Acceleration of oceanic plate following megathrust earthquakes

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Accelerated subduction of tectonic plates following megathrust earthquakes was proposed by D. Anderson (1975, Science). Heki and Mitsui (2013 EPSL) found postseismic enhancements of inter-plate coupling in the adjacent segments of the 2003 Tokachi-Oki and the 2011 Tohoku-Oki earthquakes. They hypothesized that these earthquakes caused accelerated subduction of the Pacific plate slab in addition to already-known postseismic processes such as afterslip and viscous relaxation. Melnick et al. (2017 GRL) found a similar enhancement of coupling to the north of the 2010 Maule earthquake rupture zone, and Loveless (2017 GRL) considered this a common phenomenon after megathrust earthquakes and named it as the super-interseismic phase. Accelerated subduction occurs during a period after the earthquakes, but its duration and amount depend on the magnitude. Here we investigate how long and how much is the acceleration over the time period covering several years after the earthquakes. So far, we have been using data from GNSS stations on arcs near the segments adjacent to megathrust ruptures. In the present study, we use data from GNSS stations on the subducting oceanic plates and on a subducted continental plate.

We present GNSS velocity data from oceanic islands showing post-megathrust accelerations. They include the Marcus Island (1098), Japan, that showed significant acceleration following the Mw 9 2011-3-11 Tohoku-Oki Earthquake. The Cocos Island (COCO), Australia, seems to have been accelerated after the Mw 8.4 2007-9-12 Bengkulu earthquake, Southern Sumatra. The JRGN in the west coast tip of Chile was accelerated after the Mw 8.2 2014-4-1 Iquique Earthquake. We also found there was a certain velocity change in Christmas Island (XMIS), Australia, after the Mw 7.7 2006-7-17 South Java earthquake. All stations are located on the oceanic plate except JRGN that is located on the continental plate.

Marcus Island (1098) GNSS station showed a significant velocity change after the 2011 Tohoku-Oki Earthquake. The maximum transient acceleration occurred in the period 2-3 years following the earthquake with a maximum velocity change of 9.4 mm/yr. After 3.0 years, The acceleration has been decaying, and the original velocity resumed by now. Cocos Island (COCO) GNSS station shows that the maximum transient acceleration occurred between 0.75-1.5 years after the 2007 Bengkulu earthquake with a maximum change of 4.9 mm/yr. After 1.5 years, the acceleration has decayed and has been showing the velocity similar to the value before the earthquake since 4.5 years after the earthquake. Chile (JRGN) GNSS station shows that the transient acceleration reached the maximum in ~1 year after the 2014 Iquique earthquake with a maximum change of 4.7 mm/yr. The accelerated velocity decayed to the original value in 2.5 years after that. The acceleration of the Christmas Island (XMIS) GNSS station was 2.7 mm/yr and occurred in ~1.0 year after the 2006 South Java earthquake. The acceleration seems to have decayed in 2.5 years after the earthquake.

In general, we found that the transient acceleration of oceanic plate occurs shortly after a megathrust earthquake and continue over a certain period. Then it decays, and finally the velocity before earthquake recovers in a few years.

Keywords: megathrust earthquake, plate acceleration, Subduction

