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Original Theoretical Research

Statistical Relationships between Year-to-Year Changes in Fire Hazard due to Weather Conditions in the Uluses (Districts) of Yakutia and Variations in Forest Fire Rates in Previous Years

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Abstract

Introduction. Global climate warming is exacerbating the problem of landscape fires due to increased evaporation of moisture from combustible materials, more frequent dry thunderstorms, extended fire season, and shifting boundaries of landscape zones. These processes pose a particular threat to the forest regions of Russia, especially the Republic of Sakha (Yakutia). Domestic and international researchers have found that year-to-year variations in average monthly surface air temperature (MAT) have a significant impact on variations in fire risks. The authors have previously proved the existence of a positive reverse causality between the indicators of forest fire frequency and temperature anomalies of the following year in many regions of Siberia. However, the significance of this connection at the level of individual uluses of Yakutia, the territories of which coincide with the areas of responsibility of fire departments, has not previously been assessed. This creates a gap in scientific knowledge. The aim of this research is to fill this gap by assessing the significance of this relationship for all uluses of the republic and checking its resistance to time shifts of the analyzed series.

Materials and Methods. The research was conducted using data from 2000–2024. ERA5 reanalysis was used as a source of information on MAT distribution at a height of 2 m above the studied territories, corresponding to the nodes of the 0.25° grid. Information from the Remote Monitoring Information System of the Federal Forestry Agency was used as factual material on the number of landscape fires in the territory of each ulus (district) of Yakutia and the total area of its sites covered by fire each year during the specified period. For each of the 34 uluses (districts) of Yakutia, we calculated the average MAT for their entire territory for the months from May to July, taking into account MAT information corresponding to points for which such information was provided in ERA5. The statistical relationships between interannual changes in the average MAT for the period under review and variations in forest fires indicators throughout Yakutia (one year ahead) were studied using correlation analysis for various time periods lasting 10–20 years. Linear trends were removed from the time series before performing the analysis. The significance of correlation coefficients was assessed using the Student's criterion with a confidence level of 95% or higher. The stability of these relationships was verified by examining their consistency when the series were shifted by one year and when the analyzed segments were varied between 10 and 20 years in length.

Results. The uluses (districts) of Yakutia were identified, where statistical relationships between interannual changes in the average MAT for May–July, with one-year-ahead variations in the number of landscape fires and the area of fire-affected areas of Yakutia from 2000 to 2023, were found to be significant at a confidence level ≥95%. These include uluses (districts) located both in the northern and western parts of the republic's territory, as well as in its central part. The stability of the identified relationships was proved to time shifts of the analyzed periods by units of years into the past and future, as well as to changes in the duration of time series segments within 10–20 years. It was also established that during the period from 2001 to 2023, the relationships under consideration gradually strengthened: the number of uluses and districts with reliability of conclusions ≥95% increased more than twice, and the number of territories with reliability ≥99% rose from zero to 16. The relationship between changes in MAT for the identified uluses (districts) and variations in the number of fires in the territory of Yakutia were more reliable than the relationships with variations in the area of its parts affected by fire.

Discussion. The results confirmed the existence of uluses (districts) on the territory of Yakutia, for which the influence on the interannual changes in MAT exerted by variations in the indicators of forest fires throughout Yakutia, which were 1 year ahead of them in time, was significant. The novelty consisted in identifying all uluses (districts) for which the connections between these processes were significant and resistant to time shifts. The revealed stability of the discovered relationships indicated the fundamental nature of the dependence: contamination of snow by particles of fire aerosols deposited on it reduced the albedo of the underlying surface covered with it, which accelerated melting, increased the temperature and evaporation rate, increasing fire risk. During the period under study, these relationships strengthened, which indicated the influence of climate warming on the activation of the positive reverse causality under consideration. Therefore, with further warming of the climate of Yakutia, they would increase even more. Variations in the number of landscape fires throughout Yakutia had a stronger effect on MAT changes for the identified uluses (districts) than variations in the burned area. The results obtained made it possible to use the indicators of forest fires throughout Yakutia of the previous year as predictors for long-term MAT forecasts for its identified areas (uluses).
Conclusion. Uluses (districts) in Yakutia have been identified, for which the statistical relationship between changes in forest burning rates throughout the republic and annual MAT variations in May — July are significant. With a reliability of ≥95% for such uluses (districts) for the period from 2015 to 2024, 23 were identified, and with a reliability of ≥99%, 16 were identified. The stability of these relationships to time shifts and the duration of time series have been proved. It is established that for 2001–2024, the identified relationships have significantly strengthened, which indicates the activation of the positive reverse causality in question in the region. The tasks set in the work have been solved: the locations of the uluses (districts) of Yakutia have been determined, as well as the months for which the considered relationships are the strongest and most stable. It is also shown that the number of fires on the entire territory of Yakutia serves as a more informative predictor of the prognostic models of the studied process for its uluses (districts) than the burned area. The results of the study suggest that it is possible to use the results of monitoring forest fires in Yakutia to create forecasts for the upcoming year for the identified uluses (districts). This is particularly important for optimizing fire management strategies in a changing climate, as the months of May — July account for the peak of forest fires.

Keywords: forest fires in Sakha (Yakutia), surface air temperature, forest flammability, forest fire forecast, area burned

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Оригинальное теоретическое исследование

Особенности статистических связей межгодовых изменений пожароопасности по условиям погоды в улусах (районах) Якутии с вариациями показателей горимости ее лесов в предыдущие годы

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Аннотация
Введение. Глобальное потепление климата обостряет проблему ландшафтных пожаров вследствие усиления испарения влаги из горючего материала, увеличения повторяемости сухих гроз, расширения пожароопасного сезона и смещения границ ландшафтных зон. Особую угрозу эти процессы представляют для лесных регионов России, прежде всего для Республики Саха (Якутия). В работах отечественных и зарубежных исследователей установлено значимое влияние межгодовых колебаний среднемесячных температур приземного воздуха (СТВ) на вариации пожарных рисков. Авторами ранее доказано существование во многих районах Сибири положительной обратной связи между показателями горимости лесов и температурными аномалиями последующего года. Однако значимость этой связи на уровне отдельных улусов Якутии, территории которых совпадают с зонами ответственности противопожарных подразделений, ранее не оценивалась, что формирует существенный пробел в научном знании. Целью исследования является восполнение данного пробела путем оценки значимости указанной связи для всех улусов республики и проверки ее устойчивости к временным сдвигам анализируемых рядов.
Материалы и методы. Исследование проводилось с использованием данных за 2000–2024 гг. Как источник информации о распределении СТВ на высоте 2 м над изучаемыми территориями, соответствующими узлам сетки 0,25°, использован реанализ ERA5. Как фактический материл о количестве ландшафтных пожаров на территории каждого улуса (района) Якутии и общей площади ее участков, пройденных огнем в тот или иной год из указанного периода, использованы сведения Информационной системы дистанционного мониторинга Федерального агентства лесного хозяйства. Для каждого из 34 улусов (районов) Якутии с учетом информации об СТВ, соответ-

ствующей пунктам, для которых в ERA5 представлены такие сведения, вычислены средние СТВ по всей его территории для месяцев с мая по июль. Статистические связи между межгодовыми изменениями средних СТВ за рассматриваемый период и вариациями показателей горимости лесов всей Якутии (опережающими их на один год) исследовались методом корреляционного анализа для различных отрезков времени длительностью 10–20 лет. Перед проведением анализа из сопоставляемых временных рядов удалялись линейные тренды. Значимость корреляционных коэффициентов оценивалась с использованием критерия Стьюдента при уровне достоверности не менее 95 %. Устойчивость выявленных связей проверялась путем изучения их сохранения при временных сдвигах рядов на единицы лет и при изменении длины анализируемых отрезков в пределах 10–20 лет.

