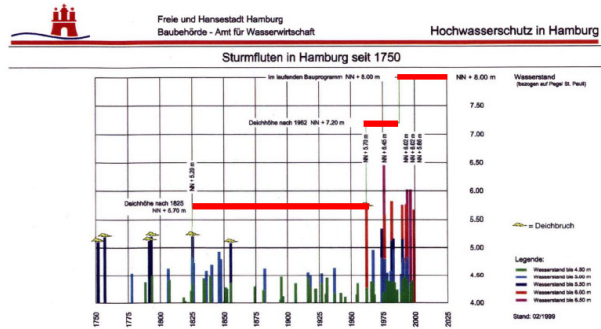


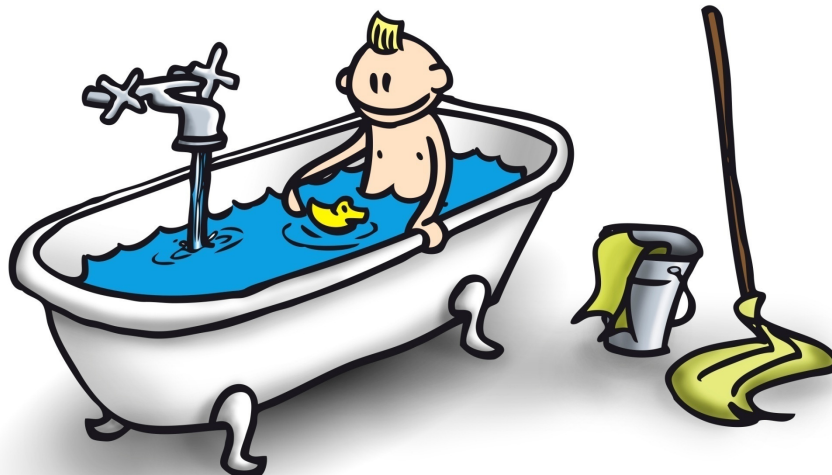
History and perspectives of storm surge management in Hamburg



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Manfred Meine, Hamburg Port Authority, Hamburg

Gabriele Gönnert, Agency of Roads, Rivers and Waters, Hamburg, Germany



Graphics: Michael Schrenk



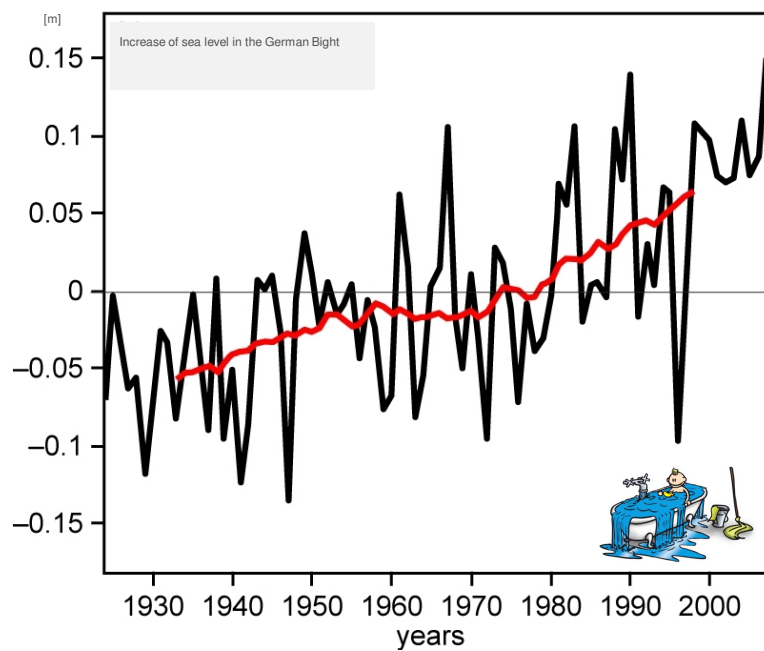
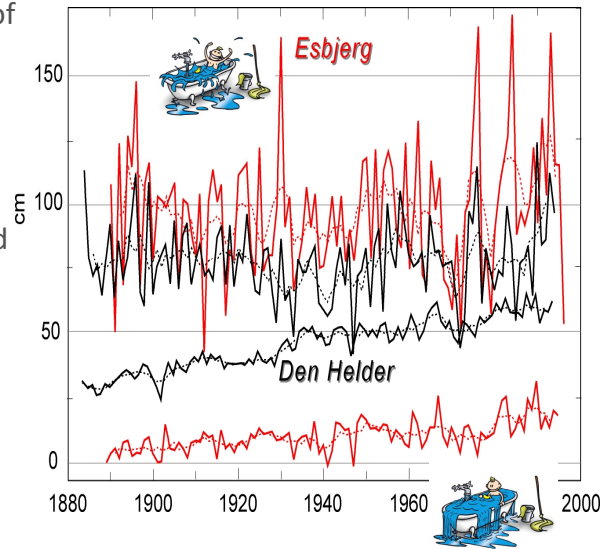
Case of German Bight

