ANALYZING EXTREME WEATHER PHENOMENA IN THE CONTEXT OF MODERN CLIMATE CHANGE IN NORTHERN REGIONS

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INTRODUCTION

Accompanied by extreme weather phenomena and hazardous natural processes in various regions of the globe, modern climate change generates much interest within the scientific community. Extreme weather and climate monitoring has become particularly important for scholars studying the specifics of environmental changes. Recently, an increase in the frequency of extreme weather events caused by climate change has been observed almost everywhere. Studies confirm a significant increase in long-term indicators of average annual air temperature, which leads to intensive permafrost thawing and affects the environment of northern regions. Scholars observe current climate warming in the northern latitudes, leading to a noticeable shift in natural zone boundaries.

Studying unfavorable and dangerous hydrometeorological phenomena is highly essential, considering their extreme character and threat to the environment, economy, human life and public health, and possibility of environmental and economic damage.

According to Roshydromet, about a thousand dangerous hydrometeorological events, including agrometeorological and hydrological phenomena, are annually observed in Russia. The largest number of dangerous hydrometeorological phenomena over a 12-year period was recorded in 2008 and 2018.

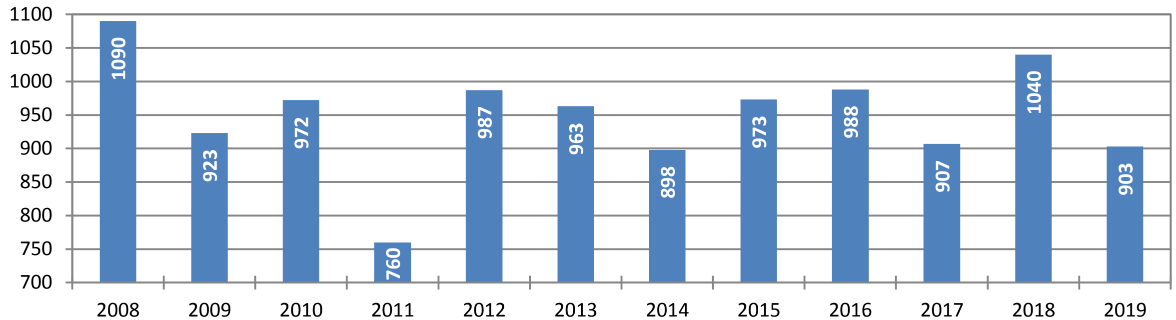


Figure 1. The total number of dangerous hydrometeorological phenomena in the Russian Federation in 2008-2019

Heavy precipitation (snow, rain, heavy rain), severe wind (including a squall), hail, snowstorms and abnormally cold weather in winter, as well as an extreme fires lead to the greatest damage of the environment, complicating the economic activity of the regions, bringing damage to the economic sectors and public activities.

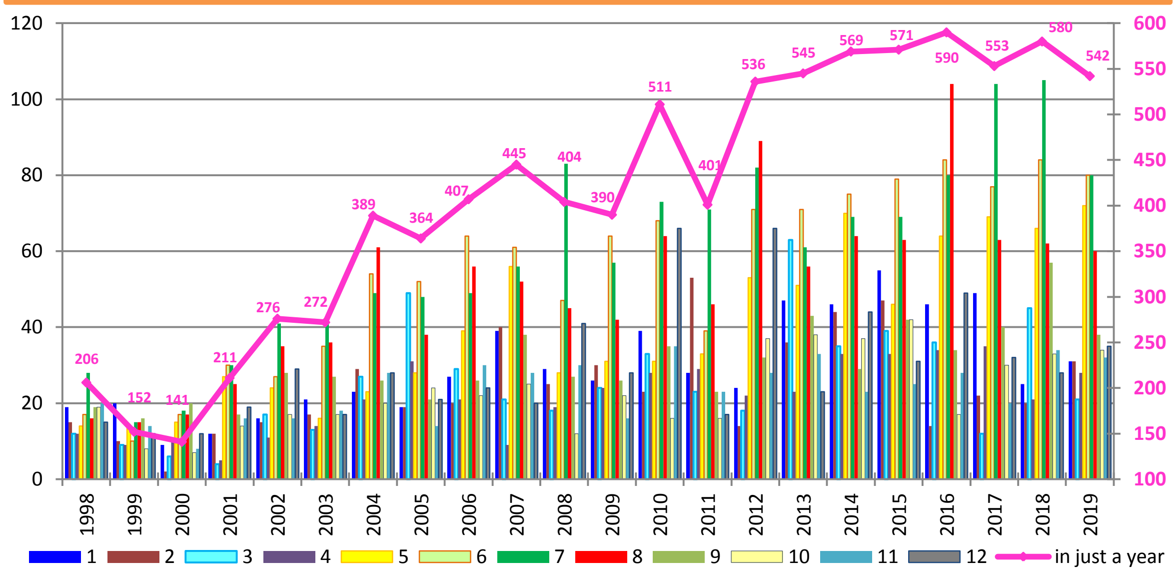


Figure 2. The dynamics of all hazardous meteorological phenomena registered in Russia in 1998-2019 by month (1-12)

MODELS AND METHODS

Khanty-Mansiysk Autonomous Area Yugra (hereinafter KhMAO Yugra) is characterized by uncomfortable and extreme living conditions, with a moderate, harsh continental climate.

This paper analyzes extreme weather conditions and hazardous hydrometeorological phenomena and studies the response of the natural environment to modern climate change based on phenological phenomena in KhMAO Yugra.

- To identify the way natural environment responds to climate change, we have collected, processed and coupled the analysis of long-term of climatic and phenological data series within the study area.
- We have analyzed long-term series of meteorological parameters based on the data of specialized arrays for climatic studies made by the Russian Scientific Research Institute of Hydrometeorological Information. According to the data provided by the Aviation Meteorological Station of Nizhnevartovsk, we have calculated the values of individual monthly and average annual climatic indicators and analyzed the indicators of the minimum and maximum air temperatures. A significant amount of data on the timing of phenological phenomena in Nizhnevartovsk and its suburbs for the period of 2007-2020 has been accumulated and certain meteorological data series for the respective years have been analyzed. An analysis of the timing fir the onset of phenological phenomena lead to some conclusions about the time boundaries and trends in the occurrence of phenological seasons under the conditions of climate change observed in the taiga zone of KhMAO Yugra.
- To determine the spatial and temporal variability of the regional climatic conditions, we have analyzed long-term average annual air temperature, the amount of precipitation and the height of the snow cover at the meteorological stations in Berezovo, Oktyabrskoye, Khanty-Mansiysk, Ugut and Nizhnevartovsk. In addition, we have analyzed the long-term duration of snow cover in Nizhnevartovsk region.

