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Competence for Waterways

Model sensitivity to bedform related bottom roughness

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Our Model

We currently develop a 3D hydro-numerical model of the North Sea to set up a comprehensive database of hydrodynamics, bathymetry and surface sediments for the UNESCO World Heritage site of the Wadden Sea (orange area in Fig. 1).
Hydrodynamic data are obtained from our numerical model that benefits from the high resolution bathymetry and surface sediment data base.
The Wadden Sea is the largest coherent channel-shoal environment worldwide. It is dominated by semidiurnal tides and shows dynamic sediment transport patterns.

Van Rijn Bedform Roughness

Modelled bottom roughness ***k*** (Fig. 4) contains grain and bedform roughness.
k_{grain} is derived from the grain size. $k_{bedform}$ according to van Rijn (2007, Unified view of sediment transport by currents and waves I) is parameterised depending on the physical input parameters: water depth (Fig. 2), sediment distribution (Fig. 3), and current velocity.
Van Rijn distinguished between ripples, mega-ripples, and dunes.

$$k_{bedform} = \sqrt{k_{ripples}^2 + k_{mega-ripples}^2 + k_{dunes}^2}$$

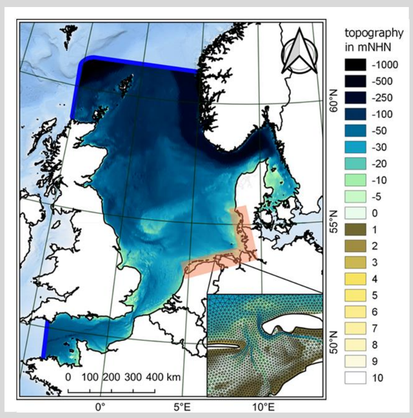

Fig. 1: Model domain

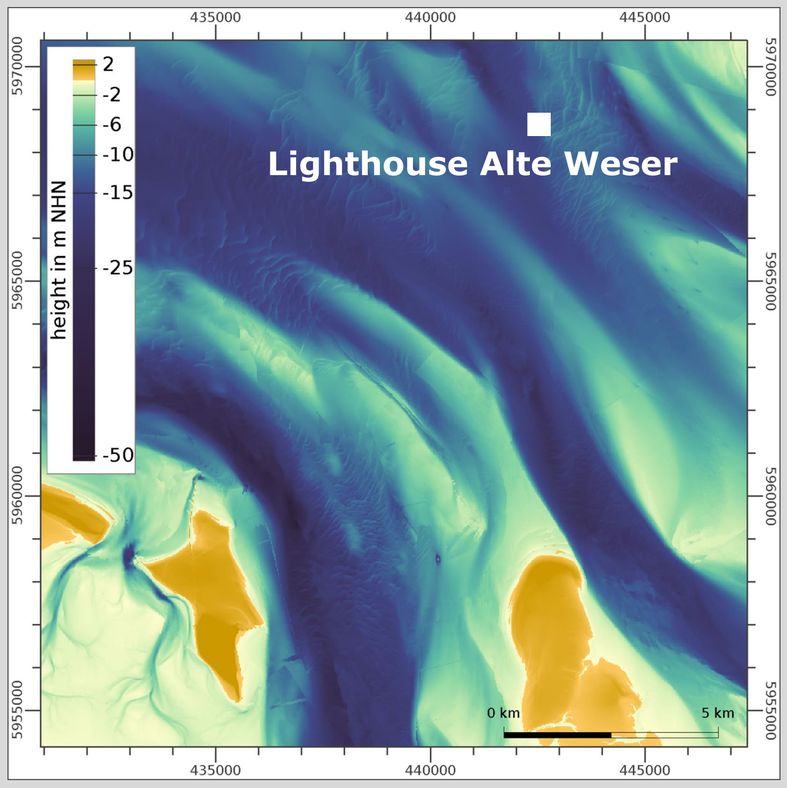

Fig. 2: Bathymetry with dunes at the study site (outer Weser estuary, Wadden Sea)

