Powder snow avalanches: Approximation as non-Boussinesq clouds with a Richardson number-dependent entrainment function

This paper presents an investigation into non-Boussinesq particle-driven gravity currents such as powder snow avalanches and pyroclastic flows. For a finite-volume current to maintain its non-Boussinesq character (i.e., a substantial density difference with its surroundings) and therefore high velocities, it must counterbalance the entrainment of surrounding fluid by entraining particles from the bed. A number of theoretical models have assumed that the volume growth rate of such currents is controlled by the local slope and the density ratio between the current and the ambient fluid. An alternative assumption, according to which the volume growth rate is controlled solely by the overall Richardson number, is examined here. Both assumptions were used successively in the same theoretical model, primarily developed by A. G. Kulikovskiy and E. I. Sveshnikova, then by P. Beghin. The model predictions were compared to laboratory experiments (release of a finite volume down an inclined channel, with particle entrainment from the bed) and field data (a well-documented large powder snow avalanche in Switzerland). In both cases, the assumption of a slope-dependent volume growth rate received little support, whereas assuming that the entrainment coefficient is controlled by the Richardson number makes it possible to describe the velocity and volume variations fairly well, except for highly concentrated particle-driven currents in the laboratory.

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