The value and challenges of high spatial resolution satellite observations for volcano science and hazard mitigation

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Volcanic eruptions pose a clear danger to society, yet relatively few of the world's potentially active subaerial volcanoes are monitored by ground-based systems. Less than one-third of volcanoes with eruptions since 1980 (N= 248) have seismic networks (Diana Roman, personal communication), while about 40% of all potentially active volcanoes (N ~ 1400) have at least one ground deformation sensor (Christina Widijayanti, personal communication). A growing number of volcano-monitoring parameters are now measurable from space, so satellites can help fill in some gaps in ground monitoring (but of course, not seismic monitoring). In particular, imagery from Synthetic Aperture Radar (SAR) satellites, especially at spatial resolutions of a few meters per pixel or better, are extremely useful to track volcanic activity before, during, and after eruptions during all weather. The international constellation of SAR satellites used at volcanoes is large and growing, including Sentinel-1A, TerraSAR-X/TanDEM-X/Paz, COSMO-SkyMed, ALOS-2, Radarsat-2, Capella Space, ICEYE, and others (see Fig. 1).

A major challenge for volcanic hazard studies using SAR data is the limited background data that are collected from most satellites (except Sentinel-1A/B) when volcanoes are not erupting. For the data that exist, acquisitions are often tasked by users after an eruption begins, and there are often little or no pre-eruptive data in the same geometry to compare against. To help address this problem, we have proposed a global observation strategy in terms of optimal SAR repeat interval for the ~1400 subaerial Holocene and older volcanoes based on their level of activity and environmental considerations that degrade interferometric coherence (Pritchard et al., 2022). Another challenge is that high spatial resolution SAR data are expensive, but there are several initiatives to increase data access including the Committee on Earth Observation Satellites (CEOS) Volcano Demonstrator project to monitor all ~720 Holocene volcanoes in Africa, Latin America, and Southeast Asia and the Geohazards Supersites and Natural Labratories project. This work contributes to the development of an integrated, international, global remote sensing geohazard monitoring effort for disaster risk management.

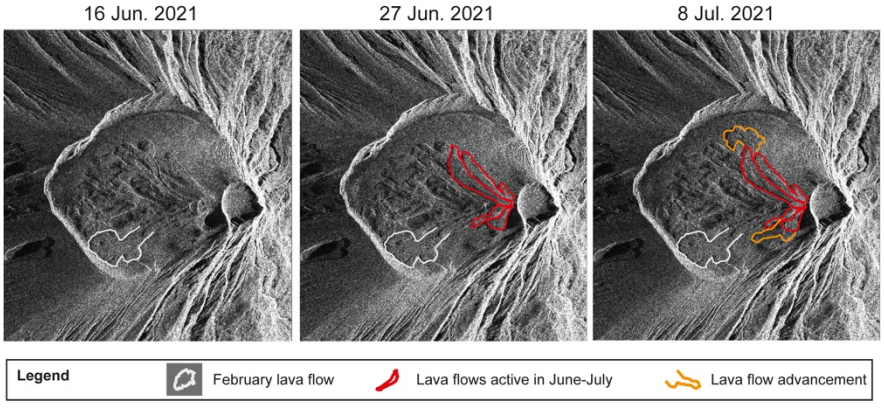

Fig. 5. Lewotolok volcano, Indonesia from TerraSAR-X satellite High Resolution mode showing formation of the lava flows during the 2021 eruption. The scenes are approximately 1 km wide.