Результаты исследования. Установлены улусы (районы) Якутии, для которых статистические связи межгодовых изменений средних СТВ для мая — июля с опережающими их по времени на один год вариациями количества ландшафтных пожаров и площади участков всей территории Якутии, пройденных огнем за каждый из 2000–2023 годов, с достоверностью ≥95 % признаны значимыми. К ним относятся улусы (районы), расположенные как в северной и западной части территории республики, так и в ее центральной части. Доказана устойчивость выявленных связей к временным сдвигам анализируемых периодов на единицы лет в прошлое и будущее, а также к изменению продолжительности отрезков временных рядов в пределах 10–20 лет. При этом установлено, что в период 2001–2023 гг. рассматриваемые связи прогрессивно усиливаются: количество улусов и районов, для которых достоверность выводов ≥95 %, увеличилось более чем в два раза, а число территорий, где достоверность ≥99 %, выросло с нуля до 16. Связи изменений СТВ для выявленных улусов (районов) с вариациями количества пожаров на территории Якутии обладают более высокой достоверностью, чем их связи с вариациями площади участков, пройденных огнем за год.

Обсуждение. Полученные результаты подтверждают существование на территории Якутии улусов (районов), для которых влияние на межгодовые изменения СТВ, оказываемое вариациями показателей горимости лесов всей Якутии, опережающими их по времени на 1 год, является значимым. Их новизна состоит в выявлении всех улусов (районов), для которых связи между этими процессами являются значимыми и обладают устойчивостью к временным сдвигам. Выявленная устойчивость обнаруженных связей указывает на фундаментальный характер зависимости: загрязнение снега осевшими на него частицами пожарных аэрозолей снижает альбедо покрытой им подстилающей поверхности, что ускоряет таяние, повышение СТВ и интенсивности испарения, усиливая пожароопасность. За изучаемый период эти связи усилились, что свидетельствует о влиянии потепления климата на активизацию рассматриваемой положительной обратной связи. Поэтому при дальнейшем потеплении климата Якутии они еще более усилятся. Вариации количества ландшафтных пожаров на всей территории Якутии сильнее влияют на изменения СТВ для выявленных улусов (районов), чем вариации площади выгорания. Полученные результаты позволяют использовать показатели горимости лесов всей Якутии предыдущего года как предикторы при долгосрочном прогнозировании СТВ для выявленных ее районов (улусов).

Заключение. Выявлены улусы (районы) Якутии, для которых статистические связи между изменениями показателей горимости лесов на всей территории республики и запаздывающими по отношению к ним на год вариациями СТВ в мае — июле являются значимыми. При достоверности такого вывода ≥95 % таких улусов (районов) для периода 2015–2024 гг. выявлено 23, а при достоверности ≥99 % — 16. Доказана устойчивость этих связей к временным сдвигам и длительности временных рядов. Установлено, что за 2001–2024 гг. выявленные связи существенно усилились, что указывает на активизацию в регионе рассматриваемой положительной обратной связи. Поставленные в работе задачи решены: определены расположения улусов (районов) Якутии, а также месяцы, для которых рассматриваемые связи являются наиболее сильными и устойчивыми. Показано также, что количество пожаров на всей территории Якутии служит более информативным предиктором прогностических моделей изучаемого процесса для ее улусов (районов), чем площадь выгорания. Результаты исследования открывают возможность использования результатов мониторинга показателей горимости лесов Якутии для разработки прогнозов на предстоящий год СТВ на территориях выявленных ее улусов (районов) для месяцев май — июль, на которые приходится пик их горимости. Это имеет практическое значение для оптимизации стратегий противопожарного менеджмента в условиях меняющегося климата.

Ключевые слова: возгорания лесов в Саха (Якутия), температура приземного воздуха, горимость лесов, лесопожарный прогноз, пройденная огнем площадь

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Introduction. Long-term forecasts of dangerous effects of climate warming are essential for improving the management of activities of the departments and services involved in fire prevention and elimination. Therefore, enhancing the accuracy of these forecasts for various months in the coming year is a critical safety concern in emergency planning.

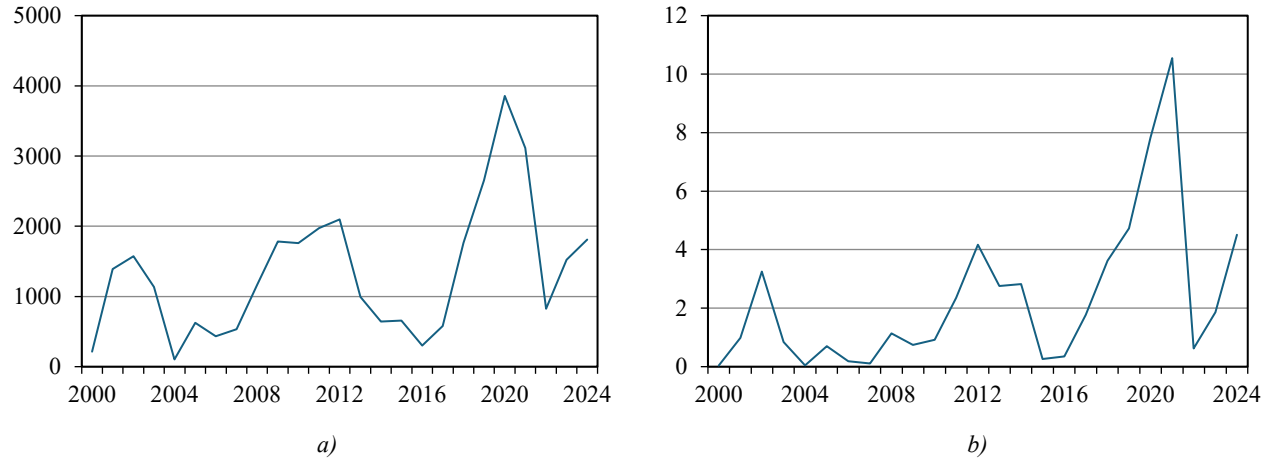
According to existing ideas about the consequences of Siberian climate warming [1], several processes contribute to an increase in the number of landscape fires (LFN) that occur there and the total area covered by fire (ACF). These processes include: disruption of the hydrological cycle due to increased evaporation of moisture from flammable material, extension of the fire season [2], and displacement of vegetation boundaries to higher latitudes [3]. Climate change also leads to the introduction of invasive species into ecosystems, which accelerates the formation of flammable materials [4]. Consequently, climate warming causes an increase in statistical relationships between changes in the average monthly temperatures of surface air over the studied area and variations in the mentioned indicators of forest burning. At the same time, not only are direct links being strengthened (an increase in forest-covered areas is the reason for an increase in their burning), but also the opposite is happening. As shown in [5], an increase in the burning rate of Yakutia's forests in the previous fire season, for some reason, leads to an increase in the amount of pyrogenic substances released into the atmosphere during this time. These substances are distributed over the territory of Siberia by the winds of the southern bearings that prevail in the autumn and winter months. Pyrogenic substances have been settling on the snow cover since autumn, increasing its heterogeneity and, consequently, reducing the albedo [6]. This results in more intense spring snowmelt. Combustible material dries out faster in these areas, increasing both the MAT [7] and the fire frequency in forests in May and June [8]. A cause-and-effect relationship can easily be seen. The more intense the fires were in the previous year, the more combustion products were formed. As a result, the temperature in the area where they occurred rose faster in spring. This is an inverse relationship. In some areas, this can be significant and long-lasting, and it is dangerous because it leads not only to an increase in the number of LFN and ACF, but also the intensification of other effects of local climate warming.

