

Shallow high-frequency seismic radiation during the 2011 Tohoku-Oki earthquake, Japan

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The megathrust earthquake that struck the Tohoku region, Japan, on 11 March 2011 was observed by dense seismic networks. Strong-motion waveforms indicated that distinct sub-events occurred during the Tohoku-Oki earthquake. To investigate source processes of the earthquake, we utilized a source location method using high-frequency (5-10 Hz) seismic amplitudes, which enabled us to locate sources of continuous signals. We estimated source locations in successive time windows using strong-motion waveforms from the KiK-net. We detected three main sub-events during a total source duration of 100 s. The sources of these sub-events were at shallow depths near the Japan Trench, where few aftershocks occurred. Our estimated source area was south of the large slip area estimated from low-frequency seismic data. The first two sub-events were determined at very similar locations with an interval of 40 s. Repeated ruptures on the same fault are extremely unlikely, implying that an auxiliary fault may have been involved during the Tohoku-Oki earthquake. Our results imply a possibility that the first sub-event ruptured an auxiliary fault, perhaps the backstop interface, and triggered the second sub-event and the main rupture along the plate interface. The third sub-event ruptured south of the main slip area near the trench. Our study indicates repetitive triggering of multiple sub-events radiating high-frequency seismic waves at shallow depths during the Tohoku-Oki earthquake.