KHANTY-MANSIYSK AUTONOMOUS AREA YUGRA ON THE MAP OF WESTERN SIBERIA

RESULTS AND DISCUSSION

Modern warming in the northern regions, with its rates rapidly increasing and extending the global average rates, leads to an increase in the average annual air temperatures, which is clearly observed in KhMAO Yugra. Long-term data series on air temperature, provided by meteorological stations, indicate a tendency for an increase in the average annual air temperature in the taiga zone of KhMAO Yugra over the past 32 years.

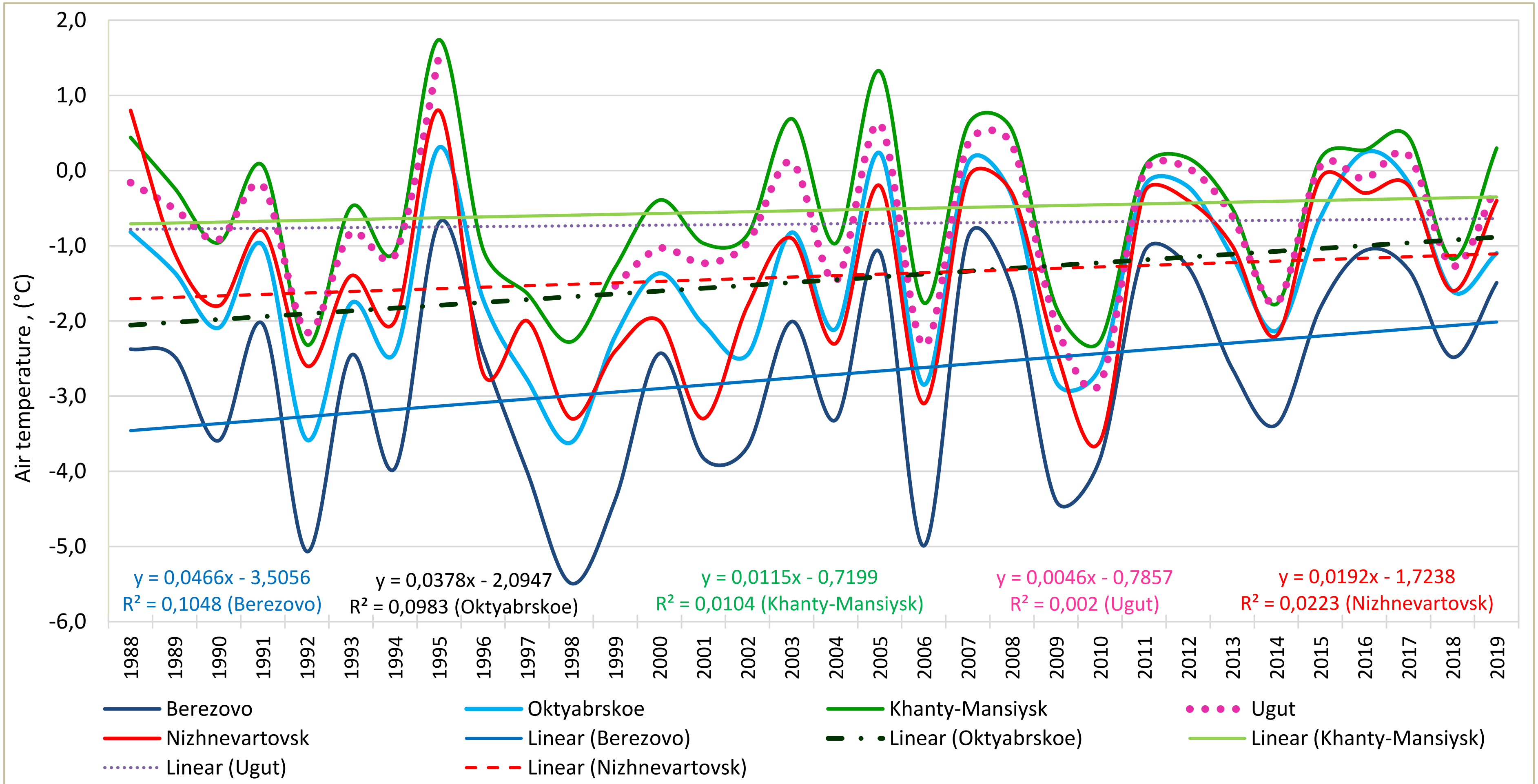


Figure 3. Long-term variations of the average annual air temperature (°C) in KhMAO Yugra for the period of 1988-2019 (according to data provided by meteorological stations in Berezovo, Oktyabrskoye, Khanty-Mansiysk, Ugut, Nizhnevartovsk)

The analysis of the minimum and maximum air temperature indicators in the autumn-winter seasons in Nizhnevartovsk in 2007-2020 reveals extreme indicators of the temperature regime, which allows identifying some specific features of climate warming in this northern region.

According to the indicators of the lowest temperature values, the winter season of 2016-2017 was characterized by persistent frosts, abnormally cold temperatures, with a deviation of -13 ...- 19 °C from the ten-day norm, in the second part of November. December was also cold with a deviation of -3 ...- 7 °C from the norm. The winter season of 2009-2010, with prolonged frosts from December to February, as well as the periods of January-February 2013-2014 and 2018-2019, with unfavorable frosty conditions, were characterized by quite low temperatures reaching below -40°C.

