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Space-time pattern of great or large earthquakes along the northern Japan to Kurile trenches

Tomoya Harada[1*], Kenji Satake[1], Katsuhiko Ishibashi[2]

[1]ERI, Univ. of Tokyo, [2]None

The northern Japan to Kurile trenches have been regarded as a typical subduction zone with spatially and temporally regular recurrence of great interplate earthquakes (Utsu, 1972; 1984). Besides great (M>8) interplate events, however, many large (M>7) interplate, intraslab, outer-rise and tsunami earthquakes have also occurred in this region.

In this study, we depict the space-time pattern of M>7 earthquakes in this region, based on the relocated mainshock-aftershock distributions of all types of earthquakes occurred since 1913. Total number of M>7 events is 72. We classified the types of earthquakes before 1950's based on both relocated hypocenter distribution and seismic intensity distribution maps in Japan. We analyzed teleseismic body waves to estimate coseismic slip distributions of major events after 1960's. As a result, we found that the more complex feature of M>7 earthquake occurrence in this region.

We relocated hypocenters reported the ISC (International Seismological Centre), ISS (International Seismological Summary), and BCIS (Bureau Central International de Sismologie) bulletins by using the HYPOSAT (Schweitzer, 2003) and the Modified Joint Hypocenter Determination (MJHD) method (Hurukawa, 1995). We referred to seismic intensity maps compiled by Utsu (1989) for events before 1926 and those of the Japan Meteorological Agency (JMA) for events after 1926. We estimated coseismic slip distributions by the Kikuchi and Kanamori's (2003) tele-seismic body-wave inversion program. In the inversion, WWSSN long-period seismic waves of events before 1990's and broadband seismic waves of events after 1990's from the IRIS-DMC are used, respectively.

The results in this study are summarized as follows. (1) The northern Japan to southern Kurile subduction zone have been divided several regions on the basis of aftershock areas of great interplate events (Utsu, 1972; The Headquarters for Earthquake Research Promotion of Janese government, 2004). Each region has been ruptured by a M8-class interplate earthquake or by multiple M7-class events. A great interplate earthquake (Mw 8.5) occurred offshore Urup Island in 1963 and two large interplate events of Mw7.6 and Mw7.9 recurred in 1991 and 1995 in the eastern and western part of the source region, respectively. From the comparison of the 1963, 1991, and 1995 cosiemic slip distributions, the 1963 southwestern asperity seems to have been re-ruptured by the 1995 event. (2) Focal depth of the 1958 Etorofu earthquake determined by using depth-phases is about 80 km. The deeper focal depth supports the previous study that the 1958 event was an intraslab event (Harada and Ishibashi, 1999). Near Shikotan Island, the 1978 and 1994 intraslab earthquakes occurred on the trench-normal fault plane within the Pacific slab. A M7-class intraslab event may have occurred in 1939 on the same fault plane. M8-class earthquakes offshore the Simushir Island in 1915 and offshore the Urup Island in 1918 may have been intraslab event. (3) In the outer-rise region, M8-class events have occurred in 1933 and 2007 and M7-class events have occurred in 1919, 1963, 1982, and 2009. The 1918 earthquake of M7.7 offshore Urup Island seems to be an outer-rise event from main-shock epicenter location and its remarkable large felt area in Japan. The 2009 earthquake of Mw7.4 within the aftershock area of the 2007 normal-fault event of Mw8.1 have reverse faulting. From comparison of the 2007 and 2009 coseismic slip distributions, the 2007 normal faulting had ruptured a shallower part of the Pacific plate and the 2009 reverse faulting ruptured a deeper part of the plate. Tsunami earthquakes occurred offshore Urup Island in 1963 and offshore Shikotan Island in 1975, respectively.

In this study, we use FORTRAN programs of the HYPOSAT, MJHD method, and tele-seismic body-wave inversion.

Keywords: northern Japan trench - Kurile trench, great or large earthquakes, space-time pattern, hypocenter relocation, coseismic slip distribution, seismic intensity distribution