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北半球的气候变化行星收费前方区域的动力学与动力学

CLIMATIC CHANGES IN THE NORTHERN HEMISPHERE AND DYNAMIC OF PLANETARY TOLL FRONTAL ZONE

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抽象。 本文探讨了地球气候系统自然气候时期背景下行星高海拔带（PTFZ）的动态变化。 结果表明，从较为寒冷的气候（稳定）到较暖的（第二波全球变暖）区域PTFZ的转变增加，这与其季节性变化相反。 建议观测动力学平方PTFZ防止地球气候系统中的不可逆过程。

关键词：全球大气环流，气候变化，地球气候系统

Abstract. *This article examines the dynamics of planetary tall frontal zone (PTFZ) on the background of natural climatic periods of the state of earth's climate system. It is shown that the transition from the colder climate of the period (stabilization) to warmer (the second wave of global warming) area PTFZ increases, which is opposite to its seasonal changes. It is suggested that the observed dynamics square PTFZ prevents irreversible processes in the earth's climate system.*

Key words*: global circulation of the atmosphere, climate change, the earth's climate system*

1. Introduction.

Global climate tendencies on the planet have affected almost all parts of the Earth's climate system (ECS). The changes affected even the ice-sphere – the most conservative element, which has the longest relaxation time comparing to all the other components there. Changes are absolutely identified with the average global and average hemispheric surface air temperature. Graphs of surface temperature are regularly submitted to the IPCC [5]. According to the reference [5, 15] and the authors [10-13], the global surface temperature at least over the past 120 years, highlighted climatic periods. These are the first and the second waves of global warming. Between these periods there is a short period of stabilization. Relatively low temperature before global warming is called little ice age in Europe. Some researchers have noted changes in circulation conditions during different natural climatic periods of the ECS condition [7, 10, 13].

2. Materials and methods.

The most striking indicator is of modern climate tendencies are changes in air temperatures. According to the data of (http://www.cru.uea.ac.uk/cru/data/temperature/#datdow), the authors of the web-site made a chart of temporary motion of anomalies of average annual air temperature of Northern hemisphere (Figure). In this graph the time intervals clearly stand out, where average near-surface temperature has the same variability tendency:

1) Little ice age in Europe, shown in the graph by interval since the middle of the XIXth century until the end of 1900s.

2) The first wave of global warming was observed since the middle of 1840s until the middle of 1905 until 1940s.

3) The period of stabilization (relative cold snap) that came out in the 1950s-1960s.

4) The second wave of global warming started at the middle of 1970s and continued until the present moment with an essential slowdown.

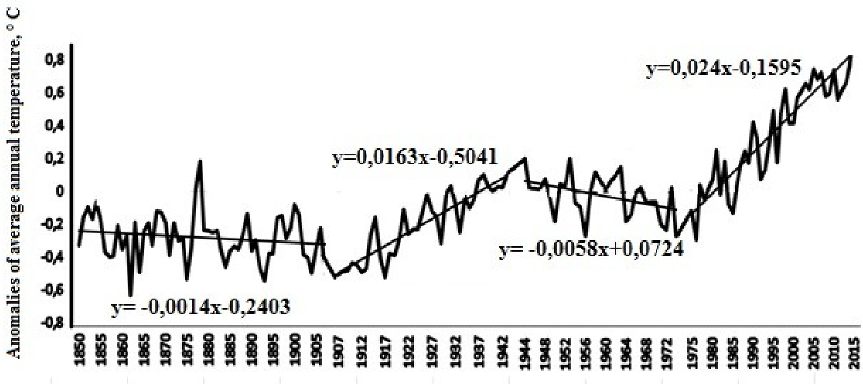

Figure. *Variability of the average hemispheric air temperature*

Variability of the average hemispheric air temperature in each of the four aforementioned intervals you can see the trend lines. As the graph shows, the lines have different incline that value of linear coefficients α. They differ not only in value but in sign as well. To define if the noticed change is climatically significant, we checked those with the synoptic one. We used the confidence interval methods with applying to Student`s statistics and 95% level of significance by the formula [1]:

$$\bar{x} \pm t\gamma \frac{s}{\sqrt{n}}, \tag{1}$$

in which $\bar{x}$ - average value; $t\gamma$ - Student's statistics, γ - Significance level indicator (95 %);.
s - mean square; n - Number of members of the series.

3. Results and discussion

Using the formula above we calculated the boarders of confidence intervals, which are represented in table 1. Except for this, in the table shows several statistical characteristics for each of the time period.

