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COMPARATIVE ANALYSIS OF ERA5 REANALYSIS DATA WITH METEOROLOGICAL DATA OBSERVED IN THE AKHANGARAN RIVER BASIN

B.E. NISHONOV[1,2], M.M. ABDURAKHMANOV[1,2]

[1] Hydrometeorological Research Institute, bnishonov@mail.ru
[2] National University of Uzbekistan named after Mirzo Ulugbek, abdurakhmanovmurodjon1@gmail.com

Abstract. *This study examines the correlation between observed meteorological data and ERA5 reanalysis data in the Akhangaran River Basin. The evaluation is conducted using five statistical metrics across three key categories: Error Magnitude (RMSE, MAE), Systematic Bias (PBIAS), and Performance or linear correlation (NSE, R²). Monthly data between 1970-2024 from six meteorological stations are compared with corresponding monthly ERA5 datasets to assess the reliability of reanalysis data in representing local meteorological conditions. Additionally, line graphs are used to visualize temporal variations and discrepancies though different years. By integrating both statistical and visual analyses, this study provides a comprehensive assessment of ERA5 reanalysis data applicability for hydrometeorological research in Akhangaran River Basin.*

Keywords: *ERA5 reanalysis, observed data, correlation analysis, statistical evaluation, Error Magnitude, Nash-Sutcliffe Efficiency (NSE), Percent Bias (PBIAS), climate data validation.*

Introduction. Reliable climate data is essential for hydrological and meteorological studies, particularly in regions where water resources are highly dependent on amount of precipitation and temperature variations. Observed meteorological data from ground stations is widely considered the most accurate source for local climate monitoring. However, due to limited spatial coverage, missing records, and measurement inconsistencies, alternative datasets such as reanalysis products have increasing attention. Among these, the ERA5 reanalysis dataset, developed by the European Centre for Medium-Range Weather Forecasts (ECMWF), provides globally consistent climate variables with high spatial (spatial resolution: 0,25° × 0,25° (31 km × 31 km)), and high temporal resolution (hourly data) [ECMWF].

Despite the widespread use of ERA5 data in climate and hydrological studies, its accuracy at the local scale varies depending on geographic, topographic, and climatic conditions [Copernicus …, 2025]. Therefore, it is crucial to evaluate the reliability of ERA5 temperature and precipitation data using ground-based observations before applying them in hydrometeorological research. Despite these improvements the accuracy of ERA5 data can vary across different regions and climatic conditions, making important of localized validation studies.

Several studies have evaluated the performance of ERA5 data in various regions. For instance, research in the Poyang Lake Basin, in the China, showed that ERA5 effectively captures air temperature patterns but tends to overestimate precipitation [Yan, et al., 2024]. ERA5 slightly overestimated summer precipitation. The study also noted that ERA5's accuracy varied with topography and climate regions, performing best in eastern, northwestern, and northern China, and showing the least bias in southeastern China [Jiao, et al., 2021].

Similarly, an assessment in Slovenia found that while ERA5-Land underestimates extreme rainfall events, it can still serve as viable alternative to ground-based data for rainfall-runoff modeling, provided that model recalibration is performed [Alexopoulos et al., 2023].

In Uzbekistan, the ERA5 reanalysis data provides relatively high accuracy in capturing temperature variations when compared with ground-based observations (77 meteorological stations), particularly for areas below 1000 meters above sea level. Locations below 500 m, the relative temperature error between ERA5 data and ground observations is about 1,44-4,55%, while for areas between 500-1000 m, the error is around 0,47-5,55%. At elevations above 1000 m, the accuracy of ERA5 data declines significantly, with relative errors reaching 12,13-33,12% [Rakhimov et al., 2023]. Even though, this research paper analyzed ERA5 performance in different temporal periods (3-hourly, daily, monthly), it does not evaluate ERA5 performance for precipitation. Moreover, this research paper shows temporal variable changes (1971-2024 y.) in different meteorological stations between ERA5 and ground-based observations for both temperature and precipitation.

In another research paper, ERA5 demonstrated improved performance compared to ERA-Interim when both are analyzed against observations from 74 meteorological stations for the period 1981–2018. The mean monthly temperature bias for ERA5 is –0.62 °C with a Pearson correlation of 0.98, compared to –1.57 °C and r = 0.97 for ERA-Interim, and its root-mean-square error falls from 2.60 °C to 2.25 °C. For maximum monthly temperature, ERA5 reduces the bias to –2.04 °C (r = 0,96) versus –3,14 °C (r = 0.95) for ERA-Interim, improving the RMSE from 3.37 °C to 2.98 °C. Total monthly precipitation bias is cut from –10,82 mm (r = 0,56) in ERA-Interim to –7.24 mm (r = 0.80) in ERA5, while the RMSE drops from 30.39 mm to 22.61 mm [Rakhmatova et al., 2021]. The main differences between this and Rakhmatova's scientific papers are that this research paper focuses evaluation of ERA5 for a single basin using different statistical measurements including line graphs to show temporal discrepancies while Rakhmatova's scientific paper used Mean error, Correlation and standard deviation.

