Geophysical Research Abstracts
Vol. 17, EGU2015-9955, 2015
EGU General Assembly 2015

Retrieval of lava and SO_2 fluxes during long-lived effusive eruptions using MSG-SEVIRI: the case of Bárdarbunga 2014 activity

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During effusive events, such as that of the 2014 Holuhraun eruption in the Bárdarbunga Volcanic System, Iceland, the lava and SO_2 fluxes can be very large and possibly last for several months. However, the magma effusion rate as well as the gas flux may vary. The monitoring of any changes is essential as it informs on the dynamics of the eruption, and possibly reflects modifications of deeper mechanisms at the origin of the eruption. Geostationary satellite sensors turns out to be particularly relevant to record rapid changes of surface activity by the continuous acquisition of infrared data at time resolution of up to one image every five minutes. However, the long time-series generated cannot easily be analyzed and interpreted using conventional techniques, and require automated processing. Here we present a new method, hereafter called the "gradient method", which can be applied for the quantification of both lava volume and gas mass fluxes during long-lived effusive eruptions using infrared geostationary satellite data. The retrieval scheme comprises the following steps: firstly, the instantaneous lava volume and SO_2 cloud mass must be calculated from each image. Then, we apply the "gradient method" to retrieve the lava and gas fluxes, leading to estimates of the true lava volume and gas mass. For the lava, the 3.9μm and 12μm wavebands are used to detect thermal anomalies and calculate related lava areas from the dual "pixel integrated temperature" method. Then, assuming the lava flow thickness, it gives an instantaneous lava volume. The SO_2 column abundance is retrieved from the 8.7μm waveband using a linear regression derived from a least square fit procedure between satellite sensor measurements and simulated radiances. It leads to an instantaneous SO_2 cloud mass. These calculations are made at each time step, generating time series of these two parameters. The actual lava volume and SO_2 mass cannot be estimated through the integration of the total time series, as significant overlap exists between two successive images. The gradient method consists of calculating the lava volume difference between each image (i.e. approximate derivative), yielding a time-average lava flux. We assume that the flow stops when the approximate derivative becomes negative (i.e. when we have a decreasing curve). Then, we can obtain the total lava volume by integrating the time-average magma flux from the onset of a given lava discharge event to the peak of the volume curve. This can be made easily on a large series of successive events as it comes down to selecting the peak values. The same retrieval procedure can be carried out for the SO_2 mass, and where each peak thus represents the total mass of each SO_2 cloud emitted. We have tested this method on the 2014 Holuhraun eruption using MSG-SEVIRI data. We processed 86 days of eruption from the 1st of September to the 25th of November at a time resolution of one image every 15 minutes, which totals 8256 images for each waveband. The preliminary results give a lava volume of 1.2km3 giving a mean output rate of 161m3/s and an estimated SO_2 mass of 8.9Tg leading to a mean output rate of 1210kg/s.