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Detection of velocity discontinuities beneath northeastern Japan subduction zone revealed from autocorrelation analysis

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Seismic interferometry is a technique used to estimate the detailed properties of Earth by analyzing the velocity boundary of seismic waves. These patterns are constructed by correlating and summing pairs of seismic traces with one another to estimate the Green's functions as a response of subsurface elastic properties. Here, we evaluate the detectability of subsurface velocity discontinuities such as the subducting plate interface and the Moho discontinuity beneath the northeastern Japan subduction zone by using ocean-bottom and onshore seismic networks. We calculate the autocorrelation functions (ACFs) of noise with a time-window length of 120 s at ocean-bottom seismometers deployed by the University of Tokyo, Tohoku University, and Hokkaido University on the landward slope of the Japan Trench in northeastern Japan. We also calculate the ACFs at Hi-net stations operated by the National Research Institute of Earth Science and Disaster Preventions that are located in northeastern Japan Island. A filtered 1-h trace in the frequency band 0.5-2 Hz is used to calculate the autocorrelation by a 1-bit correlation technique. By taking the ensemble average of ACFs over 24 h, the one-day ACFs are calculated for more than 300 days at each station. We assumed that the ACF is now derived for a random wavefield excited by a stochastic distribution of sources or scatterers; these are assumed to have random excitation times and random phase and amplitude characteristics. A plane wave from stochastic sources or scatterers is vertically incident on a seismic station. Then, the body wave reflects at a surface, and the refection reflects a subsurface velocity boundary again. The reflection could be observed as a PxP reflection at the station. We considered that the typical phases in the ACFs correspond to PxP reflections from the subsurface velocity boundary: we compared a distribution of PxP reflectors with the depth of the plate boundary and the Moho discontinuity. It was found that the depths of typical reflectors are consistent with those of the subducting plate interface and the Moho discontinuity of the landward plate, although some reflectors do not correspond to known discontinuities beneath the Japan Island.

Keywords: seismic interferometry, autocorrelation function, subduction zone, plate boundary, Moho discontinuity