This study aims to assess the correlation between observed meteorological data and ERA5 reanalysis data in the Akhangaran River Basin. The evaluation is conducted using five statistical metrics across three key categories: Error magnitude (RMSE, MAE), Systematic Bias (PBIAS), and Performance or Correlation (R^2, NSE). Additionally, time-series line graphs were plotted to analyze temporal variations and discrepancies between the datasets. The findings of this study will help determine the applicability of ERA5 data for climate studies in the region. The difference of this study from other studies about applicability of ERA5 is that this study involves a variety of statistic metrics and evaluation of precipitation at river basin scale.

The Akhangaran River Basin is bordered by the Qurama mountain range to the south and the Chatkal mountain range to the north. To the east, these two ranges converge, forming a natural boundary for the basin, while to the west, it is delineated by the Syr Darya riverbed. The lower part of the basin lies within the territory of Tashkent region, whereas the upper part extends into Namangan region (Fig. 1).

Precipitation in the basin is not evenly distributed throughout the year. If the total annual precipitation is considered 100%, approximately 41-42% falls in spring, 21-35% in winter, 18-28% in autumn, and only 6-12% in summer. The highest rainfall occurs in March and April.

The Akhangaran River has a total length of 236 km, a basin area of 7,710 km², and an average water discharge of 22,8 m³/s.

The research was conducted using monthly average datasets from six meteorological stations. The ERA5 dataset was downloaded and processed to compute monthly mean values of temperature and monthly total values of precipitation for direct comparison with observed data. When calculate mean monthly temperature values, the hourly data for [00, 03, 06, 09, 12, 15, 18, 21] downloaded since meteorological stations observe at these hours during time. From 3-hourly data, monthly mean temperature calculated. But for precipitation every hourly data download and sum of monthly data calculated. The reason this research paper evaluates using monthly data is that monthly aggregates minimize short-term variability and observational difference, providing a stable basis for comparing reanalysis and station observations. Monthly temperature means align with the reporting frequency of the meteorological stations, and monthly precipitation totals are directly relevant for catchment-scale hydrological analysis. According to the station coordinates identified in Fig. 1, the locations are listed in Table 1.

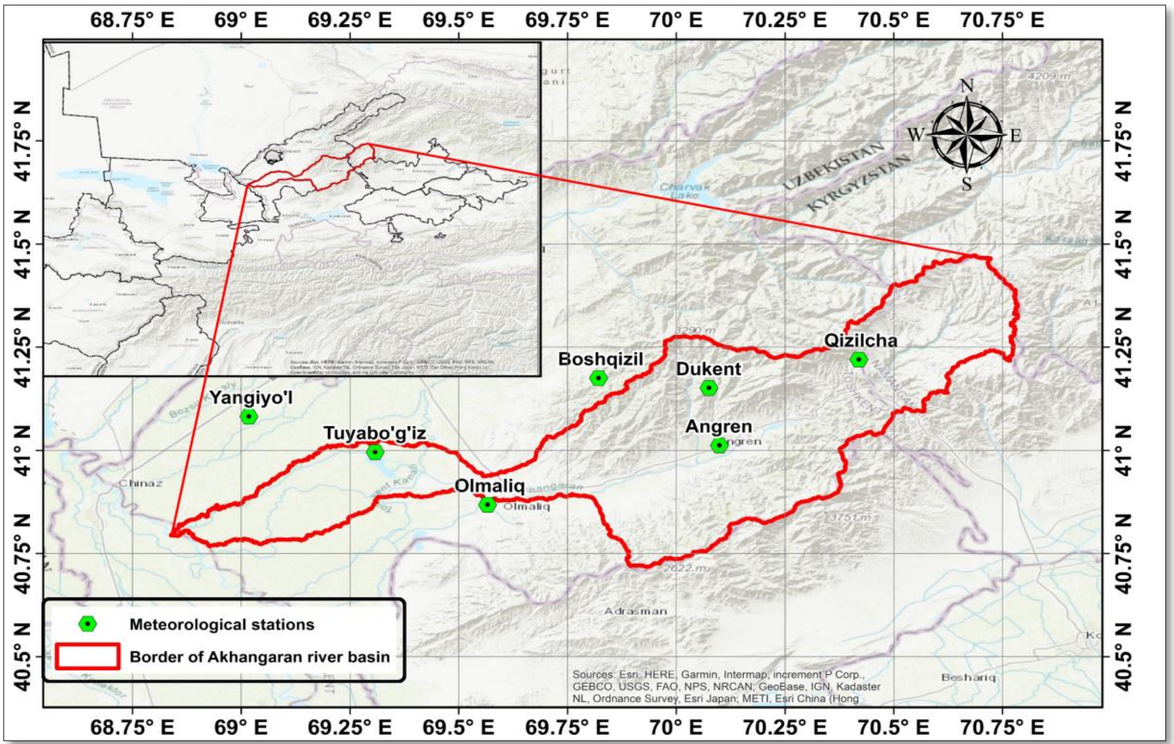

Fig. 1. Study area: Akhangaran river basin

Table 1

List of meteorological stations and their information

№	Meteorological stations	Elevation, m	Location of meteorological station		Corresponding location of ERA5 dataset		Available monthly data	n
			X	Y	X	Y		
1	Kizilcha	2600	41.212	70.42	41.25	70.5	1970-1992	272
2	Dukent	2140	41.158	70.075	41.25	70	1970-2024	660
3	Angren	945	40.999	69.585	41	70	1970-2024	660
4	Almalik	510	40.868	69.566	41	69.5	1979-2024	540
5	Tuyabogiz	404	40.998	69.934	41	69.25	1970-2020	636
6	Yangiyol	343	41.082	69.018	41	69	1970-2015	551

** Kizilcha meteorological station data is not used for plotting as it only operated during 1970-1992.*

The evaluation is conducted using five statistical metrics across three key categories: Error magnitude (RMSE, MAE), Systematic Bias (PBIAS), and Performance or Correlation (R^2, NSE).

