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Experimental and numerical analysis of turbulence/mobile-bed interactions

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Highly resoluted and co-located velocity and concentration measurements have been obtained by using an Acoustic Concentration and Velocity Profiler (ACVP) in an intense sediment transport laboratory experiment. This dataset is used to investigate the complex coupling between the turbulent fluid motion and the sediment bed. It has been shown that the bed interface position is highly intermittent because of the impact of the large-scale coherent structures. The important contribution of the streamwise turbulent fluxes observed close to the sediment bed might be related to the bed-intermittency. In return, the mobile bed affects the turbulent fluid flow. It is shown that the turbulent kinetic energy is enhanced by the bed-mobility compared with a similar clear-water flow. However the streamwise and wall-normal velocity fluctuations are observed to be less correlated in the suspension region, resulting in a reduced efficiency of turbulence for momentum mixing. In the suspension region, the turbulent particle diffusivity is shown to be twice greater than the momentum diffusivity. Two possible mechanisms might provide an explanation for this feature. First, the increased contribution of the so-called interaction turbulent events tend to increase the velocity gradients, consistently with a drop of momentum mixing. These interactions events are also efficient to increase particle dispersion and hence to increase concentration mixing. Second, the turbulent particle diffusivity is directly proportional to the particle settling velocity which is classically taken as the one measured or computed in still-water conditions. However, different mechanisms highlighted in the literatures imply a turbulence-induced modification of the settling velocity. This modification could partly explain why the turbulent concentration mixing appears to be more efficient than the momentum one in sediment-laden flows. These experimental results are utilized to improve the sub-grid dissipation and drag models in Large Eddy Simulations. The sub-grid effects in two-phase LES simulations constitute a scientific bottleneck to significantly improve our understanding of sediment transport mechanisms and therefore to accurately predict sediment transport rates and erosion in the field.