Emergent Properties of the Climate System. Extreme rates of Temperature Changes at Weather Stations of Northern Hemisphere.

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Focusing on the emergent properties of the climate system, we introduced a measure to estimate the climate variability. The measure is calculated as the correlation coefficient of extreme rates of temperature changes. Temperature data at 927 weather stations of the Northern Hemisphere from 1956 to 2016 were used. It was found that maxima and minima of the rates of temperature changes at every station have a high degree of association with each other. The most probable time distances between these opposite extrema coincide with the duration of the matched natural cycles. The developed approach aims to monitor the climate variability, using the measure.

A study of the complex systems are efficient only by identification of their distinctive properties, which are associated with the presence of the system itself and, which cannot be reduced to properties of its subsystems and individual elements or superposition of their properties. These system properties are known as emergent and should be identified.

The variability of the holistic climate system should be defined as its emergent property. The variability is a complex notion. Due to the accumulation and dissipation of external and internal energy in the open system, both the state of consistency and the stochastic state can be realized in various rations. The consistency is decreased during energy dissipation and radiation beyond the boundary of the system. External forcing and heat storage create reverse processes.

The initial values $t_{s,y}$ are the average annual temperatures under time index $y = 1955, 1956, \ldots, 2016$ at a weather station under number $s = 1, 2, \ldots, 927$.

Series of ascending differences of average annual temperatures; one-year increment is used.

$$\Delta t_{s,y} = t_{s,y} - t_{s,y\text{-}1}, \quad y > 1955$$

Monotonic relationship between heat and temperature

$$\Delta Q \gtrless 0 \Leftrightarrow \Delta t \Delta y \gtrless 0$$

The time opposite extrema:

$$\max(\Delta t_{s,y}) > 0 \quad \text{and} \quad \min(\Delta t_{s,y}) < 0;$$

The correlative measure as the modulus of the correlation coefficient of the opposite extrema rates for years under number y

$$\mathrm{cme}_y = |\mathrm{corr}_s\{\max(\Delta t_{s,y}); \min(\Delta t_{s,y})\}|.$$