Category 1 – Error Magnitude:

Root Mean Square Error (RMSE):

$$RMSE = sqrt\left(\left(\frac{1}{n}\right) * \sum_{i=1}^{n}(O_i - P_i)^2\right)$$

Mean Absolute Error (MAE):

$$MAE = \left(\frac{1}{n}\right) * \sum_{i=1}^{n}|O_i - P_i|$$

$\mathbf{O_i}$ = Observed value, $\mathbf{P_i}$ = ERA5 value, **n** = Number of data points

Category 2 - Systematic Bias:

Percent Bias (PBIAS):

$$PBIAS = \left(\frac{(\sum_{i=1}^{n}(O_i - P_i))}{\sum_{i=1}^{n} O_i}\right) \times 100$$

O_i = Observed value, P_i = ERA5 value **n** = Number of data points

Category 3 - Correlation and Performance:

Coefficient of Determination (R):

$$R^2 = \frac{[\sum(O_i - \bar{O})(P_i - \bar{P})]^2}{\sum(XO_i - \bar{O})^2 \sum(P_i - \bar{P})^2}$$

Nash-Sutcliffe Efficiency (NSE):

$$NSE = 1 - \left(\frac{\sum_{i=1}^{n} (O_i - P_i)^2}{\sum_{i=1}^{n} (O_i - \bar{O})^2}\right)$$

O_i = Observed value, P_i = ERA5 value, $\bar{P}$ = mean of ERA5 value

$\bar{O}$ = Mean of observed values, **n** = Number of data points

Table 2

Used statistical methods

N	Statistical metric	What It Measures	Range	Best Value
1	R² (Coefficient of Determination)	How well ERA5 explains variability	0 to 1	Closer to 1 is better
2	NSE (Nash-Sutcliffe Efficiency)	How well ERA5 fits observed data	∞ to 1	Closer to 1 is better
3	RMSE (Root Mean Square Error)	Overall accuracy, with emphasis on large errors	0 to ∞	Closer to 0 is better
4	MAE (Mean Absolute Error)	Overall accuracy, treating all errors equally	0 to ∞	Closer to 0 is better
5	PBIAS (Percent Bias)	Systematic over- or underestimation	∞ to ∞	Closer to 0 is better

Category 1 - Error Magnitude. Error Magnitude refers to the size or scale of the errors between observed and ERA5 values. It quantifies how much the ERA5 values deviate from actual observations in absolute terms.

The evaluation of ERA5 temperature data with observations from six meteorological stations (Kizilcha, Dukent, Angren, Almalik, Tuyabogiz, and Yangiyol) reveals notable variations in both error magnitude and correlation strength. Three main metrics – RMSE (Root Mean Square Error), MAE (Mean Absolute Error), and, while R^2 (Coefficient of Determination) indicates how much of the observed temperature variability is explained by ERA5 (Fig. 2).

Stations at lower elevations (Almalik-510 m, Tuyabogiz-404 m, Yangiyol-303 m) show exceptionally strong performance, with R^2 values close to 1,00 and very small RMSE and MAE (well under 1°C). These results suggest that, in those locations, ERA5 nearly replicates observed data with minimal systematic error (Table 3).

Higher elevation or more complex terrain stations exhibit greater discrepancies. At Angren, 945 m (R^2 = 0.74), and Kizilcha, 2600 m (R^2 = 0.76), absolute errors (RMSE, MAE) can exceed 4°C. Dukent, 2140 m (R^2 = 0.93) achieves a stronger correlation than the other high-elevation stations, with RMSE around 1-5 °C; however, overall**, temperature comparisons are highly matched with those stations with lower altitude (Table 3)**.

