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Spatiotemporal scaling properties and complexity of volcano-related earthquake swarms in the Yellowstone supervolcano

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The Yellowstone volcanic field is one of the most active volcanic systems in the world and presents intense seismic activity, which is characterized by several earthquake swarms over the last decades. In the present work, we study the spatiotemporal properties of the earthquake swarm sequences occurred on December-January 2008-2009 and the 2010 Madison Plateau swarm, using the innovative approach of Non-Extensive Statistical Physics (Tsallis 1988; 2009). This method is widely used in order to describe the behavior of complex systems where fracturing and strong correlations exist, such as in tectonic and volcanic environments (Vallianatos et. al, 2016). This framework is based on the maximization of the non-additive Tsallis entropy Sq by a q-exponential factor that expresses the degree of non-extentivity of the system. The estimation of the q-exponential factor can give us important information about the correlation among the events and the interactions that take place among them. Using the seismic data provided by University of Utah Seismograph Stations (UUSS) we analyzed the inter-event time and distance distribution of the earthquakes that occurred during the two swarm sequences calculating the q-exponential function. The results indicate that the interevent distance and the time intervals between successive earthquakes scale according to the q-exponential distribution with $q<1$ and $q>1$, which corresponds to supper-additive and sub-additive systems respectively. Furthermore, the Non-Extensive Statistical Physics approach seems to be a very promising tool for analyzing seismicity in strong correlated systems such as the Yellowstone supervolcano, since it describes successfully the cumulative distribution of the inter-event distance and time between successive earthquakes of the swarms.

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