2017

High Speed Imaging, Lightning Mapping Arrays and Thermal Imaging: A Synergy for the Monitoring of Electrical Discharges at the Onset of Volcanic Explosions

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Geophysical Research Abstracts
Vol. 19, EGU2017-16363, 2017
EGU General Assembly 2017

High speed imaging, lightning mapping arrays and thermal imaging: a synergy for the monitoring of electrical discharges at the onset of volcanic explosions

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Volcanic lightning is being increasingly studied, due to its great potential for the detection and monitoring of ash plumes. Indeed, it is observed in a large number of ash-rich volcanic eruptions and it produces electromagnetic waves that can be detected remotely in all weather conditions. Electrical discharges in volcanic plume can also significantly change the structural, chemical and reactivity properties of the erupted material. Although electrical discharges are detected in various regions of the plume, those happening at the onset of an explosion are of particular relevance for the early warning and the study of volcanic jet dynamics.

In order to better constrain the electrical activity of young volcanic plumes, we deployed at Sakurajima (Japan) in 2015 a multiparametric set-up including: i) a lightning mapping array (LMA) of 10 VHF antennas recording the electromagnetic waves produced by lightning at a sample rate of 25 Msps; ii) a visible-light high speed camera (5000 frames per second, 0.5 m pixel size, 300 m field of view) shooting short movies (approx. duration 1 s) at different stages of the plume evolution, showing the location of discharges in relation to the plume; and iii) a thermal camera (25 fps, 1.5 m pixel size, 800 m field of view) continuously recording the plume and allowing the estimation of its main source parameters (volume, rise velocity, mass eruption rate).

The complementarity of these three setups is demonstrated by comparing and aggregating the data at various stages of the plume development. In the earliest stages, the high speed camera spots discrete small discharges, that appear on the LMA data as peaks superimposed to the continuous radio frequency (CRF) signal. At later stages, flashes happen less frequently and increase in length. The correspondence between high speed camera and LMA data allows to define a direct correlation between the length of the flash and the intensity of the electromagnetic signal. Such correlation is used to estimate the evolution of the total discharges within a volcanic plume, while the superimposition of thermal and high speed videos allows to contextualize the flashes location in the scope of the plume features and dynamics.