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Climate Characteristics of Heating Period for Volga Federal District.

Nadezhda Aleksandrovna Vazhnova*.

Kazan Federal University, Kremliovskayastr, 18, 420008, Kazan, Russian Federation

ABSTRACT

In this article, we consider results of performed research, dedicated to assessment of changes in parameters of heating period (HP) of Volga Federal District (VFD). For the first time for territory of VFD we created maps for space distribution of the main characteristics of heating period; we investigated peculiarities of multiannual dynamics of characteristics of heating period that had been previously unknown, and we assessed their multiannual tendencies; for the first time for VFD we tested tightness and directionalities of interconnections between various characteristics of heating period and estimated perspectives of the application for prognostic aims. It was stated that climate indices of heating period was characterized by high level of variability in both time and territory of the district. Temporary instability of climatic indices of heating period within the territory of the district increase at a high pace from its southern parts in the direction of North and North-East, where it reaches its maximal values, which is non-stochastic. We detected the presence of rather tight and significant connections between the dates of autumn switches of mean daily air temperature (MDAT) through 8˚C and the length, which opens possibility of building one-factor regressive prognostic models with significant resolving capacity at coefficient of their determination of $[R^2{}_{(О,П)}] = 38 \div 52\%$.

Keywords: heating period, air temperature, dates of beginning and end of heating period, length.

Corresponding author

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INTRODUCTION

Topical problem of applied climatology is a calculation of specialized climatic parameters for both creation of comfortable conditions inside premises, and for energy conservation. These include: average sum of degree-days of heating period, average duration of heating period, average air temperature during heating period etc. (in cold period); duration of cooling period (condensation), average sum of degree-days of cooling period etc. in heat surplus period [1].

During the latest decades, we may observe significant diminution of climate's continentality in Volga Federal District, mainly, as a consequence of increased winter temperatures. Consideration of dynamics of climatic characteristics (CC) of heatingperiod is of practical interest.

Climate Doctrine of the Russian Federation (adopted in 2009) emphasizes the need in adaptation of regions to changing climatic conditions for the aims of their stable development [2]. Some climatic changes have positive consequences, in particular, within the latest decades at the territory of the Russian Federation, we may observer reduction of heating period (HP) and increase in average temperature for this period [3].

Climatic characteristics of heating period are widely used in industrial activities and housing and public services for development of standards for fuel consumption and stock in this or that geographic region; establishment of operational environment for various energy services; justification of strategy of functioning and development of all fuel and energy sector. A number of papers are dedicated to the problem of effective usage of CC in heating period.

A term "heating period" is usually used to denote cold period of the year, when average daily temperature of ambient air is stably lower that +8°C. For maintenance of normal temperature inside domestic premises and industrial areas, theyshould be heated during this period [5].

Traditionally [5-7], the date of stable switch of average daily temperature through 8°C in autumn is accepted as a start, and in spring – as the end of heating period, while the interval between them is considered to be its length.

MATERIAL AND METHODS OF RESEARCHES

As an informative base of the research, we used archive of Federal state budgetary institution All-Russian Research Institute of Hydro-meteorological Information (1966 – 2010) of annual data with the dates of stable switches of MDAT through 8°C in autumn and spring for 215 stations in VFD.

Mentioned informative base left roomfor consideration of wide range of questions that refer to climatography of HP. Eventually, the following indices of HP were subject to consideration:

- Dates of beginning and end of HP and multiannual (1966 – 2010) amplitudes;
- Duration of HP and its amplitude;
- Multiannual dynamics of dates of beginning, end and duration of HP (exemplified by stations N. Novgorod, Myza, Perm, Kirov, Saratov, Orenburg);
- Some manifestations of interconnections between chronologic indices of HP.