In [5], it was found that this relationship was most significant for Yakutia and to a lesser extent for the Krasnoyarsk Territory. However, the question of which districts or uluses within these regions possess this property and stability has not been adequately studied. This gap in knowledge is because the areas of responsibility for many fire departments in Yakutia overlap with these territories, and long-term forecasts for them proposed by the Hydrometeorological Center of Russia are characterized by a justification of 0.7–0.8 (according to the developers' estimates) [9].

When developing such forecasts, numerous factors of the studied processes are taken into account, which can be significant and stable under certain conditions. Therefore, expanding the list of such factors and identifying the mentioned conditions is one of the promising areas for improving the quality of such forecasts [10].

At the same time, these conditions have not been identified for such a factor of interannual MAT variations as changes in indicators of forest fires in Yakutia. This limits the possibility of considering it in forecasting. Determination of these factors is of greatest interest to regions with significant forest resources whose populations, ecosystems and economies are greatly damaged by forest fires every year [11].

In Russia, the largest of these regions is the Republic of Sakha (Yakutia) [12]. Its forest resources have been increasingly damaged in the 21st century. This is confirmed by the corresponding dependence of LFN and ACF on time (Fig. 1).



a) *b)*

Fig. 1. Time dependencies of the indicators of landscapes fires of Yakutia, constructed by the authors based on remote monitoring data[1]: *a* — LFN; *b* — ACF, million hectares

[1] *Federal Forestry Agency. Remote Monitoring Information System. Fire Hazard Monitoring Unit.* (In Russ.) URL: https://pushkino.aviales.ru/main_pages/index.shtml (accessed: 06.04.2026).

As can be seen from Figure 1, the changes in LFN and ACP for Yakutia occur quasi-cyclically, with a period close to 11 years. At the same time, in the period 2000–2023, these changes showed trends of their intensification. The maximum values of CLP and ACF in the 21st century occurred in 2020 and exceeded the minimum values of this indicator by more than 10 and 100 times [5]. Forecasts of these indicators or MAT for the coming year, which were of satisfactory quality, were necessary for managing and planning the activities of fire departments.

Consequently, the improvement of the methodology for their development is of not only theoretical but also practical interest.

According to existing ideas about the promising areas of development of such techniques [13], one of them is to identify factors of interannual MAT changes that can have a significant impact on fluctuations that are delayed by a time equal to the required earliness of forecast. The relationship of such factors with the predicted process should be resistant to time shifts of the compared fragments of their time series [14]. They should also have some resistance to changes in the length of these fragments[2]. Such stability, which has occurred in the past, allows us to assume that the identified relationships will remain significant in the future [15].

In Yakutia, the areas of responsibility for most fire departments overlap with the territories of the uluses (districts). Therefore, for each ulus, we need to develop MAT forecasts for the upcoming year, not for Yakutia as a whole, but for specific territories.

At the same time, there are no established dependencies for the uluses of Yakutia, where the links between MAT changes in current year temperatures and variations in forest fire rates in the previous year are significant and stable. This prevents them from being taken into account when developing forecasts, which are in high demand among firefighters.

The above allows us to hypothesize that there are uluses (districts) on the territory of Yakutia for which the relationship between the interannual MAT changes in the current year climate and variations in forest fire rates in the previous year are significant and stable.

Despite the causal nature of the relationship under study, its significance for the whole of Yakutia does not necessarily imply its significance and stability for any particular district. Therefore, the hypothesis put forward is by no means trivial.

Confirmation of the validity of the hypothesis for the uluses of Yakutia would allow us to take into account the dependencies in question when making forecasts for these regions and, consequently, the fire hazard for the upcoming year. However, this hypothesis has not been previously tested.

The aim of this work was to identify the districts and uluses of Yakutia for which the hypothesis was valid in certain months, as well as to assess the stability of the studied relationships to time shifts.

To achieve this goal, the following tasks were set:

– identification of uluses (districts) of Yakutia, for which, in some months, variations in LFN and ACF throughout the republic in previous years were a significant factor in the interannual MAT changes;

– assessment of the stability of the identified significant relationships to shifts in the studied segments of MAT series and their predictors over time, as well as to changes in the duration of these segments.

Materials and Methods. When solving the first task, we took into account the fact that the Republic of Sakha (Yakutia) is the largest region in Russia (3,083,523 km^2), located in northern Siberia. The climate of Yakutia is extremely continental. The fire season covers the period from May to September. The peak of forest fires on most of the territory of the republic occurs in June, although for villages located in the northern part, it occurs in July.

Yakutia includes a city of republican significance (Yakutsk) and 34 uluses (districts). In Figure 2, Yakutsk is highlighted in red. The districts are: 1 — Abyysky, 2 — Aldansky, 3 — Allaikhovsky, 4 — Amginsky, 6 — Bulunsky, 7 — Verkhnevilyuysky, 8 — Verkhnekolymsky, 9 — Verkhoyansky, 10 — Vilyuysky, 14 — Lensky, 16 — Mirninsky, 17 — Momsky, 19 — Neryungrinsky, 20 — Nizhnekolymsky, 21 — Nyurbinsky, 23 — Olenyoksky Evenkiysky National, 24 — Olyokminsky, 26 — Suntarsky, 28 — Tomponsky. The following uluses are designated: 5 — Anabarsky national (Dolgano- Evenkiysky), 11 — Gorny, 12 — Zhigansky, 13 — Kobyaysky, 15 — Megino-Kangalassky, 18 — Namsky, 22 — Oymyakonsky, 25 — Srednekolymsky, 27 — Tattinsky, 29 — Ust-Aldansky, 30 — Ust-Maysky, 31 — Ust-Yansky, 32 — Khangalassky, 33 — Churapchinsky, 34 — Eveno-Bytantaysky National. The same numerical designations of districts and uluses of Yakutia are used in tables with research result.