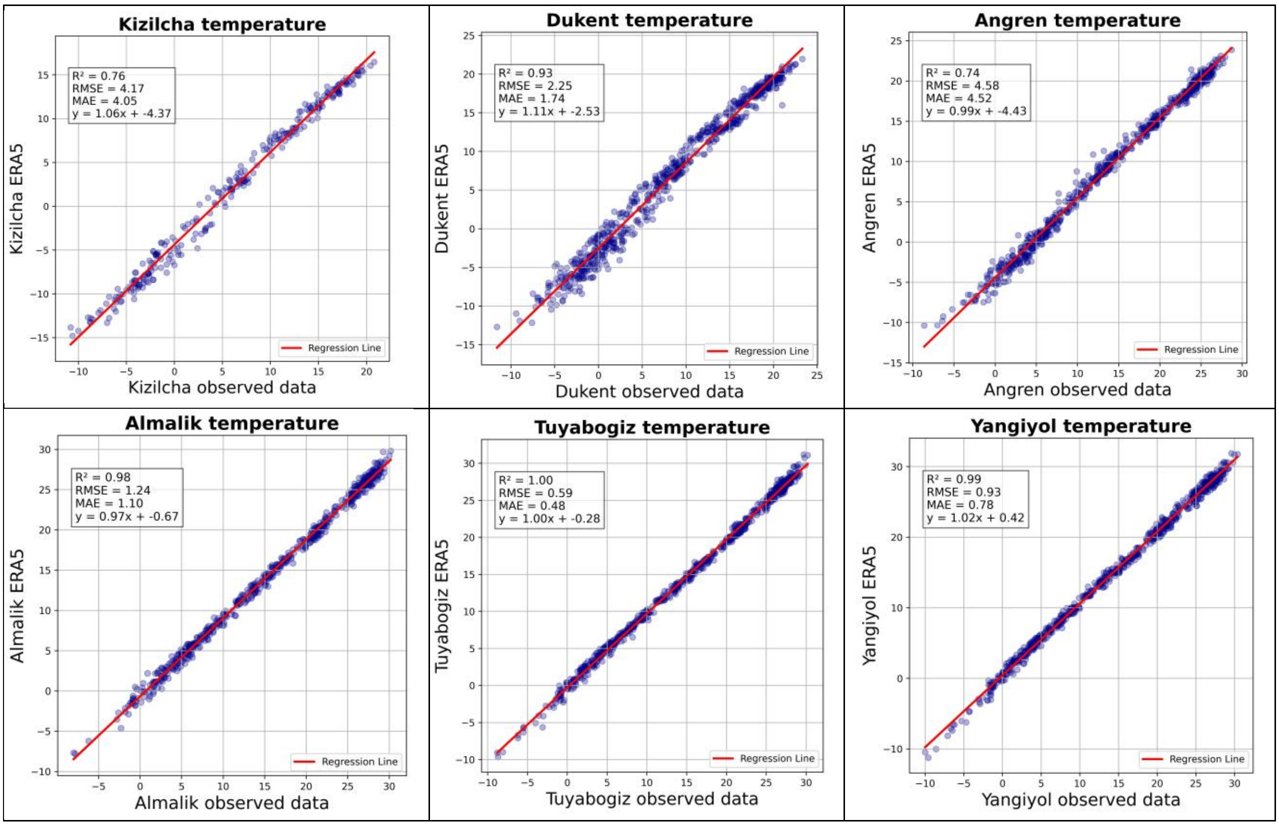

Fig. 2. Temperature (°C) scatter plots of different meteorological stations with corresponding ERA5 data

Table 3

Error magnitude statistical metrics for temperature

№	Stations	Elevation, m	Temperature		
			R^2	RMSE	MAE
1	Kizilcha	2600	0.76	4.17	4.05
2	Dukent	2140	0.93	2.25	1.74
3	Angren	945	0.74	4.58	4.52
4	Almalik	510	0.98	1.24	1.10
5	Tuyabogiz	404	1.00	0.59	0.48
6	Yangiyol	343	0.99	0.93	0.78

Angren meteorological station achieved an R^2 of 0,79, indicating that ERA5 accounts for nearly three-quarters of its observed precipitation pattern (Fig. 3). However, an RMSE of 24.04 mm and MAE of 17.72 mm imply substantial discrepancies, and these deviations become especially pronounced when observed precipitation is low. Dukent (R^2 = 0.87) stands out for having highest correlation, though its errors, at 23.92 mm RMSE and 17,04 mm MAE (Table 4).

