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OPTEL: Studies on wind set-up in the River Elbe

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The basic purpose of the project OPTEL is the development of an operational hydro-numerical model to supply permanent forecasts for water levels, currents and other hydrological parameters in the tidal Elbe River. General aims are to provide hydrological information e.g. for shipping traffic on the Elbe River as well as to improve the storm surge forecast for Hamburg.

Within OPTEL, the Hamburg Port Authority (HPA) carries out empirical studies on storm surges in the Elbe estuary. This work is of high interest especially for Hamburg´s own storm surge forecast service (Hamburger Sturmflutwarndienst, WADI), which is part of the HPA. It was established after the big storm surge in 1976, which caused severe damage in the Port of Hamburg. The current forecast system is an empirical method to provide forecasts of water levels in Cuxhaven and Hamburg, preliminary based on the wind set-up caused by wind development in the German Bight. In OPTEL, studies about storm surges in the Elbe estuary are basically focused on empirical analyses of the propagation of the wind set-up from Cuxhaven to Hamburg.

For the project OPTEL 152 storm surges since 1980 had been analysed. As results of analyses show, the progression of storm surges within the inner estuary from Brokdorf towards Hamburg can be described as linear. Thus, parameters causing the wind set-up are located either in the German Bight or the mouth of the River Elbe. Analyses of specific events indicate that the local wind in the mouth of the river in many cases has a remarkable influence on height and propagation of wind set-up in the whole estuary.

A multiple regression implying wind set-up in Cuxhaven (W_CUX) and Hamburg-St. Pauli (W_STP), upstream water discharge (Q), wind velocity (WV) and wind direction (WD) of Brunsbüttel as well as the most effective wind set-up producing wind direction (WD_0) for Brunsbüttel verify the significant influence of local wind effects in the mouth of the Elbe River on the storm surge:

$$W\_STP = 1{,}158 \cdot W\_CUX + 0{,}010 \cdot f(Q) + 0{,}061 \cdot (WV^2 \cdot \cos^2(WD - WD_0))$$

With this formula it is possible to reach a significant improvement of the correlation between wind set-up at Cuxhaven and Hamburg-St. Pauli due to the consideration of the local wind in Brunsbüttel, in some cases up to 45 cm. This demonstrates the possibility for remarkable improvements of high water forecasts in Hamburg.

Besides the local wind in the mouth of the estuary the progression of storm surges from Cuxhaven to Hamburg is also influenced by many other effects of the highly complex natural dynamics of the tidal River Elbe. The next step in OPTEL will be to detect those effects and describe their impact on storm surges.

The empirical studies in OPTEL will be finished until September 2010. Even the first results show the prospects to improve the empirical and statistical approach of the forecast system of the WADI.