Tidal triggering of earthquakes precursory to the 2004 Off Sumatra earthquake

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We observed tidal triggering of earthquakes precursory to the Mw = 9.0 Off Sumatra earthquake that occurred on December 26, 2004, as thrust faulting on the interface between the Indian and Burma plates. We measured the correlation between the earth tide and earthquake occurrence in the rectangular area, 1600 km by 800 km, covering the aftershock zone of this large megathrust earthquake. The data we used are the origin times, hypocenter coordinates and focal mechanism solutions of 216 earthquakes with Mw 5.0 or larger and with focal depth shallower than 70 km, which are reported in the Harvard CMT catalog for the period from 1977 to 2004. For each earthquake, we theoretically calculated the tidal shear stress on the fault plane; this calculation includes 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 earthquake, 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, no correlation was found for the data set including all the earthquakes (p = 53%). However, we observed a characteristic pattern in the temporal variation of the tidal effect. The p-value exhibited a clear decrease in the pre-seismic stage attaining a significantly small value of 1.6% for about four years just prior to the occurrence of the Off Sumatra earthquake. The frequency distribution of tidal phase angles in the pre-event period showed 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 stress change.