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Short communication

Trend analysis of monthly and seasonal temperature in different districts of Hyderabad-Karnataka region

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Climate change is a critical global issue, and understanding regional temperature trends is essential for effective mitigation and adaptation strategies. Rising temperatures, driven by climate change and anthropogenic activities, are altering hydrological cycles, weather patterns, and environmental systems (Chi *et al.,* 2023). Over the past few decades, climate change has significantly affected agricultural productivity worldwide (Yadav *et al.,* 2020). Increasing climate variability and frequent extreme weather events have become major challenges for sustainable development and food security (Gregory *et al.,* 2005). Rising temperatures have also intensified evapotranspiration, amplified agricultural droughts and increased crop water demand, which has led to severe water scarcity in several Indian regions (Singh, 2019). To study climatic trends, both parametric and non-parametric statistical methods such as the Mann-Kendall test, Theil-Sen slope estimator, and linear regression have been widely applied (Abdulfattah *et al.,* 2025; Swami, 2024; Sridhara and Pradeep, 2021). The Hyderabad-Karnataka region in southern India exemplifies an area where assessing temperature trends is vital. Understanding these patterns provides critical insights into climate impacts and supports strategies for sustainable development and regional climate adaptation (Kalli and Jena, 2023).

The Hyderabad-Karnataka region is the northeastern part of state of Karnataka comprising six districts (Bidar, Kalaburgi, Yadgir, Raichur, Koppal and Bellari) sharing the eastern boundaries with the states of Telangana and Andhra Pradesh and lies between latitudes 14°60' to 18°30' North and longitudes 75°60' to 77°70' East. It is now known as Kalyana Karnataka region, renamed in 2019 to move away from its colonial association and reflect a new era of development. The climate of the region is predominantly dry for most of the year, with extremely hot summers reaching temperatures of up to 45°C. The hot summer begins in mid-February and lasts until the end of May. The region receives rainfall from both the South-West and North-East monsoons, with an average annual rainfall of 692 mm. Evaporation rates in the region vary significantly, reaching a high of 9.0 mm day^{-1} during summer and dropping to 1.1 mm day^{-1} in winter.

The temperature data utilized for the current study was sourced from the NASA POWER (https://power.larc.nasa.gov/) database, specifically focusing on average temperature records of six districts (Bidar, Kalaburgi, Yadgir, Raichur, Koppal and Bellari) spanning a period of 42 years, from 1981 to 2022. The raw data was processed and aggregated into monthly and seasonal averages. The seasons were categorised as *kharif* (June to September), *rabi* (October to February) and summer (March to May). The long-term temperature trends were analyzed using the non-parametric Mann Kendall test (Mann, 1945; Kendall, 1975). The details of MK test analysis are presented by several workers (Abdulfattah *et al.,* 2025; Swami, 2024).

The Mann Kendall trend analysis (Table 1) revealed a

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Table 1: Mann-Kendall trend analysis (*z*-values) for monthly, seasonal, and annual temperature in different districts

Month	Bidar	Bellari	Koppal	Kalaburgi	Raichur	Yadgir
January	-1.40	-0.71	-1.15	-0.97	-0.65	-0.99
February	-0.71	-1.80	-1.44	-0.75	-1.85	-1.19
March	-0.38	-0.54	-0.22	-0.62	-0.88	-0.81
April	-0.03	-0.62	-0.55	-0.44	-0.16	-0.44
May	-0.82	-1.18	-0.93	-0.39	-1.07	-0.31
June	0.26	0.40	0.78	0.26	0.27	0.62
July	2.49	1.90	1.23	2.48**	2.02*	2.70**
August	4.04**	2.64**	2.70**	3.59**	2.76**	3.19**
September	2.21	-0.26	0.10	1.37	0.06	0.87
October	1.53	0.83	0.49	1.37	0.91	1.15
November	1.34	1.60	1.76	1.09	1.51	1.19
December	0.40	0.56	0.56	0.55	0.57	0.49
Kharif	2.66**	1.33	1.72	2.35*	1.90	2.33*
Rabi	-0.06	0.03	-0.07	0.24	0.10	0.00
Summer	-0.40	-1.26	-1.02	-0.55	-0.80	-0.60
Annual	1.52	0.16	0.57	1.47	0.57	1.25