RESULTS AND THEIR DISCUSSION

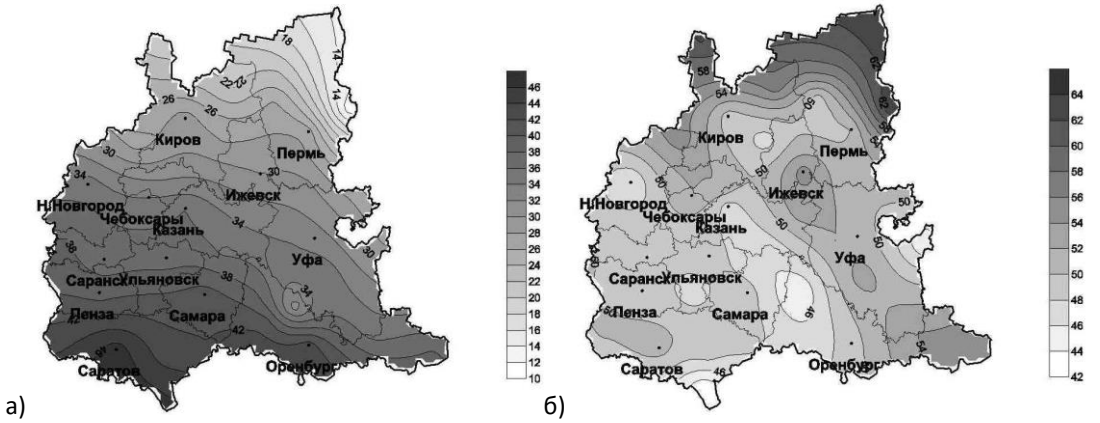
Data analysis shows that at the average heating period in most part of VFD territory starts from the 21st of September – the 17th of October, and ends in the period of the 19th of April-the 14th of May, i.e., at territory differences of about 20 days, considering extreme northern and southern stations, Average duration of HP varies within the period of 50 days – from 186 to 236 days (Lalsk station is detached), and the average temperature during HP changes from -3.4 to -7.9 ^{o}C [7].

Similar researches, earlier performed for the Republic of Tatarstan [8] and Middle Volga region [6], show that at the average, duration of HP shortens, and average air temperature in HP rises; similar situation is observed in VFD [9, 10]. Certainly, all this is of great economic importance, since expenses in heating in the RF

equal not less than 30-40% of overall costs on supplied heat energy [4]. According to climatic prognosis, completed under direction of N.V. Kobysheva in Main state hydro-meteorological observatory named after A.I. Voyekov, which refers to duration of HP for various regions of the RF for the period of 2071 – 2090 per ensemble of IPCC models, in our region there would be significant decrease of HP to 170-190 days. At the same time, we may observe significant temporal instability of HP duration.

According to "Assessment Report. Vol. 2" [11], in comparison with the norms of 1961-1990, at the most part of the territory of the RF, duration of heating period will have decreased not more by 5% by 2015, and by 5-10% by the middle of the 21st century. In connection with expected temperature rise of cold days by 2015, Assessment Report contains the conclusion about decrease of heating period's duration in Russia by 1-4 days. Expected relative changes in expenses for room heating (index of fuel consumption) have the same spatial consistent patterns, but they are characterized by twofold values. These mentioned estimations concord with results of later works [12], in which specialists predict moderate warming in winter (by 0.9 – 1.3 ºC) for the next few decades at the territory of Volga Region, which would lead to reduction of heating period for about 2-3 days.

Climatic indices of HP are characterized by high scale of variability in both time and territory of the district. For example, at Biser station (extreme north of Perm Region) average multiannual date of autumn switch of MDAT through 8°C falls on the 11th of September (Figure 1a); in 1975 this switch was observed much earlier (on the 9th of August), and in 2009 – much later – on the 12th of October. Equally variable are values of HP duration. At the abovementioned station during different years, they varied from 245 to 296 days. Data, presented at Figures 1b, 2, 3 show that temporary instability of climatic indices of HP within the territory of the districts quickly increases from its southern regions towards north and north-east, where it reaches its highest values, which is non-random - if it is remembered that extreme north and north-east of the district are closely connected with irregular region of significant space migration of Arctic front.



