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The role of unsteady forces for sediment particles in bedload transport

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In engineering, bedload transport is usually predicted by a variety of formulas, and huge uncertainty is found from case to case. One of the fundamental reasons is the lack of fully understanding the dynamic behavior of bedload particles. We explore the dynamic characteristics of sediment particles transported in turbulent open-channel flows. A numerical model of sediment transport is built by combining the large eddy simulation (LES) with discrete element model (DEM) using a fully four-way coupling method. Particular attention is paid to the hydrodynamic forces acting on bedload particles. The result shows that, in addition to drag force, the unsteady forces (i.e. Basset history force and added mass force) are important (40%∼60% in the summation of all the time-averaged magnitude of forces) for fine sediment particles (with a diameter of 0.5 mm), which are usually ignored for computational complexity. While the lift force has been found to be significant for gravel particles (with a diameter of 31 mm)[1], it is not relatively dominant for such fine particles (less than 3% in the summation). This helps explaining why the prediction of the same formula change greatly from case to case. The comparison with experimental data also shows great potential of the current LES-DEM model for fundamental research in bedload transport.

Reference:
[1] Nino, Y., & Garcia, M. (1994). Gravel saltation 2. Modeling. Water Resources Research, 30(6), 1915–1924.