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Numerical simulations and parameterizations of volcanic plumes observed at Reunion Island

Sandra Gurwinder Sivia (1), Francois Gheusi (1), Celine Mari (1), Andrea DiMuro (2), and Pierre Tulet (3)

(1) CNRS - Laboratoire D'Aerologie, University of Toulouse, Toulouse, France (sandra.sivia@aero.obs-mip.fr), (2) Institut de Physique du Globe de Paris (IPGP), UMR7154, Paris, France (dimuro@ipgp.fr), (3) LACy, UMR8105, CNRS - University of La Reunion, Meteo-France, France (pierre.tulet@univ-reunion.fr)

Volcanoes are natural composite hazards. The volcanic ejecta can have considerable impact on human health. Volcanic gases and ash, can be especially harmful to people with lung disease such as asthma. Volcanic gases that pose the greatest potential hazards are sulfur dioxide, carbon dioxide, and hydrogen fluoride. Locally, sulfur dioxide gas can lead to acid rain and air pollution downwind from a volcano. These gases can come from lava flows as well as volcano eruptive plumes. This acidic pollution can be transported by wind over large distances.
To comply with regulatory rules, modeling tools are needed to accurately predict the contribution of volcanic emissions to air quality degradation. Unfortunately, the ability of existing models to simulate volcanic plume production and dispersion is currently limited by inaccurate volcanic emissions and uncertainties in plume-rise estimates.

The present work is dedicated to the study of deep injections of volcanic emissions into the troposphere developed as consequence of intense but localized input of heat near eruptive mouths. This work covers three aspects. First a precise quantification of heat sources in terms of surface, geometry and heat source intensity is done for the Piton de la Fournaise volcano. Second, large eddy simulation (LES) are performed with the Meso-NH model to determine the dynamics and vertical development of volcanic plumes. The estimated energy fluxes and the geometry of the heat source is used at the bottom boundary to generate and sustain the plume, while, passive tracers are used to represent volcanic gases and their injection into the atmosphere. The realism of the simulated plumes is validated on the basis of plume observations. The LES simulations finally serve as references for the development of column parameterizations for the coarser resolution version of the model which is the third aspect of the present work. At spatial resolution coarser than $\sim$1km, buoyant volcanic plumes are sub-grid processes. A new parameterization for the injection height is presented which is based on a modified version of the eddy-diffusivity/mass-flux scheme initially developed for the simulation of convective boundary layer.