Influence of sea level rise on highest water levels during storm surges in the Ems estuary

The Project EXTREMENESS

The project EXTREMENESS (Extreme North Sea Storm Surges and Their Consequences) investigates the interaction of factors and conditions contributing to the formation of storm surges. A variety of data sets are searched for conditions associated with extreme storm surge events. These events are modified in a way that their intensity is enhanced, e.g. by shifting the tidal phase or by applying a sea level rise. The objective is to examine whether there might be exceptional combinations of conditions that can lead to exceptional high or long lasting water levels which have not been observed yet but which are possible and plausible. As a first example, the historical storm surge of 1st November 2006 is analyzed. The focus of the analyses are the estuaries of the rivers Elbe and Ems.

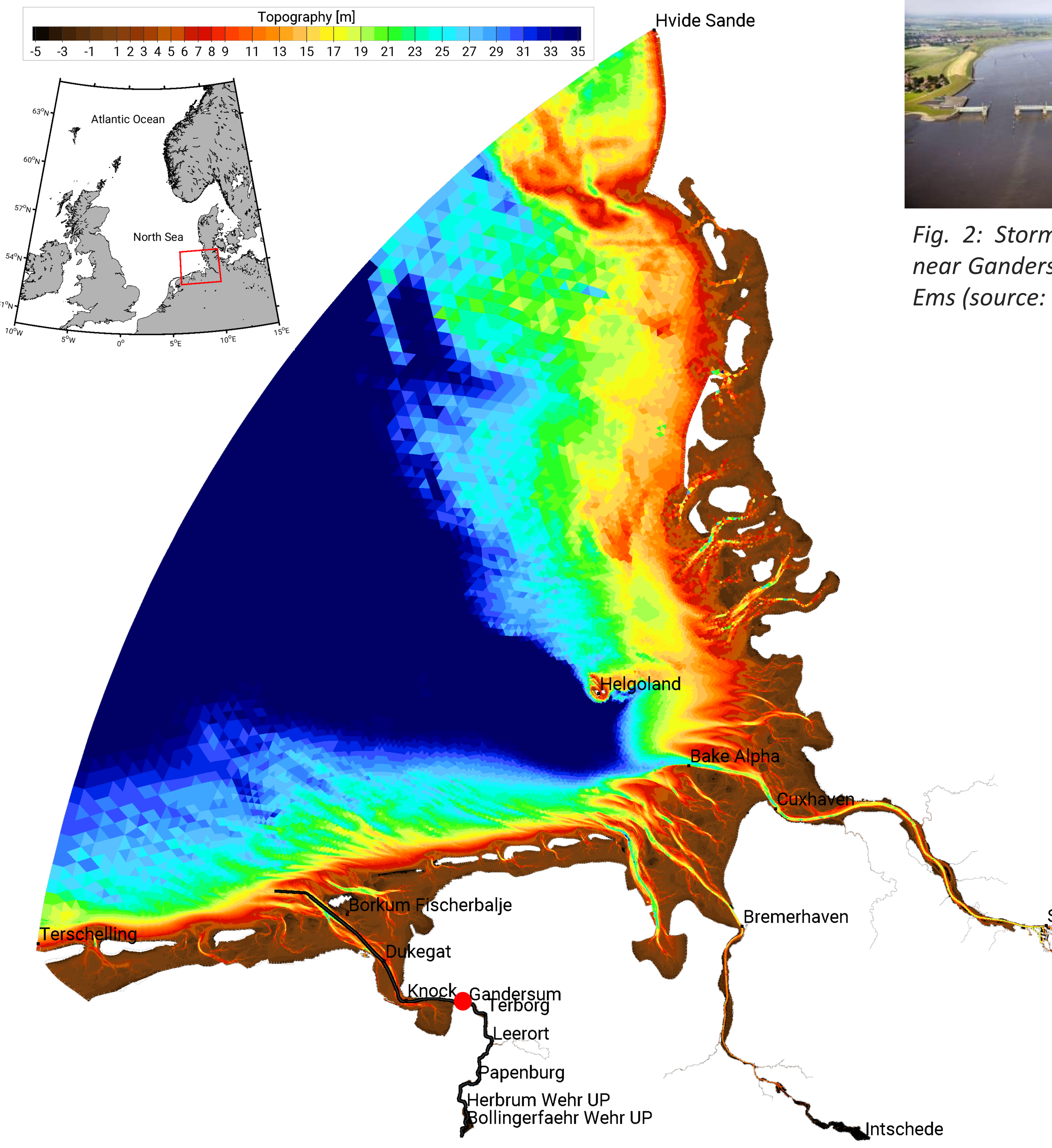

Fig. 1: Topography of the modelled region (German Bight, southeastern corner of North Sea); black line denotes profile where highest water levels were evaluated and red dot marks position of storm surge barrier in the river Ems

