Shallow undersea SSEs off the western Japan monitored by the GNSS-A

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In the last two decades, many kinds of SEQs including non-seismic SSE have been detected using the onshore high-precision seismometer and GNSS networks. Along the Nankai Trough having dense seismic and geodetic monitoring network, their relationships were discussed and compared in detail [e.g., Hirose et al., 2010, Science; Obara and Kato, 2016, Science]. Observation of deep and shallow SEQ analogies and differences has multidisciplinary value for the physical properties of the plate boundary, submarine geology and earthquake disaster research. However, comparison between deep underground SEQs and shallow undersea SEQs cannot easily be performed due to the undersea observation technical constraint.

In these several years that the technology has been upgraded, shallow SEQs (tremor, LFE, VLF and short-term SSE) have been detected along the pan-Pacific subduction zones in high-precision onshore seismometers, seafloor seismometers, ocean bottom pressure gauges and submarine borehole strainmeters [e.g., Wallace et al., 2016, Science; Araki et al., 2017, Science]. However, there was no geodetic monitoring technology for detecting undersea longer sequence of SSE than week-scale. Longer-term SSE than week-scale cannot be monitored except for the GNSS-A technique.

Recently, we improved the GNSS-A technology and upgraded observation frequency and precision [Yokota et al., 2017, Rep. Hydro. Ocean. Res; Yokota et al., 2018, MGR]. With the present observation capability, yearly time change of the amount of undersea crustal deformation was newly unclosed. Then, the GNSS-A monitoring uncloses the occurrence situation of undersea SSE which could not be observed by the onshore geodetic network.

We detected SSE signals in the GNSS-A data using c-AIC detection process based on the method of Nishimura et al. [2013, JGR]. Then, SSE rectangle models were estimated by the grid search process using the GNSS-A signals and the onshore GEONET data. The detected models are located off the Kii channel and the Bungo channel at shallow side around the Nankai Trough historical seismogenic zone and strong coupling regions estimated by Yokota et al. [2016, Nature] and Nishimura et al. [2018, Geosphere]. We detected about M_w 6.0 and 6.5 events off the Kii channel and a migration of about M_w 6.1 ~ 6.2 events off the Bungo channel.

Shallow VLF events [NIED and Asano et al., 2008, EPS] were also activated simultaneously with these undersea SSEs. Off the Kii channel, VLF activity in 2009 was a little closer to the western side than 2018. Off the Bungo channel, VLF activity after 2015 was synchronized with the undersea SSEs. These suggest the temporal synchronization and the spatial relationship between SSE and VLF in these regions.

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