New empirical approach to estimate proximal volcanic hazard zones

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The conceptual model of the energy line is a simple but useful tool for the spatial analysis of volcanic processes. It is based in a basic frictional behavior, where the potential energy of a solid body sliding downward over a slope totally degrades by friction forces during the transport. This model parameterizes the maximum runout of the flow with the HL ratio where H is the vertical drop and L the lateral extent of each deposit. Because of the mobility is related to flow dynamics, there are typical values of HL for different flow types.

Cartographic application of this concept is straightforward and therefore useful to delineate hazard zones around stratovolcanoes. They are shaped from the intersection of surface topography with the theoretical cone produced by rotation of the energy line defined by the HL ratio, usually considering some additional elevation at the summit. However, most classical problems with this model are related to the large runouts of pyroclastic flows and large volume debris avalanches. In fact, the use of HL cones usually underestimates runouts in topographically depressed areas whereas it overestimates the hazard zone in the proximal area.

On the other hand, several studies based on morphometric analysis of regular shaped volcanoes depict highly non linear flank geometries. In fact, curved geometries as those traced from parabolic and logarithmic expressions seem to fit better the natural volcano shapes.

Here we propose a modified strategy to trace areas inundated by non-water saturated, high energy, gravitational-driven volcanic processes, now using parabolic-shaped energy cones. Because of the fast declining at the source and asymptotic behavior at the terminal zone, parabolic surfaces fit better the area inundated by high-mobility, channelized, pyroclastic density currents. Our initial test in the Central Andes shows promising results especially with high volume volcanic avalanches and some unusually large pyroclastic flows. This tool is intended as an empirical solution and understanding of the physical basis is beyond the scope of this contribution. However, we hypothesize that lateral momentum transfer, gas fluidization and interaction forces within the flow are playing a role in such a high mobility density currents, whose impact areas are better depicted with parabolic surfaces.