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Modern climate change is accompanied by an increase in the growth of dangerous hydrometeorological phenomena, including floods, strong winds, torrential rains, hail, droughts, which cause serious damage to the economy and the life of the population, which is also noted on the territory of the Yugra.

The reaction of the natural environment to climate change is accompanied by the occurrence of dangerous hydrometeorological phenomena in the Northern region. Adverse and dangerous hydrometeorological phenomena are observed on the territory of the district, including those caused by modern climate change, including the spring-summer flood, which leads to flooding of low-lying areas. For example, the last of the large-scale floods in the region was also affected by a large stock of snow in the winter of 2014-2015, as well as intense rainfall in the summer of 2015. High water levels cause serious damage to the environment, residential areas, transport and engineering infrastructure, as a result of which the established boundaries of flood zones and settlements are being revised. Features of meteorological conditions determine the functioning of natural complexes and economic activities of the population. The temperature regime, the distribution of precipitation, the timing of snow removal and establishment, water levels in rivers and reservoirs, have a significant impact on the development of the fire season, as happened, for example, in 2012 on the territory of the region.

In addition, climate change is accompanied by dangerous hydrometeorological phenomena that are not typical for the physical and geographical conditions of the territory of the Yugra. For example, in recent years, tornadoes have been observed in the vicinity of the cities of Nefteyugansk (summer 2010), Khanty-Mansiysk (June 2012) and Surgut (July 2016). in the city of Nizhnevartovsk, on February 28, 2017, a snow storm was observed – a rare natural phenomenon that has never been previously recorded in Yugra.

As a result of the observed climate changes, there is an increase in the frequency of extreme and catastrophic natural phenomena in 2007-2020 on the territory of the Yugra. Many of the most important characteristics of the climate such as frost-free period, the timing of snow cover, the occurrence of first and last frost and rainfall distribution, the timing of the onset of phenological periods have become more variable and change the local climate is most severe in the transitional seasons – spring and fall. In vulnerable Northern regions, it is necessary to continue research on adverse and dangerous hydrometeorological phenomena that pose a threat to the natural environment, economy, life and health of the population and lead to environmental as well as economic damage.

Correlation of lightning frequency and convective thermodynamicparameters of the atmosphere over of Western Siberia

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Currently, lightning activity parametrizations are being introduced into climate models, which relate the frequency of lightning discharges to the characteristics of convective cloudiness. Many studies was aimed to find the ratio between lightning parameters (eg, frequency, polarity) with hazardous phenomena associated with convective clouds [1], which results can be used to improve forecasts of convective phenomena, especially in territories where there are no weather radar network and / or lightning detection systems.

We studied the spatial correlation of atmospheric instability parameter over the southeast of Western Siberia and lightning discharge density recorded by OTD (Optical Transient Detector) aboard the Microlab-1 satellite (NASA) [2] during the summer seasons of 1995–1999. The estimation of atmospheric instability is based on the average spatial pattern of KIND index [3] according to the ERA5 reanalysis, for the days when the centers of lightning activity were located over different regions of study area. The values of lightning discharge density and KIND index are determined for a square of 1×1° in the range of 50–64 N and 61–90 E (total 420 squares).

To check relationship between the two samples, the Fechner correlation coefficient and Pearson's chi-squared test were used. The Fechner coefficient signed a potential direct correlation between the lightning discharge density and KIND values (F = 0.17). Based on the Pearson's chi-squared test, longitude groups were determined where a significant positive correlation (> 0.4) was observed at a confidence level of 95%: 69–71 E (Ob-Irtysh interfluve, Siberian ridges, Ishim plain, Kazakh small hills) and 82–88 E (southeastern part of the West Siberian Plain, Vasyugan, Salair Ridge, Kuznetsk Alatau and Altai-Sayan Mountain System).

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Extreme cyclones over the Ural region

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Atmospheric circulation is a single mechanism. It consists of separate circulation structures of various spatialand temporal scales. They affect the variability of weather and climate in different regions. The main factor in the variability of weather conditions is the frequency of atmospheric vortices: cyclones, which usually bring precipitation with them, and anticyclones, which provide long dry periods. The features of regional circulation can be detected by the characteristics of cyclonic and anticyclonic activity, including by observing the variability of the trajectories of movement of baric formations over the study area.

This paper presents an analysis of extreme cyclones that determined the weather conditions in the Ural region in the period 1998–2019. The research material was an electronic archive of synoptic maps, Katz index values, monthly, weather reviews, and CFS / NCEP reanalysis data.

In general, the influence of cyclonic systems on the territory of the Urals gradually decreased. 1411 cyclones, of which 11 are extreme baric formations, influenced the territory of the Urals for the period 1998–2019. The frequency of extreme cyclones is less than 1% of the total number of cyclones. Extremely low pressure cyclones in the center are rare and not regular. The greatest number of extreme cyclones was observed in 2008; their repeatability is 27% of the total number of extreme cyclones over the Urals. The pressure in their center varies from 980 to 985 hPa.

Air masses shifting from the west have the highest repeatability throughout the year. The prevailing cyclones along the displacement trajectory are Scandinavian cyclones. These cyclones, approaching the Urals, are at the stage of maximum development, some of them reach the stage of filling. Cyclones displace at an average speed of 42 km/h; they contain four closed isobars with a minimum pressure in the center of 982 hPa.The cyclone from the western direction corresponds to the highest average displacement rate; the southern type cyclone has the largest number of closed isobars and the greatest depth. For cyclones of the northwestern type, maximum repeatability is observed.

To determine the direction of air mass transfer in extreme cyclone systems, the Katz index was used. Its minimum value is observed in October 2008 and amounts to 0.65, the maximum value of the indicator is observed in February 2012 (-1.58). In general, the meridional type of atmospheric circulation predominates.

Most of the extreme cyclones during their operation on the territory of the Urals were at the filling stage, while the overall indicator corresponded to the zonal type, or was close to the value of the transition to the zonal type of large-scale circulation. A small part of the extreme cyclones were at the stage of maximum development against the background of high values of the general indicator (more than 0.75), which indicated the meridional type of large-scale circulation.

A daily analysis of extreme pressure formations according to the reanalysis of the CFS model and synoptic maps showed that the greatest pressure difference in the center (up to 20 hPa) is observed in Scandinavian cyclones. The difference in pressure is observed throughout the entire period of action of baric formations on the region, which can partially be explained by differences in the methodology for conducting isobars. The mean absolute pressure error in the center of the cyclones was -1.6 hPa, and the relative error was -0.002. The average distance between the centers of extreme pressure formations on the synoptic and reanalysis maps was 326 km. Analysis of the location of extreme pressure formations revealed that the largest number (36%) of cyclone centers on maps according to the CFS model are located north than their centers on synoptic maps. Centers of extreme pressure formations coincide in only 1.3% of cases.

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