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A variable resolution transitions perspective on time series: applications regarding pattern change in surface air temperature records

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The proposed approach to the detection and characterization of pattern change considers time series as a representation of successive states of the studied system.

Analyzed data often offer just snapshots of systems that evolve over time, with temporal resolutions or sampling rates that do not exhaustively reflect system behaviour. On the other hand, the resolution of the measured quantities is often dependent on criteria that are not entirely dependent on the studied system alone, while different choices would be capable of illuminating various aspects of system dynamics. For these reasons, the operations performed on what we call "system states" are approached here with a spectrum of different resolutions both in time and in terms of the measured quantity.

Given a certain time series, every passage of the system from one (multi-resolution) state to another is recorded, and transition frequencies are established. A matrix based on all transitions among accessible states is created. The resulting transition matrix is represented graphically and characterized numerically. A "distinct transitions index" (di) and a "transition symmetry index" (si) are calculated for each matrix. The distinct transitions index is given by the ratio between the number of distinct transitions and the total number of transitions recorded in the matrix. The symmetry index is calculated as the normalized sum of the absolute values of differences between symmetric elements in the matrix. The calculated indices reflect thus system variability from different points of view. On the other hand, system fluctuations are also characterized with the help of Haar wavelet analysis of the actual time series.

This approach is applied to daily surface air temperature records from different Canadian meteorological stations, including stations in the Arctic. Data records are divided in windows of different size, from 3 to 10 years in length. Diagrams are created that reflect the ways in which temperature patterns change over time, in terms of variable resolution transitions and fluctuations analysis. The provided examples show that the method can capture aspects of pattern change that are otherwise difficult to identify.