

Recurring slow slip events and earthquake nucleation in the source region of the *M* 7 Ibaraki-Oki earthquakes revealed by earthquake swarm and foreshock activity

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Abstract

Slow slip events (SSEs) on the plate interface are closely related to the occurrence of earthquakes, and often trigger earthquake swarms in subduction zones. Moreover, some SSEs, accompanied by intensive foreshocks, precede large interplate earthquakes. Therefore, detecting and monitoring SSEs is important for assessing the potential of future large earthquakes. However, there are many SSEs not followed by large earthquakes, and it is unclear whether these can be distinguished from SSEs preceding large earthquakes. Here we use the epidemic-type aftershock sequence (ETAS) model and matched-filter technique to examine the spatial-temporal distribution of earthquake swarms and foreshocks at Ibaraki-Oki in the Japan Trench. We found that 19 swarm sequences repeatedly occurred during the period 1982–2008 at the same location as the foreshock sequences of the 1982 and 2008 *M* 7 Ibaraki-Oki earthquakes. Both the foreshock and swarm sequences contain repeating earthquakes and have anomalously high seismicity rates inexplicable by the ETAS model, suggesting the recurrence of SSEs. The foreshock sequences in 1982 and 2008 contain more events inexplicable by the ETAS model than the swarm sequences. The fault slip of repeating earthquakes in the 2008 foreshock sequence was also larger than those of the swarm sequences, and the slip rate showed an abrupt increase 12 hours before the 2008 *M* 7 event. Our results imply that the SSEs that preceded the *M* 7 events had larger seismic moments than the other SSEs. These large SSEs might be related to the nucleation phase of the *M* 7 earthquakes.