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Testing a continuum approach for the modeling of pyroclastic flows

G. Cordoba (1), H.M. Mader (2) and R.S.J. Sparks (2)

(1) University of Bristol, Universidad de Narinno (Contact glgcg@bristol.ac.uk). (2) University of Bristol

Explosive volcanism can produce collapsing columns or dome explosions. Both phenomena develop particle-laden gravity currents, which are known as pyroclastic flows. Typical volcanic hazards maps only account for the run-out distance. We here present numerical work in progress aimed at giving a better idea of the emplacement mechanism, deposit, structure, and dynamical parameters of pyroclastic flows.

Modeling is now an attractive tool for hazard assessment which can provide a better understanding of the phenomenon to the decision makers. At least three major approaches of pyroclastic flow modeling are in research: 1) quasi-empirical models, which try to use the knowledge of past flows to arrive a simple and general laws (i.e. Energy Lines); 2) quasi-analytical models, which adopt analytical solutions by simplify the problem, and 3) the continuum approach, which assume that the flow can be described by pure fluid dynamics equations.

A pyroclastic flow is usually divided into two parts: a granular basal part and a dilute companion cloud. The basal part is characterized by its high concentration of particles ranging from 10's of centimeters to microns whose dynamical behavior is mainly governed by particle interactions. As a result a pure fluid dynamical description is not valid.

By contrast the companion cloud is typically dilute, so a fluid dynamical approach is possible and we use the Navier-Stokes equations, coupled with one Convection-Diffusion-Sedimentation equation for each particle size to describe the flow. The assumption of the same velocity for particles and fluid allow us to use only one set of Navier-Stokes equations which reduces the CPU cost. The equation system is solved by the Finite Element Method.

In order to provide confidence in the model, several tests have been performed. The resulting velocity and concentration fields have been tested against several laboratory experiments, which account for run-out distance, concentration profiles, and deposit shapes. Also, the change in time of the concentration and velocity has been tested. The modeled amount of deposited material is tested for mono and polidisperse flows. For the front advance in time, the model shows no statistical difference between the numerical approach and the experiments. Good agreement is shown between the modeled concentration and deposited material and the experiments.