Crustal Deformation Associated with the 2020 Eruption of the Taal Volcano, the Philippines, Detected by Sentinel-1 and ALOS-2

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The Taal volcano, the Philippines, erupted on January 12, 2020, and forced local residents and visitors to evacuate from towns around the volcano. It was also reported that fissure swarms were formed on the southwestern frank of caldera, suggesting intrusion of dyke. In order to detect crustal deformation associated with this activity, we collected and analyzed SAR images acquired by Sentinel-1 and ALOS-2 satellites since the beginning of 2019.

Sentinel-1 satellites make observations every 6 or 12 days with the same configuration, so that we can detect temporal variation in surface deformation. Drawback of Sentinel-1 is short wavelength of radar, which causes decorrelation in heavily vegetated area. On the other hand, ALOS-2 uses L-band SAR that can provide us with high coherence even in tropical regions. However, recurrence of ALOS-2 is 14 days or more and its observation is not regularly made. Therefore, we mainly utilize Sentinel-1 images to detect temporal variation in deformation before the eruption. ALOS-2 images can be utilized to reveal cumulative deformation, especially in the region of low coherence in Sentinel-1 images. Deformation spanning the eruption was detected by both ALOS-2 and Sentinel-1. We used Gamma software to analyze ALOS-2 for all cases and Sentinel-1 images spanning the eruption, and LiCSBAS (Morishita et al., 2020) to detect temporal variation before the eruption.

Rapid decreases of line-of sight, which exceeds 40 mm/yr, were detected in the central part of the caldera during 1 year before the eruption from both the ascending and descending orbits. Spatial pattern of LOS changes suggests inflation of magma reservoir beneath the central cone. An ascending interferogram of ALOS-2 spanning a year also shows similar spatial pattern to that of Sentinel-1.

Interferograms spanning the eruption show remarkable deformation in and around the volcano. The spatial pattern of deformation is quite different from the pre-eruptive one. Area of pre-eruptive LOS decrease turned to LOS increase larger than 40 cm, which suggests deflation of magma reservoir. Large deformation was observed on the southern frank of caldera, where fissure swarms were found. We could not obtain information in Sentinel-1 interferogams due to decorrelation. On the east and west sides of this decorrelation zone, ground may have moved east- and westward, respectively. Range offsets of ALOS-2 indicate sharp boundary between LOS decrease and increase along the western edge of the zone of decorrelation. Azimuth offsets show north-south extension of up to 4 m across this decorrelation zone. These observations imply that deflation of magma reservoir beneath the central cone and intrusion of dyke beneath the southwestern frank of caldera occurred during the 2020 eruption. We tried to model these observations with simple spherical source and tensile fault. We preliminary found that the combination of deflation source located at a shallow depth beneath the central cone and a tensile fault extending southwestward from the central cone beyond the caldera rim can explain the observed deformation. We, however, need further adjustment of parameters.

ALOS-2 images are shared among PIXEL and provided from JAXA. Its copyright and owneship belongs to JAXA. Sentinel-1 data are obtained from COMET-LiCS Sentinel-1 InSAR portal and Copernicus Open Access Hub, ESA.

Keywords: Taal volcano, SAR, crustal deformation, dyke intrusion, deflation

