Temperature Forecasting Of Coming Years For Five Different Locations Of North East India: An Adjuvant

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Abstract: Agricultural productivity is prone to change in temperatures. Knowledge of climate change, especially high temperatures, is essential for agronomists and crop producers to ensure food security across the globe. The effect of high temperature situations leads to a significant reduction in yield. The elevated temperature on crops is expected to have a widespread negative effect as a consequence of global warming. Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the prediction of future values based on previously observed values. In the present study forecasting has been done by centered moving average method upto year 2027, in five stations of North East India viz., Guwahati, Dibrugarh, Silchar, Tezpur and Dhuburi for maximum and minimum temperature i.e. we can predict the maximum and minimum temperature of upcoming years for those areas. It has been obvious from the analysis of time series forecasting that except station Dhubri, three other stations viz. Dibrugarh, Guwahati and Silchar will show gradual increasing of maximum temperature of surface air temperature from 2024 to 2027 (Dibrugarh-37.58 ℃, 37.61 ℃, 37.65 ℃, 37.67 ℃ respectively, Guwahati-36.87 ℃, 36.90 ℃, 36.92 ℃, 36.95 ℃ respectively, Silchar- 40.99 ℃, 41.11 ℃, 41.23 ℃, 41.34 ℃ respectively) whereas station Tezpur will show somewhat un-uniformity. No sharp increasing or decreasing order will be seen regarding maximum and minimum temperature of maximum temperature in this station. Dhubri will show gradual decreasing of maximum temperature. Regarding minimum surface air temperature of studied stations, time series forecasting predicted that, there will be gradual increasing of minimum temperature from 2024 to 2027 (Dhuburi- 10.39 ℃, 10.42 ℃, 10.45 ℃, 10.50 ℃ respectively, .Dibrugarh- 7.01 ℃, 7.03 ℃, 7.06 ℃, 7.09 ℃ respectively, Guwahati-8.52 ℃, 8.54 ℃, 8.56 ℃, 8.58 ℃ respectively, Silchar-8.97 ℃, 8.97 ℃, 8.98 ℃, 8.98 ℃ respectively) except Tezpur station. Tezpur will show gradual decreasing of minimum temperature.

Index Terms: Seasonality, minimum temperature, time series forecasting, moving average

I. INTRODUCTION:

The air temperature is one of the principal climatological parameters which have perceptible control on other parameters and is a continuous and highly variable weather element. Thus, the knowledge about the characteristics of surface air temperature over Assam might be helpful to a great extent to understand the typical climatic pattern of the region and its relation with the physiography of the region of India. So the increasing surface air temperature over Assam affects the environment of Assam and its neighboring states.

The broad sweep of temperature change through the calendar days of the year is the seasonal variation of temperature. It is one kind of periodic variation, which related entirely with seasonal variation of isolation due to revolution of the earth around the sun. However this variation pattern is highly perturbed by the weather elements in co-operating a random component to the time series. The temperature of air is controlled partly locally. These local factors are: altitude of the sun, length of the day and night, nature of surface in respect of topography, soil types like- sandy, clay, and rocky etc. and surface conditions; may

covered by snow, ice, vegetation of different kinds, such as forest, bush or grass; all of which may be subdivided into humid and dry. The Vegetation of any regions depends mainly upon the weather conditions, such as temperature rainfall etc. The studied region is mostly a tropical wetland and annual rainfall varies in the range of 200mm over parts of Assam to 12000mm over a few hillocks in Meghalaya (Jhajharia *et al*. 2012). In early part of the present century the region covering Assam and its surrounding was famous for its dense forest and having rich bio-diversity and Eco-friendly environment. But in course of time, especially last few decades, increase in land utilization for various purposes, such as cultivation, housing, etc., because of growth of population, industrialization, urbanization, etc., caused large scale deforestation and a sizable part of forest areas have been cleared out. Besides other effects leading to the general degradation of the natural environment of the region, it may cause the temporal variation in surface air temperature of the region them of which the increasing of annual and seasonal surface air temperature is the important topic to be discussed. Although global warming is perceived to be a universal phenomenon, many researchers have found contrasting results in urban climatic studies (Griffiths *et al*. 2005; Lim *et al*. 2005; Parker 2006; Ren *et. al.* (2007); Fujibe (2009). Some studies indicated an increase in daily minimum temperature (New *et al*. 2000; Jin and Dickson 2002) while daily maximum temperature had increased at a smaller rate, resulting in decreased diurnal temperature range. Mean temperatures have increased even in small towns in Japan (Schaefer and Domroes, 2009) but Hansen *et al*. in 2010, reported that urban influences are minute. It is believed that diurnal asymmetry in temperature trends has close links with changes in cloudiness, humidity, wind and soil moisture (IPCC 1990). Therefore, it is relevant to understand the changes in maximum temperature and minimum temperature, as these would reflect in diurnal temperature range pattern. Zhou *et al*. 2010 analyzed the trends and variability in T_{max}, T_{min}, and DTR.

II. MATERIALS AND METHODS:

The study areas are located in the state of Assam which is situated in the north eastern part of India, extending from 89°42$^/$ E to 96° E longitude and 24° 8$^/$ N to 28°2$^/$ N latitude. It is surrounded by two international boundaries; border of Bhutan and Bangladesh and north eastern neighboring states. Bhutan and Arunachal Pradesh on the north, Nagaland and Manipur on the east, Mizoram and Meghalaya on the south and Bangladesh and West Bengal on west are the boundaries of Assam State.

Table 1.1 Configuration of stations and period of data.

