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Interaction of asperities and its effect on the earthquake cycles in the Sanriku-Oki region, northeast Japan

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Asperity is the region where two plates are tightly locked during interseismic term and the accumulated energy is released when earthquakes occur. In this paper, we focus on the Tohoku region in northeast Japan, especially on the Sanriku-Oki region. A lot of researchers have investigated asperities in that region. As a result of these researches, an asperity map was constructed to show the location and the size of asperities (Yamanaka and Kikuchi, 2004). According to the asperity map, two or three M7 class asperities are neighboring. Therefore we can expect that they may interact closely with each other to change earthquake cycles and that the magnitude of earthquakes could also change depending on the number of asperities which slip at the same time. For example, the 1968 Tokachi-Oki earthquake broke three asperities, which caused the comparatively larger magnitude. On the other hand, the 1994 Sanriku-Oki earthquake broke only the south patch of asperity in the Sanriku-Oki region, and hence the magnitude was smaller. Moreover, the location of asperities in the Sanriku-Oki region has not been changed for a long time. In this study, we perform numerical simulations of earthquake cycles to get a clearer explanation of observed complex earthquake sequences, using a composite rate- and state- dependent friction law (Kato and Tullis, 2001) which well explains rock experiences of friction.

In the Sanriku-Oki region, the Pacific plate is subducted under the Eurasian plate.We make a 2-D flat fault in an infinite uniform elastic medium to model asperities on the plate interface. And we determine the location and the size of the asperities based on the slip distributions obtained from seismic wave form analyses.

The way to set up asperity is to assign a distribution of the frictional parameters, A and B. Basically we expect that the zones with negative and positive (A-B) values are asperity and stable slip regions, respectively. By assigning a variety of distributions of frictional parameters in this way, we consider the effect of interaction of asperity on seismic cycle mainly in terms of (A-B) value and asperity size.

Kato (2003) has already investigated the interaction of two asperities in the northern region. In this paper, we add one more asperity in the southern region, and take into consideration the effect of slow slip event occurring there on the coupled seismic events in the northern asperities. As a result of simulation, it turns out that the earthquake cycles are completely different between one asperity model and three asperity one. In case of one asperity model, recurrence time of earthquake is constant and the interval is depending on A, B and L values. On the other hand, in case of more than one asperity model, the recurrence intervals are not constant and that the intervals are changing depending on not only values of friction parameters and but also the size and the relative location of asperities. This shows that the complex sequences of coupled seismic events are produced from asperity interaction. Here, we focus on the effect of friction parameters, the location and size of asperity on earthquake cycles, though we have not yet completely reproduced the observed earthquake cycles in Sanriku-Oki region, northeast Japan