Temporal development of
intra-seasonal 99%ile of
high tide levels AFTER
subtraction of annual
mean high tide

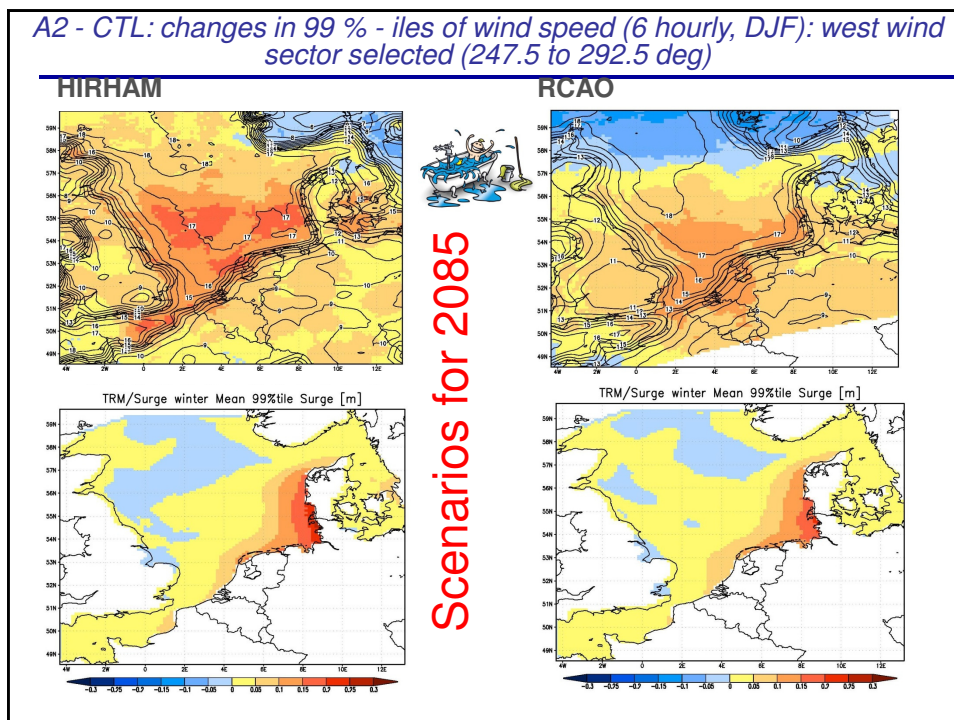
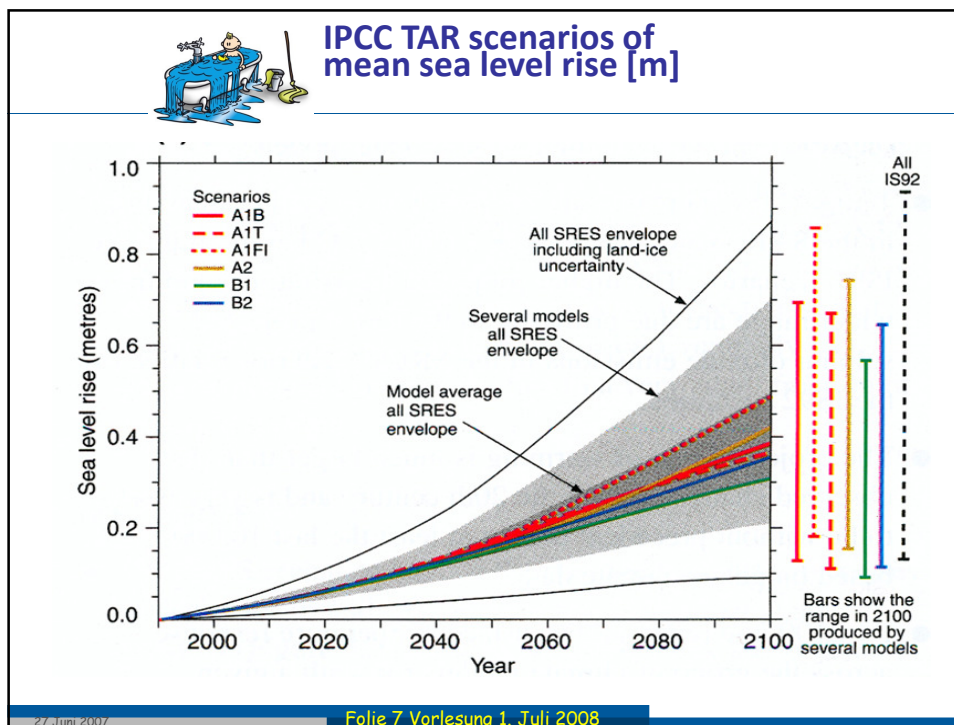
and mean annual high
tide

in Esbjerg (Denmark) and
Den Helder (The
Netherlands)

until 1995.