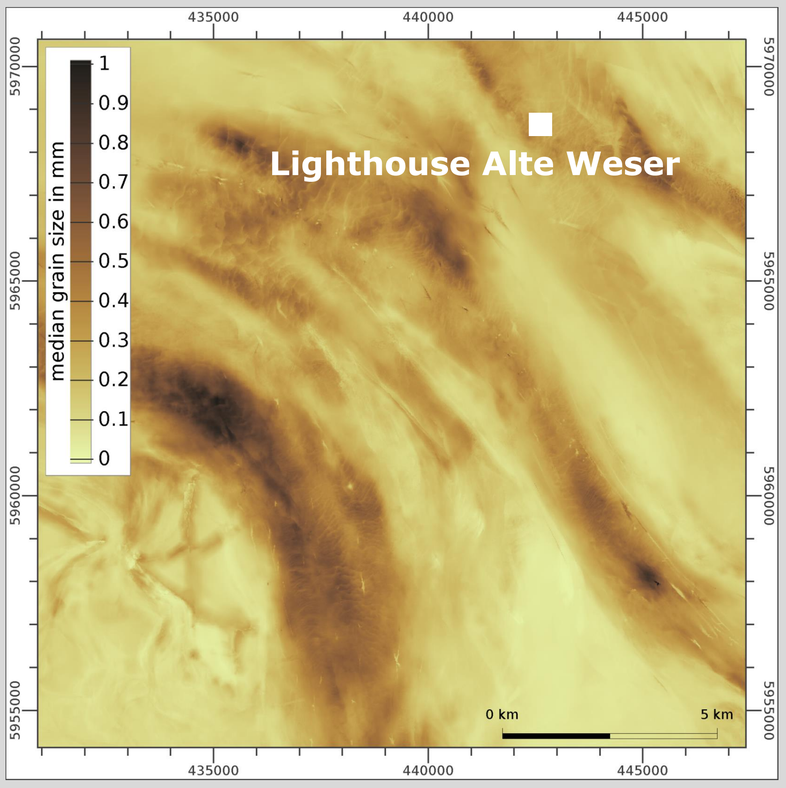

Fig. 3: Surface sediments represented by median grain size at the study site

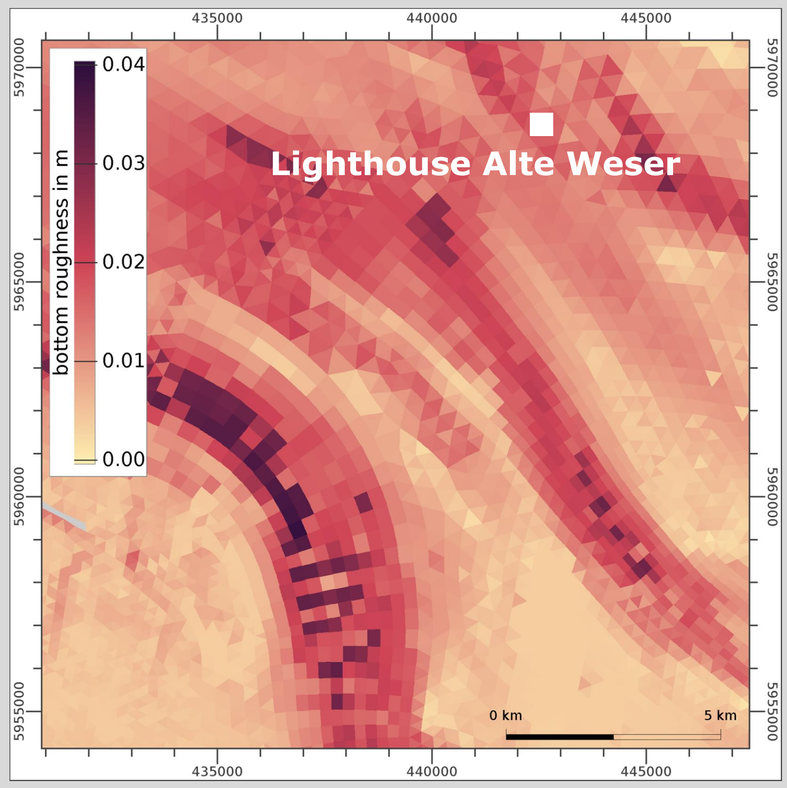

Fig. 4: Modelled bottom roughness at the study site

Calibrated Simulation Parameters

Shallow water depths at the study site make tidal characteristics highly sensitive to bottom roughness. Our calibration was based on more than 150 tide gauges and ca. 60 iterations. We found an optimal parameter configuration of ripples, mega-ripples, and dunes of (0.4, 0.07, 0.005) where ripples and mega-ripples were most beneficial for reproducing the observed sea surface height (Fig. 5).
We obtained a sea surface height RMSE of less than 10 cm at all tide gauges in the Wadden Sea.

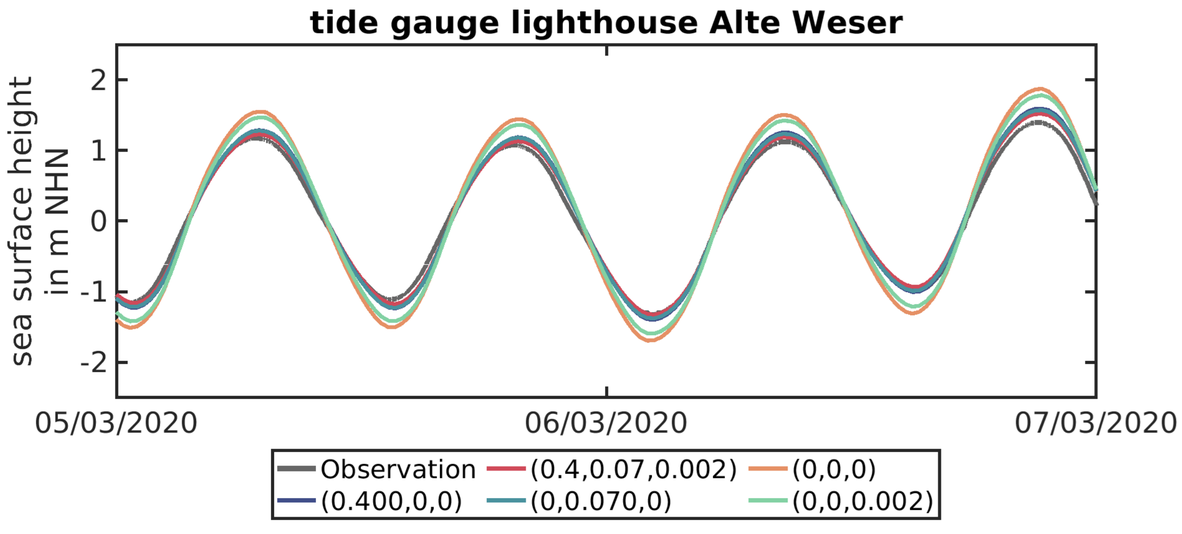

Fig. 5: Measured and modelled sea surface height at tide gauge Lighthouse Alte Weser