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CHANGE IN SURFACE AIR TEMPERATURE REGIME AND ITS POTENTIAL IMPACT ON THE CONDITIONS OF TAKE-OFF AND LANDING OF AIRCRAFT IN GANJA-GAZAKH REGION

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The article analyzes changes in surface air temperature regime in the Ganja-Gazakh region using the relevant temperature data for 1961...2014 on the example of Agstafa, Dashkasan, Shamkir, Gadabay, Ganja, and Goygol-resort meteorological stations. Assumptions are made about the influence of the found changes in the temperature regime on the conditions of take-off and landing of aircraft in the Ganja-Gazakh region.

Keywords: air temperature, statistical analysis, seasonal changes, Ganja-Gazakh region, airline flights, take-off running distance, take-off speed, fuel consumption

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INTRODUCTION

During the descent and climbing stages of aircraft, their speed and take-off distance depend on the physical characteristics of the atmosphere, especially on the air temperature. Increasing the temperature of the air requires increased speed at the departure of aircraft. Change of take-off speed causes the aircraft to change the running and the take-off distance. More favorable conditions for speeding up the aircraft are observed mainly in low-temperature levels in the tropopause and low stratosphere. The air temperature diminishes when the air temperature changes, which results in a decrease in engine power, increase the speed of the engine, and, respectively, increase running distance. So, increasing the temperature by 100 °C causes the take-off distance to be increased by 7...13 % [5, 1]. Calculations show that the change in air temperature by 300 °C (e.g. from winter to summer or vice versa) results in hourly fuel consumption of up to 5...6%, lowering of air to 50 °C, maximizing the maximum speed by 1%. At a standard elevation of 11 km, the maximum velocity of the boom increases as compared to the zero level due to the decrease in temperature in the standard atmosphere [2]. The maximum speed decreases with increasing temperature. The maximum vertical speeds of the aircraft primarily depend on the engine's current thrust. Temperature mode also affects the engine's force, as it affects the maximum vertical speed. The temperature incrementing above the standard temperature leads to a decrease in maximum vertical speed. The standard vertical speed of the aircraft shrinks by 10...20 % when relative air temperature increases by about 100 °C relative to the standard atmosphere [1]. Accordingly, civilian airline flights are operated at optimum speeds of high altitudes. From this point of view, the study of the observed temperature regime is becoming even more urgent, given that international flights are being explored. The time-spatial distribution of the temperature indices of the area is mainly carried out in time intervals, such as the seasons, months, and days of the year, in large, medium, or small areas. It is more appropriate to analyze the space templates characteristics of the temperature indices at constant date intervals, and intervals were selected for the calendar months and year as the time interval to evaluate the time-space variability of the thermal regime of the investigated area. For this purpose, the analysis of the long-term dynamics

of temperature indices has been carried out using the evaluation of observations on the temperature of 1961...2014 in meteorological stations Agstafa, Dashkasan, Shamkir, Gadabay, Ganja, and Goygol-resort located in the study area.

MATERIALS AND METHODS

The trends of average annual rate of air temperature for 1961…2014 are shown in the figure 1. From the trends in the graphs, it is clear that in the area where the research is being conducted, average annual temperature increases are observed. Increasing the temperature of the area both on months and in seasons leads to an increase in fuel consumption on aviation flights. Another important challenge to modern climate studies is to determine the average annual or normative values of climate values, including air temperature. The solution to this problem is important because there are trends in the dynamics of meteorological sequences due to climate change, and there are serious difficulties in selecting the optimal length of the period for calculating average value. Thus, the calculated average or normal evaluation should remain statistically stable beyond the limits of the chosen period. It is impossible to predict such relative stability for any calculation period. Taking these into consideration, the average statistical period for the 1961...1990 period, as recommended by the World Meteorological Organization, is also used in our country as well as in many countries. Using this method, it is possible to make comparative analysis of climate change results for different regions of the world.

