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Understanding Year Wise Deviation and Trend of Monthly Value of Meteorological Parameters for Some Cities in India for the Month of April in Comparison with Normal by AIML

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ABSTRACT

This paper is based on research study with meteorological parameters related with monthly day summary data from historical years since 1969 till 2026. The month of study was the month April. The data collection platform was 'Data supply platform IMD Pune'. The stations under study were some important cities in India. The historical meteorological day summary monthly data for some important meteorological parameters for each city were collected similarly since 1969 till 2026 along with corresponding historical record of monthly normal values for those meteorological parameters for those cities for analysis. The study was to understand the deviation of monthly value of these parameters from the monthly normal value of the same parameters since 1969 till 2026 and also to understand the predicted trend of the deviation of the same parameters for recent future years. For better understanding of the pattern change or deviation from past as well as understanding of future trend of the deviation of those meteorological parameters through all over India, data for cities from all parts of India among which Srinagar and Shimla from north, Jaipur and Mumbai from west, Bhubaneswar and Kolkata (Alipore) from East , Chennai and Bengaluru from south and Delhi as city from central part of India were chosen whose historical monthly data were collected for the analysis with python programming language on google collaborator platform. The meteorological day summary data, for these cities and monthly deviation from normal for the parameters MMAX, mean maximum temperature in 0c, HMAX, highest maximum temperature in 0c, MMIN, mean minimum temperature in 0c, LMIN, lowest minimum temperature in 0c, TMRF, total rainfall in the month in mm, RD, number of rainy days in the month having rainfall more than 2.4 mm ,MWS, mean wind speed in kmph,P2, number of days with precipitation 0.3 mm or more and also for HA,TH,FG,DS,SQ, respectively number of days with hail, thunder, fog, dust storm data in month ,were collected for those cities for this analysis with concerned month APRIL under study.

***Keywords**: AIML, Meteorological Parameters, MMAX, HMAX, MMIN, LMIN, HA, TH, FG, DS, SQ.*

Introduction

For latest research, study with deviation of weather parameter in comparison with recorded normal and also study with trend of predicted value of deviation for each meteorological parameter had been done. The insights are valuable for various fields such as agriculture, tourism, various stakeholders and organizations those have need for climate and weather information. For drought management, flood management, policy formulation, irrigation, power supply management, farmers, tourism company, aviation sector, transportation sector, insurance and financial institutions, research and academic institutions all are immensely benefitted by weather and weather parameter trend prediction insights which has much importance for sustainable climatic conditions.

Literature Review

In the latest research study, under preparation, with topic to study the trend of meteorological parameters by artificial intelligence and machine learning, initially the future prediction for deviation from normal with respect to meteorological parameters, was done by simple neural network model. But the accuracy of model performance by neural network to get the output for future insights of predicted value of deviation from normal with respect to all meteorological parameters was not satisfactory enough, as this latest research study was associated with mean monthly value of all meteorological parameters, day summary data, the data set being small. Then all suitable machine learning models under supervised learning were performed one by one, compared to check model performance and the insights obtained for prediction of trend of weather parameters for 2026 onwards till 2028, were observed with higher accuracy and the best model performance was obtained by gradient boosting method. Different papers on machine learning based on weather prediction by gradient boosting method had been studied to understand the concept and technique of prediction of future trend of meteorological parameters. Advantage of gradient boosting for weather prediction is the output can be obtained with high accuracy. 'Almost similar type of technique has been followed in this research study also. Gradient boosting has been shown to outperform traditional models, achieving superior accuracy in various studies, including precipitation and temperature forecasting'(Dass, 2025). 'This technique excels at identifying intricate relationships among multiple weather variables, which is crucial for accurate predictions in chaotic atmospheric conditions'(Nagaraj et al., 2023). Regarding robustness against overfitting, this can be quoted "By combining multiple weak learners, gradient boosting reduces the risk of overfitting, enhancing model generalization across different weather scenarios(Mathur et al., 2024). Regarding extreme temperature forecasting "Gradient boosting has been successfully applied to predict extreme high temperatures, such as in Paris and Cairo, where it demonstrated promising accuracy in forecasting rare heat events (A., 2025)".

