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Article

Dynamics and Trends of Key Meteorological Indicators in Navoi City During 2012–2024

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Abstract: This study examines the annual dynamics of major meteorological parameters observed in Navoi city between 2012 and 2024, including average, maximum and minimum air temperatures, relative humidity, wind speed, and atmospheric pressure. Based on annual statistical data, the research identifies long-term trends, climatic extremes, anomalous years, and explores potential factors contributing to these variations. Particular emphasis is placed on identifying periods of climatic instability and their possible environmental or anthropogenic causes. The findings provide scientific insights into recent climatic changes in the Navoi region and offer forecasts regarding future developments. This article may serve as a valuable resource for specialists in climatology, meteorology, and environmental monitoring.

Keywords: Navoi City, Meteorological Parameters, Air Temperature, Relative Humidity, Wind Speed, Atmospheric Pressure, Climate Change, Statistical Analysis

1. Introduction

In recent decades, global climate change has emerged as one of the most pressing environmental challenges faced by humanity. According to the World Meteorological Organization (WMO), the period from 2011 to 2020 was the warmest decade ever recorded, marked by rising global temperatures, intensified droughts, and increasingly frequent extreme weather events in many regions worldwide [1]. This warming trend is largely attributed to the continuous increase in greenhouse gas concentrations resulting from human activities such as fossil fuel combustion, deforestation, and intensive agriculture [2].

While climate change is a global phenomenon, its consequences manifest most distinctly at the regional and local levels. Arid and semi-arid regions like Central Asia are particularly vulnerable to climatic fluctuations due to their fragile ecosystems and limited water availability. In Uzbekistan, several areas are already experiencing rising average temperatures, declining water resources, and a shift in seasonal weather patterns [3], [4]. Moreover, scientific observations confirm that in recent decades, annual mean temperatures in Uzbekistan have increased more rapidly than the global average, particularly in the central and southern regions [5].

Navoi region, situated in the central part of Uzbekistan, exemplifies these challenges. The region is characterized by a harsh continental desert climate, with long, hot summers and short, mild winters. Low annual precipitation, reduced relative humidity, and elevated summer temperatures significantly influence the livelihoods of local communities, agricultural productivity, industrial operations, and public health [6]. Furthermore, the variability in wind speed and atmospheric pressure adds complexity to

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the climatic conditions, influencing air quality, dust storm activity, and evapotranspiration rates.

In such a sensitive environment, continuous observation and analysis of key meteorological parameters are essential. Long-term monitoring of temperature (average, maximum, and minimum), relative humidity, wind speed, and atmospheric pressure helps identify climatic anomalies and evaluate the region's susceptibility to climate-related risks. These data-driven insights are crucial for scientific forecasting, sustainable urban and agricultural planning, and developing effective climate adaptation policies [7].

Therefore, this study presents a comprehensive assessment of the year-to-year variation in meteorological elements in Navoi city over the period from 2012 to 2024. By analyzing multi-year trends in temperature, humidity, wind speed, and air pressure, the research seeks to identify key patterns and anomalies that may serve as indicators of long-term climate change. The findings are expected to provide valuable information for scientists, policymakers, and local stakeholders engaged in regional climate resilience planning.

2. Materials and Methods

This scientific study is based on the statistical analysis of long-term meteorological data collected in Navoi city during the period 2012–2024. The core aim is to evaluate year-by-year fluctuations in key atmospheric parameters—namely air temperature (average, maximum, and minimum), relative humidity, wind speed, and atmospheric pressure—and to determine the direction and intensity of climatic trends.

The data were obtained from the official records of the Navoi Regional Hydrometeorological Center, which maintains meteorological monitoring in accordance with standards approved by the Uzhydromet and the World Meteorological Organization (WMO) [7][8]. A 13-year time series was formed for each parameter, allowing a detailed comparative analysis of annual changes.

