Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS23-P16 Room:Poster Time:May 1 18:15-19:30

Semblance analysis for the 2011 Tohoku earthquake using strong-motion and 1Hz GPS data

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Source inversion is well used for the analysis of the earthquake source-process. However in the source inversion some assumptions and constraint conditions are used and there are cases where the settings of these affect the result. On the other hand, array analysis can produce the direct image for the seismic-wave radiation. In this analysis, we investigate the seismic-wave radiation characteristics for the 2011 Tohoku earthquake with the semblance array analysis using strong-motion and 1Hz GPS data.

We use not only the strong-motion data recorded by K-NET, KiK-net, and F-net of NIED and JMA but also 1 Hz GPS data recorded by GEONET of GSI. Additional use of 1 Hz GPS data leads to increase the station density and therefore the number of the available arrays increased remarkably compared to previous work (Kubo & Kakehi, 2013). Except for F-net data, the strong-motion acceleration waveforms are integrated into velocity waveforms. 1Hz GPS data is converted into displacement waveforms using Kinematic PPP as implemented in RTKLIB Ver. 2.4.2 (Takasu, 2013) and they are differentiated into velocity waveforms. These waveforms are bandpass-filtered from 10s to 25s and resampled with a sampling interval of 0.1s. From the comparison of the observed velocity waveforms for the 2011 Tohoku earthquake at the GEONET and strong-motion stations which distance is less than 3 km, we confirmed that the waveform of 1Hz GPS data matches one of strong-motion data at above period-band.

We use the same method of the semblance analysis in Kubo & Kakehi (2013). In this method, we firstly assumed the fault surface model consisting of some subfaults. Then the semblance value for each subfault is calculated assuming spherical-wave incidence when the subfault is the seismic-wave radiation source, and these values are plotted on the fault surface. By doing this analysis with time shift, we can obtain temporal change of the seismic-waves radiation source on the fault surface. The incident waves are assumed to mainly consist of S-wave because the estimated apparent velocity through the semblance analysis assuming plane-wave incidence is approximately 4 km/s and it don ' t have the dispersion. As the velocity structure model for the calculation of the travel time, we use one-dimensional velocity structure model in Asano & Iwata (2012). In this analysis, we constructed nine arrays at Tohoku and Kanto regions, and estimated the snapshot of semblance images at each array for 250s after the synthetic S-wave onset, which is comparable to the rupture starting time. The time length for semblance calculation is 20s and the time shift is 10s. The semblance value is obtained by averaging the three semblance values of the three-component waveforms.

The semblance images at the arrays north of 39^{o}N are different from ones at the arrays south of 39^{o}N. The images at the former arrays demonstrate that the seismic waves were strongly radiated from off Miyagi up to approximately 150s and that then the seismic waves were continued to be weakly radiated from off Miyagi. On the other hand, the images at the latter arrays demonstrate that the duration time of the seismic-wave radiation from off Miyagi is approximately 100s, that subsequently the radiation source moved to off Fukushima and Ibaraki, and that its radiation continued up to approximately 180s. This image difference indicates that the seismic-wave radiation area for the 2011 Tohoku earthquake extended to south approximately 100s after the rupture start and that off Miyagi radiated the seismic-waves during long time (~200s). We will also investigate the spatial variation for the seismic-wave radiation source along dip direction.

[Acknowledgments] The strong-motion data recorded by K-NET, KiK-net, and F-net of NIED and JMA and the 1Hz GPS data recorded by GEONET of GSI were used for this analysis.

Keywords: The 2011 Tohoku earthquake, Seismic-wave radiation characteristics, Semblance analysis, Strong-motion data, 1Hz GPS data