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Algorithm-based high-speed video analysis yields new insights into Strombolian eruptions

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Strombolian eruptions are characterized by mild, frequent explosions that eject gas and ash- to bomb-sized pyroclasts into the atmosphere. The observation of the products of the explosion is crucial, both for direct hazard assessment and for understanding eruption dynamics. Conventional thermal and optical imaging allows a first characterization of several eruptive processes, but the use of high speed cameras, with frame rates of 500 Hz or more, allows to follow the particles on multiples frames, and to reconstruct their trajectories.
However, the manual processing of the images is time consuming. Consequently, it does not allow neither the routine monitoring nor averaged statistics, since only relatively few, selected particles (usually the fastest) can be taken into account. In addition, manual processing is quite inefficient to compute the total ejected mass, since it requires to count each individual particle.
In this presentation, we discuss the advantages of using numerical methods for the tracking of the particles and the description of the explosion. A toolbox called “Pyroclast Tracking Velocimetry” is used to compute the size and the trajectory of each individual particle. A large variety of parameters can be derived and statistically compared: ejection velocity, ejection angle, deceleration, size, mass, etc.
At the scale of the explosion, the total mass, the mean velocity of the particles, the number and the frequency of ejection pulses can be estimated. The study of high speed videos from 2 vents from Yasur volcano (Vanuatu) and 4 from Stromboli volcano (Italy) reveals that these parameters are positively correlated. As a consequence, the intensity of an explosion can be quantitatively, and operator-independently described by the total kinetic energy of the bombs, taking into account both the mass and the velocity of the particles. For each vent, a specific range of total kinetic energy can be defined, demonstrating the strong influence of the conduit in the explosive behavior.