Drivers of storm surge change in Hamburg

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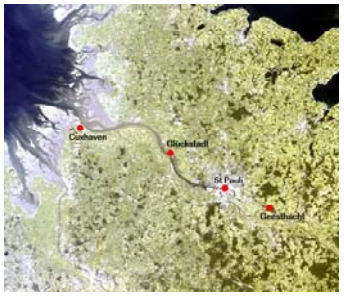
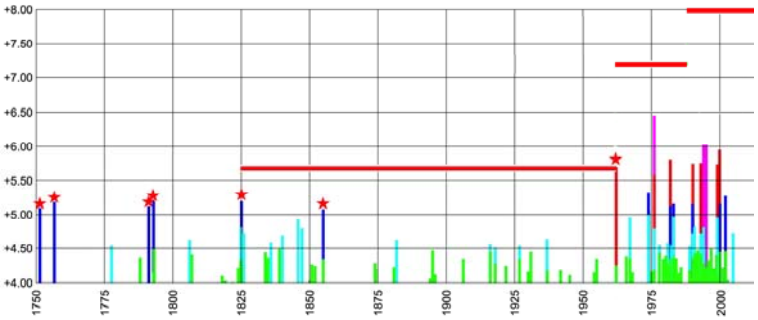
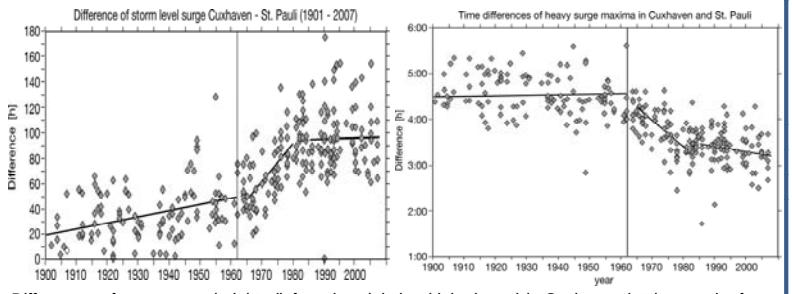


For the time prior to 1850, coastal defense failure was a regular phenomenon; from about 1850-1960 coastal defense was hardly challenged, and after 1962 storm surge heights rose to levels never recorded before. The most likely causes for this change are modifications of the Elbe estuary, related to coastal defense and improving the shipping channel. Anthropogenic climate change may lead in the future to even higher storm surges (mainly because of increased sea level in the German Bight). However, this increase possibly may be mitigated by the "tidal Elbe project", designed to reduce upstream river sediment transport.

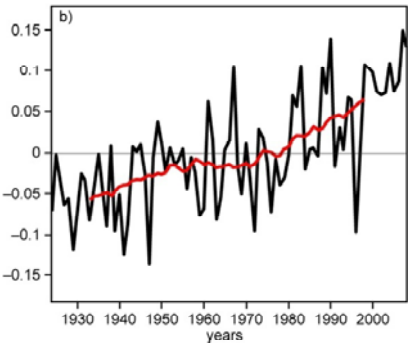
Past development in Hamburg



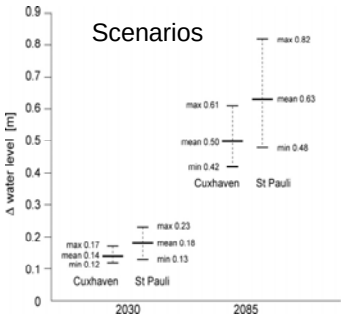
Storm surge heights (vertical bars) and dike heights (green horizontal lines) as recorded at the tide gauge St Pauli in Hamburg from 1750 to 2004. The red stars indicate dyke failures. Adapated from Landesbetrieb für Strassen, Brücken und Gewässer in Hamburg.



Differences of storm surge heights (left; cm) and timing (right; hours) in Cuxhaven (at the mouth of the river Elbe) and Hamburg St. Pauli (some 140 km upstream of Cuxhaven). The 1962 event, which was causing the significant investments into coastal defense, is marked by a vertical line. The linear curves are subjective estimates.



