Full bandwidth remote sensing for total parameterization of volcanic plumes

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If we are to adequately track the emission, ascent and dispersion of a volcanic plume, we first need to measure a number of source condition parameters. These include mass flux, exit velocity, particle size distribution, and plume density or ash concentration. Because of the difficulty of close approach to an active volcanic vent, such measurements need to be remote. Moreover, these need to span a broad range of the electromagnetic spectrum in order to fully parameterize the volcanic plume. With this in mind, we designed in 2012 an experiment involving the full range of modern ground-based remote sensing capabilities, from microwave to ultraviolet wavelengths. Stromboli (Italy) was selected for this test deployment, both for its ease of access and reliability as particle emitter. Our aim was to: characterize explosive eruption dynamics at the highest possible spatio-temporal resolution, test the combined deployment of a complete instrument package, and evaluate its potential for operational plume tracking with a special emphasis on extracting source condition parameters. The equipment package deployed involved the following instruments, beginning with the longest wavelength: (i) 1 Doppler radar (VOLDORAD2, 23.5 cm wavelength) sampling at 10 Hz, used to quantify the ejection velocities and mass fluxes, (ii) 2 thermal infrared cameras (FLIR Systems, 8-14 micrometers) sampling at 200 Hz and 30 Hz, used to track the near-vent emission and the plume ascent and dispersion, (iii) 1 very high frame rate camera (Photron Fastcam SA3, visible and near-infrared) sampling up to 2000 Hz, used to characterize the highest velocities for particles carried by the gas phase, (iv) 2 stereoscopic cameras (IP Basler, visible and near infrared) sampling at 25 Hz, used to reconstruct 3-D particle trajectories and further constrain their sizes, (v) 1 SO_2 camera (310 and 330 nm) and 1 OP-FTIR, used to quantify the mass of gas. In addition, a permanent seismic and infrasonic array was used to characterise the seismic and acoustic signal associated with explosive activity, and in-situ sampling of particles landing in well-defined areas was done to carry geochemical, density, vesicle, and crystal analysis of the ejecta. The ongoing work involves creating code to process and integrate all data sets so as to output the source terms in a rapid-to-real-time frame. We here give special emphasis on the mutual feedback between infrared cameras and Doppler radar, where the first provide particle size distribution to the second to constrain the mass flux.