Various slip pattern in earthquake generation cycle modeled with heterogeneous fracture energy distribution

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On the plate boundaries, large earthquakes occur with various recurrence interval and size, episodic slow slip events and after slip also occur. Such various slip pattern on the plate boundary is usually modeled with heterogeneous velocity dependence of friction based on rate- and state-dependent friction law (Rice, 1993; Kato, 2004, etc.). However, as Nakatani(2001) shows, this friction law is composed of the framework law (stress- and strength-dependent slip law) and the evolution law for the interface strength. From this point of view, the parameters 'b' and 'L' for the strength evolution law partially correspond to those determine fracture surface energy in rupture propagation problem with slip weakening law. The parameter 'L' is mainly related to the slip weakening distance 'Dc'.

We model asperities as heterogeneity in 'L' as dynamic rupture propagation model by Ide and Aochi(2005) in 'Dc'. In order to simplify the model setting, we treat two asperities with similar scale (not multi-scale as Ide and Aochi, 2005). The background of the asperity has larger value in 'L' similar to Ide and Aochi (2005). Velocity dependence in frictional property (as parameterized by 'a-b' value) changes only with depth similar to Hillers et al.(2006;2007).

Simulation results show that a great earthquake, which ruptures almost whole seismogenic zone, and large earthquakes, which rupture two asperities separately, occur alternately. Slip amount at the center of one of the asperities is several times larger for the great earthquake than for the large earthquake. Recurrence interval also varies significantly (roughly twice after the great earthquake). Significant afterslip occur around asperities after large earthquakes. Episodic slow slip event also occurs near the deeper edge of the asperities before the great earthquake. Thus earthuqake generation cycle simulation with heterogeneous 'L' distribution, which corresponds to fracture energy or 'Dc' heterogeneous distribution, can qualitatively reproduce various slip pattern observed on the plate boundaries. One important aspect of our results is that slip pattern can significantly differ from each earthquake cycle. Such variation in earthquake generation cycles has been revealed recently based on various observation data.