GC2024-SG033

Nonextensive analysis of earthquakes and man-made impacts

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The paper examines the application of Tsallis q-statistics, based on the principles of non-extensive statistical physics, to the analysis of seismic events and man-made impacts. Non-extensive statistical physics (NESP) is based on the concept of entropy, which was introduced in 1988 by Constantino Tsallis [1] as a generalization of the standard Boltzmann-Gibbs entropy.

To describe the energy distribution functions of events, a modified stick-slip earthquake source model was used – intermittent sliding of two plates relative to each other along a fault in the presence of friction and filling fragments between the fault surfaces and the principle of maximum entropy Tsallis [2]. In this model, fragments filling the space between fault planes can play the role of bearings and also impede the relative movement of the planes. In this model, stress accumulates until the filling fragments are displaced or destroyed, and energy is released. Based on this, the displacement of tectonic blocks and the energy released are proportional to the size of the fragments between the faults. In [3], an analytical expression was obtained that describes the energy distribution of earthquakes over the entire range of magnitudes, in contrast to the empirical Gutenberg–Richter formula, which is demanding in choosing the boundaries of the linear section of the recurrence graph. In addition, it is possible to approximate the frequency distributions of time and distances between successive events with a q-exponent and find the value of the Tsallis parameter q.

It is shown that the flow of earthquakes is a system with memory and long-range spatial correlations, and the obtained values of the Tsallis parameter $q \sim 1.5$ practically coincide with the values calculated for the magnitudes of the catalogs of various seismically active regions[4]. At the same time, series of industrial explosions occurring in the same regions are not processes with memory and long-range correlations, since they have reduced values of the Tsallis parameter q. Such areas where blasting operations are carried out are characterized by a low value of the Tsallis parameter q. This may mean that there is no mutual correlation between these events.

References

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