Stations	Station code (*IMD)	Latitude (°N)	Longitude (°E)	Elevation (m)**msl	Period	Duration in years
Guwahati	42410	26°11'	91°47'	55	1969-2023	55
Dibrugarh	42314	272°9'	94°58'	106	1969-2023	55
Tezpur	42415	26°37'	92°50'	79	1969-2023	55
Silchar	42619	24°50'	82°51'	29	1969-2023	55
Dhuburi	42404	26°01'	89°59'	35	1969-2023	55

** mean sea level, * Indian Metrological Department.

2.1. Experimental site

The present investigation was carried out with analysis of surface air temperature data series period of 1969-2023 for 55 years. The period of data 1969-2023 were subjected to the purposes of the study of variations in temperature pattern in the study area by using the mean of monthly and annual mean surface air temperature values for three half decade and also to analyze the effects of temperature variation in the studied area. The temperature data were collected from the studied locations of the Indian metrological department. The studied locations are in north east of India in Assam in five different weather stations situated in different districts of Assam which are belongs to Brahmaputra and Barak valley. Only the station Silchar belongs to Barak valley among all five weather stations. These stations are Guwahati, Dibrugarh, Dhubri, Silchar and Tezpur, them of which Guwahati is the biggest city of north east India located in the Brahmaputra valley and is also one of the most recently growing (in population and industrialization) city of India. Dibrugarh and Dhubri are also growing city of Assam in recent decades.

2.2. Experimental methods of analysis

The present investigation has been done by the following methods:-

Finding of mean value:

The data were collected as daily and monthly annual mean values for all five stations and calculated on the formula

$$X = \sum (x_i)/n \quad \text{……………….……………………………………(1)}$$

The integrity of the data were determined by collecting data from each of the data source and checking for inconsistencies and missing gap using linear regression equation to estimate the missing value using the variable values. It can be written as follows:

$$y = a + bx \quad \text{…………..……………………….……… (2)}$$

where,

$$b = n\sum x \; - \; (\sum x)/n\sum x^2 - (\sum X)^2 \quad \text{………………..……....... (3)}$$
$$a = \sum y/n \; - \; b\sum bx/n = y' \; -bX \quad \text{………… …………………..(4)}$$

where,

a = intercept.
b = regression coefficient.
x = time in years.
X = mean time and
y' = the mean temperature value.

The collected data for maximum, minimum and mean temperature have been subjected to few statistical analyses such as mean and standard deviation. These statistical analysis were done for

(a) Annual mean of daily surface air temperature.
(b) Monthly mean of daily surface air temperature.

From the monthly mean maximum and mean minimum temperature, the monthly mean temperature has been calculated separately for each month. Accordingly the yearly totals were calculated for each year. From the monthly mean maximum, mean minimum and mean temperature mean and standard deviation have been computed for each month.

Calculation of standard deviation:

The standard deviation is the square root of variance. Thus the way we calculate standard deviation is very similar to the way we calculate variance. In fact, to calculate standard deviation, we first need to calculate the variance, and then take its square root.

The standard deviation formula is similar to the variance formula. It is given by:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

σ = standard deviation

x_i = each value of dataset
x (with a bar over it) = the arithmetic mean of the data (This symbol will be indicated as mean from now)
N = the total number of data points
$\sum (x_i$- mean$)^2$ = The sum of $(x_i$ - mean$)^2$ for all data points.

Time series forecasting: A time series is a series of data points indexed (or listed or graphed) in time order. Most commonly, a time series is a sequence taken at successive equally spaced points in time. The time series forecasting has been done by using centered moving average introduced by Armstrong (2006). It is the most used model for forecasting (Zoran *et al* 2018). According to Abdullah *et al* (2020) also moving average model is an efficient model for time series forecasting with 91% accuracy. The Moving Average forecast is based on the average of known values from a number of periods. All the calculations have been done by using Microsoft Excel 2007.

III. RESULTS:

Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the prediction of future values based on previously observed values.

In the present study forecasting has been done up to year 2027, for maximum and minimum i.e. we can predict the maximum and minimum temperature of upcoming four years.

From Fig. 1, it can be assume that in 2024, 2025, 2026 and 2027, Dhubri will shows maximum 33.62 ℃, 33.58 ℃, 33.54 ℃ and 33.49 ℃ respectively in the month of April for maximum temperature and minimum 10.39 ℃, 10.42 ℃, 10.45 ℃, 10.50 ℃ (Fig 6) in the month of January for minimum temperature.

For Dibrugarh station (Fig 2), it can be assume that in 2024, 2025, 2026 and 2027, the month of August will shows maximum 37.58 ℃, 37.61 ℃, 37.65 ℃, 37.67 ℃ respectively for maximum temperature and minimum 7.01 ℃, 7.03 ℃,7.06 ℃, 7.09 ℃ (Fig 7) in the month of January for minimum temperature.

For Guwahati station (Fig.3.), it can be assume that in 2024, 2025, 2026 and 2027, the month of June will shows maximum 36.87 ℃, 36.90 ℃, 36.92 ℃, 36.95 ℃ respectively for maximum temperature and minimum 8.52 ℃, 8.54 ℃, 8.56 ℃, 8.58 ℃ (Fig 8) in the month of January for minimum temperature.

For Tezpur station (Fig 4.), it can be assume that in 2024, 2025, 2026 and 2027, the month of August will shows maximum 36.06 ℃, 36.07 ℃, 35.44 ℃ and 35.44 ℃ respectively for maximum temperature and minimum 8.79 ℃, 8.79 ℃, 8.78 ℃ and 8.78 ℃ (Fig 9) in the month of January for minimum temperature.

