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Improvement on the estimation of seismic moment of short-term slow slip events

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Slow slip events (SSE) accompanied by deep low-frequency tremor (Obara, 2002) have repeatedly occurred along the Nankai trough subduction zone in southwest Japan (Obara et al., 2004; Hirose and Obara, 2005, 2006). This synchronous phenomenon is called ‘episodic tremor and slip’ (ETS; Rogers and Dragert, 2003). ETS has been thought to occur on the deeper extention of megathrust earthquake source areas on the plate interface, indicating that the repeating SSE activity may episodically increase the stress on the megathrust source areas. This means that ETS is not only important for understanding the subduction zone dynamics, but also a key process for investigating the preparation process of megathrust earthquakes.

It is very important to know the long-term slip history and recurrence behavior of the SSEs as precise as possible for the above objectives. We have determined fault slip models for a number of SSEs by means of a method which assumes a simple rectangular fault (e.g., Hirose and Obara, 2005). This method can simultaneously estimate both non-linear parameters such as fault location and size and linear parameters for a slip vector. Practically, there are trade-offs among model parameters in the inversion, especially between fault depth and seismic moment. This causes a severe uncertainty on studies based on the estimated seismic moment of the SSEs, for example, a study on the relation between the seismic moment of an SSE and the associated tremor activity (e.g., Obara, 2009). Here we try to estimate the seismic moment of a number of SSEs more precisely without determining the fault area and depth, by means of a grid search method for the fault location among fault candidates placed on the plate interface.

The analysis procedure is as follows: NIED Hi-net tilt records that include an SSE are decimated to be a data set with a sampling rate of one hour. The tidal components and the response to atmospheric pressure are subtracted with BAYTAP-G (Tamura et al., 1991). A linear trend in each trace is also subtracted. We define a tilt change due to an SSE as a difference between two averages for each one day time interval before and after the SSE. The fault elements (or ‘grids’) are placed based on the plate configuration models (Ishida and Sakanashi, 2003; Shiomi et al., 2008). A fault element has an area of $10 * 10$ km^2. On each element, the slip direction is fixed to that of the relative plate motion (Miyazaki and Heki, 2001) and an amount of slip is inverted. Finally, the best fault element where the residual is minimum is selected among all the candidates, and the seismic moment of an SSE can be estimated.

We analyzed 20 SSEs for eight years from 2001 in the western Shikoku and the Bungo channel regions, and found that the long-term moment release rate for this period is 1.9e+18 Nm/year. If a typical size of an SSE fault of, for example, $60 * 30$ km^2 is chosen, on average 2.6 cm of slip per year as SSEs should occur. In an actual case, however, slip is not uniform on such a wide fault area, but distributes heterogeneously (Hirose and Obara, 2009). These pieces of evidence suggest that slip is not uniform in the ETS zone, but there are places where most of the accumulated strain is released as SSEs and where quasi-steady sliding is taking place in the zone.

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