Development of a method to estimate spatial stress pattern from *P*-wave first motion data: an application to a real dataset

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A method of estimating spatial stress pattern from *P*-wave first motions has been developed in Iwata [2016, JpGU meeting; AGU meeting]. In this method, it is assumed that the strike and dip angles of a fault plane are randomly distributed with the uniform distribution and that the direction of slip of the fault is parallel to the direction where the shear stress is maximized. Under these two assumptions, spatial stress pattern that fits the dataset of P-wave first motions is estimated with the smoothness constraint on a spatial variation of the stress pattern. In this method, it is unnecessary to determine the focal mechanisms of each events.

To demonstrate the performance of the method, a numerical experiment was done. 3,000 events were randomly and uniformly distributed and five seismic stations were deployed in a study area. The strike and dip angels of each of the events were taken from the uniform distribution. The rake angle (or focal mechanism) of the event that maximizes the shear stress was computed from an assumed stress field at the hypocenter of the event. Then, the polarities of the *P*-wave first motion that are expected to be observed at the five stations were determined; in total, 15,000 *P*-wave first motions were generated. They were reversed with a probability of 0.05 to consider the possibility of error recording. As a result of the application of the method to this synthetic dataset, the assumed stress field and the probability of error recording were successfully reproduced.

In the next step, this method was applied to the real dataset that was taken from the aftershocks of the 2000 Western Tottori Earthquake, which was complied and analyzed in Kawanishi et al. [2009, JGR]. From this dataset, 47,570 *P*-wave first motions from 3592 events were chosen on the basis of O-C time for the *P*-wave arrival (and *S*-wave arrival if it was picked). The estimated spatial stress pattern reveals that the sigma_1 (maximum principal stress) axis has the direction of WNW-ESE in the northern part of the aftershock area while is is almost parallel to the direction of EW in the southern edge of the area. This is consistent with the result of Kawanishi et al. [2009], suggesting the validity of this developed method.

Keywords: stress field, spatial statistics, P-wave first motion, Bayesian estimation, smoothness constraint