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A Bayesian approach to estimating focal mechanisms based on the spatial stress pattern inferred from a *P* wave first-motion dataset

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Horiuchi et al. [1995, JGR] and Abers & Gephart [2001, JGR] have proposed their methods to find the best stress field to be consistent with the *P* wave first-motions (polarities) directly (i.e., without pre-determined focal mechanisms). Iwata [2018, JGR] (hereafter IW2018) expands their methods to make it possible to estimate a spatial stress pattern.

In similar to Horiuchi et al. [1995] and Abers & Gephart [2001], the method of IW2018 enables us also to estimate focal mechanisms simultaneously with the estimation of a stress pattern, but the simultaneous estimation is difficult because of the enormous number of parameters. For instance, in IW2018, the number of parameters to represent the spatial stress pattern is a few hundred whereas it is necessary to use several thousand or several ten thousand parameters to focal mechanisms. It is impractical to deal with such a huge number of parameters with a Markov chain Monte Carlo method that is used as an estimation algorithm in IW2018.

However, after we estimate a spatial stress pattern (and accompanying parameters), the computational load to estimate focal mechanisms is much reduced, because each of the focal mechanisms is independent each other if a particular spatial stress pattern is given. In other words, we can make each of the estimations of a focal mechanism separately.

Based on this idea, this study conducts the numerical experiment of a Bayesian estimation of focal mechanisms. The dataset of *P* wave first-motions analyzed here was generated in IW2018 (datasetA.txt at https://doi.org/10.5281/zenodo.1188466). Using this dataset and the spatial stress pattern estimated in IW2018, a (Bayesian) Monte Carlo sampling of focal mechanisms was carried out.

Fig. 1 depicts a demonstrative example of the estimation. As seen in Fig. 1(a), most of the sampled focal mechanisms (black lines) based on this framework (i.e., in the estimation of a focal mechanism, we incorporate the information of *P* wave first-motions with the estimated stress field at the hypocenter) are close to the "true" focal mechanism (an assumed focal mechanism in the generation of the dataset, purple lines). By contrast, the sampled focal mechanisms have a wide variety if we only consider the information of *P* wave polarities in the estimation (Fig. 1(b)) because the small number of polarities (only 5) cannot provide sufficient constraint on the choice of a focal mechanism; this feature suggests that this approach is useful in the determination of focal mechanisms.

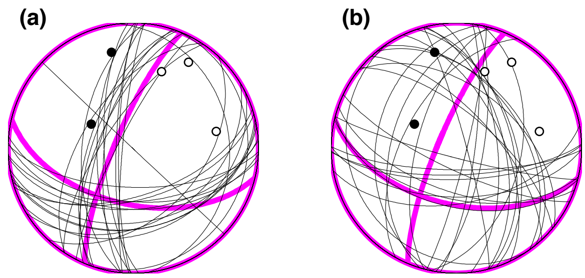

Figure 1. An example of the estimated focal mechanism (a) using both of the *P* wave first-motions (open and solid circles) and stress field at the hypocenter (b) using only the *P* wave first-motions. The black and purple lines correspond to 15 focal mechanisms taken from a Monte Carlo sampling and the one assumed in the generation of the analyzed *P* wave first-motion dataset, respectively.