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Physics-based modelling of earthquake generation cycles at plate subduction zones in and around Japan

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In and around Japan, the lithosphere is divided into four plates; the Pacific (PA), the North American (NA), the Philippine Sea (PH), and the Eurasian (EU) plates. These four plates are interacting with each other at four plate interfaces; PA-NA, PA-PH, PH-NA and PH-EU. Kinematic interaction at a plate interface is rationally represented by the increase of tangential displacement discontinuity across the interface. Then, plate subduction is represented by steady slip motion along a curved plate interface. The occurrence of large interplate earthquakes can be regarded as its perturbation. The earthquake generation cycle consists of tectonic loading, quasi-static rupture nucleation, dynamic rupture propagation and stop, and subsequent stress redistribution and fault restrengthening. The occurrence of unstable dynamic slip brings about decrease both in fault strength and shear stress to a constant residual level. After the arrest of dynamic slip, restoration of the fault strength begins and the process of stress accumulation starts again in the seismogenic region. Such space-time changes in the shear stress, the fault slip and fault strength during earthquake generation cycles are controlled by a fault constitutive law. Given a crust-mantle structure, the entire process of earthquake generation cycles should be consistently described by a coupled nonlinear system of a slip-response function and a fault constitutive law. The driving force of this system is observed relative plate motion. Thus, we can construct a realistic 3-D simulation model for earthquake generation cycles at plate subduction zones in and around Japan, by combining a 3-D model of plate interfaces in and around Japan (CAMP Standard Model), the viscoelastic slip-response functions for this structure model, and the slip- and time-dependent fault constitutive law with an inherent strength-restoration mechanism.