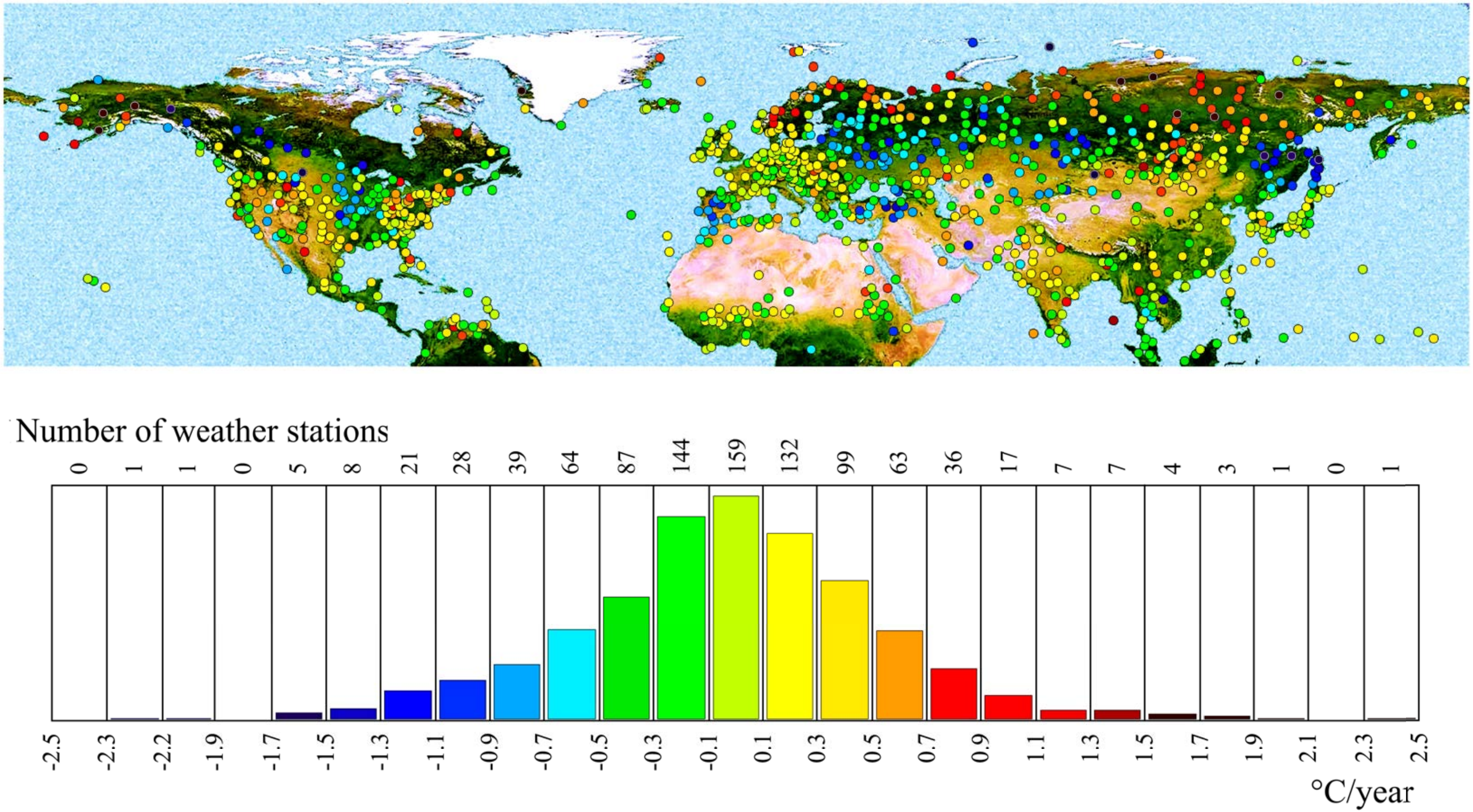
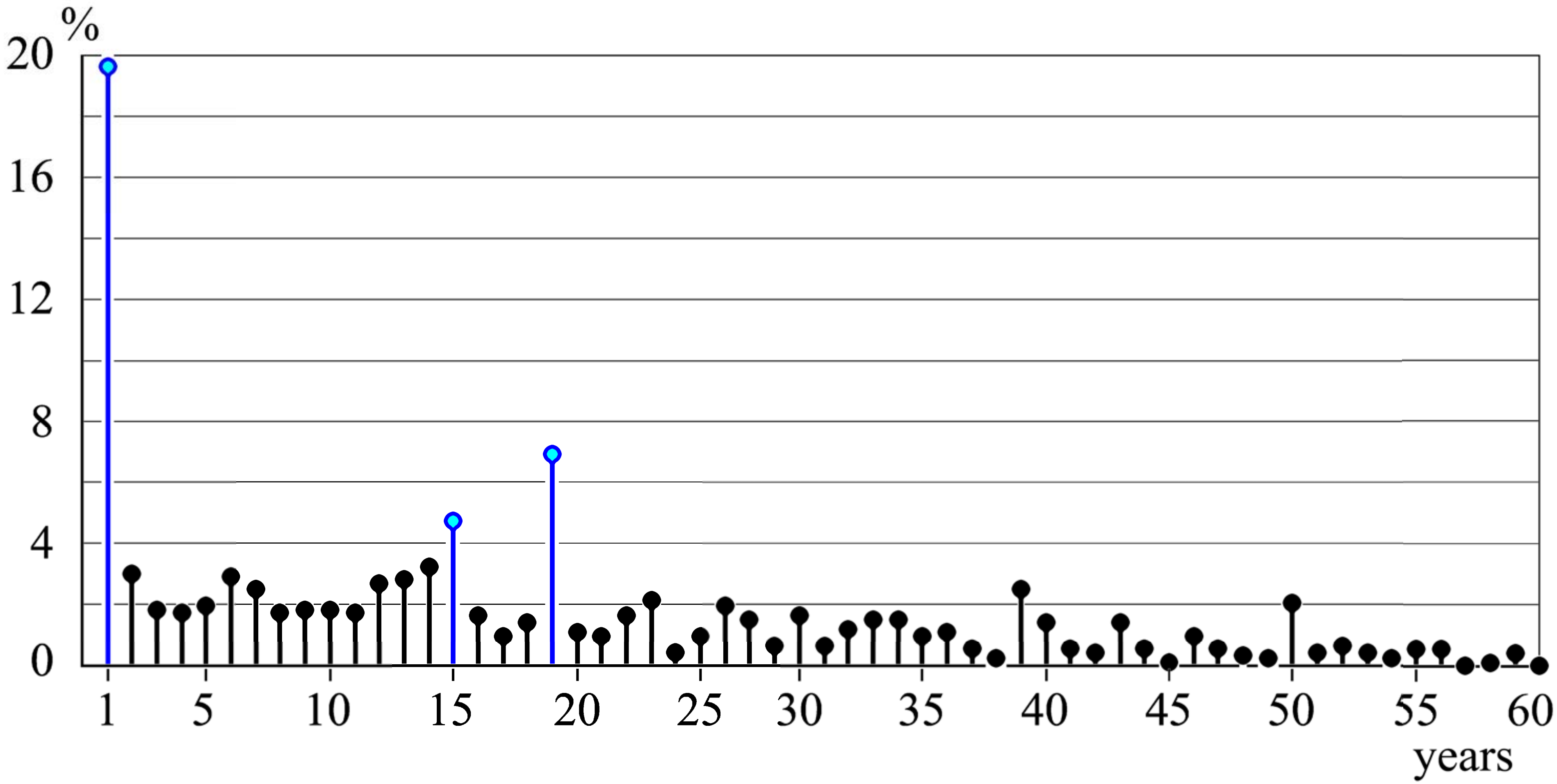
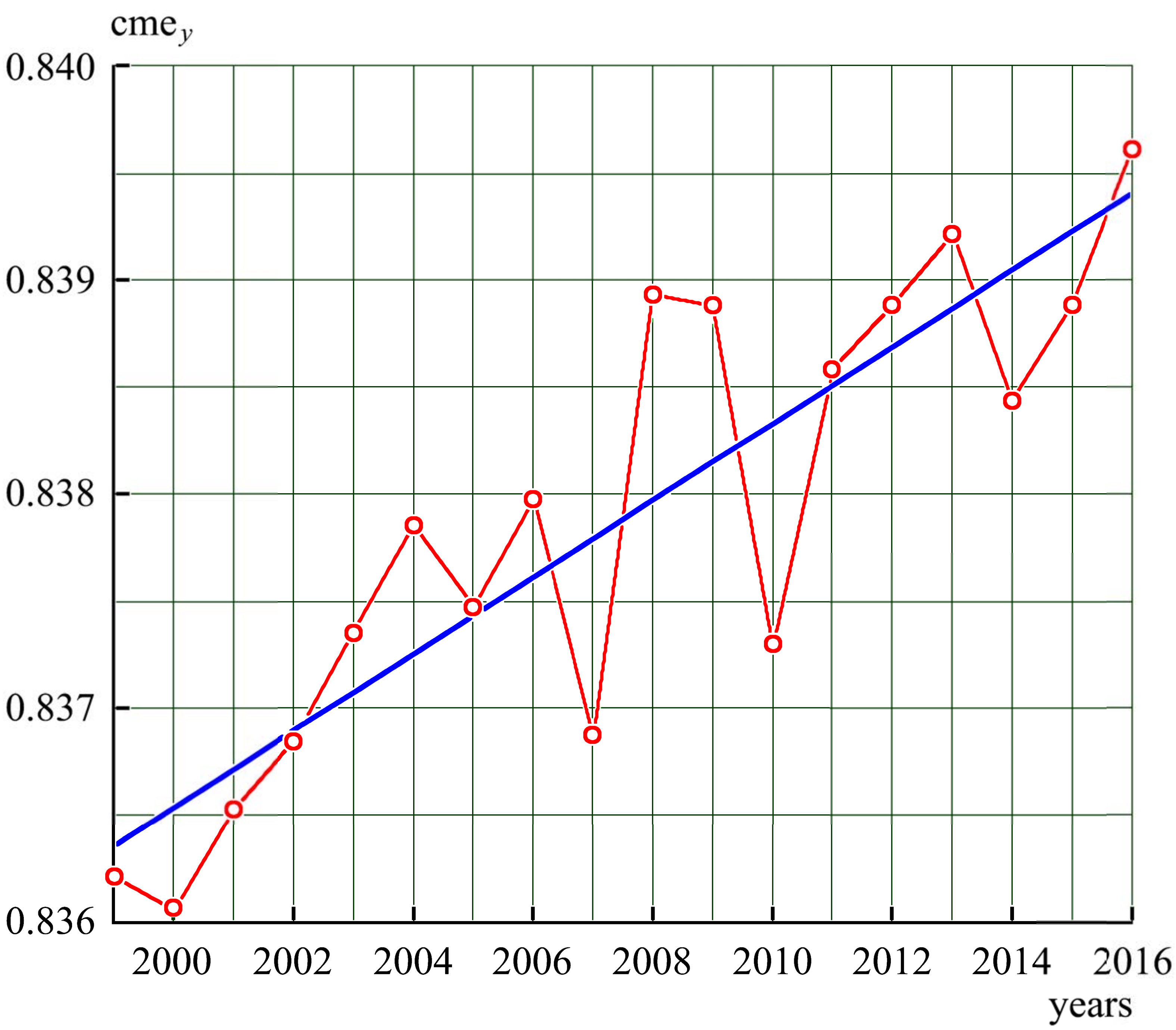


