Corrections of individual properties of relative gravimeters by using cooperative precise gravity measurement data in Izu-Oshima volcano

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1. Introduction

Meteorological Research Institute, JMA (MRI) has conducted repeated microgravity surveys in Izu-Oshima volcano in order to understand volcanic processes. Two relative gravimeters, LCR D#109 and Scintrex CG-5#033, have been used since 2008. However, resultant data contain some uncertainties due to the relative measurements. Earthquake Research Institute, The University of Tokyo (ERI) has conducted hybrid absolute and relative gravity measurements. MRI and ERI started a cooperative observational study of Izu-Oshima volcano in order to help understanding subsurface processes of the volcano. In this presentation, we mainly show correction processes of properties of MRI relative gravimeters and show significances of the cooperative study.

2. Scale Factor Calibrations

As for the two MRI relative gravimeters, absolute scale factors were not well calibrated until recently. Relative scale factors between the gravimeters using maker-suppled scale factors show clear temporal change and its magnitude reaches up to 1,000 ppm within ten years. Since gravity difference in Izu-Oshima is about 180 mGal, this temporal change can lead to about 180 μGal of false gravity changes. Further, it seems the relative scale has a non-linear relationship in low dial ranges of the D#109.

2.1 D#109

MRI conducted calibration measurements of the D#109 at Izu-Oshima in May and June 2017 by visiting the two ERI absolute gravity sites (111 mGal of difference). While the maker-supplied scale factor coincides with the measured one with an accuracy of approximately 10^{-4} in the high dial range, it deviates significantly in the low dial range as expected from the non-linear characteristics of the relative scale factors. Therefore, we reconstructed the scale factor for the low dial ranges by using this calibration measurement data.

2.2 CG-5#033

Six calibration measurements of the CG-5#033 were conducted from 2012 to 2017 using absolute gravity sites of the Japan Gravity Standardization Net (JGSN). According to the dataset, the scale factor depends primarily on the gravity reading ranges regardless of site combinations and observed times. Therefore, the gravity readings can be corrected by introducing a reading-dependent scale factor. Further, even though the scale factor essentially depends on gravity readings and not on time, temporal changes were recognized during repeated measurements at the same site combinations. A long-term instrumental drift could explain this phenomenon. That is, the calibration shifts during repeated measurements were apparently caused by: 1) the scale factor dependence on the gravity reading ranges, and 2) the shift of the gravity reading ranges due to the instrumental drift (Onizawa, 2019). The temporal changes found in the relative scale factors can be attributed to this apparent calibration shift of the CG-5#033.

2.3 Verifications

A cooperative hybrid measurement was conducted at Izu-Oshima in Nov. 2018. The scale factors of the D#109 and CG-5#033 constructed as mentioned above were checked by using gravity values of the two absolute sites. Gravity differences observed by both the gravimeters coincided well with that of the absolute measurements (1 μGal of difference). The coincidence of the CG-5#033 is particularly important because the reading-dependent scale factor relationship was constructed by completely independent dataset. Further, we could verify that prominent calibration shift did not occur in the D#109.

3. Effect of Vertical Gravity Gradients on Instrumental Height Correction

MRI has conducted *in situ* vertical gravity gradient measurements at Izu-Oshima gravity sites in order to quantify gravity changes due to ground deformations, particularly vertical movements. For over 20 sites where the gradient was measured, the gradients range from 0.30 to 0.44 mGal/m. These vertical gradients play an important role in the instrumental height corrections in case that different types of gravimeters such as LCR and Scintrex are used because of the difference of the effective instrumental height. Uses of inappropriate vertical gradient easily lead biases up to several tenth μGal (e.g. Lederer, 2009). For the 2018 campaign data, we applied site-dependent vertical gravity gradients to the height corrections of both the D#109 and CG-5#033. Except for two sites of about 30 μGal difference, gravity values of the two gravimeters coincide within 14 μGal of difference.

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