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Editorial: Remote sensing in volcanology

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Editorial on the Research Topic
Remote sensing in volcanology

Remote sensing has become an essential tool for monitoring various phenomena on Earth, including volcanic unrest and eruptions (Pyle et al., 2013). Although ground-based measurements are powerful in understanding volcanic activity, they are not always available at active volcanoes because various factors, including steep topography and dangerous environments, prohibit access to them. Therefore, insights gained from remote sensing complement those from ground-based measurements or can even be crucial in understanding volcanic activity.

Because volcanic activity produces various phenomena, monitoring the volcano with various types of remote sensing instruments is crucial. Optical images may be straightforward to interpret, observing changes in surface morphology (Moussallam et al., 2021). Radar images from Synthetic Aperture Radar, for example, also observe morphological changes (Pinel et al., 2014; Biggs and Pritchard, 2017). While radar waves have less spatial resolution than optical images because of their longer wavelength, they can take images day and night regardless of the weather. SAR images can also detect surface displacements induced by various reasons, including migration of magmatic fluids at depth and instability of the volcano edifice.

The migration of magmatic fluids releases gases dissolved in them. These gases are observed at the surface as chemical and temperature anomalies (Ramsey and Harris, 2013). Thermal remote sensing using infrared or thermal infrared can detect thermal anomalies in high spatial resolution. Thermal remote sensing is thus one of the crucial techniques for understanding the volcanic activity.

This Research Topic attracted six contributions. Here we introduce the outlines of these contributions.

Müller et al. identified 315 fracture segments associated with the 2014–2015 Holuhraun, Iceland, eruption from Terrestrial Laser Scanning (TLS) and Unmanned Aerial Vehicles (UAV). Because these fractures result from inelastic deformation induced by dike intrusions during the eruption, most of the fractures result from left- or right-lateral slip, as well as transtensional openings. Because these fractures are usually eroded over time, it is essential to observe such fractures by remote sensing techniques such as TLS or UAV to understand the complex deformation of the host rock in response to dike intrusions.

Henderson et al. investigated deformation and thermal anomalies preceding and during the most recent eruption of Mount Pagan, Mariana Islands, in 2012. While SAR images from the Envisat and ALOS satellites detected continuing subsidence by compacting scoria of the 1981 eruptive deposits, no precursory surface deformation was detected. CosmoSkyMed InSAR measurements spanning the eruption detected no co-eruptive deformation, although

continuing subsidence of the scoria was detected. At the same time, thermal time series from the MODIS and ASTER satellites detected more or less stationary thermal anomalies but did not detect pre-eruptive thermal anomalies. The lack of precursory signals is probably because the volcano had an open conduit and persistent degassing at the time.

Shevchenko et al. investigated the growth and collapse of lava domes in Shivelch Volcano, Kamchatka, during the 2018–2019 eruption from optical (areal and Pleiades), SAR (TerraSAR-X and TanDEM-X), and thermal (areal, MODIS, Sentinel-2, and Landsat 8) remote sensing images. These data shed light on the structural architecture of the volcano and the complex interplay of the constructive and destructive processes of the volcano. The authors developed a conceptual model for constructing the architecture of the plumbing system based on these data. The model is vital for an enhanced understanding of assessing potential hazards not only in Shivelch Volcano but also in dome-building volcanoes in general.

Mania et al. investigated precursors to the 2017 eruption of Bezymianny Volcano, Kamchatka, from SAR (TerraSAR-X and TanDEM-X) images, camera images, and seismic data. SAR interferograms indicate that precursory deformation started at least 9 days before the eruption onset. Seismic activity and anomalous degassing preceded the eruption onset by tens of days. These observations substantially contribute to understanding the shallow magma plumbing system at Bezymianny Volcano. They may also be relevant to early warning strategies not only at Bezymianny Volcano but also at similar volcanoes.

Coppola et al. reported Volcano Radiative Power (VRP) measured by Visible Infrared Imaging Radiometer Suite (VIIRS) at La Fossa Crater, Vulcano Island, over the last 10 years. VRP significantly decreased in 2020, leading to unrest from September 2021. The unrest consists of an elevated VRP uplift between September and October 2021, followed by a decline in VRP and a resurgence between May and July 2022. The authors interpret this thermal pulse as a migration of magmatic fluids toward shallower depths, consistent with seawater discoloration during the same time period. These measurements indicate that VIIRS is a useful tool even in volcanoes that are poorly monitored.

Remote sensing techniques can also image the internal structure of a volcano. Barnoud et al. developed a method to image a three-dimensional density structure by inverting gravimetric and muographic observations. They applied the method to Puy de Dôme volcano, France. Because gravimetric observations at the surface inherently have non-uniqueness in estimating the density, adding muographic observations, which have different sensitivities to the density structure, enhances the robustness of the estimation of the density structure. Indeed, thanks to the muographic observations, the authors found that the dome is dry and permeable. They also found a trachytic dense core surrounded by a less dense talus.

Some of these contributions try to understand volcanic activity from multiple types of remote sensing techniques. As different remote sensing techniques have different sensitivities to volcanic activity, it is crucial to combine different techniques to gain insights into the volcanic activity. As data from many more satellites or other instruments will be available in the future, such studies using multiple instruments will be more prevailing to gain more insights into volcanic activity.

Author contributions

YA wrote and reviewed this editorial.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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