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Characteristics of slip and stress due to interaction between fault segments

Keisuke Ariyoshi[1*], Toru Matsuzawa[2], Yasuo Yabe[2], Naoyuki Kato[3], Ryota Hino[2], Akira Hasegawa[2], Yoshiyuki Kaneda[1]

[1]DONET, JAMSTEC, [2]RCPEV, Tohoku University, [3]ERI, Tokyo University

As a method of a long-term earthquake prediction, Shimazaki and Nakata (1980) proposed two recurrence models to explain the quasi-periodic nature of repeating earthquakes: the time-predictable and slip-predictable models. It remains difficult, however, to successfully apply either the time- or slip-predictable model to most of major earthquakes. This is partly because the stressing rate is assumed to be constant in both the models; the condition cannot be applied to real large earthquakes due to intermittent slip in the surrounding area as seen for Miyagi-oki earthquakes. We have performed a two-dimensional numerical simulation to elucidate the physical processes governing earthquake behavior when significant stress perturbations are produced by interaction between fault segments. Our model involves two seismogenic segments separated down-dip on a subduction plate boundary and incorporates a rate- and state-dependent friction law. Our simulations show that slip amounts in the seismogenic segment increase in all of the co-, pre- and post-seismic stages when an earthquake occurs shortly after another earthquake in the other seismogenic segment. Conversely, when earthquakes occur in a single seismogenic segment several times in succession while the other segment remains locked, all three pre-, co-, and post-seismic slip amounts become smaller. These results imply that precursory changes do not necessarily occur at the same level on every occasion. In cases of multiple rupturing, the co-seismic slip of the later earthquake in a pair is approximately characteristic when frictional stability in the aseismic segment between the two seismogenic fault segments is strong enough to produce different rates of seismicity on each segment. We also try to interpret the 2004 Sumatra earthquakes by applying the simulation results, and discuss the variation of preseismic stress changes and rupture initiation points.

Keywords: Perturbation of earthquake cycle, Constant stress drop model, Characteristic slip model, Preseismic slip, the 2004 Sumatra earthquake, Numerical simulation