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Seismic phenomena on the plate interface are diverse, including ordinary earthquakes, shallow and deep slow earthquakes, and stable slip. Ordinary earthquake, which is characterized by power-law statistics, and slow earthquake have different scaling relation between seismic moment and duration of the event. The M9 Tohoku earthquake in 2011 provides us interesting observation about the hierarchical structure of ordinary earthquakes. Foreshocks and aftershocks on the plate interface occurred only at the area where seismicity has been observed so far. This observation suggests that hierarchical structure is stick to space. This view of seismic source is similar to the model by Ando et al. (2010, 2012) and Nakata et al. (2011), which reproduce the behavior of slow earthquakes. In their model, brittle patches are distributed on the ductile background.
Nakata et al. (2011) showed that their model could reproduce both ordinary earthquake and slow earthquake with different density of brittle patches. However, Nakata et al. (2011) did not show the detail condition how slip behavior of the fault transit from ordinary earthquake to slow earthquake. This study will investigate how this boundary is determined. For easy understanding, we use a 2D model space (line fault) with rate and state friction, which can explain the slip behavior of rock at slow slip speed, although Nakata et al. (2011) used slip-weakening law with Newtonian rheology as friction law. We calculate quasi-static elastic stress interactions between sub-faults with a cyclic boundary condition and radiation damping at a prescribed seismic speed. Frictional parameter (a and b) was set heterogeneously on the fault as either velocity weakening (VW, a-b < 0) or velocity strengthening (VS, a-b > 0), but characteristic length (Dc) was distributed uniformly. We tested bimodal distributions of frictional parameter. The distribution of frictional parameter is characterized by the length of cyclic unit L and the ratio h of VW region within the fault. The stress loading by the plate is characterized by stiffness k. We have tested many sets of h and k, and have investigated the slip behavior. As a result, three types of slip behavior are observed, (i) stable slip, (ii) seismic slip in VW regions and afterslip in VS regions, and (iii) entire seismic slip. When h is small, the size of a VW region is smaller than the nucleation size of constant-weakening regime (a/b=5/6 in our study, Rubin and Ampuero, 2005), and slip occurs stably. Stable slip also occurs with a sufficiently large k. When k is below a critical stiffness, slip in VW regions is accelerated to the seismic speed. The boundary between (ii) and (iii) is determined by whether slip in VS regions exceeds Dc, accelerated by seismic slip in the adjacent VW regions. When h is small, slip in VS regions does not reach Dc and the decrease of state variable is small, before the termination of the seismic slip in the VW regions. Later, relatively slow slip occurs in VS regions as an afterslip. When h is large, slip in VS regions exceeds Dc and state variable decreases rapidly, before the termination of seismic slip in the VW region. Therefore, the slip in VS regions is also accelerated to the seismic speed, and the entire fault slips seismically at the same time. The boundary between the regimes (ii) and (iii) shifts to smaller h when k is decreased. Given that small randomness exists in the bimodal distributions in the regime (ii), seismic slip in VW regions occurs independently separated by slowly slipping VS regions. These successive slip events occurring in a short period appear to be a single event with almost constant moment rate function, which looks like a slow earthquake. On the other hand, the entire seismic slip in the

regime (iii) is considered as an ordinary earthquake. Thus the boundary between regimes (ii) and (iii) separates two modes of seismic slip.

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