Research Gap

In this research study, the output and all insights related with all meteorological parameters had been judged by neural network model and several machine learning models for the future predicted value of deviation from normal value. Ultimately the insights obtained from gradient boosting method was accepted from the point of view of best performance.

Research Questions / Hypothesis

For each city in India under this study, the deviation trend from historical past to present year including predicted value for some near future years had been analysed to get insights about the trend of deviation for each meteorological parameters whether any anomaly has been taken. Several valuable insights could be obtained towards steps of sustainable environment.

Methods

The latest research study is based on study of deviation of mean monthly value of meteorological parameters from recorded normal value of the same, the study of historical years from 1969 to 2025 and the study of prediction value of the deviation from normal is for 2026 to 2028. To study monthly deviation total nine Indian cities have been selected from India. Two cities from each part, north, south, east, west and central India were taken for the analysis for study the historical and predicted trend. The cities were Srinagar and Shimla, Alipore(Kolkata) and Bhubaneswar, Chennai and Bengaluru, Jaipur and Mumbai and Delhi respectively from north, east, south, west and central India. Firstly from the online data supply platform IMD PUNE, the day summary data of all the 9 cities of India were obtained. Thus obtained monthly day summary data for all cities consisting of monthly value of meteorological parameters as MMAX (mean maximum temperature in degree celcius), HMAX(highest maximum temperature in degree celcius), MMIN(mean minimum temperature in degree celcius), LMIN (lowest minimum temperature in degree celcius), TMRF(Total rainfall in the month in mm), HVYRF (heaviest 24 hrs rainfall in mm), RD (Number of rainy days in the month, days with rainfall>2.4 mm), MWS (Mean wind speed in kmph),MEVP(mean evaporation in mm),MSSH(duration of sunshine in hours),P1(number of days with precipitation 0.1 to 0.2 mm, P2 (number of days with precipitation 0.3 mm or more) and also meteorological weather phenomena like SN,HA,TH,FG,DS,GF,GA,SQ,LS which are actually number of days with snow or sleet, hail, thunder, fog, dust storm, ground frost, gale, squall, line squall in respective order. All these meteorological parameters were obtained till 2025, months as available there and data obtained and available as per relevance of that particular meteorological station. In this study day summary data of nine (9) meteorological stations have been obtained from the IMD NDC portal. From the whole data set, for analysis, only the data for the month 'April' was extracted. Then the data of recorded

normal value for all parameters under analysis according as the availability of the normal value for that parameter for each particular station were collected, saved as csv file and merged with the observation file of that particular station. Then from the newly created merged file, consisting of monthly value of April for observational data, created separately for each meteorological city, column of deviation from normal for each weather parameter was created to continue analysis to observe historical data of deviation from normal for weather parameters. Rather than studying trend of deviation of meteorological parameters from historical years, the trend of predicted deviation for future years till 2028 was also obtained by machine learning technique. On account of small data set, prediction by neural network model could not achieve model accuracy score to the satisfactory level, then model evaluation to predict deviation from normal for each selected meteorological parameter was performed by machine learning models one by one to get predicted value for near future years by best model with highest accuracy. The machine learning models used were linear regression, random forest, gradient boosting method and the gradient boosting method was observed as the best model achieving highest accuracy and so the predicted value of deviation for the future years as obtained from gradient boosting model was accepted ultimately.

Significance of the Study

The insights obtained from the whole analysis could help to understand about weather anomalies on the basis of selected cities of India. Regional insights also could be drawn accordingly.

Timeline

Longitudinal study**.** Model evaluation for neural network as well as various machine learning models were performed to verify insights obtained.

