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PRESENT CLIMATE CHANGE IN BELARUS

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A b s t r a c t. The analysis of long-period changes of temperature and precipitation in Belarus (1881-2000) has shown a rise in temperature in a cold season (I-IV) for the last thirty five years and a decrease in the quantity of precipitation in post-war period in the warm season. (IV-X). The frequency of droughts has increased in July-August. In recent decades the frequency of light frosts in the boreal and southern part of Belarus has become commensurable. The causes of the increase of frequency of light frosts and droughts are considered.

K e y w o r d s: droughts and light frosts, climatic changes

INTRODUCTION

The analysis of instrumental data observations of hydro-meteorological stations in Belarus has revealed changes of temperature and precipitation varying in period and scale [3,5]. In the large scales there are local and regional changes of climate under the influence of natural and anthropogenic factors.

The question of definition of anthropogenic "signal" in the change of modern climate is a key one in modern climatology [3]. It is known, that change of properties of a spreading surface as a result of amelioration, urbanization, agricultural activity and other factors result in change, at least, of micro- and mezoclimate. The influence of changes of the contents of greenhouse gases in the atmosphere, as the simulation results show, will result in a rise of temperature in the latitudinal belt of Belarus by 1.5-2.0°C to the middle of current century.

This rise should be especially noticed in a cold season in high latitudes. The changes of amount of precipitation are less determined, but their rise is also predicted by existing models, at least, in average and high latitudes. The spatial-temporal regularities of temperature change and precipitation in the republic of

Belarus, received on the basis observation data analysis, will mainly be concorded with results of mathematical simulation. The most complex subject of the research are extreme climatic phenomena (drought, light frosts, inundation). The analysis has shown a change of frequency of the extreme climatic phenomena in connection with a change of properties of a spreading surface [2].

RESULTS AND DISCUSSION

Long-period changes of temperature and precipitation

Research of changes of the Belarus climate for the period 1881 to 2000 has shown a distinct rise of temperature in the last 2-3 decades in an overwhelming number of months of the year and the year as a whole (Fig. 1). Of great interest is an analysis of temperature and precipitation for largest warmings for the last century, i.e., change of temperature in various areas of the Republic of Belarus for the last years (1964-2000) and previous warmings (known as Arctic Region warming), which started in the beginning of the 20^{th} century and lasted till the end the 30's (1910-1939) [4].

The current warming has appeared to be more powerful, than previous; separate months of a cold season the temperature within 30 years has increased by several degrees. Especially powerful was warming in January. For the last 13 years (1988-2000) only one winter was cold. In the same term in a warm season the temperature in the majority of months of a year has not changed essentially. The greatest change of temperature is registered in a cold season in the north of Republic.

The change of precipitation on the territory of the Republic of Belarus differs by large diversity not only in space, but also in time (Fig. 2). The growth of precipitation in post-war term in boreal part of the republic is marked in cold time and the first months of the warm term of the year. In southern part of the republic the intensive fall of precipitation is observed in a warm season and especially in its second part (VIII-X). A statistically meaningful reduction of mean annual precipitation in comparison with the period of maximal one (1900-1930) in the south of the republic has been revealed. The greatest reduction of precipitation in the second part of the warm season falls on active amelioration period of the Polesye (the 60-80'-s). The change of variation in the central area closely correlates with its change in Belarus southern part. Here the decrease of mean annual precipitation after the 50-s' of the 20-th century is observed. The decrease of precipitation

