Data Assimilation for Earthquake Cycle Simulations: Application of a spring-block model to the earthquake sequence off Kamaishi

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Earthquake cycle simulations have become popular recently, but most of them are based on model parameters or initial conditions given rather arbitrarily. In order to conduct a realistic simulation to make a forecast, it is essential to assume model parameters and initial conditions in accordance with observations. This process is called data assimilation, which is indispensable to predict crustal activities like earthquakes.

We try to estimate frictional parameters of the source area of the characteristic earthquake sequence off Kamaishi, northeastern Japan, by using a single degree of freedom spring-block model. M4.9+-0.1 earthquakes have occurred at recurrence intervals of 5.52+-0.68 yrs at the same location on the plate boundary off Kamaishi [Uchida et al., 2007]. Because of the regularity of earthquake recurrence, the rupture area of these earthquakes is regarded as an isolated patch surrounded by aseismic sliding area. Therefore, a single degree of freedom spring-block model is applicable to this earthquake sequence. We employ the rate- and state-dependent friction law [Dieterich, 1979; Ruina, 1983], and estimate parameters to a, b and D_c.

We first assume other model parameters except for 3 frictional parameters based on the tectonic setting. Then we conduct simulations with the spring-block model with various combinations of the frictional parameters, and calculate the recurrence interval and the amount of the coseismic slip. Frictional parameters satisfying each observable form a smooth curved surface in the 3-D parameter space. Frictional parameters satisfying the two observations can be obtained as a crossing curve of those two surfaces. The instability condition for the spring-block gives additional constraint, and we can constrain frictional parameters into a finite curve in the 3-D parameter space. With additional observable such as the amount of pre-slip before the main shock, we will be able to get a unique solution. We will extend our study to other cases of repeated ruptures of an isolated patch.