Geophysical Research Abstracts
Vol. 16, EGU2014-11307, 2014
EGU General Assembly 2014

Application of a quadrature-based moments method to the modeling of volcanic plumes

Mattia de' Michieli Vitturi (1), Sara Barsotti (2), and Augusto Neri (1)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Pisa, Italy (demichie@pi.ingv.it), (2) Icelandic Meteorological Office, Reykjavìk, Iceland

In the past decades, numerical simulation of volcanic eruptions has greatly advanced and models are now often able to deal with the multiphase nature of volcanic flows. This is the case, for example, of models describing the dynamics of pyroclastic particles in a volcanic plume, or that of bubbles and crystals dispersed in the magma rising in a volcanic conduit.
Despite that, in numerical models, the polydispersity associated with the multiphase nature of volcanic flows is often ignored or largely simplified. For instance, in most of the existing conduit models, crystals and bubbles are treated as simple flow components and described by volume fractions only, while in plume dynamics and ash dispersal models the grain size distribution of pyroclasts is discretized in a finite number of classes (i.e. phases). Both these approaches make difficult a proper treatment of the continuous variability of fundamental physical and chemical properties of the dispersed phases, such as, for instance, the dimension of pyroclastic particles and gas bubbles. Literature results clearly show that this variability can largely affect relevant physical/chemical processes that occur during the transport of the dispersed phase such as, for example, the nucleation and grow of bubbles and the coalescence/breakage of bubbles and crystals in the conduit or the aggregation of pyroclastic particles in a volcanic plume.
Recently, a theoretical framework and the corresponding computational models, namely the method of moments for disperse multiphase flows, have been developed, mostly in the chemical engineering community, to tracks the evolution of these systems not only in the physical space, but also in the space of properties of the dispersed phase (called internal coordinates).
According to this method, a population balance equation is formulated as a continuity statement written in terms of a number density function (NDF). From the NDF transport equations some integral quantities of interest (namely the moments) are then derived and their transport equations formulated.
For this work we extended, by adopting the method of moments, the Eulerian steady-state volcanic plume model presented in Barsotti et al. (2008). Differently from the original works where pyroclastic particles were partitioned in a finite number of classes with different size and properties, the new model is able to consider a continuous size distribution function of pyroclasts, f(D), representing the particles (for unit volume) with diameter between D and D+dD. Accordingly, transport equations for the moments of the ash particles size distribution are derived and the equations of the plume are expressed in terms of the moments.
Here we present the new multiphase model formulation based on the implementation of the quadrature method of moments together with its advantages and drawbacks with respect to previous approaches. Results of a sensitivity analysis of the model with respect to the parameters of the continuous distribution describing the grain sizes at the vent (lognormal or beta distributions) are also shown and discussed.

Barsotti, S., Neri, A., and Scire, J.: The VOL-CALPUFF model for atmospheric ash dispersal: 1. Approach and physical formulation, Journal of Geophysical Research, 113, 2008.