QUANTIFYING THE INFLUENCE OF SAND WAVE ORIENTATION ON FORM ROUGHNESS

The Netherlands Continental Shelf, a dynamic seabed dominated by tides is characterized by the presence of sand waves. These sinusoidal features have wavelengths spanning from 100 to 1000 meters, heights of several meters, and migration rates of the order of meters per year. Existing hydrodynamic models, like the Dutch Continental Shelf Model, lack the resolution to capture these features and rely solely on calibration based on water level observations, hindering physical understanding and accurate flow simulations.

While previous research explored the link between sand wave properties and form roughness under perpendicular tidal flow in a 2DV setting, this study extends the analysis to a 3D setting adding additional complexities such as flow structures in both horizontal directions (in the presence of the Coriolis effect), the distribution of two-dimensional shear stress, and the rotation of a sand wave field. Our aim is to analyze the influence of various configurations of a sand wave field (e.g., height, wavelength, orientation) on form roughness.

Using the Delft3D numerical model, we simulated tidal flow over a morphostatic bed with varying sand wave field characteristics. By considering that tidal flow is characterized by several tidal constituents, each represented by an amplitude and a phase, we establish four criteria for quantifying form roughness. The criteria are amplitude-based and phase-based to determine the form roughness that best replicates the observed depth-averaged flow in the direction of the tidal wave propagation and sea surface elevation over the sand waves.

Our findings reveal distinct dependencies of form roughness on sand wave configuration. Increasing height and decreasing wavelength lead to higher form roughness. Orientation impacts roughness differently in each hemisphere, with the Coriolis effect playing a significant role (Figure 1). At the equator, form roughness is symmetrical for some criteria but varies with rotation direction for others.

Notably, for our model configuration, the phase-based criteria are highly sensitive to the starting bathymetric phase. This makes the resulting form roughness for the phase-based criteria highly dependent on the specific bathymetry.

This study highlights the limitations of mimicking flow over sand waves with solely roughness adjustments in flat seabed models. While our method does not provide a single, definitive form roughness value due to the varying dependencies observed, it offers a valuable approach for incorporating bedform information into model calibration. This approach leads to a more physics-based representation of roughness compared to current practices.

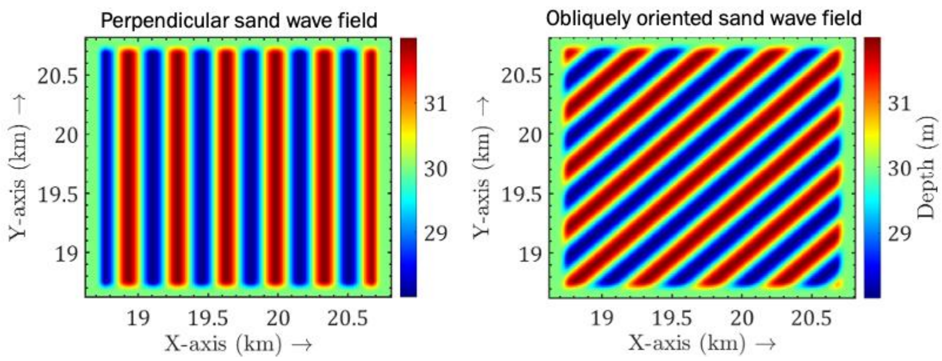

Figure 1: Bathymetric chart of perpendicular (left) and obliquely oriented (right) sand wave field (w.r.t. the dominant tidal flow direction, which is from left to right and vice versa).

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