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Storm surge modelling in the North Sea-Baltic sea transition zone: model inter-comparison of static wind simulations

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Extreme water levels in the micro-tidal transition zone between the North Sea and the semi-enclosed Baltic sea are predominantly determined by wind forcing associated with synoptic-scale weather systems. This connection between the two seas is partly blocked by low-lying islands, and the bathymetry comprises a complex mixture of narrow, deep channels and shallow sills. Coastlines in the Southern Kattegat and the Western Baltic Sea are therefore exposed to wind forcing from a large range of directions, and the extent of water build-up varies strongly between locations.

In the present study, we aim to determine the most critical wind direction for most of the Danish coastlines by employing numerical modelling experiments. The simulations are conducted with two different regional 3D ocean models to enable model inter-comparison. The DMI-HBM model implements a structured grid with fully dynamic 2-way nesting, while the MIKE 3 FM invokes an unstructured mesh. Both models have grid resolutions of ~0.5–1 km within the Danish Straits and 4–6 km in the offshore Baltic Sea. The models are forced by synthetic wind fields, where both wind speed and wind direction are maintained at fixed levels over the entire model domains. Pairs of model simulations are then obtained by varying the angle from which the wind is blowing.

From the model outputs, we describe the temporal evolution of the water level by the site-specific peak water level, and the time required for the response to reach its peak value. Our results show a steady rise of the water level up until the peak value. The peak water level significantly overshoots the final equilibrium water level, which develops further into the simulations. Our study facilitates a better understanding of the sea level's response to extreme and persistent winds in a region with highly complex geometry.