Diagram of the location of the sums of maxima and minima of temperature rates and histogram of the sums at 927 weather stations. Characteristics of the histogram: sample value = 927; mean value = –0.029°C/year; RMS = 0.564°C/year; skewness = –0.014; kurtosis =1.073. The observable interval is from 1955 to 2016.



Distribution of time distances between maxima and minima of temperature rates at weather stations. Blue circles indicate distances of one, 15, and 19 years. Increment is equal to one year along the abscissa axis. The calculated mean distance is equal to 17.531 years.



#1 Sample value

18

#2 Level of significance

0.01

#3 Student's bilateral criterion

2.92

#4 Determination coefficient

0.76

#5 Slope coefficient of the regression line

$1.79 \cdot 10^{-4}$

#6 Standard error of the slope coefficient

$0.25 \cdot 10^{-4}$

#7 Confirmation of significance of the slope - #3 < #5 / #6

2.92<7.16

#8 Exceeding the last value of the regression line over the first one

0.36%

The introduced correlation measure takes into account information about rates of temperature changes. The estimates of the measure demonstrate a statistically significant slow increasing consistency in the climatic system during the period under study in the Northern Hemisphere.

Cyclical movements are an intrinsic property of external forcing. Therefore, the established unique features will be repeated
if the state of "flow equilibrium" will be maintained.