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Morphological and dynamical evolution of transient volcanic plumes and their relationship to source properties

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Transient volcanic plumes, typically generated by Strombolian and Vulcanian eruptions, are time-dependent features characterized by rise and development time scales similar to the eruption duration. Their dynamical and morphological properties are thus strongly related to the source conditions and evolution over time. In this study, the initial dynamics-shape-source evolution of transient volcanic plumes have been investigated using high-speed and high-resolution visible and thermal videos from Strombolian to Vulcanian eruptions of Stromboli (Italy), Batu Tara (Indonesia), Fuego (Guatemala) and Sakurajima (Japan) volcanoes.

Physical parametrization of plume dynamics has been performed by defining their front velocity, volume and apparent surface temperature. For the first time, plume shape evolution was characterized by applying the box-counting fractal analysis method. The ejection of gas-pyroclast mixture at the erupting vents has been characterized both: qualitatively in terms of number, location, duration and frequency of individual ejection pulses; and quantitatively in terms of time-resolved mass eruption rate and source instability factor methods.

Results indicate similar trend evolution between plumes in terms of velocity, volume and fractal dimension. Coefficients characterizing these trends display variations that can be directly correlated to differences in ejection parameters. Time-resolved mass eruption rates may vary up to two orders of magnitude within a few seconds from the onset of the eruption and can evolve with varying degrees of non-linearity. This variability is responsible of different momentum input patterns that can be spread in space and time, and result in the observed variety of morphological and dynamical evolution.

Higher time-space resolution imaging tools and processing techniques enable this wide range and diverse dataset to highlight: 1) the crucial impact of discharge history upon the initial and, possibly, later evolution of transient plumes; 2) source condition information held by their shape evolution.