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Bedforms induced by solitary waves: laboratory studies on generation and migration rate

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This study presents experiments on the formation of sandy bedforms, produced by surface solitary waves (SSWs) in shallow water conditions. The experiments were carried out in a 12.0 m long, 0.15 m wide and 0.5 m high flume, at Saint Anthony Falls Laboratory in Minneapolis. The tank is filled by fresh water and a removable gate, placed at the left hand-side of the tank, divides the flume in two regions: the lock region and the ambient fluid region. The standard lock-release method generates SSWs by producing a displacement between the free surfaces that are divided by the gate. Wave amplitude, wavelength, and celerity depend on the lock length and on the water level difference between the two regions. Natural sand particles (D_{50}=0.64) are arranged on the bottom in order to form a horizontal flat layer with a thickness of 2 cm. A digital pressure gauge and a high-resolution acoustic velocimeter allowed us to measure, locally, both pressure and 3D water velocity induced on the bottom by each wave. Image analysis technique is then used to obtain the main wave features: amplitude, wavelength, and celerity. Dye is finally used as vertical tracer to mark the horizontal speed induced by the wave. For each experiment we generated 400 waves, having the same features and we analyzed their action on sand particles placed on the bottom. The stroke, induced by each wave, entails a shear stress on the sand particles, causing sediment transport in the direction of wave propagation. Immediately after the wave passage, a back flow occurs near the bottom. The horizontal pressure gradient and the velocity field induced by the wave cause the boundary layer separation and the consequent reverse flow. Depending on the wave features and on the water depth, the boundary shear stress induced by the reverse flow can exceed the critical value inducing the back motion of the sand particles. The experiments show that the particle back motion is localized at particular cross sections along the tank, where the wave steepening occur. For this reason, the pressure and velocity measures were collected in several cross sections along the tank. The propagation of consecutive waves with the same features induces the generation of erosion and accumulation zones, which slowly evolve in isometric bedforms.