For Silchar station (Fig 5.), it can be assume that in 2024, 2025, 2026 and 2027, the month of August will shows maximum 40.99 ℃, 41.11 ℃, 41.23 ℃, 41.34 ℃ respectively for maximum temperature and minimum 8.97 ℃, 8.97 ℃, 8.98 ℃, 8.98 ℃ (Fig. 10) in the month of January for minimum temperature.
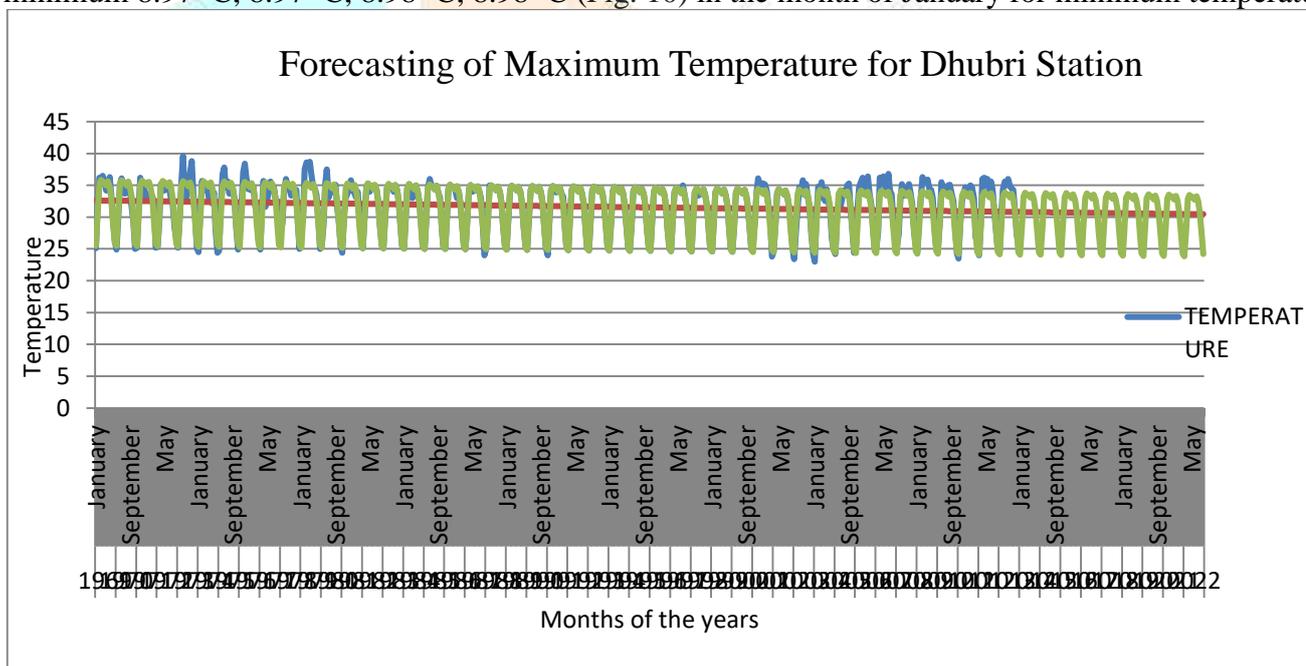

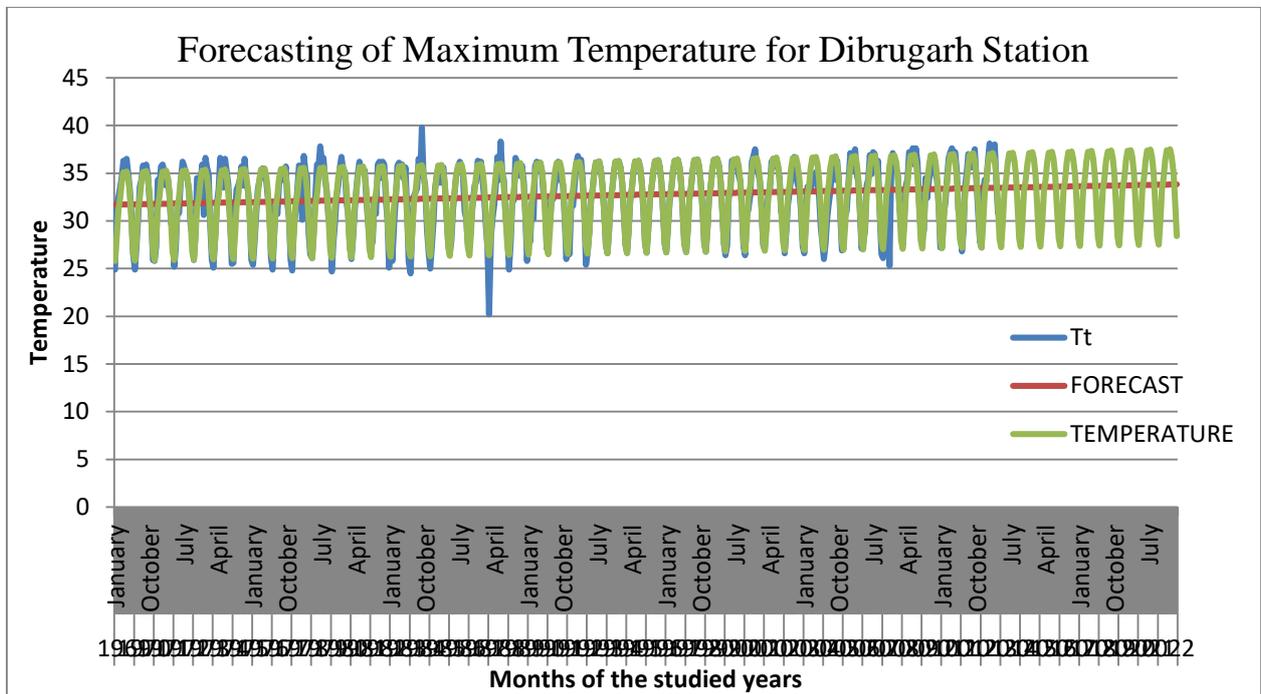Figure 1: Time series forecasting for maximum temperature of Dhubri Station

