Symplectic-adjoint-based uncertainty quantification of frictional inhomogeneity on slow-slipping fault

*Shin-ichi ITO[1], Masayuki KANO[2], Hiromichi NAGAO[1]

1. Earthquake Research Institute,The University of Tokyo, 2. Tohoku University

Slip motion along a fault largely depends on the inhomogeneity of friction that occurs between the fault interfaces. Thus, it is a crucial task to estimate the spatial-dependent frictional features from the observations of the slip motion and then to identify essential parts that contribute to the principal slip motion by quantifying uncertainties involved in the estimates. This study considers an uncertainty quantification problem of the spatially-dependent frictional features based on a fault motion model that mimics the slow-slipping region along the Bungo Channel in the southwestern part of Japan. The fault motion model employs a rate-and-state dependent friction law, in which the frictional parameters are spatially dependent. Although uncertainty quantification in high-resolution is needed to attain the above task, such quantification based on the conventional statistical ways is computationally hard since the complexity exponentially increases with the spatial resolution. This study employs a variational data assimilation method based on a second-order adjoint method to avoid such complexity. Since the data assimilation method enables a selective extraction of the uncertainty of interest, we can attain a fast uncertainty quantification of the frictional parameters in high-resolution. The application of the data assimilation to the fault motion model together with the synthetic observational data of the slip velocity quantifies the spatial dependency of the uncertainty involved in the frictional parameters in high-resolution and reveals how the amount or quality of the observational data of the slip motion influences to the spatial distribution of the frictional parameters. Such quantification provides valuable information to the observational design.