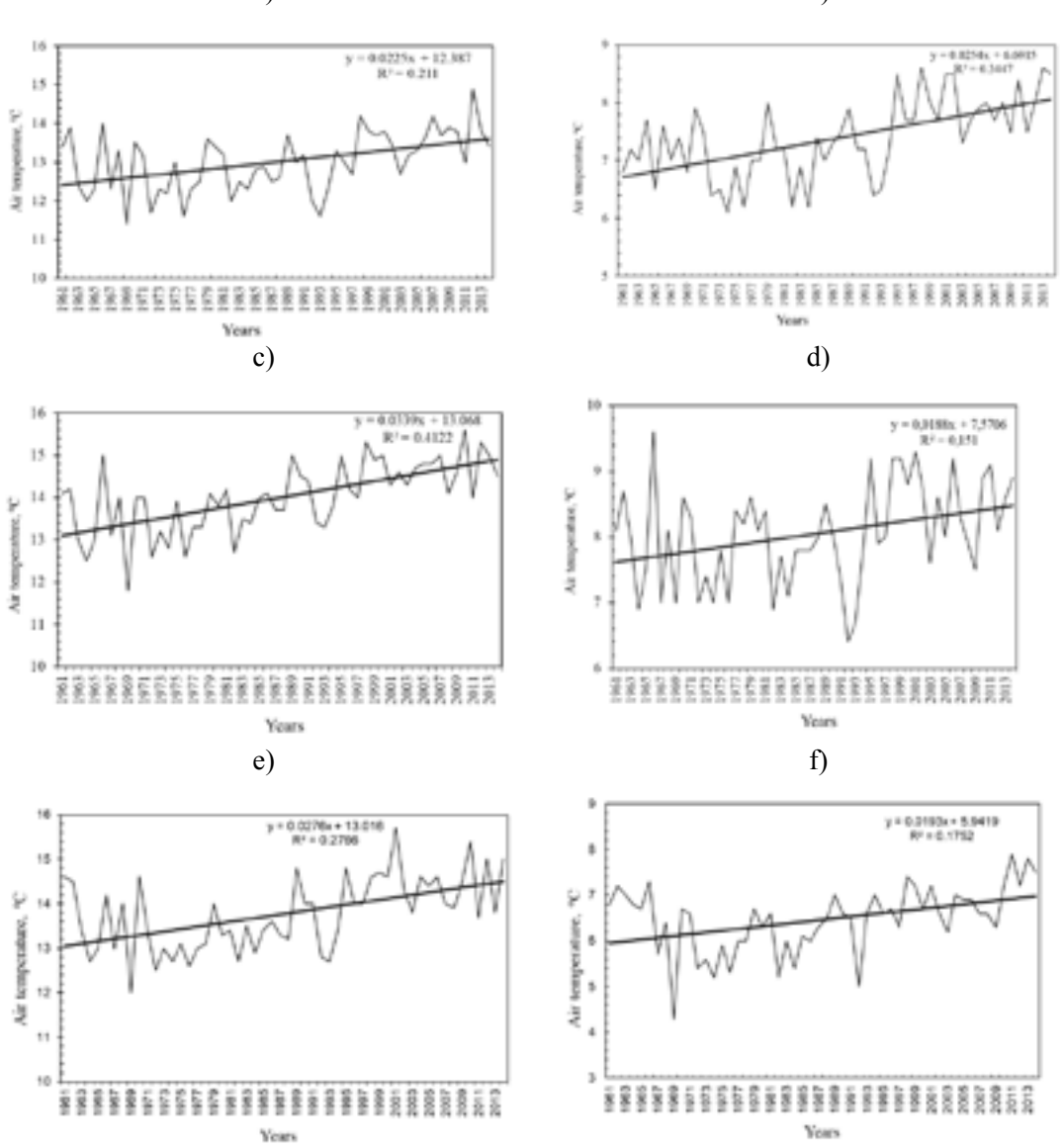

Fig. 1. Time series of the mean annual air temperature (0C) for the period 1961...2014 in meteorological stations: a) Agstafa; b) Dashkasa; c) Shamkir; d) Gadabay; e) Ganja; f) Goygol-resort.

When compared with the norm (1961...1990), a substantial increase was observed in the study of the average (Table 1).

When compared to Table 1, the highest increase in the average air temperature was observed at Dashkesen, Shamkir, Ganja stations 0.9 °C, Aghstafa, 0.7 °C at Goygol-resort, and at least at Gedebey station 0.5 °C. Increasing the average air temperature in the area is shown for months as well (Table 2) [4]. In the research, anomalies were also examined for months, in addition to the average annual temperature in terms of the norm.

