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Imaging of the high-frequency energy radiation sources of the 2011 off the Pacific coast of Tohoku Earthquake

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We report the preliminary results of imaging of the high-frequency energy radiation sources (HFSs) of the 2011 off the Pacific coast of Tohoku Earthquake (PcT Eq.) using the Source Scanning Algorithm (SSA) [Kao and Shan, 2007, GJI]. In SSA, normalized amplitude of RMS envelope observed at each seismic station is back-projected with the correction of the S-wave travel time and stacked at a grid point in potential 3D source volume. The stacked value is called a brightness. The image of the brightness of all grid points illuminates the locations and timings of seismic rupture (e.g. HFS). Aoki et al. [(2010, SSJ), (2011, this meeting)] succeeded in depicting the rough image of rupture of the 2003 off Tokachi Earthquake using regional strong motion data.

The PcT Eq. was a Mw 9.0 undersea mega-thrust earthquake with the fault area of 450km x 200km [Yoshida et al, 2011, submitted to EPS]. The grid points are arranged in and around the aftershock area (4 to 80km in depth) with 4km interval. Owing to the gigantic fault, we introduce two modifications to the method used by Aoki et al. (2010). One is limitation to epicentaral distance from a grid point to a station (150km in this study; however, if the number of stations is not enough, the limitation distance is gradually modified up to 300km). Another is the introduction of the azimuthal weighting in order to reduce the effect of the unbalanced station distribution.

We used the EW component accelerograms of K-NET and KiK-net accelerometer networks installed by the National Research Institute for Earth Science and Disaster Prevention (NIED). The accelerograms are integrated to velocity, and are band-pass filtered with a frequency band of 4.0 - 8.0 Hz. Then the RMS envelopes are computed. The features of envelopes are as follows: Two distinct peaks are observed at the stations in Miyagi prefecture and northward, and one distinct peak is observed at the stations in Ibaraki prefecture and southward.

In SSA, the grid point with higher brightness is considered to be a candidate of the HFS. Our results show there are at least three stages of the high-frequency energy radiation in the PcT Eq. In this analysis, the relative maximum point (RMP) of brightness appears around the actual HFS. However a ghost peak of brightness tends to move greatly from east to west via the actual HFS due to a gap of station distribution. Therefore we mainly explain the locations and timings of RMP of the brightness in the following.

1st stage: The RMP appears at 38s from initial ruputure, and is located approximately 40km north-east from the Oshika Peninsula. If the S-waves radiate from this point, the travel times almost correspond to the first peak of the envelopes observed in Miyagi and northward. These also correspond to the expansion of the high seismic intensities of real-time manner in the Tohoku district.

2nd stage: Two RMPs are included in this stage. One appears at 57s, and is located 20km east from the epicenter. The other appears at 74s, is located 55km west from the epicenter. The S-wave travel times from these points correspond to the second peak of the envelopes in Miyagi and northward. High seismic intensities are observed at some stations in the southern Tohoku district under the influence of this stage.

3rd stage: Two RMPs are included in this stage. One appears at 105s, is located 85km off the coast of southern Fukushima prefecture. The other appears at 130s, and is located 25km off the coast of northern Ibaraki. The S-wave travel times from these points correspond to one distinct peak of the envelopes in Ibaraki and southward. These also correspond to the expansion of the high seismic intensities in the Kanto district.

In this study, we found three stages of the high frequency energy radiation in the PcT Eq. These may show that the gigantic earthquake of Mw 9.0 is interpreted as a superposition of successive occurrences of some giant earthquakes during about 160s.

Keywords: The 2011 off the Pacific coast of Tohoku Earthquake, High-frequency energy radiation sources, Distribution of the seismic intensity, Source process