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Integration of seismic and Ground-Based InSAR displacement data: a tool to understand conduit dynamic at Stromboli Volcano

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Stromboli is an open-conduit volcano, which does not experience pressurization of the magma storage and/or plumbing system able to produce ground deformations at the scale of the volcanic edifice. For any such system, localized inflations/deflations are rather expected in response to conduit processes, such as magma convection and uprising. Indeed, detectable ground deformations at Stromboli volcano have only been observed in association with dyke intrusion at shallow depth, prior to the opening of new eruptive fractures.

In this work, we present the integration of seismic and Ground-Based Interferometric Synthetic Aperture Radar (GBInSAR) system displacement data recorded at Stromboli volcano aimed at a better understanding of the geophysical signals associated with magma dynamics in an open volcanic system.

A cross-analysis between the tiny GBInSAR deformations and ground displacements in the seismological frequency band (0.02-10 Hz) is performed for the period spanning 6 June 2011 – 27 August 2011, which was characterized by an activity of higher intensity than usually observed. The period under study includes seven major explosions and two lava overflows from the NE vents (1-2 August and 18 August 2011). The time series of GBInSAR displacement at the summit vents area is positively correlated with both volcanic tremor amplitude and the number and amplitude of very-long-period (VLP) signals that are associated with the Strombolian explosions. While the correlation between GBInSAR and tremor time series takes its maximum at zero lag time, the variation in frequency and energy of VLP events anticipate by a few days the inflation of the vents area and the increase of volcanic tremor. We thus suggest a general mechanism to explain the observed trend in the geophysical signals. In our model, the arrival of fresh, gas-rich magma from below enhance slug formations, promoting convection and gas transfer throughout the conduit system. At the shallowest portion of the conduit, increase of volatile content causes density decrease/expansion of the magmatic column and augmented degassing activity, which respectively induce inflation of the conduit and increased tremor amplitudes. The temporal delay between increase of VLP and tremor amplitudes/conduit inflation can be interpreted in terms of the different time scales characterizing bulk gas transfer versus slug formation and ascent.