Spatiotemporal gravity variations from the 1970s in Sakurajima Volcano, revealed by repeated relative gravity measurements

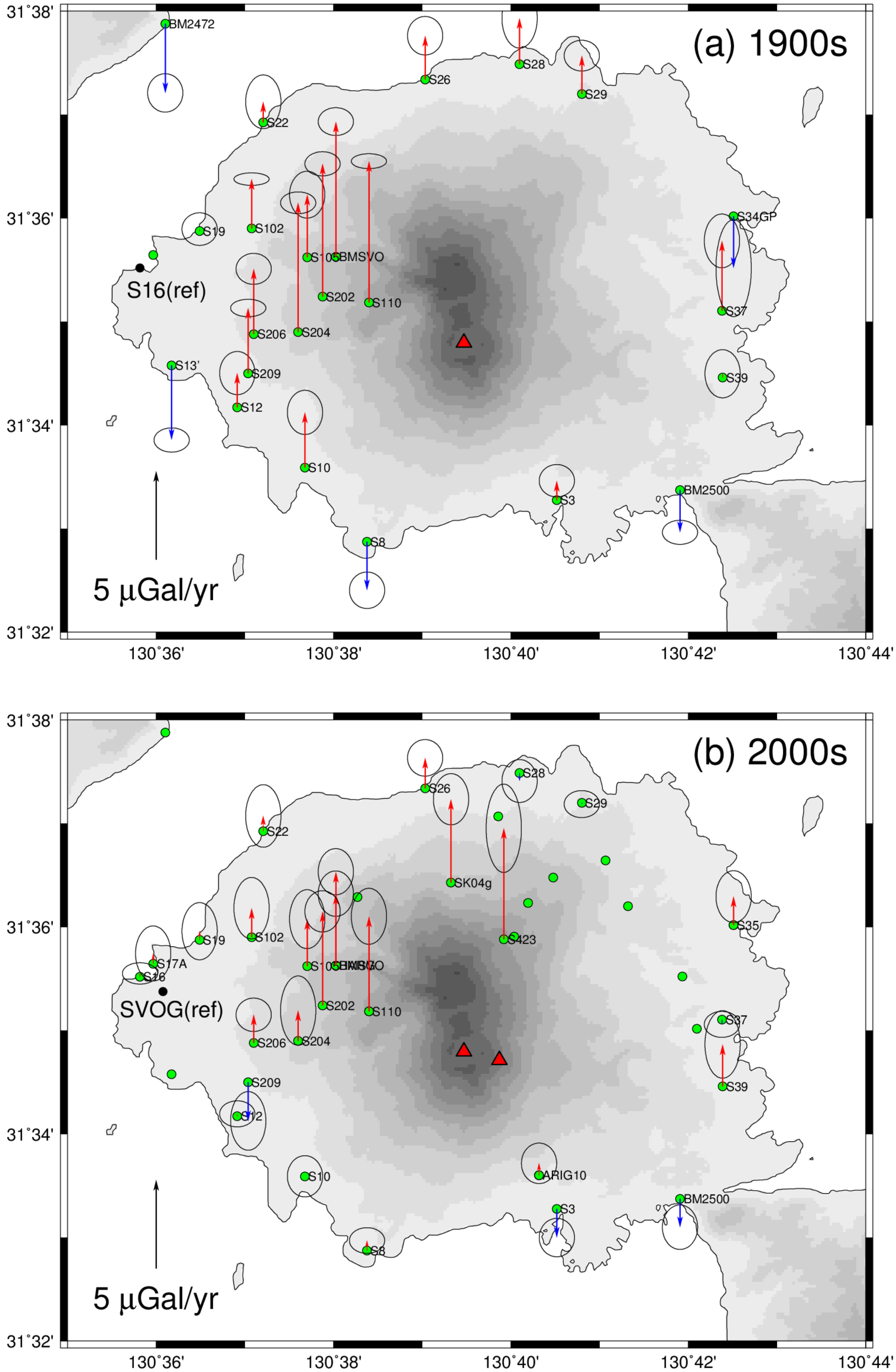
*Takahito Kazama[1], Keigo Yamamoto[2], Masumi Hirayoshi[1], Hiromitsu Ohshima[3], Tokumitsu Maekawa[3], Kazumi Okada[3], Tadaomi Sonoda[2], Masato Iguchi[2]

