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1-D numerical simulation of the gas-particles flow in vertical conduits during large-scale experiments on the mechanics of explosive eruptions

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Explosive volcanic eruptions are the most dangerous events that can affect the areas surrounding active volcanoes. It is well known that conduit exit conditions play a major role in determining the rate and style of explosive eruptions, which in turn determines the typology of impact on the areas subjected to volcanic risk. For these reasons many researchers tried to develop models for the forecasting of conduit exit conditions. Theoretical and numerical modeling are the most widespread approach in volcanology. Experimental models are not common because of the difficulties to set-up large-scale experiments. For this reason theoretical and numerical models always lack in the experimental validation. Dellino et al. (2007) developed the first large-scale experiments on the mechanics of explosive eruptions that proved to scale well to natural cases. From these experiments, Dellino et al. (2009) developed an experimental model for the forecasting of exit velocity of eruptive mixtures and the conditions of stability of the main eruptive styles. The next step is to create numerical models that reproduce the large-scale experiments and then to apply them to the real eruptions. This would be the first time that a numerical model is validated against large-scale experiments in volcanology. Here we present a steady 1-D two-phase numerical model of the gas-particles flow in the conduit, that is the first stage of the experiments. The equations of conservation of mass and momentum for gas and volcanic particles are solved via the Runge-Kutta scheme with an adaptive stepsize. All the experimental runs were simulated. The model takes in account the real shape of volcanic particles and uses the well established law of Dellino et al. (2005) for the calculation of particles terminal velocity. The pressure gradient in the conduit, which is the main driving force of the vertical two-phase flow, is obtained by the same empirical model. Finally the interphase drag force and the friction between the phases and the conduit wall are included by using the empirical laws for wall-particles and wall-fluid frictions developed in industrial engineering and classic fluid dynamics. All the experimental runs have been simulated and the model results in mixture exit velocities that are consistent with the ones measured in the experiments. Therefore the numerical model is promising and can be improved and used for the simulation of real cases.