Determination of source parameters of the 2011 Tohoku-Oki earthquake from three-component pre-P gravity signals recorded by dense arrays in Japan

*Nobuki Kame[1], Masaya Kimura[1], Shingo Watada[1], Akito Araya[1], Takashi Kunugi[2], Rongjiang Wang[3]

1. Earthquake Research Institute, the University of Tokyo, 2. National Research Institute for Earth Science and Disaster Resilience, 3. Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences

Dynamic earthquake rupture causes a mass redistribution around the fault, and the emitted propagating seismic waves are accompanied by bulk density perturbations. Both processes cause transient gravity changes before the arrival of P-waves. Such a pre-P gravity signal has been detected in previous studies on several huge earthquakes. However, the detections were limited to the signal's vertical component because of the high noise level in horizontal records. This study analyzed the dense tiltmeter array data in Japan to search for the signal's horizontal components from the 2011 Mw 9.1 Tohoku-Oki earthquake. Based on the synthetic waveforms for a realistic Earth model, we stacked the horizontal records and identified a signal that exceeded the noise level. We further performed a waveform inversion analysis to estimate the source parameters. The combination of the horizontal tiltmeter data and vertical broadband seismometer array data yielded a constraint on the earthquake's dip angle and magnitude in the ranges of 11.5˚-15.3˚ and 8.75-8.92, respectively. Our results indicated that the analysis of the three components of the pre-P gravity signal avoids the inherent trade-off problem between the dip angle and seismic moment in determining the source mechanism of shallow earthquakes. Pre-P gravity signals opened a new observation window for earthquake sources.

Keywords: earthquake pre-P gravity signal, determination of dip angle and moment for shallow earthquakes, earthquake prompt elastogravity signal

