Tsunami excitation of the 2006 and 2007 Kuril Islands earthquakes

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An earthquake of Mj 7.9 (depth 30km) occurred on 15 November 2006 on the boundary between the Pacific plate and the Okhotsk plate at east Kuril Islands. During this event, weak seismic motion was felt in Hokkaido and northern Honshu in Japan. Tsunami waves were also observed along the Pacific coast and Izu-Ogasawara island chain. Three months later, on 13 January 2007, another earthquake of Mj 8.2 (depth 30km) occurred at almost the same place but within the outer-rise portion of the Pacific plate. Relatively strong seismic motion was observed in the wide range of Japan compared to the previous event, so that larger or similar tsunami waves had been expected to arrive at the coast. However, the tsunami observed at the second event was smaller than that of the first event. This study analyzes tsunami and seismic records of the two events to discuss the reason why the second event with relatively large magnitude excited small tsunami waves compared to the first event.

At first, we investigate the relation between the seismic magnitude and tsunami waves by numerical simulations. Calculating the sea-floor deformation due to the seismic fault with the assumption of homogeneous subsurface structure (Okada 1992), and regarding the sea-floor deformation as the initial condition of sea-level elevation, we calculate tsunami propagation based on the linear long-wave theory. When we set the magnitude of the 1st event 7.9 as JMA reported, we obtain calculated tsunami amplitude 1cm off Kushiro-tokachi region. This value is smaller than the value of 4cm observed at a station deployed by JAMSTEC (JAMSTEC Web page). When we use the magnitude 8.2 for the 2nd event, we obtain calculated tsunami amplitude 4cm. This is larger than the observed value of 1cm. Supposing the seismic fault geometry as the one proposed by Yamanaka (EIC Seismological note), we estimated the magnitude of the 1st event as Mw 8.3 and the 2nd event as Mw 7.9 from the tsunami records. This result contradicts the magnitude estimated from the seismic records.

To reconcile the results obtained by seismic and tsunami records, one may consider the difference between the time-scales for the seismic and tsunamigenic events. Hence, we analyze seismic records observed by IRIS stations all over the world to examine broad-band seismic wavefield including long-period motions. Taking the spectral ratio of the P-waves of the two events, we found that the seismic-wave energy radiated at the 2nd event was larger than that of the 1st event over the wide range of the frequency band (0.5s to 100s). In the analysis, we did not recognize any particular behaviors of seismic wavefield in the long period range to reconcile the observations.

At present, we cannot specify factors which cause the disagreement of the two magnitudes determined from seismic and tsunami records. To clarify this, further investigations are needed; it would be important to analyze more broad-band records, or to include 3-D subsurface structure (including subducting plate and oceanic sediment) into numerical tsunamigenic simulations by the method of Saito and Furumura (2006).