Fig. 2: Storm surge barrier near Gandersum in the river Ems (source: BAW)

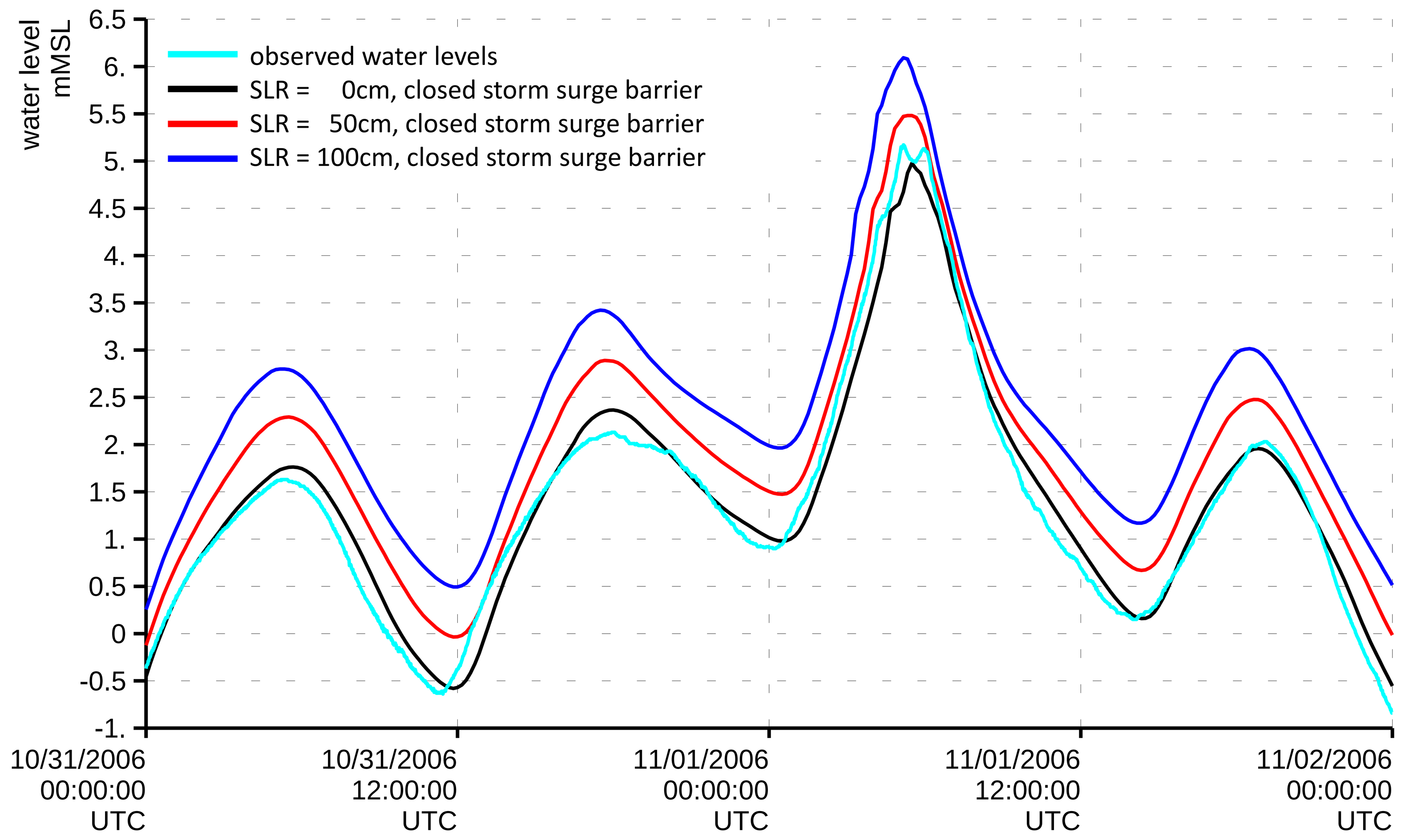

Fig. 3: Measured and simulated water levels at Emden (Ems)

Storm surge of 1st November 2006

On 1st November 2006, a severe storm caused high water levels in the German Bight and in the Ems estuary (see figure 3). Due to strong north-west winds, water was retained in the Ems estuary causing the low water preceding the storm surge to remain relatively high. Furthermore, the peak of the storm occurred simultaneously with high tide and lead to the highest water levels since 1906 in the Ems. During this event the storm surge barrier near Gandersum (see figure 2) was closed.

