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Changes in the interplate coupling beneath NE Japan estimated from velocity gradients and small repeating earthquakes

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1. Introduction

A number of studies have attempted to estimate the spatial variations of interplate coupling on subducting plate interface beneath northeastern Japan based on the surface velocity fields deduced from Global Positioning System (GPS) observations (e.g., Ito et al., 2000, Nishimura et al., 2004, Suwa et al., 2006, Hashimoto et al., 2009). These studies estimated several common strong coupling zones, but, there are significant differences among their results due to the differences of the plate interface models and inversion methods. Especially, each study estimated significantly different coupling strengths at the deep portion beneath the Tohoku district and at Fukushima-Oki region. We can not ignore such differences to consider the strain accumulation process. Iinuma et al. (2010, 114th Meet. Geod. Soc. Japan) have reported that the regions of the large displacement rate gradient correspond to the rupture zones of recent interplate large earthquakes, where the coupling strengths must be strong in interseismic periods, based on the GPS observations. They also reported changes in the displacement rate gradients at several regions that suggest temporal changes in the interplate coupling at such regions. We carried out further analysis in order to confirm whether the temporal changes in the interplate coupling strength really occur or not.

2. Data and analysis

We used daily site coordinate time series of GEONET (F3 solutions) that are provided by the Geographical Survey Institute of Japan. We extracted displacement rate field from the time series by fitting the function that consists of long-term trend, annual and biannual trigonometric curve, and steps due to the earthquakes and antenna replacements. The long-term trend is estimated for each one-year time window being shifted by one week. The gradient of the surface velocities is calculated at each belt-like region configured along the direction of the plate convergence. The gradient of horizontal velocities is large when the interplate coupling at shallow part (less than about 50 km in depth) beneath the profile is strong, and the sign of the gradient of the vertical velocity is sensitive to the existence of the coupling at deep part.

We also used the slip rate and number of the interplate small repeating earthquakes to infer the temporal change of coupling. The small repeating earthquakes are identified based on the similarity of the seismograms by calculating the coherence of waveforms. We considered an earthquake pair to be repeating earthquakes when the averaged coherences at 1-8 Hz were larger than 0.95 at two or more stations. The analysis time window was 40 seconds, starting from the first P-wave motion. We then linked a pair (group) of repeaters with another pair (group) if the two pairs (groups) shared the same earthquake. The small repeating earthquakes also have a good sensitivity in coupling in wide depth range. They are thought to be occurring due to the stress accumulation by the surrounding aseismic slip and thus we can infer the aseismic slip or coupling change from the activity.

3. Results and Discussion

We found that many small repeating earthquakes occurred when the horizontal velocity gradient is small at the belt-like regions where the offshore interplate coupling is relativity low along the Japan Trench, such as offshore Ibaraki Prefecture and southern Iwate Prefecture. Both high activity of the small repeating earthquakes and small gradient of the horizontal surface velocities suggest the week interplate coupling and occurrence of the aseismic slip. This suggests that at the weak coupling area along the trench the accumulated strain due to the interplate coupling at the shallow plate interface is released by episodic slow slip event. This imply that the *stable sliding* at the plate interfaces shallower than the seismogenic zone (about 20 ~ 50 km in depth) near the Japan Trench is not perfectly *steady* but *episodic*.

Keywords: Interplate Coupling, GPS, Small Repeating Earthquakes, Northeastern Japan, Slow Slip Event, Crustal Deformation