Analysis and Interpretation for Nine Cities (By Gradient Boosting)

- **Alipore**

Temperature

Parameter	1969	2025	2026	2027	2028	Trend
Max	0.70	-1.10	-0.93	-0.93	-0.93	Overall, narrowing of the diurnal temperature range, warmer nights and moderated daytime temperature extremes.
Min	-0.30	0.50	0.59	0.59	0.59	
Hmax	1.90	-0.60	-0.45	-0.46	-0.45	
Lmin	-0.70	-1.90	-1.60	-1.69	-1.70	

Rainfall

Parameter	1969	2025	2026	2027	2028	Trend
TMRF (mm)	85.40	-7.1	-11.9	-11.9	-11.9	Significant deficit in rainfall, decreasing rainy days.
RD	-0.20	-0.2	-0.42	-0.41	-0.41	
P2	-1.30	-1.3	-1.62	-1.61	-1.61	

Wind

Parameter	1969	2025	2026	2027	2028	Trend
MWS	3.60	0.886	0.778	0.770	0.777	Near normal margin

Thunderstorm

Parameter	1969	2025	2026	2027	2028	Trend
TH	-0.90	-2.9	-2.81	-2.81	-2.80	Both thunderstorm, squall gradually declining.
SQ	3.10	-1.9	-1.74	-1.74	-1.70	

Hail, Fog and Dust Storm

Parameter	1969	2025	2026	2027	2028	Trend
HA	-0.10	-0.10	-0.0986	-0.098	-0.09	Almost same as normal, indicating climate stability.
FG	0	0	0	0	0	
DS	0	0	0	0	0	

NN (Neural network) vs GB (gradient boosting)

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	1.3008	0.38	0.39	0.40	0.1209	-0.93	-0.93	-0.93
Min	0.7569	0.80	0.83	0.86	0.0538	0.59	0.59	0.59
Hmax	1.5126	1.15	1.19	1.23	0.1150	-0.46	-0.46	-0.46
Lmin	2.6429	0.92	0.95	0.98	0.2021	-1.70	-1.70	-1.70
Tmrf	1946.2189	-14.39	-14.97	-15.55	115.3319	-11.96	-11.96	-11.96
Rd	3.9924	-1.09	-1.13	-1.17	0.2913	-0.42	-0.42	-0.42
Mws	1.3126	-0.32	-0.33	-0.33	0.0674	0.78	0.78	0.78
P2	9.0393	-2.37	-2.47	-2.57	0.7053	-1.62	-1.62	-1.62
Ha	0.1319	0.02	0.03	0.04	0.0004	-0.10	-0.10	-0.10
Th	15.4717	-1.94	-1.98	-2.03	1.5471	-2.81	-2.81	-2.81
Fg	0.0913	-0.00	-0.00	-0.00	0.0000	0.00	0.00	0.00
Ds	0.0000	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Sq	4.5678	-0.83	-0.86	-0.88	0.2720	-1.74	-1.74	-1.74

- **Bhubaneswar**

Parameter	1969	2025	2026	2027	2028	Trend
Max	0.00	-1.40	-1.25	-1.25	-1.25	Moist, more storm-prone environment than past.
Min	0.00	-0.20	-0.15	-0.15	-0.15	
Hmax	1.90	-1.50	-1.26	-1.26	-1.26	
Lmin	1.80	-1.00	-0.82	-0.82	-0.82	
Tmrf	-34.50	38.50	34.78	34.78	34.78	
Rd	-1.20	1.80	1.63	1.63	1.63	
Mws	15.30	3.60	3.26	3.26	3.26	
P2	-2.80	3.20	2.90	2.90	2.90	
Ha	0.00	0.00	0.00	0.00	0.00	
Th	3.70	7.70	7.28	7.28	7.28	
Fg	0.00	0.00	0.02	0.02	0.02	
Ds	0.00	0.00	0.00	0.00	0.00	
Sq	0.00	0.00	0.00	0.00	0.00	

