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Regional Manifestations of Changes in Atmospheric Circulation in the Central Black Earth Region (By the Example of Belgorod Region)

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ABSTRACT

The change of the circulation of the atmosphere exerts a significant influence on the formation of weather conditions. Depending on the duration and intensity of the latitudinal or longitudinal types of atmospheric circulation can be formed in periods of extreme weather and climatic characteristics. The aim of this work is the estimation of the reasons of occurrence of the area of dangerous hydrometeorological phenomena and the analysis of the circulation processes, leading to the establishment of extreme weather conditions in the region.Using the calendar of the consistent changes of elementary circulation mechanisms and daily observations of the weather in the south of Central Black Earth region (by the example of Belgorod region). The total frequency of occurrence of stationary anticyclones over the European part of Russia (with the continuous duration of 6 days or more) has increased both in summer and winter periods. The scheme of development of the circulation processes leads to an increase in the frequency of extreme high temperatures, natural fires, soil and atmospheric droughts. During the period under review such a dangerous agrometeorological phenomena as «soil drought» was observed for the first time. Given the size of the synoptic facilities, hazardous hydrometeorological events should be expected at the same time in several subjects of the Federation. The most vulnerable sectors of the national economy are agriculture, housing and communal services and transport.

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INTRODUCTION

Change of the nature of circulation of the atmosphere causes essential influence on formation of weather conditions, to a large extent determining formation of extreme values of meteorological parameters.

This research considers the Central Black Earth region (CBER), located in the area of moderate continental climate. The prevailing circulation here if western (latitude) air-mass transport, conditioned by interaction of the Azores high and the Icelandic depression. Sometimes it is broken by development of meridional circulation, which causes large fluctuations and sharp changes in the course of meteorological elements [1, 2]. Depending on the duration and intensity of latitude or meridional types of circulation of the atmosphere there may periods be formed with extreme weather and climatic characteristics.

Methods:

Using the calendar of consecutive change of elementary circulation mechanisms [3] and the everyday data of observations over the weather at the South of the Central Black Earth region [4], there was role of blocking highs in formation of hazardous hydrometeorological phenomena detected.

Main part:

In accordance with the research [3] starting from 1899, 3 circulation epochs have changed: meridional North (1899–1915), characterized by positive deviations of the summary annual duration of meridional North (blocking) processes from their average one over 1899–2011; zonal (1916–1956); meridional South (from 1957 till now), characterized by positive deviations of the summary annual duration of the influence of South lows from the average multi-year parameter.

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During the latest epoch there were periods of fast growth of the summary annual duration of the South lows distinguished (1981–1997). Simultaneously (from 1984) there was growth of the summary annual duration of the blocking processes distinguished, which in 2009 achieved the third maximum since 1899: 263 days a year (the first two were fixed in 1915 and 1969) [3].

The starting growth of meridional North circulation since 1998 [3, 5] forms the instability of the atmosphere and influences the regularity of meteorological extremes. The duration of South lows is fast reducing, though also in the present time it exceed the average duration over the period 1899 – 2011 by 40 days. Starting from 1999, growth of the average temperatures of the air has stopped, which coincides with the end of growth of the duration of the South circulation processes.

The evaluation, performed within the framework of realization of the state assignment of the Ministry of education and science of RF, by the Belgorod state national research university (project code: 185) of the observed climatic changes within the recent years, testifies to the fact of change of the frequency of extreme meteorological and climatic phenomena in graduation of Roshydromet [6].

Over the recent 15 years at the meteorological stations of Belgorod region there was 231 distinguished concerning hazardous meteorological weather phenomena (WP) in graduation of Roshydromet (Fig.1). Out of them 117 cases of meteorological, and 114 – argometeorological. The largest number of WP is «Intense heat» (82 cases), then comes «Ground frost» (53 cases) and «Air frost» (17 cases).

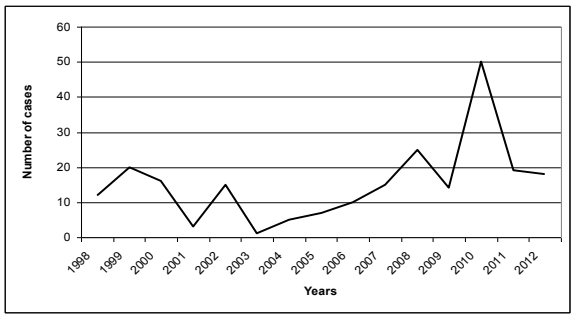

Fig. 1: Number of hazardous meteorological phenomena cases in Belgorod region.

In the category «Hazardous meteorological phenomena» the share of processes has increased, which are connected with stationary highs: these are «Intense heat» - air temperature $\geq 35^0$ C, «Intense frost» - air temperature $\leq -35^0$ C, «Abnormally cold weather» and «Abnormally hot weather». Out of 82 cases, 35 cases of WP «Intense heat» were detected in July-August 2010.

