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# Volcano monitoring based on a re-interpretation of seismicity data

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Although earthquakes are a particularly useful source of information regarding volcanic processes, the space-time irregularity of patterns and their change from episode to episode make it difficult to effectively interpret seismicity patterns. In this study, our objective is to analyze the existing data regarding volcano-related earthquakes (position, time of occurrence, magnitude) in a framework that emphasizes their interrelationships, with the aim of identifying pattern change trends on different time scales. To this end, the set of earthquakes occurring in a certain time interval is transformed into a directed network: its nodes correspond to event locations, and the directed edges characterize relationships among nodes. Weight functions for network edges are calculated as a product of temporal, spatial, and magnitude weight components. Power laws are applied for the decreasing inter-event influence as a function of time and distance, while event size weights are obtained by normalizing the magnitude of the first event in each pair with respect to the largest event size in the set. We consider that an earthquake can exert an influence upon other earthquakes in the network only if the resulting overall weights are higher than a certain threshold. We explore the influence of weight functions and thresholds upon the resulting network. In all cases, we find power law distributions both for the degree and the weight distributions of the networks generated in this way. The dynamics of the earthquake networks is evaluated by following the change in the exponent values for these power laws, identified for successive network windows in time. This methodology is applied to the Big Island of Hawaii, between 18.50 and 20.51 degrees northern latitude, and between 154.50 and 156.51 degrees western longitude. Earthquakes data from the Advanced National Seismic System catalog are used for this study. We find that earthquake interrelationships reflected in the generated networks undergo consistent transformations: they gradually change, over years, for instance, from states dominated by low connectivity values, to those in which high connectivity plays an increasingly important role. Interestingly, while earthquake swarms systematically coincide with high values of network connectivity, the gradual year-long transformation of the seismicity networks cannot be distinguished by analyzing the earthquake succession alone. This study suggests that the applied approach to volcano monitoring, based on data commonly available, captures property changes in the analyzed volcanic system which may provide fruitful insights with respect to volcanic processes.