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A dynamic multilayer shallow water model for polydisperse sedimentation

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Resumen

A multilayer shallow water approach for the approximate description of polydisperse sedimentation in a viscous fluid is presented. The fluid is assumed to carry finely dispersed solid particles that belong to a finite number of species that differ in density and size. These species segregate and form areas of different composition. In addition, the settling of particles influences the motion of the ambient fluid. A distinct feature of the new approach is the particular definition of the average velocity of the mixture. It takes into account the densities of the solid particles and the fluid and allows us to recover the global mass conservation and linear momentum balance laws of the mixture. This definition motivates a modification of the Masliyah-Lockett-Bassoon (MLB) settling velocities of each species. The multilayer shallow water model allows one to determine the spatial distribution of the solid particles, the velocity field, and the evolution of the free surface of the mixture. The final model can be written as a multilayer model with variable density where the unknowns are the averaged velocities and concentrations in each layer, the transfer terms across each interface, and the total mass. An explicit formula of the transfer terms leads to a reduced form of the system. Finally, an explicit bound of the minimum and maximum eigenvalues of the transport matrix of the system is utilized to design a Harten-Lax-van Leer (HLL)-type path-conservative numerical method. Numerical simulations illustrate the coupled polydisperse sedimentation and flow fields in various scenarios, including sedimentation in a type of basin that is used in practice in mining industry and in a basin whose bottom topography gives rise to recirculations of the fluid and high solids concentrations. This presentation is based on joint work with Enrique D. Fernández-Nieto (Universidad de Sevilla, Spain) and Víctor Osores (Universidad de Concepción).

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