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Particle-scale fluid-particle interactions in particle-laden gravity flows over the flat slope

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This study used the LES-DEM (Large-Eddy Simulation and Discrete Element Method) model to simulate the lock-exchange particle-laden gravity flow over a flat slope and studied its fluid-particle interactions. The following understandings are obtained. According to the longitudinal particle-fluid interaction force, the flat-slope lock-exchange PGF process can be divided into two stages: fluid conveying particles (Stage I) and particles pushing fluid (Stage II). In the early Stage I, due to the positive vorticity and the positive slip velocity, the lift force plays a leading role in the interaction force. And in the later Stage I, the drag force causes the fluid to push the particles when the lift force decreases and becomes negative due to the negative vorticity caused by the bottom resistance. In Stage II, the lift force hinders the particles' advancement, which exceeds the drag force that transports the particles forward. The vertical suspension of particles mainly benefits from drag force and contact force, and the former is more prominent. In addition, the longitudinal transport of head particles is mainly controlled by the lift force caused by positive vorticity which is cause by the resistance from the ambient fluid at the current profile. Based on the interaction force, the study distinguishes two energy conversion modes. The final destination of the energy in the two modes is longitudinal particle kinetic energy and longitudinal fluid kinetic energy, respectively.