Emergent Properties of the Climate System. Positive and Negative Rates of Temperature Changes at Weather Stations of Northern Hemisphere.

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Temperature data at 927 weather stations of the Northern Hemisphere from 1956 to 2016 was studied, 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 the mean-positive and mean-negative temperature rates, which are monotone connected to influent and effluent components of energy at a specific weather station.

It was found that mean-positive and mean-negative rates at every station are balanced and have a high degree of association with each other. A hypothesis about the essence of the geospheric balancing was put forward, and estimates for it were obtained. Changes of the introduced measure was calculated in the period from 1999 to 2016.

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:

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

Monotonic relationship between heat and temperature

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

The positive and negative rates:

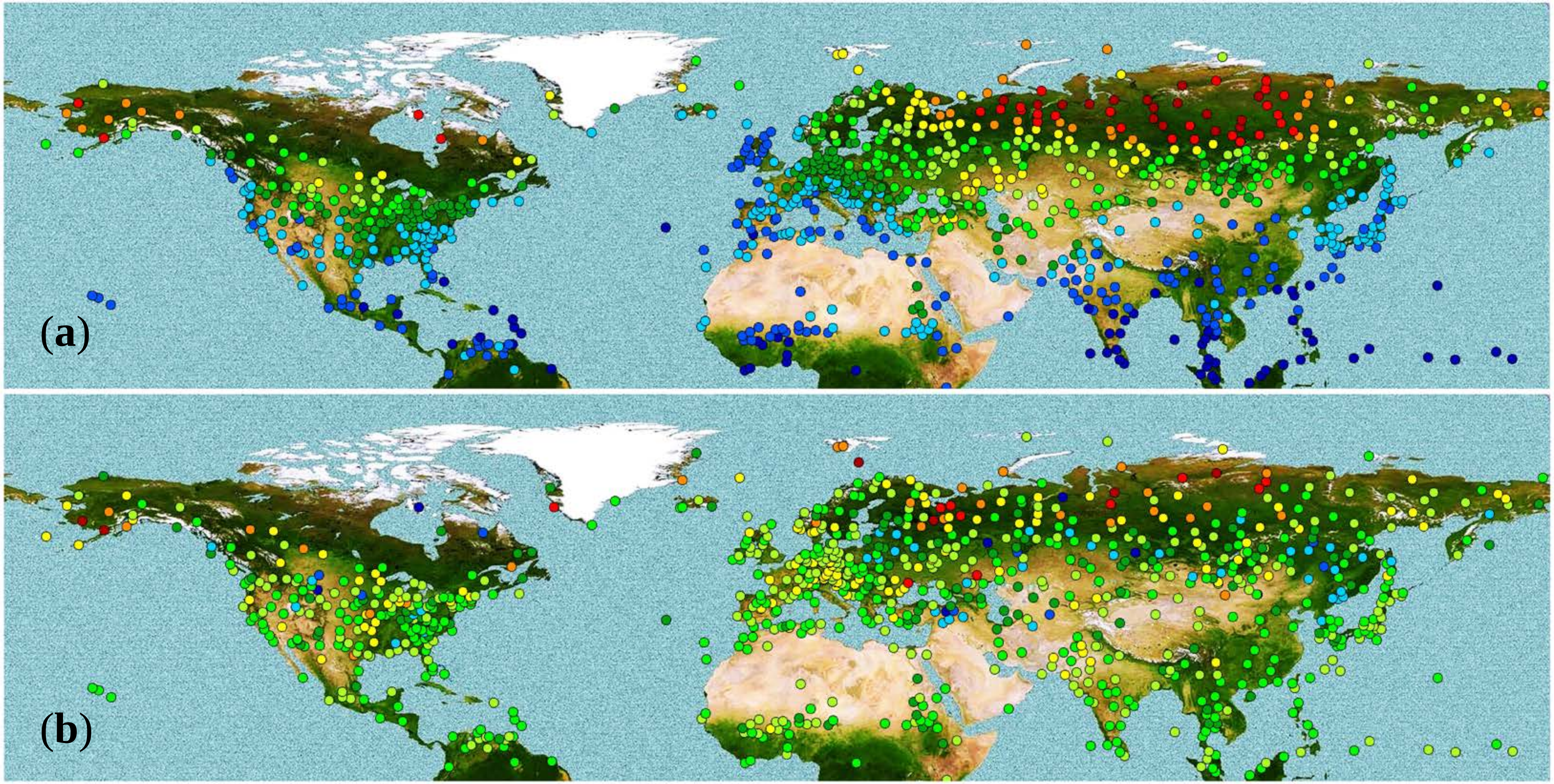
$$\Delta t^{+}_{s,y} = \Delta t_{s,y}, \text{ if } \Delta t_{s,y} > 0, \text{ else } 0 , \qquad \Delta t^{-}_{s,y} = \Delta t_{s,y}, \text{ if } \Delta t_{s,y} < 0, \text{ else } 0 .$$

The averaging values:

$$\langle \Delta t^{+}_{s,y} \pm \Delta t^{-}_{s,y} \rangle_y , \quad y = 1955, 1956, \ldots, 2016 .$$

The correlative measure as the modulus of the correlation coefficient of mean-positive rates and mean-negative rates for years under number *y*:

