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Spatio-temporal global patterns of 70 years of daily temperature using Fisher-Shannon complexity measures

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Global climate has been the focus of an increasing number of researches over the last decades. The ratification of the Paris Agreement imposes to undertake the necessary actions to limit the increase in global average temperature below 1.5^{o}C to ensure a reduction of the risks and impacts of climate change.

Despite the importance of its spatial and temporal distribution, warming has often been investigated only in terms of global and hemispheric means. Moreover, although it is known that climate is characterised by strong nonlinearity and chaotic behaviour, most of the studies in climate science adopt statistical methods valid only for stationary or linear systems. Nevertheless, it has already been shown that warming trends are characterised by strong nonlinearities, with an acceleration in the increase of temperatures since 1980.

In this work, we investigate the complex nature of global temperature trends. We study the maximum temperature at two meters above ground using the NCEP CDAS1 daily reanalysis data, with a spatial resolution of 2.5^{o} by 2.5^{o} and covering the time period from 1 of January 1948 to 30 of November 2018. For each spatial location, we characterize the corresponding temperature time series using methods from Information Theory. Specifically, we analysed the temperature by computing the Fisher Information Measure [1] (FIM) and the Shannon Entropy Power [2] (SEP) in a temporal sliding window, which allows to follow the temporal evolution of the two parameters. We find a significant change in the spatial patterns of the dynamic behaviour of temperatures starting from the early eighties. Specifically, two different patterns are recognizable. In the period from 1948 to the early eighties the latitudes higher than 60^{o}N and lower than 60^{o}S show high levels of SEP and low levels of FIM. The situation completely revers starting from 1980s, and in a faster way for the latitudes higher than 60^{o}N, so that tropical and temperate zones are now characterized by high levels of entropy. The stronger growth of SEP is measured in the northern mid-latitudes. These regions are also known to have been characterized by higher warming trends. Finally, a drastic difference between oceans and land surfaces is detectable, with the former generally interested by significant increases of SEP since the eighties.

[1] Fisher, R. A Theory of statistical estimation. Math. Proc. Camb. Philos. Soc.22, 700–725, DOI: 10.1017/S0305004100009580 (1925).

[2] Shannon, C. E. A mathematical theory of communication. Bell Syst. Tech. J.27, 379–423, DOI:

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