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Fluctuations of climatic indicators of the Fergana valley under conditions of global climate change

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Abstract: The article examined changes in air temperature over two climatic periods based on data recorded at meteorological stations located in the Fergana Valley. For this purpose, data from 8 meteorological stations conducting observations in various natural and geographical areas of the valley were used. The research also examined changes in air temperature in the base and current climatic periods, and identified differences between them. The trend lines were also transferred to graphs of air temperature changes constructed based on changes in air temperature at the meteorological stations studied, and trend equations were calculated.
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Keywords: Fergana Valley; climate change; climate change problem; meteorological station; air temperature; temperature change; base climate period; current climate period; trend line

1. Introduction

Today, as a result of global industrial development, the amount of hydrocarbon gases emitted into the atmosphere is increasing every year. This is strengthening the "greenhouse effect" on our planet and causing climate change. As a result, natural disasters of hydrometeorological origin are increasing. For example, in some parts of the world, precipitation is much higher than usual, while in other regions drought is increasing [2].

According to the World Meteorological Organization, as a result of the increase in the average annual temperature on Earth by one degree Celsius, at least one billion people have been forced to adapt to the emerging climatic conditions or move to another place for agriculture, animal husbandry and field work. It should be noted that the modern climatic era is very different from previous ones. The current trend in climate change is of particular importance, since the temperature is rising very rapidly. Since 1975, the temperature on the Earth's surface has been increasing by approximately 0.15-0.20 degrees Celsius every decade. As a result, the water level of the world's oceans has risen to a certain extent, the area of ice covers on the Earth's surface is decreasing, and other extreme hydrometeorological phenomena are observed [6].

A new report from the World Meteorological Organization confirms that 2015, 2016 and 2017 were the warmest years on record. This is irrefutable evidence of climate change caused by the excess of greenhouse gases in the atmosphere. The world record in this regard still “remains” with 2016. Of the 18 warmest years since records began, 17 have occurred in the current century. In particular, the rate of warming in the last three years is completely different from previous years. This is evidenced by the fact that meteorological stations in the Arctic have recorded an increase in air temperature. Such events have a long-term impact on sea levels and weather patterns in other parts of the planet [3].

In the context of recent global climate change, geoecological problems of various levels are emerging. Such problems require the study of the natural and climatic potential of the regions, the elimination of adverse meteorological processes and their negative consequences, and the preservation of a favorable natural environment for the regions. Our republic, in particular, the Fergana Valley, has accumulated rich scientific and practical experience in studying, researching such problems, and providing adequate recommendations for the national economy. In particular, in the sources described on the basis of agrometeorological studies led by Y.N. Babushkin, in the hydrometeorological studies of A.A. Abdullayev,

B.A. Kamolov, V.E. Chub, D.A. Ivanova, N.S. Kopovalova, O.N. Reizvikh, F.A. Mominov, F.H. Hikmatov and others, the hydroclimatic characteristics of the Fergana Valley have been directly studied [1]. However, despite this, the trend of changes in natural geographical phenomena and processes in the context of climate change, as in the case of the Fergana Valley, has remained unnoticed by researchers.

The purpose of this study is to determine the trend in air temperature changes in the Fergana Valley over time.

To achieve the research goal, the following tasks were set:

- Collection of air temperature data recorded at meteorological stations in the Fergana Valley;
- Statistical processing of data on average annual air temperature;
- Analysis of changes in air temperature based on comparison of data related to the base and current climate periods.

2. Material and Methods

The Fergana Valley was chosen as the object of research in the work. The subject of the work is to determine changes in air temperature in the Fergana Valley and assess the impact of these changes on natural geographical processes.

In the process of carrying out the work, long-term (1961-2020) air temperature data observed at meteorological stations in various regions of the Fergana Valley were used. The study used modern meteorological calculations, mathematical statistical methods, geographical generalization and comparison methods.

