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Numerical estimations of hydrological gravity changes at Cibinong, Indonesia with empirical and physical models

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Gravity measurement is one of the effective methods for probing mass changes and it enables us to monitor an earthquake deformation, a volcanic activity or a carbon dioxide reservoir performance. However, rainfall causes a gravity change of around 0.04 micro-gal/mm . Especially, heavy rainfall can cover over the fore mentioned gravity signals. Thus we should correct the gravity disturbance attributed to a rainfall, a soil water and an underground water as precisely as possible.

In this study, we empirically calculated and corrected the gravity response of underground water and soil water using continuous gravity data measured at Cibinog, Indonesia from March 2009 to January 2012. First, we calculated proportionality coefficient of gravity change to underground water level. It is estimated to be +0.12 micro-gal/cm, which is in the same range of that of Isawa, Japan (+0.16 micro-gal/cm; Hanada et al., 1990). Then, after taking the estimated gravity change of the underground water from the measured gravity data, we found the residual gravity change of 1.7 micro-gal in terms of RMS (Root Mean Square). This gravity change is considered that of soil water which sink in the underground after rainfall and is becoming underground water. Thus we found the response function of the residual gravity change to the rainfall.

As a result, we succeeded to replicate gravity change within a residual error of 0.51 micro-gal in terms of RMS after empirically correcting the effects of the underground water and the soil water between April 2011 and June 2011. However, the residual gravity change before April 2011 is calculated to be 1.8 micro-gal in terms of RMS, which means we could not precisely correct it even if we factor in the soil water. The cause could be attributed to the limitation of the empirical model with the assumption of linearity because the soil water flow may be dominated by non-linear physics. Then we will calculate more realistic and reproducible distribution of land water and gravity change using physical model (Kazama et al., 2012).