*Statistically significant at 0.05 level of significance; **Statistically significant at 0.01 level of significance.

consistent pattern of significant warming during the monsoon months across the Kalyana Karnataka region, particularly in July and August. The standardized statistics (Z) was used to test the significance of trends at the 99 per cent significance level ($|Z_{MK}|>2.575$) and at 95 per cent significance level ($|Z_{MK}|>1.96$). Most districts, including Bidar, Kalaburgi, Raichur, Yadgir, Ballari, and Koppal, showed statistically significant positive trends during these months, with *z*-values generally ranging between 2.0 and 4.0 ($p \leq 0.05$). This indicates a regional intensification of temperatures during the peak monsoon period, suggesting an overall warming of the monsoon climate. Bidar and Kalaburgi also exhibited moderate warming trends in September, indicating a possible extension of warming into the late monsoon season. In contrast, pre-monsoon months (January to May) generally showed weak negative or negligible trends, reflecting minor cooling or temperature stability before the onset of the monsoon. Similarly, post-monsoon and winter months did not display any significant changes in temperature, indicating that warming is largely confined to the monsoon phase. At the seasonal scale, the *kharif* season showed a significant positive trend across most districts, with *z*-values typically between 1.9 and 2.7 ($p \leq 0.05$), reaffirming the dominance of monsoon-related warming in the region. However, the *rabi* and summer seasons exhibited no significant trends, pointing to relatively stable temperature conditions outside the monsoon months (Table 1).

On an annual basis, most districts recorded positive but statistically insignificant trends, with *z*-values ranging from 0.16 to 1.52 ($p > 0.05$). This indicates that while annual temperatures show a slight upward tendency, the most pronounced warming is concentrated within the monsoon season rather than being evenly distributed throughout the year. Overall, the Kalyana Karnataka region is undergoing seasonally focused warming, primarily confined to the monsoon months (July–August) and reflected in the *kharif* season, aligning with broader regional climate change patterns observed across peninsular India.

Across all six districts, a consistent pattern of warming during the monsoon months, particularly in July and August, is evident. August consistently exhibited significant warming trends across all stations, with Bidar (z = 4.04) and Kalaburgi (z = 3.59) experiencing the most pronounced increases. The *kharif* season also exhibited significant warming trends in Bidar, Kalaburgi, and Yadgir, reinforcing the observation that temperature increases are concentrated during the monsoon period. Stations such as Bellari, Koppal, and Raichur showed weaker trends, indicating spatial variability in the extent of warming. In contrast, the *rabi* and summer seasons showed no significant trends across any of the stations, suggesting stability during these periods. On an annual scale, none of the stations exhibited statistically significant trends, with z-values remaining below the threshold for significance. This indicates that the observed changes are largely seasonal rather than year-round, with the monsoon months driving the overall warming patterns. Spatially, Bidar, Kalaburgi, and Yadgir emerged as the stations with the strongest and most consistent warming trends, particularly during the monsoon and *kharif* season. In contrast, Bellari, Koppal, and Raichur showed less pronounced changes, indicating localized differences in climatic responses. These findings suggest that while the region is experiencing significant warming during the monsoon, the intensity and extent of these changes vary across stations.

The results highlight a clear regional warming pattern concentrated during the monsoon months of July and August, with significant implications for agriculture, water resources, and local ecosystems. The warming trends during the *kharif* season further underscore the need to adapt agricultural practices and water management strategies to cope with changing climatic conditions. The lack of significant trends during the *rabi* and summer seasons suggests that these periods remain relatively stable, but continued monitoring is essential to detect any emerging changes. Overall, this study provides valuable insights into the spatial and temporal dynamics of temperature trends in the Hyderabad Karnataka region.

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