NN vs GB

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	1.3854	0.46	0.47	0.47	0.1114	-1.25	-1.25	-1.25
Min	0.5217	-0.08	-0.10	-0.13	0.0367	-0.15	-0.15	-0.15
Hmax	3.6538	1.56	1.62	1.68	0.2750	-1.26	-1.26	-1.26
Lmin	2.9530	-0.36	-0.37	-0.39	0.1952	-0.82	-0.82	-0.82
Tmrf	1222.6221	-1.19	-1.17	-1.15	82.6349	34.78	34.78	34.78
Rd	2.2095	0.37	0.43	0.48	0.2012	1.63	1.63	1.63
Mws	12.5778	0.47	0.43	0.38	0.6260	3.26	3.26	3.26
P2	5.6810	1.48	1.61	1.75	0.5633	2.90	2.90	2.90
Ha	0.0153	0.00	-0.01	-0.02	0.0000	0.00	0.00	0.00
Th	15.1447	6.90	7.22	7.54	0.6798	7.28	7.28	7.28
Fg	0.3411	0.83	0.88	0.93	0.0007	0.02	0.02	0.02
Ds	0.0645	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Sq	0.1649	-0.00	-0.00	-0.00	0.0003	0.00	0.00	0.00

- **Chennai**

Parameter	1969	2025	2026	2027	2028	Trend
Max	-0.10	0.10	0.18	0.18	0.18	
Min	0.40	0.60	0.56	0.56	0.56	
Hmax	-1.00	0.50	0.42	0.42	0.42	

Lmin	0.50	-0.10	0.06	0.06	0.06	Warmer, significantly enhanced rainfall but decreased thunderstorm activity.
Tmrf	-17.50	37.00	34.91	34.91	34.91	
Rd	-1.00	1.00	0.89	0.89	0.89	
Mws	4.50	0.87	0.80	0.80	0.80	
P2	-1.50	1.50	1.35	1.35	1.35	
Ha	0.00	0.00	0.00	0.00	0.00	
Th	-1.20	-0.20	-0.37	-0.37	-0.37	
Fg	0.00	0.00	0.00	0.00	0.00	
Ds	0.00	0.00	0.00	0.00	0.00	
Sq	0.00	0.00	0.00	0.00	0.00	

NN vs GB

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	0.3825	0.60	0.63	0.66	0.0358	0.18	0.18	0.18
Min	0.1574	0.50	0.52	0.54	0.0129	0.56	0.56	0.56
Hmax	2.2255	0.30	0.32	0.33	0.1617	0.42	0.42	0.42
Lmin	1.0047	0.72	0.73	0.75	0.1126	0.06	0.06	0.06
Tmrf	840.7196	-0.30	-0.56	-0.82	19.4793	34.91	34.91	34.91
Rd	1.1163	0.03	0.04	0.04	0.0444	0.89	0.89	0.89
Mws	0.7749	-0.42	-0.42	-0.42	0.0481	0.80	0.80	0.80
P2	2.0509	-0.14	-0.14	-0.14	0.0999	1.35	1.35	1.35
Ha	0.0000	-0.00	-0.00	-0.00	0.0000	0.00	0.00	0.00
Th	1.5955	-0.66	-0.70	-0.73	0.1050	-0.37	-0.37	-0.37
Fg	0.0168	0.03	0.03	0.03	0.0000	0.00	0.00	0.00
Ds	0.0000	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Sq	0.1006	-0.01	-0.01	-0.01	0.0000	0.00	0.00	0.00

- **Bengaluru**

Parameter	1969	2025	2026	2027	2028	Trend
Max	0.00	-0.70	-0.60	-0.60	-0.60	Warming minimum temperatures, declining overall rainfall.
Min	-0.20	0.20	0.27	0.27	0.27	
Hmax	-1.00	-1.10	-1.01	-1.01	-1.01	
Lmin	-2.00	0.90	0.91	0.91	0.91	
Tmrf	60.00	-29.40	-27.84	-27.84	-27.84	
Rd	-1.00	1.00	0.87	0.87	0.87	
Mws	3.60	0.54	0.49	0.49	0.49	
P2	-0.30	1.70	1.58	1.58	1.58	
Ha	-0.10	-0.10	-0.10	-0.10	-0.10	
Th	-1.20	-1.20	-1.35	-1.35	-1.35	
Fg	0.00	0.00	0.00	0.00	0.00	
Ds	0.00	0.00	0.00	0.00	0.00	
Sq	-0.20	-0.20	-0.19	-0.19	-0.19	

