Geophysical Research Abstracts
Vol. 20, EGU2018-16154-1, 2018
EGU General Assembly 2018

Can foreshocks be used routinely in earthquake forecasting? A numerical investigation of the advantages and limitations of foreshocks as useful precursors

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Several phenomena have been characterized as precursors of large events. For them to be useful, they need to occur largely exclusively prior to stronger earthquakes and before many of these events. Perhaps the most promising possible precursors are the ones related to seismicity patterns. Foreshocks are a commonly investigated example in this case. In our previous studies empirical seismicity data was superimposed in order to search for possible generic seismicity patterns, which revealed an increasing rate prior to larger events. Our analyses implied that the limited number of data currently available from existing networks probably limits our possibilities to correctly identify foreshock activity. If more data is available the precursory patterns might be routinely used in earthquake forecasting. We here investigate this hypothesis numerically, using synthetic earthquake catalogues produced based on different clustering models and assumptions for aftershock productivity. Multiple realizations of generalized cases and data-based scenarios are tested for different presumed network sensitivity. Our results show that if foreshocks exist and our assumptions are reasonable, then more foreshock sequences should be correctly identified as such, if network sensitivity increases. With more smaller data recorded, genuine changes in the mechanical situation prior to larger earthquakes might be revealed. We also discuss the apparently increasing possibility of having misleading information (false alarms) due to e.g. random fluctuations of seismicity that might be wrongly identified as foreshocks in such cases. Our numerical simulations show that the level of false alarms would be low in comparison to the number of clearly identified foreshocks, giving more opportunities to observe an increasing rate in real time, on a specific area of interest.