The methodology employed included the following steps and analytical techniques:

1. Compilation and systematization of annual average, maximum, and minimum values for each variable;
2. Graphical visualization of long-term changes using line charts, bar graphs, and trend lines;
3. Determination of average annual change rate (Δ%) for each parameter to assess the direction of variability;
4. Identification of anomalous years with sharp deviations from long-term means, highlighting potential extreme climate events;
5. Application of linear regression analysis and computation of trend coefficients to evaluate the strength and significance of changes;
6. Utilization of descriptive statistics including mean, variance, standard deviation, and range to measure data consistency and fluctuation intensity [9].

The graphical and statistical analysis was carried out using Microsoft Excel and IBM SPSS, which enabled detailed modeling and visualization of climatic tendencies. In particular, linear trend models were fitted to determine whether specific parameters exhibit upward or downward trends over the observation period [10].

Relative comparisons across the parameters were also made to explore correlations—for example, between rising temperature and decreasing humidity, or pressure shifts associated with wind dynamics. This multifaceted approach provided a more complete picture of the climatic behavior in Navoi city [11].

3. Results and Discussion

During the period from 2012 to 2024, significant fluctuations in meteorological elements such as temperature, relative humidity, wind speed, and atmospheric pressure

were observed in the city of Navoi. The annual dynamics of these climatic parameters indicate notable changes in the region's weather patterns. The variations in average, maximum, and minimum temperatures, humidity levels, wind speed, and pressure reflect the influence of broader climatic shifts over time.

Table 1. Annual meteorological indicators in Navoi city for 2012–2024

No.	Year	Temperature (°C)	Max Temp (°C)	Min Temp (°C)	Relative Humidity (%)	Wind Speed (m/s)	Air Pressure (mmHg)
1	2012	15.37	29.2	2.7	43.2	17.6	733.45
2	2013	16.1	30.4	3.2	44.5	18.4	726.7
3	2014	15.16	29.92	2.0	45.94	13.83	727.7
4	2015	16.13	31.75	3.17	46.31	21.42	721.99
5	2016	16.63	34.25	3.33	44.84	20.25	732.23
6	2017	15.89	30.83	2.33	43.58	22.17	730.83
7	2018	15.8	30.4	2.6	43.2	23.6	731.9
8	2019	15.4	29.8	2.4	40.2	17.4	–
9	2020	15.2	29.8	1.3	43.6	22.3	730.8
10	2021	16.93	34.75	2.33	39.17	22.3	728.3
11	2022	16.9	31.0	4.9	44.3	22.9	731.8
12	2023	17.5	32.0	3.0	41.7	22.3	731.7
13	2024	16.41	34.4	3.25	46.7	22.75	726.0

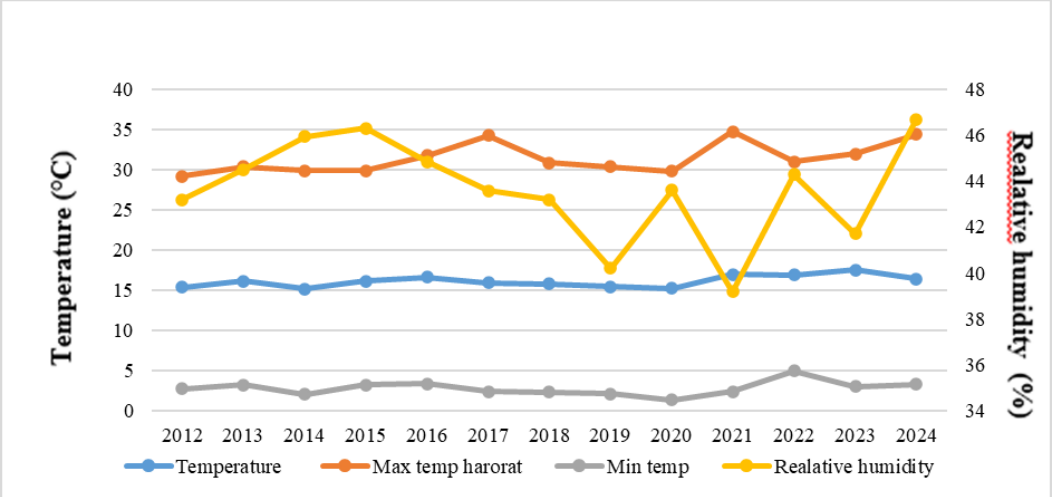

Figure 1. Graph of the correlation between air temperature and relative humidity in Navoi city from 2012 to 2024.