Over the period under consideration the following meteorological WP were observed for the first time as «Soil drought», as well as «Atmospheric drought», «Hot wind», which were almost not observed during the previous years (Fig.2).

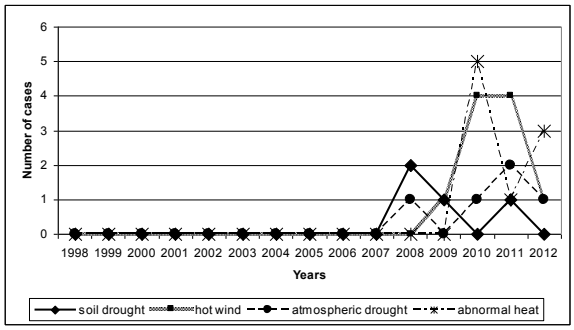

Fig. 2: Regularity of hazardous argoclimatic phenomena.

Evaluation of the temperature risks has shown that for the territory under study there are more characteristic risks, connected with positive extreme temperatures [7-10]. For the purpose of studying the circulation conditions, contributing to formation of these or those risks for each case of WP, elementary circulation mechanisms (ECM) detected during this time were analyzed under the classification of B.L.Dzerdzeyevskiy, selected from the calendar of consecutive change of ECM [3].

At the beginning of XX century, the absolute maximums of the air temperature in the region under study were connected with the latitude West transfer and spread in the CBER of the edges of the Azores highs. The regularity of the highs increased up to the middle of the century and during the period from 1931 to 1960 they

were 1,5 times more than at the beginning of XX century (1901–1930) and at the end of the century (1971–2000).

The second process in order of importance, having reasoned maximum summer temperatures was the meriodional process 10 grades, the so called "arctic high", which stimulated carry-over of dry air masses into the South regions. Similar processes led to formation of extremely high summer temperatures in the region and were the most often in the period of 1931–1960. In the period of increase of the duration of blocking processes there were essential positive abnormal temperature in summer and abnormal negative abnormal temperature in winter observed, which led to the growth of the annual range of the air temperature. The minimum of the abnormal annual range of the air temperature was fixed in 1990 (-6,5^o), and the maximum (9,5^o) was fixed in 2010.

From 1998 growth of meridional North circulation and fall of meridional South circulation started. Reduction of the duration of certain ECM is observed (from 4–5 days in the first epoch up to 2 days in the third epoch), which testifies to the growth of instability in the atmosphere during XX century, having been reflected at the regularity of meteorological extremes. The data obtained clearly testify to the fact of increase of regularity of stationary high processes both 0 during the summer and the winter seasons (Fig.3, 4).

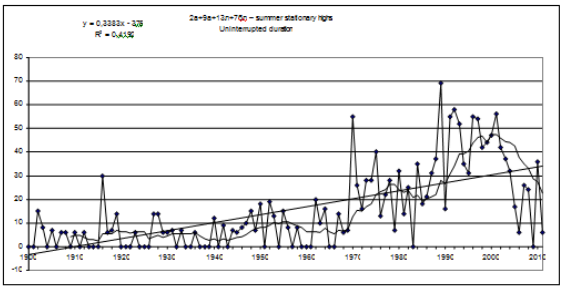

Fig. 3: Summary duration of stationary highs in the South of ETP in the summer period.

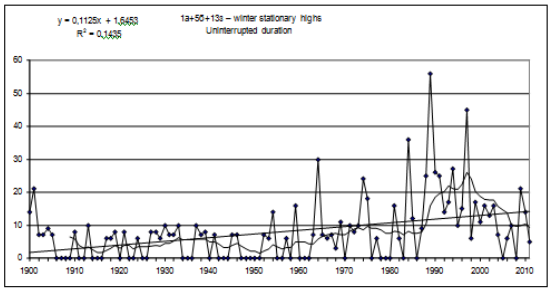

Fig. 4: Summary duration of stationary highs in the South of ETP in the winter period.

In accordance with the opinion of N.K.Kononova [3] growth of the summary annual duration of blocking processes, and, consequently, hot summer seasons and cold winter seasons may last for 15 years, after which, taking into account the duration of circulation epochs, it is possible to expect the subsequent warming.

Conclusions:

During XX century significant changes took place in formation of the temperature mode of the Central Black Earth region and its extreme characteristics. The most continental the climate was during the period of 1931-1960. At this period of time there were long periods with extreme heat in summer observed and more probable as compared to the beginning and the end of the century there were intense frosts in winter. By the end of XX century the weather and the climate (first of all, occurrence of extreme temperatures) were formed by the stationary highs, both – in winter and in summer periods.

The scheme of development of circulation processes permits supposing that during the following 10–20 years the regularity of hazardous phenomena will be still increasing. Taking into account the sizes of synoptic objects, hazardous hydrometeorological phenomena are to be expected simultaneously in several RF entities. The most sensitive sectors of the national economy will be agriculture, housing and public utilities and transport.

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