NN vs GB

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	0.7094	0.78	0.81	0.84	0.0669	-0.60	-0.60	-0.60
Min	0.2737	0.65	0.68	0.70	0.0249	0.27	0.27	0.27
Hmax	0.7731	0.54	0.56	0.58	0.0523	-1.01	-1.01	-1.01
Lmin	0.8530	1.04	1.07	1.11	0.0633	0.91	0.91	0.91
Tmrf	3277.6573	-1.77	-2.55	-3.32	119.5724	-27.84	-27.84	-27.84
Rd	4.2317	-0.74	-0.79	-0.83	0.2957	0.87	0.87	0.87
Mws	0.4305	-0.74	-0.75	-0.76	0.0170	0.49	0.49	0.49
P2	7.1011	-1.34	-1.41	-1.47	0.4556	1.58	1.58	1.58

Ha	0.0983	-0.03	-0.03	-0.02	0.0001	-0.10	-0.10	-0.10
Th	9.4486	-2.37	-2.48	-2.59	0.7955	-1.35	-1.35	-1.35
Fg	0.0146	0.01	0.01	0.01	0.0000	0.00	0.00	0.00
Ds	0.0145	-0.01	-0.02	-0.03	0.0000	0.00	0.00	0.00
Sq	0.7329	-0.33	-0.36	-0.39	0.0023	-0.19	-0.19	-0.19

- **Jaipur**

Parameter	1969	2025	2026	2027	2028	Trend
Max	-0.20	2.30	2.22	2.22	2.22	Hotter and relatively drier environment
Min	-0.90	2.70	2.56	2.56	2.56	
Hmax	-1.50	1.40	1.26	1.26	1.26	
Lmin	0.00	2.80	2.76	2.76	2.76	
Tmrf (Rainfall)	-6.60	-5.20	-4.56	-4.56	-4.56	
Rd (Rainy Days)	-0.90	-0.90	-0.81	-0.81	-0.81	
Mws	0.49	0.49	0.54	0.54	0.54	
P2	-0.90	-0.90	-0.80	-0.80	-0.80	
Ha	0.00	0.00	0.00	0.00	0.00	
Th	-0.10	1.90	1.93	1.93	1.93	
Fg	0.00	0.00	0.00	0.00	0.00	
Ds	0.80	-0.20	-0.14	-0.14	-0.14	
Sq	0.00	0.00	0.00	0.00	0.00	

NN vs GB

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	2.0735	0.58	0.58	0.58	0.1185	2.22	2.22	2.22
Min	1.7109	1.94	2.05	2.16	0.1217	2.56	2.56	2.56
Hmax	1.7330	-0.34	-0.39	-0.43	0.0991	1.26	1.26	1.26
Lmin	3.7232	2.07	2.14	2.22	0.3260	2.76	2.76	2.76
Tmrf	173.4670	-1.36	-1.42	-1.48	4.4170	-4.56	-4.56	-4.56
Rd	0.9933	-0.21	-0.23	-0.26	0.0601	-0.81	-0.81	-0.81
Mws	0.5411	0.99	1.07	1.15	0.0154	0.54	0.54	0.54
P2	2.0208	-0.67	-0.75	-0.83	0.1704	-0.80	-0.80	-0.80
Ha	0.0000	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Th	3.5644	1.33	1.37	1.41	0.1726	1.93	1.93	1.93
Fg	0.0290	0.21	0.23	0.24	0.0000	0.00	0.00	0.00
Ds	0.9172	0.46	0.48	0.49	0.0196	-0.14	-0.14	-0.14
Sq	0.0697	0.00	0.00	0.00	0.0000	0.00	0.00	0.00