Figure 2.: Time series forecasting for maximum temperature of Dibrugarh Station
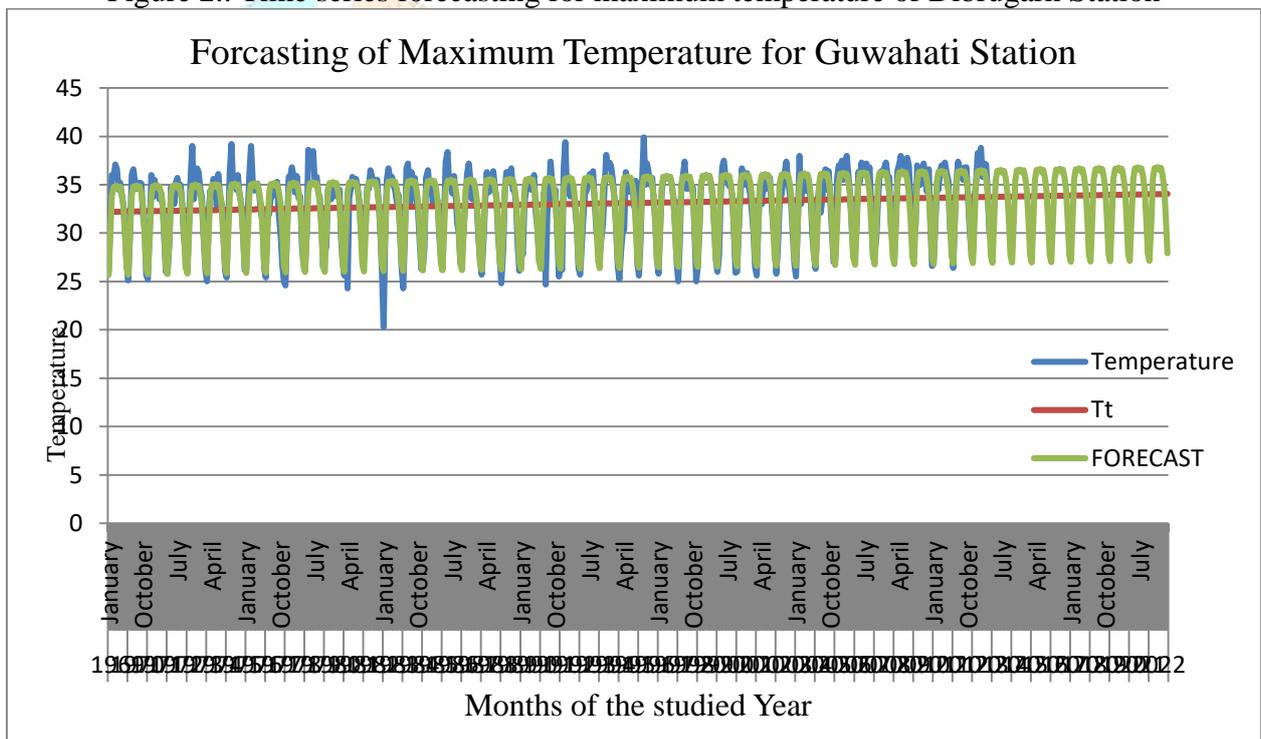

