# Tidal triggering of earthquakes in the Off Miyagi region

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We examined the statistical correlation between the earth tide and earthquake occurrence in the Off Miyagi region, where a Mj 7.2 earthquake occurred on August 16, 2005. From the earthquake catalog of the Japan Meteorological Agency, we used the origin times and hypocenter locations of the earthquakes with Mj 1.5 or greater that occurred along the plate interface for the period from October 1997 to July 2005. Clustered events were removed from the catalog. As for the study area, we set the rectangular area, 240 km by 140 km, which includes the focal region of the Mj 7.2 earthquake. We theoretically calculated the tidal stress at the hypocenter of each earthquake. For the stress components, we considered the shear and normal stresses on the fault plane, which was assumed as the same as that of the Mj 7.2 earthquake. We also considered the Coulomb failure stress giving different values of the frictional coefficient between 0.2 and 1.0. 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 significant correlation was found for the data set including all the earthquakes. In this case, the p-value was smallest (p = 14%) for the shear stress, and was greater than 30% for all the other components. Focusing on the shear stress for which the smallest p-value was obtained, however, we found a characteristic pattern in the temporal variation of the p-value. The p-value was larger than 50% for the early years in the investigation period, but a clear decrease appeared for the period from August 2002 to July 2003 (period A; p = 13%). After that, the p-value returned to a level higher than 40%. However, it dropped again for the period from August 2004 to July 2005 (period B; p = 8.1%). Further examining the spatial distribution of p-values in both the small-p periods, we found a clear relation between the distributions of small p-values and large earthquakes occurring just after those periods.

In the period A, the spatial distribution of p-values showed two dominant low-p areas, in which the p-value was smaller than 1%. We found that one of those dominant low-p areas (about 35 km by 30 km) was located in the northern part of the focal region of a Mj 6.8 earthquake that occurred on October 31, 2003, three months after this period. The frequency distribution of the tidal phase angles in this period exhibited a peak near 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.

Just after the period B, in which the p-value exhibited the most remarkable decrease, the recent Mj 7.2 earthquake occurred within the study area. The spatial distribution of p-values in this period showed that a dominant low-p area, covering an area about 30 km by 35 km, appeared in the central part of the study area. This dominant low-p area was found to be located in the central part of the focal region of the Mj 7.2 earthquake, which includes a large slip area near the initial rupture point of this earthquake. The frequency distribution of the tidal phase angles in this period again had a peak near the phase angle where the tidal shear stress is at its maximum to accelerate the fault slip.

In the Off Miyagi region, we observed the strong correlation between the earth tide and earthquake occurrence that was spatially and temporally in close relation to the occurrence of the Mj 6.8 and Mj 7.2 earthquakes. The results we obtained strongly suggest that a precursory tidal triggering effect appeared for about one year preceding those earthquakes.