Statstical Properties of the Olami-Feder-Christensen Model on the Complex Network

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As a statistical model of seismicity, Olami-Feder-Christensen (OFC) model, which is thought to represent the stress distribution on the fault plane, has been studied and found that the model reproduces statistical properties similar to the real earthquakes including Gutenberg-Richter law and Omori formula for aftershock sequence. In most cases, OFC model has been studied on two-dimensional lattice, and the system is uniform in the sense that the cells are under the same condition. On the other hand, it is well known that earthquakes occur spatially non-uniformly. Recent studies showed that the network constructed by connecting the epicenters of successive earthquakes behaves as a Barabasi-Albert (BA) type scale-free network. Therefore in this study we simply incorporate such a spatial non-uniformity by thinking the OFC model on BA scale-free network and examine the statistical properties. This model includes two parameters; one is for the model construction, and the other is the dissipation-rate between nodes during stress redistribution. We mainly study the dissipation-rate dependence of statistical properties.
As a result, it is found that the magnitude frequency obeys nearly power law as well as the GR law, regardless of the dissipation-rate. Furthermore, by changing the dissipation-rate, the statistical behavior varies and is roughly categorized into three types; (1) Mainshock-Aftershock, (2) Foreshock-Mainshock-Aftershock, and (3) Stationary sequences. Especially first two behaviors are similar to the characteristic intermittent-clustering behavior of earthquakes.
Characteristic feature of this model is that even if the node has largest degree, sometimes multiple-releases occur in one event. During such a large event (regarded as the mainshock) stress redistribution is repeated between large degree nodes and overwhelmingly many smaller nodes. Therefore, as almost all nodes in the network are involved in the mainshock, aftershocks in this model are not considered to be the events releasing the remaining stresses which are not released by the mainshock.
In order to understand the role of aftershocks in this model, we propose a roughness parameter, which is thought to reflect the non-uniformity of stresses on the network, to make clear the total behavior of OFC model. With this parameter we found that aftershocks are not thought to be the events in order to release remaining stress at the edge of the mainshock rupture zone, but to be the process that nodes interact and cooperate to return to a stable roughness level specific to the construction of the network.