Figure 3: Time series forecasting for maximum temperature of Guwahati Station
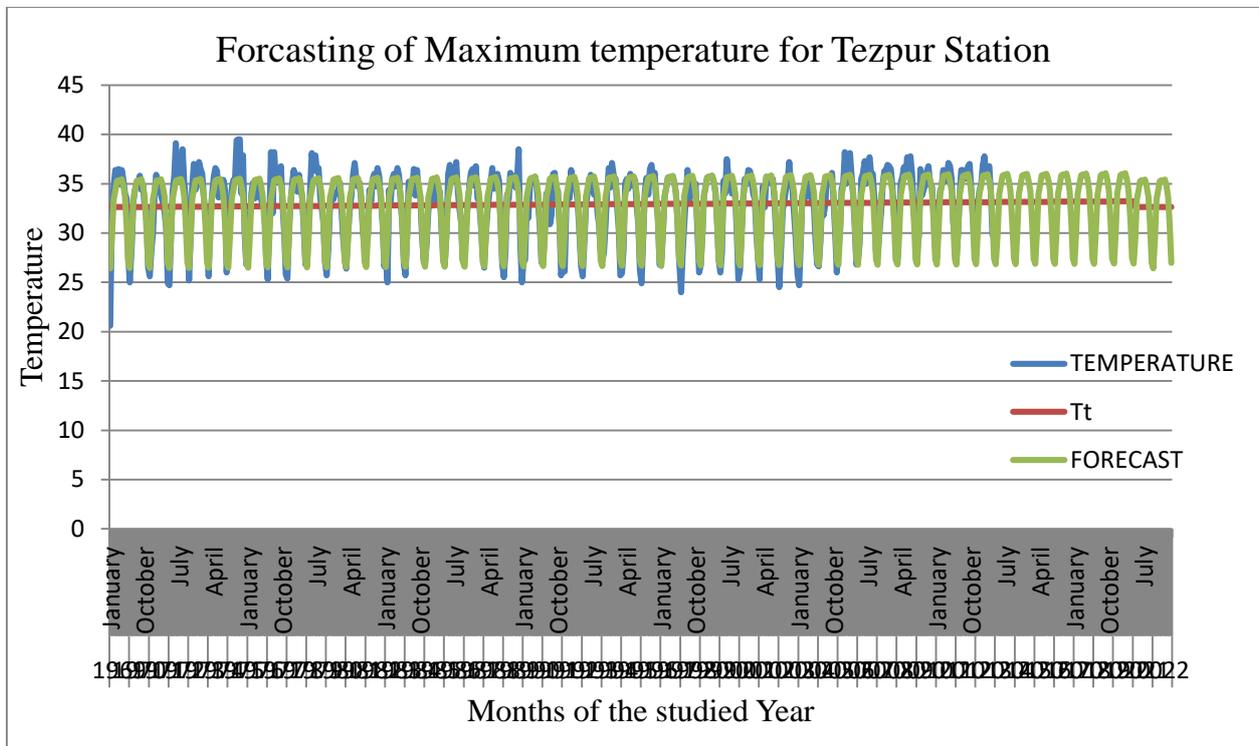
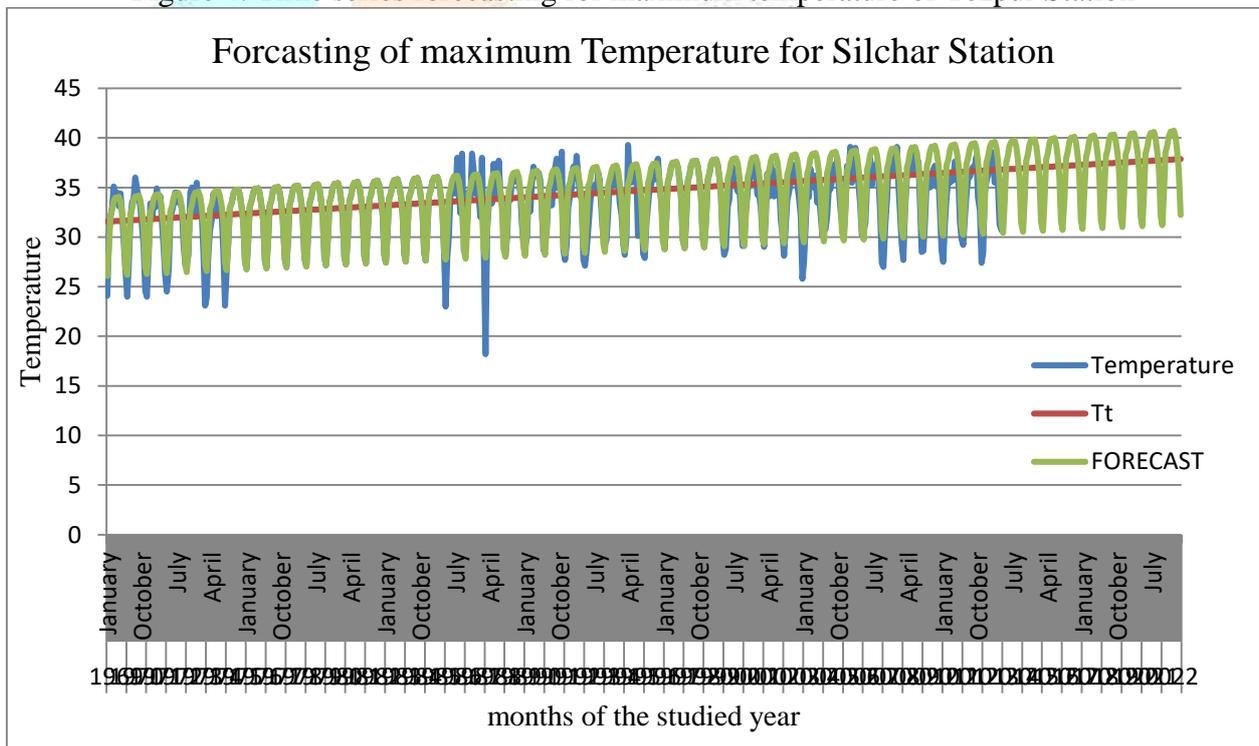Figure 4: Time series forecasting for maximum temperature of Tezpur Station