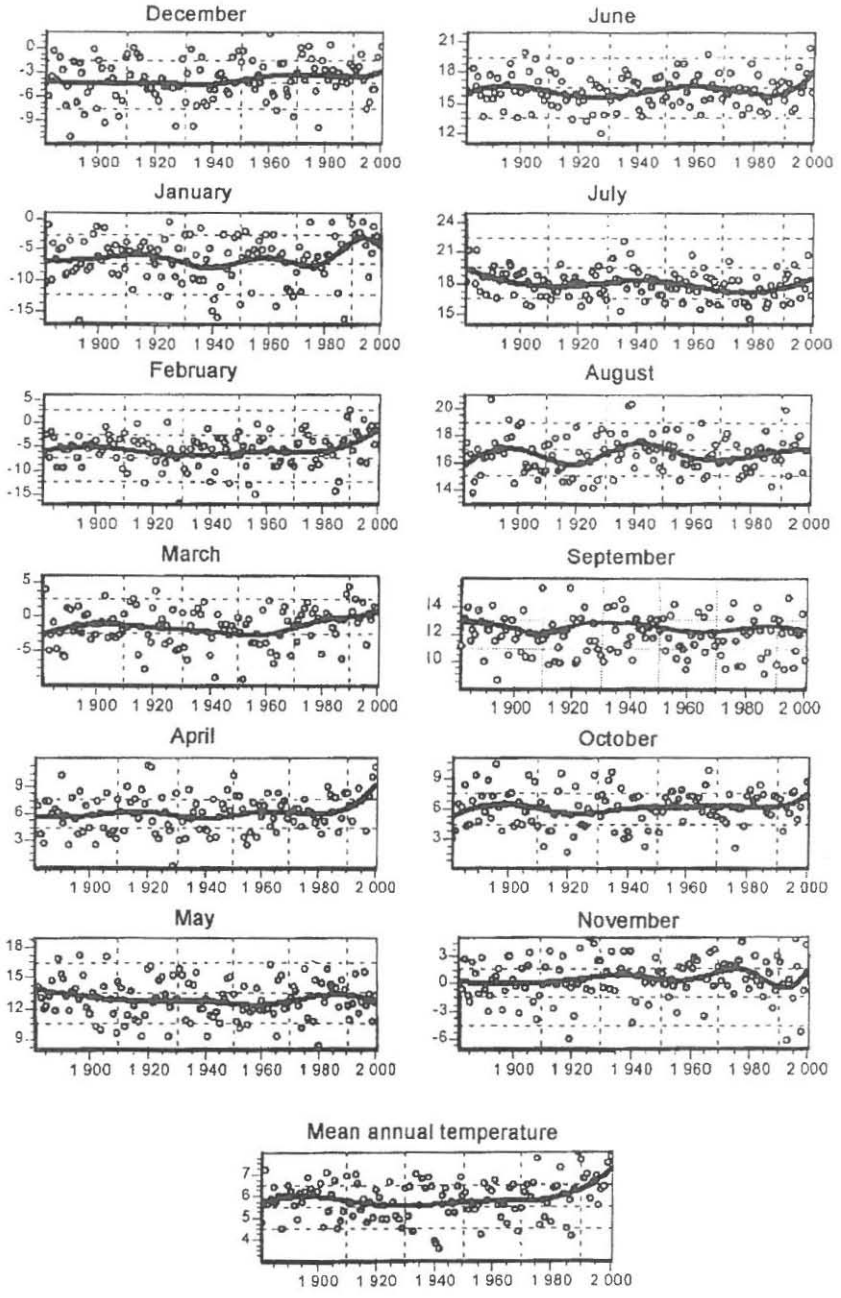

Fig. 1. Trends of mean monthly and mean annual temperature in the whole of Belarus for 1881-2000

