KLIWAS
Climate · Water · Navigation

Impacts of Rising Mean Sea Level on German Estuaries

Ingrid Holzwarth, Fred B. Hesser, Annette Schulte-Rentrop and Aissa Sehili

Departmental Research Programme
- National Meteorological Service of Germany (DWD)
- German Maritime and Hydrographic Agency (BSH)
- German Federal Institute of Hydrology (BfG)
- German Federal Waterways Engineering and Research Institute (BAW)

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Motivation

Due to changing climatic conditions several parameters influencing hydrodynamics and transport characteristics at the German North Sea Coast are expected to change.
Among these parameters mean sea level rise is supposed to have the strongest impacts at the coast and in the estuaries. Embedded in the two joint venture programs called KLIWAS and KLIMZUG-NORD these impacts are investigated at the German Federal Waterways Engineering and Research Institute.

Method

In the presented study, a 3D hydrodynamic-numerical model (using UnTRIM, Casulli and Zanolli (1998)) of the North Sea is used. It is run for a spring-neap-cycle to evaluate the effects of rising mean sea level in the North Sea.
Furthermore the North Sea model is used to generate boundary conditions for the hydrodynamic-numerical models of the Elbe Estuary, the Jade-Weser Estuary and the Ems Estuary which are run subsequently.
Two situations are modelled and analyzed: a situation representing actual conditions (*ACT*) and an experimental situation with an assumed mean sea level rise of +80 cm (*EXP +80cm*). This sea level rise is simulated by adding 80 cm on the actual condition's water level at the boundaries of the North Sea model.

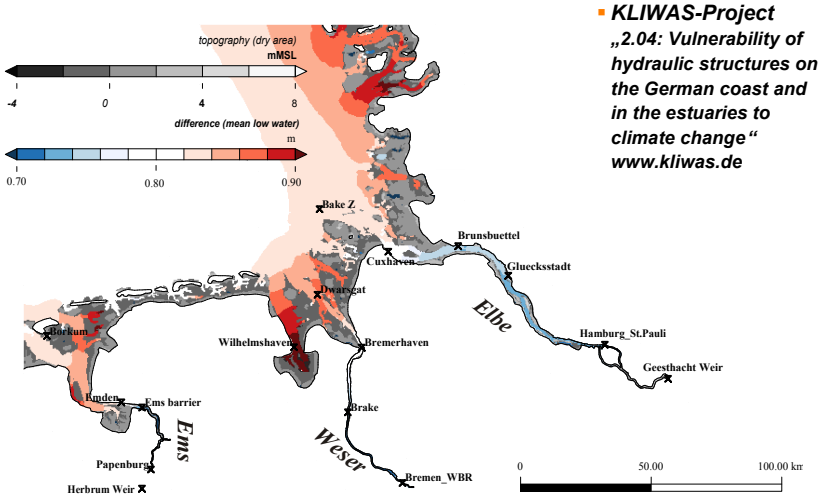


Fig. 1: Investigation area: the German Bight and the estuaries of Elbe, Weser and Ems. Colours indicate the difference in mean low water of the situations *EXP+80cm - ACT* .

Results

The two situations *ACT* and *EXP+80cm* are compared for one spring-neap-cycle. The following effects on mean values can be observed at the coast and in the outer parts of the estuaries:

- High Water increases between +86 cm and +100 cm
- Low Water increases up to +86 cm (see Fig. 1)
- Tidal Range increases between +6 cm in the Outer Weser and Outer Ems and up to +10 cm in the Outer Elbe

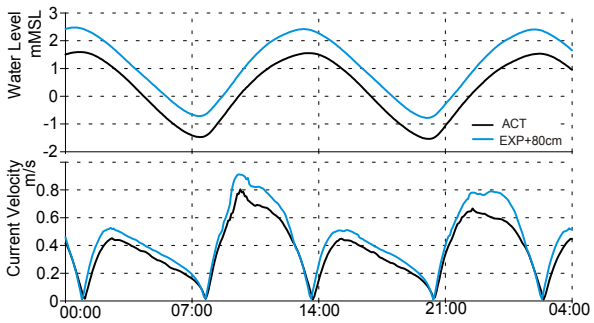


Fig. 2: Time series of water level and depth averaged current velocities of the actual situation and the experiment at the station Glueckstadt (Elbe Estuary)

