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Source and path effects in the wave fields from the eastern off Aomori earthquake on 14 August 2001

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An earthquake of M = 6.2 occurred to the eastern off the coast of Aomori Prefecture on 14 August 2001. The earthquake has a focal depth of 43 km and a focal mechanism of reverse faulting, which led us to interpret this earthquake as an interplate thrust event. We have investigated the characteristics of seismograms of this event by both waveform inversion and forward modeling. We used the seismograms recorded by dense arrays of accelerographs of K-NET and KiK-net. We determined a moment tensor solution by a waveform inversion method. We found a remarkable and systematic spatial bias of residual amplitude between the observed and the synthetic seismograms. We then examined some possible causes of amplitude anomaly by considering the effect of source rupture and lithospheric heterogeneous structure.

The displacement seismograms were obtained by integrating the accelerograms twice in frequency domain, and then by removing long-period undulation due to integration. We can see very clear near-field displacements on the seismograms at stations in the eastern coast of Aomori and Iwate Prefectures. The amplitude of near-field displacements show systematic variation with azimuth and hypocentral distance. The decay rate of amplitude with hypocentral distance is in the middle range of theoretical rate between the near- and the intermediate-field terms in an infinite homogeneous medium.

We determined the moment tensor solution by minimizing the summed power of residual between the observed and synthetic displacement records from nine stations. The Green's functions were calculated by a discrete wavenumber method assuming a layered velocity structure based on the model used for the routine hypocenter locations. The solution is a type of reverse faulting with one nodal plane dipping gently to the west and with one nearly vertical nodal plane, which is very consistent with the Harvard CMT solution. Since we used low-frequency component (0.03 - 0.1 Hz) in the inversion, the synthetics match reasonably well with the major phases that appear in a time window used in the analysis (50 s). However, a distinct phase after the S-wave observed at a station in Hokkaido could not be reproduced by the synthetics.

The next step of analysis is the investigation of error (summed residual power) using much more stations than those used for the inversion. In this process we used the seismograms in higher frequency range (0.03 - 0.5 Hz). Though the value of error depends both on component and time windows, it's spatial distribution exhibits markedly systematic variation with the location of stations. For example, the error from seismograms of vertical component in a time window between P- and S-waves takes large values at stations in the Pacific coast of Iwate Prefecture and at stations to the east of Ishikari Lowlands in Hokkaido. This pattern seems to be explained by a bilateral propagation of earthquake rupture because the two areas are located to the southern and the northern extension along the strike of one nodal plane. We calculated the synthetic seismograms by taking the effect of rupture propagation into account, and found the observed amplitude is much larger than the synthetics. Thus we have to find another/additional factors for amplification. The other possibility is the effect of structural heterogeneity in the lithosphere. Wave propagation to the eastern Hokkaido where large pulses were observed is probably affected either by the bending of subducting Pacific plate in the junction between the two island arcs and by the low-velocity zone beneath the Hidaka Mountains. The observed pulses may be explained if the focusing of seismic energy occur due to these heterogeneities. Though we need quantitative examination and more case studies to reach the final interpretation, the present analysis proves the usefulness of dense seismograph arrays to clarify the characteristics of wave propagation even in low-frequency ranges as treated here.