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Estimation of Frictional Parameters and Initial Values of Simulation Variables Using Adjoint Method with Afterslip Data

Masayuki Kano[1*], Shin'ichi Miyazaki[1], Kosuke Ito[1], Kazuro Hirahara[1]

[1]Geophysics, Kyoto Univ.

Since variations of slip on plate boundaries depend on frictional properties, it is essential to know frictional parameters on the fault, as well as initial values of simulation variables for earthquake generation prediction. In this study, an adjoint data assimilation method is introduced to a simplified fault model with a rate- and state-dependent friction law as a first step toward the goal of estimating the frictional parameters and initial values of simulation variables in a realistic situation. Compared to the grid search method, particle filtering and Monte Carlo method, the adjoint data assimilation method is a computationally efficient method to estimate control variables such as frictional parameters and initial values by time-trajectory fitting of observation data. In this study, the method is applied to the simplified model which mimics the 2003 Tokachi-oki afterslip. We make synthetic data set by assigning the true frictional parameters and initial values artificially. We investigate the feasibility of estimating frictional parameters and initial values through the adjoint data assimilation method which digest the observations on the assumption of knowing background values. We confirm the legitimacy and its computational efficiency of the estimation. Also, we examine the sensitivity of each frictional parameter and initial value to the observed afterslip velocity data. In the range of our search using afterslip data, we find that 1) the initial value of velocity can be constrained, 2) the initial value of state variable cannot be constrained, 3) the frictional parameter value of a-b is well retrieved in the region where aftreslip velocity is observed, and 4) the value of characteristic length L can be retrieved only from the early portion of afterslip velocity data, where the velocity is rapidly changing.