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Seafloor seismological/geodetic observations in the rupture area of the 2011 Tohoku-oki Earthquake

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A number of important aspects of the 2011 Tohoku-oki earthquake (Mw 9.0) were clarified by the seafloor seismological and geodetic observation above the rupture area of the earthquake. Besides the extraordinarily large coseismic displacements, various kinds of slow slip phenomena associated with intensive micro-seismicity on the plate boundary fault were identified by near field ocean bottom seismographs and seafloor geodetic observation networks.

The Tohoku-oki earthquake was preceded by evident foreshock activity with a spatial expansion of this seismicity. The activity became significantly intense after the occurrence of the largest foreshock two days before the mainshock rupture. During the period, clear continuous seafloor deformation was identified caused by the aseismic slip following the largest foreshock. Another different type of aseismic slip event had occurred before this pre-imminent activity had started about a month before the largest foreshock happened. The observed increased seismicity associated with aseismic slip suggests that there must have been some chain reaction like interplay of seismic and interseismic slips before the large earthquake broke out. However, no evident deformation signals were observed indicating acceleration of fault slip immediately before the mainshock.

Seafloor geodetic measurements reveals that the postseismic deformation around the rupture area of the Tohoku-oki earthquake shows complex spatial pattern and the complexity is mostly due to significant viscoelastic relaxation induced by the huge coseismic slip. The effects of viscoelastic deformation makes it difficult to identify the deformation associated with the after slip or regaining of interplate coupling and requires us to enhance the abilities of seafloor monitoring to detect the slip activities on the fault. We started an array of seismometer arrays observation including broad-band seismographs to detect and locate slow-slip events and low-frequency tremors. Another observation we started is direct-path acoustic ranging across the trench axis. Slip rate of the shallow fault can be measured by monitoring the change in distance between the benchmarks on the incoming and overrding plates.