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平成 23 年東北地方太平洋沖地震発生後の地震クラスター地震活動・小繰り返し地震活動の特徴
Seismic activities of earthquake clusters and small repeating earthquakes in Japan after the 2011 Tohoku earthquake

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The 2011 off the Pacific coast of Tohoku earthquake (Mw9.0) was the largest earthquake in recorded history in Japan. The coseismic slip expanded into the areas covered the occurrence areas of interplate earthquakes off Iwate to off Ibaraki, northeastern Japan. For the impact of this earthquake, the seismic activities in and around the source regions have changed significantly. In this study, I investigated spatio-temporal changes of seismic activities of earthquake clusters and small repeating earthquakes in Japan after the mainshock. Furthermore, I estimate the space-time characteristics of the interplate slip from sequences of small repeating earthquakes.

I have already reported slip-rates in the 21st century before the 2011 mainshock at the upper boundaries of the subducting plates. The resultant slip-rates correspond to relative plate motion in the Ryukyu arc. In contrast, they indicated slip deficits in the northeastern Japan arc. There were few postseismic slips following the 2005 off Miyagi prefecture earthquake (M7.2), which located near the hypocenter of the 2011 mainshock. On the other hand, slip deficits were slightly decreased in the southern shallow part of the northeastern Japan after postseismic slips following the 2003 off Miyagi earthquake (M6.8), the 2008 off Ibaraki earthquake (M7.0), and the 2008 off Fukushima earthquake (M6.9). Furthermore, I identified quasi-static slips associated with foreshocks off Miyagi that started from 2011.

After the 2011 mainshock, I detect many small repeating earthquakes. They distributed in the northern, southern and deeper part of the source region. Small repeating earthquakes with relatively long recurrence intervals occurred just after the 2011 mainshock. The cumulative slips are consistent to the value estimated by GPS data analysis in the northwestern deeper part. My result also suggests postseismic slips at the trench-side of the southeastern part. On the other hand, I can not detect small repeating earthquakes in some areas of source region. Distributions of small repeating earthquakes may suggest zero or slightly slipped areas in the 2011 mainshock and the largest aftershock. Some of small repeating earthquakes are burst-type sequences which occurred only after the 2011 mainshock. Observed seismograms may be distorted by the multiplicity of the waves to come from various locations, the seismic velocity changes at the propagation path or site, or changes of physical properties at the plate interface. I also detected many small repeating earthquakes beneath the Kanto district. They suggest induced interplate slips at the subducting Philippine Sea plate and the subducting Pacific plates. In other areas, I can not identify noticeable velocity increases.

Furthermore, I automatically extracted earthquake clusters by using the unified JMA hypocenter catalogue and investigated seismicity changes before and after the mainshock at each earthquake cluster. As a result, I identified that seismic activities after the mainshock have become active in the deeper part of the source region. The largest earthquakes in the analysis period have occurred in some clusters including small repeating earthquakes after the 2011 mainshock. In addition, they activate in several areas around the Kanto, Tokai, and Ryukyu areas of the Philippine Sea plate, and the inland shallow part of eastern Japan. On the other hand, seismic activities decrease with some clusters in the source areas and many intra-plate clusters in intermediate-depths. It suggests the large effects of interplate large slips and stress changes at the mainshock and/or postseismic slip. We should pay attention to future activities to investigate whether physical property at these areas has changed or not.

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