Gravity changes before and after the 2016 Kumamoto Earthquake observed by relative gravimeters in Aso Volcano

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Gravity measurement is one of the most effective methods to understand mass variations due to volcanism. In Aso Volcano, Kumamoto Prefecture, spatiotemporal gravity variations have been monitored by repeated relative gravity measurements every several years since 1981 (Yoshikawa et al., 2009). Gravity data was frequently collected 3-4 times every year during the active period of Aso Volcano from 2011 to 2015, and spatiotemporal variations in hydrothermal mass under the ground of the volcano were revealed using the gravity data (Sofyan et al., 2016). However, gravity data was not collected in 2016, because traffic network and some of geodetic points were lost due to the Kumamoto Earthquake in April 2016. Since the volcanism became quieter after 2015, a series of volcanic activities including the quiet period should be discussed in terms of mass variations to predict future volcanic activities.

We therefore measured relative gravity values around Aso Volcano in May, August, and November 2017 to monitor gravity variations during the volcanically quiet period. We used the CG5 and LaCoste-G680 relative gravimeters belonging to Aso Volcanological Laboratory (AVL) and Kyoto University, respectively. Since the CG5 gravimeter has a large instrumental drift of about 2 microGal/min, we first corrected the long-term part of the instrumental drift by regressing a polynomial function to the continuous gravity data obtained in the AVL faculty. We then determined gravity values relative to the AVL faculty at each gravity point, by correcting the effects of instrument height, tide, and short-term drift from the gravity data collected by two gravimeters. We also corrected gravity differences associated with the scaling factor, by multiplying corresponding factor values to the gravity values collected by two gravimeters. We finally estimated absolute gravity changes at geodetic points in the Aso area before and after the Kumamoto Earthquake, using absolute gravity values measured by absolute gravity meter before and after the earthquake. We here removed the effect of crustal deformation due to the Kumamoto Earthquake, by subtracting a product of the InSAR’ s vertical displacement (Geospatial Information Authority of Japan, 2016) and a typical Bouguer gravity gradient (-0.2 mGal/m).

As a result, the gravity values showed a decrease of more than -0.090 mGal at 5 points located within the 4 km area at the west of the crater, and the largest gravity decrease of -0.180 mGal was obtained at AsoCC, the closest point to the crater. Because the gravity decrease was smaller at the foot of Aso Volcano, the large gravity decrease at the top of the volcano suggests mass loss in the shallow part of the volcano. For example, assuming a point mass variation at the depth of 500 m just under AsoCC, a mass loss of 6.7 E9 kg is expected to reproduce the gravity decrease at AsoCC. However, this mass loss cannot perfectly explain the decreasing gravity values at the other points near the crater, which implies that the mass loss occurs at a wide range under the top of the volcano. In future studies, we will develop a physical model on the mass variation in Aso Volcano, and repeat relative gravity measurements to monitor spatiotemporal gravity changes.

Keywords: Gravity change, crustal deformation, mass variation, Aso Volcano, Kumamoto Earthquake

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