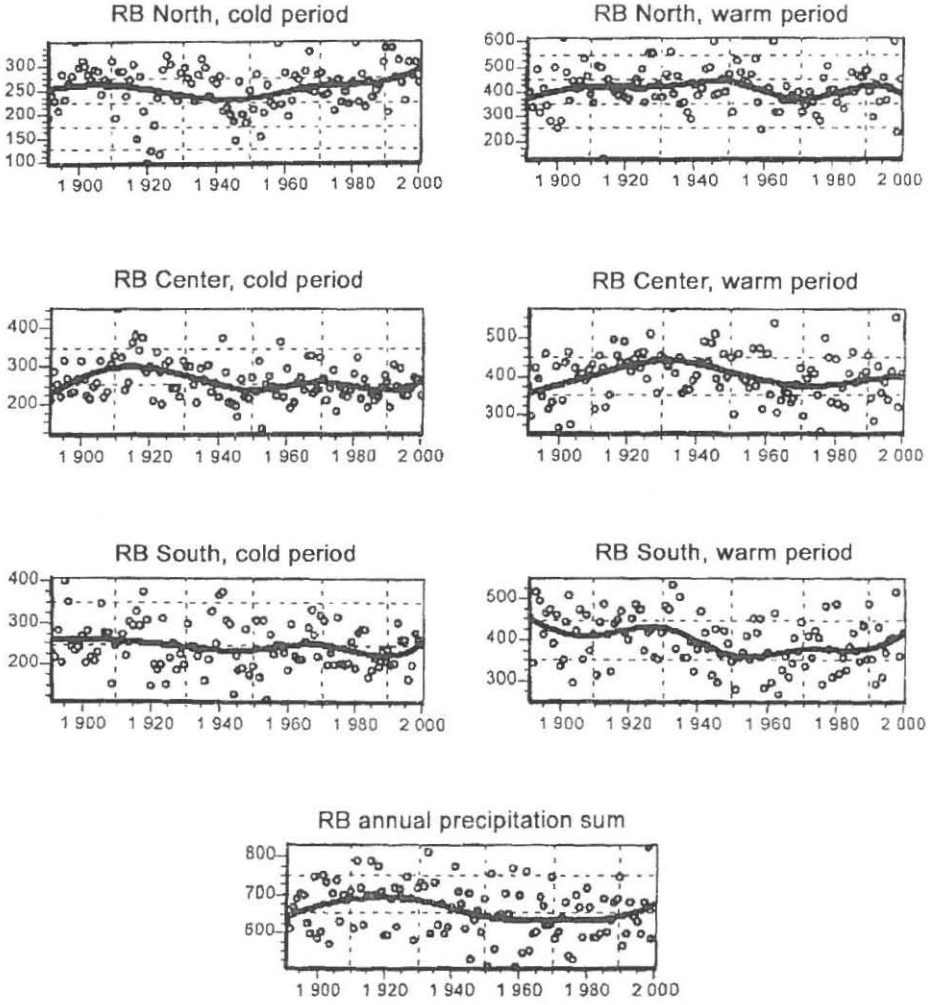

Fig. 2. Trends of sums of precipitation of cold (October-March), warm period (April-September) for Northern Central and Southern Republic's parts and for the year for the whole of Belarus for 1881-2000.

amount in post-war period in the central southern parts of Belarus in warm season constituted 50-80 mm.

Change of frequency of droughts and light frosts

Many thousand works are devoted to the research of the origin of droughts, however till now there is no complete representation about conditions of droughts formation, there are no reliable methods of their prediction [1,5-7].

The majority of the explorers in studying a drought gave a basic attention to one of the sides of this complex phenomenon: either to atmospheric processes, resulting in a drought, or to the processes in soil and crops productivity. All this has resulted in the fact that either an atmospheric ("meteorological") drought, or atmospheric-soil, or only soil droughts was started to be regarded. A great number of definitions of droughts and a number of criteria of their indexation has appeared. The reviews of scientific researches devoted to droughts are given in a great number of published works. In these works, in particular, both definition of droughts and criterion of their indexation or assessment of their intensity are considered [1,6,8].

Despite the fact that Belarus is located in the region of sufficient humidification, the temporary and spatial irregularity of atmospheric precipitation distribution on its territory causes formation of droughty seasons of various duration. Let's consider frequency of the droughty phenomena for the last 110 years in Belarus. The southern and south-eastern parts of Belarus are largely subjected to droughts . Here, on the average once per 4-5 years any of the months of warm season can be droughty, and once per 8-10 years two months in succession may occur droughty. On the other territory of Belarus droughts repeat less often and a month occurs droughty once per 5-10 years, and a bi-monthly term – once at 10-15 years. On highlands, where there's more precipitation and less repeatability of high temperatures, the droughty seasons are observed less often, than in flat terrain. The area of distribution of a drought in Belarus does not cover more 10% of the territory, but once per 7-12 years of a drought at least in one of the months cover more than 50% of the area of the republic.