Table 1

Comparison of the long-term annual air temperature for 1991...2014 and norms for 1961...1990 (°C)

Stations	Years		Difference
	1961...1990 (norm)	1991...2014	
Agstafa	12.7	13.4	0.7
Dashkasan	7.0	7.9	0.9
Shamkir	13.6	14.5	0.9
Gadabay	7.8	8.3	0.5
Ganja	13.4	14.3	0.9
Goygol-resort	6.2	6.9	0.7

Table 2

Changes in the long-term monthly air temperature for 1991…2014 relative to norms of 1961…1990 (°C)

Stations	Months												Annual
	1	2	3	4	5	6	7	8	9	10	11	12	
Agstafa	0.9	1.1	1.1	0.4	0.1	0.9	0.4	0.9	0.6	1.4	0.1	0	0.7
Dashkasan	1.1	0.7	1.4	0.7	0.8	1.3	0.6	1.1	0.5	1.5	0.1	0.8	0.9
Shamkir	1.0	0.8	1.5	0.8	0.7	1.3	0.9	1.7	1.0	1.7	0.2	0.3	0.9
Gadabay	0	0	0.9	0	0.3	0.9	0.2	1.6	1.0	1.5	-0.3	-0.1	0.5
Ganja	1.4	1.0	1.0	0.1	0.2	1.3	0.9	1.6	1.0	1.7	0.7	0.2	0.9
Goygol-resort	0.8	0.8	1.5	1.0	0.5	0.9	0.4	1.3	0.6	0.7	0.1	0.2	0.7

As mentioned on the Table 2, there are no changes in Agstafa and Gadabay territory during several months. However, the change is observed in each hydrometeorological stations. Thus, in December in Agstafa and in January and February in Gadabay anomaly is equal to zero. Except for November and December in Gadabay, the value of changes was positive in the study area [1]. Given the effect of the maximum and minimum amount of the temperature on aviation flights, each one has been analyzed individually [3]. The value rate of air temperature can cause a sharp decrease in density, which in turn increases the running distance on the runway. But in minimum evalution it can lead to increase of ice build-up events and reduce braking effect on the runway [1]. Accordingly, the absolute maximum temperature in the area in July is about Agstafa 41 °C, Dashkasan 34 °C, Shamkir 39 °C, Gadabay 35 °C, Ganja 41°C and Goygol -30 °C. Absolute minimum temperatures were observed in Agstafa -26 °C, Dashkasan -24 °C, Shamkir -17 °C, Gadabay -25 °C, Ganja -180C in January and -24 °C in Goygol-resort in January [3]. The seasonal changes in air temperature indications for the study area are clearly shown in Table 3.

It is clear from the table that global warming has also influenced to season changes. The results of the statistical analyzes show that the average air temperature is higher than norm, in each stations of studied region. İncrease of the average air temperature in the winter months were observed in the winter season at 0.9 °C in Ganja, 1.0 °C in Goygol-resort, 1.2 °C in Shamkir in the summer, and 0.9 °C in Dashkasen, Shamkir and Ganja hydrometeorological stations in the autumn. In general, the winter is 0.6 °C in the winter, 0.7 °C in

summer, 1.0 °C in summer, and 0.8 °C in the fall [4]. As you can see, the high amount of changes coincides with the summer season. These temperature changes will naturally not be neglected on aviation flights. This trend will lead to increase of fuel consumption and increase the running distance on the runway. Therefore, construction of new airports in the area to be explored in the future should be carried out in more adequate areas. Specifically, the length of the runways should be taken into account.