Figure 5: Time series forecasting for maximum temperature of Silchar Station
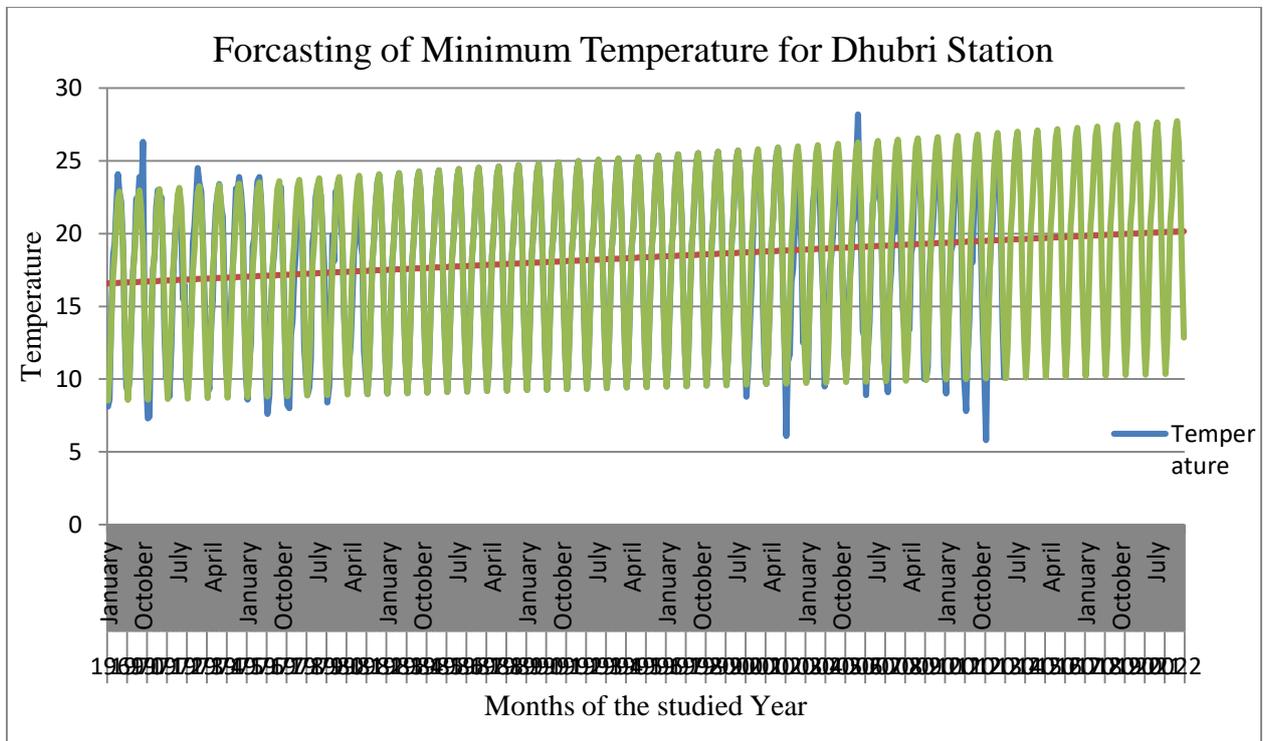
Figure 6: Time series forecasting for minimum temperature of Dhubri Station
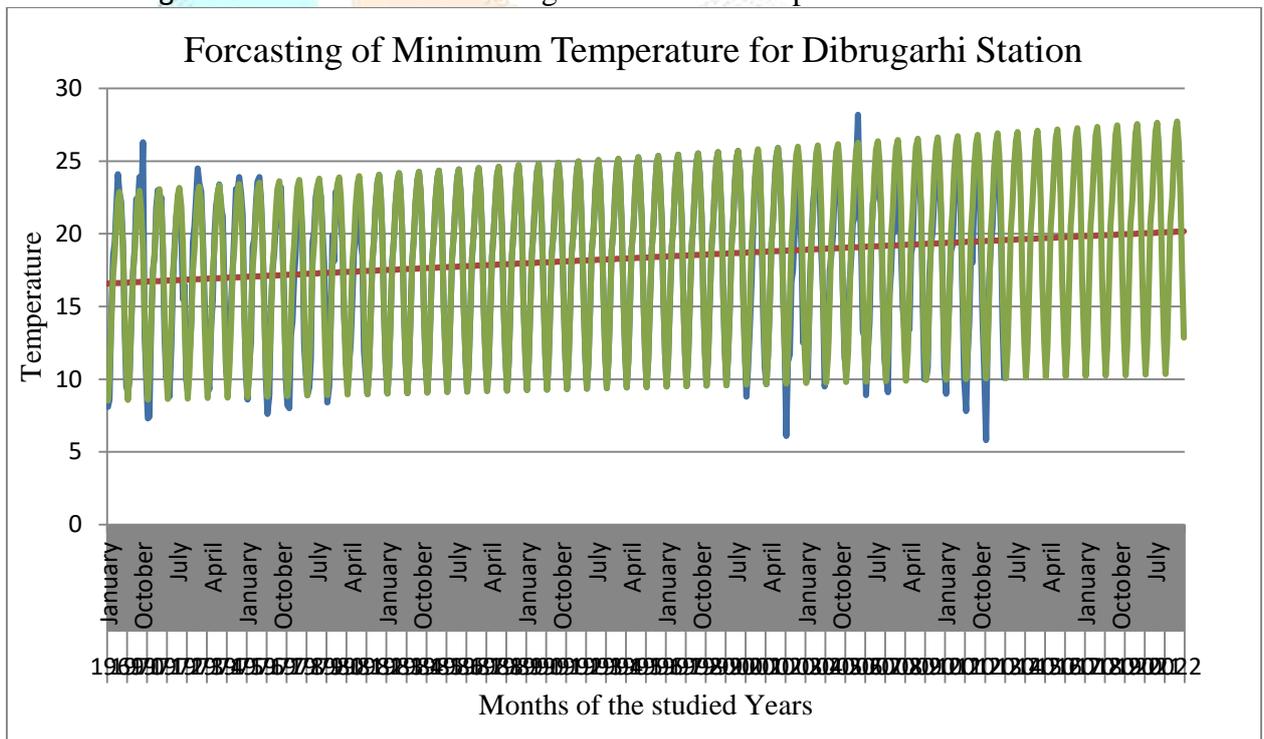

