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# Tidal correlations of earthquake swarms associated with slow slip events off Boso Peninsula

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We investigated statistical correlations between Earth tides and earthquakes in the four swarms associated with slow slip events (SSEs) off Boso Peninsula in 2002, 2007, 2011, and 2014. Following Hirose et al. (2012), we selected the SSE-related events from the Hi-net earthquake catalog. For each event, we assigned the tidal phase angle at the origin time by theoretically calculating tidal Coulomb failure stresses with a frictional coefficient of 0.2. For the fault plane, we assumed a landward-dipping reverse fault from the F-net moment tensor solution of the largest earthquake (Mw 4.9) in the 2014 swarm. Based on the distribution of tidal phase angles, we statistically tested whether they concentrate near some particular angle or not by using the Schuster 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. The result of analysis shows the 2014 swarm was strongly correlated with tidally-induced stresses (p = 0.01%). The distribution of tidal phase angles exhibited a peak near the angle 0, which corresponds to the time of the maximum tidal stress promoting fault slip. We suggest that tidal stress fluctuations can trigger earthquakes when superimposed on stress buildup caused by nearby slow slip. On the other hand, the other three swarms show insignificant correlations with tides. The resultant p-values are 87%, 16%, and 14% for the 2002, 2007, and 2011 activities, respectively. Geodetic observations indicate larger slow slip in these three episodes than in 2014 (Hirose et al., 2013; Kimura, 2014). It is highly likely that the swarm earthquakes in those activities were fully triggered by stress perturbations imparted by large slow slip. Tides appear to have exerted little or no influence on triggering in that case.

Keywords: Boso Peninsula slow slip events, Earth tides, earthquake triggering