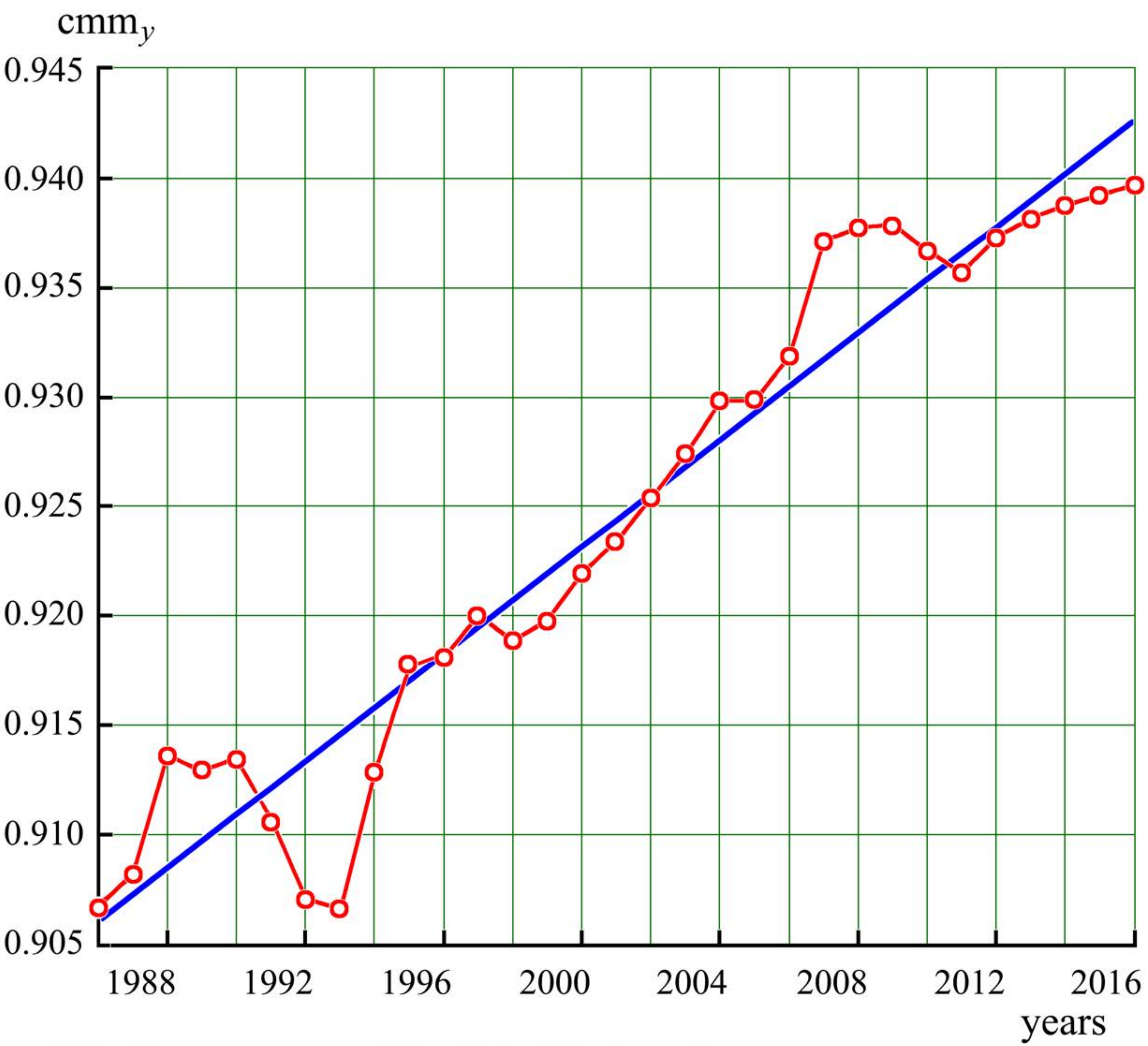
$$\mathrm{cmm}_y = \left| \mathrm{corr}_s \left\{ \langle \Delta t^{+}_{s,y} \rangle_y ; \langle \Delta t^{-}_{s,y} \rangle_y \right\} \right|, \quad y = 1955, 1956, \ldots, 2016 .$$



	Color scale										
(a)	$\overline{\langle \Delta t^{+} \rangle - \langle \Delta t^{-} \rangle}$	0.510	0.827	1.144	1.462	1.779	2.096	2.414	2.731	3.048	3.365
	Station numbers	65	148	202	168	122	91	58	29	28	16
(b)	$\overline{\langle \Delta t^{+} \rangle + \langle \Delta t^{-} \rangle}$	-0.405	-0.311	-0.216	-0.122	-0.027	0.067	0.161	0.256	0.350	0.445
	Station numbers	6	8	41	105	326	290	107	28	10	6

Characteristics of the distribution of sums at 927 weather stations, in comparison to the Normal distribution, from 1955 to 2016

Characteristics of distribution	Dimension	$\langle \Delta t^{+} \rangle + \langle \Delta t^{-} \rangle$	Normal
Sample value	Stations	927	
Min value	°C/year	-0.452	-∞
Max value	°C/year	0.492	+∞
Mean value	°C/year	0.016	0
RMS deviation	°C/year	0.119	σ
Skewness		0.035	0
Kurtosis		1.769	0
σ rule	%	74.87	68.26
2σ rule	%	94.71	95.44
3σ rule	%	98.17	99.73



#1 Sample value
31

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#2 Level of significance
0.01

#3 Student's bilateral criterion
2.756

#4 Determination coefficient
0.934

#5 Slope coefficient of the regression line
$1.223 \cdot 10^{-3}$

#6 Standard error of the slope coefficient
$6.026 \cdot 10^{-5}$

#7 Confirmation of significance of the slope - #3 < #5 / #6
2.756<20.297

#8 Exceeding the last value of the regression line over the first one
4.05%

The introduced correlation measure takes into account information about rates of temperature changes. The estimates of the measure demonstrate a statistically significant 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.

ИМКЭС СО РАН