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Inverse cascades and hierarchical aggregation in percolation model

I. Zaliapin (1,2), H. Wong (1), A. Gabrielov (3)

(1) Institute of Geophysics and Planetary Physics, UCLA, Los Angeles, CA, USA, (2) International Institute for Earthquake Prediction Theory and Mathematical Geophysics, Russian Ac. Sci., Moscow, Russia, (3) Departments of Mathematics and Earth and Atmospheric Sciences, Purdue University, West Lafayette, USA

The dynamics of a 2D site percolation model on a square lattice is studied using the hierarchical approach based on the Horton-Strahler rule for ranking elements within a hierarchical structure. In percolation model a hierarchy is created by the temporal evolution of the system that allows one to represent an inverse cascade of particle aggregation as a time-oriented tree. Accordingly, the evolution of percolation model is considered as a hierarchical inverse cascade of cluster aggregation. The main results are the following: We a) reported the three-exponent time-dependent scaling for the cluster rank distribution, in deviation from the two-exponent scaling well-known for the mass distribution; b) analyzed the growth of the percolation cluster and established the time-dependent rank distribution of its subclusters, as well as corresponding laws for its mass, rank, and their relationship; c) report several phenomena premonitory to the onset of percolation; they complement the traditional power-law increase of the model's observables; d) demonstrated that the Tokunaga side-branching constraint uniquely determines the mass-rank relationship for a general aggregation process (not necessarily originated from percolation model).