Smooth and rapid slip near the Japan Trench during the 2011 Tohoku-oki earthquake

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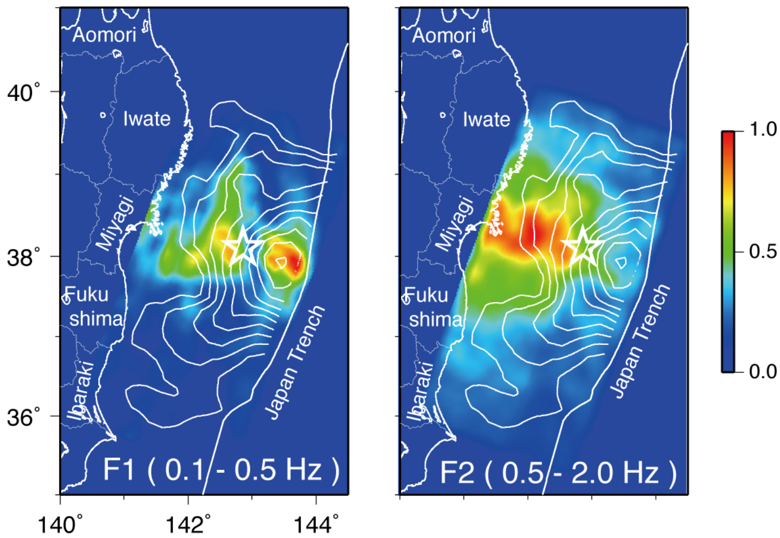
We developed a new back-projection method that uses teleseismic P-waveforms to integrate the direct P-phase with reflected phases from structural discontinuities near the source for estimating the distribution of the seismic energy release of the 2011 Tohoku-oki earthquake, and then performed dynamic rupture simulations using simplified fault models and the mechanism of thermal fluid pressurization.

We projected a normalized cross-correlation of observed waveforms with corresponding Green' s functions onto the seismic source region to obtain a high-resolution image of the seismic energy release. Applying this method to the 2011 Tohoku-oki earthquake, we obtained spatiotemporal distributions of seismic energy release for two frequency bands, a low-frequency dataset and a high-frequency dataset. We showed that the energy radiated in the dip direction was strongly frequency dependent. The area of major high-frequency seismic radiation extended only downdip from the hypocenter, whereas the area of major low-frequency seismic radiation propagated both downdip and updip from the hypocenter. We detected a large release of seismic energy near the Japan Trench in the area of maximum slip, which was also the source area of the gigantic tsunami, when we used only the low-frequency dataset. The timing of this large seismic energy release corresponded to an episode of smooth and rapid slip near the Japan Trench, and reflects the strong dependence of the seismic energy distribution obtained on the frequency band of the input waveform dataset.

The large slip area for the Tohoku earthquake included the source region of a previous (1896) tsunami earthquake. We performed dynamic rupture simulations using simplified fault models. We found that small fluctuations of initial shear stress near a trench, within 1 MPa, lead to differences in seismic moment release greater than two orders of magnitude. Moderate slip events with trapezoidal source time functions appear to occupy a transition position, between shallow megathrust earthquakes with surface rupture and smaller ordinary earthquakes without surface rupture. We interpret this result as representing the differences in interplate slip between shallow megathrust earthquakes, tsunami earthquakes, and ordinary earthquakes in the same region. It implies that tsunami earthquakes are failed shallow megathrust earthquakes.



Distribution of normalized total seismic energy release determined by the hybrid back-projection method for the F1 (left) and F2 (right) datasets. The star indicates the epicenter determined by JMA. The color scale (normalized beam power) shows the amount of seismic energy released (warmer colors indicate greater energy release). White contours (interval 5 m) show the total slip distribution determined by Yagi and Fukahata (2011).

次回のお知らせ
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