- **Mumbai**

Parameter	1969	2025	2026	2027	2028	Trend
Max	-0.10	0.90	0.83	0.83	0.83	Warmer days, relatively stable rainfall conditions, weaker wind anomalies, and an exceptional increase in fog occurrence.
Min	0.20	0.70	0.65	0.65	0.65	
Hmax	-0.70	-0.60	-0.48	-0.48	-0.48	
Lmin	0.50	1.90	1.81	1.81	1.81	
Tmrf (Rainfall)	0.00	-0.20	-0.16	-0.16	-0.16	
Rd (Rainy Days)	0.00	0.00	0.00	0.00	0.00	
Mws	4.70	1.11	1.06	1.06	1.06	
P2	-0.20	-0.20	-0.19	-0.19	-0.19	
Ha	0.00	0.00	0.00	0.00	0.00	
Th	-0.10	-0.10	-0.10	-0.10	-0.10	
Fg	0.00	30.00	30.00	30.00	30.00	
Ds	0.00	0.00	0.00	0.00	0.00	
Sq	0.00	0.00	0.00	0.00	0.00	

NN vs GB

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	0.4232	0.22	0.22	0.22	0.0339	0.83	0.83	0.83
Min	0.3084	0.32	0.32	0.33	0.0213	0.65	0.65	0.65
Hmax	1.5131	-0.12	-0.14	-0.17	0.0853	-0.48	-0.48	-0.48
Lmin	0.5137	0.54	0.57	0.60	0.0460	1.81	1.81	1.81
Tmrf	13.4108	0.21	0.22	0.24	0.0094	-0.16	-0.16	-0.16
Rd	0.0877	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Mws	0.8514	-1.42	-1.46	-1.51	0.0229	1.06	1.06	1.06
P2	0.1988	0.05	0.05	0.05	0.0052	-0.19	-0.19	-0.19
Ha	0.0000	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Th	0.1102	-0.11	-0.11	-0.12	0.0008	-0.10	-0.10	-0.10
Fg	11.1875	8.71	9.17	9.47	0.0000	30.00	30.00	30.00
Ds	0.0000	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Sq	0.0000	0.00	0.00	0.00	0.0000	0.00	0.00	0.00

- **Shimla**

Parameter	1969	2025	2026	2027	2028	Trend
Max	-2.10	3.00	2.85	2.85	2.85	Significantly enhanced heat stress, warmer nights, reduced frequency of thunder storm event.
Min	-1.80	2.10	1.97	1.97	1.97	
Hmax	-3.10	2.20	2.07	2.07	2.07	
Lmin	-1.80	1.20	1.27	1.27	1.27	
Tmrf (Rainfall)	-47.30	-28.60	-24.66	-24.66	-24.66	
Rd (Rainy Days)	-2.40	-0.40	-0.59	-0.59	-0.59	
Mws	3.00	0.65	0.59	0.59	0.59	
P2	-3.20	-2.20	-1.87	-1.87	-1.87	
Ha	0.30	-1.70	-1.59	-1.59	-1.59	
Th	-2.80	-3.80	-4.05	-4.05	-4.05	
Fg	-0.30	-0.30	-0.30	-0.30	-0.30	
Ds	0.00	0.00	0.00	0.00	0.00	
Sq	0.00	0.00	0.00	0.00	0.00	

NN vs GB

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	1.9036	1.18	1.22	1.25	0.1281	2.85	2.85	2.85
Min	1.7060	0.53	0.55	0.57	0.0958	1.97	1.97	1.97
Hmax	1.5610	1.22	1.25	1.27	0.0849	2.07	2.07	2.07
Lmin	2.8237	1.17	1.21	1.24	0.1733	1.27	1.27	1.27
Tmrf	2024.4153	9.87	10.13	10.38	141.6340	-24.66	-24.66	-24.66
Rd	7.2570	0.41	0.42	0.43	0.3304	-0.59	-0.59	-0.59
Mws	1.0333	-0.36	-0.37	-0.38	0.0146	0.59	0.59	0.59
P2	11.3905	-0.68	-0.68	-0.69	0.6897	-1.87	-1.87	-1.87
Ha	1.7882	-0.87	-0.85	-0.84	0.0737	-1.59	-1.59	-1.59
Th	8.7657	-4.41	-4.50	-4.58	0.4845	-4.05	-4.05	-4.05
Fg	0.1228	-0.41	-0.42	-0.43	0.0000	-0.30	-0.30	-0.30
Ds	0.0512	0.00	0.00	0.00	0.0000	0.00	0.00	0.00
Sq	0.0000	-0.00	-0.00	-0.00	0.0000	0.00	0.00	0.00