3. Results

It is very important to determine the consequences of increasing air temperature in the Fergana Valley and draw appropriate practical conclusions from it, and at the same time it requires conducting hydrometeorological studies on this. Due to the unique geographical location of the valley we are studying, monthly and annual changes in air temperature here are unique from other regions [7].

The general climatic features of the Fergana Valley are associated with its geographical location, the fact that it is surrounded by high mountain ranges, the fact that the territory belongs to the continental type of the subtropical climate zone, its remoteness from large water bodies and its proximity to vast deserts. Summers are hot, dry and long, and winters are short. Precipitation falls mainly in spring and winter, summer and autumn are quite dry. The sun shines 2550-2800 hours a year, and in this respect the valley is not inferior to Tashkent and Bayramaly. The total solar radiation is 150 kcal/cm2 per year, increasing with altitude and reaching around 170 kcal/cm2 at an altitude of 4000 m [4]. About 65 kcal of it falls on the summer months, and 26 kcal falls on the winter months. This means that the valley receives 4 times more heat in summer than in winter. The average annual temperature is 15-17°C on the plains, and 10-12°C in the mountains. The coldest temperature in the valley is observed in January. Cold air blowing from the mountains accumulates in the central part of the valley in winter, as a result of which the average temperature in January is 3°C. In some years, cold air masses blow from the north and northeast and pass over the low mountains in the western part of the valley. As a result, the temperature drops. At such times, the minimum temperature in the valley drops to -30°C. The warming of the air continues until July, and from August to January the temperature decreases [4].

Cold air blowing from the mountains surrounding the valley accumulates in the central part in winter, as a result of which the average January temperature drops to -7°C. In some years, cold air masses blow from the north and northeast, overtake the mountains, and significantly reduce the temperature in the valley. At such times, the lowest temperature drops to -27, -31°C. However, along with frosts in winter, there are sometimes warm days of + 22°C. One of the main meteorological elements affecting the change in natural geographical phenomena and processes in the Fergana Valley is air temperature. Based on this, 8 meteorological stations located in the valley were selected in the study to study air temperature changes in the Fergana Valley (Table 1).

Table 1. Changes in air temperatures observed at meteorological stations located in the Fergana Valley

S/n	Meteorological station	Air temperature during the BCP (base climate period), ˚C			Air temperature during the CCP (current climate period), ˚C			$\Delta t_{average.} = t'_{CCP} - t'_{BCP}$
		max	min	o'rt.	max	min	o'rt.	
1	Fedchenko	20,4	8,82	13,5	18,19	13,16	14,64	1,14
2	Sokh	11,86	8,94	10,32	12,34	9,72	10,89	0,57
3	Shahimardan	10,8	6,10	8,90	12,8	7,92	10,2	1,3
4	Andijan	20,31	8,38	13,16	16,01	13,2	14,5	1,34

5	Fergana	14,74	11,85	13,66	15,7	13,29	14,63	0,97
6	Kokand	20,16	11,69	14,14	16,27	13,93	15,14	1
7	Pap	15,04	12,53	14,09	18,0	13,7	15,2	1,11
8	Namangan	20,1	12,3	14,2	15,88	12,22	14,84	0,64

Note: BCP – base climate period (1961-1990); CCP – current climate period (1991-2020); $\bar{t}_{bcp}$ *and* $\bar{t}_{ccp}$ - average multi-year air temperatures in BID and JID, respectively; $\Delta t_{average}$ – difference in air temperatures, °C.