Figure 7: Time series forecasting for minimum temperature of Dibrugarh Station
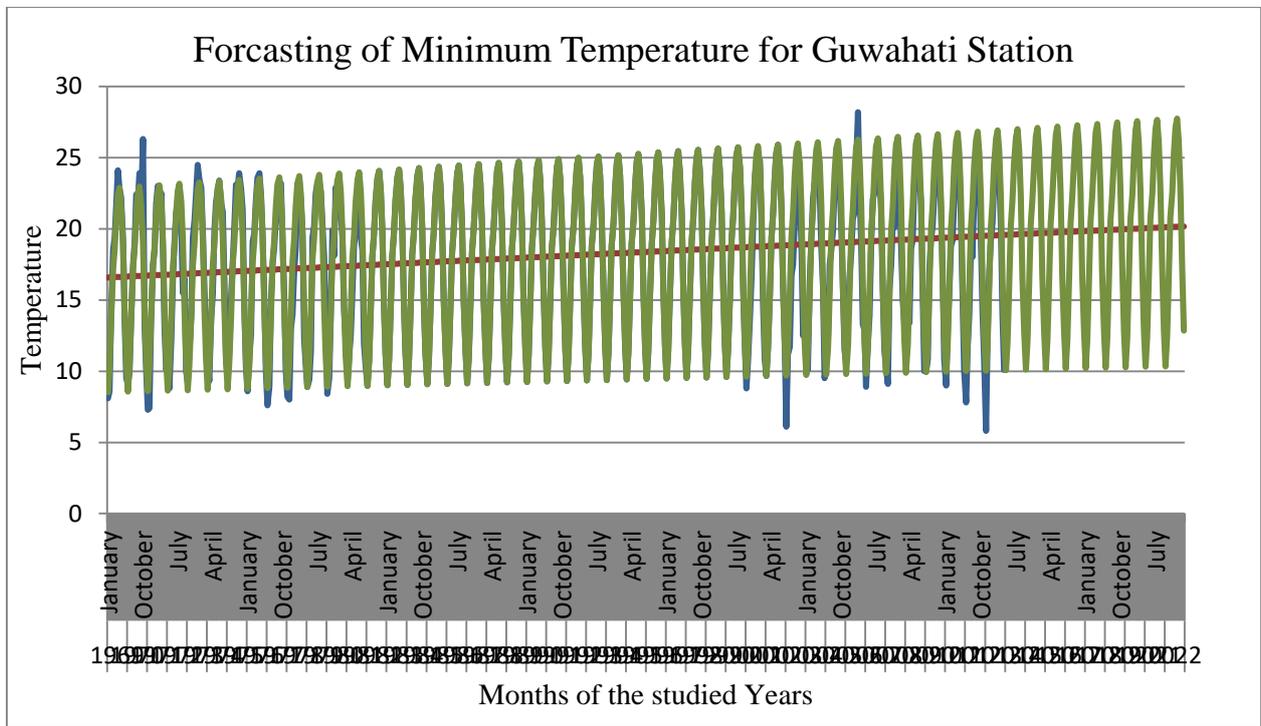
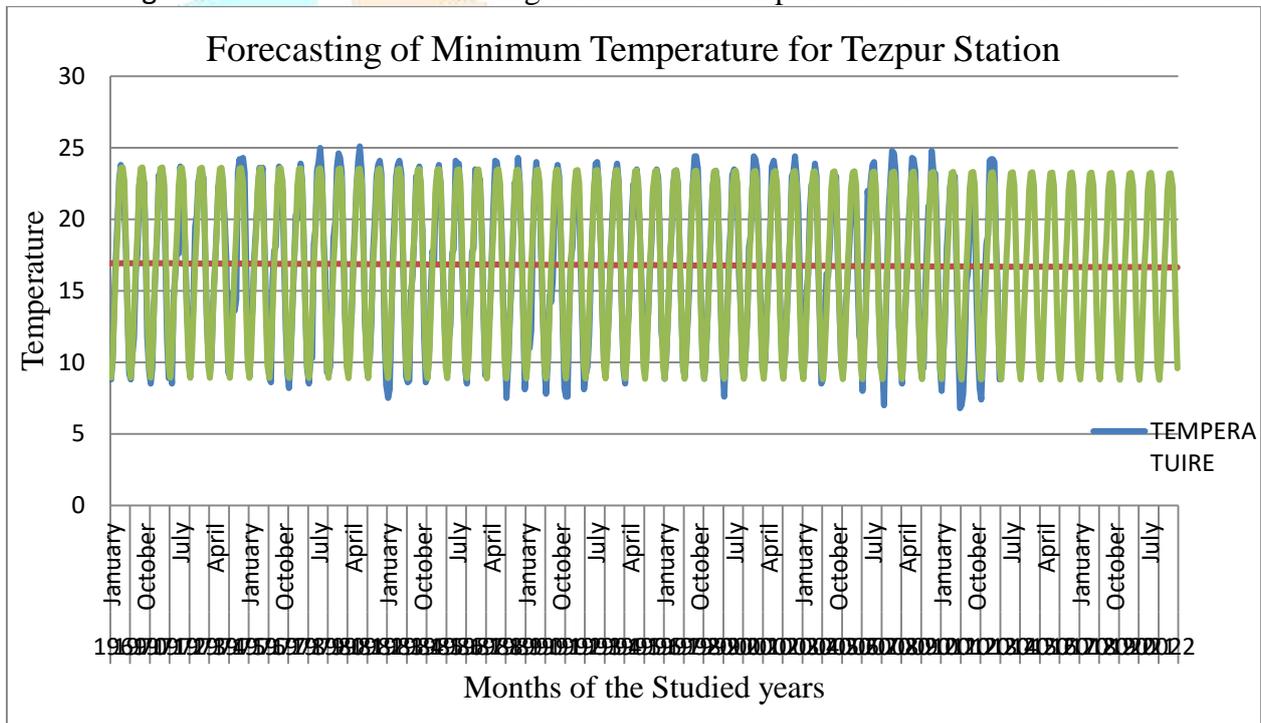Figure 8: Time series forecasting for minimum temperature of Guwahati Station

Figure 9: Time series forecasting for minimum temperature of Tezpur Station
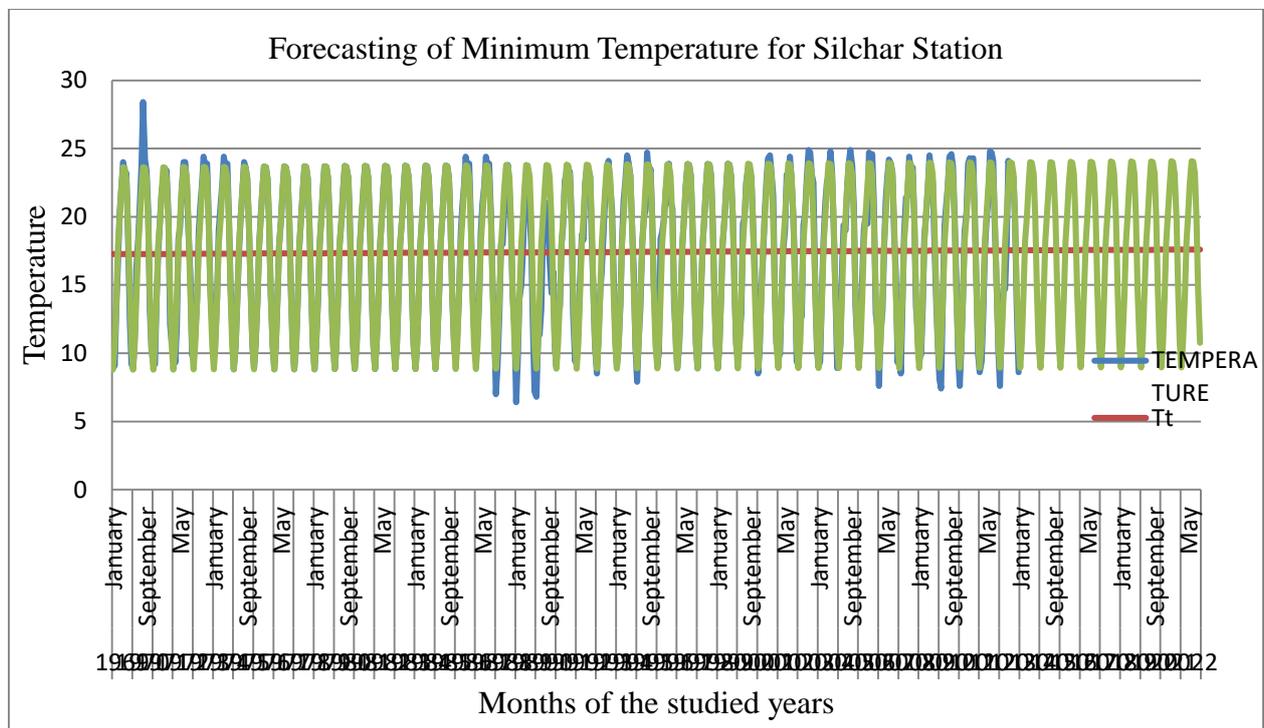
Figure 10: Time series forecasting for minimum temperature of Silchar Station