Albrecht et al., 2010



Summary of knowledge about change of storm surge heights

Significant drivers of changing storm surge heights	Recent changes 1967-2008	Possible changes until 2030	Possible changes until 2100
Global mean sea level rise	ca. 2 dm	ca. 1 – 2 dm	ca. 2 – 8 dm
Meteorological short term effects (storms)	none	ca. 0 – 1 dm	ca. 1 – 3 dm
Regional and local sea level change	ca. 2 dm	So far unknown	So far unknown
waves	none	So far unknown	So far unknown
tides	Regionally very different	So far unknown	So far unknown
bathymetry	Regionally very different	So far unknown	So far unknown

See: GKSS, 2009 : **Nordseesturmfluten im Klimawandel** .GKSS Wissenschaftler fassen aktuellen Forschungsstand zusammen.

Case of German Bight

Recent, ongoing:

Natural climate variability in storminess.
Effect of water works.
Mean sea level rise possibly about 2 mm/yr.



Scenarios of possible future conditions:

To the end of 21st century strongest westerly winds enhanced by about 10%.
Wind/Air pressure induced increase of storm surges: 20-25 cm.
Mean sea level rise – unclear, likely larger than global mean sea level.
Increase in coastal storm surge heights in 2030 about 20 cm, in 2085 about 70 cm. Uncertain numbers!

