Geoid height and sea surface changes due to the 2004 Sumatra-Andaman earthquake and the 2012 Indian-Ocean earthquake from satellite gravimetry and satellite altimetry

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A research article about irreversible local geoid height changes on ocean area by the 2004 and 2012 Sumatra huge earthquakes is in press as of 18th February, 2019 (Tanaka et al., accepted by TAO in 2018). I hope to introduce the results in the session of ocean sciences. The abstract of the article is below.

We first report the results from analyzing the GRACE satellite data for the co-seismic and long-term post-seismic changes in the Earth’ s gravity field and geoid height induced by the 2004 Sumatra-Andaman earthquake (Mw9.2) and the 2012 Indian-Ocean earthquake (Mw8.6). The results suggest that the two earthquakes have changed the gravity field and geoid height irreversibly (as opposed to cyclically). We next use satellite ocean altimetry measurements to search for the geoid height change induced by the Sumatra-Andaman earthquake, employing an effective method of extracting coherent space-temporal signals, namely the empirical orthogonal functions (EOF) analysis. Our results demonstrate that the sea level variation in the studied (tropical) area during the studied (10-year) period is dominated by the strong steric changes related to ENSO, to the point that the earthquake-induced signals, even using EOF for the largest earthquakes, are obscured and thus undetectable by ocean altimetry. However, this also means that steric and non-steric changes can be observed separately from artificial satellites.

[Figure] (a) Coseismic geoid height changes induced by the 2004 Sumatra-Andaman earthquake (its rectangular faults are depicted). (b) The sum of short- and long-term post-seismic geoid height changes from the earthquake occurrences till May 2016. (c) The sum of (a) + (b), i.e. co- and post-seismic geoid height changes. (d, e, f) The same as (a, b, c) but for the 2012 Sumatra/Indian-Ocean earthquake. (g) The total geoid height changes by the two earthquakes. The fault mechanisms of the two earthquakes are shown at the epicenters. (h) The time series of geoid height changes at the red circles marked in (a)-(g). The overall mean and average seasonal changes have been removed. The black dots with error bars (assumed uniform in time and have been scaled with post-fit residuals) show monthly gravity data and the red curve is the least-squares fit. The two vertical green lines indicates the occurrences of the two earthquakes.

Keywords: Geoid height change, Sea level variation, Satellite gravimetry (GRACE), Satellite altimetry (Jason), earthquake