Table 1. Minimum and maximum air temperature indicators (°C) in Nizhnevartovsk. autumn-winter seasons of 2007-2020

Air temperature (°C)	September	October	November	December	January	February
2007-2008						
Min (Date)	-1,5 (23.9)	-4,3(16.10)	-20,2 (23.11)	-39,9 (21.12)	-36,7 (3.1)	-29,4 (12.2)
Max (Date)	+20,1 (5.9)	+12,4 (5.10)	+5,7 (4.11)	-2,2 (3.12)	-3,1 (5.1)	+1,8 (25.2)
2008-2009						
Min (Date)	+0,4 (30.9)	-16 (19.10)	-28 (30.11)	-32,8 (17.12)	-40,5 (29.1)	-40,8 (9.2)
Max (Date)	+27,5 (1.9)	+14,9 (9.10)	+4,6 (2.11)	-0,6 (5.12)	-3 (1.1)	-6,5 (28.2)
2009-2010						
Min (Date)	+0,2 (17.9)	-18,5 (26.10)	-36 (27.11)	-43,8 (28.12)	-43,2 (2.1)	-41,1 (25.2)
Max (Date)	+22,8 (9.9)	+18,8 (1.10)	+1,4 (1.11)	+0,2 (3.12)	-13,2 (28.1)	-11,1 (16.2)
2010-2011						
Min (Date)	-2,6 (15.9)	-2,4 (20.10)	-31,8 (30.11)	-35,3 (21.12)	-35,6 (1.1)	-34,7 (14.2)
Max (Date)	+21,8 (21.9)	+11,7 (13.10)	+5,1 (6.11)	-8,4 (14.12)	-7 (14.1)	-4,4 (11.2)
2011-2012						
Min (Date)	+0,9 (12.9)	-18,8 (31.10)	-29 (25.11)	-29,8 (16.12)	-34,6 (17.1)	-31,6 (1.2)
Max (Date)	+24,3 (19.9)	+16,7 (10.10)	+0,4 (4.11)	-0,8 (7.12)	-5,1 (1.1)	-5,8 (4.2)
2012-2013						
Min (Date)	+0,8 (29.9)	-18 (25.10)	-31,8 (29.11)	-28,8 (1.12)	-38,2 (18.1)	-29,2 (16.2)
Max (Date)	+23,5 (9.9)	+8,5 (15.10)	+0,4 (2.11)	-17,8 (1.12)	-6,6 (23.1)	-4,5 (10.2)
2013-2014						
Min (Date)	-3,8 (29.9)	-12,7 (19.10)	-20,2 (7.11)	-35 (21.12)	-43,2 (29.1)	-41 (19.2)
Max (Date)	+17,9 (8.9)	+6,4 (2.10)	+2,8 (9.11)	-0,2 (30.12)	-2,7 (1.1)	-9,8 (28.2)
2014-2015						
Min (Date)	-5,1 (27.9)	-19,6 (26.10)	-35,2 (23.11)	-36,6 (7.12)	-39,2 (3.1)	-37,7 (18.2)
Max (Date)	+14,3 (23.9)	+12 (3.10)	+1,7 (6.11)	+0,2 (24.12)	-2,2 (19.1)	-0,5 (27.2)
2015-2016						
Min (Date)	-2,8 (27.9)	-21,5 (22.10)	-27 (21.11)	-36,7 (21.12)	-34,3 (18.1)	-22,3 (1.2)
Max (Date)	+20,9 (1.9)	+9,1 9.10	+0,3 (6.11)	+0,1 (9.12)	-4,7 (13.1)	-19,9 (1.2)
2016-2017						
Min (Date)	-3,7 (30.9)	-11,3 (23.10)	-36,4 (18.11)	-48,9 (21.12)	-43,5 (6.1)	-40,1 (9.2)
Max (Date)	+23,6 (4.9)	+6,7 (2.10)	-2 (30.11)	-5,9 (27.12)	-6,8 (1.1)	+3,5 (27.2)
2017-2018						
Min (Date)	-1,6 (24.9)	-7 (12.10)	-26,4 (4.11)	-27 (30.12)	-42 (22.1)	-33,4 (26.2)
Max (Date)	+19 (3.9)	+8 (10.10)	+2,8 (2.11)	-2,1 (6.12)	-0,4 (15.1)	-5,6 (19.2)
2018-2019						
Min (Date)	-0,8 (17.9)	-9,3 (31.10)	-32,7 (30.11)	-34,4 (23.12)	-41,9 (31.1)	-45 (1.2)
Max (Date)	+22,5 (26.9)	+23,1 (6.10)	-0,6 (2.11)	-1 (17.12)	-3 (14.1)	-3 (14.2)
2019-2020						
Min (Date)	-2,4 (29.9)	-12,2 (31.10)	-32,5 (18.11)	-34,5 (25.12)	-33,6 (31.1)	-26,6 (9.2)
Max (Date)	+19,5 (16.9)	+20,4 (6.10)	+2,6 (7.11)	+0,6 (11.12)	-2,7 (24.1)	+12,1 (13.2)

NOTE:

Minimum air temperature	Maximum air temperature
– lowest values	– highest values
– highest values	– lowest values

Based on the data provided by the Federal Service for Hydrometeorology and Environmental Monitoring, **the winter 2019-2020 was very warm in the whole Northern Hemisphere.** The air temperature anomaly (+ 2.254°C) had reached its maximum value since 1886, and generally that winter was really warm everywhere in Russia, with an anomaly of + 5°C.

As for KhMAO Yugra, the winter season of 2019-2020 had been extremely warm over the entire observation period, with the minimum air temperature reaching only -34.5°C (on December 25), according to the data provided by meteorological station in Nizhnevartovsk. February 2020 was abnormally warm, with the air temperatures not falling below -26.6°C (on February 9), which was commensurate with the average air temperature in February in some past years. **A new temperature record was registered on February 13, 2020, with the air temperature rising to an anomalous value of +12.1°C.** The average air temperature in February 2020 was only -9.3°C, which is usually close to the average monthly temperature in March. During this period, the changes in weather conditions entailed such phenomena as early thaws, intense snow melting, which were unusual for the area and led to significant changes in natural rhythms.