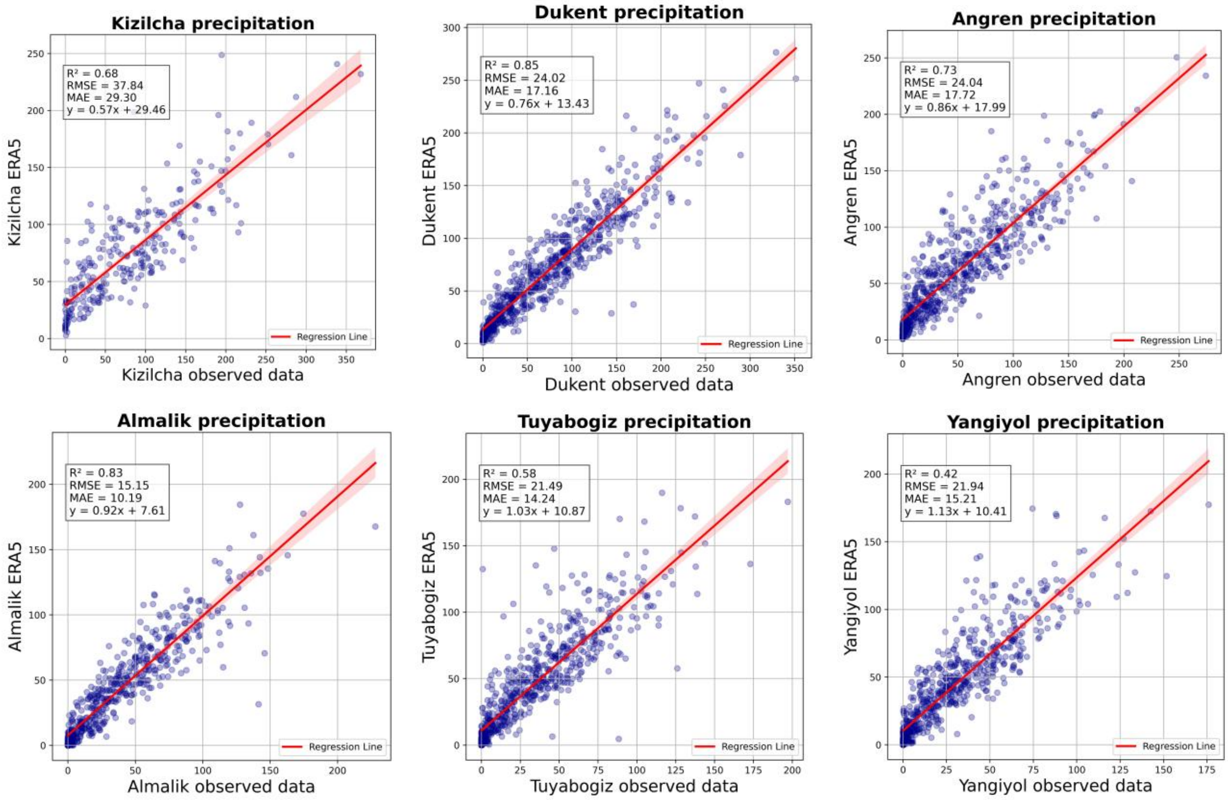

Fig. 3. Precipitation (in mm) scatter plots of different meteorological stations with corresponding ERA5 data

Table 4

Error magnitude statistical metrics for precipitation

№	Stations	Elevation, m	Precipitation		
			R^2	RMSE	MAE
1	Kizilcha	2600	0.71	37.84	29.3
2	Dukent	2140	0.87	24.02	17.16
3	Angren	945	0.79	24.04	17.72
4	Almalik	510	0.85	15.15	10.19
5	Tuyabogiz	404	0.78	21.49	14.24
6	Yangiyol	343	0.8	21.94	15.21

Category 2 – Systematic Bias (Using PBIAS). Percent Bias (PBIAS) is a statistical measure used to quantify the average tendency of ERA5, to investigate whether the reanalysis data overestimates or underestimates observed data. In many hydrological and meteorological studies:

a value PBIAS within: ±10% is often viewed as excellent, ±10–20% as good, ±20–40% as satisfactory, more than ±40% as poor.

In the Temperature column, most stations show negative PBIAS ERA5 data shows lower temperatures than observed. In particular, Kizilcha's large negative PBIAS (–67,87%) suggests a substantial bias. In higher altitude stations like Kizilcha, Dukent, Angren, Almalik, Tuyabogiz ERA5 underestimated the temperature. Meanwhile, Yangiyol has a small positive PBIAS (+4.83%), meaning it's slightly warmer than observed on average (Table 5).

Table 5

PBIAS values for both precipitation and temperature

№	Station	Elevation, m	PBIAS, (%)	
			Temperature	Precipitation
1	Kizilcha	2600	-67.87	-5.38
2	Dukent	2140	-19.73	-6.06
3	Angren	945	-33.98	21.63
4	Almalik	510	-7.07	11.64
5	Tuyabogiz	404	-1.86	35.50
6	Yangiyol	343	4.83	50.20

- Negative PBIAS indicates that ERA5 underestimates observations (red color)
- Positive PBIAS indicates that ERA5 overestimates observations (green color)

In the Precipitation column, Angren, Tuyabogiz, Yangiyol, and Almalik all have positive PBIAS, indicating overestimation of precipitation, with Yangiyol's bias being the highest (+50.2%). Dukent, and Kizilcha show negative PBIAS, so ERA5 underestimates precipitation in those locations.

Category 3 – Efficiency (NSE) and linear graphs.

R (Coefficient of Determination) measures of the linear relationship between two variables namely how strongly they move together (and in which direction). Its value ranges from **-1 to 1: +1**= Perfect positive linear relationship, and **0** = No linear relationship.

Nash Sutcliffe Efficiency (NSE) is a statistical metric used to **evaluate the predictive accuracy** of ERA5 data by comparing its performance to the mean of observed values.

NSE = 1 → Perfect data (ERA5 data match observations exactly).

NSE > 0.5 → Good ERA5 data performance.

NSE = 0 → ERA5 is as accurate as the mean of observations.

NSE < 0 → ERA5 performs worse than just using the mean.

In all stations, there is high linear correlation between observed temperature data and ERA5 reanalyses data Tuyabogiz and Yangiyol, Almalik points show the best alignment between ERA5 and observations, as reflected by R^2 values above 0.9. Nash–Sutcliffe Efficiency (NSE) is negative for most higher-altitude stations (Kizilcha, Dukent, Angren, and Almalik), suggesting that ERA5's estimates at those sites perform worse than simply using the long-term mean. In contrast, the lower-elevation stations Tuyabogiz and Yangiyol show positive NSE, indicating that ERA5 does provide better data for both the absolute values and variations in temperature there (Fig. 4).

While ERA5 precipitation values with meteorological stations with higher altitudes have higher linear correlation, in lower altitude stations, there are higher linear differences (Fig. 5).