[2] *Technologies of Dynamic and Statistical Long-Term Meteorological Forecasts: Current State and Prospects.* (In Russ.) URL: https://old.meteoinfo.ru/training/206-2011-02-20-07-18-08 (accessed: 20.02.2011).

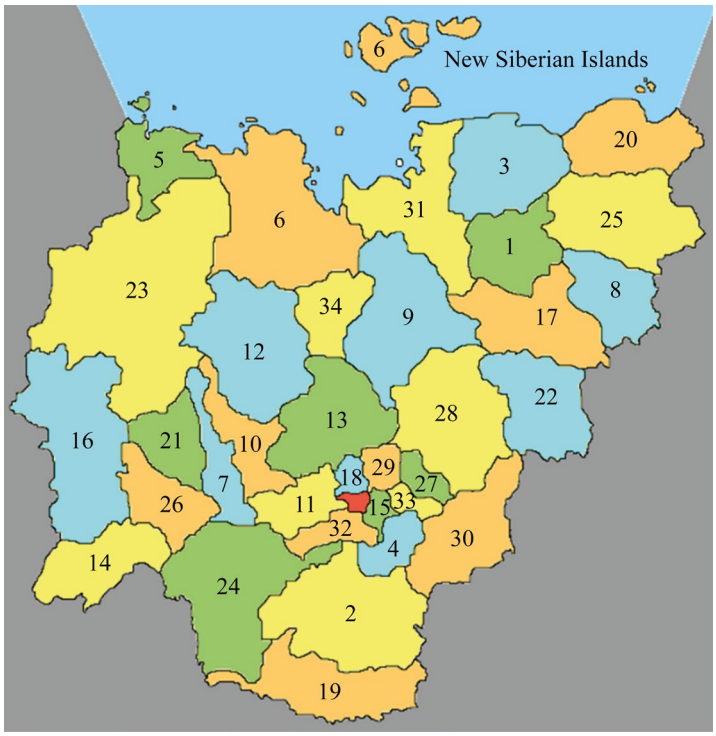


Fig. 2. Location of uluses (districts) of the Republic of Sakha (Yakutia) [16]

Information from the ERA5 reanalysis on changes in this indicator at an altitude of 2 m above the Earth's surface was used as factual material on MAT changes in various points of the territory of each ulus of Yakutia [17]. The information used described MAT changes for May — July from 2001 to 2024[3]

For each of the 34 uluses (districts) of Yakutia, we calculated the average MAT for its entire territory for the months from May to July, taking into account the information about the MAT corresponding to its points, for which such data was available in ERA5.

For selective testing of the reanalysis results, information was used on changes in the period from 2010 to 2023 in the settlements of Yakutsk, Sangar, Aldan, Amga, Oymyakon, Olekminsk, Lensk, Vilyuysk, Verkhoyansk and Chersky[4].

It was found that for any time periods lasting 10–20 years for the period from 2000 to 2024, the correlation coefficient of the time series formed from station data and the series formed from the results of ERA5 were at least 0.99. Thus, the testing confirmed the suitability of the ERA5 reanalysis information for solving the tasks set.

The Information System of Remote Monitoring of the Federal Forestry Agency was used as a source of information on changes in the LFN and ACF in 2000–2023 in the territory of Yakutia, as well as in each of its ulus (districts).

The relationships between the interannual changes in MAT in 2001–2024 over the territory of a particular district of Yakutia in a certain month and the one-year-ahead LFN and ACF variations for the entire territory were studied for various periods ranging from 10 to 20 years. The method of correlation analysis was used in this case.

Before performing the analysis, linear trends were compensated in the compared series. For this, the corrected value of the studied indicator $X(k)$ was calculated:

$$X(k) = X_0(k) - L \times (k - k_0).$$

Here k — year corresponding to the considered term of the studied segment of the time series of the process or its factor, which could take values from 2000 to 2024; k_0 — year corresponding to the first term of the considered segment of the studied time series; X_0 (k) — term of the initial time series corresponding to year k; L — value of the angular coefficient of the linear trend, calculated by the least squares method for the studied segment of the time series under consideration.

The decision on the significance of the considered relationships was made if the reliability of such a statistical conclusion exceeded 0.95. The value of the correlation coefficient was considered as a characteristic of the relationship.

[3] *ERA5 hourly data on pressure levels from 1940 to present.* URL: https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-pressure-levels?tab=form (accessed: 06.04.2026).

[4] *Global climate data tutiempo net climate data.* URL: https://www.google.com/search?q=tutiempo+net+climate+data&rlz (accessed: 06.04.2026).

It was assumed that deviations of the indicators of the studied processes from the corresponding trends were normal random processes. Its validity was confirmed using the Pearson's criterion. Therefore, to assess the significance of the calculated value of the correlation coefficient, the Student's criterion was used. The threshold level of this coefficient, at which a decision was made on the significance of the studied relationship, was determined according to the Student's distribution tables, taking into account the number of degrees of freedom of the compared time series. The latter was determined by their autocorrelation functions. Also, according to the Student's distribution tables, the values of the same coefficient were determined, when exceeded, the reliability of conclusions about the significance of the relationship was 0.9 and 0.99. It was established that the number of degrees of freedom of the studied series was equal to their length. Therefore, with a length of 10 years, the reliability of the statistical conclusion about the significance of the studied relationships was at least 90% if the corresponding value of the correlation coefficient exceeded 0.52. The reliability of this conclusion was at least 95% if the value of the correlation coefficient of the processes under consideration exceeded 0.635, and if its value was 0.745, the reliability of this conclusion was at least 99%.

With a series length of 20 years, the reliability of the conclusion on the significance of the studied relationships of 90% corresponded to the threshold level of the correlation coefficient of 0.36, and the reliability of the same conclusion of 95% and 99% corresponded to the threshold levels of this coefficient of 0.45 and 0.58, respectively.

When solving the second task, the stability of the identified significant relationships between interannual MAT changes and LFN and ACF variations to time shifts in the considered segments of the time series under study, as well as to changes in their length, was evaluated. Time shifts by units of years were considered, both in the past and in the future. It was assumed that the lengths of the studied time series could range from 10 to 20 years.

To assess the stability of the studied relationships, the values of the correlation coefficient of the MAT time series were compared with the LFN or ACF series for each ulus (district) of Yakutia, corresponding to the studied time periods, which differed in the year of their beginning, as well as in length. At the same time, the values of the threshold levels of the correlation coefficient were taken into account, corresponding to the considered reliability of conclusions about their significance, as well as the number of degrees of freedom of the studied series.

The relationships between the studied processes were recognized as stable to the time shifts under consideration if they were significant for all the studied periods with a confidence level of at least 95%.

