Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS39-16 Room:IC Time:May 25 16:00-16:15

Dynamic overshoot near the trench caused by a large asperity breaking at depth

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We investigated an earthquake generation model caused by subduction of a plate having a bumpy shaped interface geometry by a realistic numerical modeling of earthquake dynamic rupture. Bumpy shaped plate interfaces might be formed by subduction of old submarine volcanoes or seamounts. We assumed that during the inter-seismic period, slip only occurs outside the bump area and the stress is further accumulated inside the bump. Since we assumed a constant rate subduction as a long-term average, we could estimate roughly the amount of slip outside the bump during the inter-seismic period and then we could estimate the accumulated stress inside the bump. We constructed the initial stress distribution based on the stress change caused by the slip deficit distribution. We then constructed constitutive relations based on slip-weakening friction law. From the result of the computations, we found that large slip can occur between the free surface and the bump where very low stress is accumulated before the rupture. This is caused by the interaction between the free surface and the fault slip. At deeper side of the asperity, since the fault is sustained by the un-slipped zone, such slip overshoot never occurs. But at shallower side, when the rupture approaches the free surface, the fault becomes the un-sustained situation between the free surface and bump. In this region, such a large slip can occur without releasing large amount of stress. This idea could be applied for the interpretation of the 2011 Tohoku-Oki earthquake where large amount of slip were observed at shallow depth near the trench.

Keywords: Dynamic rupture, Slip overshoot, Bumpy fault