Very Long-term Post-seismic Gravity Change due to the 2004 Sumatra-Andaman Earthquake Detected by GRACE + GRACE-FO satellites

*Yusaku Tanaka[1]

1. Earthquake Research Institute, University of Tokyo

Earthquakes change the Earth's gravity field because they re-distribute mass on the Earth. Previous studies about mega-thrust earthquakes on plate boundary reported that satellite gravimetry observes coseismic gravity jumps by main ruptures, short-term gravity decreases for first several months after the earthquakes by afterslips, and long-term gravity increases by viscoelastic relaxation of upper mantle. Also, a previous study in 2015 on time-variable gravity (TVG) and crustal deformation by the 2004 Sumatra-Andaman earthquake reported that the crustal deformation had another longer component which can be understood on a rheology model, so-called "Burgers rheology", and it did not conflict with TVG.

In this study, I analyze TVG obtained by old and new satellite gravimetries (GRACE + GRACE-FO) covering a longer time-span. First, I check TVG at a point where the long-term post-seismic gravity change of the 2004 Sumatra-Andaman earthquake appeared most dramatically (hereafter "peak-TVG") based on a previous study. Peak-TVG shows that gravity was increased along an exponential function from the 2004 Sumatra-Andaman earthquake to the 2012 Indian-Ocean earthquake but the gravity increasing had turned constant in 2012. This suggests that the main causes of the gravity changes were probably switched before 2012. I have two interpretations about this.

First interpretation is to attempt to explain the peak-TVG on Maxwell model. Post-seismic gravity change of the 2004 earthquake was almost completed in 2012 and that of the 2012 earthquake proceeded constantly. In this case, the difference of the two post-seismic gravity changes might possibly have stemmed from different mechanisms and epicenters of the two earthquakes and heterogeneous viscosity structure of upper mantle. Assuming this, I calculate their spatial distributions and they shows post-seismic gravity change of the 2012 earthquake was expanded along the faults of the 2004 earthquake. Furthermore, the peaks of post-seismic gravity changes of the two earthquakes appeared at a same location.

Alternative interpretation is to attempt to explain the peak-TVG on Burgers rheology. Post-seismic gravity change of the 2004 earthquake had another longer-term component while post-seismic gravity change of the 2012 earthquake was slight. Spatial distributions of post-seismic gravity change estimated on this assumption support this interpretation as shown in the below figure.

This also indicates for the first time, based only on TVG, that Burgers rheology is more appropriate to consider the viscosity structure of upper mantle than Maxwell model.

Keywords: viscoelastic relaxation, Burgers rheology, crustal deformation, GRACE, GRACE-FO, post-seismic gravity change