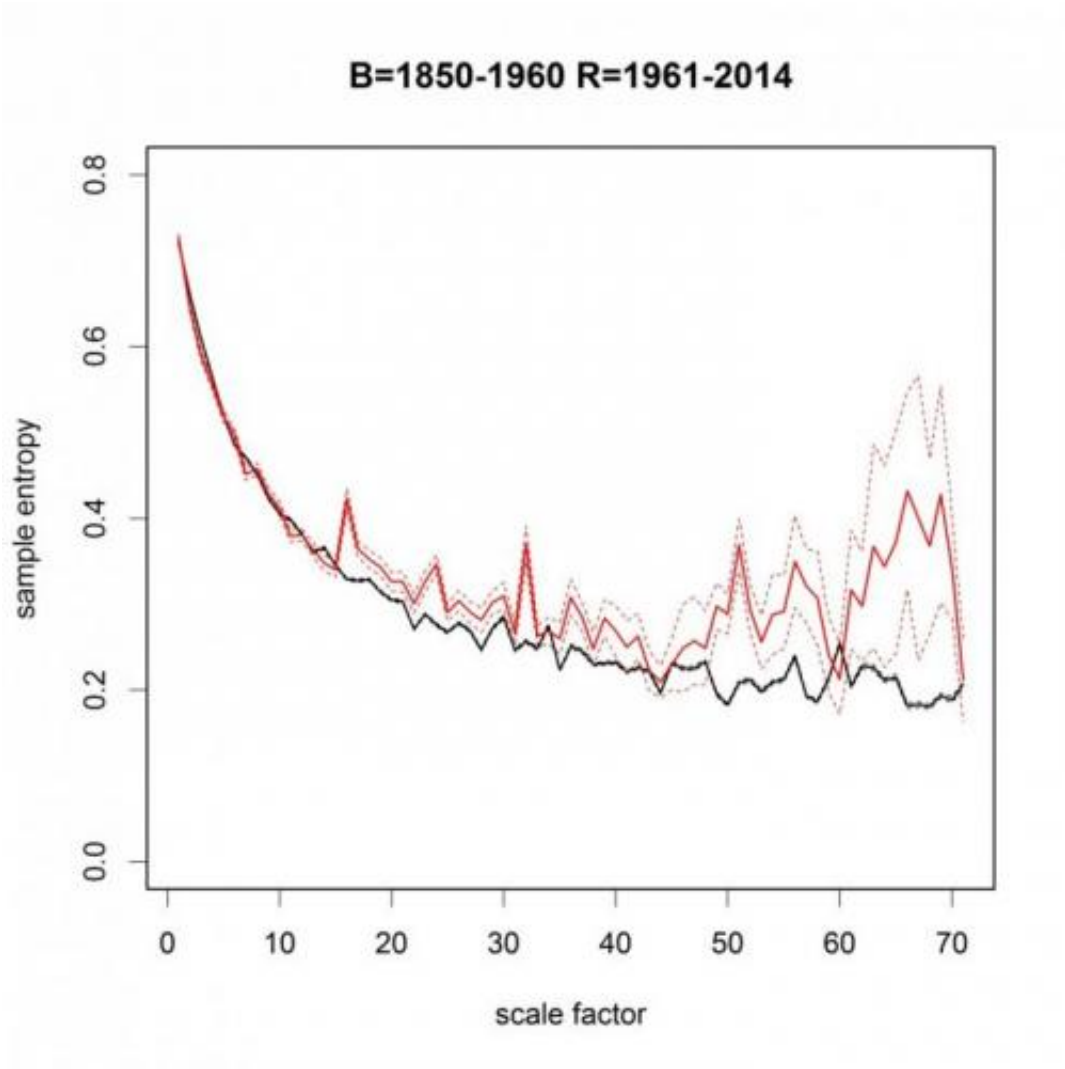
New research measures pulse of planet Earth

March 16 2015



"Multi-scale sample entropy" of the CRUTEM4v temperature anomaly data over Central Europe. Time-scales at which the data are aggregated are shown as the scale factor (in months). Black=1850 to 1960. Red=1961 to 2014. Bold lines show the mean of all grid boxes and thin lines show the upper and lower bounds of the 95 percent confidence interval.

