Slow slip events in the Bungo Channel and Hyuganada areas from May 2018 to June 2019 detected by a GNSS observation network

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GNSS observations reveal that slow slip events (SSEs) that last for months--year have repeatedly occurred around the Bungo Channel area, southwest Japan (e.g., Hirose et al., 1999; Ozawa et al., 2020). These events have a similar size in seismic moment, but have different source slip evolutions. In the Hyuganada area, south of the Bungo Channel area, repeating SSE activities have also been reported (e.g., Yarai and Ozawa, 2013). It is important to better constrain a time development of an SSE because this provides not only critical constraints on the generation mechanisms of slow earthquakes in general, but also useful information for estimating the interplate strain budget, that is, strain accumulated by relative plate motions and one released by slip episodes. To do this, we have installed continuous GNSS stations around the Bungo Channel and Hyuganada areas since 2014. In this study, we estimate time evolution of slow slip sequences in these areas from May 2018 to June 2019, including a long-term SSE in the Bungo Channel and another long-term SSE in the Hyuganada area.

We used GNSS data from our stations in addition to GSI's GEONET stations located in Kyushu, Shikoku and southern Chugoku areas. These observed RINEX data were processed with GIPSY-OASIS 6.4 to estimate daily coordinates of these stations in ITRF2014. We selected five stations in the Chugoku area as reference sites. A constant velocity component (a linear trend) and an annual and a semi-annual components are estimated from the two one-year-long time windows before and after the slip sequences for each displacement component as a background, and are subtracted from the data of entire time period of each component of each station. Jumps caused by coseismic deformations and station maintenances are also removed.

These processed data from March 2018 to June 2019 are inverted by using a Network Inversion Filter technique (Segall and Matthews, 1997; Hirose et al., 2014). We assume that slip occurs on the plate interface and model the interface geometry by placing 19 x 11 square fault elements (15 km x 15 km each).

From the estimated slip history of the entire inverted time period, we identified at least four slip stages: (1) slip starts around the Oita--Miyazaki boundary area (hereafter, area A) near the east coast of Kyushu at May 2018 and continues until around September 2018 with the slip area expands to the south; (2) slip propagates from the area A to the Bungo Channel area following the slip (1) and continues until around May 2019; (3) the southern slip propagation described in (1) is followed by a long-term SSE around the Miyazaki Plain that lasts until around April 2019; (4) slip at the western Shikoku area appears from late September 2018 to October 2018, corresponding to a short-term SSE (event "201810" in Hirose and Kimura, 2020).

The northern end of the slow slip in the Bungo Channel corresponds to the "updip tremor belt" (Obara et al., 2010), suggesting that a tremor activity there is induced by slow slip in the Bungo Channel area. Northward slow slip propagations around the area A have been observed (e.g., Ozawa, 2017; Takagi et al.,

2019). This study shows clearer evidence of a southern propagation behavior there. Uchida et al. (2020) suggest a slow slip pathway from south to north of the Hyuganada area from repeating earthquakes activity. Our result shows that the Hyuganada slow slip pathway is not "one-way" but bi-directional.

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