3D ballistic transport of volcanic projectiles considering variable drag and wind advection: Applications, inverse modelling and probabilistic hazards

Daniel Bertin[1]

[1]Servicio Nacional de Geología y Minería, Red Nacional de Vigilancia Volcánica, Chile

Key words: Ballistic projectiles; wind advection; inverse modelling; forward modelling; probabilistic hazard map

An innovative model for the trajectory of volcanic ballistic projectiles is presented here. The model considers ellipsoidal particles subjected to virtual mass forces, drag forces, and a two-dimensional wind field. Unlike other models developed so far, a correction term called 'effective drag coefficient' is proposed in order to weight up drag coefficients for different block sizes. Surprisingly, numerical modelling suggests that besides the straightforward initial velocity and launch angle, another first-order parameter influencing ballistic trajectories is the minor radius. Drag forces, block density, major radius and the wind field are second-order factors, whereas intermediate radius and virtual mass forces are of third-order. The wind field influences trajectories in a similar way as that of drag forces, suggesting that it should not be neglected in any ballistic model, especially those focused on inverse modelling. This model was used to constrain the input parameters behind the biggest and farthest impact crater formed during the 1984-1993 eruptive cycle of Láscar volcano (northern Chile), finding out 34 plausible arrays that satisfy the field data. This procedure enabled to set up the upper value of some crucial parameters for random ballistic modelling, where up to 1,000 simulations were run at every launch azimuth and their results summarized as a quantitative probabilistic ballistic hazard map. Moreover, two transects were also done in order to depict aerial hazard zones based on the same probabilistic procedure. Both maps combined can be useful as a prevention tool for ground and aerial transit nearby unresting volcanoes, as well as a valid hazards appraisal during volcanic crises.