These relationships were considered to be resistant to variations in the length of the studied segments, if at any value ranging from 10 to 20 years they were significant with a confidence level of at least 95%.

Results. When solving the first problem, we found that there were significant statistical correlations between interannual MAT changes over the territories of some uluses of Yakutia over time periods of 10–20 years and one-year-ahead variations in forest fire rates in the period from 2000 to 2023. These correlations were significant only for the months of May — July.

As an example, Table 1 shows the values of the correlation coefficient of the interannual MAT changes over the territories of uluses (districts) of Yakutia for the period from 2012 to 2021 with the ACF variations in 2011–2020. In this and future tables, the values of these coefficients will be highlighted in yellow for values with reliability exceeding 90%; green for values with a reliability of 95%; and blue for values with a reliability of 99% or higher.

Table 1

Values of the correlation coefficient of interannual MAT changes over the territories of uluses (districts) of Yakutia for the period from 2012 to 2021 with ACF variations in 2011–2020

Ulus no. (district)	May	June	July	Ulus no. (district)	May	June	July	Ulus no. (district)	May	June	July
1	0.661	0.626	0.556	13	0.599	0.462	0.572	25	0.410	0.567	0.409
2	0.028	0.318	0.264	14	0.452	0.243	0.553	26	0.578	0.440	0.626
3	0.673	0.680	0.580	15	0.499	0.606	0.503	27	0.504	0.576	0.564
4	0.206	0.505	0.280	16	0.654	0.217	0.544	28	0.459	0.649	0.559
5	0.669	0.185	0.638	17	0.528	0.652	0.438	29	0.492	0.577	0.616
6	0.610	0.381	0.695	18	0.028	0.318	0.264	30	0.213	0.557	0.274
7	0.590	0.490	0.616	19	0.165	0.455	0.297	31	0.728	0.535	0.568
8	0.414	0.500	0.500	20	0.778	0.553	0.586	32	0.302	0.488	0.478
9	0.694	0.609	0.673	21	0.616	0.468	0.662	33	0.475	0.554	0.530
10	0.575	0.518	0.629	22	0.304	0.570	0.373	34	0.745	0.585	0.702
11	0.458	0.469	0.536	23	0.468	0.446	0.520	Yakutsk	0.494	0.595	0.511
12	0.597	0.469	0.719	24	0.722	0.329	0.572	The whole Yakutia	0.628	0.545	0.683

As follows from Table 1, the conclusion about the significance of the relationship between the interannual MAT changes for May from 2012 to 2021 and the one-year-ahead ACF variations was characterized by a reliability of at least 99% for the Nizhnekolymsky district and the Eveno-Bytantaysky national district. The reliability of this conclusion exceeded 95% for the Abyysky, Allaikhovsky, Bulunsky, Verkhoyansky, Mirninsky, Olenyoksky districts, as well as the Afor nabarsky national (Dolgano-Evenkiysky) ulus. As we can see from Figure 2, the considered relationships with the indicated reliability could be considered significant for the districts and uluses of Yakutia located in its northern and western parts.

For June, the same conclusion was valid with a confidence of at least 95% for Allaikhovsky, Momsky and Tomponsky districts. For July, it was adequate with the same reliability for the Bulunsky, Verkhoyansky, Nyurbinsky districts, as well as the Anabarsky national (Dolgano-Evenkiysky), Eveno-Bytantaysky national and Zhigansky districts. For the whole of Yakutia, the conclusion under consideration was valid with a reliability of at least 90% for May and June and 95% reliability for July.

Table 2 demonstrates the correlation coefficient values of the interannual MAT changes over the territories of uluses (districts) of Yakutia for the period from 2012 to 2021 with LFN variations in 2011–2020.

Table 2

Correlation coefficient values of interannual MAT changes over the territories of uluses (districts) of Yakutia for the period from 2012 to 2021 with LFN variations in 2011–2020

Ulus no. (district)	May	June	July	Ulus no. (district)	May	June	July	Ulus no. (district)	May	June	July
1	0.859	0.675	0.393	13	0.734	0.630	0.516	25	0.723	0.659	0.164
2	0.069	0.450	0.226	14	0.352	0.243	0.433	26	0.520	0.479	0.491
3	0.872	0.744	0.525	15	0.600	0.804	0.533	27	0.608	0.797	0.536
4	0.325	0.694	0.310	16	0.605	0.239	0.420	28	0.601	0.875	0.552
5	0.757	0.297	0.731	17	0.746	0.799	0.303	29	0.579	0.791	0.613
6	0.748	0.507	0.749	18	0.069	0.450	0.226	30	0.348	0.687	0.318
7	0.568	0.593	0.507	19	0.071	0.463	0.313	31	0.835	0.653	0.511
8	0.716	0.591	0.188	20	0.897	0.596	0.544	32	0.332	0.679	0.426
9	0.760	0.703	0.583	21	0.607	0.512	0.565	33	0.584	0.773	0.572
10	0.542	0.654	0.545	22	0.557	0.763	0.349	34	0.818	0.706	0.592
11	0.489	0.673	0.517	23	0.326	0.490	0.381	Yakutsk	0.593	0.794	0.531
12	0.701	0.603	0.680	24	0.724	0.383	0.567	The whole Yakutia	0.736	0.790	0.611

It follows from Table 2 that the conclusion about the significance of the relationship between the interannual MAT changes in 2012–2021 for May and the LFN variations for 2011–2020 was characterized by a reliability of at least 0.99 for the Abyysky, Allaikhovsky, Bulunsky, Verkhoyansky, Momsky, Nizhnekolymsky Ust-Yansky districts and the Anabarsky national (Dolgano- Evenkiysky), Eveno-Bytantaysky national, as well as Kobyaysky uluses.

For June, this conclusion was equally valid for Momsky, Tomponsky district, Megino-Kangalassky, Tattinsky, Ust-Aldansky, Churapchinsky districts, as well as for Yakutsk.

For July, it was equally adequate only for the Bulunsky district.

Throughout Yakutia, the conclusion under consideration was valid with confidence: for May — at least 95%; for June — at least 99%; for July — at least 90%.

From the comparison of Table 1 and Table 2 it was clear that the districts and uluses of Yakutia, for which the relationship of interannual MAT changes with ACF and LFN variations was significant, largely coincided. But the reliability of conclusions about the significance of the relationship between the average MAT and LFN (both for individual districts and Yakutia as a whole) was noticeably higher.

Similar patterns were evident in the distribution of the characteristics of the considered relationships across the territory of Yakutia for other time periods under study. At the same time, the reliability of conclusions about the significance of the relationships between the average MAT and LFN was higher than the similar characteristic of the relationships between the average MAT and ACF not for any values of the duration of the studied segments of the time series under consideration.

When solving the second problem, it was found that the significant statistical relationships identified for the period 2012–2021 for the interannual MAT changes for the months from May to July, as well as for the one-year-ahead ACF or LFN, remained significant for many other time periods of the same duration.