This event is modelled using the hydrodynamic-numerical model UnTRIM^2 (Casulli, 2008). The model region encompasses the German Bight and the estuaries of the rivers Ems, Weser and Elbe (see figure 1).

Enhancing the flood from 1st November 2006

By increasing the water level at the open boundary to the North Sea two sea level rise scenarios are simulated (50cm and 100cm). Each scenario is modelled for an open storm surge barrier and for a closed storm surge barrier in the Ems estuary.

Impact of sea level rise (SLR)

A sea level rise leads to an increase of highest water levels during storm surge throughout the entire Ems estuary. However, the exact amount of the increase varies spatially (see figures 5 & 6). Closing the storm surge barrier in the Ems cuts off the impact of the sea level rise so that upstream water levels remain unaffected (see figure 4). The closure of the storm surge barrier causes a positive surge leading to higher peak water levels downstream of the barrier. Upstream, the protective function of the barrier leads to lower peak water levels during storm surge.

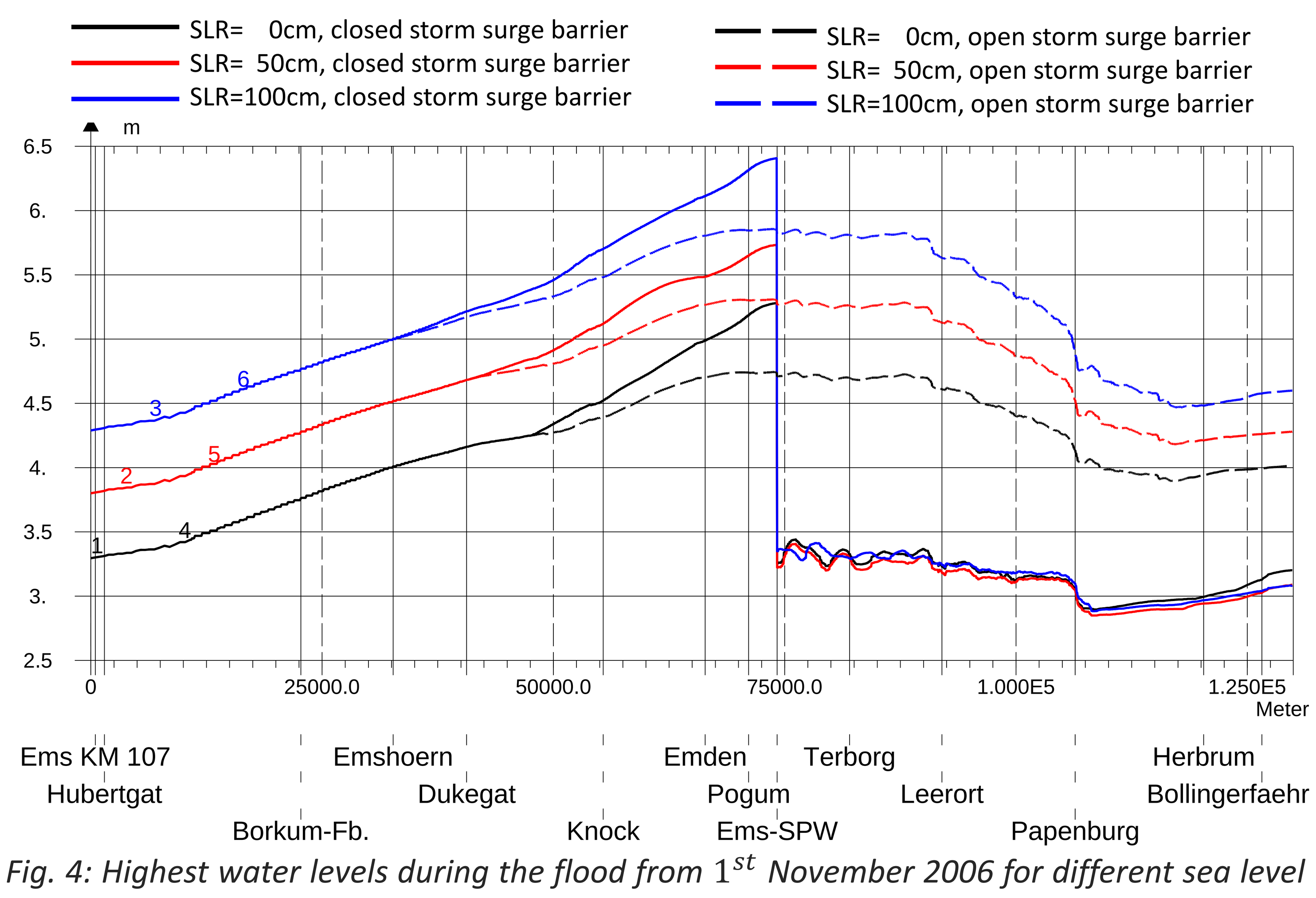

Fig. 4: Highest water levels during the flood from 1st November 2006 for different sea level rise (SLR) scenarios and with open or closed storm surge barrier along a profile in the Ems estuary

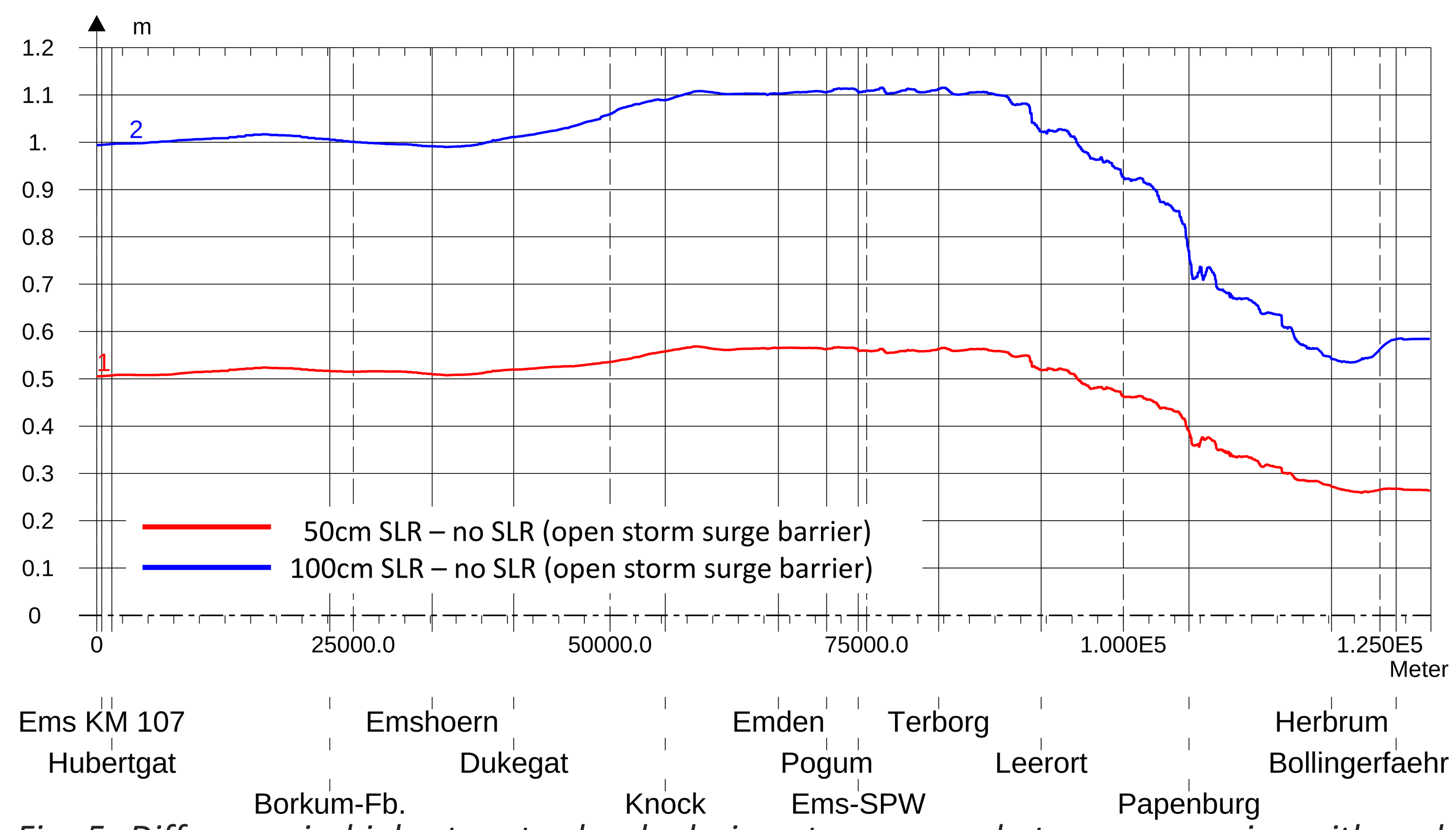

Fig. 5: Difference in highest water levels during storm surge between scenarios with and without sea level rise (SLR) along a profile in the Ems estuary

