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Hierarchical asperity model for multiscale characteristic earthquakes: a numerical study for the off Kamaishi events

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We develop a numerical model to simulate the occurrence of multiscale characteristic earthquakes in off Kamaishi area at the Japan Trench, northeast Japan. It is known that microearthquakes occur during the interseismic period between two successive M 4.9 characteristic earthquakes, especially in the second half, in the interior of the asperity for those characteristic earthquakes. We introduce spatial heterogeneity in the state evolution length dc in the asperity such that a small patch corresponds to a microasperity, the rupture area of microearthquakes, with a smaller nucleation size than its own spatial size. On the contrary the nucleation size in the rest of the asperity (which we call a conditional asperity) is set to be comparable to the spatial size of the entire asperity. Such a dependence of dc on the size of an asperity, or the moment of an earthquake, which is called hierarchical asperity model, successfully reproduces the observed earthquake sequence, including the seismic moment, the recurrence time interval, and the seismic coupling. The simulation result shows that both microearthquakes and the moderate earthquake nucleate at the microasperity in a similar manner. The absolute stress value in the conditional asperity deterimines whether the rupture terminates just outside the microasperity to result in a microearthquake or propagates out into the conditional asperity to induce a moderate earthquake.