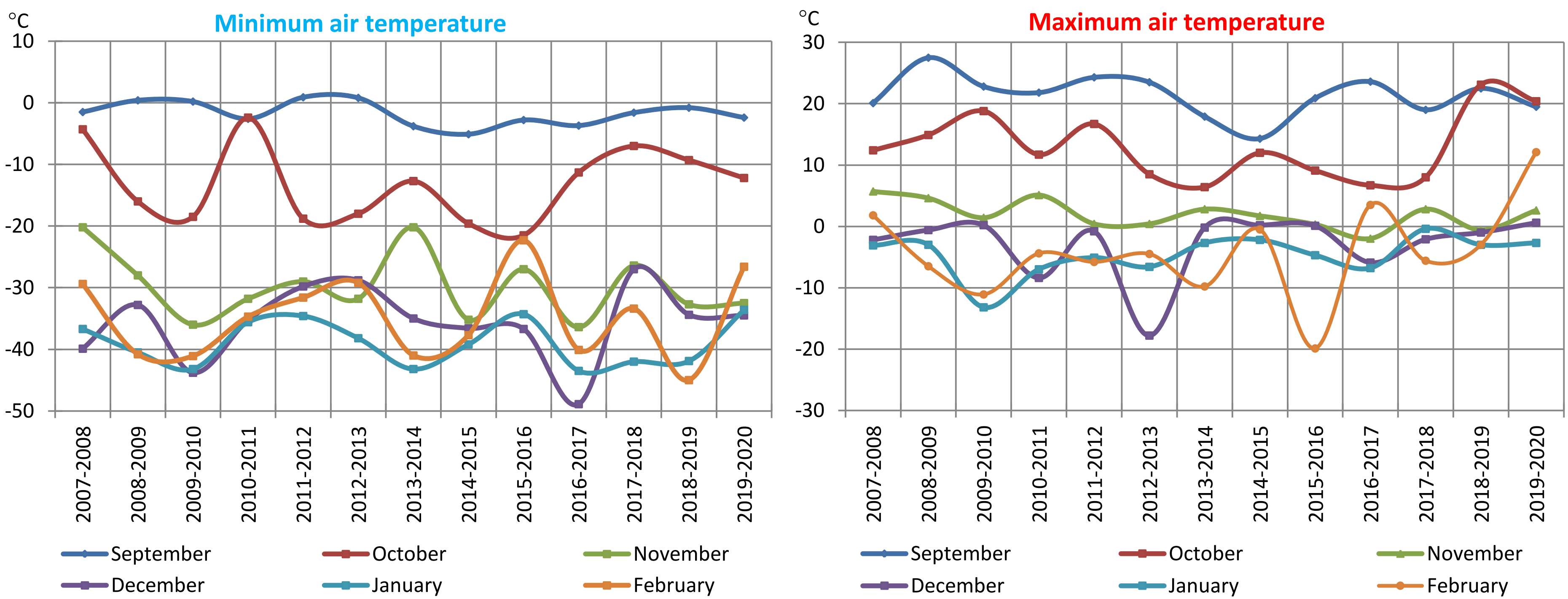


Figure 4. Minimum and maximum air temperatures (°C) in Nizhnevartovsk in the autumn-winter periods of 2007-2020

Following the winter season, the spring-summer period of 2020 in KhMAO Yugra also distinguished itself by an unusual meteorological situation and temperature records. As in 2017 and 2019, March 2020 became very warm (the average monthly temperatures were -3.4°C, -2.8°C and -3.5°C, respectively). April 2020 was extremely warm (with the maximum average temperatures since 2007, reaching + 5.8°C). May 2020 was particularly warm, with the average temperatures of +13.8°C, which is comparable with the average temperatures of the summer months in northern latitudes. According to the Federal Service for Hydrometeorology and Environmental Monitoring, the air temperature anomaly in Western Siberia in the spring 2020 was +6.69°C .

In the long-term, we have observed an increase in the average annual air temperature. For instance, the data of Nizhnevartovsk Meteorological Station showed that in 2007-2019 the average air temperature was -1°C and there is a tendency for increase in the average air temperature. In 2007, 2008, 2011, 2015, 2016 and 2019, the observations showed quite high indicators of the average annual air temperatures in the studied region. In Russia, the year 2019 was the fourth warmest year observed since 1936, with the average annual temperature 2.07°C higher than the average norm typical for the period of 1961-1990. According to HydroMetCenter of the Russian Federation, 2015 and 2019 were among the warmest years in the history of meteorological observations. The coldest years were recorded in 2009 and 2010.

The study found that the average annual air temperature in Nizhnevartovsk has been -1°C for the last 10 years (2010-2019). As for the period of 1988-2019, the year 2010 is characterized by the lowest air temperature (-3.6°C), which is 0.3°C lower than the values in 1998 and 2001. When analyzing the indicators of the average annual air temperature dynamics in Nizhnevartovsk over the past three decade we discovered that the last decade was the warmest. As for the periods of 1990-1999 and 2000-2009, the highest growth rates of the average annual air temperature were revealed.

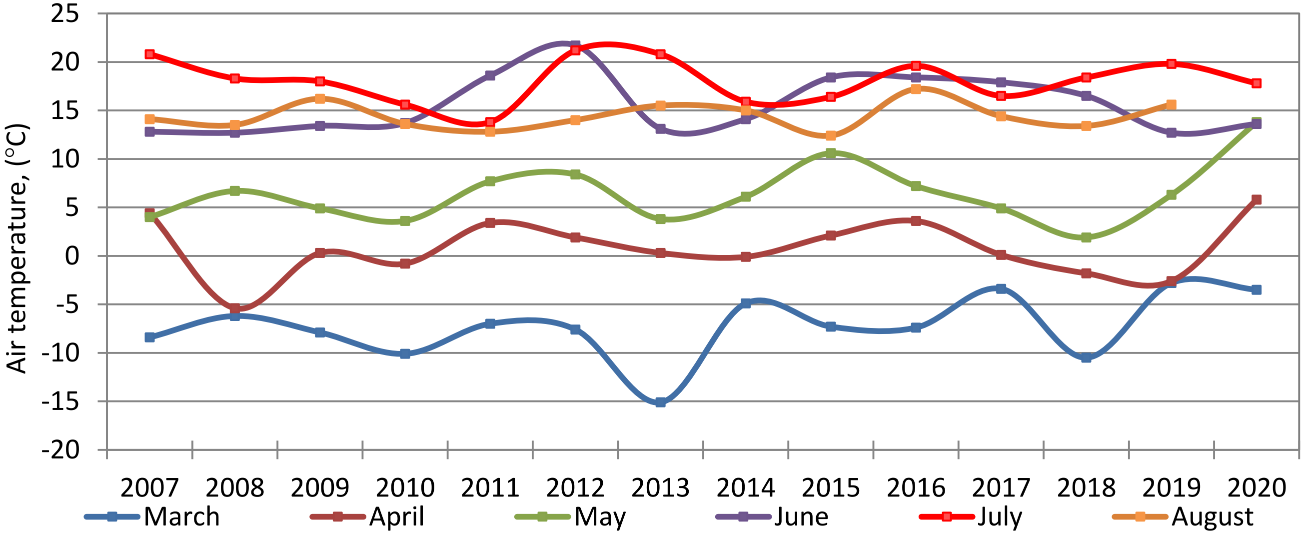


Figure 5. Average air temperatures (°C) for the spring-summer months of 2007-2020 in Nizhnevartovsk

In Nizhnevartovsk region, the years of 2007 and 2015 were distinguished by the maximum amount of atmospheric precipitation (766 and 708 mm per year, respectively), which were particularly intense in certain seasons of the year along with the unusual thermal regime for this territory. Abnormal weather conditions, characterized by a significant amount of atmospheric precipitation exceeding the climatic norm, were established in May, June and August 2007, and were also observed in the summer 2015. The maximum amount of precipitation (149 mm) was recorded in Nizhnevartovsk region in August 2019.