Precipitation fairly well correlated across all six stations, with R-values ranging from 0.71 at Kizilcha to 0.87 at Dukent. Even the lowest correlation (0.71) still suggests a strong linear relationship between observed precipitation and ERA5 data (Table 7).

Looking at the Nash–Sutcliffe Efficiency (NSE), the highest value (0.99) appears at Dukent, indicating that ERA5 captures the observed precipitation patterns there most accurately. In contrast, ERA5 reanalysis for Yangiyol shows the lowest NSE (-4.48), despite having an R-value of 0.85, which highlights how a high correlation alone does not necessarily guarantee a strong match to the magnitude and timing of observed values.

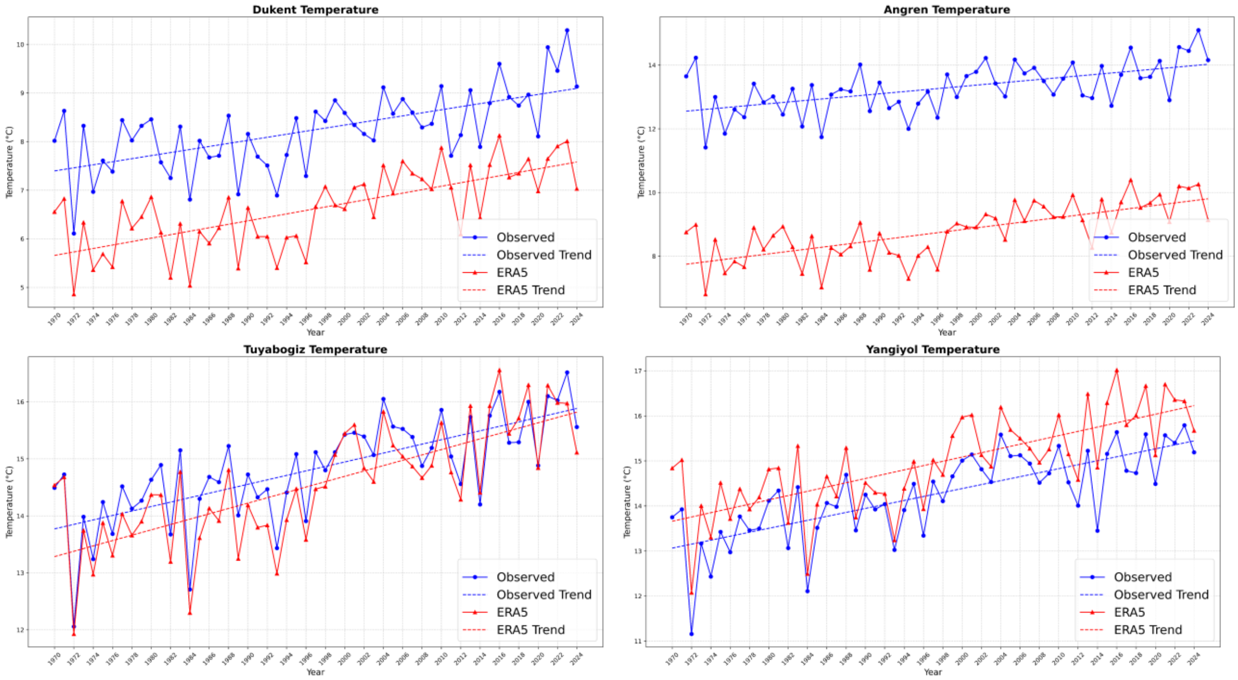

Fig. 4. Temperature linear graphs of different meteorological stations with corresponding ERA5 data

Table 6

Linear correlations and NSE values for temperature

№	Station	Elevation, m	Observed annual mean temperature, °C	ERA5 annual mean temperature, °C	Difference in temperature, °C	Linear correlation (R^2)	Efficiency (NSE)
1	Kizilcha	2600	5.95	1.91	4.04	0.76	-41.36
2	Dukent	2140	8.25	6.62	1.63	0.93	-3.43
3	Angren	945	13.29	8.77	4.52	0.74	-34.28
4	Almalik	510	15.17	14.10	1.07	0.98	-1.61
5	Tuyabogiz	404	14.83	14.55	0.28	1	0.79
6	Yangiyol	343	14.25	14.94	-0.69	0.99	0.35

Conclusion. This study evaluated the accuracy of ERA5 reanalysis data for temperature and precipitation by comparing monthly averages from six meteorological stations located at varying elevations within the Akhangaran River Basin. The analysis used popular statistical metrics – RMSE, MAE, PBIAS, R, and NSE to capture error magnitude, systematic bias, and the degree of correlation between ERA5 and observed station data. However, Akhangaran river basin's terrain is very complex. Thus, disparities in both temperature and precipitation occur. The reason that there are high correlation between observed and ERA5 reanalyses data is because of similar oscillations throughout the period in those datasets (Fig. 4 and Fig. 5).

ERA5 reanalysis data for temperature. High Agreement at Lower Elevations: Stations at lower altitudes (Almalik, Tuyabogiz, and Yangiyol) consistently showed R ≥ 0.99 and NSE close to 1, indicating near-perfect correspondence. Both RMSE and MAE were under 1°C, and PBIAS was minimal.