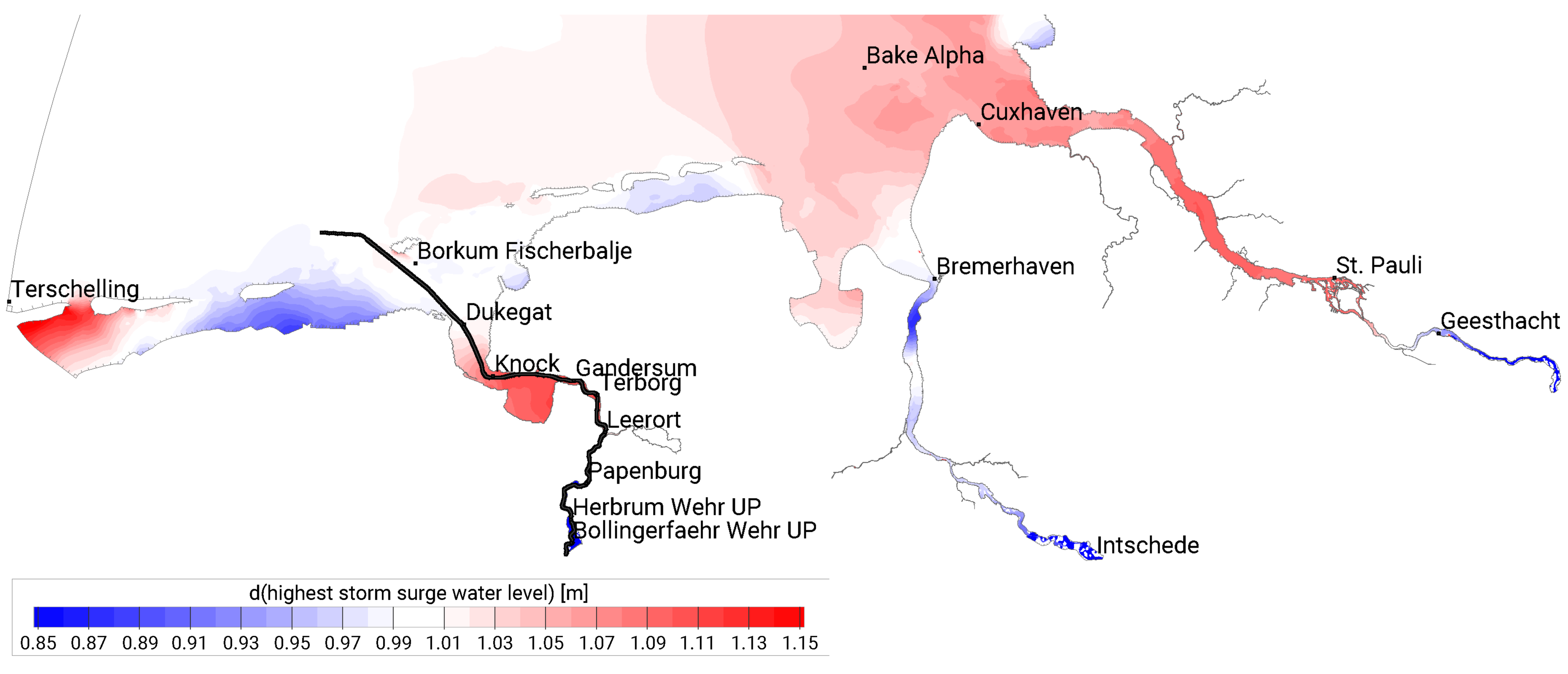

Fig. 6: Difference in highest storm surge water levels between a scenario with SLR = 100cm and a scenario without sea level rise (SLR). In both simulations the storm surge barrier in the Ems estuary is open. The black line denotes profile where highest water levels were evaluated

Literature:
Casulli, V. (2008) A high-resolution wetting and drying algorithm for free-surface hydrodynamics. Int. J. Numer. Meth. Fluids. DOI: 10.1002/fld.1896

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