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Volcanic geomorphology using TanDEM-X

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Topography is perhaps the most fundamental dataset for any volcano, yet is surprisingly difficult to collect, especially during the course of an eruption. For example, photogrammetry and lidar are time-intensive and often expensive, and they cannot be employed when the surface is obscured by clouds. Ground-based surveys can operate in poor weather but have poor spatial resolution and may expose personnel to hazardous conditions. Repeat passes of synthetic aperture radar (SAR) data provide excellent spatial resolution, but topography in areas of surface change (from vegetation swaying in the wind to physical changes in the landscape) between radar passes cannot be imaged. The German Space Agency's TanDEM-X satellite system, however, solves this issue by simultaneously acquiring SAR data of the surface using a pair of orbiting satellites, thereby removing temporal change as a complicating factor in SAR-based topographic mapping.

TanDEM-X measurements have demonstrated exceptional value in mapping the topography of volcanic environments in as-yet limited applications. The data provide excellent resolution (down to ∼3-m pixel size) and are useful for updating topographic data at volcanoes where surface change has occurred since the most recent topographic dataset was collected. Such data can be used for applications ranging from correcting radar interferograms for topography, to modeling flow pathways in support of hazards mitigation. The most valuable contributions, however, relate to calculating volume changes related to eruptive activity. For example, limited datasets have provided critical measurements of lava dome growth and collapse at volcanoes including Merapi (Indonesia), Colima (Mexico), and Soufriere Hills (Montserrat), and of basaltic lava flow emplacement at Tolbachik (Kamchatka), Etna (Italy), and Kīlauea (Hawai'i). With topographic data spanning an eruption, it is possible to calculate eruption rates—information that might not otherwise be available, as was the case at Tolbachik and Kīlauea. With a dense time series of TanDEM-X imagery over an erupting volcano, lava discharge over time can be determined. At Kīlauea, such results revealed relatively low rates of lava discharge during 2011-2014, which suggests a decrease in magma supply to the entire volcano, and which has important implications for lava flow hazards assessment. Some problems remain in using TanDEM-X data for volcano monitoring, like variations in satellite imaging geometry over time and distinguishing vegetation from the ground surface. Nonetheless, we are convinced of the high value of TanDEM-X data that, if utilized to its full potential, offer a unique opportunity for elucidating a range of volcanic processes around the world.