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► **To cite this version:**

Hideo Aochi, Satoshi Ide. Scaling relation in slip deficit during the interseismic period from numerical simulations. Seismological Society of America Annual Meeting 2015, Apr 2015, Pasadena, United States. hal-01101249

HAL Id: hal-01101249

<https://brgm.hal.science/hal-01101249>

Submitted on 8 Jan 2015

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Scaling relation in slip deficit during the interseismic period from numerical simulations

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Scaling relation of “standard” earthquakes can be explained by the hierarchical property and structure in fracture energy during the coseismic weakening process from the mechanical point of view (e.g. Aochi and Ide, GRL, 2004; Ide and Aochi, JGR, 2005). Namely it is important that the slip weakening distance in friction law is proportional to the heterogeneity (patch) size. Now we are interested in the scaling of slow or aseismic slip during interseismic hardening process. According to the analogy from our previous studies, we consider patches of different sizes, attributed particular frictional parameters. For the simplicity, we suppose a simple equation, $\tau(w) = \Delta\tau(w/w_c)^\gamma \exp(1-(w/w_c)^\gamma)$, where shear friction τ is a function of cumulative slip w and with a factor $\gamma (>0)$, a constant $\Delta\tau$ and characteristic length w_c . We then consider a constant loading rate V surrounding the model area. Stress accumulation on patches prior to the weakening process depends on the patch size, and slip deficit is cumulated the most when stress is at peak. The time to the maximum slip deficit and the slip deficit amount are briefly proportional to the patch size, regardless if w_c is scale-dependent or not. The numerical simulations suggest that slip deficit rate is size-invariant under the same loading if w_c is proportional to the patch size and $\gamma = 1$. Furthermore if w_c is scale-dependent and $\gamma = 2$, the slip deficit rate is inversely related to the patch size. Namely, slip deficit rate is smaller for a large patch. In other words, large patches always slip slowly, accumulating only a part of plate motion. So-called background stable slip region can be substituted by an extremely large patch, which may include small patches rupturing repeatedly (repeating earthquakes).