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Sediment sorting in tidal sand waves fields: the internal structure revealed?

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Tidal sand waves are rhythmic bed forms found on coastal shelves all around the world. An important property of sand waves is their mobility, as they display migration rates of several meters per year. Insight in these dynamics is of practical relevance, as this behaviour may interfere with offshore engineering activities. State-of-the-art morphodynamic models are used to predict sand wave dynamics, but they still overestimate dimensions such as their height (Van Gerwen et al, 2018). Moreover, these models often assume a uniform grain size distribution, whereas field observations indicate a clear sorting of sediments along sand waves. Previous modelling studies found that a combination of sediment mobility effects and tidal current strength may explain these sorting patterns (e.g. van Oyen and Blondeaux, 2009). However, as these models were limited to the early stage of sand wave formation, they did not account for the nonlinear effects of increasing sand wave amplitudes. Our goal is to include these nonlinear effects in order to further unravel sorting processes, in particular the internal sand wave structure.

Hereto we extend the work by van Gerwen et al (2018), allowing for an arbitrary number of sediment fractions, and we adopt the active layer approach of Hirano (1971) to account for bed stratigraphy. To investigate the role of asymmetry in hydrodynamic forcing, we include a residual current superimposed on the dominant tidal component.

Results show that in general the crests of sand waves are coarser than the troughs. In the case of an asymmetrical forcing, larger sediments are found on the upper lee slope, whereas the smaller grains are deposited on the lower lee slope. Due to migration, also the internal structure of the sand wave is revealed over time, showing the same pattern as found on the lee slope surface. Many field studies have shown that these model results qualitatively agree with observations on surficial sorting patterns (e.g. Cheng et al, 2018). However, as field data on the internal sediment structure is scarce, it is difficult to validate this model output.

Hence, the question remains whether the results on the internal sorting are a true representation of the substrate of sand waves. Nonetheless, the model results give insight in the processes governing grain size sorting over and in sand waves, which could be a valuable element in developing future coastal management strategies, such as sand extraction.

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