1. Kyoto University, 2. DPRI, Kyoto University, 3. ISV, Hokkaido University

Sakurajima Volcano, which is located in the south of Aira caldera, is one of the most active volcanoes in Japan. Leveling surveys have been repeated since 1891 in and around the volcano, and vertical ground deformation obtained from the surveys was modeled by inflation/deflation of sphere pressure sources (e.g., Mogi, 1958; Yamamoto et al., 2013). In recent years, satellite geodetic technologies such as GNSS and SAR have helped us monitor broad ground deformation of the volcano in real time (e.g., Hotta et al., 2016; Morishita et al., 2016).
On the other hand, gravity measurements at leveling points in and around Sakurajima Volcano were started in 1975 (Tajima et al., 1975). Campaign relative gravity measurements have been repeated 19 times as of February 2018, and continuous gravity data have also been collected at a few gravity points these days. However, long-term (> 10 years) gravity variations in the volcano have never been discussed until now, while gravity changes within 10 years have modeled by some researchers (e.g., Ishihara et al., 1986; Okubo et al., 2013; Kazama et al., 2016). Long-term volcanic mass variations should be discussed from the past gravity data, because it can help to forecast future volcanic activities of Sakurajima Volcano. We therefore estimated the long-term gravity variations in Sakurajima Volcano by reprocessing the relative gravity data collected from 1975 to 2017, in order to understand the long-term mass redistributions under the volcano in the same period.

We first collected a set of original gravity data stored in Sakurajima Volcanic Observatory, and computerized gravity values in the data set which were measured from the 1970s to the 1990s. We then corrected gravity changes due to instrumental height, tide, and instrumental drift from the newly computerized gravity data, along with the already computerized gravity data collected in the 2000s. We finally estimated gravity variation rate for each gravity site from the least square method, using the corrected gravity values.
Arrows and ellipses in the figure (a) indicate the gravity variation rates and those standard deviations from the 1970s to 1990s in Sakurajima Volcano. A large gravity increase of up to +8.0 microGal/yr is clearly seen at gravity sites located in the western side of the volcano. The spatial pattern of the gravity variation rates can be modeled by a point mass of +3.0 E9 kg/yr at 1300 m below sea level (b.s.l.) of the western Sakurajima with a deflation source of -1.2 E6 m3/yr at 1800 m b.s.l. of the Minami-dake crater (Hirayoshi, master thesis).
The figure (b) also shows the gravity variation rates from the 2000s to the 2010s in the volcano. The gravity increase in the western Sakurajima during this period is smaller than that from the 1970s to 1990s by about one third, and the largest gravity change of +6.3 microGal/yr is seen at S423, located in the northern hillside of Sakurajima. These results imply that mass redistribution systems under the ground of Sakurajima Volcano changed around 2000. We will model mass redistributions in Sakurajima Volcano physically, by considering gravity changes outside the volcano and vertical ground deformations obtained from leveling surveys.

Keywords: Sakurajima Volcano, relative gravity, crustal deformation, mass variation, magma, hydrology


(a) 1900s
31°38'
31°36'
31°34'
31°32'
130°36'
130°38'
130°40'
130°42'
130°44'
BM2472
S26
S28
S29
S22
S19
S102
S105
BMSVO
S202
S110
S34GP
S37
S16(ref)
S206
S204
S13'
S209
S12
S39
S10
S3
BM2500
S8
5 μGal/yr
(b) 2000s
31°38'
31°36'
31°34'
31°32'
130°36'
130°38'
130°40'
130°42'
130°44'
S26
S28
S29
S22
SK04g
S19
S102
S17A
S16
S423
S35
SVOG(ref)
S202
S110
S37
S206
S204
S209
S12
S39
S10
ARIG10
S3
BM2500
S8
5 μGal/yr