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A sedimentological model for quantifying the sedimentation rate from particle laden turbulent boundary layer shear flows

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Particle laden turbulent boundary layers are a common natural process, the most notable examples being turbidity currents and pyroclastic density currents (PDCs). Both are characterized by a vertical particle concentration stratification, which develops as a results of segregation mechanisms of the polydisperse particles mixtures in a turbulent flow. Understanding the sedimentation mechanisms in these flows is crucial for predicting their mobility (e.g. travelled distance) and eventually their impact on the environment. In fact, the motion of these flows is mainly driven by the density contrast with the surrounding environment (water for turbidity currents, atmosphere for PDCs). Additionally, the sedimentation rate can be used to calculate the sedimentation time, i.e. the time that particles take to settle in the flow and form the deposit.
Here we present a new model for calculating the sedimentation rate of these flows. The model has been obtained by large-scale experiments on explosive volcanic eruptions. In the experiments, PDCs were generated as a result of the impact of a dense gas-particle fountain on the ground. The subsequent flows were monitored via an array of video-cameras, which allowed to quantify the space and time evolution of the flow velocity and thickness. The deposits left by the PDCs were sampled at regular distances and analysed in the laboratory to quantify the deposit mass over unit area and the grainsize distribution. The measurements allowed to obtain a correlation between the sedimentation rate and particles and flow properties (particle size, density, shape, flow Rouse number, etc.).
The new model has been implemented into a simplified computational model designed for calculating the flow properties of past PDCs based on their deposits' characteristics and applied to past PDCs at Vesuvius and Campi Flegrei (Italy). As a result of the calculation of the sedimentation rate of these two cases, important insights on the duration of these flows have been obtained, which has implication on the hazard quantification of PDCs.