The timing of the snow cover formation and melting characterizing the duration of the frost period is the most important indicator of climatic changes in the northern latitudes. The number of days with snow cover in Nizhnevartovsk and its suburbs reaches 190-210 per year [7]. The taiga zone in the east of KhMAO Yugra (in Nizhnevartovsk) is characterized by a noticeable decrease in the duration of the period with a stable snow cover. After analyzing the duration of snow cover in Nizhnevartovsk we discovered that the period of stable snow cover has a tendency to reduce in 1988-2020, with a confirmed statistical significance at the level of 0.05.

- The abnormally warm weather, with a maximum air temperature of + 4.6°C in November 2008, +5.1°C in November 2010, and +2.8 °C in November 2013 led to a very late formation of the snow cover, namely, which led to significant changes in fauna biorhythms.

- In 2020, the snow cover melted by April 19, which was rather yearly due to abnormally warm weather, with the average air temperature reaching its maximum value since 2007 (+5.8°C) in April. In 1988-2020, the average stable snow period in Nizhnevartovsk amounted to 203 days.

- The period of 2007-2019 was characterized by the maximum height of the snow cover particular for May (33 cm), which was observed in 2019.

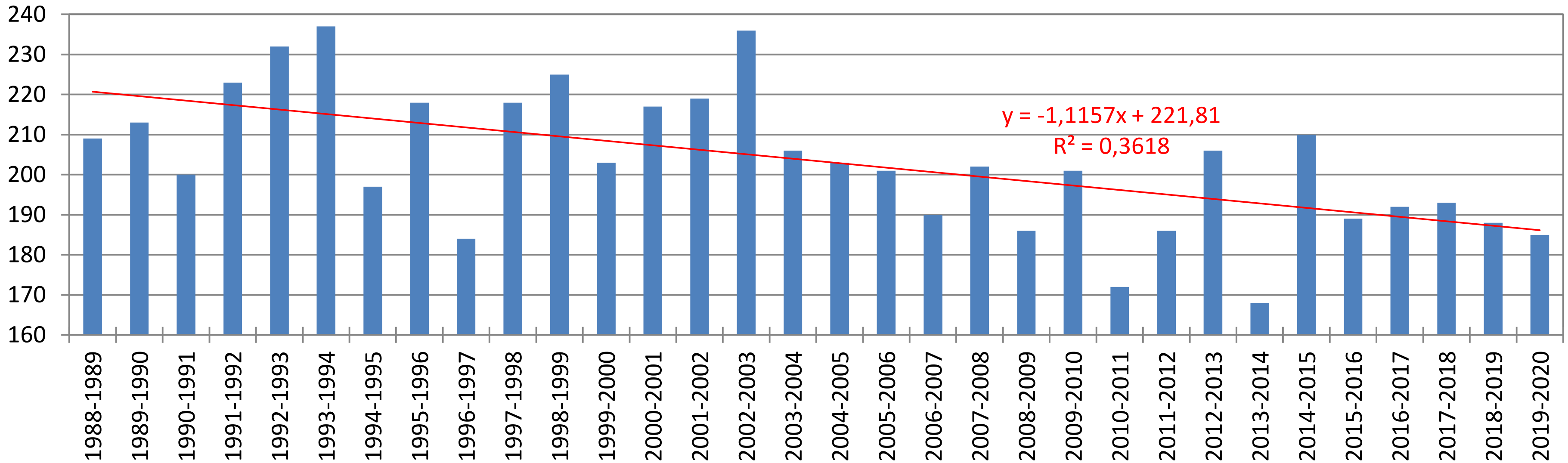
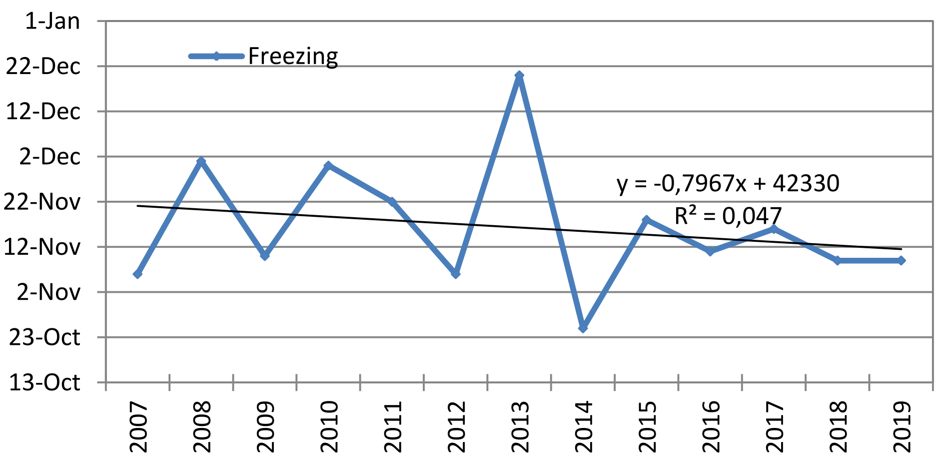


Figure 6. Number of days with snow cover in the suburbs of Nizhnevartovsk in 1988-2020

During abnormally warm periods, meteorological conditions make a significant impact on the functioning of natural complexes and adjust the economic activities of the local population.

For instance, in the winter 2013-2014, the dates for commissioning winter roads and ice crossings were postponed to later dates due to the warm autumn and very late freeze-up on the rivers in KhMAO Yugra.
In 2019-2020, winter was extremely warm, which led to the limited operation of winter roads and ice crossings.

