Gravity Changes Associated with the 2004 Sumatra-Andaman earthquake - Comparison between GRACE and SNREI model

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GRACE, satellite gravimeter launched in 2002, has been providing monthly gravity field data with unprecedented accuracy. The time-varying gravity fields recovered by GRACE reflect mass redistribution on and in the Earth, which caused by, for instance, hydrology cycles and ocean currents. Earthquakes also change the Earth's gravity field. GRACE detected gravity associated with the 2004 Sumatra-Andaman earthquake. The Sumatra event is the only earthquake whose gravity changes were detected by satellite gravimeter. GRACE data also revealed the associated postseismic gravity changes (Ogawa and Heki, 2007). There are some studies which tried to interpret these postseismic signals. Ogawa and Heki [2007] proposed the mechanism of supercritical upper mantle water diffusion. Panet et al. [2007] showed highly viscous material beneath the Andaman Basin could explain the postseismic signals.

There are some remaining issues in previous studies. One is no study detected gravity signals induced by afterslip from GRACE data, although large amount of afterslip were reported from geodetic data (Hashimoto et al., 2005; Chlieh et al., 2007). Another problem is no studies took into account effects of Earth's curvature and stratification for the computation of coseismic gravity changes. Sun et al. [2004] indicated the neglects of curvature and stratification make significant errors for the computation coseismic gravity changes in a far field. Because spatial resolution of GRACE is more than a few hundred kilometers, the effects of curvature and stratification should be strictly taken into account.

In this study, we employed a dislocation theory (Sun et al., 1993) in SNREI (a spherically-symmetric, non-rotating, perfect elastic and isotropic) Earth model which strictly take into account the effects of Earth's curvature and stratification. From comparisons of coseismic gravity changes computed from different earth models, the effects of curvature and stratification of Earth reached greater than 100% at scales of a few hundred kilometers. Comparison between GRACE level-2 data and coseismic prediction based on PREM Earth model indicated two different postseismic gravity changes; fast gravity decrease continued 1-2 months and gradual increase continued about 1 year after the mainshock. We found these postseismic signals can be interpret by two different afterslips; fast slip in shallow portion (0km˜20km) and gradual slip in deeper portion (40km˜60km). The predicted afterslip agreed well with GPS observed postseismic surface displacement (Hasegawa et al., ASC 2008 Fall Meeting; Hasegawa et al., AGU 2008 Fall Meeting).

These results indicate afterslip signals are surely included in GRACE data. The 1-2 months scale postseismic gravity changes mainly caused by afterslip because such fast gravity changes cannot be explained by viscoelastic relaxation and poroelasticity (Panet et al., 2007; Ogawa and Heki, 2007). On the other hand, about 1 year scale gravity changes include both afterslip and viscoelastic signals. We need to take into account both of them for more realistic interpretation of GRACE data. In this studies, we try to isolate afterslip and viscoelastic signals from GRACE data employing dislocation theory in SNRVEI (a spherically symmetric, non-rotating, viscoelastic and isotropic) Earth model formulated by Tanaka et al. [2006].