Crustal deformation in and around the Atotsugawa fault before and after the Tohoku-Oki earthquake

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The 2011 Tohoku-Oki earthquake (Mw9.0) provides us the first opportunity to examine the responses of strain accumulation zones and active faults to megathrust earthquakes with dense permanent GPS network. In this presentation, we report the differences and/or similarities between pre, co, and post seismic crustal deformation of the Tohoku-Oki earthquake using GPS data in and around the Atotsugawa fault, located at the central part of Niigata-Kobe Tectonic Zone (NKTZ, Sagiya et al., 2000).
We used daily coordinates obtained from the GPS stations operated by university group in addition to GEONET by Geospatial Information Authority (GSI). For the pre-seismic period, we estimated the velocity field by removing annual and semi-annual components from the daily coordinates. For the post-seismic deformation, we extracted the period from 25 November 2014 to 2 July 2016, and estimated the velocity field in the same manner. For the co-seismic displacement, we calculated the average coordinates for 5 to 10 March 2011 and 12 to 17 March 2011, and subtracted the former from the latter. From the velocities and displacements thus determined, we calculated the strain rates following the method of Shen et al. (1996) with CCD of 20 km.
Spatial pattern of the co-seismic strain is completely different from the pre and post seismic strain rates pattern. The co-seismic deformation indicates elastic strain, and its spatial variation indicates heterogeneity in the elastic constants. Therefore we conclude that the pre and post seismic strain concentration is mainly caused by the inelastic straining. The strain rates before and after the earthquake are similar to each other, which can be explained by considering inelastic deformation responsible for the strain rate concentration. The inelastic strain, viscous flow for example, depends on the absolute stress accumulated over a long time scale, which is far larger than the stress change by one earthquake. The similarity in pre and post-seismic strain rates is consistent with a previous study for the northern part of NKTZ (Meneses-Gutierrez and Sagiya, 2016).
The deformation pattern before and after the earthquake are characterized by high strain rates along the Atotsugawa fault and its eastern and western ends where volcanic activity is high. In the volcanic areas, due to the high temperature, the viscous flow would be dominant. Along the Atotsugawa fault, on the other hand, the fault slip at the depth would be dominant. Thus, different mechanisms of inelastic deformation would proceed simultaneously in and around the Atotsugawa fault.
Looking in detail, we noticed some differences between pre and post-seismic strain rate pattern. For example, the sense of strain rates reversed in the south of the Hida mountain range and to the east of Mt. Ontake. Both regions are known as thermally active areas and many small earthquakes have been occurring frequently. Considering these points, the change in the strain rates in these regions are probably related to the volcanic activities.

Keywords: Tohoku-Oki earthquake, GPS, inelastic strain

