Topographic effects on pyroclastic density current dynamics: examples from Merapi, Lascar and Soufriere Hills volcanoes

Sylvain J Charbonnier[1], Eliza Calder[2], Sarah Ogburn[2], Chuck B Connor[1], Jean-Christophe Komorowski[3], Ralf Gertisser[4]

[1]University of South Florida, USA, [2]SUNY at Buffao, USA, [3]IPGP, France, [4]Keele University, United Kingdom

E-mail: sylvain@usf.edu

The scale, duration, periodicity and spatial distribution of pyroclastic density currents (PDCs) are remarkably difficult to predict. This is partly due to the characteristics of the source itself (for example, size, volume, orientation and material rheology), but also to the nature and complexity of the topographic profile of the volcanoes both near the source (proximal areas) and down the flanks (medial to distal areas). Traditionally, qualitative techniques for studying PDCs have been crucial to improve knowledge of the topographic effects on flow dynamics. Detailed work on the small-volume PDCs at Merapi, Lascar and Montserrat support delineation of significant flow features: (1) a main transport and deposition model for valley-confined flows that involves unsteady flow conditions generated by pulses of collapse at the source and/or by the development of kinetic waves during flow movement; (2) the development of syn-eruption deposit accretion in areas where the original channel morphology/topography provides accommodation space and/or creates distinct flow barriers; (3) the breakout of valley-confined PDCs into overbank flows and/or ash cloud surges, where the topography of the infilling valley deposits reaches a critical distance relative to the retaining capacity of the topography. For any given flow, and location in the valley, this distance is a dynamic function relating to the depth of the previous in-filling material, the height and detailed morphology of the valley, the cross-sectional area of the valley, the velocity and thickness/volume of the flow and, possibly, the presence/influence of kinetic waves in the main flows. Moreover, PDC hazards related to overbanking processes are often associated with the dynamic pressure associated with large block impacts, stressing the importance to better resolve the relationship between block velocity, block deposition, and topography.

The 2006 and 2010 events at Merapi Volcano, as well as some case studies from volcanoes in Central and South Americas, offer great opportunities to test the ability of some conceptual flow models to reproduce the studied actual events. It can also be shown that the use of high-resolution satellite datasets and digital elevation models (DEMs) allow us to better understand the influence of varying topographic parameters on the dynamics of PDCs by quantifying the relationships between deposit sedimentological features, retaining capacity of landscape features and scale-dependent tendencies for flows to overbank.

The integration of results and constraints from field-derived data, satellite imagery and numerical modeling is one of the main challenges for future research into the dynamics of PDCs. A combination of these different techniques is vital for an accurate characterization of areas prone to such currents and their associated hazard levels, thereby reducing their future risk and impact.