In 2020, the ice drift on the Ob River (in Nizhnevartovsk) started on April 17, with was a record early date because it was 12 days earlier than the average multi-year date for the period of 2007-2020.



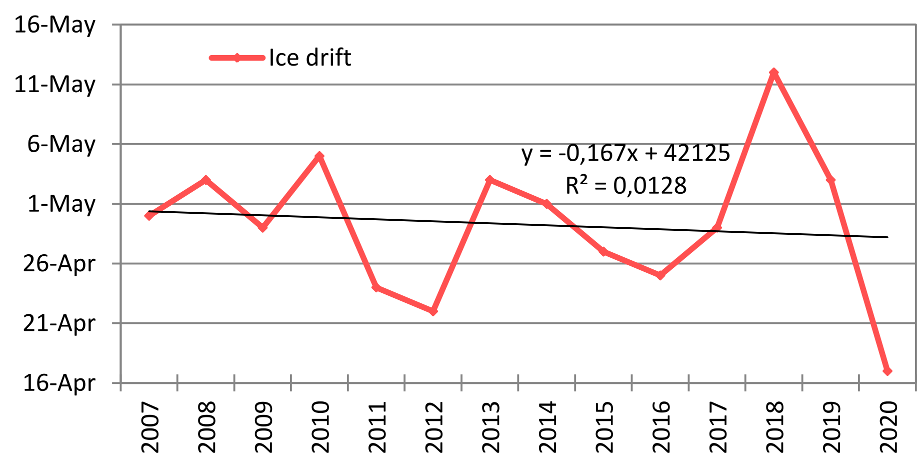
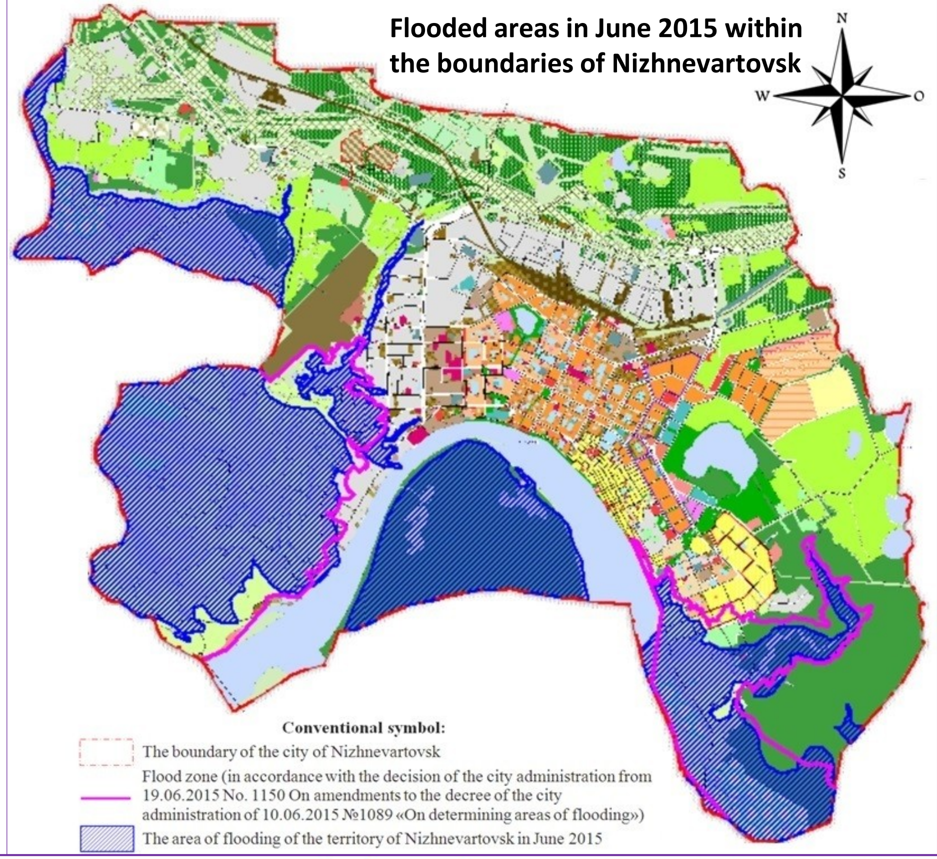
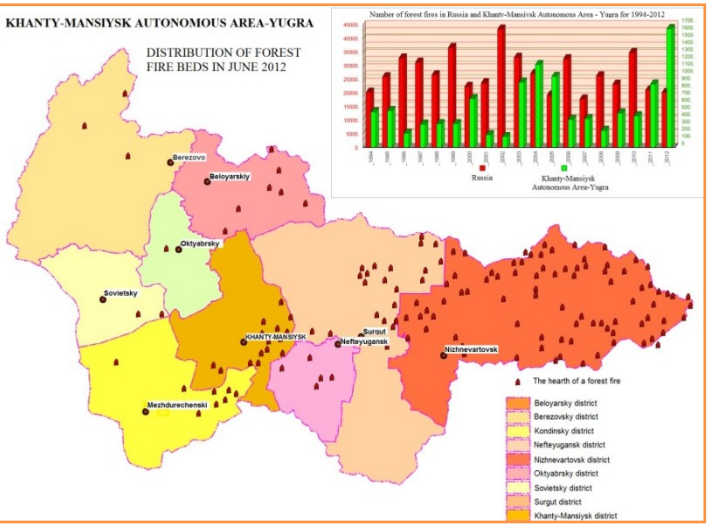


Figure 7. Schedule of ice formation and ice drift on the Ob River within in Nizhnevartovsk in 2007-2020

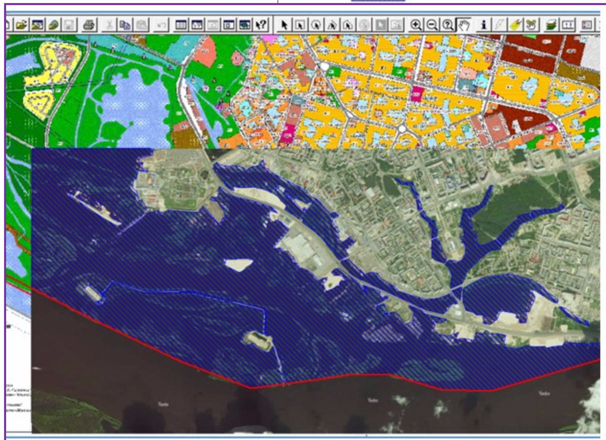
In some years, extremely unfavorable hydrological conditions were observed in KhMAO Yugra, particularly, spring and summer floods leading to flooding of low terrain areas. The previous large-scale floods in the region were caused by a large amount of snow in the winter period of 2014-2015, as well as by intense heavy rainfall in the summer 2015, when the water level in the Ob River in Nizhnevartovsk reached 1061 cm. High water levels cause serious damage to the ecological conditions, residential areas, transport and engineering infrastructure, and lead to the revision of the established flood zone boundaries.