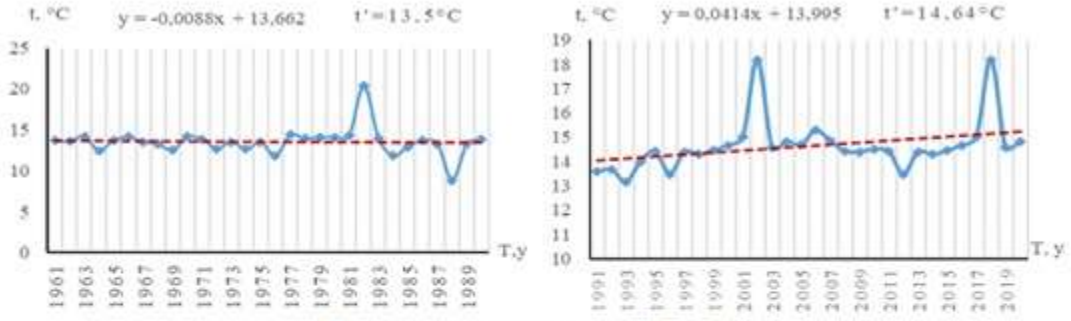
It is known from the studies that, based on observational data from meteorological stations of Uzbekistan, a comparative analysis of the average monthly, semi-annual and annual values of air temperature and precipitation in the base (1961-1990) and current (1991-2016) climatic periods was conducted. Observational data show that, first of all, in all climatic regions of Uzbekistan, an increase in the long-term average monthly air temperature compared to the base climatic period is characteristic [5]. On this basis, at the next stage of the research work, changes in air temperature in the Fergana Valley were determined by comparing data relating to two climatic periods (BCP - 1961-1990 and CCP - 1991-2020).

Analysis of the table shows that the average annual air temperature recorded at the Fedchenko meteorological station during the base climatic period (1961-1990) was 13.5°C. The average annual air temperature at the same meteorological station during the current climatic period (1991-2020) was 14.64°C.

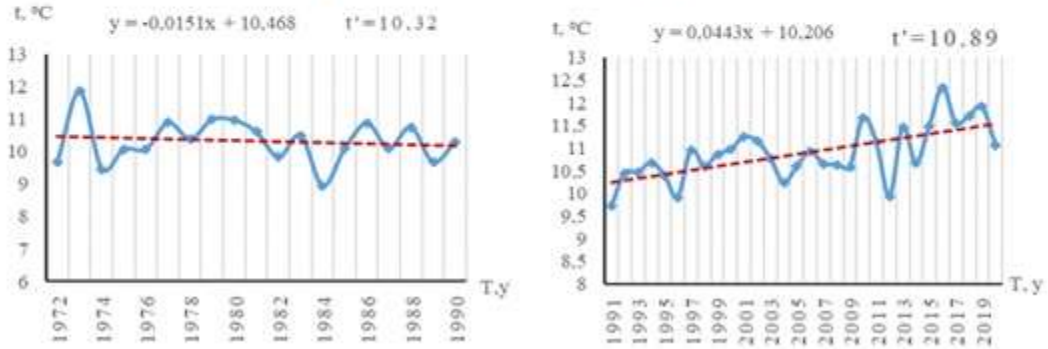
These values show that the average annual air temperature increased by 1.14°C during the current climatic period compared to the base climatic period.

The largest difference in the average annual air temperature between the two selected periods was observed at the Andijan meteorological station, amounting to 1.34°C. The smallest difference was observed at the Sokh meteorological station, reaching 0.57°C. In general, at all meteorological stations located in different geographical areas of the Fergana Valley, the air temperature increased significantly by 1.1°C during the current climatic period.

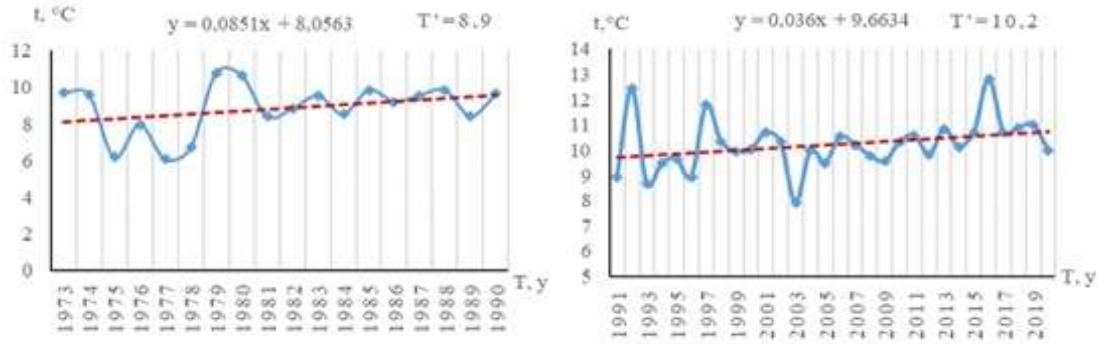
In the next stage of the research, in order to more accurately express the interannual changes in air temperature in the Fergana Valley during the base and current climate accounting periods, graphs of the interannual changes in air temperatures recorded at meteorological stations located in the valley were drawn and analyzed (Fig. 1).



