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Comparing slab curvature effects on deep slow slip events

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Fault slip phenomena observed at subduction margins are now known to span the spectrum of slow-to-fast ruptures, which include deep slow slip events (SSEs) that can occur just downdip of the seismogenic zone. This transition of slip behavior along the depth extent of the locked megathrust boundary has been speculated to be linked to conditions either within the overriding or downgoing plate, as well as to properties of the interface itself such as the frictional state or fluid content. Another factor that has been proposed to control the occurrence of such deep SSEs is the plate interface geometry (Mitsui and Hirahara, 2006; Okada et al, 2022). At the Nankai subduction zone in southwest Japan, the slip rate of SSEs with durations ranging from a few days to several weeks long was found to be inversely correlated with the dip angle of the subduction zone plate interface (Okada et al, 2022). This result implies that the steepness of the subducting slab plays a role in controlling the amount of slip during SSEs. In our work, we extend this hypothesis by investigating whether the curvature of the plate interface is also a relevant factor in controlling SSEs, as it was shown in previous studies that low-curvature (relatively flat) areas of megathrust faults seem to correlate well with rupture areas of large megathrust earthquakes (Bletery et al, 2016).

We calculate the curvature of the slab surface by using the depth to the plate interface from a plate model (Iwasaki et al, 2015) and then computing its higher-order spatial derivatives. The depth to the slab surface is assumed to represent the deflection due to the bending at flexural wavelengths. Thus, based on the appropriate scale, we applied a spatial filter to the slab depth, after which we computed the maximum and minimum slab curvatures using formulas from differential geometry in which these are expressed in terms of the second fundamental form of the surface assuming a Monge patch (Zhang et al, 2021).

The fault parameters from a published catalog (Okada et al, 2022) which spans the years 1997-2021 were then used to determine the slip areas of the SSEs. The slip and duration estimates for the SSEs were used to compute an average slip rate for each coordinate in an area covering the Nankai Trough subduction zone. For the ensuing analysis, locations at which fewer than 5 SSEs had occurred were excluded. Then, along the 30-kilometer iso-depth contour (Iwasaki et al, 2015), the various quantities that were calculated related to the curvature were sampled, and then compared with the average slip rate at the corresponding coordinates.

Our preliminary results show that along the 30-kilometer iso-depth of the slab surface, the average slip rate of the SSEs is moderately correlated with the minimum curvature of the slab surface. For the sign convention that we adopted, this is equivalent to the lowest negative value of the curvature in areas where the slab is bending downward. In that case, the direction along which the minimum curvature is aligned with is also the orientation along which the greatest bending of the slab surface occurs. One possible interpretation of this result is that the average slip rates of SSEs at the Nankai subduction zone are inversely related to the absolute value of the downward bending curvature of the slab. This then implies that flatter areas of the subduction interface are conducive to higher slip rates at locations where SSEs occur.

In addition, there was also some modest correlation with the difference between the minimum and maximum curvatures of the slab surface. This hints at some dependence of the average slip rate on the second partial derivative of the depth to the top of the slab with respect to both horizontal dimensions. However, this potential correlation may only be linear for low values of this difference in curvature. A possible implication of this finding is that if the stress state within the slab as induced by elastic flexure is indeed relevant for possible controls on SSE occurrence, then plate bending in three dimensions needs to be considered.

References

Bletery, Q., Thomas, A. M., Rempel, A. W., Karlstrom, L., Sladen, A., & De Barros, L. (2016). Mega-earthquakes rupture flat megathrusts. *Science*, 354(6315), 1027-1031

Iwasaki, T., Sato, H., Shinohara, M., Ishiyama, T. & Hashima, A., (2015). Fundamental structure model of island arcs and subducted plates in and around Japan, 2015 Fall Meeting, American Geophysical Union, San Francisco, Dec. 14-18, T31B-2878.

Kano, M., Aso, N., Matsuzawa, T., Ide, S., Annoura, S., Arai, R., Baba, S., Bostock, M., Chao, K., Heki, K., Itaba, S., Ito, Y., Kamaya, N., Maeda, T., Maury, J., Nakamura, M., Nishimura, T., Obana, K., Ohta, K., Poiata, N., Rousset, B., Sugioka, H., Takagi, R., Takahashi, T., Takeo, A., Tu, Y., Uchida, N., Yamashita, Y., & Obara, K. (2018). Development of a Slow Earthquake Database, *Seismological Research Letters*, 89 (4), 1566-1575

Lindquist, K. G., K. Engle, D. Stahlke, & E. Price (2004). Global Topography and Bathymetry Grid Improves Research Efforts, *Eos Trans. AGU*, 85(19), 186.

Mitsui, N., & Hirahara, K. (2006). Slow slip events controlled by the slab dip and its lateral change along a trench. *Earth and Planetary Science Letters*, 245(1–2), 344–358.

Okada, Y., Nishimura, T., Tabei, T., Matsushima, T., & Hirose, H. (2022). Development of a detection method for short-term slow slip events using GNSS data and its application to the Nankai subduction zone. *Earth, Planets and Space*, 74(1), 18.

Zhang, J., Zhang, F., Lin, J., & Yang, H. (2021). Yield failure of the subducting plate at the Mariana Trench. *Tectonophysics*, 814, 228944.