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Sand-wave field generated by solitary waves

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This study presents experiments on the formation of bedforms, produced by successive surface solitary waves (SSW) propagating over an initially flat sandy bottom. We investigated the reverse flow that induces boundary layer separation, as produced by SSWs, in order to define the bedforms generation conditions. Immediately after the wave transition, the reverse flow caused by the deceleration occurring in the adverse pressure gradient region occurs. 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 lock exchange method is applied: the tank is preliminary filled by fresh water, then a removable gate is placed at one hand-side of the tank in order to divide the flume into the lock and the ambient fluid regions. At a later stage, further fresh water is added into the lock in order to produce a displacement between the free surfaces divided by the gate. The gate removal induces the generation of a single SSW. We produced 15 SSWs characterized by different amplitude, wavelength, and celerity and propagating over a flat bottom at different depths. Natural sand particles with a mean diameter of 0.64 mm are arranged on the bottom in order to form the 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 5 mm from the bottom by each wave. For each experiment we generated 400 waves, having the same features and we analyzed their action on sand particles placed on the bottom. For 7 experiments the action of consecutive waves with the same features induced the generation of a sand-wave field characterized by equal to each other and asymmetric dunes. 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. We show how the wave surface and celerity do not directly affect the bedforms triggering process, rather only for particular combination of wave amplitude, wavelength and water depth the reverse flow is strong enough to induce bedforms generation. The reverse flow takes place much more easily as much as the hydrodynamic process assumes an unsteady behavior.