

## Rupture process variability of repeating earthquakes at subduction zone

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It has been debated whether the size of earthquake is determined randomly or characteristically for each seismic region. These are two end members of earthquake occurrence, each of which is conceptually represented by fractal heterogeneity model and the characteristic earthquake model. Most of earthquakes probably have intermediate properties between them with wide variations. However, earthquake occurrence model still remains qualitative due to the insufficient observation of the repetitive ruptures in specific study regions. To quantify diverse characteristics of rupture process, moderate size repeating earthquakes can be ideal targets for case study.

In this thesis work, I investigated three families of moderate size ( $M \sim 5$ ) repeating earthquakes and nearby smaller events that occurred in Naka-Oki, Kushiro-Oki, and Kamaishi-Oki regions of the Tohoku-Hokkaido subduction zone, Japan, during 2002-2017, using a hypocenter relocation method based on waveform cross correlations and a waveform inversion method with the empirical Green's function. Every moderate size repeating earthquake included complex and variable rupture processes including the directivity and the initial rupture location. Nevertheless, their rupture areas were overlapped significantly and elongated in parallel to the slip direction. Some parts of these areas were also repeatedly ruptured by smaller earthquakes, which tend to occur prior to the mainshock occurrence. It would be important to note that these foreshocks-like small earthquakes and moderate events sometimes started from the almost same locations with indistinguishable initial seismic waves.

These results suggest the existence of some characteristic structure, represented by several elliptical patches elongated in the slip direction, on the plate interface. The patches may be distributed hierarchically with small patches, which may be ruptured earlier than larger patches due to the long-term stress increase. When a small patch ruptures, it may stop soon as a small earthquake, or grow into a large earthquake, depending on some conditions or just randomly. This is the first demonstration of clear observation for such hierarchical rupture growth, and obviously further quantitative and statistical studies are required for complete understanding of this process.

Keywords: cascade-up, repeating earthquake, streak structure

