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Tidal triggering of shallow very low frequency earthquakes in southwest Japan

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We widely observed tidal triggering of shallow very low frequency (VLF) earthquakes in southwest Japan. We investigated the statistical correlation between the Earth tide and VLF earthquakes occurring in ten active swarms in Hyuga-nada, off Cape Muroto, and southeast off Kii Peninsula. We detected and located VLF earthquakes by applying the array signal processing method (Asano et al., 2008) to the seismograms recorded by the high-sensitive borehole tiltmeter network (Hi-net TILT) throughout Japan for the period from 2003 to 2010. For each event, we assigned the tidal phase angle at the origin time by theoretically calculating the tidal normal and shear stresses on the fault plane. For the fault plane, we assumed a landward-dipping reverse fault from a well-determined focal mechanism solution by using the centroid moment tensor method (Ito and Obara, 2006). Based on the distribution of the tidal phase angles, we statistically 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 VLF earthquakes occur randomly irrespective of the tidal phase angle. Of the ten VLF swarms, significantly small p-values less than 0.01% were found for nine, and seven of them (two, three, and two swarms in the Hyuga-nada, off Cape Muroto, and southeast off Kii Peninsula regions, respectively) showed extremely strong phase selectivity. In the regions we examined, the normal and shear stresses are nearly in phase, although their amplitudes differ (about 10 kPa for the normal stress and 1 kPa for the shear stress). For all the seven cases of strikingly high correlation, the frequency distributions of tidal phase angles exhibited a peak near the angle 0, which corresponds to the maximum extension for the normal stress and maximum in the slip direction for the shear stress. This indicates that the observed high correlation is not a stochastic chance but is a physical consequence of tidal influence.

Keywords: shallow very low frequency earthquakes, Earth tide, triggering, subduction zone