Tidal triggering of earthquakes preceding the Sumatra megathrust earthquakes

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We observed tidal triggering of earthquakes preceding the three megathrust earthquakes occurring off Sumatra Island (2004 Sumatra-Andaman, Mw 9.0; 2005 Nias, Mw 8.6; 2007 southern Sumatra, Mw 8.5). For each event, we measured the correlation between the earth tide and earthquake occurrence in the rectangular area covering its focal region. The data we used are the origin times, hypocenter coordinates and focal mechanism solutions of 906 earthquakes with Mw 5.0 or larger and with focal depth shallower than 70 km, which are reported in the global CMT catalog for the period from 1976 to 2007. For each earthquake, we theoretically calculated the tidal shear stress on the fault plane; this calculation included the direct solid earth tide and the indirect term due to the ocean tide loading. Assigning the tidal phase angle at the occurrence time of each event, we tested whether they concentrate near some particular angle or not by using the Schuster's test. In this test, the result is evaluated by *p*-value, which represents the significance level to reject the null hypothesis that the earthquakes occur randomly irrespective of the tidal phase angle. As a result of analysis, we found a common characteristic pattern in the temporal variation of the *p*-value. For all the three cases, the *p*-value had been larger than 30% for early years in the investigation period, but a clear decrease appeared prior to the occurrence of the megathrust earthquakes. The *p*-values for the 3000 days just before it are 2.4%, 0.71%, and 6.4% for the 2004, 2005, and 2007 events, respectively. After the occurrence of those events, the *p*-value returned to a high level again (31%, 68%, and 11%, respectively). The frequency distributions of tidal phase angles in the pre-event period exhibited a peak at the phase angle where the tidal shear stress is at its maximum to accelerate the fault slip. This indicates that the observed small *p*-value is not a stochastic chance but is a physical consequence of the tidal triggering effect.