The analysis of the number of extreme droughty phenomena (P<50% of norm) has shown an increase in the droughty phenomena in recent decades (1951-2000) in comparison with the term from 1891 to 1950. In the period of active amelioration of the Polesye and subsequent period (1965-2000) the rise of the extreme droughty phenomena was especially pronounced in July-August, and also as a

whole in a warm season (IV-X months) in the republic's southern part. In May-June there are no large changes in the number of droughty phenomena, and in the north of the republic the fall of their number is marked (Table 1).

Table 1. Difference of the number of aridness (P<50% of the norm) in 1891-1950 and 1951-2000 period

No.	Months / Station name	V-VI	VII-VIII	IX-X	IV-X	XI-III
1	Verkhnedvinsk	+8	-6	+3	-5	+24
2	Polotsk	+1	-9	-4	-15	+8
3	Vitebsk	-7	-14	-11	-35	+3
4	Gorki	+5	-4	-3	+5	+12
5	Mogilyov	+1	-3	-10	-14	-9
6	Minsk	-7	-18	+3	-23	+8
7	Grodno	0	-17	-4	-22	+5
8	Vasilevichi	+1	-15	-9	-26	+13
9	Pinsk	+1	-20	-11	-38	-4
10	Brest	-7	-1	-5	-19	-6
Sum of differences for northern stations		+8	-36	-25	-64	+38
Sum of differences for southern stations		-12	-71	-26	-128	+16
Sum of differences for all 10 stations		-4	-107	-51	-192	+54

Further research in repeatability of the droughty phenomena in various spans (P1 – 1946-1964; P2 – 1965-1984; P3 – 1985-1995) has shown, that the number of droughty periods has increased especially in August-September 1965-1984. In May-June the quantity of the droughty phenomena has decreased even in comparison with the period of 1946-1964 (Table 2).

Last analyzed years (1985-1995) the quantities of the droughty phenomena even have decreased a little in comparison with periods of 1946-1964 and 1965-

Table 2. Variation of the number of arid periods in various parts of Belarus in periods selected*

	May-June			August-September		
	P2-P1	P3-P2	P3-P1	P2-P1	P3-P2	P3-P1
Republic's North	-1.4	(-0.3)	(-1.7)	+1.6	(-2.3)	(-0.7)
Center	-1.0	(-0.9)	(-1.9)	+1.6	(-2.4)	(-0.8)
South	-2.1	(-0.8)	(-2.9)	+0.7	(-0.7)	(0.0)

*In brackets the repetition of droughts regarding the adjustment of the last ten-year period (P3) to twenty-year scale P1 – 1946-1964, P2 – 1965-1984, P3 – 1985-1995

1984, though last large-scale droughts in 1992, 1994 and 1999 restore a positive tendency in frequency of droughts.

Thus, increase of air temperature in the south within the last two decades, and decrease of precipitation at the end of summer and beginning of autumn result in the frequent appearance of aridness in the years of active amelioration. A slight weakening of droughts in the 80-s' has been replaced by its increase since 1992.

In the period of active amelioration and following years (1965-1995) there was an essential increase in the number of light frosts in various months of the year (Table 3). In Table 3 follows, that if in the period from 1946 to 1964 the quantity of light frosts in the north was 2.2 times higher, than in the south, so in the period from 1985 to 1995 the quantity of light frosts in the north and south of the country became commensurable; considering the area this interrelation varies from 1.0 up to 1.3. The quantity of light frosts in the period of active amelioration (1965-1984) was more than in the pre-amelioration period. This distinction was greatest in the south of the country. The analysis has shown, that the number of light frosts in recent decades has grown in comparison with the background period (1945-1964) in the central and southern areas in all considered months (May-September). The exception has been made for a small drop in the frequency of light frosts in 1985-1993 in comparison with the background term. The especially significant change of number of days with light frosts in May-June occurs in droughty years (hydrothermal coefficient (HTQ) ≤ 0.7). The sharp changes of frequency of light frosts are marked on drained peat deposits. The frequency of both spring and autumn light frosts on drained peat lands not only more than twice as much exceed the number of light frosts on and above sandy-loam soils of the south of the republic, but it is also much higher than the repeatability of light frosts in boreal re-

