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Numerical modelling of bedload sediment transport

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We present a numerical study of sediment transport in the bedload regime. Classical bedload transport laws only describe the variation of the vertically integrated flux of grains as a function of the Shields number. However, these relations are only valid if the moving layer of the bed is at equilibrium with the external flow. Besides, they do not contain enough information for many geomorphological applications. For instance, understanding inertial effects in the moving bed requires models that are able to account for the variability of hydrodynamical conditions, and the discrete nature of the sediment material.

We developped a numerical modelling of the behaviour of a three-dimensional bed of grains sheared by a unidirectional fluid flow. These simulations are based on a combination of discrete and continuum approaches: sediment particles are modelled by hard spheres interacting through simple contact forces, whereas the fluid flow is described by a 'mean field' model. Both the drag exerted on grains by the fluid and the retroactive effect of the presence of grains on the flow are accounted for, allowing the system to converge to its equilibrium state (no assumption is made on the fluid velocity profile inside the layer of moving grains).

Above the motion threshold, the variation of the flux of grains in the steady state is found to vary like the cube of the Shields number (as predicted by Bagnold). Besides, our simulations allow us to obtain new insights into the detailed mechanisms of bedload transport, by giving access to non-integral quantities, such as the trajectories of each individual grains, the detailed velocity and packing fraction profiles inside the granular bed, etc. It is therefore possible to investigate some effects that are not accounted for in usual continuum models, such as the polydispersity of grains, the ageing of the bed, the response to a variation of the flowrate, etc.