Such factors as temperature conditions, atmospheric precipitation distribution, time of snow cover formation and snow melting, and water levels in rivers and reservoirs have a significant impact on the development of the fire hazards. In the area under study, natural fires are dangerous phenomena aggravated in extremely dry weather conditions. In 2012 the authorities introduced a special fire safety regime in the area, while in 2020 was also distinguished by high level of fire hazard.





Distribution of forest fire beds Khanty-Mansiysk Autonomous Area Yugra in June 2012



Superimposing the flooded zones identified from satellite images within the urban area on the urban planning zones map of Surgut city area in the geo-information system (compiled by author).

A satellite image of Megion in Khanty-Mansiysk Autonomous Area-Yugra during the flood in June 2015 (DigitalGlobe).

Are frequent local phenomena:

- ✓ very strong wind (with wind speed of 25 m/s and stronger; observed all year round);
- ✓ strong blizzard (visibility of less than 500 m at a wind speed of 15 m/s, lasting more than 12 hours; observed during the cold season and in spring, up to early June);
- ✓ severe frost (in the period from mid-December to mid-February, for 3 days or more, with the minimum air temperature remaining at below -45°C).

CLIMATE CHANGE IS ACCOMPANIED BY DANGEROUS HYDROMETEOROLOGICAL PHENOMENA THAT ARE NOT TYPICAL FOR THE PHYSICAL AND GEOGRAPHICAL CONDITIONS OF KHMAO YUGRA

For example, in recent years, tornadoes have been observed in the vicinity of the cities of Nefteyugansk (in the summer 2010), Khanty-Mansiysk (June 2012) and Surgut (July 2016).

Nefteyugansk (2010). https://www.1tv.ru/news/2010-07-08/140313-v_nefteyuganske_proizoshlo_unikalnoe_dlya_etih_mest_prirodnoe_yavlenie_tornado

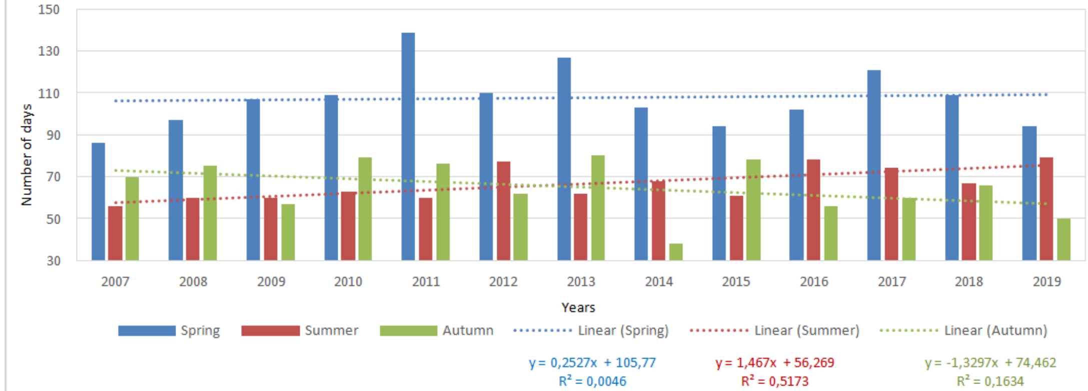
Khanty-Mansiysk (2012). https://www.1tv.ru/news/2012-06-13/94528-po_hanty_mansiyskomu_avtonomnomu_okrugu_proshyolsya_moschnyy_smerch

Surgut (2016) https://www.1tv.ru/news/2016-07-07/305553-gigantskiy_tornado_napugal_zhiteley_surguta

On February 28, 2017, a snow thunderstorm was observed In Nizhnevartovsk. It was a rare natural phenomenon that had never been previously recorded in Yugra.

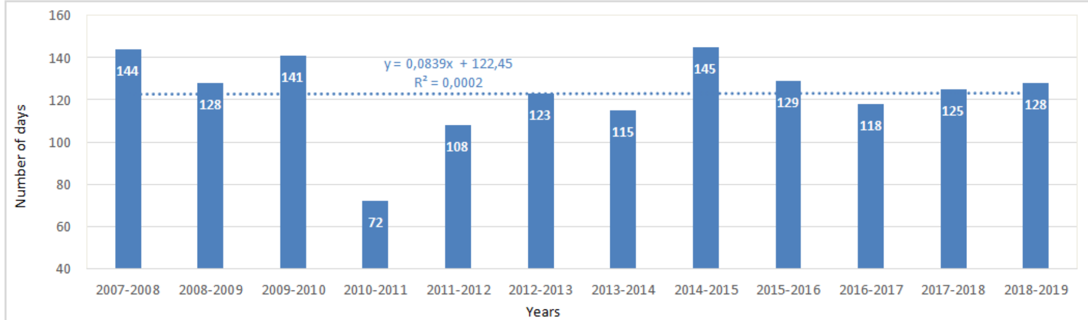
Climate change processes and extreme weather conditions have a significant impact on changing the timing of phenological phenomena in the northern region. Within the city, there is a tendency when first touches of spring are moved to earlier dates. In 2007-2020, the end of the pre-growing sub-season, determined by snow melt, tended to occur at early dates in Nizhnevartovsk. Many of the phenological phenomena have a distinct reaction (early onset) to the spring warming periods in 2009, 2011, 2012, 2017, and, especially, in 2020. After overcoming the initial phenological stages, cold weather may return and weather conditions may deteriorate. For example, in 2010 and 2014, birch leaves completely unfolded and bird cherry trees blossoms relatively late.

The timing of the autumn phenological season in the taiga zone of KhMAO Yugra is diverse. Depending on the meteorological conditions and the nature of weather change, autumn can end in different times in KhMAO Yugra. In 2010, when a cold snap was noted, unfavorable meteorological conditions were observed throughout the area, leading to the early onset of the autumn season. In some years, the duration of autumn is reduced due to the early formation of permanent snow cover, which is a phenological indicator of winter. During the study period, one could clearly observe the time shift of the onset of phenological phenomena in the autumn towards delay on the territory of the taiga zone of KhMAO Yugra.



