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Slope-driven sediment transport of sand-mud mixtures in coastal environments

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Estuaries, deltas and tidal basins are highly dynamic systems where sand and mud are transported under the complex interactions of bathymetry, currents and waves. A fundamental understanding of the formation of these coastal environments and how they will respond to changes in the future requires a better understanding of natural dynamics at the scale of individual channels and bars. The current research aims to investigate sediment transport of mud and sand mixtures at bar margins under combined waves and currents, with a particular interest in the effect of varying bedforms. To this end, experiments were conducted in an 11m long recirculating flume with an initially transversely sloped bed, representing a side-slope of a coastal sand bar. Wave intensity and mud content were systematically varied between runs. Results showed two significantly different mechanisms of sediment transport depending on the erodibility of the sediment with a clear threshold of mud content and wave intensity. During experiments with only sand, the transverse slope developed towards a flat bed over the cross-section as a result of waves stirring up the sediment and gravity pulling the sediment downslope. Symmetrical ripples formed over the width of the slope and sediment was actively transported downslope along the ripple crests. Additionally, sand waves with a longer wavelength formed in the longitudinal direction. Adding a relatively low volume of cohesive sediment did not have a significant effect on the speed at which the transverse slope decreased towards a flat bed, but there was a slower adaptation of the morphology in longitudinal direction. Ripples were three-dimensional and with highly varying dimensions based on local mud content and location on the transverse slope. With increasing mud content however, the cohesivity of the sediment mixture increased the threshold of sediment motion and only the higher part of the transverse slope experienced shear stresses that were high enough to transport sediment. Here, the mud was winnowed out of the mixture into suspension and only the sand fraction was transported downslope. Future experiments will focus on linking the direction of sediment transport under combined waves and currents to landscape development to study the larger-scale implications of the observed differences in transport mechanisms and bedform dimensions.