The 2007 Sumatra seismic sequence revealed by a regional seismic network in Indonesia

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On September 12, 2007, a great earthquake with Mw 8.3 occurred at 11:10 (UTC) off Bengkulu, Sumatra, Indonesia. This event was followed by a large earthquake with Mw 7.9, which occurred at 23:49 (UTC) on the same day in the northwest of the Mw 8.3 earthquake. Another earthquake with Mw 6.8 occurred off Padang, in the northwest of the second earthquake, at 03:35 (UTC) on the next day. These earthquakes caused dozens of casualties and damage to the buildings in Bengkulu and Padang areas. Tsunami with a hight of 2-3m was observed along the coast between Padang and Bengkulu, but no severe damage due to tsunami was reported.

We investigated centroid moment tensor (CMT) solutions of these seismic sequence and aftershocks using data obtained from a broadband seismograph network in Indonesia (JISNET), by waveform inversions carried out in the frequency domain. In order to stably estimate source parameters using data from a small number of stations, a point source and a pure double-couple focal mechanism are assumed. The fault and slip orientations are estimated by a grid search with respect to the strike, dip, and rake angles. Source centroid location is estimated by a spatial grid search. The source centroid of the first event is located off Bengkulu at a depth of 25 km, and its magnitude (Mw) is estimated as 8.3. The second event is located about 150 km northwest of the first event at a depth of 30 km, with magnitude of 7.9. The third event, with estimated magnitude of 6.8, is located about 120 km northwest of the second event at a depth of 25 km. The focal mechanisms of the events are thrust type, consistent with the subduction of the Indo-Australian plate. We also estimated CMT solutions for aftershocks larger than Mw 5, which also show reverse-fault focal mechanisms similar to the first three events. The aftershocks are mainly distributed in two regions: one is off Padang, around the source of the Mw 6.8 event (region A), and the other is off Bengkulu, around the source regions of the Mw 8.3 and 7.9 events (region B).

We next investigated the static Coulomb stress changes caused by the first three largest earthquakes (Mw 8.3, 7.9, and 6.8) around the source region. Coulomb stress changes on reverse-type fault planes obtained for the aftershocks are calculated. We obtain stress increase around the region A, suggesting that the aftershocks in this region were triggered by the largest three events. We also obtain stress increase around the region B. The aftershocks in this region may have been also triggered by the three events, but detailed slip distributions of the three events are necessary to conclude that since these aftershocks are distributed on the fault planes of the three events. In the source region, an M 8 class earthquake occurred on 1833. Another large earthquake occurred on 1797 off Padang, in the northwest of the source region. The 2007 Sumatra seismic sequence did not rupture the northern part of the source region of the 1833 event and the entire source region of the 1797 event, according to the source models of these events by Natawidjaja et al. (2006, JGR). We also investigated the static Coulomb stress changes caused by the 2007 seismic sequence in the source region of the 1797 event. We obtain stress increase of about tens of MPa in this region.

In the off-Bengkulu region, large earthquakes with M 8 or above occurred in 1381, 1608 and 1833, approximately every 230 years. Now 174 years have passed since the last event in 1833. We did not experience M 8 class earthquakes during the last 210 years in the off-Padang region, which is to the north of off-Bengkulu. The off-Padang region corresponds to a seismic gap between the source regions of the 2007 Sumatra seismic sequence and M 8.7 Nias earthquake on March 2005. The Coulomb stress increase around the seismic gap caused by the 2007 seismic sequence suggests the imminency of a large earthquake off Padang.