Hybrid Gravity Measurement during the 2003 Tokachi-oki Earthquake - Another Tunnel Effect Found !

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[1] Introduction

We carried out hybrid gravity measurement during the 2003 Tokachi-oki earthquake in Hokkaido. It enables us to estimate coseismic gravity change around the focal area. To our surprise, we find significant discrepancy as large as 40 microgals between the observed and modeled gravity changes at Erimo absolute gravity station (ERM) where we expected the most accurate observation. The disagreement casts serious doubt on the validity of the theory of Okubo (1992) on the coseismic gravity change. We describe how such significant disagreement arises. In particular, we shall point out the importance of gravity gradient on the theoretical computation; Tunnel effect. We shall also present a fault model of the 2003 Tokachi-oki earthquake by applying the inversion scheme to displacement (GPS) and gravity change (this study).

[2] Observation result

(2-1) Preprocessing for the pre-seismic data and coseismic gravity change.

Absolute gravity measurements were carried out at ERM in 2001 and Akkeshi (AKS) and Obihiro (OBH) in 1998. Since significant gravity change is expected after these measurements until just before the earthquake, we must apply necessary corrections to these data so that we may estimate coseismic changes. In particular, we must estimate the effect of plate subduction during the last 2 to 5 years. We used the scheme of Savage's backslip model to estimate the interseismic gravity changes at ERM, AKS and OBH as -1.4microgal, -3.8microgal,and -2.5microgal, respectively (Okubo et al,2003). Taking these estimate into account, we derive coseismic change at ERM, AKS and OBH as +16microgal,+8microgal and +14microgal, respectively.

Since relative gravity measurements do not require such correction since they were carried out 3 weeks before the earthquake. In total, we observe -5 to +56 gravity change in Hokkaido.

(2-2) Disagreement between the observation and theory - tunnel effect.

The coseismic increase of +16 microgal at ERM appears to be physically inconsistent with those at two points close to ERM(distance c.a. 2km): +28microgal and +43microgal. During the process of checking out computer code, we find that the vertical gravity gradient is fixed to 3.086 microgal/cm (Free-air gradient). We notice that it over-estimates the effect uplift/subsidence in areas of low gradient such as ERM in a vault where Bouguer gravity gradient of 2 microgal/cm is expected; observed gradient at ERM is 2.19 microgal/cm. Since the ground motion around ERM is -18 cm after GSI's GPS measurement, the gravity on the ground of ERM should be + 34 microgals, which is much more consistent with the observed changes around ERM. We conclude that the effect of vertical gravity gradient, or a tunnel effect, clearly appears on the coseismic gravity changes.

[3] Fault Model

Simultaneous inversion of coseismic gravity change (after correction of the tunnel effect) and displacement (GPS) enables us to model the fault geometry and slip on it. We find an asperity just beneath the Erimo region consistent with the seismological inference (Kikuchi and Yamanaka, 2003).

[4]Summary

(1)Hybrid gravity measurement successfully detects coseismic gravity change due to a large earthquake around the subduction zone.

(2)Backslip model can be used to estimate the gravity values just before the earthquake even if measurements were done several years before an earthquake

(3)Vertical gravity gradient may significantly disturb the coseismic gravity change in a vault (low gradient) or at the top of mountain (high gradient).