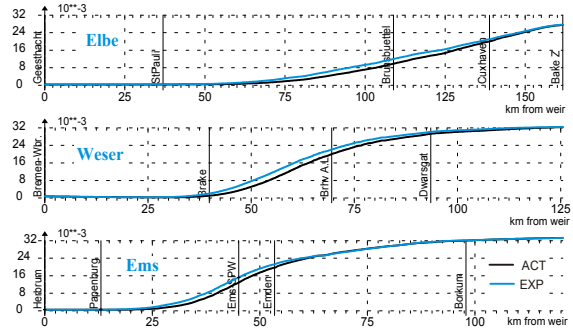
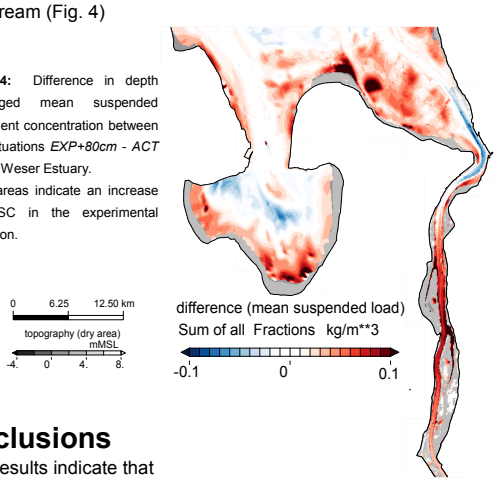


Fig. 3: Depth averaged mean salt concentration in PSU along the navigation channel of each estuary. Left : weir, right: North Sea

The changes in hydrodynamics and transport characteristics due to the increased water level in most parts of the estuaries are:

- Mean High Water increases stronger than Mean Low Water
- Stronger increase in Tidal Range
- Deformation of the tidal wave (upper panel in Fig. 2)
- Increase in current velocities; higher Flood Current Velocities compared to Ebb Current Velocities (lower panel Fig. 2)
- Enhancement of tidal pumping
- Salt water intrusion several kilometres further upstream (Fig. 3)
- Increase in suspended sediment concentrations further upstream (Fig. 4)

Fig. 4: Difference in depth averaged mean suspended sediment concentration between the situations *EXP+80cm - ACT* in the Weser Estuary.
Red areas indicate an increase in SSC in the experimental situation.



Conclusions

These results indicate that

- The estuaries are sensitive to increasing mean sea level,
- In the estuaries the effects of rising mean sea level are similar to the effects of deepening the navigation channel,
- Actual problems are expected to exacerbate, especially the upstream transport of sediments and related maintenance efforts.

In KLIWAS and KLIMZUG-NORD measures to adapt to these possible changes have to be developed to ensure the sustainable use of the estuaries as waterways for shipping, for irrigation and tourism which, however, must go hand in hand with the estuaries' natural demands. This work provides the physical elements for vulnerability studies and for the development of creative adaption strategies.

Authors:

Ingrid Holzwarth
Tel.: ++49 (0) 40/81908-425
Email: Ingrid.Holzwarth@baw.de

Fred B. Hesser
Tel.: ++49 (0) 40/81908-332
Email: Fred.Hesser@baw.de

Dr. Annette Schulte-Rentrop

Dr. Aissa Sehili

German Federal Waterways Engineering and Research Institute

Department of Hydraulic Engineering in Coastal Areas

Wedeler Landstraße 157
22559 Hamburg
www.baw.de

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BAW Bundesanstalt für Wasserbau
Federal Waterways Engineering and Research Institute