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Slow earthquakes linked along dip in the Nankai subduction zone

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In the southwest Japan subduction zone, a wide variety of 'slow earthquakes' has been detected with fundamental observation networks, such as Hi-net operated by National Research Institute for Earth Science and Disaster Prevention and GEONET by Geospatial Information Authority of Japan. Those are deep low-frequency tremor (Obara, 2002), short-term slow slip events (SSEs; Obara et al., 2004), and deep very low-frequency earthquakes (VLFEs; Ito et al., 2007) in the deeper extension of the locked zone of the subduction plate interface, long-term SSEs updip of these three kinds in Bungo Channel and Tokai (SSE; Hirose et al., 1999; Ozawa et al., 2002), and shallow VLFEs (Obara and Ito, 2005) near the Nankai trough. Each phenomenon has a characteristic dominant wave frequency or duration, depth and activity. Not all of them occur independently, but some of them occur simultaneously. For example, tremor, short-term SSEs and deep VLFEs occur at the same time in a same place (Episodic Tremor and Slip (ETS): Rogers and Dragert, 2003; Obara et al., 2004; Ito et al., 2007). Also, long-term SSEs that recur every six years in the Bungo channel region affect the frequency of occurrence of ETS episodes in western Shikoku (Hirose and Obara, 2005) and the tremor activity in the Bungo channel (Obara et al., 2010). However, the relation between shallow VLFEs and the other slow earthquakes has not been clear. Here we present the coincidence of the Bungo channel SSEs in 2003 and 2010 and deep tremor and shallow VLFEs that are distant from the source region of the SSEs and the tremor (Hirose et al., 2010).

The controlling process of this along-dip correlation is possibly the SSE because the SSE is several orders of magnitude larger in the corresponding seismic moment than the tremor and the shallow VLFEs. In addition, the locations of the correlated tremor is covered by the SSE source area, while those of the VLFEs occurred near the Nankai trough, distant from the SSE area. A plausible explanation is that a similar relation to the one between the SSE and the tremor is held between the SSE and the shallow VLFEs; that is, the SSE slip area may extend through the region of no measurable slip to the shallow VLFE source area and activate the VLFEs.

If this is the case, the source area of these slow earthquakes might act as a barrier to nearby megathrust rupturing because the slow slip area repeatedly releases the accumulated strain in an interseismic period of the megathrust events. Moreover, the slip area adjoins the megathrust rupture zone, suggesting that the repeating aseismic slip can modulate the stress buildup on the rupture zone. This indicates the importance of monitoring slow earthquakes as proxies for the stress modulation process.

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Keywords: subduction zone, nonvolcanic tremor, very low-frequency earthquakes, slow slip events, earthquake generation cycle