**The secrets behind the occurrence of extreme events are unlocked using information theory beyond Shannon.**

Extreme events affect nature, industry, agriculture and the human society in general. Uncomfortable heat waves threatening human lives, spring frosts destroying crops in orchards and vineyards, or other extremes ranging from epileptic seizures to financial market crashes, all these phenomena scientists strive to understand. They describe the mechanisms behind extreme events and propose methods of early warning of their arrival.

The determination of causal relationships, i.e., the distinction between cause and effect, is also an intensively developing branch of science. Mathematicians, physicists, computer scientists and specialists in other fields are designing computational methods and developing computer algorithms that extract knowledge about causal relationships from experimental data. In this way, scientists determine which of the observed variables represents the cause of the phenomena and processes under study.

Despite the increased interest in these scientific areas, surprisingly few research teams combine the study of causality and extreme phenomena. There are papers investigating whether extremes in one variable cause extremes in another variable. Researchers at the Institute of Computer Science of the CAS have asked a more general question: Which of two or more potential cause variables causes extremes in the effect variable, regardless of whether the causal variable itself contains the extremes. The answer is provided by a mathematical and computational method that the team led by Dr. Milan Paluš presented in the prestigious journal Science Advances. This computational method uses the concept of Rényi entropy, which overcomes the standard Shannon information theory. The developed algorithms are tested in a series of numerical simulations of extreme events, and climate data are used as a real-world example. The causes of cold extremes in the winter and spring months in Europe are analysed, for example, the cause of spring frosts threatening the crops of French winegrowers and others is revealed.

This research was supported by the Academy of Sciences of the CAS, Praemium Academiae awarded to RNDr. Milan Paluš, DrSc.

M. Paluš, M. Chvosteková, P. Manshour: Causes of extreme events revealed by Rényi information transfer. Science Advances 2024. [<https://www.science.org/doi/10.1126/sciadv.adn1721>](https://www.science.org/doi/10.1126/sciadv.adn1721)