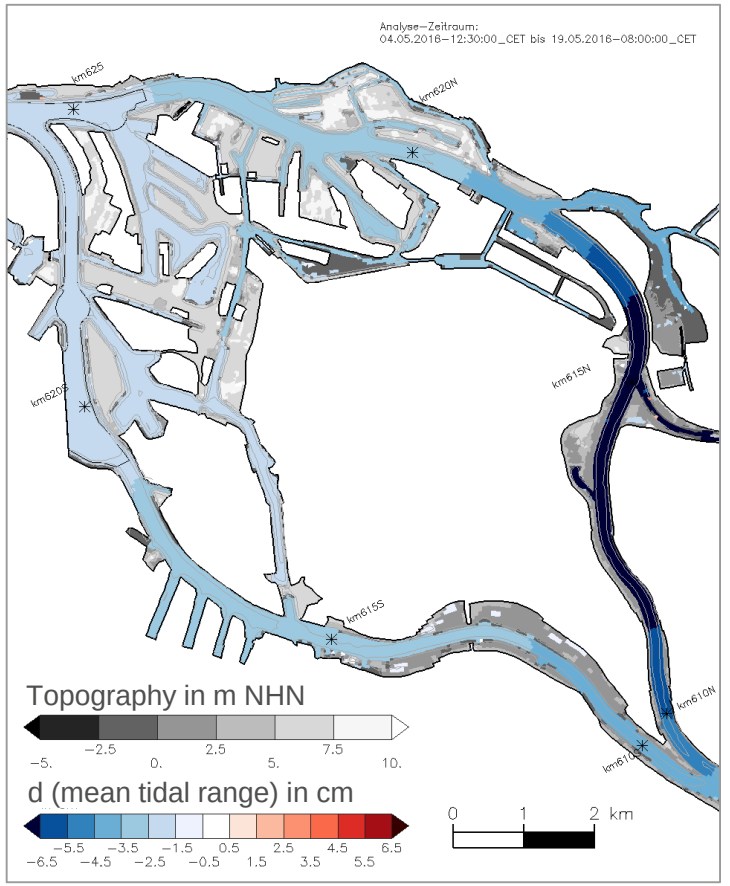
Results

Local tidal range reduction

- Tidal range lowers 2 to 3 cm in Hamburg port area



Results of the tidal range along the tidal Elbe

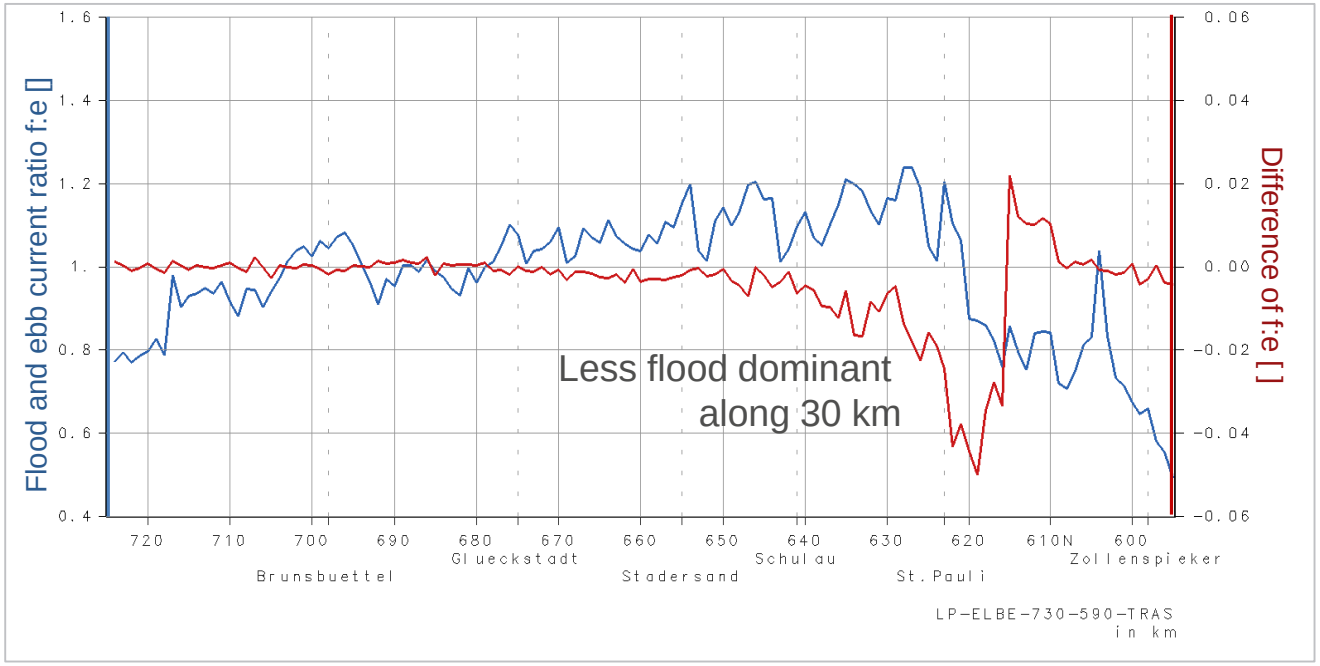


Difference on tidal range in Hamburg

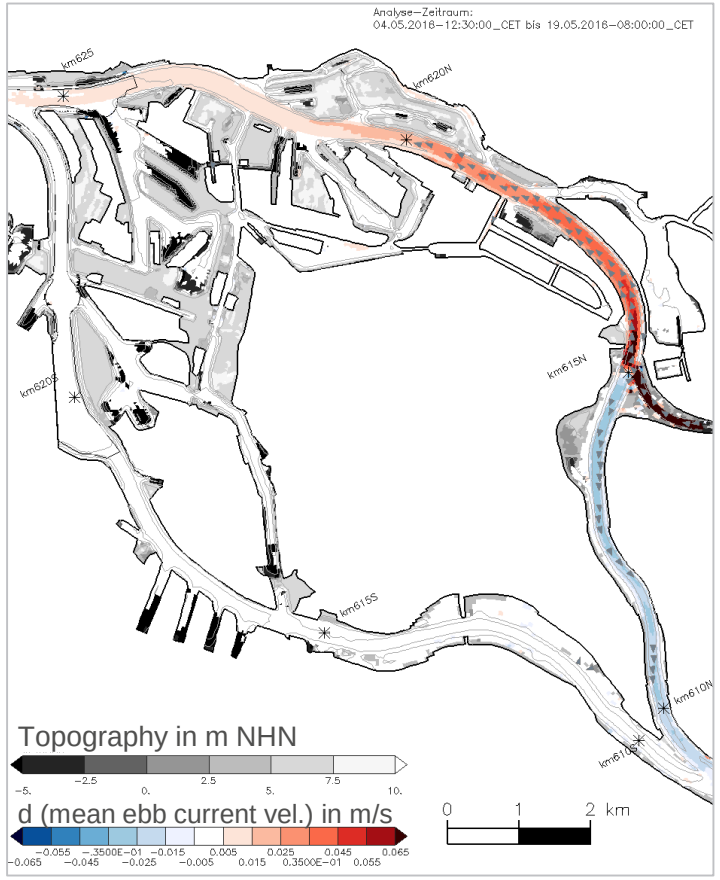
Results

Positive effect on the hydrodynamic regime

- Reduction flood dominant flow



flood : ebb current ratio, along the tidal Elbe

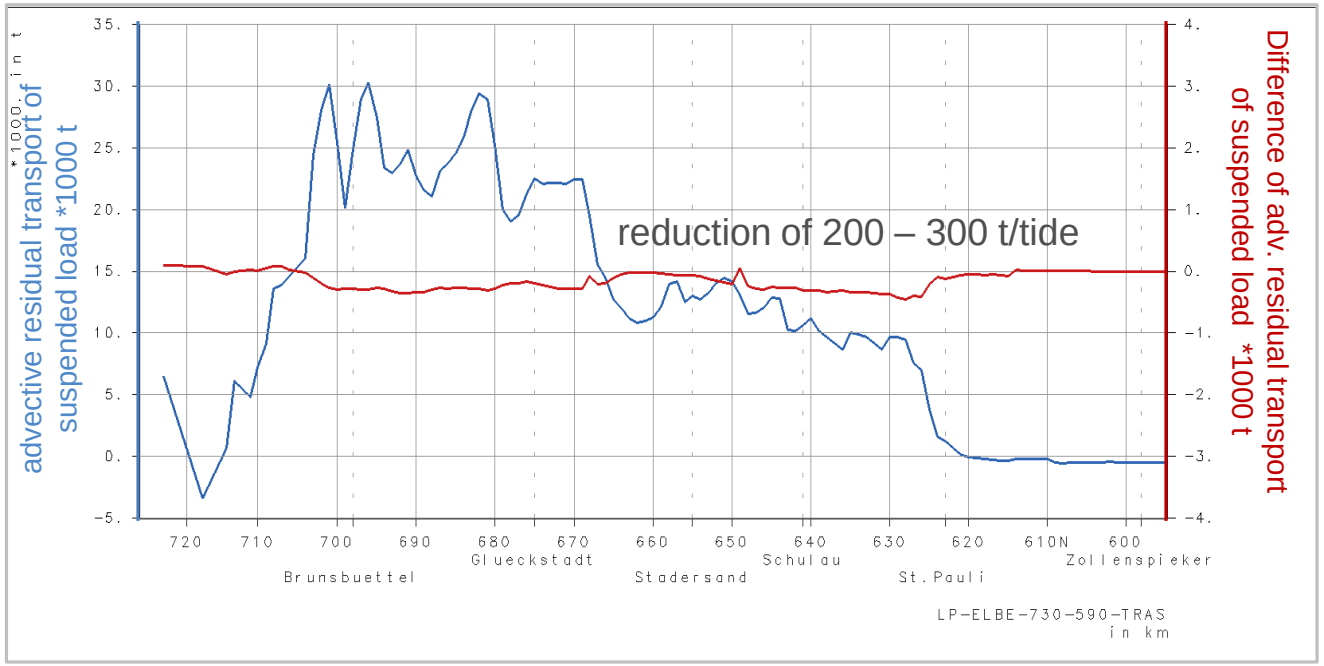


Difference on ebb velocity in Hamburg

Results

Lowered upstream sediment transport

- 1-2% less advective residual upstream transport of suspended load (towards Hamburg)



Advective residual transport of suspended load along the tidal Elbe

