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ScienceDirect

Polar Science 7 (2013) 260–277

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Gravity measurements with a portable absolute gravimeter A10 in Syowa Station and Langhovde, East Antarctica

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Received 26 March 2013; revised 13 June 2013; accepted 18 July 2013
Available online 31 July 2013

Abstract

Absolute gravity values were measured with a portable absolute gravimeter A10 in East Antarctica, for the first time by the Japanese Antarctic Research Expedition. This study aims to investigate regional spatiotemporal variations of ice mass distributions and associated crustal deformations around Syowa Station by means of repeated absolute gravity measurements, and we obtained the first absolute gravity value in Southern Langhovde on the Antarctic Continent. The average absolute gravity value at the newly installed benchmark AGS01 in Langhovde (obtained on 3 February 2012) was 982535584.2 ± 0.7 μgal (1 [μgal] = 1×10^{-8} [m/s^2]), which was in agreement with the gravity values obtained by the past relative gravity measurements within 1 mgal. In addition, the average absolute gravity value obtained at AGSaux in Syowa Station was consistent with both previous absolute gravity values and those obtained by simultaneous measurements using an FG5 gravimeter, owing to adequate data corrections associated with tidal effects and time variations in atomic clock frequencies. In order to detect the gravity changes associated with the ice mass changes and other tectonic phenomena, we plan to conduct absolute gravity measurements at AGS01 again and at other campaign sites around Syowa Station as well in the near future, with careful attention paid to the impacts of severe environmental conditions in Antarctica on gravity data collection.

Keywords: Absolute gravity; Antarctica; A10 gravimeter; Ice mass balance; Glacial isostatic adjustment

1. Introduction

Gravity measurements provide a powerful approach to the detection of time variations in mass distributions on Earth, such as those related to seismic crustal

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http://dx.doi.org/10.1016/j.polar.2013.07.001

deformations (e.g., Imanishi et al., 2004), volcanic eruptions (e.g., Furuya et al., 2003), and water transfer (e.g., Kazama et al., 2012). In Antarctica, gravity measurements have been conducted to monitor ice mass balance, the viscoelastic response of the Earth to past changes in ice mass loading (so-called postglacial rebound or glacial isostatic adjustment), and the elastic response of the Earth to present-day deglaciation (e.g., Mäkinen et al., 2007). In addition, crustal deformation data, such as those available from global positioning system (GPS) measurements (e.g., Ohzono et al., 2006) and InSAR (e.g., Rignot et al., 2011), are often used in conjunction with gravity data, because the gravity data alone cannot distinguish the sources of the gravity changes (e.g., Wahr et al., 1995).

In Syowa Station, a Japanese research station on East Ongul Island (white stars in Fig. 1a–b), several geodetic datasets have been obtained since the Japanese Antarctic Research Expedition (JARE) was launched in 1956. For example, FG5 absolute gravimeters (e.g., Niebauer et al., 1995) have been used to repeatedly measure absolute gravity values at International Absolute Gravity Basestation Network, category A site #0417 (IAGBN(A); Boedecker and Fritzer, 1986) in the Gravity Observation Hut (Gravity Hut; Fig. 2b) since 1995 (Sugawara, 2011). Also, superconducting gravimeters (SGs) in the Gravity Hut and GPS instruments located at SYOG (Fig. 2b) have continuously observed time variations in gravity and three-dimensional coordinates, respectively (Iwano et al., 2005; Ohzono et al., 2006). On the other hand, relative gravity and GPS measurements have been conducted only once a year at campaign sites on outcrops along Lützow-Holm Bay near Syowa Station (gray circles and triangle in Fig. 1b; Geospatial Information Authority of Japan (GSI), 2002), except for a continuous GPS site installed by GSI (GPScont; Fig. 2c). In addition, large systematic errors can be present in the relative gravity data on account of instrumental drift and gravity gaps, because transport of the gravimeters between Syowa Station and the campaign sites by snowmobile or helicopter subjects the gravimeters to vibrations. Therefore, to obtain precise gravity values at the campaign sites as well as at Syowa Station, absolute gravity measurements should be conducted with a portable absolute gravimeter.

Recently, satellite gravity data from GRACE (e.g., Tapley et al., 2004) and GOCE (e.g., Floberghagen et al., 2011) have been used to investigate

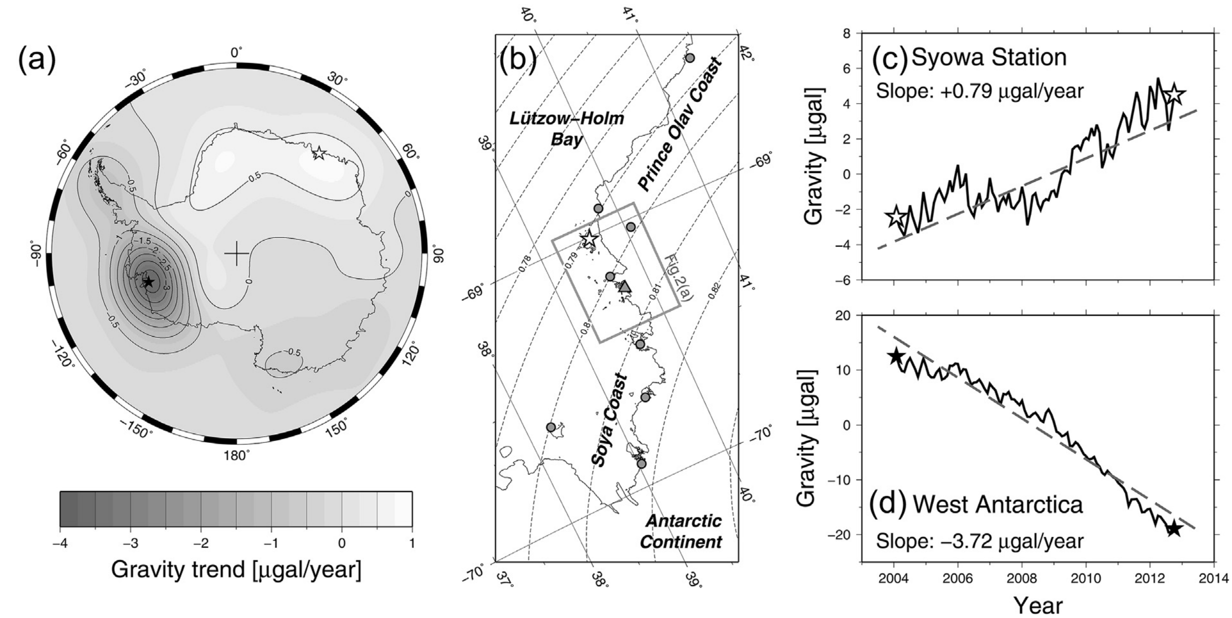

Fig. 1. Gravity variation rates in Antarctica, estimated with GRACE data. (a) Spatial distribution of the gravity variation rate on the Antarctic Continent. (b) Spatial distribution of the gravity variation rate along Lützow-Holm Bay. The white star, gray triangle, and gray circles show Syowa Station, AGS01 in Langhovde, and the planned absolute gravity sites along Lützow-Holm Bay, respectively. The gray square indicates the map area of Fig. 2a. (c) The solid and dashed lines show the observed gravity change at Syowa Station (white stars in panels (a) and (b)) and the regression line to the observed gravity, respectively. (d) The solid and dashed lines show the observed gravity change in West Antarctica (75°S, 108°W; black star in the panel (a)) and the regression line to the observed gravity, respectively.