а) б)

Fig. (1).Average dates (a) and amplitude (b) of stable autumn switches of average daily air temperatures through 8˚C in VFD (1966 – 2010).

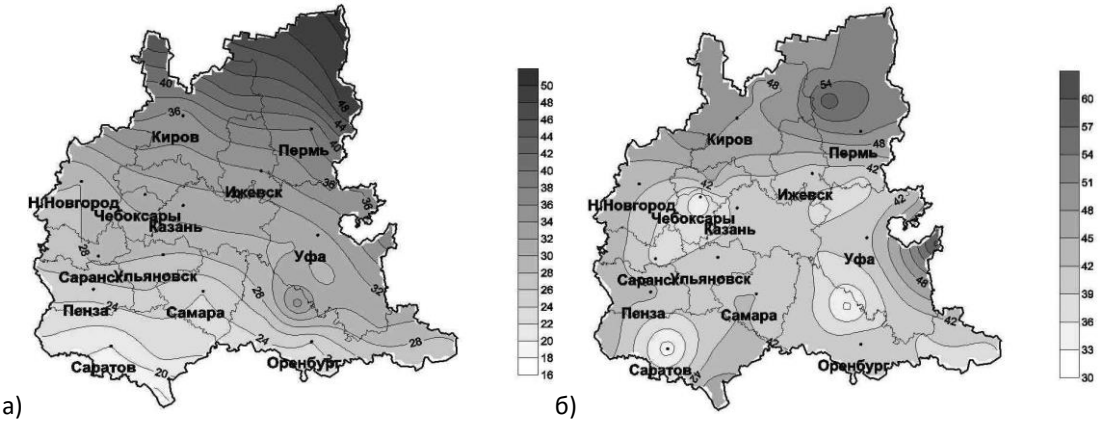


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Fig. (2).Average dates (a) and amplitude (b) of stable spring switches of average daily air temperatures through 8˚C in VFD (1966 – 2010).

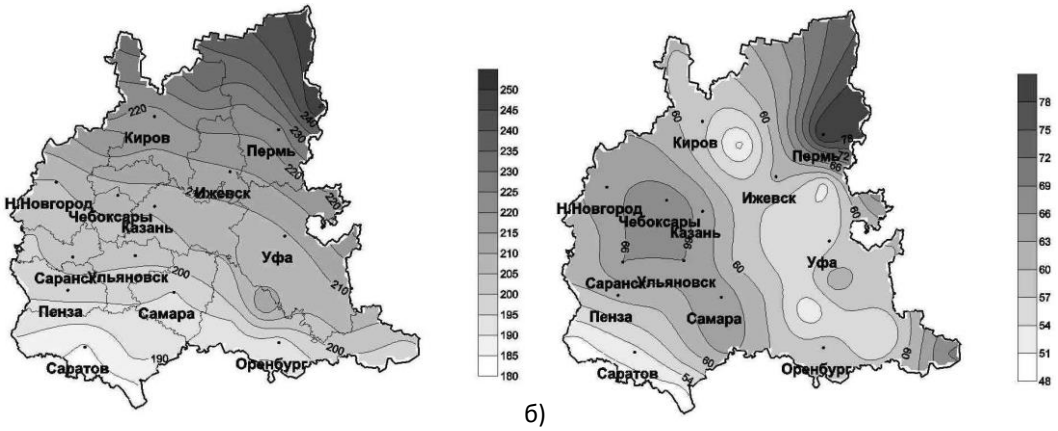

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Fig. (3).Average duration (a) and amplitude (b) of periods with stable preservation of average daily air temperatures, which are higher than 8˚C in VFD (1966 – 2010).

Significant instability of HP indices leads to:

a) very limited information value of their average indices;
b) serious difficulties for business entities at planning preparatory measures to HP, and, as a consequence,
c) acute topicality of the problem of developing methods of long-term forecasting of chronologic indicators of HP, adapted to conditions of the districts.