Table 1. *The statistical significance estimation of anomalies change of the average annual North hemisphere`s temperature*

Periods, years	Statistical characteristics of the significance of changes			Confidence Intervals
	a	$\bar{x}$	s	
1) Small glacial age (1850-1907)	-0,0014	-0.28	0.147	[-0,508; -0, 315]
2) First wave (1908 – 1943)	0,0163	-0.19	0.194	[-0,240; -0,130]
3) Stabilization (1944 – 1974)	-0,0058	-0.02	0.124	[-0,078; 0,038]
4) Second wave (1975 – 2016)	0,0240	0.357	0.320	[0,273; 0,439]

According to the average quadratic deviation (σ), characterizing the range of random value concerning its average value, we can see that the greatest variability is typical for the second wave of global warming. It is noteworthy that during the little ice age and period of stabilization, the temperature range was less than in relative warm ones. Maximum variability of the temperature regime in the second wave of global warming compared to all other periods shows the increase in climatic instability. Selected natural climatic periods are distinguished in all seasons of the year [10 -13].

Consider how PTFD changes during these climatic periods. PTFZ is the zone of greatest thermal contrasts and maximum wind speeds [1, 6, 16]. The planetary toll frontal zone has many characteristics - intensity, tortuosity, position axial isohypsum and others. For the study, we select the area of PTFZ. The area of PTFZ is understood as the area of the circumpolar space, which limits the axial isogypsum.

It is known that PTFZ is characterized by a quasi-constant area bounded by axial isogypsum for the respective months and seasons of the year [1, 6]. If the axial isogypsum in the hemispheric scales shifts to the south, the area limited by it will increase. Consequently, the range of negative temperature anomalies will expand. With a decrease in the PTFZ area, the regions of the above zero temperature anomalies move northward. Such migrations can affect global temperatures.

The data on the long-term averages of the area of the PTFZ are published in [14]. Average long-term values of the PTFZ area in the period of stabilization (1949 – 1974 years) and the second wave of global warming (1975 – 2010 years) are calculated. The average many years area of the PTFZ is 57,01 million km2. Over the years, its values have changed greatly. The smallest area was in 1951 year – 50,045 million km2. The largest area was in 1978 year – 62,378 million km2. The variability of the average annual areas σ is 2,83, and a dispersion (σ2) is 8,01. For each of the selected periods (stabilization and the second wave of global warming), the average areas, standard deviations σ and variation coefficients cv are calculated (tabl. 2).

Table 2. *Dynamics of the area of the planetary toll frontal zone*

Periods, years	**PTFZ area value (million km^2)**	**σ**	**c_v**
1) 1949-1974 (Stabilization)	56,97	3,65	0,06
2) 1975-2010 (Second wave)	57,77	1,68	0,03

The strongest variability of the areas of PTFZ (tabl. 2) manifested itself during the period of stabilization (1949 – 1974 years). This conclusion confirms the position of the theory of climate: in warm epochs, the character of circulation is quieter than in cold epochs [2]. According to our data, the Fisher`s statistic is equal to 4,72. The critical value of the Fisher`s statistic for our numbers of degrees of freedom and significance level $\alpha = 0{,}05$ is 1,98. Thus, the hypothesis about the equality of the variances of the areas of PTFZ in these periods is rejected, and the difference in variability can be considered statistically significant.

Pay attention:

1). From the first period to the second (from the stabilization period to the warming period) there was an increase in the PTFZ area by 1.5%;

2). The growth of the average area occurs during the transition from a colder period to a warmer period;

3). An increase in the average area of the PTFZ implies the promotion of the PTFZ to more southerly latitudes and the expansion of the zone of the below zero temperature anomalies;

4). Detected offset is opposite to seasonal. From winter to summer, PTFZ shifts to the north and the area of PVFZ decreases.

Thus, the revealed climatic shift of the PTFS is interesting and opposite to its seasonal shift.

Let us estimate the statistical significance of changes in the area, for which in each period we calculate 95% confidence intervals for mathematical expectations using Student's statistic. The boundaries of the confidence intervals (formula 1) are given in table 3.

Table 3. *Assessment of the statistical significance of the change in the area of the PTFZ*

Periods, years	Confidence Intervals (million km^2)
1) 1949-1974 (Stabilization)	[49,61 – 62,32]
2) 1975-2010 (Second wave)	[54,99 – 60,53]

Since the confidence intervals overlap, we do not reject the hypothesis about the equality of the mathematical expectations of the areas at the significance level $\alpha = 0{,}05$. Thus, the change in space by one and a half percent is statistically insignificant and cannot significantly affect the processes in the Earth's climate system and lead to any noticeable changes in it. However, to deny the role of atmospheric circulation and its structural elements in global climate processes and to make an unequivocal conclusion about the absence of the influence of the dynamic factor on the global climate is not worth it. The application of statistical methods to natural processes has a certain degree of conventionality [8]. Small perturbations of any component of the ECS may result in noticeable changes in it as a result of resonance.

