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Sediment bed destabilization induced by oscillating horizontal pressure gradients

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Experiments in a physical model of a beach in a two-dimensional wave flume were designed to investigate processes leading to bed destabilization and sediment transport. The mobile bed consists of a coarse material of low density ($\rho_s = 1.19$ kg/m^3, median diameter of 0.64 mm). The wave conditions consist in the succession of two bichromatic wave groups with carrier wave periods of 2 s and 2.5 s. The repetition of identical wave series over quasi-equilibrium beach profiles enables ensemble averaging in order to determine oscillatory and fluctuating quantities. By means of an acoustic Doppler velocimeter, the cross-shore and vertical velocities were measured in the surf zone along a vertical profile from the free-stream elevation down to the bed level with a resolution of 3 mm. Additional measurements of the pressure at two close positions aligned horizontally were undertaken. The bed destabilization was detected via acoustic and optical methods. Both methods are cross-compared and give similar results, indicating strong bed erosion at the wave front that is clearly leading the phase of maximum velocity and bed shear stress. The shear stress and the horizontal pressure gradient are computed at a near-bed elevation (between the bed elevation and 3 mm above it). Turbulence over the bed is analyzed and gives results in agreement with previous works (see van der A, D.A., O'Donoghue, T., Davies, A.G. and Ribberink, J.S. 2011, Experimental study of the turbulent boundary layer in acceleration-skewed oscillatory flow. *J. Fluid Mech.* 684, 251-283, for example). In contrast with fixed bed studies, the Reynolds shear stress is found to be small compared to the orbital flow transfer of momentum. A simple model for bed incipient motion derived from the work of Sleath (Sleath, J.F.A. 1999, Conditions for plug formation in oscillatory flow. *Cont. Shelf Res.* 19 (13), 1643-1664) is recalled. Both the model and the measurements confirm that destabilization occurs when the horizontal pressure gradient exceeds a threshold value. The shear stress measured at the phase of destabilization is found to be negative. Indeed, during those phases, the destabilized bed in the form of a plug flow, is driving the fluid into motion.