An ETAS model incorporated with focal mechanisms
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【Motivation and aim】
The widely used space-time ETAS (epidemic-type aftershock sequence) model was developed by Ogata (1998). This time, we incorporate focal mechanisms into the original ETAS model. To find a proper mathematical form of the new model, we use the stochastic reconstruction method developed by Zhuang et al. (2004) to rebuild probability distributions of focal mechanism of background seismicity and the correlation in focal mechanisms between parent and offspring events. We hypothesize that the distribution of the focal mechanisms of the direct offspring is separable from the other component, only relying on the rotation angles from the parent event. We also test whether the rotation poles are uniformly distributed. Finally, we suggest an extended model by incorporating focal mechanisms. This model is helpful for us to understand the mechanism of aftershock triggers and tectonic stress field.

【Theory and Methodologies】
1. The ETAS model - Time-varying seismicity rate
\[ \lambda(i, t) = \lambda_0(i) \exp \left( M_i \alpha \right) \left\{ \exp \left( \gamma_i \right) - 1 \right\} \]
where \( \lambda_0(i) \) is the background seismicity rate of location \( i \), \( M_i \) is the magnitude of the \( i \)-th event, \( \alpha \) and \( \gamma_i \) are the scaling factors.

2. Stochastic reconstruction
We fit the original ETAS model the F-test data, and estimate the following probabilities:
\[ p_1 = P(\text{event } j \text{ is background}) = \frac{\lambda_j}{\lambda_j + \lambda_0} \]
where \( \lambda_j \) is the rate for the \( j \)-th event.

3. Mean background ground focal mechanism
The mean background focal mechanism is calculated based on the method in Kagan (2014):
\[ m_i = \sum_{j} m_j \# \text{rotation angles between } i \text{ and } j \]

【Data】
F-net catalog by NIED
(National Research Institute of Earth Science and Disaster Prevention)
Latitude (N): 30° - 45°
Longitude (E): 120° - 146°
Time: 1997/01/11 to 2017/12/31

【Results】
Maps of epicenters in the F-net catalog
Probability density of rotation angles: left - uniform random rotation, right - uniform random rotation
Symmetry of focal mechanisms:
Double couple focal mechanism (DC FM) has 3 kinds of symmetries: DC1, DC2, and DC4.

【Conclusion】
Using stochastic reconstruction, a proper form of new ETAS model which incorporates the correction between focal mechanisms is constructed.

【References】