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Dealing with hydrothermal unrest in active calderas by jointly exploiting geodetic and seismic measurements: the 2021-22 Vulcano Island (Italy) crisis case study

Federico Di Traglia[1,2], Valentina Bruno[3], Francesco Casu[2], Ornella Cocina[3], Claudio De Luca[2], Flora Giudicepietro[1,2], Riccardo Lanari[2], Giovanni Macedonio[1,2], Mario Mattia[3], Fernando Monterroso[2], and Eugenio Privitera[3]

[1]Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano – Sezione di Napoli, Napoli, Italy
[2]Consiglio Nazionale delle Ricerche, Istituto per il Rilevamento Elettromagnetico dell'Ambiente, Napoli, Italy
[3]Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo – Sezione di Catania, Catania, Italy

Active calderas are typically characterized by shallow magmatic systems associated with marked geothermal anomalies and significant fluid releases. Ground deformation are generally associated with uplift or subsidence, induced by recharges or emptying/cooling of the magmatic storage system, by expansions or contractions of hydrothermal systems, or by combinations of these factors. The pressure variations in the hydrothermal systems can lead to an increase in the fumarolic and distributed soil degassing activity or in the sudden release of gas, leading to phreatic explosions, even to violent ones.

The Island of Vulcano (Italy), part of the Aeolian archipelago (southern Tyrrhenian Sea), contains an active caldera (La Fossa caldera) showing a widespread degassing and fumarolic activity, mainly localized in the main active volcano (La Fossa cone) and in other emissions zones within the caldera. The La Fossa caldera has shown signs of unrest since September 2021 and to date monitoring parameters have not returned to background levels.

Accordingly, the geophysical measurements obtained through the Vulcano Island monitoring infrastructures, which include geodetic and seismic data, were analysed. GNSS and DInSAR data, the former processed using the GAMIT-GLOBK software to calculate both time series and velocities of every remote station of the 7-stations network in Vulcano and Lipari islands, the latter processed through the P-SBAS technique, were used to identify the source of deformation. The seismic network data were exploited to discriminate the seismicity induced by regional tectonics from that induced by the magmatic or hydrothermal system (VT, VLP, tremor).

The inversion of the ground deformation measurements made possible to investigate the source within the hydrothermal system of the Fossa cone. Moreover. the seismic data analysis reveals the activation of regional crustal structures during the hydrothermal unrest, as well as the flow of hydrothermal fluids within the caldera structures linked to the presence of a pressurized hydrothermal system.

The presented results will provide a general overview of the main findings relevant to the Vulcano Island geodetic and seismic data inversion and analysis.