As observed from the data in Table 1 and Figure 1, temperature dynamics over the years reflect the gradual warming trend in Navoi city. The average annual temperature increased from 15.16 °C in 2014 to a peak of 17.5 °C in 2023, supporting the hypothesis of regional climate warming. The years 2015, 2016, and especially 2021–2024 indicate consistent rises in maximum temperatures, with 2024 reaching 34.4 °C, one of the highest values recorded during the study period. Such a persistent rise aligns with observed global climate trends and can have profound implications for water demand, energy consumption, and public health in arid regions [12].

Relative humidity fluctuated slightly but exhibited an overall pattern of decline followed by stabilization. The lowest humidity (39.17%) occurred in 2021, coinciding with increased temperatures, which may indicate a drying atmosphere—a typical consequence

of climate change in semi-arid regions. These changes can affect soil moisture, evapotranspiration rates, and ultimately, agricultural productivity in the region. Wind speed also showed a clear upward trend: from 13.83 m/s in 2014 to 22.75 m/s by 2024, suggesting increased wind circulation, possibly caused by thermal imbalances between the land surface and atmosphere [13].

Air pressure trends were more variable. Although data for 2019 was unavailable, a general decline was recorded during the earlier years, with the lowest value of 721.99 mmHg in 2015, which may reflect increased cyclonic activity or atmospheric instability that year. Pressure anomalies can influence precipitation systems and storm potential—particularly important in regions prone to dust transport and wind-related hazards [14].

Furthermore, the increasing occurrence of extreme temperature events—notably in 2016 (34.25 °C), 2021 (34.75 °C), and 2024 (34.4 °C)—underscores the growing risk of heatwaves in Navoi city. These temperature extremes are likely to impact human health, especially among vulnerable populations, and may lead to higher demand for cooling, electricity, and water during summer months. The rising wind speed observed after 2020 could also signify changing regional atmospheric circulation, possibly influenced by larger-scale climate variability. In desert-prone areas like Navoi, this can increase dust transport and pollution levels, aggravating respiratory and cardiovascular diseases [15].

4. Conclusion

The analysis of meteorological indicators in Navoi city from 2012 to 2024 demonstrates clear evidence of climate variability and gradual environmental shifts. The steady rise in annual average and maximum temperatures strongly suggests a localized expression of global climate warming. For instance, the increase from 15.16 °C in 2014 to 17.5 °C in 2023 marks a significant warming trend that could substantially affect agriculture, public health, and water availability in this semi-arid region.

Beyond temperature changes, the upward trend in wind speed, combined with noticeable fluctuations in relative humidity and atmospheric pressure, reflects shifts in local atmospheric circulation. These patterns indicate a possible intensification of climate-related stressors, such as heatwaves, reduced air moisture, and increased meteorological instability. For example, the sharp drop in atmospheric pressure recorded in 2015 could be a sign of changing pressure systems that may bring unpredictable weather conditions.

These findings underline the importance of consistent and long-term environmental monitoring at the regional level. Reliable meteorological data is crucial not only for scientific understanding but also for practical decision-making. Hydrometeorological centers must continue to collect, analyze, and disseminate accurate climate information to support urban planning, disaster preparedness, and resource management.

Given the observed trends, local authorities should begin to integrate climate adaptation strategies into development policies. This may include revising building codes, strengthening health systems to cope with extreme heat, optimizing irrigation calendars, and investing in early warning technologies.

Moreover, the outcomes of this study provide a foundation for further interdisciplinary research, particularly on the linkages between meteorological changes and ecological or socio-economic vulnerabilities. Future studies should examine the connections between climate indicators and other environmental challenges, such as dust pollution, water scarcity, or the rise in temperature-related illnesses in Central Asian urban areas.

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