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Applying Multifractal Theory and Statistical Techniques for High Energy Volcanic Explosion Detection and Seismic Activity Monitoring in Volcanic Time Series

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Understanding volcanic activity through time series data analysis is crucial for uncovering the fundamental physical mechanisms governing this natural phenomenon.

In this study, we show the application of multifractal and fractal methodologies, along with statistical analysis, to investigate time series associated with volcanic activity. We aim to make use of these approaches to identify significant variations within the physical processes related to changes in volcanic activity. These methodologies offer the potential to identify pertinent changes preceding a high-energy explosion or a significant volcanic eruption.

In particular, we apply it to analyze two study cases. First, the evolution of the multifractal structure of volcanic emissions of low, moderate, and high energy explosions applied to Volcán de Colima (México years 2013-2015). The results contribute to obtaining quite evident signs of the immediacy of possible dangerous emissions of high energy, close to 8.0x10^8 J. Additionally, the evolution of the adapted Gutenberg-Richter seismic law to volcanic energy emissions contributes to confirm the results obtained using multifractal analysis. Secondly, we also studied the time series of the Gutenberg-Richter b-parameter of seismic activities associated with volcanic emissions in Iceland, Hawaii, and the Canary Islands, through the concept of Disparity (degree of irregularity), the fractal Hurst exponent, H, and several multifractal parameters. The results obtained should facilitate a better knowledge of the relationships between the activity of volcanic emissions and the corresponding related seismic activities.