Eruptions on the fast track, part a): computational routines for processing visible and thermal high-speed videos of explosive eruptions

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Recent advancements in the use of high speed thermal and visible cameras allowed a precise quantification of key parameters of explosive eruptions. However, the large volume of video data poses several processing issues and hinders parameter extraction. In this methodological investigation we show how computing techniques based on Particle Image Velocimetry (PIV, measuring the displacement of sub-areas of an image between successive frames by correlating features identified in any sub-area) and Particle Tracking Velocimetry (PTV, detecting and tracking single particles along a series of images) allows for the automatic processing of high-speed videos and explosion parameterization.

We developed a 3-steps automatized routine for volcanic high-speed video processing. Step 1 pre-processes the images, removing image background with different techniques to improve image contrast and possibly accounting for camera shaking. Step 2 involves running the custom-made PTV and PIV softwares. Step 3 processes the softwares outputs while operating a first filtering for numerical errors, and then operates the post-processing of the results, where several additional filters can be applied to the results and volcanologically-relevant parameters are finally computed. A sensitivity study was used to define the best settings for each of the above steps and their effect on output parameters.

The overall suitability of our routine and its limitations have been tested on high-speed videos of explosions of Stromboli (Italy) and Yasur (Vanuatu) volcanoes, including a variety of recording conditions and styles of explosive activity.

From the above videos, PTV enables us to construct, for each explosion, a database including the size and trajectory of a large number (order of 10000) of cm-to m-sized pyroclasts. From the database a broad variety of key parameters are then extracted, from single particle ones (e.g., temperature, drag coefficient, deviation from theoretical ballistic trajectories), through explosion evolution ones (e.g., time variation of mean exit velocity, angle, mass and related standard deviations), up to whole-explosion ones (e.g., grain-size distribution and total mass of ejecta, thermal to kinetic energy balance, depth of the explosion, geometry of the vent). PIV provides the velocity vectors of diffuse features, i.e., gas and ash clouds, from which the time and space evolution of: 1) gas ejection velocity; 2) total ejected volume of gas plus pyroclasts; and 3) plume buoyant rise can be assessed.

Automatized results are in general agreement with previous manual estimations on the same videos but on a limited number (order of thousands) of particles, supporting the robustness of out procedure. An illustration of the variety of the volcanological application of this routine is presented in the companion abstract Eruptions on Fast Track, part b.