Feasibility of the GNSS carrier phase to fault slip approach for the estimation of slip phenomena in subduction zone

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Precise detection of coseismic deformation and estimation of its source model are especially important in the case of earthquake occur in subduction zones, because it is directly related to accurate tsunami forecasting. Recent years, many researchers have tried to estimate earthquake source model and/or tsunami wave field in real-time using Global Navigation Satellite System (GNSS). However, conventional GNSS-based monitoring requires huge computational cost for positioning analysis. Using coordinate time series for observation also causes difficulty to evaluate accuracy of separation between deformation and other unknown parameters such as tropospheric delay. Additionally, current positioning analysis strongly depends on precise orbit information which is provided externally.

According to such background, we investigate the feasibility of deformation monitoring based on the GNSS carrier phase to fault slip approach for subduction zone. This method, which we call PTS (Phase To Slip) detects fault slip directly from GNSS carrier phase variation without positioning analysis. As PTS method estimates all unknown parameters in parallel, computational costs for real-time seismic monitoring can be reduced. Moreover, PTS does not require high-quality satellite orbit because it relies only on changes in azimuthal site-to-satellite ranges (Tanaka, Ohta, and Miyazaki, GRL, 2019).

Here we applied the PTS method to the largest aftershock of the 2011 Tohoku-Oki earthquake. In the analysis, we used both precise orbit provided by International GNSS Service (IGS) and broadcast orbit submitted from satellite without any network connection. As a result, we obtained very similar coseismic slip distribution in the two cases. Inferred fault slip showed clear thrust slip and was equivalent to M_w 7.8. These results well agree with the estimation based on conventional GNSS analysis such as Nishimura et al. (EPS, 2011). Calculated surface displacements also agree with independent conventional GNSS analysis result. These results indicate that the PTS method can be useful as a supplementary system of current deformation monitoring, which does not require any external information. Furthermore, once we could obtain slip distribution, we can also convert it into deformation of sea bottom, which is equivalent to initial tsunami source. Thus, our results suggest potential feasibility of PTS method for tsunami forecasting.
In the presentation, we will describe application of the PTS method to whole process of Tohoku-Oki earthquake, including its foreshock, mainshock and following aftershocks. Beside detail of its result, we will also demonstrate quantitative evaluation of parameter separation accuracy inside PTS analysis.

