Spatial-temporal and seismogram characteristics of foreshock and aftershock activities for tsunami earthquakes

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A tsunami earthquake is an abnormal earthquake type causing a large tsunami compared to the magnitude measured by short-period seismic waves. There is a high risk to induce a massive tsunami damage for the reason that people who live in the coastal area do not feel quakes a lot, and it is difficult to keep themselves safe after the unusual earthquake happened. Additionally, as for the tsunami earthquakes, their observation cases are much fewer than ordinary earthquakes, so the mechanism of its occurrence is still an open question. To address spatio-temporal features and the mechanism of tsunami earthquakes, we focus on three typical examples of tsunami earthquake and their foreshock & aftershock sequences, which are (Nicaragua (1992/09/02, Mw 7.7), Jawa island (2006/07/17, Mw 7.7) and Mentawai (2010/10/25, Mw 7.8)). We also investigated whether a small earthquake showing the same characteristics as the tsunami earthquake is contained in the foreshock and aftershock activity.

First, we use seismic catalogs and waveform recording provided by ISC/USGS and IRIS respectively to extract the foreshock and aftershock activity, then evaluate the spatio-temporal features. We have found that four foreshock sequences (1992/08/10 06:09:20 Mb 5.2, 1992/08/10 06:34:14 Mb4.7, 1992/08/11 05:23:51 Mb 5.1, 1992/08/13 08:41:17 Mb 4.7) near the epicenter of mainshock area were observed before the occurrence of the Nicaragua mainshock. We have also analyzed the regional and spatio-temporal characteristics of three tsunami earthquake regions by dividing the area of 5*5 around the epicenter into twenty-five segments with the size of 1*1. As a result, in each of the three regions, we have found out that there is a seismic quiescence period in the vicinity of the mainshock area in each tsunami earthquake. Meanwhile, regarding aftershocks of the Nicaragua earthquake, seismic quiescence area is still detected in the same segment as the foreshock.

Migration phenomenon is observed in the foreshock activity near the focal region of the mainshock, especially before the mainshock of the Nicaragua earthquake. Meanwhile, the waveforms of aftershocks occurring in the same area as the events included in the migration have been compared with those of the mainshock. Next, we have calculated the ratio of maximum absolute amplitude of surface wave to that of body wave, in order to address features on waveforms of tsunami earthquake. As a result, the ratio of the mainshock, such as the tsunami earthquake shows extremely high value, whereas for the foreshocks and aftershocks, it does not show the same characteristic as the tsunami earthquake does. This suggests that small earthquakes occurring within the tsunami seismogenic region show the same phenomenon as ordinary earthquakes, but only the mainshock has the characteristics of the tsunami earthquake.

Keywords: tsunami earthquake, seismic activity, waveform analysis