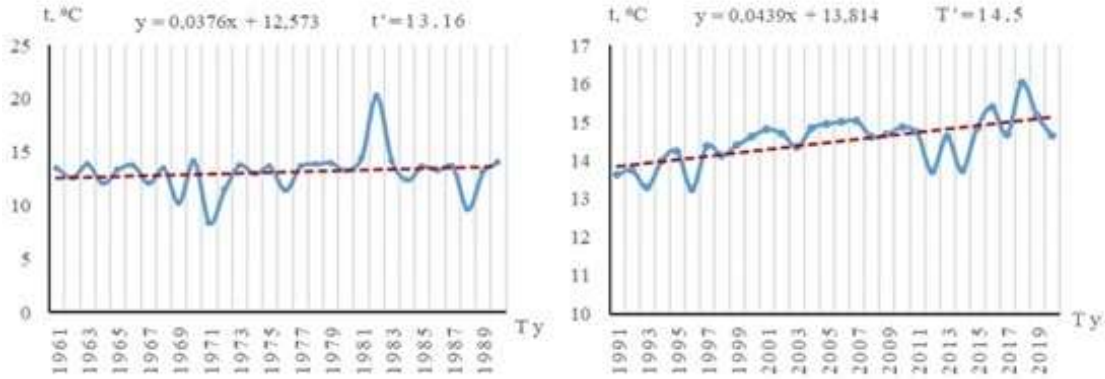
a) Fedchenko meteorological station



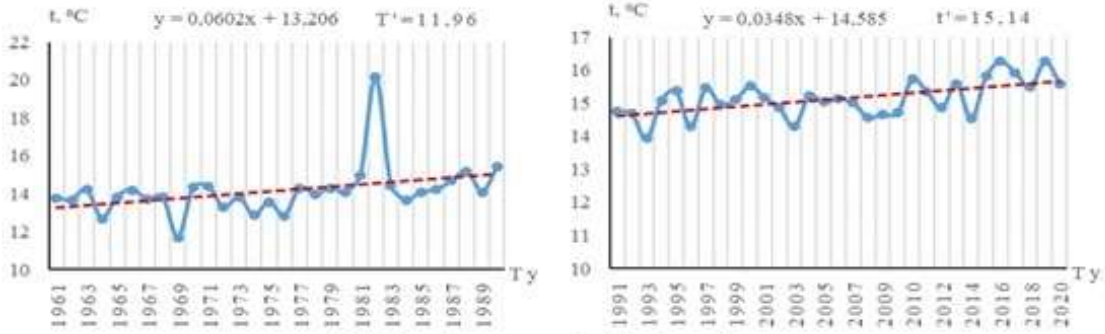
b) Sokh meteorological station



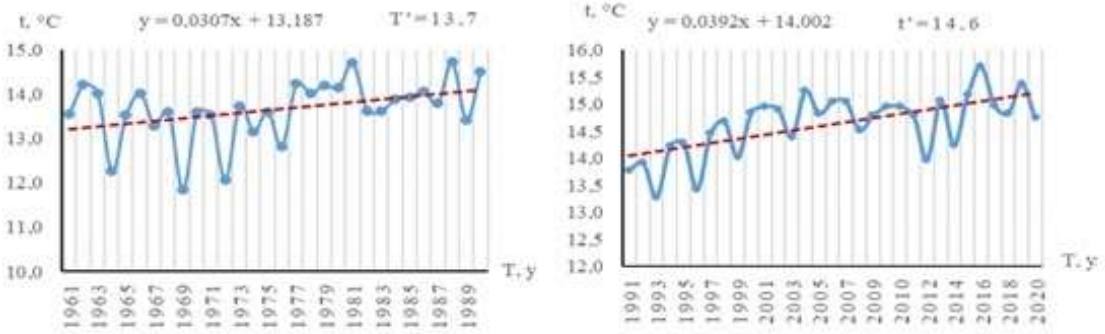
c) Shahimardan meteorological station



d) Andijan meteorological station



e) Kokand meteorological station



f) Fergana meteorological station

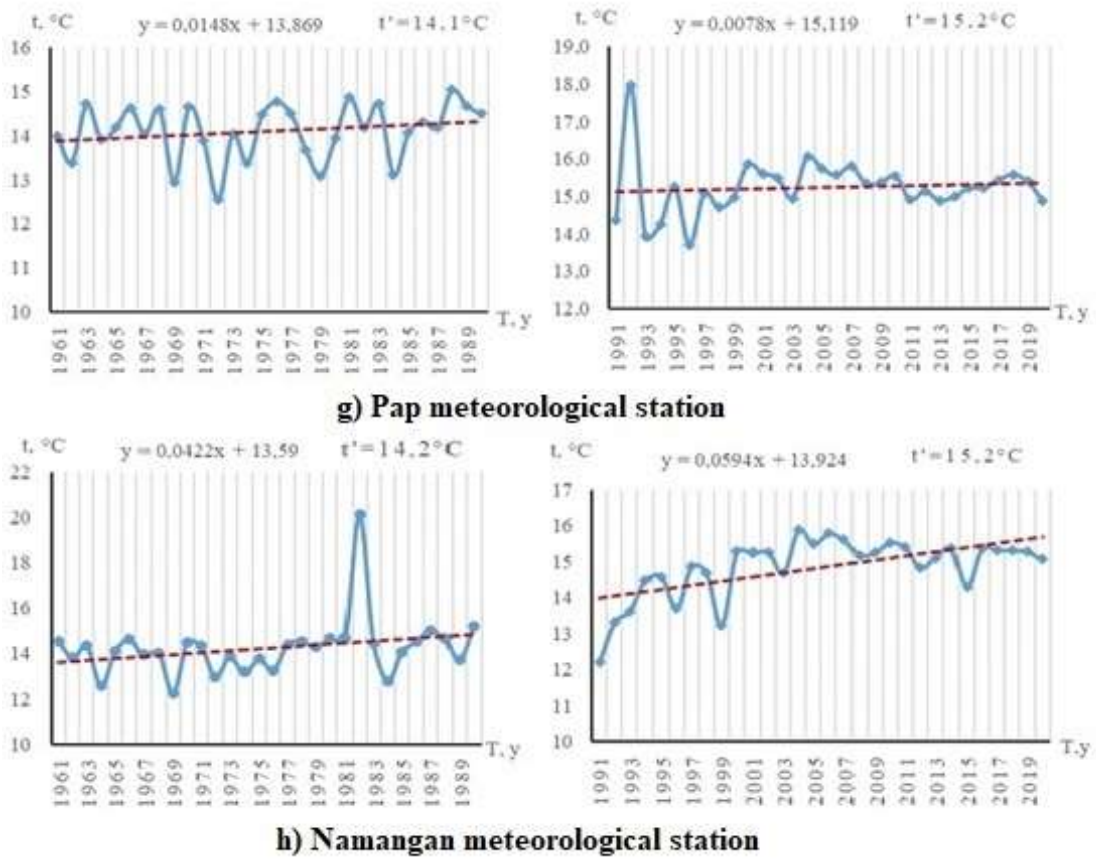


Figure 1. Changes in average annual air temperatures recorded at meteorological stations located in the Fergana Valley during the base climate period (BCP) and the Current Climate Period (CCP)

As can be seen from the graphs, the maximum value of the average annual air temperature at the Fedchenko meteorological station in the base climate period was 20.42 °C, which corresponds to 1982, and the maximum value of the average annual air temperature in the current climate period was 18.2 °C, which corresponds to 2002. Also, the highest values of average annual air temperature during the baseline climate period were observed at Andijan and Kokand meteorological stations in 1982, at Namangan and Fergana meteorological stations in 1981, and at Sokh and Shokhimardon meteorological stations in 1973 and 1979.