Table 3. Period mean number of light frosts days in Belarus (May-September)

	1945-1964 (P1)	1965-1984 (P2)	1985-1995 (P3)	Periods light frosts mean number difference (1965-1984) – (1945-1964)
North	2.7	3.3	1.4	0.6
Center	1.7	2.4	1.6	0.7
South	1.2	2.1	1.4	0.9
Ratio of number of cases of light frosts north/south	2.2	1.5	1.0	

gions, in summer months especially. Even in June light frosts on the surface of peat lands are observed every 2-3 years, while on mineral soils they are registered on average in the south in 20-50, and in the north once every 10 years. July light frosts are also possible – once every 10 years. Nowhere in the republic have light frosts been registered in July on mineral bedrocks for the last 50 years. The rise of intensity of light frosts on peat lands is especially considerable. In all months of the warm period a fall of temperature up to 5°C is probable, with varying probability. On the surface of mineral soils of the south of the republic these decreases are marked only at the end of September. Accordingly with the rise of repeatability and intensity the duration of (number of days) with light frosts on the drained moor increases.

If on the average in May-September there are 3 days with light frosts on the surface of mineral soil, so on the surface of drained peat lands 13 days can be marked.

The average duration of a frostless season above drained peat lands is 15-20 days less, than above mineral soils of the republic's South and it is less (on the average by 5 days), than in the republic's North.

Thus, with the area of the drained peat-mire areas being increased, the areas of possible frosts in the republic have increased too. The latter invoke a certain cooling for neighboring territories with mineral bedrocks.

Against the background of a weakening of the role of active light frosts local features of light frosts formation more often started to appear. In separate years soil light frosts in southern areas are even more intensive than light frosts in boreal areas. This growing light frost danger of southern areas of the country originates from the inclusion of rotation of the drained peat-mire soils in farming activity. The important feature in the change of light frosts and, to a greater extent, droughty seasons is a certain decrease of their frequency in the last span (1985-1995). It can be caused by a current increase in the mass share of sandy component in the process of a soil's peat layer cut-off, that has resulted in the increase of minimal and the decrease of maximal temperature of a soil surface. As a result, the frequency of light frosts and droughty phenomena is reduced.

Other causes of the above stated feature are:

- decrease of cultivated ameliorated territories,
- decrease of the areas of peat mining,
- increase of the area of bushes,

- sands exposition to the surface. It has resulted in surface albedo increase, maximal temperature fall, decrease of frequency of droughts and a certain degree of light frosts due to the decrease of minimal temperature at the expense of the reduction of a soil heat reserve in diurnal time.

CONCLUSIONS

The current warming has appeared to be more powerful, than previous; separate months of a cold season the temperature within 30 years has increased by several degrees. Especially powerful was a warming in January. The growth of precipitation in the post-war term in the boreal part of the republic is marked in a cold time and the first months of the warm term of the year. In the southern part of the republic the intensive fall of precipitation is observed in a warm season and especially in its second part. In the period of active amelioration of the Polesye and subsequent period (1965-2000) the rise of the extreme droughty phenomena was especially pronounced in July-August, and also as a whole in a warm season in the republic's southern part. In the same period the amount of frost increased if compared to the pre-ameliorative period. This distinction was greatest in the south of the country.

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WSPÓŁCZESNE PRZEMIANY KLIMATU NA BIAŁORUSI

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S t r e s z e n i e. Analiza zmian temperatury oraz opadów na Białorusi w ciągu długiego okresu (1881-2000 r.) wskazują na wzrost temperatury w okresach zimnych za ostatnie 35 lat i zmniejszenie ilości opadów w sezonach letnich w czasie powojennym. Powtarzalność posuch wzrosła w lipcu – sierpniu. W ostatnim dziesięcioleciu powtarzalność przymrozków na Białorusi północnej i południowej jest podobna. Rozpatruje się przyczyny wzrostu powtarzalności przymrozków oraz posuch.

S ł o w a k l u c z o w e: posucha, przymrozek, zmiana klimatyczna