Possible Dynamic Rupture Scenarios of the Nankai-trough Earthquake: Effects of Hypocenter Locations and Friction Parameters

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We investigated possible dynamic rupture scenarios of anticipated megathrust earthquakes along the Nankai-trough, southwest Japan, to understand where the rupture is likely to start, how the rupture propagates along the Nankai-trough, and conditions under which the rupture grows to a large earthquake.

We computed many 3-D dynamic rupture propagations by the boundary integral equation method with triangular elements (Hok & Fukuyama, 2011, GJI) in an infinite homogeneous medium to obtain 3-D dynamic rupture scenarios of the Nankai-trough earthquake. We examined the dependency of several possible friction parameter sets and hypocenter locations because they were most uncertain parameters in the simulation.

For the plate interface geometry, we used a realistic 3-D non-planar plate interface geometry in and around Japan constructed by Hashimoto et al. (2004, Pageoph). The model extended from the Hyuga-nada region to the Izu Peninsula along the Nankai Trough.

We used the slip-deficit rate distribution estimated from GNSS and GPS-Acoustic observations (Noda et al., 2018, submitted). We constructed initial stress distribution as the sum of back ground stress field and that computed from the slip-deficit rate distribution by using completely relaxed responses in a 60-km-thick elastic surface layer overlying Maxwell-type viscoelastic half-space. We assumed that slip deficit rate was constant for an interseismic period of 200 years and that the accumulated stress will be completely released where the slip amount is higher than the slip-weakening distance during the Nankai-trough earthquake. We also assume that the initial shear stress (i.e., slip) direction was the same as the plate subduction direction.

We used the slip-weakening law with the Coulomb failure criteria (Ida, 1972, JGR) to describe the frictional property on the plate interface. The stress drop was assumed to be the same as that expected from the accumulated shear stress distribution ($\Delta\tau$). Here we examined several friction parameter sets. The fracture strength was set to either spatially uniform yield stress or that defined by spatially uniform S-value (the ratio of the yield stress to the stress drop). The slip-weakening distance was set to be either constant or proportional to the slip deficit. In addition, we assigned 237 possible hypocenter locations at 20-km intervals where the stress accumulation rate was positive on the plate interface. For all friction parameter sets, we assumed the same nucleation zone size where the shear stress was raised just above the yield stress to initiate the spontaneous rupture.

For each friction parameter set, we computed 237 rupture scenarios with different hypocenters and obtained a frequency distribution of the seismic moment, and the relation between the nucleation locations and the seismic moment (i.e., hypocenter locations from which a rupture grew and the seismic moment became high). The maximum moment magnitude was 8.6 in the present experiments.
The variation of the dynamic rupture scenarios partly come from the spatial variation of the fracture energy (G). The ruptured area could have a relation to the critical nucleation length L' qualitatively, which is defined as $G/\Delta\tau^2$ for $\Delta\tau > 0$ and ∞ for $\Delta\tau \leqq 0$. If L' was longer than the assumed nucleation

size, the rupture did not propagate, and vice versa. *L*' values at and around the nucleation points could be related to how large earthquake can occur. These features can be consistent with the theoretical consideration of Andrews (1976, JGR) for 2-D modes II and III cracks. It should be noted that such relation is obtained under uniform stress distribution. If the stress distribution is highly heterogeneous such as like after the 1944 Tonankai and before the 1946 Nankai earthquakes, the above relation on *L*' might not hold.