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A numerical code of explosive conduit flows constrained by large-scale experiments

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Conduit exit conditions during explosive eruptions play a major role in determining the rate and style of the eruptive column. The main parameter characterizing the eruptive mixture at conduit exit is mass eruption rate (MER), which is the product of velocity, density and conduit section area. This was perceived by the first researchers, who constructed theoretical model on the dynamics of explosive eruptions (Wilson et al., 1980; Woods, 1988; Bursik and Woods, 1991). Numerical modelling also helped scientists in the understanding of the complex dynamics of this kind of eruptions (Macedonio et al., 2005; Neri et al., 1998; Papale, 2001; Papale et al., 1998). Finally, the first large scale experiments on the mechanics of eruptive columns and pyroclastic flows (Dellino et al., 2007) allowed the development of an empirical model for the prediction of exit velocity of eruptive mixtures and the conditions of existence of the main eruptive styles (Dellino et al., 2009). Since the experiments were successfully scaled to real eruptions, we implemented a numerical model that reproduces the main quantities measured in the experiments, with the aim of eventually extending the model to the natural case. This would be the first time that a numerical model on the mechanics of explosive eruptions is validated against large-scale experiments. A steady 1-D two phase numerical model of the conduit flow is presented here. In this model the equations of conservation of mass and momentum for gas and volcanic particles are solved via a Runge-Kutta method with an adaptive stepsize. The numerical model is implemented in a code written in Fortran 77 language. The use of an adaptive stepsize control over the Runge-Kutta method allows the achievement of a predetermined accuracy (in this case of the order of 10-5) with minimum computational effort. All the conditions of the experimental runs are implemented and the velocity field is initialized using the empirical model for mixture velocity (Dellino et al., 2009). The model takes in account the real shape of volcanic ash 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 represents the main driving force of the vertical two-phase flow, is obtained by the same empirical model (Dellino et al., 2009). Finally the interphase drag force and the friction between the phases and the conduit wall are included: the classic empirical laws for wall-particles and wall-fluid frictions developed in industrial engineering and classic fluid dynamics are implemented in the code. All the experimental runs have been simulated with the numerical code, and the model results in velocities that are quite consistent with experiments.