Results of the eruptive column model inter-comparison study

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Plume heights developed during explosive volcanic eruptions are key observable data for estimating crucial parameters such as mass eruption rate, and they are commonly used as input for dispersal models of tephra particles. Therefore, the accurate description of the relationships between plume heights and eruption conditions has been required. In the past decades, several volcanic plume models have been developed, including the more recent sophisticated computational fluid dynamics models. In this study, we presents results of the volcanic plume model inter-comparison study promoted by the IAVCEI Commission on Tephra Hazard Modelling.

This study compared empirical parameterizations (0D), and simulations of one-dimensional (1D) and three-dimensional (3D) numerical models in a set of inter-comparison exercises to evaluate model capabilities and highlight aspects requiring improvement and future research. The study involved four 0D, nine 1D models based on different extensions of the Buoyant Plume Theory (Morton et al,, 1956), and four 3D models describing the transient dynamics of volcanic plumes. The exercises were designed as tests in which a set of common input parameters was given for two reference eruptions, representing a strong and a weak eruption column, under different meteorological conditions.

Despite their different formulations, the 1D and 3D models provide reasonably consistent predictions of maximum height of plume. Variability in plume height, estimated from the standard deviation of model predictions, is within ~20% for the weak plume and ~10% for the strong plume. Predictions of neutral buoyancy level where the plume density is equal to the atmospheric density, are also in reasonably good agreement among the different models with a standard deviation ranging from 9 to 19%. There are important differences amongst models in terms of local properties along the plume axis, particularly for the strong plume. Our analysis suggests that the simplified treatment of air entrainment in 1D models is adequate to resolve the general behavior of the weak plume. However, it is inadequate to capture complex features of the strong plume such as large vortices. There is a need to more accurately quantify entrainment rates, improve the representation of plume radius, and incorporate the effects of column instability in future versions of 1D volcanic plume models.

Keywords: explosive volcanism, eruptive plumes dynamics, fluid dynamic models, model inter-comparison, eruption source parameters