Consider how the detected trend changes in the area of PTFZ in different months. Calculate the values of the areas of PTFZ for each month in climatic periods of the ECS (table 4).

Table 4. *The values of the PTFZ area (million km2) in different natural climatic periods*

Month	Values of the PTFZ area (million km^2)	
	Stabilization (1949-1974 years)	Second wave (1975-2010 years)
January	62,44	64,19
February	69,46	66,61
March	61,44	64,47
April	63,43	56,43
May	61,24	63,93
June	56,61	50,59
July	56,15	59,58
August	41,91	51,22
September	41,42	42,63
October	47,58	55,14
November	53,03	55,39
December	56,67	63,02

Table 5. *Assessment of the statistical significance of the change in the area of the PTFZ*

Month	Confidence Intervals (million km^2)	
	1949-1974 years (Stabilization)	1975 – 2013 years (Second wave)
January	[41,56; 83,20]	[50,52; 77,86]
February	[48,34; 90,59]	[46,77; 86,45]
March	[52,42; 70,46]	[59,87; 69,07]
April	[53,76; 73,53]	[39,78; 73,08]
May	[48,89; 73,59]	[59,06; 68,89]
June	[48,!4; 65,08]	[33,12; 68,06]
July	[49,45; 62,84]	[52,88; 66,28]
August	[37,47; 46,35]	[32,25; 70,19]
September	[38,08; 44,76]	[38,85; 46,41]
October	[43,57; 51,61]	[45,08; 65,20]
November	[46,14; 59,91]	[50,99; 59,79]
December	[46,47; 66,88]	[53,83; 72,21]

The observed growth trend in areas from the stabilization period to the second wave of global warming (tabl. 4) is found in almost all months of the year except February, April and June. In all other months, the area of the PTFZ increased. Most strongly in August, October and December (by 18 %, 14 % and 10 % respectively). In other months, the increase in area is less - by 3 % - 6 %.

It was obtained that such a global circulation object as a planetary toll frontal zone responds to changes in the Earth's climate system. The climate change of the PTFZ is opposite to the seasonal one. This is manifested in general for the year, and in most months of the year.

Calculate the confidence intervals of area change for each month (tabl. 5).

For each month, changes in areas from one natural climatic period to another are insignificant.

Let us estimate at what values of the areas of the PTFS, at the existing values of the variances, the changes will be significant. For this, the inverse task was solved. The condition of the task was the absence of overlapping intervals at the extreme possible positions of the expectation on the number line. For calculations, apply the formula for the area of the ball segment (formula 2).

$$S = 2\pi R^2 \left(1 - \sin \varphi_{c.n.}\right), \qquad (2)$$

где R – Earth's radius,

$\varphi_{c.n.}$.- the mean latitude of the axial isogypsum PTFZ for the Northern Hemisphere.

According to formula (2), we find the latitude of the axial isohypsum. According to the calculation, in order to achieve statistical significance of changes at the level of 0,05, the area of localization of the PTFZ should fall to values of 30 º - 35 º latitude. At present, the PTFZ is located in the region of the fiftieth latitudes of the northern hemisphere.

Thus, to achieve statistical significance of changes in the area, the planetary high-altitude frontal zone should shift by 15–20 degrees to the south. Accordingly, the cyclone trajectories will be shifted by the same amount.

This will lead to a change in the position of arid and humid regions. Similar changes have taken place in the past. According to climatic reconstructions, very wet conditions in the arid tropical belt were observed with the destruction of the Quaternary glaciation and the beginning of the Holocene epoch/ the trajectories of cyclones and PTFZ were located very south. This contributed to a strong wetting of these arid regions at the present time [2, 9, 17].

There is no question of such large-scale changes in the very small time period under study (60 years). Pay attention, we have the fact of ***increasing t***he area of the PTFZ against the background of ***rising*** global temperature.

4. Summary

The presented materials allow to draw the following conclusions:

1). The global circulation object, the planetary toll frontal zone, responds to changes in the Earth's climate system. With an increase in the near-surface temperature, its area increases: causing the region of negative temperature anomalies to move to the south.

2). The reaction of the planetary toll frontal zone to changes in the Earth's climate system was discovered: the climate dynamic that is opposite to the seasonal dynamic.

3) The peculiarity of the PTFZ dynamics is one of the natural factors that inhibit the growth of temperatures and prevent the bifurcation point (non-return) from interfering with the Earth's climate system.

4). The dynamics of PTFZ in natural climatic periods of the ECS condition contributes to the preservation of the fragile ecological and climatic equilibrium.

5). The peculiarity of the dynamics of the planetary toll frontal zone indicates one of the approaches to the dynamic explanation of the change in the temperature field. Studying the dynamics of PTFZ is a way of explaining changes in the temperature field and a method of forecasting global temperature field.

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