Autumn switch of MDAT through 8°C in VFD starts from the regions that are located in extreme north-east of Perm Region, and, going further towards south and south-west, in approximately 33 days finishes at the southern part of Saratov oblast (Novouzensk and Pereliub stations). In someyears, this process may be prolonged for up to 59 days. In spring the process of switching MDATthrough 8°C in the opposite direction and (on the average) somehow quicker – it takes 30-31 days.

It was stated that at the territory of the district within the latest 45 years (1966 – 2010) there was an all-round reduction of HP duration, which varied from -7.4 (at Saratov station) and up to -17.9 days (at Kirov station) (Table 1).

The abovementioned reduction of HP duration was accompanied with significant switches to later terms (from 18 days at Saratov station to 23 days at Perm station) of autumn dates of switches of MDAT through 8°C. It was surprising that the dates of spring switches through 8°C also shifted to later terms, however, they appeared to be: a) much lesser and b) in half of the cases they were statistically insignificant (Table 1).

Table 1: Integral estimations of switches of dates of autumn (AS) and spring switches (SS) of MDAT through 8°C, and estimations of changes in duration of AS (days) for the last 45 years (1966 – 2010) as a result of trends' linear components.

Stations	AS	SS	Duration of HP
Perm	23,4	*7,1*	*-15,7*
Kirov	21,4	*4,4*	-17,9
Saratov	18,0	11,1	*-7,4*
Orenburg	24,8	10,7	-14,5

Testing of interconnections between HP characteristics showed (Table 2):

1) Presence of very close and significantly accurate (at significance level of $\alpha < 0{,}001$) connections between

a) dates of autumn (A) switches of MDAT through 8°C and duration (D) of heating periods next to them (negative connections: r(О,П)=(-0,62):(-0,72) and

b) duration (D) of HP and dates of spring (S) switches of MDAT (positive connections: r(П,В)=0,55 – 0,62).

Table 2: Correlation coefficients between characteristics (A and S stand for the dates of switches through 8°C in autumn and spring; D stands for duration of HP)
$r_{0.05}$=0,29$r_{0.001}$=0,4

Stations	Correlation coefficients		
	r(О,П)	r(О,В)	r(П,В)
Perm	-0,761	0,059	0,603
Kirov	-0,723	0,114	0,532
N. Novgorod, Myza	-0,718	0,137	0,590
Saratov	-0,812	0,030	0,556
Orenburg	-0,696	0,226	0,543

2) Absence of statistically significant ($\alpha \gg 0{,}005$) connections between the dates of autumn (A) and spring (S) switches of MDAT through 8°C.

3) Presence of very close and significantly accurate connections between the dates of autumn switches of MDAT through 8°C.

CONCLUSIONS

1. Temporal instability of climatic indices of HP within the territory of the districts increases at a high pace from its southern regions towards north and north-east, where it reaches its extreme values, which is a non-random phenomenon, if we remember that extreme north and north-east of the district are closely connected with irregular region of significant space migration of Arctic front.
2. Autumn switch of MDAT through 8°C in PFD starts from the regions that are located in extreme north-east of Perm Region, and, going further towards south and south-west, in approximately 33 days finishes at the southern part of Saratov oblast (Novouzensk and Pereliub stations). In particular years this process may be prolonged for up to 59 days. In spring the process of switching MDAT through 8°C in the opposite direction and (on the average) somehow quicker – it takes 30-31 days.

SUMMARY

It was stated that at the territory of the district within the last 45 years (1966 – 2010) there had been observed an all-round reduction of HP duration, which varied from -7.4 (at Saratov station) and up to -17.9 days (at Kirov station). Abovementioned reduction of HP duration was accompanied with significant switches to later terms (from 18 days at Saratov station to 23 days at Perm station) of autumn dates of switches of MDAT through 8°C. It was surprising that the dates of spring switches through 8°C also shifted to later terms, however, they appeared to be: a) much lesser and b) in half of the cases they were statistically insignificant.

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