Rupture Process of the 2003 Tokachi-oki Earthquake Estimated from Strong Ground Motions (0.1-1Hz)

Atsushi Nozu[1]

[1] PARI

A huge subduction earthquake occurred on September 26, 2003 off Tokachi Region, Hokkaido, Japan. Estimation of the rupture process of the earthquake will play a vital role in the effort to construct more sophisticated source models of future subduction earthquakes for use in strong motion prediction. Because the earthquake occurred in the subduction zone, where horizontal heterogeneity of the media is significant, validity of the use of theoretical Green's functions based on layered half-space model in the waveform inversion is not self-evident. In this study, a waveform inversion was conducted to construct a variable-slip rupture model of the earthquake using empirical Green's functions.

The mainshock ground velocities (0.1-1.0Hz) at five K-net stations located in the near-source region (see the figure) were modeled. Original NS and EW components were rotated to obtain components parallel to the direction of subduction, which were used for the inversion. The conventional least-squares linear waveform inversion (Hartzell and Heaton, 1983) was adopted. Instead of the JMA hypocenter, the hypocenter determined by the Hi-net project (42.039N, 143.925E, depth=25.4km, origin time=04:50:11.43 JST) was used as the starting point of the rupture front. A fault plane with a dimension of 120km times 120km was assumed, whose strike and dip angles were set to be 231 and 22 degrees, respectively, referring to the results of geodetic data inversion (Geographical Survey Institute, Japan; see the web site at www.gsi.go.jp). The fault was divided into 30 times 30 fault elements. The rupture front is then assumed to propagate radially at a constant velocity of 2.6km/s. Each fault element is allowed to slip eight times in 4.8 seconds after passage of the rupture front at equal time intervals. The moment release of each slip relative to the moment of the September 26, 7:20 (JST) aftershock (MJ=5.2) was determined through the inversion. Absolute time information for both the mainshock and the aftershock recordings was used. In the inversion analysis, constraints were imposed to minimize the second order derivative of the slip on the fault. Non-negative least-square solutions were obtained using the algorithm of Lowson and Hanson (1974).

Final dislocation of the 2003 Tokachi-oki Earthquake obtained by the inversion is shown in the figure (aftershock moment magnitude is assumed to be 5.4). The obtained slip model is rather simple, with one prominent asperity located around the rupture starting point for the inversion (i.e., Hi-net hypocenter). On the northwestern part of the fault, slip is rather small. Because the northwestern part of the fault is close to the sites used for the inversion, the author expects a good resolution for the slip on that part of the fault. On the other hand, agreement between the observed and synthetic ground velocities using the same model is poor at sites to the east of the fault. Although this fact may be due to the difference of radiation coefficient between the large and the small event, further investigation is needed to resolve the slip on the eastern part of the fault.