As an example, Table 3 shows the values of the correlation coefficient of the interannual MAT changes corresponding to June for the time periods 2011–2020, 2012–2021, 2013–2022, 2014–2023, with one-year-ahead ACF variations.

Table 3

Correlation coefficient values of the interannual MAT changes corresponding to June for various uluses and districts of Yakutia, as well as for different time periods of 10 years with one-year-ahead ACF variations

Ulus no. (district)	Period				Ulus no. (district)	Period			
	2011–2020	2012–2021	2013–2022	2014–2023		2011–2020	2012–2021	2013–2022	2014–2023
1	0.583	0.626	0.625	0.719	19	0.419	0.455	0.494	0.500
2	0.139	0.318	0.415	0.425	20	0.546	0.553	0.554	0.630
3	0.615	0.680	0.679	0.723	21	0.454	0.468	0.465	0.463
4	0.272	0.505	0.651	0.663	22	0.449	0.570	0.619	0.613
5	0.320	0.185	0.186	0.263	23	0.063	0.446	0.442	0.456
6	0.362	0.381	0.381	0.489	24	0.442	0.329	0.324	0.406
7	0.363	0.490	0.487	0.481	25	0.425	0.567	0.564	0.638
8	0.509	0.500	0.514	0.584	26	0.109	0.440	0.436	0.431
9	0.612	0.609	0.606	0.648	27	0.412	0.576	0.687	0.704
10	0.437	0.518	0.520	0.513	28	0.495	0.649	0.732	0.741
11	0.273	0.469	0.492	0.483	29	0.429	0.577	0.620	0.633
12	0.451	0.469	0.476	0.511	30	0.374	0.557	0.882	0.880
13	0.588	0.462	0.597	0.603	31	0.552	0.557	0.588	0.640
14	–0.129*	0.243	0.235	0.250	32	0.225	0.488	0.533	0.535
15	0.430	0.606	0.662	0.675	33	0.416	0.554	0.654	0.671
16	–0.008*	0.217	0.208	0.221	34	0.544	0.585	0.589	0.654
17	0.609	0.652	0.655	0.701	Yakutsk	0.412	0.595	0.649	0.661
18	0.146	0.318	0.406	0.414	The whole Yakutia	0.485	0.645	0.683	0.707

Note: * The limits of the correlation coefficient — from –1 to +1. The table shows that negative indicators were insignificant (close to zero), and therefore could be the result of unaccounted-for random factors. The same applied to small positive coefficient.

Table 3 demonstrates that the values of the correlation coefficient of the interannual MAT changes, corresponding to June, with one-year-ahead ACF variations for 2013–2022, 2014–2023 exceeded the threshold of significance corresponding to the reliability of 0.9 for all districts and uluses of Yakutia, where this was the case for the period from 2012 to 2021.

For the period 2011–2020, a similar conclusion was valid only for the Abyysky, Allaikhovsky, Verkhoyansky, Momsky, Nizhnekolymsky districts, as well as Ust-Yansky, Kobyaysky, and Eveno-Bytantaysky national districts. It follows from this that in the modern period, the stability of the identified links increased over time. As you can see, these relationships were also strengthening.

For the period 2011–2020, we found only eight uluses or districts of Yakutia, for which the reliability of the conclusion about their significance for June exceeded 90%. At the same time, its reliability did not reach the level of 0.95 or 0.99 anywhere.

For the period 2012–2021, 16 districts were identified, and three districts were found with the reliability of the same conclusion exceeding 95%. The 99% level of this indicator was also nowhere to be reached.

For the period 2013–2022, 19 districts were identified where the reliability of the same conclusion exceeded 90%. The confidence level of 95% was exceeded in nine districts. For Ust-Maysky ulus, the reliability of the conclusion about the significance of the studied relationships exceeded 99%.

For the period 2014–2023, the reliability of the considered conclusion exceeded 90% for 20 districts. Its level of 95% was exceeded in 13 districts, and the level of 99% was exceeded in two (in Ust-Maysky ulus and Tomponsky district).

The correlation coefficient values of the interannual MAT changes corresponding to June for the time periods 2011–2020, 2012–2021, 2013–2022, 2014–2023, with one-year-ahead LFN variations are presented in Table 4.

Table 4

Correlation coefficient values of interannual MAT changes over the uluses (districts) Yakutia, for different time periods of 10 years with one-year-ahead LFN variations on its territory

Ulus no. (district)	Period				Ulus no. (district)	Period			
	2011–2020	2012–2021	2013–2022	2014–2023		2011–2020	2012–2021	2013–2022	2014–2023
1	0.617	0.675	0.715	0.830	19	0.427	0.463	0.450	0.458
2	0.340	0.450	0.456	0.470	20	0.549	0.596	0.647	0.742
3	0.721	0.744	0.777	0.841	21	0.480	0.512	0.560	0.559
4	0.494	0.694	0.756	0.774	22	0.652	0.763	0.767	0.764
5	0.327	0.297	0.298	0.401	23	0.445	0.490	0.510	0.530
6	0.409	0.507	0.513	0.653	24	0.267	0.383	0.404	0.508
7	0.341	0.593	0.614	0.611	25	0.629	0.659	0.682	0.776
8	0.588	0.591	0.629	0.718	26	0.467	0.479	0.519	0.514
9	0.619	0.703	0.731	0.786	27	0.543	0.797	0.842	0.867
10	0.635	0.654	0.658	0.654	28	0.626	0.875	0.903	0.918
11	0.569	0.673	0.667	0.662	29	0.662	0.791	0.794	0.814
12	0.608	0.603	0.623	0.672	30	0.590	0.687	0.876	0.873
13	0.694	0.630	0.785	0.796	31	0.488	0.593	0.657	0.762
14	–0.081*	0.243	0.317	0.337	32	0.464	0.679	0.679	0.684
15	0.598	0.804	0.813	0.832	33	0.555	0.773	0.809	0.835
16	–0.050*	0.239	0.327	0.345	34	0.558	0.706	0.738	0.822
17	0.655	0.799	0.802	0.863	Yakutsk	0.584	0.794	0.801	0.820
18	0.353	0.450	0.452	0.465	The whole Yakutia	0.692	0.790	0.763	0.792

Note:* The correlation coefficient limits — from –1 to +1. The table shows that negative indicators were insignificant (close to zero), and therefore could be the result of unaccounted-for random factors. The same applied to small positive coefficients.

Table 4 demonstrates that the correlation coefficient values of the interannual MAT changes corresponding to June with one-year-ahead LFN variations for the time periods 2013–2022, 2014–2023 also exceeded the threshold of significance corresponding to the reliability of 90% for all districts or uluses of Yakutia, where this occurred for the period 2012–2021. For all the time periods under consideration, they exceeded this threshold for 19 uluses or districts of Yakutia (out of 35 possible ones, including the city of Yakutsk).

It followed from this that the stability of the revealed MAT—LFN relationships to changes in the start date of the compared segments of the studied time series with a length of 10 years was higher than the MAT—ACF ones. At the same time, it also increased over time. The number of districts was increasing, where the reliability of the conclusion about their significance exceeded 99%.