Summary and conclusions

- Energy is **insufficiently dissipated in the estuary**, thus, the estuary is subject to tidal amplification and tidal pumping
- The measure is **suitable to address tidal pumping**, it furthers the sustainable development of the estuary
- Given the regulation of the water level in the anabranch, the **potential hydrological benefits were constrained**
- **Beneficial effects** on the hydrodynamics of the tidal Elbe are expected within a **local extent**, principally in the side arm Norderelbe (Northern Elbe) in the Hamburg area
- Along the reconnection of flood space like at the **Dove Elbe cannot reverse the impacts of longtime anthropogenic changes -> Combination of measures and flexible sediment management**

References

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- Internationale Kommission zum Schutz der Elbe (IKSE), 2005. Die Elbe und Ihr Einzugsgebiet, Magdeburg.
- Weilbeer, 2015. Sediment transport and sediment management in the elbe estuary, Germany. Online available http://iadc.stage.mobilem.net/wp-content/uploads/2017/02/article-sediment-transport-and-sediment-management-in-the-elbe-estuary-germany-139-2.pdf, last visited Nov 12, 2020.
- Weilbeer et al., 2020. Analyse der hydrologischen und morphologischen Entwicklungen in der Tideelbe für den Zeitraum 2013-2018 (unpublished).

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Thank you for you attention!
Questions?

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