Continuous relative gravity observation at Sakurajima Volcano: Disturbance corrections of tilt and gravity time series

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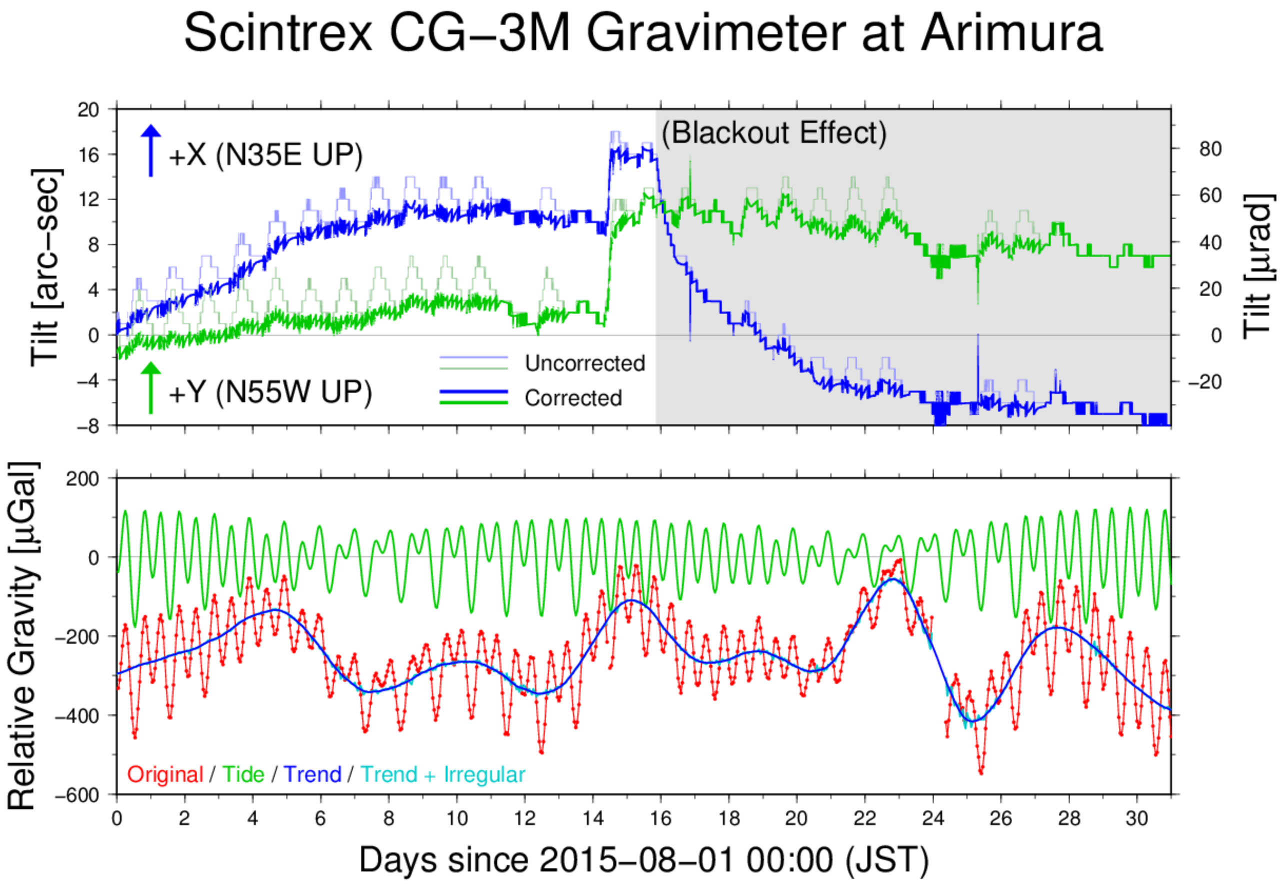
Gravity observation is one of the most effective methods to monitor mass movements in volcanoes. Gravity changes due to volcanism have been observed mainly with campaign gravity measurements using portable relative gravimeters (e.g., Furuya et al., 2003) and with continuous absolute gravity measurements (e.g., Kazama et al., 2015). However, most of the previous studies only have focused on the clear volcanic gravity signals with periods of more than a day, because the short-period gravity data tends to become noisier due to the low sampling rate of the gravity observations. Since other geodetic data have already revealed broadband volcanic signals with periods of seconds to years (e.g., Iguchi et al., 2008; Hotta et al., 2016), short-period volcanic gravity changes should be monitored to understand more about the volcanic activities in terms of mass movement.
We were thus motivated to collect the continuous gravity data with the sampling rate of one minute, using a Scintrex CG-3M relative gravimeter at Arimura Observatory, Sakurajima Volcano (Kagoshima Prefecture, Japan). The gravimeter was first installed in May 2010 and continues collecting the gravity data as of January 2016. It also records the minutely tilt values of the gravimeter, which are utilized to correct the apparent gravity changes due to the tilt. This presentation mentions how to correct some disturbances in the gravity/tilt data as follows, and the volcanic gravity/tilt signals will be discussed at the presentations in the “Active volcanism” session.
Instrumental drift and tidal effect in gravity data: We first corrected the large instrumental drift (rate: more than 300 micro-Gal/day) from the original gravity data by subtracting the long-period gravity change calculated with the cubic spline curve, which was obtained from the 2-day average of the original gravity data. We also corrected the tidal gravity changes (amplitude: up to 300 micro-Gal) with periods of less than a day, using the BAYTAP-G software (Tamura et al., 1991). In the lower panel of the attached figure, the red curve shows the corrected gravity change from which the long-period instrumental drift was removed, and the blue curve also shows the corrected gravity from which both of the drift and tidal effect were removed. The blue curve contains the non-periodic gravity changes associated with volcanism, along with the periodic gravity change with periods of less than a few days.
Insolation effect in tilt data: The gravimeter tilted diurnally during sunny days, possibly because the insolation tilted the building of Arimura Observatory slightly. In order to correct the insolation effect in the tilt data, we first estimated the diurnal tilt variation for each component of the N35E-S35W and N55W-S55E axes, by averaging the daily tilt variations on 1 to 11 August 2015. We then corrected the insolation-derived tilt disturbances by removing the estimated diurnal tilt variations from the original tilt data. The light and dark lines in the upper panel of the attached figure show the tilt time series before/after the insolation effect was corrected, respectively. Significant tilt changes associated with the volcanic event on 15 August 2015 can be identified clearly, owing to the correction of the insolation effect. Note that the tilt changes in the second half of August 2015 might be affected by the air temperature change in Arimura Observatory, because the blackout on the night of 16 August turned off the air conditioners in the observatory.

Keywords: relative gravity, gravity change, tilt change, Sakurajima Volcano, instrumental drift, tide


Scintrex CG−3M Gravimeter at Arimura
+X (N35E UP)
+Y (N55W UP)
(Blackout Effect)
Uncorrected
Corrected
Tilt [arc−sec]
Tilt [µrad]
Relative Gravity [µGal]
Original / Tide / Trend / Trend + Irregular
Days since 2015−08−01 00:00 (JST)

