EGU21-13221, updated on 29 Jan 2022
https://doi.org/10.5194/egusphere-egu21-13221
EGU General Assembly 2021

Investigation on hydrodynamic forces leading to coarse particle entrainment using Large-Eddy Simulations

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The prediction of particle motion in a fluid flow environment presents several challenges from the quantification of the forces exerted by the fluid onto the solids -normally with fluctuating behaviour due to turbulence- and the definition of the potential particle entrainment from these actions. An accurate description of these phenomena has many practical applications in local scour definition and to the design of protection measures.

In the present work, the actions of different flow conditions on sediment particles is investigated with the aim to translate these effects into particle entrainment identification through analytical solid dynamic equations.

Large Eddy Simulations (LES) are an increasingly practical tool that provide an accurate representation of both the mean flow field and the large-scale turbulent fluctuations. For the present case, the forces exerted by the flow are integrated over the surface of a stationary particle in the streamwise (drag) and vertical (lift) directions, together with the torques around the particle's centre of mass. These forces are validated against experimental data under the same bed and flow conditions.

The forces are then compared against threshold values, obtained through theoretical equations of simple motions such as rolling without sliding. Thus, the frequency of entrainment is related to the different flow conditions in good agreement with results from experimental sediment entrainment research.

A thorough monitoring of the velocity flow field on several locations is carried out to determine the relationships between velocity time series at several locations around the particle and the forces acting on its surface. These results a relevant to determine ideal locations for flow investigation both in numerical and physical experiments.

Through numerical experiments, a large number of flow conditions were simulated obtaining a full set of actions over a fixed particle sitting on a smooth bed. These actions were translated into potential particle entrainment events and validated against experimental data. Future work will present the coupling of these LES models with Discrete Element Method (DEM) models to verify the entrainment phenomena entirely from a numerical perspective.