The data show that the aggregated temperature data with scale factors greater than about 12 months have a markedly higher sample entropy in the recent past (red) than before 1960 (black). Credit: Balzter et al. (2015), *Climate*. se.

The University of East Anglia is part of an international research team to use a method, normally employed by heart surgeons, to reveal the pulse of planet Earth.

The statistical method is called 'multi-scale entropy analysis' and has not been used to study climate data before.

The results show hidden patterns of climate change which are often overlooked by other types of analysis.

Data from UEA's Climatic Research Unit was used in the project, which was led by the University of Leicester.

Prof Phil Jones, from CRU and UEA's School of Environmental Sciences, said: "This method harnesses technology typically used to diagnose heart disease. It literally takes the pulse of the planet to detect the regularity of climate change data.

"The results reveal subtle changes in Europe's climate, and we can now see the time scales in which climate has changed he most," he added.

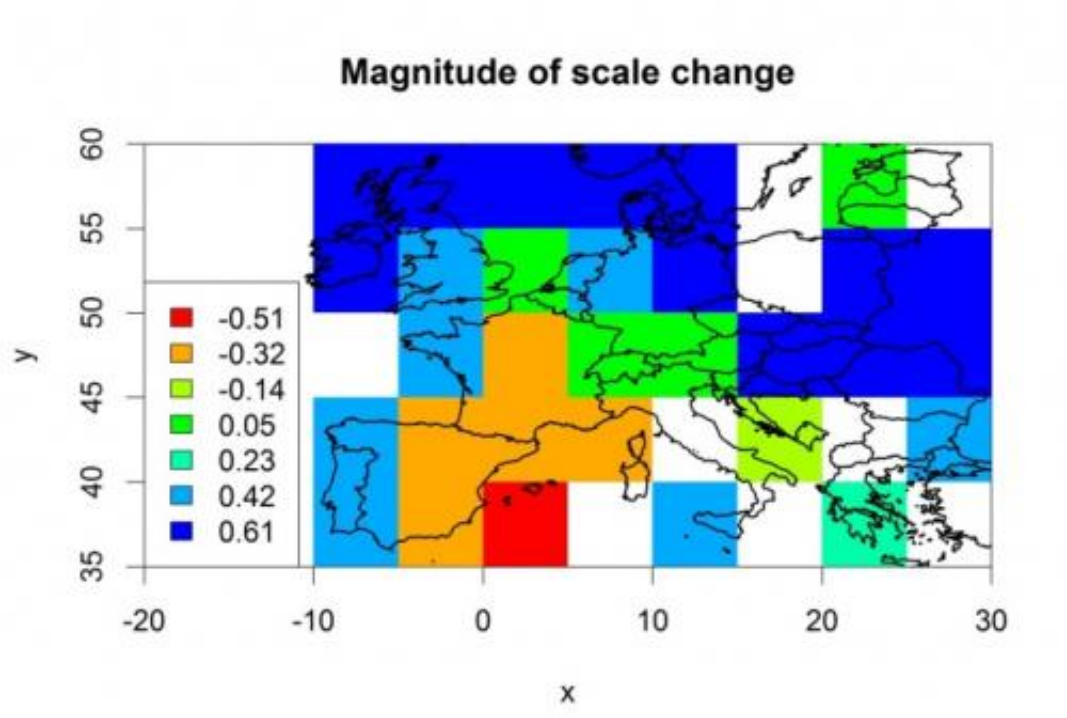
Multi-scale entropy analysis works by pattern-matching and searches data for repetitive small chunks - or pattern templates - that appear over and over again.

If many of these chunks are found, then the data has low entropy and high regularity. If few are found, the entropy is high and the system is

harder to predict.

Lead author Prof Heiko Balzter from the University of Leicester, said: "I had the idea to apply a new method to the climate data. It has been applied a lot to diagnose heart disease, because it is good at detecting regularity and randomness in time-series data."

The study shows that some scientific data analysis methods overlook subtle changes in the 'regularity' of the temperature data.