Greater Discrepancies in Mountainous Areas: Elevated stations (Kizilcha, Angren) exhibited larger temperature errors (RMSE often >4°C). Although their correlations (R) remained decent

(≥0,74), relatively lower NSE values revealed limitations in ERA5's precise predictive skill at higher elevations. Dukent, despite its high elevation, performed better than other mountain stations in terms of linear correlation (R^2 up to 0.93).

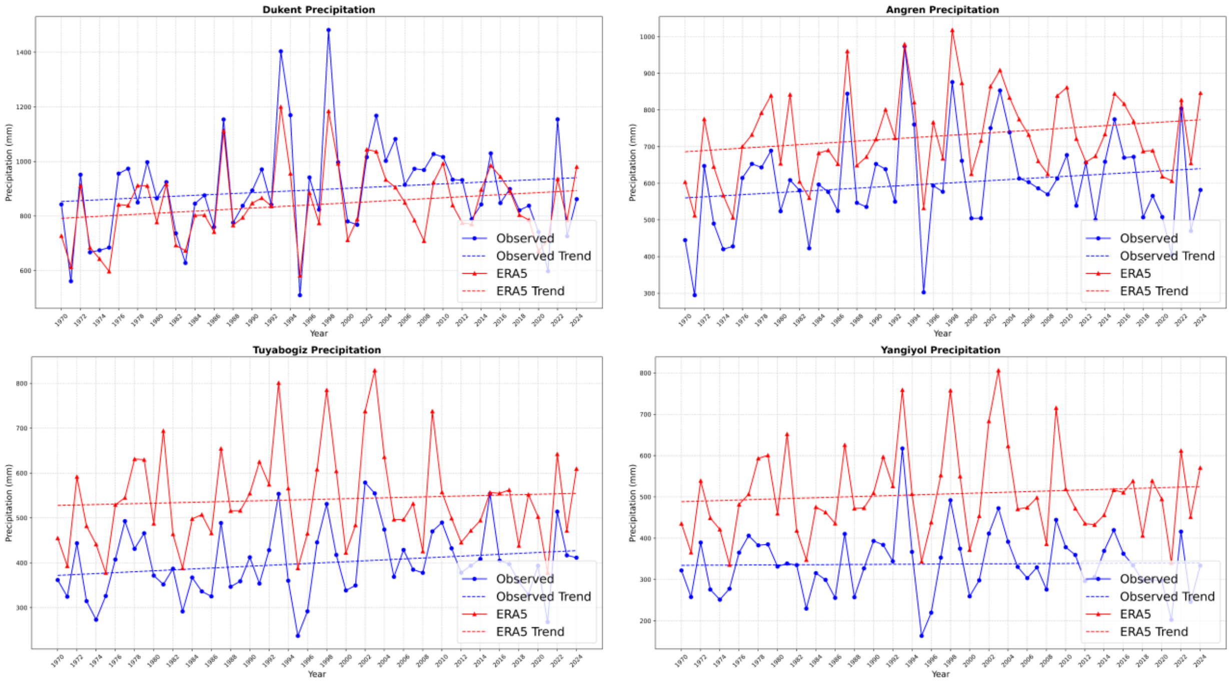

Fig. 5. Linear graphs of different meteorological stations with corresponding ERA5 data

Table 7

Linear correlations and NSE values for precipitation

№	Station	Elevation, m	Observed annual mean precipitation, mm	ERA5 annual mean precipitation, mm	difference in precipitation, mm	Linear correlation (R^2)	Efficiency (NSE)
1	Kizilcha	2600	391.2	370.2	21.0	0.71	0.99
2	Dukent	2140	896.8	842.4	54.4	0.87	0.67
3	Angren	945	600.0	729.8	-129.8	0.79	-0.16
4	Almalik	510	380.2	424.4	-44.2	0.85	0.89
5	Tuyabogiz	404	399.5	541.3	-141.8	0.78	-3.20
6	Yangiyol	343	337.4	506.8	-169.4	0.80	-4.48

In this study, our results closely match those of Rakhimov. At lower-elevation stations (below 1000 m, such as Almalik, Tuyabogiz, and Yangiyol), the RMSE ranges from 1.24 to 0.93 °C, compared with 1.20 to 0.69 °C in Rakhimov's paper. Likewise, our coefficient of determination varies from 0.98 to 1.00, while Rakhimov reports values around 0.99, demonstrating high accuracy in both studies. Both papers also show that the discrepancy between ERA5 and observed temperatures increases with elevation. Similarly, Rakhmatova's research paper demonstrated high correlation (0.98) with observed station data.

ERA5 reanalysis data for precipitation. Moderate Correlations but High Absolute Errors: ERA5 captured monthly precipitation trends reasonably (R^2 ranging roughly from 0.71 to 0.87), yet RMSE and MAE values (often exceeding 50-100 mm). These large relative errors reflect the impact of small observed values, especially at mountainous stations.

Rakhmatova's research paper evaluated ERA5 precipitation and found a correlation coefficient of 0.8. Remarkably, when we calculate the average correlation coefficient for six stations in the Akhangaran River Basin, we also obtain 0.8, confirming that our results closely match theirs.

Station-Specific Bias: PBIAS indicated that ERA5 tends to underestimate precipitation at certain high-altitude stations (e.g., Dukent, Kizilcha) and overestimate at lower-altitude stations (Angren, Almalik, Tuyabogiz, Yangiyol). Among the stations, ERA5 for Almalik achieved the best combination of correlation ($R^2 = 0.85$) and NSE (0.89), highlighting relatively strong agreement but still requiring site-specific corrections. In other stations, especially Yangiyol and Tuyabogiz, NSE showed worse results.

