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Short-term foreshock activity and its value for the earthquake prediction

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Seismicity often occurs in space-time clusters: swarms, short-term foreshocks, aftershocks. Swarms are space-time clusters that do not conclude with a mainshock. Earthquake statistics shows that in areas of good seismicity monitoring foreshocks precede sizeable (M5.5 or more) mainshocks at a rate of about half percent. Therefore, discrimination between foreshocks and swarms is of crucial importance with the aim to use foreshocks as a diagnostic of forthcoming strong mainshock in real-time conditions. We analyzed seismic sequences in Greece and Italy with the application of our algorithm FORMA (Foreshocks-Mainshock-Aftershocks) and discriminate between foreshocks and swarms based on the seismicity significant changes in the space-time-magnitude domains. We support that different statistical properties is a diagnostic of foreshocks (e.g. b-value drop) against swarms (b-value increase). A complementary approach is based on the development of Poisson Hidden Markov Models (PHMM's) which are introduced to model significant temporal seismicity changes. In a PHMM the unobserved sequence of states is a finite-state Markov chain and the distribution of the observation at any time is Poissonian with rate depending only on the current state of the chain. Thus, PHMM allows a region to have varying seismicity rate. PHMM is a promising diagnostic since the transition from one state to another does not only depend on the total number of events involved but also on the current state of the system. A third methodological experiment was performed based on the complex network theory. We found that the earthquake networks examined form a scale-free degree distribution. By computing their basic statistical measures, such as the Average Clustering Coefficient, Mean Path Length and Entropy, we found that they underline the strong space-time clustering of swarms, foreshocks and aftershocks but also their important differences. Therefore, network theory is an additional, promising tool to discriminate between different styles of seismicity.