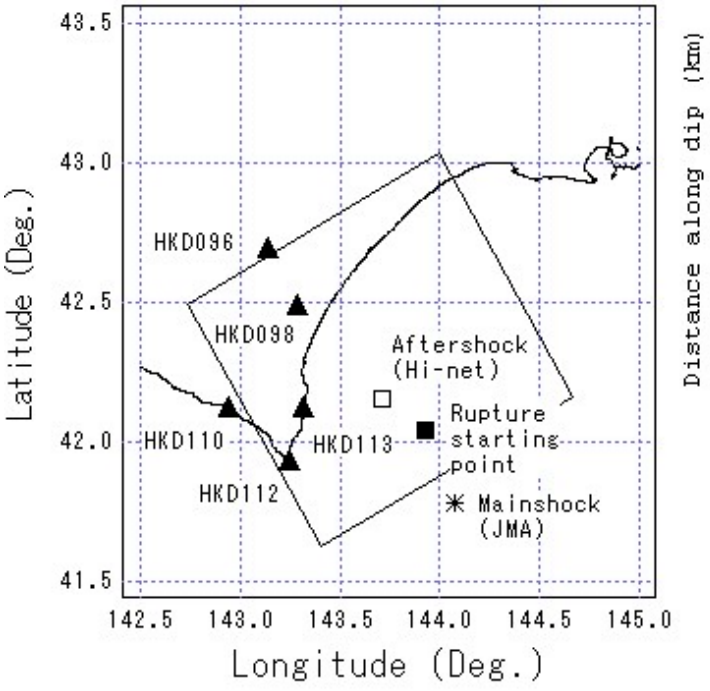
Acknowledgment

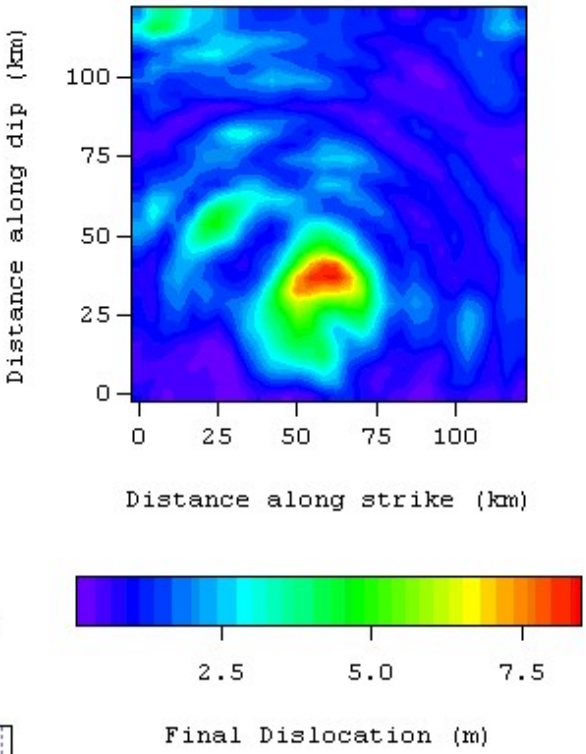
The author would like to express his sincere gratitude to the National Research Institute for Earthquake Science and Disaster Prevention, Japan, for providing us data from K-net and Hi-net projects.

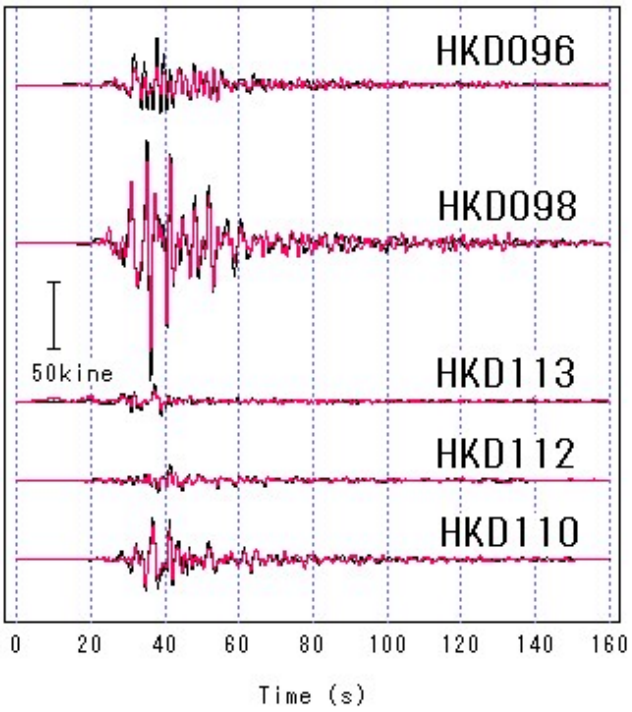
References

Hartzell, S.H. and T.H. Heaton, Bull. Seism. Soc. Am., 73, 1553-1583, 1983.

Lowson, C.L. and R.J. Hanson, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1974.







Fault plane assumed for the inversion (top left), final dislocation (top right) and the comparison between the observed and synthetic ground velocities (bottom).