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Inference of a slip distribution from aftershock data and friction law: a Bayesian model with a prior of magnitude

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An statistical method to estimate a fault slip distribution of a mainshock with the spatial distribution of its aftershocks and rate- and state-dependent friction law [Dieterich, 1994] has been suggested [Iwata, 2008]. In this method, the fault plane of a mainshock is divided into subfaults, and then the amplitudes of slip in each of the subfaults are optimized to fit the real spatial distribution of the aftershock activity with the distribution expected from the rate- and state-friction law. Because we optimize a large number of parameters simultaneously in this approach, a roughness penalty is imposed to stabilize the optimization; for this purpose, a Bayesian model with a smoothness prior for the spatial slip distribution is constructed and the estimation is carried out.

One of the problems in this method is how to determine the strength of the roughness penalty objectively. In many cases of seismological/geophysical studies, the strength is determined by the principle of the minimization of Akaike's Bayesian Information Criterion [ABIC; Akaike, 1980] and ABIC is computed through the Laplace approximation [Tierny and Kadane, 1986]. However, because of some technical reasons originated from the formula of the friction law, the Laplace approximation is not applicable to this method and the computation of the value of ABIC is impractical.

This study proposes that the information on the magnitude of a mainshock is incorporated in the Bayesian model. This is because it has been empirically found that the amplitudes of the estimated slip in the subfaults or the corresponding magnitude to the estimated slip distribution much depends on the strength of the roughness penalty; if we impose a constraint on the magnitude, then the appropriate strength could be chosen objectively. To implement this idea, a prior distribution of the magnitude of a mainshock is constructed. It is supposed to be a normal distribution of which mean is retrieved from the Global CMT catalogue and standard deviation is given from Kagan [2010]. Then, the posterior distributions of the strength and the spatial slip distribution are computed simultaneously through the Markov chain Mote Carlo method. This framework provides the practical computational method to estimate the spatial slip distribution of a mainshock inferred from its aftershock data.

References:

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