Testing foreshock hypothesis against the ETAS model: why is it so difficult?

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Starting from the Epidemic-Type Aftershock Sequence (ETAS) model, which is widely used in seismology for describing clustering features of the earthquake process, we can derive the probability of the foreshock phenomenon and the distribution of largest aftershock magnitude related to the Bath law, both of which are close to the values in real seismicity. Theoretically, if the earthquake clustering is a coin, the foreshock phenomenon is on the head and the Bath law in the tail. It is hard to believe htat there is a mechanism that produces the foreshock phenomenon without changing other parts of this coin. Studying how the tectonic environment changes influence the earthquake clustering behavior is more meaningful than seeking foreshocks only.

For simulation studies, I found that, in previous researches where the foreshock phenomenon is concluded as a significant earthquake precursor, “weak-clustering” or biased estimated ETAS models have been used. Especially, ETAS parameters *c* and *D* parameters are difficult to estimated correctly when short-term missing events exist. Another pitfall is the magnitude threshold.

Therefore, to completely reject the hypothesis that the ETAS model does not produce the foreshock phenomenon, one must show that no ETAS simulations can produce the corresponding characters. Only showing that some particular ETAS model cannot produce foreshock characteristics in real catalog, especially only in the quantities of these characteristics, is not enough for rejecting this conjunction. Unless we can distinguish foreshocks before the entire earthquake sequence finishes completely, the foreshock is an impractical concept.

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