No such districts have been identified for the period 2011–2020. There were eight districts for the period 2012–2021, 12 districts for the period 2013–2022, and 16 districts for the period 2014–202.

Similar features corresponded to the considered relations also for May and July.

When solving the second task, uluses (districts) of Yakutia were identified, for which the reliability of the conclusion about the correlation coefficient significance of the time series of the average MAT for different months, as well as the series of one-year-ahead LFN and ACF, was 95% and 99%, provided that they contained from 10 to 20 terms.

As an example, Table 5 shows the correlation coefficients values of the time series of the average MAT over the territories of various uluses and districts of Yakutia for June, corresponding to the periods 2001–2021 and 2012–2021, as well as the series of LFN and ACF for the time periods 2000–2020 and 2011–2020.

Table 5

Correlation coefficients values of the series of average MAT over the territories of various uluses and districts of Yakutia for June, corresponding to the periods 2001–2021 and 2012–2021, as well as the series of LFN and ACF for the periods 2000–2020 and 2011–2020

MAT — LFN						MAT — ACF					
Ulus no. (district)	2001–2021	2012–2021	Ulus no. (district)	2001–2021	2012–2021	Ulus no. (district)	2001–2021	2012–2021	Ulus no. (district)	2001–2021	2012–2021
1	0.521	0.675	19	0.115	0.463	1	0.657	0.626	19	0.142	0.455
2	0.131	0.450	20	0.515	0.596	2	0.139	0.318	20	0.617	0.553
3	0.597	0.744	21	0.327	0.512	3	0.643	0.680	21	0.525	0.468
4	0.302	0.694	22	0.341	0.763	4	0.312	0.505	22	0.396	0.570
5	0.276	0.297	23	0.197	0.490	5	0.399	0.185	23	0.218	0.446
6	0.451	0.507	24	0.222	0.383	6	0.517	0.381	24	0.467	0.329
7	0.340	0.593	25	0.559	0.659	7	0.493	0.490	25	0.525	0.567
8	0.559	0.591	26	0.255	0.479	8	0.598	0.500	26	0.384	0.440
9	0.461	0.703	27	0.324	0.797	9	0.584	0.609	27	0.382	0.576
10	0.341	0.654	28	0.322	0.875	10	0.486	0.518	28	0.394	0.649
11	0.336	0.673	29	0.379	0.791	11	0.364	0.469	29	0.451	0.577
12	0.358	0.603	30	0.276	0.687	12	0.515	0.469	30	0.304	0.557
13	0.484	0.630	31	0.518	0.606	13	0.560	0.462	31	0.627	0.513
14	0.053	0.243	32	0.339	0.679	14	0.199	0.243	32	0.348	0.488
15	0.464	0.804	33	0.340	0.773	15	0.460	0.606	33	0.389	0.554
16	0.214	0.239	34	0.453	0.706	16	0.428	0.217	34	0.573	0.585
17	0.530	0.799	Yakutsk	0.414	0.794	17	0.643	0.652	Yakutsk	0.454	0.595
18	0.127	0.450	The whole Yakutia	0.457	0.790	18	0.131	0.318	The whole Yakutia	0.566	0.645

Table 5 allowed us to conclude that for many uluses and districts of Yakutia, the studied relationships for June with a confidence level of at least 95% were significant when the length of the time series segments used for their study was equal to both 10 years and 20 years.

Similar conclusions were valid for other values of the length of the studied series from the range of 10–20 years, as well as for the months of May and June.

As we can see, the results obtained in solving the second problem allowed us to assert that the revealed significant relationships between the annual MAT changes over the uluses and districts of Yakutia with one-year-ahead LFN and ACF variations were resistant both to time shifts of these series and to changes in their length.

Discussion. The results indicated that the hypothesis put forward has been confirmed about the existence of uluses (districts) of Yakutia, for which the relationship between annual MAT changes for May and July of the year with variations in forest fire rates throughout its territory for the previous year is significant and stable. However, these results need to be meaningfully interpreted, compared with available scientific data, and critically analyzed.

First of all, let us pay attention to the spatial distribution of the uluses (districts) of Yakutia, for which the hypothesis is confirmed. As can be seen from the Tables 1 and 2, for May, the highest values of the correlation coefficient of the interannual MAT changes with the leading LFN and ACF variations are typical for the districts and uluses of Yakutia, which are located in the northern and western parts of its territory. Such districts include Abyysky, Allaikhovsky, Bulunsky, Verkhoyansky, Nizhnekolymsky, and Ust-Yansky. The corresponding uluses are Anabarsky national and Eveno-Bytantaysky.

For June, significant connections are also characteristic of central and eastern Yakutia (Allaikhovsky, Momsky and Tomponsky districts).

For July, the identified relationships are significant for Bulunsky, Verkhoyansky, Nyurbinsky districts, as well as Anabar National, Eveno-Bytantaysky National and Zhigansky districts (north of Yakutia).

Such a spatial distribution seemed to be physically justified. The northern regions of Yakutia, where the landscapes are tundra and forest tundra, are characterized by a later onset of snow cover melting. Therefore, the positive inverse relationship described in the introduction is valid for these territories for longer (from May to July).

In the central regions of Yakutia, where the territories are covered with taiga, the snow cover has already largely disappeared by June. This month, moisture evaporates from the combustible material and transpiration occurs in the phytocenoses, and the growing season begins. These processes have a more intense cooling effect on the surface layer of the atmosphere, the more moisture is in the combustible material and is available to plants. Since the combustible material dries out by July, the rate of evaporation of moisture from it decreases; the mechanism under consideration in such territories operates mainly in June.

For a number of districts and uluses located in the southern and central part of the territory of Yakutia (Aldansky, Neryungrinsky districts, Namsky ulus), no significant relationships between the studied processes were revealed for any given month. This may be explained by the fact that in the southern regions, the drying of combustible material was already completed in May, as a result of which the acceleration of melting of snow cover, which ended by April, could not in any way affect the corresponding changes in average temperatures. In addition, the characteristics of the landscape complexes of the southern regions of Yakutia are significantly different in comparison with similar characteristics for the areas of the central part of its territory belonging to the boreal forest zone. There are not only coniferous forests, but also broad-leaved forests, as well as forest-steppes, where the melting of snow cover and the drying of combustible material occurs earlier. As a result, the influence of circulatory and other climatic factors masking the studied effect can be more significant on the changes in the average MAT over these territories.

The physical mechanism described in [7] confirmed the conclusions of [8] about the significant effect of deposition of combustion products on the albedo and the rate of melting of snow cover. The ideas [5] about the mechanism of soot and aerosol transport from forest fires in the high latitudes of Siberia have been confirmed. The conclusions about the role of southern bearing winds prevailing here in the autumn and winter months due to the Siberian anticyclone have been confirmed.

