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Gravity variation near the crater of Aso volcano and gravity contribution of precipitation

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We investigated the gravity variation continuously measured near the active crater of Aso volcano. At the period of low volcanic activity, the gravity variation is dominated by a contribution of water mass movement arisen from percolation of rain water and discharge in a permeable layer under about 100m.

In this study, it is used a time series measured by a superconducting gravity meter, CT-200, which installed in Hondo tunnel under 30m located in about 1000m southwest of Nakadake first crater. An analysis period is for 3 years from February, 1998 to January, 2001. Aso volcano was quiet low active for this period. The hot lake in Nakadake first crater, Yudamari, which its state is an index of the volcanic activity, had been in high water level. There were no events of drying up and eructation of volcanic ash. The gravity variation removed tide and air response shows large seasonality, increasing 20 - 40 μGal at July and August after rainy season and decreasing gradually after that. It also has some minor changes in response to precipitation, for example, an increase of about 10 μGal after autumnal rain.

It is known that precipitation has an affect on gravity. However, the effect near the crater of Aso volcano did not well understand. We computed water flux by percolation into underground and water discharge from a permeable layer using a kind of physical model of storage function method known as tank model. Model input is amount of precipitation measured at Asosan meteorological station by Japan Meteorological Agency. The change of water volume contained in underground is computed from input-output difference of tank model. The gravity contribution is obtained from the corresponding density change in a region of 1400km in north-shouth and in east-west around the gravity meter with thickness from surface to 200m depth. It assumes that there is no gravity change by volcanic activity. Outflow resistance of a tank and permeable layer depth are decided so that the gravity contribution fits in the measured gravity variation as much as possible.

The gravity contribution of water mass movement by model computation is well coincident with the measured gravity variation in the case that rainwater percolates under 100m in vertically and is discharged horizontally from the permeable layer at 100 - 110 m depth. The model value correlates highly with the measured gravity value in the coefficient of 0.9. The root mean squares (RMS) are 10.5 μGal for the measured gravity and 11.4 μGal for the model computation, and 4.8 μGal for difference between the two. The model computation overestimates to a certain degree. It is considered for a reason of the discrepancy that percolation and ground water flow in general are complicate and non-linear phenomena in contrast to our linear model. However, the model computation represents sufficiently figures of the measured variation and explains it in accuracy of 14.4 μGal in 3σ RMS of the difference. The contribution of water mass movement in shallow underground to 110m depth is inferred to be main component of gravity change near the crater.

The water mass movement can be computed at any period of time. In this study, we obtained the gravity contribution under 30m where the gravity meter located in. Converting it to on ground, the model prediction is available for use in correction of values measured near the crater in the repeated gravity survey at Aso volcano area. A part of discharge from the permeable layer in the computing region is considered as a source of ground water flow into Yudamari. A seasonal peak of precipitation is for about a month from June to July, however the ground water flow continues for several months after rainy season. This is coincident with the seasonal water level change of Yudamari. It is expected to estimate a possible quantity of ground water flow into Yudamari as time variation.

Keywords: Aso volcano, Gravity, Water mass movement, Precipitation, Groundwater, Superconducting gravity meter