

Post-seismic vertical crustal movements due to the Tohoku-Oki earthquake of 11 March 2011

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This presentation reports the progress of investigations on the vertical crustal movements due to the 11 March 2011 Tohoku-oki earthquake (Mw9.0), northeastern Japan. Nationwide GPS array showed more than 1m of co-seismic land subsidence along the pacific coast of the Tohoku district. While the coast was not uplifted by the co-seismic slip, it was expected that the coastal subsidence before the earthquake together with co-seismic subsidence could be recovered by the post-seismic uplift due to combined effects of a slow slip at the deeper extension of the plate interface and subsequent visco-elastic stress adjustment in the crust and the upper mantle. For example, post-seismic crustal deformations in the southern Shikoku after the 1946 Nankai earthquake had been interpreted by this mechanism.

Time series of coordinates of GEONET array after the 2011 earthquake during the first several months after the earthquake showed slight uplift of the Sanriku coast and they were assumed to be due to the slip along the deeper plate interface along the Sanriku coast (Fukuda et al., AGU Fall meeting 2011). The maximum slip amounted to about 2.5m. However, the slip is not reaching deep enough to uplift the coast efficiently. The uplift of the coast in the first half year after the main shock has been only a few centimeters. A simple extension of the transient displacements with a logarithmic function suggests that the coast will never recover the co-seismic subsidence in the coming decades of years.

Visco-elastic adjustment using a model that assumes elastic crust and a visco-elastic upper mantle, predicts a little more complicated progress of vertical motions in the area (Tanaka et al., AGU Fall meeting 2011). Though it suggests some recovery uplift, in particular, in the southern part of the source area, the whole coast will subside in the coming 1000years or longer. Such visco-elastic process may continue for more than several thousand of years and might converge to slight subsidence compared with that before the earthquake. Considering that the super large earthquake may repeat in 1000 years or so, integrated effects of visco-elastic stress adjustments may accumulates subsidence in longer time elapse, which seem to contradict with a geomorphological evidence.

One question we may have to raise, given this consequence, is that the pre-seismic subsidence along the Sanriku coast would be due not to the coupling of the plate interface but to the visco-elastic effects by one or multiple super large earthquakes that have ever occurred in the past hundreds or thousands of years. More detailed investigations will be needed to confirm the mechanism.

Keywords: GPS, Tohoku-oki earthquake, post-seismic crustal movement, crustal movement, visco-elastic adjustment