- **Srinagar**

Parameter	1969	2025	2026	2027	2028	Trend
Max	-2.10	3.00	2.79	2.79	2.79	Significant day temperature increase, huge change in total rainfall declining pattern, with
Min	-0.80	0.90	0.85	0.85	0.85	
Hmax	-1.10	3.80	3.62	3.62	3.62	

Lmin	0.38	1.70	1.57	1.57	1.57	lower frequency of rainy days but increase of thunderstorm activity, indicating climate change pattern.
Tmrf (Rainfall)	101.40	-15.50	-9.19	-9.19	-9.19	
Rd (Rainy Days)	3.00	0.00	0.31	0.31	0.31	
Mws	2.80	0.20	0.26	0.26	0.26	
P2	0.90	-3.10	-2.73	-2.73	-2.73	
Ha	-0.30	-0.30	-0.26	-0.26	-0.26	
Th	-4.30	3.70	3.58	3.58	3.58	
Fg	-0.10	-0.10	-0.10	-0.10	-0.10	
Ds	-0.10	-0.10	-0.10	-0.10	-0.10	
Sq	0.00	0.00	0.00	0.00	0.00	

NN-GB

Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	2.8905	0.29	0.30	0.32	0.2210	2.79	2.79	2.79
Min	0.6915	0.42	0.43	0.44	0.0500	0.85	0.85	0.85
Hmax	2.6730	0.97	1.00	1.04	0.2067	3.62	3.62	3.62
Lmin	1.2212	0.87	0.89	0.91	0.0935	1.57	1.57	1.57
Tmrf	2277.5037	16.10	16.73	17.36	201.8607	-9.19	-9.19	-9.19
Rd	6.1072	1.49	1.55	1.62	0.4048	0.31	0.31	0.31
Mws	0.4839	0.61	0.67	0.72	0.0132	0.26	0.26	0.26
P2	11.7447	0.45	0.47	0.49	0.6725	-2.73	-2.73	-2.73
Ha	0.1871	0.14	0.15	0.16	0.0043	-0.26	-0.26	-0.26
Th	5.2031	3.00	3.20	3.40	0.4582	3.58	3.58	3.58
Fg	0.0143	-0.08	-0.08	-0.08	0.0000	-0.10	-0.10	-0.10
Ds	0.0651	-0.08	-0.07	-0.07	0.0000	-0.10	-0.10	-0.10
Sq	0.0000	0.00	0.00	0.00	0.0000	0.00	0.00	0.00

- **Delhi**

Parameter	1969	2025	2026	2027	2028	Trend
Max	0.30	2.50	2.33	2.33	2.33	Heat stress and dry weather
Min	0.70	0.70	0.58	0.58	0.58	
Hmax	-1.00	0.70	0.68	0.68	0.68	
Lmin	2.30	-2.10	-1.91	-1.91	-1.91	
Tmrf (Rainfall)	-11.50	-11.80	-10.64	-10.64	-10.64	
Rd (Rainy Days)	-1.00	-1.00	-0.87	-0.87	-0.87	
Mws	5.60	0.95	0.85	0.85	0.85	
P2	-1.60	-1.60	-1.45	-1.45	-1.45	
Ha	0.00	0.00	0.00	0.00	0.00	
Th	0.70	-1.30	-1.03	-1.03	-1.03	
Fg	0.00	0.00	0.00	0.00	0.00	
Ds	-0.30	-0.30	-0.23	-0.23	-0.23	
Sq	0.70	-1.30	-1.27	-1.27	-1.27	

