CFD Modelling of the Local Effects of Caldera, Crater Walls and Windfield Variations on Trapping Potentially Harmful Volcanic Gases

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In the recent decades, progress in affordable computing capacity and the development of reliable computational fluid dynamics (CFD) solutions to solve high-resolution engineering issues have opened the possibilities to simulate environmental micro- to meso-scale fluids and solid-fluid processes with ease at an ever decreasing cost.
In the present contribution, the author assesses the role of volcanic crater morphometry on different windfields, in order to better understand the hazards that gases pose to local inhabitants and tourists. Indeed, eco-tourism and adventure tourism is bringing an ever increasing number of non-locals to various volcanoes, which aren't always sufficiently instrumented (i.e. the Kelut or Semeru and Tengger Caldera in Java, Indonesia).
The method uses the fluid dynamic solution FLUENT, recognized as one of the best and most reliable engineering software for CFD computing. The computation domain is a 2D 100 m length x 100 m height with the boundary conditions being the ground using consolidated ash material, the "outlets" controlled by pressure variation and the inlet controlled through a velocity field. The ground represents the caldera walls, which have been grown and reduced from 5 m height to 50 m height in order to experiment the effects of a change in the caldera/crater floor. The velocity field was also experimented with velocities from 10 m.s-1 to 30 m.s-1.
The results have shown that the velocity field variation and the size of the caldera/crater have a direct incidence on the formation of dynamic eddies inside and outside the crater/caldera. Flow separation is most likely to occur at higher wind-speeds and deeper caldera/craters also create pool effects where rotating eddies can trap volcanic gases.
This simulation does not take into account the temperature inversions that often occur in topographic depressions, creating pools of cold air trapped in the topographic low. The air is considered to be at a constant temperature with a limited effect of ground heating from radiation.

Keywords: volcanic gases, hazards, computational fluid dynamics, volcanic vent, caldera, crater