Analysis of the accuracy of determining values of the trend equation parameters

Nizhnevartovsk	Statistical significance (at a significance level of 0,05)	
	coefficient a	coefficient b
Spring	Is not confirmed	confirmed
Summer	confirmed	confirmed
Autumn	Is not confirmed	confirmed



Analysis of the accuracy of determining values of the trend equation parameters

Nizhnevartovsk	Statistical significance (at a significance level of 0,05)	
	coefficient a	coefficient b
Winter	not confirmed	confirmed

Over the multiyear period under study, in some years, the formation of permanent snow cover in Nizhnevartovsk occurred much later than the multiyear average – at the beginning and in the second half of November (2008, 2010, and 2013). In the autumn and winter seasons, the observed warming processes are also manifested in the delayed formation of freeze-up on rivers and lakes, the occurrence of thaws, and winter rain.

In 2007-2019, the territory of Nizhnevartovsk and its suburbs is characterized by an increase in the duration of the spring period, compared with the average long-term value: +2 days in 2010, +32 days in 2011, +3 days 2012, + 20 days in 2013, +14 days in 2017, and +2 days in 2018. There is also a steady trend towards an increase in the summer season, exceeding the long-term average, especially in 2012 (+11 days), 2016 (+12 days), 2017 (+ 8 days) and 2019 (+13 days).

The extremely warm winter 2019-2020, anomalous meteorological conditions in 2020 on the territory of KhMAO Yugra led to the very early onset of the spring and summer phenological seasons for the entire observation period. Within the city, birch leaves unfolded 23 days earlier than usual (May 07), while bird cherry trees blossomed as early as May 12, 24 days earlier than the average long-term date (this is the phenological indicator of the beginning of *pre-summer*, the final stage of the spring vegetation sub-season); rose hips and raspberries began to bloom by May 20 (26–27 days earlier than the long-term average, respectively).

May 15, 2016 May 15, 2017 May 15, 2018 May 15, 2019 May 15, 2020

Figure 8. Phenological state of bird cherry trees in 2016-2020 within Nizhnevartovsk region

As for the autumn season, there has been a tendency for duration decrease, as evidenced by the linear trends in the onset of indication phenomena (the appearance of yellow strands on birches, complete yellowing of birches, complete exposure of birches, first snow) in 2007-2019.
In 2007-2020, the average long-term duration of phenological winter (from the formation of a stable snow cover to the beginning of snow melt and appearance of first thawed patches) in the city of Nizhnevartovsk and its suburbs is 122 days. During the specified period, the winter seasons of 2007-2008, 2009-2010 and 2014-2015 turned out to be the longest (144, 141, 145 days, respectively), and the winters of 2010-2011 (72 days), 2011-2012 (108 days), 2013-2014 (115 days), 2016-2017 (118 days) and 2019-2020 (112 days) were characterized by the shortest duration.
The observed climate changes led to an increase in the frequency of extreme and catastrophic natural phenomena in 2007-2020 on the territory of KhMAO Yugra.

Many important climate characteristics, such as the length of the frost-free period, the timing of snow cover formation, the onset of the first and last frosts and the distribution of precipitation, the timing of the onset of phenological periods have become more variable. Local climate change is most intensely manifested in spring and autumn, the transitional seasons of the year.

THE OBSERVED CLIMATE CHANGE, THE OCCURRENCE OF EXTREME WEATHER CONDITIONS IN NORTHERN LATITUDES LEAD TO A REACTION OF THE NATURAL ENVIRONMENT, WHICH MANIFESTS ITSELF IN THE SEASONAL RHYTHM OF THE LANDSCAPES OF THE TAIGA ZONE, AFFECT THE RIVER REGIME, THE DEVELOPMENT OF A FIRE HAZARDOUS SITUATION AND DETERMINE THE FUNCTIONING OF THE ECONOMIC ACTIVITY OF THE POPULATION.

THE OBSERVED CLIMATE CHANGE AND THE OCCURRENCE OF EXTREME WEATHER CONDITIONS IN NORTHERN LATITUDES LEAD TO SUCH AN ENVIRONMENTAL REACTION MANIFESTING ITSELF IN THE SEASONAL RHYTHM OF THE TAIGA LANDSCAPES, AFFECTING RIVER REGIME, CAUSING FIRE HAZARDS AND DETERMINING THE FUNCTIONING OF LOCAL ECONOMIC ACTIVITY.

CONCLUSIONS

The study allowed making conclusions on the peculiarities of modern climatic conditions and weather phenomena in the northern latitudes.

1. **Studying the data over a long period (1988-2019), we have observed a tendency to an increase in the average annual air temperature in Khanty-Mansiysk Autonomous Area Yugra. We have found that the previous decade (2010-2019) was the warmest period over the studied time. The observed climate change is characterized by seasonal weather anomalies, an increase in atmospheric precipitation in some seasons of the year. We have observed an increase in the average height of the snow cover and a decrease in the duration of the stable snow cover period.**

2. **The study showed clear environmental reaction to modern climate change, manifested in a change in the timing of phenological phenomena in the taiga zone of KhMAO Yugra. The most intense change in the local climate is manifested in spring and autumn, the transitional seasons of the year, which is confirmed by the reaction of phenological processes. In taiga, we have observed a shift in the phenological boundaries of the autumn season towards later dates.**

3. **In the context of modern climate change, dangerous hydrometeorological phenomena are observed in the area, such floods, natural fires, strong winds, intense rainfall, and severe frosts. Such phenomena cause significant damage to local economy and life of the population. Physical and geographical conditions of the northern region under study are characterized by atypical meteorological phenomena.**

AS FOR VULNERABLE NORTHERN REGIONS, IT IS ESSENTIAL TO CONTINUE STUDYING UNFAVORABLE AND HAZARDOUS HYDROMETEOROLOGICAL PHENOMENA POSING A THREAT TO THE NATURAL ENVIRONMENT, ECONOMY, LIFE AND HEALTH OF THE POPULATION IN ORDER TO PREVENT ADVERSE ENVIRONMENTAL AND ECONOMIC CONSEQUENCES.

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THANK YOU FOR YOUR ATTENTION!