

Complex Space-Time Pattern of Great and Large Earthquakes in the Northern Japan to Kurile Subduction Zones

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The northern Japan to southern Kurile trenches have been regarded as a typical subduction zone with spatially and temporally regular recurrence of great ($M > 8$) interplate earthquakes. The source regions were grouped into six segments by Utsu (1972; 1984). The Headquarters for Earthquake Research Promotion of the Japanese government (2004) divided the southern Kurile subduction zone into four regions and evaluated future probabilities of great interplate earthquakes. Besides great interplate events, however, many large ($M > 7$) interplate, intraslab, outer-rise and tsunami earthquakes have also occurred in this region.

First, we depicted the space-time pattern of $M > 7$ earthquakes along the northern Japan to Kuril trench, based on the relocated mainshock-aftershock distributions of all types of earthquakes occurred since 1913. We relocated hypocenters in the ISC, ISS, and BCIS bulletins by using the HYPOSAT (Schweitzer, 2003) and the Modified JHD method (Hurukawa, 1995). Then, in order to examine more detail space pattern, or rupture areas, of $M > 7$ earthquakes since 1963 (WWSSN waveform data have been available since this year), we estimated coseismic slip distributions by the Kikuchi and Kanamori's (2003) teleseismic body wave inversion method. The WWSSN waveform data were used for earthquakes before 1990, and digital teleseismic waveform data compiled by the IRIS were used for events after 1990. Relocated main-shock hypocenters were used as initial rupture points.

As a result, we found complex feature of earthquake occurrence. Each region has been ruptured by a M8-class interplate earthquake or by multiple M7-class events. Offshore Urup Is. is source region of the 1963 Urup earthquake (M 8.5). Large interplate earthquakes occurred in the eastern and western part of the 1963 source region in 1991 (M 7.6) and 1995 (M 7.9), respectively. Their aftershock areas almost re-occupied the 1963 aftershock area. The 1963, 1991, and 1995 coseismic slip distributions show that the southwestern asperity of the 1963 event seems to be re-ruptured by the 1995 earthquake. Giant (the 2011 Tohoku earthquake of M 9.0 which occurred just southern region of our study area), great and large interplate earthquakes occurred in the Kurile to Japan subduction zone after 1990s successively. The aftershock areas and coseismic slip distributions clearly show that three seismic gaps (offshore northern part of Aomori pref., offshore eastern Hokkaido to Etorofu Is., and offshore between Urup and Simushir Is.) have remained in this region.

Great intraslab earthquakes occurred in 1958 and 1994. The 1915 and 1918 great earthquakes may have been intraslab events.

Many outer-rise earthquakes and the 1963 and 1975 tsunami earthquakes occurred near the trench axis. The 2009 Simushir earthquake (M 7.4) with reverse faulting occurred within the aftershock area of the 2007 great outer-rise event (M 8.1). The 2007 and 2009 coseismic slip distributions show that the 2007 normal faulting occurred in the shallower part of the Pacific plate and the 2009 reverse intraplate faulting occurred in the deeper part.

Keywords: Northern Japan - Kurile subduction zones, space-time pattern of $M > 7$ earthquakes, hypocenter relocation, teleseismic body-wave inversion, seismic gap