It is noteworthy that the reliability of the conclusions about the significance of the relationship between changes in the average MAT and variations in LFN is generally noticeably higher than the similar characteristic of the links between these changes and variations in ACF. This can be explained by the fact that the value of LFN on the territory of any district (ulus) is less determined by random extreme events than the corresponding value of ACF.

Such events, which affect both the LFN and the ACF, include both natural phenomena (for example, dry thunderstorms) and the consequences of human activity (unintentional and intentional arson). The sensitivity of changes in forest safety to such events is also affected by the forest fire control regime in the area of the territory where the fire occurred.

If this situation is monitored in such a site by all existing means, including ground-based means (mainly by foresters), fire elimination on it occurs, as a rule, promptly, and ACF values are low.

The fire lasts much longer (as a result, there are more ACFs) in areas where forest fire conditions are monitored only by aviation or space means. Such sites are usually remote from populated areas and locations of firefighting units. This means that they need first deliver forces and means necessary to eliminate fire there. And it can take a lot of time.

A fire develops without any time limits (until it is extinguished by rain) in areas where the forest fire situation is controlled by space means, but the elimination of fires is considered impractical. Such sites prevail in the sparsely populated territory of Yakutia.

An increase in the average MAT for the mentioned sites, as a rule, leads to a significant increase in the ACF. LFN also increases, but less significantly (dry thunderstorms occur more often). One abnormally large fire in such areas can significantly increase the ACF in the corresponding ulus (district), while it adds only one to the LFN value.

The significant results of this work include the established strengthening of the studied relationships in the period from 2000 to 2024. As follows from Tables 3 and 4, with the transition from earlier studied segments to later ones, the number of uluses for which the reliability of the conclusion about the significance of the considered relationships exceeds the set thresholds increases. Thus, for the relationship of changes in the average MAT in June with variations in the LFN, the number of districts where the reliability exceeds 99% increases from zero (for 2011–2020) to 16 (for 2014–2023).

This fact seems to be very important and allows for the following interpretation. With the ongoing climate warming, the intensity of fires in Yakutia is increasing (as can be seen from Figure 1). Therefore, the amount of combustion products increases. The latter leads to an increase in the mechanism of positive inverse relationship between the forest fire rate of the entire Yakutia for the previous year, as well as the average MAT, and hence the forest fire rate of its ulus (district) for the current year. In other words, the detected strengthening of statistical relationships may reflect a real strengthening of the corresponding physical mechanism in the context of climate warming, which is consistent with the ideas about the activation of positive inverse relationship in the climate system.

The revealed properties of the relationships between the processes under study suggest that their consideration in the development of long-term forecasts of average weather conditions and forest fire conditions in the territories of the identified uluses (districts) of Yakutia can increase the feasibility of such forecasts.

At the same time, it should be noted that the applied research methodology is based on a number of simplifying assumptions, the correct verification of which cannot be carried out due to the peculiarities of the applied factual material. The most significant assumption is that the distribution of deviations of the studied indicators from the corresponding trends is normal. The validity of this assumption cannot be reliably verified due to the short length of the time series being studied.

Although such a test using the Pearson's criterion did not reveal any contradictions with this assumption, the power of this criterion is low for such short samples (10–20 terms). As a result, differences in the actual distribution laws of the quantities under consideration from the normal law (manifested on their tails) could not be identified. Therefore, it is advisable to consider the results obtained as having a qualitative character.

It should also be noted that the relatively short length of the studied time series segments limits the possibilities of their correlation analysis. As a result, some real-life but moderate-strength relationships may not have been identified.

It should be noted that the work considered the relationship of changes in the average temperature for a given month over the territories of individual uluses (districts) of Yakutia with one-year-ahead variations in the indicators of landscape fires throughout Yakutia for the entire fire season. This approach is justified by the physical mechanism of the phenomenon under study.

Combustion products formed during a fire in any month and in any part of the territory of Yakutia, by the beginning of the snow cover formation period (autumn) in the studied area (ulus) can be brought into it by the wind and pollute it. Nevertheless, it is possible that a study of the relationship between the interannual MAT changes over each ulus (district) of Yakutia with variations in fire indicators in certain areas of the territory of Yakutia can clarify the results obtained and increase their predictive value.

It is also of undoubted interest to study the effect on MAT changes of certain uluses (districts) of Yakutia of changes in the state and species composition of phytocenoses in areas where landscape fires have occurred, as well as other factors that can affect variations in the albedo of their snow cover in the spring and summer months.

Thus, the results obtained indicate that changes in the forest fire situation in the territories of some uluses of Yakutia are regulated by positive inverse relationship, which increases with climate warming. Since the latter can pose a significant danger to the population, ecosystems and the economy, it is urgent to accelerate and adequately develop the forces and means of the relevant fire departments of Yakutia.

Conclusion. Thus, the validity of the hypothesis has been confirmed. It is proved that significant factors of interannual changes in the average monthly air temperatures in the surface layer of the atmosphere over many uluses and districts of the Republic of Sakha (Yakutia) over time periods from 10 to 20 years are variations in the one-year-ahead indicators of forest fires throughout its territory. The reliability of the conclusions about their significance for many such territories exceeds 95%, and for some it exceeds 99%.

It has been established that these relationships are significant only for the months from May to July, which corresponds to the physical mechanism of the effect of combustion products on the albedo of snow cover and, as a result, on the temperature regime during the spring snowmelt.

Uluses and districts of Yakutia have been identified for which the relationship between annual changes in the average monthly air temperatures in their territories and one-year-ahead variations in the burning rates of their forests are significant with a reliability of at least 95%.

For May, these are mainly the northern and western parts of the republic's territory (Abyysky, Allaikhovsky, Bulunsky, Verkhoyansky, Nizhnekolymsky, Ust-Yansky districts, Anabarsky National and Eveno-Bytantaysky national districts, and a number of others). For June, significant relationships were also found for the central and eastern regions (Momsky, Tomponsky districts, Megino-Kangalassky, Tattinsky, Churapchinsky districts, etc.). For July, they were found for Bulunsky, Verkhoyansky, Nyurbinsky districts, Anabarsky National, Eveno-Bytantaysky national and Zhigansky districts.

The relationships of the studied processes with these factors in the modern period are resistant to shifts in years corresponding to the beginnings of the compared segments of the studied process and its factors in the past and future by units of years, as well as to changes in their duration within 10–20 years. At the same time, in the period 2000–2024, the relationships between the studied processes and their factors for the identified uluses increased (over time, both the values of the correlation coefficients characterizing the studied relationships and the number of uluses for which these connections are significant increased).

The results obtained indicate the expediency of developing forecasts for the upcoming year for the identified uluses (districts) of the Republic of Sakha (Yakutia), the average monthly air temperatures for their territories for the spring and summer months, as well as fire hazard in weather conditions. Taking this into account, promising areas of further research include:

– development of forecasts for the identified uluses of Yakutia for the coming year of interannual changes in temperature conditions and fire risks, as well as the study of their properties;

– identification of areas of other subjects of the Russian Federation for which the studied relationships have similar properties and can also be used in predicting fire danger for them.

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