The highest average annual air temperature at the Sokh meteorological station in the base climate period was 11.86 °C, which corresponds to 1973, and the highest average annual air temperature in the current climate period was 12.34 °C, which corresponds to 2016. Also, the highest average annual air temperature values in the current climate period were observed at the Shokhimardon and Fergana meteorological stations in 2016, the Andijan meteorological station in 2018, the Kokand meteorological station in 2019, the Pop meteorological station in 1992, and the Namangan meteorological station in 2004.

In general, the maximum values of the average annual air temperature recorded at the valley meteorological stations during the baseline climate period ranged from 11.86÷20.4 °C, and during the current climate period they ranged from 12.34÷18.2 °C. The maximum values of the average annual air temperature at the Fedchenko, Andijan, Kokand, and Namangan meteorological stations decreased from -2.21 °C to -4.3 °C in the current climate period compared to the baseline climate period. At the Sokh, Shokhimardon, Fergana, and Pop meteorological stations, the temperature increased significantly, from +0.48 °C to +2.96 °C.

At meteorological stations located in the Fergana Valley, the lowest average annual air temperatures in the base climatic period were observed in 1969, 1971, 1972, 1977, 1982, and 1988, and in the current climatic period, the lowest average annual air temperatures were observed in 1991, 1993, 1996, 2003, and 2012.

Trend lines were also drawn on the graphs of air temperature changes drawn at the meteorological stations of the Fergana Valley and trend equations were calculated (Table 2).

Table 2. Trend equations of average annual air temperatures recorded at meteorological stations located in the Fergana Valley

S/n	Meteorological station	Trend equations	
		Base Climate Period (BCP)	Current Climate Period (CCP)
1	Fedchenko	t = -0,0088x + 13,662	t = 0,0414x + 13,995
2	Sokh	t = -0,0151x + 10,468	t = 0,0443x + 10,206
3	Shahimardan	t = 0,0851x + 8,0563	t = 0,036x + 9,6634
4	Andijan	t = 0,0376x + 12,573	t = 0,0439x + 13,814
5	Fergana	t = 0,0307x + 13,187	t = 0,0392x + 14,002
6	Kokand	t = 0,0602x + 13,206	t = 0,0348x + 14,585
7	Pap	t = 0,0148x + 13,869	t = 0,0078x + 15,119
8	Namangan	t= 0,0422x + 13,59	t = 0,0594x + 13,924

The trend line drawn on the graphs of air temperature changes in the baseline and current climate periods shows an upward trend. However, this was not observed for the Fedchenko and Sokhda meteorological stations in the baseline climate period.

4. Discussions

Summarizing the research results, the following conclusions can be drawn:

The average annual air temperature in various geographical areas of the Fergana Valley has increased significantly by 1.1°C in the current climatic period compared to the baseline climatic period;

The maximum values of the average annual air temperature at meteorological stations located in the central parts of the Fergana Valley decreased from -2.21 °C to -4.3 °C compared to the base climate period during the current climate period. At meteorological stations located in the foothills and mountainous regions, they increased significantly, from +0.48 °C to +2.96 °C;

The lowest average annual air temperatures were observed at almost all meteorological stations in the valley before 2000;

The trend in air temperature changes at the studied weather stations had positive values for almost all of them for both periods. Only for the Fedchenko and Sokhda weather stations, positive values were noted, while the trend was negative in the base climate period.

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