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Automated estimation of mass eruption rate of volcanic eruption on satellite imagery using a cloud pattern recognition algorithm

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The need to detect and track the position of ash in the atmosphere has been highlighted in the past few years following the eruption Eyjafjallajokull. As a result, Volcanic Ash Advisory Centers (VAACs) are using Volcanic Ash Transport and Dispersion models (VATD) to estimate and predict the whereabouts of the ash in the atmosphere. However, these models require inputs of eruption source parameters, such as the mass eruption rate (MER), and wind fields, which are vital to properly model the ash movements. These inputs might change with time as the eruption enters different phases. This implies tracking the ash movement as conditions change, and new satellite imagery comes in. Thus, ultimately, the eruption must be detectable, regardless of changing eruption source and meteorological conditions.

Volcanic cloud recognition can be particularly challenging, especially when meteorological clouds are present, which is typically the case in the tropics. Given the fact that a large fraction of the eruptions in the world happen in a tropical environment, we have based an automated volcanic cloud recognition algorithm on the fact that meteorological clouds and volcanic clouds behave differently. As a result, the pattern definition algorithm detects and defines volcanic clouds as different object types from meteorological clouds on satellite imagery. Following detection and definition, the algorithm then estimates the area covered by the ash. The area is then analyzed with respect to a plume growth rate methodology to get estimation of the volumetric and mass growth with time. This way, we were able to get an estimation of the MER with time, as plume growth is dependent on MER.

To test our approach, we used the examples of two eruptions of different source strength, in two different climatic regimes, and for which therefore the weather during the eruption was quite different: Manam (Papua New Guinea) January 27 2005, which produced a stratospheric umbrella cloud and was difficult to distinguish from meteorological clouds, and Okmok (Alaska) July 12 2008, which was also an umbrella cloud, but started as an ash-rich cloud before getting a vapor rich pulse into the cloud.

The new methods may in the future allow for fast, easy and automated detection of volcanic clouds as well as remote assessment of the MER with time, even for inaccessible volcanoes. The methods may thus provide an additional path to estimation of the ESP and the forecasting of ash cloud propagation with time as the eruption changes.