NN -GB

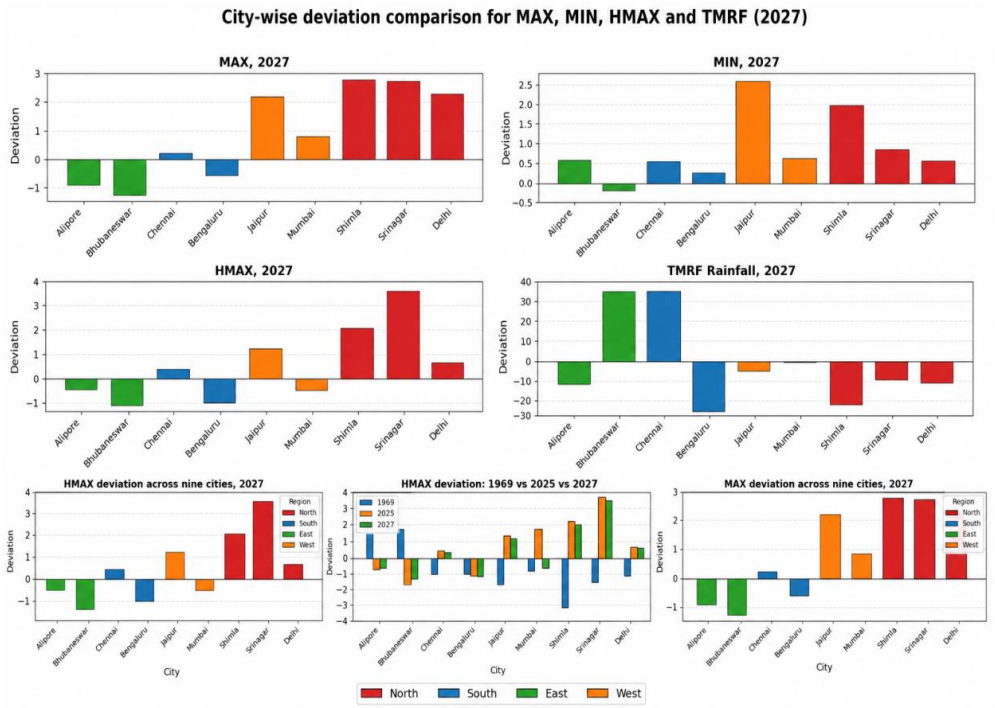
Parameter	NN MSE	NN 2026	NN 2027	NN 2028	GB MSE	GB 2026	GB 2027	GB 2028
Max	2.0591	0.59	0.60	0.62	0.1163	2.33	2.33	2.33
Min	1.1392	-0.57	-0.62	-0.68	0.0788	0.58	0.58	0.58
Hmax	1.5536	-0.23	-0.24	-0.25	0.1022	0.68	0.68	0.68
Lmin	2.3340	-1.84	-2.06	-2.26	0.1738	-1.91	-1.91	-1.91
Tmrf	675.9930	-7.22	-7.53	-7.84	7.5475	-10.64	-10.64	-10.64
Rd	1.4731	-0.50	-0.54	-0.59	0.0929	-0.87	-0.87	-0.87
Mws	2.1593	-1.92	-2.01	-2.10	0.0658	0.85	0.85	0.85
P2	4.1855	-0.56	-0.58	-0.60	0.2374	-1.45	-1.45	-1.45

Ha	0.0572	-0.00	-0.00	-0.00	0.0000	0.00	0.00	0.00
Th	4.3402	0.55	0.57	0.60	0.4923	-1.03	-1.03	-1.03
Fg	0.0145	-0.09	-0.11	-0.13	0.0000	0.00	0.00	0.00
Ds	0.6233	-0.17	-0.19	-0.21	0.0137	-0.23	-0.23	-0.23
Sq	2.9505	-1.79	-1.91	-2.03	0.0613	-1.27	-1.27	-1.27

Conclusion and Future Work

Similar type of research study will be done in future also to get insights regarding anomalous value, deviation from normal of all types of weather parameters. Now these type of analysis and insights are necessary from the point of steps taken towards sustainable climate condition. Scientists, researchers are devoting themselves in such type of studies to reach sustainable development goals.

Bar Plot Insights



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