Geophysical Research Abstracts
Vol. 14, EGU2012-7713, 2012
EGU General Assembly 2012

The Predictive Value of Foreshocks

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Foreshock activity was considered as a potential precursor of mainshocks since the 1960's. This is because foreshocks come directly from the source where mainshock is under preparation. However, the precise predictive value of foreshocks remained unrevealed due to the lack of precise earthquake catalogue data. We use recent examples of foreshocks from Japan, Italy, Greece and California and show that significant changes of seismicity in space-time-size domains during precisely located foreshock sequences provide seismicity patterns bearing high probability gain before the mainshock. The power-law increase of the event rate and the move of foreshocks towards mainshock epicenter indicate an accumulated or cascade stress redistribution process and a nucleation process, respectively. On the other hand, the statistically significant drop of b-value during foreshock sequences, from physical point of view provides clues for a softening material process in the seismogenic volume. We show analytically that the microstructural parameter α of the Olami-Feder-Christensen model controls the macroscopically observed b-value. This is further supported by our simulation results. The seismicity changes in the time, space and size domains during foreshocks provide information about the time and space of mainshock preparation as well as about the lower threshold of the mainshock magnitude, M. However, they do not provide an approximation of M. The recent examples used yield evidence that the foreshock area is likely a function of M. We propose that in selected target areas the close seismicity monitoring may provide evidence for foreshock activity beforehand, which may open possibilities for the predictability of mainshocks.