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Complex Network Analysis of Seismicity and Applications to Short-Term Earthquake Forecasting

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Abstract : Earthquakes are complex phenomena, exhibiting complex correlations in space, time, and magnitude. Recently, the concept of complex networks has been used to shed light on the statistical and dynamical characteristics of regional seismicity. In this work, we study the relationships and interactions of seismic regions in Chile, Japan, and the Philippines through weighted and directed complex network analysis. Geographical areas are digitized into cells of fixed dimensions which in turn become the nodes of the network when an earthquake has occurred therein. Nodes are linked if a correlation exists between them as determined and measured by a correlation metric. The networks are found to be scale-free, exhibiting power-law behavior in the distributions of their different centrality measures: the in- and out-degree and the in- and out-strength. The evidence is also found of preferential interaction between seismically active regions through their degree-degree correlations suggesting that seismicity is dictated by the activity of a few active regions. The importance of a seismic region to the overall seismicity is measured using a generalized centrality metric taken to be an indicator of its activity or passivity. The spatial distribution of earthquake activity indicates the areas where strong earthquakes have occurred in the past while the passivity distribution points toward the likely locations an earthquake would occur whenever another one happens elsewhere. Finally, we propose a method that would project the location of the next possible earthquake using the generalized centralities coupled with correlations calculated between the latest earthquakes and a geographical point in the future.

Keywords : complex networks, correlations, earthquake, hazard assessment
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