Seismic velocity change in Tokai region detected by Morimachi ACROSS

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In this study, we monitored seismic waves generated by Morimachi ACROSS using High sensitivity seismograph network Japan (Hi-net) stations in Tokai region, and detected two types of temporal travel time changes, secular change and co-seismic change at the time of the 2011 Tohoku-oki Earthquake. We associated the secular and co-seismic changes to closing and opening of the cracks beneath the region due to tectonic strain and strong shaking of the ground, respectively.
ACROSS (Accurately Controlled Routinely Operated Signal System) is a kind of artificial seismic source system for monitoring the temporal variation in propagation properties of seismic waves in the crust. We measured temporal variation in the travel time of S-wave during a period from 2007 to 2014 at five Hi-net stations within 35km away from the ACROSS source. The temporal variation of each component was fit by secular, annual, half-annual and offset at the time of the 2011 Tohoku-Oki earthquake (Fig.1).
In all stations, the secular changes were advance in contrast that the co-seismic changes were delay. The secular advances ranged from 0 to 1 ms/yr and the co-seismic delays ranged from 0 to 5 ms. Both the secular and co-seismic changes showed significant polarization anisotropy. The secular advances were larger in NW component in the five stations. On the other hand, the co-seismic delays were larger also in the same NW component (Fig.2).
If we assume travel time was changed by closing or opening of cracks, the anisotropic changes suggest the selective closing and opening of the cracks in the NE direction. We analyzed the crustal strain during the observation period using GNSS earth observation network system (GEONET). This region showed NW-SE compression and NE-SW extension as the inter-seismic and co-seismic strain, respectively. For the secular changes, inter-seismic strain is well-matched to suggested crack closing. Thus the secular changes may reflect the stress changes in the crust due to tectonic stress buildup. In the co-seismic changes, the co-seismic strain don't match to suggested crack opening. Thus we give the following interpretation. In this region, the crack density in the strike of NE is larger than that in other directions. The strong shaking of 2011 Tohoku-Oki earthquake caused spontaneous opening of all cracks due to increase of pore pressure. So the observed anisotropy should reflects persistently existing preferred orientation of cracks. Considering the geological structure of Tokai region, the interpretation may possible.
Acknowledgments.
We used the data by Hi-net, provided by National Research Institute for Earth Science and Disaster Prevention.
Reference
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Figure Caption
Fig1. Travel time advance at Kakegawa Hi-net station

Blue and red open circles show observed and predicted travel time advance with reference to Feb 28, 2007.
Predicted one is expressed by linear combination of secular, annual, half-annual variations and offset at the time of the 2011 Tohoku-Oki earthquake (red vertical line).
Fig2. Co-seismic (top) and Secular (bottom) travel time changes
Star shows the location of Morimachi ACROSS source. Ellipses show travel time variations with uncertainty expressed by their width of the arc colored by red (advance) and blue (delay). The axes of each ellipse correspond to the travel time variation of Tt and Rr components.

Keywords: seismic ACROSS, seismic velocity change, travel time change, Hi-net, Tokai region

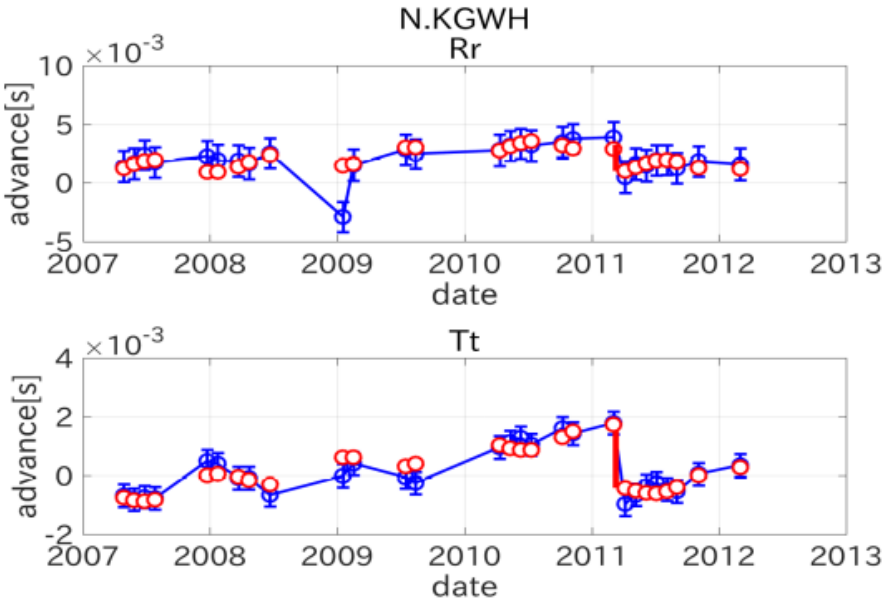

Fig.1 Travel time advances at Kakegawa Hi-net station

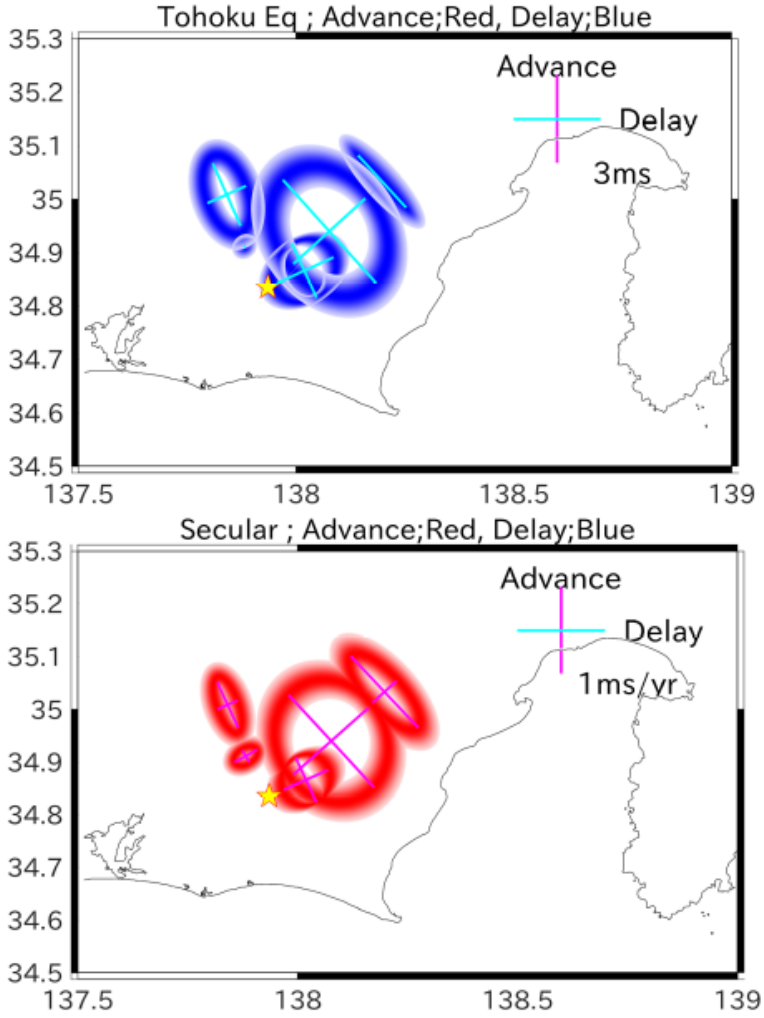

Fig.2 Co-seismic (top) and Secular (bottom) travel time changes

