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Classification of time series of temperature variations from climatically homogeneous regions using Hurst Space Analysis

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We used the Hurst Space Analysis (HSA), a technique that we recently developed to cluster or differentiate records from an arbitrary complex system based on the presence and influence of cycles in their statistical functions, to classify climatic data from climatically homogeneous regions according to their long-term persistent (LTP) character. For our analysis we selected four types of HadCRUT4 cells of temperature records over regions homogeneous in both climate and topography, which are sufficiently populated with ground observational stations. These cells bound: Pannonian and West Siberian plains, Rocky Mountains and Himalayas mountainous regions, Arctic and sub-Arctic climates of Island and Alaska, and Gobi and Sahara deserts.

It was shown for LTP records across different complex systems that their statistical functions are rarely, as in theory, and due to their power-law dynamics, ideal linear functions on log-log graphs of time scale dependence. Instead, they frequently exhibit existence of transient crossovers in behavior, signs of trends that arise as effects of periodic or aperiodic cycles. HSA was developed so to use methods of scaling analysis – the time dependent Detrended Moving Average (tdDMA) algorithm and Wavelet Transform spectral analysis (WTS) – to analyse these cycles in data. In HSA we defined a space of p -vectors h^{ts} (that we dubbed the Hurst space) that represent record ts in any dataset, which are populated by tdDMA scaling exponents α calculated on subsets of time scale windows of time series ts that bound cyclic peaks in their WTS. In order to be able to quantify any such time series ts with a single number, we projected their relative unit vectors $s^{ts} = (h^{ts} - m) / (\sum_{i=1}^n (h_i^{ts} - m_j)^2)^{1/2}$ (with $m_j = 1/n \sum_{ts=1}^n h_i^{ts}$) onto a unit vector e of an assigned preferred direction in the Hurst space. The definition of the 'preferred' direction depends on the characteristic behavior one wants to investigate with HSA - projection of unit vectors s^{ts} of any record with a 'preferred' behavior onto the unit vector e is then always positive.

By using HSA we were able to cluster records from our selected climatically homogeneous regions according to the 'preferred' characteristic that those do not 'belong to the ocean'. We further extended HSA constructed from our dataset to group teleconnection indices that may influence their climate dynamics. In this way our results suggested that there probably exists a necessity to examine cycles in climate records as important elements of natural variability.

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