Reconstruction of volcanic plume properties through integration of infrared imagery and analytical one-dimensional models

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The most effective approach to understanding the dynamics of volcanic ash plumes is through synergy of data acquisition (in field and/or laboratory settings) and data modeling (with analytical and/or numerical methods). The aim of this study is to explore the feedbacks between these two aspects, using infrared thermal videos of short-lived ash plumes imaged at Santiaguito (Guatemala). The first step was to carry out a stationary analysis of the video data, by filtering the time-dependent dynamic fluctuations of the plume. To do so, we reconstructed a mean image out of the entire movie sequence, where each pixel ascribed a time-averaged temperature. This image was then compared with the plume characteristics predicted by mean analytical models (e.g., spreading rate and vertical variations of temperature, velocity and particle concentration), in which electromagnetic radiation equations were introduced to simulate a synthetic radiometric image. The end objective is to use inversion models to recover the best input parameters (e.g., source ash mass, particle size distribution and air entrainment coefficient) that reproduce the observed data. The second step was to carry a time-dependent analysis of the plume dynamics. Data processing here mainly consisted of the algorithm development to analyze the video sequences, and extract key parameters that characterize the ash plumes through time, such as ascent velocities, volume, heat budget, etc. These algorithms were managed using an open-source user-friendly interface plumeTracker developed in Matlab, which can deal with a variety of video data collected at any wavelength (IR, VIS, or UV). Output was then compared with transient integrated models, which simulate the bulk plume motion through time. The end objective was to identify the most relevant features to track from the plume motion to inform on the source parameters, and in particular to yield the mass flux at the source.