Table 3

Distribution of the long-term seasonal air temperature for the period of 1961…1990 (norms) and 1991…2014 (°C)

Hydrometeorological stations	Years and differences	Winter	Summer	Spring	Autumn	Annual
	1961...1990	1.9	11.9	23.5	13.5	12.7
Agstafa	1991...2014	2.5	12.4	24.3	14.2	13.4
	change	+0.6	+0.5	+0.8	+0.7	+0.7
	1961...1990	-1.5	5.6	15.7	8.2	7.0
Dashkasan	1991...2014	-0.7	6.5	16.8	8.9	7.9
	change	+0.8	+0.9	+1.1	+0.7	+0.9
	1961...1990	3.1	12.6	24.1	14.4	13.6
Shamkir	1991...2014	3.8	13.5	25.3	15.4	14.5
	change	+0.7	+0.9	+1.2	+1.0	+0.9
	1961...1990	-1.0	6.8	16.6	9.0	7.8
Gadabay	1991...2014	-1.0	7.2	17.5	9.7	8.3
	change	0	+0.4	+0.9	+0.7	+0.5
	1961...1990	3.0	12.4	23.9	14.0	13.4
Ganja	1991...2014	3.9	12.8	25.1	15.2	14.3
	change	+0.9	+0.4	+1.2	+1.2	+0.9
	1961...1990	-2.6	5.0	14.8	7.4	6.2
Goygol-resort	1991...2014	-2.0	6.0	15.6	7.8	6.9
	change	+0.6	1.0	+0.8	+0.4	+0.7

RESULTS

During 1991...2014, the surface air temperature at all stations located in the study area increased compared to the multi-year norm (1961...1990). This increase was 0.7 °C in Agstafa, 0.9 °C in Dashkasan, 0.9 °C in Shamkir, 0.5 °C in Gadabay, in Ganja 0.9 °C, in Göygol-resort 0.7 °C. İn general, the temperature increase for the years of research in the region was 0.77 °C. The analysis of the distribution of temperature change in Ganja-Gazakh region by seasons showed that it is positive in winter was 0.6 °C, in spring 0.68, in summer 1.0 °C, in autumn 0.78 °C. The results show that the increase in temperature due to climate changes is most often observed in the summer months. An increase in air temperature leads to a sharp drop in air density, which in turn leads to an increase in the flight distance of aircraft. In this case and taking into account the current trend, we recommend that the horizontal length of the runway of future airports in the region be 0.3…0.5 km larger than the existing runway.

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ЖЕР БЕТІНДЕГІ АУА ТЕМПЕРАТУРАСЫНЫҢ ӨЗГЕРУІ ЖӘНЕ ОНЫҢ ГАНДЖА-ГАЗАХ АЙМАҒЫНДАҒЫ ҰШАҚТАРДЫҢ ҰШУ ЖӘНЕ ҚОНУ ЖАҒДАЙЛАРЫНА ӘСЕР ЕТУІ

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Мақалада Агстафа, Дашкесан, Шамкир, Кедабек, Гянджа және Гейгель курортының метеорологиялық станциялары мысалында 1961-2014 жылдардағы тиісті температуралық деректерді қолдана отырып, Гянджа-Газах ауданындағы ауаның жер бетіндегі температуралық режимінің өзгерістері талданды. Анықталған температуралық режим өзгерістерінің Гянджа-Газах ауданындағы ұшақтардың ұшу және қону жағдайларына әсері туралы болжамдар жасалды.

Түйін сөздер: ауа температурасы, статистикалық талдау, маусымдық өзгерістер, Гянджа-Газах ауданы, авиакомпаниялардың рейстері, ұшу қашықтығы, ұшу жылдамдығы, отын шығыны

ИЗМЕНЕНИЕ РЕЖИМА ТЕМПЕРАТУРЫ ПОВЕРХНОСТНОГО ВОЗДУХА И ЕЕ ПОТЕНЦИАЛЬНОЕ ВОЗДЕЙСТВИЕ НА УСЛОВИЯ ВЗЛЕТА И ПОСАДКИ САМОЛЕТОВ В ГАНДЖА-ГАЗАХСКОМ РЕГИОНЕ

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В статье анализируются изменения приземного температурного режима воздуха в Гянджа-Газахском районе с использованием соответствующих температурных данных за 1961...2014 гг. на примере метеорологических станций Агстафа, Дашкесан, Шамкир, Кедабек, Гянджа и Гейгель-курорт. Сделаны предположения о влиянии обнаруженных изменений температурного режима на условия взлета и посадки самолетов в Гянджа-Газахском районе.

Ключевые слова: температура воздуха, статистический анализ, сезонные изменения, Гянджа-Газахский район, рейсы авиакомпаний, взлетная дистанция, взлетная скорость, расход топлива