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Migration of sand ripples under shoaling waves

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Onshore migration of vortex ripples that form in the oceanic coastal zone under shoaling waves are studied by laboratory experiments and a semi-empirical parameterization to characterize ripple migration velocity is proposed. Experiments are conducted in a large wave-tank (32m x 0.9m x 1.8m) with a slopping (slope = 1/24) sandy bottom (grain size, d = 0.04 cm) that mimics the oceanic coastal zone. Sinusoidal waves are generated by oscillating a vertical paddle with chosen frequency (0.2-0.75 Hz) and excursion (10-25 cm) values. Although generated waves are initially sinusoidal, as they propagate up the sandy slope towards shallower waters, wave shoaling process takes place and waves become increasingly nonlinear. While propagating up the slope, waves induce an oscillatory shear stress at the sand-water interface, which then causes formation of vortex sand ripples. Since wave forcing is nonlinear over the slope, formed ripples are not stationary, but they migrate in the onshore direction due to more pronounced onshore wave forcing. To elucidate the migration characteristics of vortex ripples, ripple migration velocities under a range of experimental conditions are collected. A parameterization for ripple migration velocities in terms of a new parameter that characterizes the wave asymmetry [$\Lambda = (U_+/U_-)^2$, where U_+ and U_- are maximum onshore and offshore near-bed water velocities, respectively] is proposed and verified by experimental observations. The results are expected to have useful applications in modeling of shallow water cross-shore sediment transport.