Fault friction properties inferred from the early afterslip of the 2011 Tohoku-Oki EQ estimated by the PTS analysis

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Early afterslip within a few minutes to half-day after the earthquake has a significant contribution to the slip budget of the fault. Additionally, some previous studies have suggested that estimating the spatio-temporal evolution of early afterslip is critical to understanding the friction properties of the fault. However, in the time scale of a few minutes to half-day, there is a lack of precision pertaining to GNSS positioning analysis caused by the difficulty of separation between fault slip and other error factors such as tropospheric delay. Therefore, few studies investigated early afterslip and estimated the friction properties of the fault. According to such background, we propose an alternative approach (phase-to-slip; PTS) that detects fault slip directly from GNSS carrier phase variation without conventional positioning. Since this method estimates the temporal evolution of the fault slip and other unknowns in parallel, we can quantitatively evaluate the situation of parameter separation.

This study attempted to estimate the spatio-temporal evolution of the early afterslip within approximately 40 minutes (from 14:46 to 15:30 JST) following the 2011 Tohoku-Oki earthquake. We used 1-Hz carrier phase data of 73 GEONET sites around East Japan. As a result, 0.1–0.2 m early afterslip was suggested in the downdip region near Iwate and Miyagi with a depth of approximately 50 km, adjacent to the mainshock rupture. The slip area near Iwate showed a slightly larger slip amount compared to the slip area near Miyagi. Locations of the estimated early afterslip areas correspond to the downdip limit of an interplate earthquake. They are well complementary to the rupture areas of the mainshock and the past major earthquakes.

Additionally, our results show spatial heterogeneity of the onset time of the early afterslip. For example, the slip area near Iwate starts to increase around 14 minutes after the mainshock origin and exceeds the estimated uncertainty around 24 minutes after the mainshock. On the other hand, the slip area near Miyagi appears around 24 minutes after the mainshock, a few or ten minutes later than Iwate. Our results also show time variation of slip velocity. Both two slip areas slow down in the latter part of the analysis. Such characteristics have not been proposed in the previous studies. Our results demonstrate the capability of the PTS for broadband fault slip monitoring, including the time scale of a few minutes to half-day. More significant and earlier occurrence of the afterslip near Iwate indicates that this region has higher sensitivity to shear stress change. In the presentation, we describe the quantitative estimation of the friction properties of the plate interface based on the early afterslip time series deduced from the PTS. Then, we will discuss its spatial heterogeneity by comparing between the observations from the seismological approach.

