Tidal response in shallow micro low-frequency tremors

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Various types of slow earthquakes, such as tectonic tremor [Obara, 2002], low-frequency earthquake [Katsumata and Kamaya, 2003] and slow slip events [e.g. Rogers and Dragert, 2003] have been recently observed at both the updip and downdip edges of the coseismic slip areas [Obara, 2002; Yamashita et al., 2015]. Here, we show micro low-frequency activity with very weak amplitudes detected using the modified frequency scanning method (mFSM) at a single station [Sit et al., 2012], and successfully detected micro low-frequency tremors (mLFTs) that have not been previously reported. These mLFTs are the almost same as ordinary tectonic tremors, but we define them here in this matter in order to discuss the differences and distinguish the tremor amplitudes, which have amplitudes that are one tenth of the amplitude of tremor detected by the envelope correlation method [Yamashita et al., 2015].
We also evaluated tidal response of the tremor activity at each site. The clear response to tides of slow earthquake activity at depth is well known [Ide, 2010], but the relationship between shallow slow earthquakes and tides is still debatable. We calculated the sea surface change due to the Earth using a computational model, and evaluated the relationship between shallower tremor activity and tidal stress changes ocean loading tides from the model NAO.99b [e.g. Matsumoto et al., 2010]. We used perturbation of the tides at each OBS site and statistically evaluated the relationship based on the Schuster *p* test. We consequently found high tidal responses of shallow tremors especially latter part of tremor migration which reported Yamashita et al., (2015). Specifically, mLFTs have clear response to tides.
We suggest two different occurrence mechanisms for slow earthquake activity off south-eastern Kyushu. The start of the tremors is mainly modulated by larger stress changes, such as from nearby, slow slip events, and later controlled by ambient shear stress perturbations such as tides. In other words, tremor, especially mLFTs could have been induced under the neutral stress regime by tidal stress perturbation.

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