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Postseismic deformation following the 2004 Sumatra-Andaman earthquake deduced from GRACE and GPS measurements

Takashi Hasegawa[1*], Yoichi Fukuda[1], Yoshiyuki Tanaka[2], Shin'ichi Miyazaki[1], Guangyu Fu[1], Manabu Hashimoto[3], Keiko Yamamoto[4]

[1]Department of Geophysics, Kyoto Univ., [2]ERI, Univ. Tokyo, [3]DPRI, Kyoto Univ, [4]RIHN

GRACE satellite gravimeter detected gravity changes caused by the 2004 Sumatra-Andaman earthquake for the first time. In our previous study, we revealed the postseismic gravity changes could be explained by rapid updip and slow downdip propagation of coseismic rupture (). It was inferred that the rapid afterslip in the updip direction occurred at shallow depths (0-20 km) beneath the offshore area of the Nicobar Islands. The energy released from this region had a moment magnitude (Mw) of 9.0. The slow propagation in the downdip direction at deep depths (4 0-60 km) was thought to have occurred beneath the major parts of the Sumatra-Andaman arc. The cumulative energy released from the deep depths was estimated to be Mw 9.2. Furthermore, the afterslip model that was derived from GRACE data showed good agreement with the postseismic displacements observed by GPS measurements.

On the other hand, viscoelastic mantle relaxations could cause the postseismic displacements and gravity changes which continue more than 1 year (Pollitz et al. [GRL, 2006]; Panet et al. [GJI, 200 7]). These results indicate viscoelastic effect, as well as afterslip, must be taken into account for more realistic modelling of the postseismic deformation. Therefore, this study constructed afterslip and viscoelastic relaxation models following the Sumatra earthquake from GRACE and GPS datasets, spanning from 2002 to 2009.

Assuming 3 different asthenosphere models whose viscosity is 10^17, 10^18 and 10^19 [Pa s], displacements and gravity changes induced by viscoelastic relaxation were computed in a spherically layered non-rotating viscoelastic and isotropic Earth model (Tanaka et al. [GJI, 2006]). The computations showed observed displacements and gravity changes cannot be explained only by viscoelastic effects. This result indicates afterslip surely contributed to the postseismic deformation. Therefore, in each asthenosphere model, afterslip to interpret the residuals between observation and predicted viscoelastic relaxation was constructed. We found best fit afterslip model was constructed in asthenosphere of viscosity 10^19 [Pa s].

In asthenosphere of viscosity 10^19 [Pa s], effects of viscoelastic relaxations were ignorable small during 1 year after the earthquake. The result indicates postseismic deformations during this period were certainly induced by afterslip. On the other hand, viscoelastic effects contributed some parts of observed postseismic signals at a time scale more than 1 year. In the presentation, we show revised afterslip model which were inversed from the differences between GRACE and GPS observation and viscoelastic relaxation model.

Keywords: GRACE, GPS, 2004 Sumatra-Adnaman earthquake, Afterslip, Viscoelastic relaxation