Implications of ERA5 reanalysis data for hydrometeorological applications within Akhangaran River Basin.

Lowland suitability (<1000 m): ERA5 temperature data in lower-altitude areas appears highly accurate and generally suitable for practical applications without major correction. But precipitation in lower elevation places are needed to use correction for other studies but still viable tool for those areas.

Mountainous terrain suitability (>1000 m): Elevated stations demand further bias correction and calibration, as complex terrain leads to more differences in deviations in temperature. ERA5 precipitation data for the area is generally satisfactory in mountainous area of the basin proving NSE > 0.66 and NSE < 0.99 and strong linear correlation in higher altitudes.

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Authors contribution. B.E. Nishonov: concept and design of the article, methodology, choosing the study area, editing. **M.M. Abdurakhmanov:** data collection, data processing, analysis of results, formatting the article, drafting the manuscript, making graphs and maps. All authors have read the version of the manuscript recommended for publication and have given their consent.

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Eletronic resources:

ECMWF (European Centre for Medium-Range Weather Forecasts) URL: https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5

Copernicus climate portal. URL: https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels

ERA5 РЕАНАЛИЗ МАЪЛУМОТЛАРИНИ ОҲАНГАРОН ДАРЁ ҲАВЗАСИДА КУЗАТИЛГАН МЕТЕОРОЛОГИК МАЪЛУМОТЛАР БИЛАН ҚИЁСИЙ ТАҲЛИЛИ

Б.Э. НИШОНОВ[1,2], М.М. АБДУРАҲМАНОВ[1,2]

[1] Гидрометеорология илмий-тадқиқот институти, abdurakhmanovmurodjon1@gmail.com
[2] Мирзо Улуғбек номидаги Ўзбекистон Миллий университети, bnishonov@mail.ru

Аннотация. *Ушбу мақолада Оҳангарон дарёси ҳавзасида кузатилган метеорологик маълумотлар билан ERA5 реанализ маълумотлари ўртасидаги корреляция таҳлил этилди. Баҳолаш учта асосий тоифада бешта статистик мезон ёрдамида амалга оширилади: хатолик ўлчами (RMSE, MAE), меъёрдан четлашиш (PBIAS) ва бошқа статистик кўрсаткичлар (NSE, R²). 1970-2024 йиллар оралиғидаги ҳар ой маълумотлари олтита метеорология станциясидан олинган кузатилган маълумотлар билан мос келувчи ойлик ERA5 маълумотлари солиштирилади, бу орқали реанализ маълумотларининг маҳаллий метеорологик шароитларни тасвирлашдаги яроқлилиги баҳоланади. Бундан ташқари, чизиқли графиклардан турли йиллардаги вақт ўтиши билан боғлиқ ўзгаришлар ва тафовутларни визуализация қилиш учун фойдаланилди. Статистик ва визуал таҳлилларни бирлаштириш орқали ушбу тадқиқот минтақадаги гидрометеорологик тадқиқотлар учун ERA5 реанализ маълумотларининг қўлланиш имкониятларини кенг қамровли баҳолашни таъминлади.*

Калит сўзлар: *ERA5 реанализ, кузатилган маълумотлар, корреляция таҳлили, статистик баҳолаш, хато ўлчами, Nash Sutcliffe самарадорлиги (NSE), фоиз четлашиш (PBIAS), маълумотларни валидация қилиш.*

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ДАННЫХ РЕАНАЛИЗА ERA5 С НАБЛЮДЕННЫМИ МЕТЕОРОЛОГИЧЕСКИМИ ДАННЫМИ В БАССЕЙНЕ РЕКИ АХАНГАРАН

Б.Э. НИШОНОВ[1,2], М.М. АБДУРАХМАНОВ[1,2]

[1] Научно-исследовательский гидрометеорологический институт, bnishonov@mail.ru
[2] Национальный университет Узбекистана имени Мирзо Улуғбека, abdurakhmanovmurodjon1@gmail.com

Аннотация. *В данной статье анализирована корреляция между наблюдаемыми метеорологическими данными и данными реанализа ERA5 в бассейне реки Ахангаран. Оценка проводилась по пяти статистическим показателям в трёх ключевых категориях: величина ошибки (RMSE, MAE), систематическая погрешность (PBIAS) и показатели эффективности или линейной корреляции (NSE, R²). Ежемесячные данные за период 1970–2024 гг. с семи метеостанций сравнивали с соответствующими ежемесячными наборами данных ERA5 для оценки достоверности реанализа при отражении локальных метеорологических условий. Также, использовались линейные графики для визуализации временных изменений и расхождений по разным годам. Интегрируя статистический и визуальный анализ, исследование обеспечивает всестороннюю оценку применимости данных реанализа ERA5 для гидрометеорологических исследований в регионе.*

Ключевые слова: *реанализ ERA5, наблюдаемые данные, корреляционный анализ, статистическая оценка, величина ошибки, коэффициент эффективности Нэша–Сатклиффа (NSE), процентное смещение (PBIAS), валидация данных.*