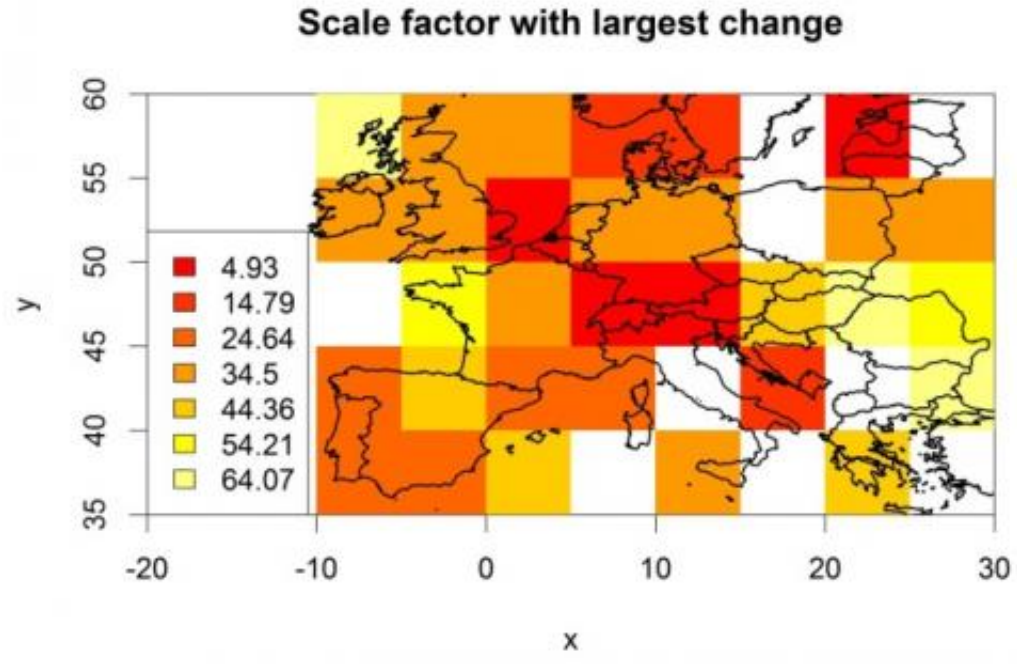
A map of Central Europe showing where the CRUTEM4v temperature data show a change in entropy. Non-significant values are set to zero. (Map 1) Colors show the largest change in entropy over all scale factors. Negative values show a decrease from 1850-1960 to 1961-2014, positive ones an increase. Credit: Balzter et al. (2015), *Climate*.

The unique way of analysing the data involves an analysis at several temporal scales. The data are aggregated to scales of months and analysed at each scale separately to find the time-scales at which the regularity of the data changes.

The researchers analysed the Central European variance-adjusted mean monthly air temperature anomalies (CRUTEM4v) produced at UEA.

The results show that the temporal scales of the current temperatures (1961-2014) are different from the long-term average (1850-1960). At temporal scales longer than 12 months the researchers found a marked loss of regularity in the data for the past 54 years.

"Interestingly, the changes we found only operated on time-scales longer than about a year. On these time-scales the climate seems to have become less predictable," added Prof Balzter.



A map of Central Europe showing where the CRUTEM4v temperature data show a change in entropy. Non-significant values are set to zero. (Map 2) Temporal scale factor with the largest difference in entropy (in units of months). Credit: Source: Balzter et al. (2015), *Climate*.

The study reveals that from 1961 to 2014, at time-scales from 12 to 70 months the air temperatures in Europe show less regularity compared to 1851-1960.

This may be a sign that the regional temperatures are now influenced by more complex forces at work – and the researchers suggest that it could be possible that climate system feedbacks express themselves in altered temporal scales of European temperatures.

The study also provides a map visualisation of the entropy results for the first time, showing the time scales which have changed most.

The study, entitled 'Multi-scale entropy analysis as a method for time-series analysis of climate data', is published in the Multidisciplinary Digital Publishing Institute journal *Climate*.

The research team included co-authors from UEA, the University of Leicester, the Centre for Ecology and Hydrology, Norwegian University of Science and Technology and King Abdulaziz University.

More information: "Multi-Scale Entropy Analysis as a Method for Time-Series Analysis of Climate Data", *Climate* 2015, 3, 227-240. DOI: 10.3390/cli3010227

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