Estimated regional mean sea level (time series of the leading EOF mode of annual mean RMSL) in the German Bight, North Sea –
in **red**: the 19-year moving average. Units: m
(Albrecht et al., 2010)



Scenarios for future changes of storm surge heights in Cuxhaven at the mouth of the estuary and Hamburg St. Pauli 140 km upstream of the river Elbe. Incorporated are the effects of changing storminess and of global mean sea level; ongoing geological processes are not considered. The ranges represent uncertainties related to the usage of different models and different emission scenarios.
(Grossmann at al., 2007)

Turning back the Tide – The Tidal Elbe Concept has options for responding to the perspective of heightened storm surges

Though initially driven by unfavourable changes in the sediment regime leading to dramatically increased dredging necessities in Hamburg, the Tidal Elbe Concept of the Hamburg Port Authority and the Federal Administration for Waterways and Navigation shows potential also to reduce future storm surge levels.

Focussing on a hydromorphological improvement of the Elbe estuary by 1) dissipating the incoming tidal energy through hydraulic engineering measures (e.g. "feeding" sand banks in the mouth; fig. 1) and 2) (re)establishing flooding areas in the upper part of the estuary (fig. 2), some of the past topographic changes that have led to higher storm surge levels in Hamburg, could be set back. In addition, an innovative and intelligent design e.g. of flooding areas as special storm surge polders could, when needed, cut of the peak of a surge significantly and thus be, in support to fortifying the conventional flood protection, an answer even to the perspectives of heightened storm surges in the future (fig. 3).

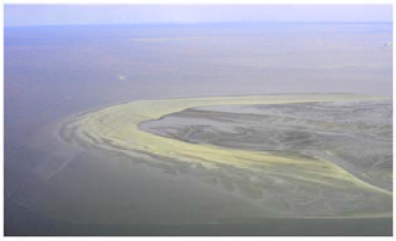


Fig. 1: A typical sand bank in the mouth of the Elbe estuary. Over the last decades some 200 Million tons of sand have been eroded in the mouth. By "feeding" these sand banks with coarse sandy material, the incoming tidal energy could be reduced.

Fig. 2: (Montage) Newly created shallow water areas in the upper estuary will not only benefit the sediment regime, but could – depending on size and design - also be used as flooding areas or polders to reduce storm surge peak levels.

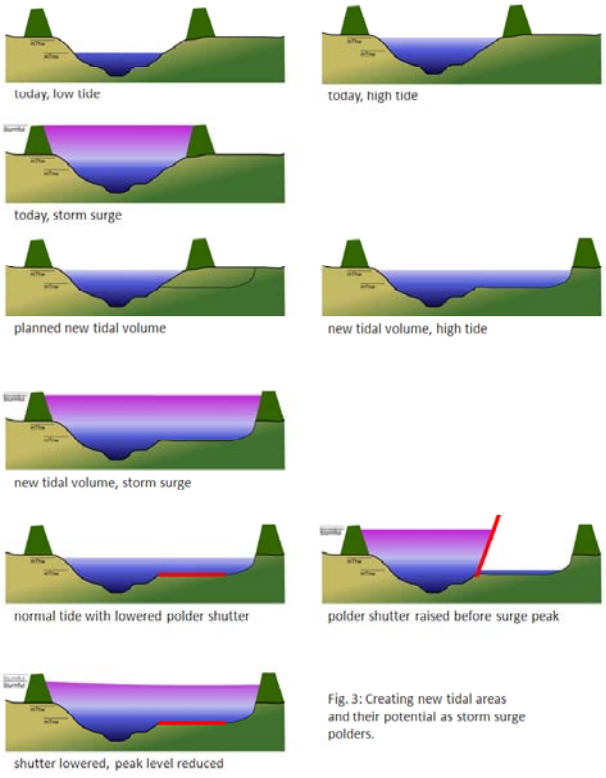


Fig. 3: Creating new tidal areas and their potential as storm surge polders.