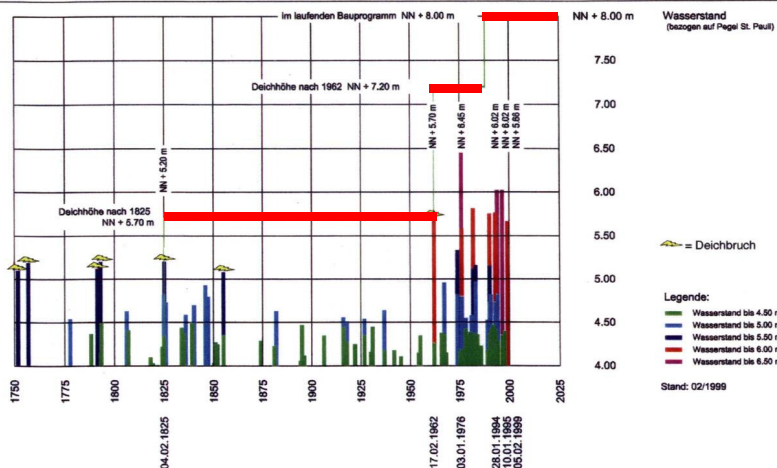
Hamburg – storm surges



Freie und Hansestadt Hamburg
Baubehörde - Amt für Wasserwirtschaft

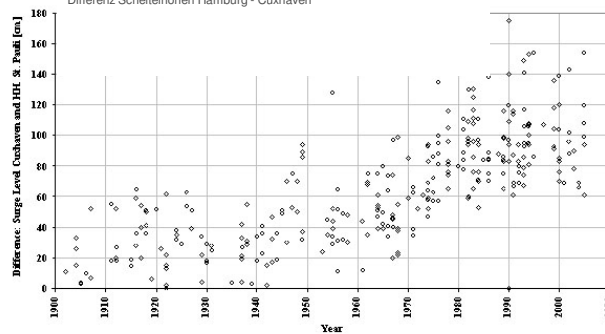
Hochwasserschutz in Hamburg

Sturmfluten in Hamburg seit 1750

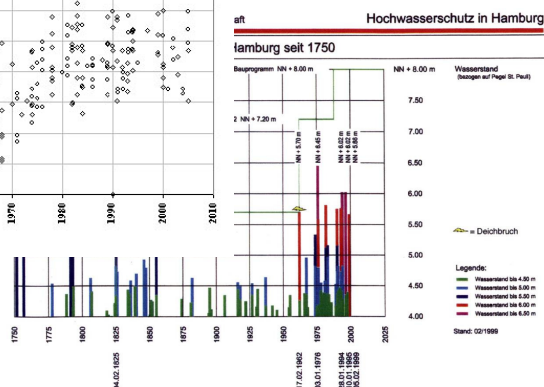


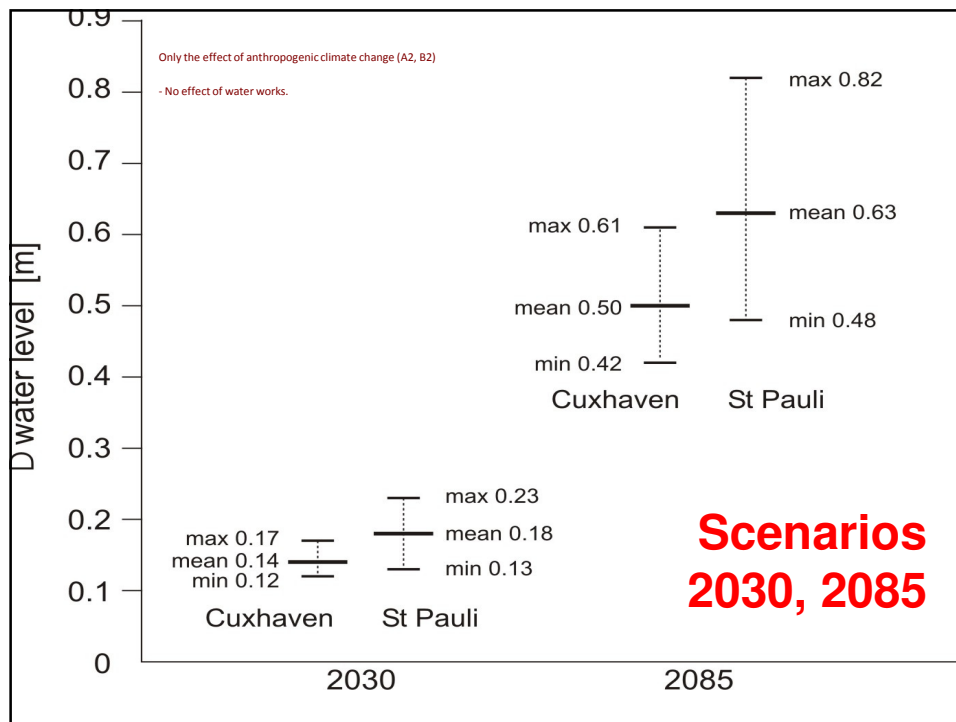
Sturmfluten in der Elbe Vergangenheit

Differenz Scheitelhöhen Hamburg - Cuxhaven



Sturmfluten in der Elbe deutlich erhöht seit 1962 – aufgrund wasserbaulicher Maßnahmen, vor allem wegen der Verkürzung der Deichlinie





Options for dealing with future elevated storm surge levels

- at the **coast**:

- + fortifying, extending presently installed coastal defence
- + flexible response strategies;
- + design dykes such that the amount of water which may safely spill over for a few hours is considerably larger than allowed today.

- additionally in the **estuary**: partial undoing of previous man-made increases



Graphics: Michael Schrenk

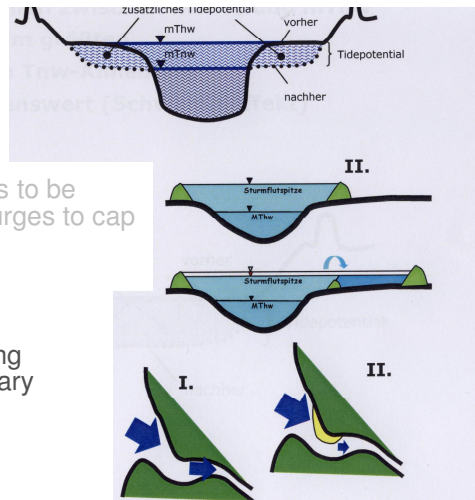
Dealing with rising sea level and elevated storm surge heights in **Hamburg**

1. Additional flooding areas

The Tidal Elbe concept of Hamburg Port Authority

2. Availability of additional polders to be flooded during severe storm surges to cap the peaks of such surges.
3. Additional dissipation of tidal (and surge) energy by narrowing the mouth segment of the estuary

Heinz Glindemann, HPA, pers. comm.



Conclusions

Storm surges are a serious issue

Climate change and coastal development are drivers in changing storm surge risk.

The North Sea is the best studied area, with no indications for present man-made change but perspectives for increases of 20 cm and 70 cm in 2030 and 2085 in its SE storm surges. These numbers are uncertain and represent scenarios.

Most of the increase will take place even if the ambitious climate control measures will be successful. Thus the preparation of adaptive measures is needed.

Novel adaptive measures need to be developed and examined, e.g.,

- damping of incoming tidal energy in estuaries
- improving dyke design to allow for stronger overtopping.
- strengthening the coastal protection facilities.