Jamir *et al*. (2012) had been observing an increasing trend of surface air temperature in maximum, minimum and mean temperature in Assam comparing other regions of north eastern part of India. They concluded that the extreme temperatures on annual and seasonal basis for the N.E indicates that majority of the stations had showed increase in maximum temperature on annual basis. However, none of them is significant. Out of four stations, three stations had showed significant trend (Gangtok, Imphal and Agartala). They also revealed that on seasonal basis, six out of thirteen stations indicate increasing trend during the winter season, but none of them is significant. Three stations, viz., Silchar, Gangtok and Agartala had shown significant decreasing trend in T_{max}, so the NE suffering the rising in T_{max}. This is in accordance with the result of the present investigation.

From the whole investigation across studied (different five weather) stations in Assam for the period of (1969-2023), trend of maximum, minimum and mean temperature are observed. It is observed that mean of maximum, minimum and mean temperature are increasing at the rate of 0.0296°C, 0.0134°C and 0.0176°C per year as a whole considering all studied locations in Assam respectively. The results of present study is in accordance to the result of Rathore *et al*. 2013 (they studied in Assam at different weather stations for the period of 1951 to 2010), where they observed an increasing trend of 0.02°C, 0.01°C and 0.01°C per year in mean of maximum, minimum and mean temperatures respectively. The slight difference of the result of the present study and the study of Rathore, may be due to the change of daily mean temperature, different data period, number of studied weather stations etc.

The rise in the three sets (maximum, minimum and mean) of temperature data series, maximum temperature may be due to the effect of the growth of population and subsequence of human activities on the environment leading to deforestation urbanization and industrialization etc. the increase or decrease of mean temperature is mainly depends upon the trends of maximum and minimum temperature and factor effecting those trends. The increasing trend of maximum temperature over all the station except Dhubri around the period of 1978–2008 may be due to the consequence of the rise in industrialization, urbanization and deforestations etc within that period in Assam.

It has been obvious from the analysis of time series forecasting that except station Dhubri, three other stations viz. Dibrugarh, Guwahati and Silchar will show gradual increasing of maximum temperature of surface air temperature from 2024 to 2027, whereas station Tezpur will show somewhat ununiformity. No sharp increasing or decreasing order will be seen regarding maximum and minimum temperature of maximum temperature in this station. Dhubri will show gradual decreasing of maximum temperature.

Regarding minimum surface air temperature of studied stations, time series forecasting predicted that, there will be gradual increasing of minimum temperature from 2024 to 2027 except Tezpur station. Tezpur will show gradual decreasing of minimum temperature.

It is certain from the time series forecasting tables that January is the coldest month in the past years and will be remain coldest month in coming years also. But different stations will show different months as hottest month of forthcoming years. Dibrugarh, Tezpur and Silchar will show August as the hottest month whereas, Dhubri will show April and Guwahati will show June as the hottest month in the coming years.

REFERENCES:

[1] Abdallah, W., Abdallah, N., Marion, J.-M., Oueidat, M. and Chauvet, P. (2020) A Hybrid Methodology for Short Term Temperature Forecasting. International Journal of Intell igence Science , 10, 65-81. https://doi.org/10.4236/ijis.2020.103005

[2] Armstrong, Scott, J. 2006. Findings from evidence-based forecasting: Methods for reducing forecast error. International Journal of Forecasting 22: 583–589.

[3] Fujibe, F., 2009, Detection of urban warming in recent temperature trends in Japan. International Journal of Climatology. **29**: 1811–1822.

[4] Griffiths, G.M., Chambers,L.E., Haylock, M.R., Manton, M.J., Nicholls, N., Baek, H.J., Choi, Y., Della-Marta, P.M., Gosia, A., Iga, N., Lata, R., Laurent, V., Nakamigawa, H., Ouprasitwong, N., Solofa, D., Tahani, L., Thuy, D.T., Tibig, L., Trewin, B., Vediapan, K., Zhai, P., 2005, Change in mean temperature as a predictor of extreme temperature change in the Asia-Pacific Region, International Journal of Climatology. **25**, 1301–1330.

[5] Hansen, J., Ruedy, R., Sato, M., Lo, K., 2010, Global surface temperature change. Reviews of Geophysics. **48**, RG4004.

[6] IPCC 1990, Climate Change, The IPCC Scientific Assessment. Cambridge, U.K, Cambridge University Press.

[7] Jamir,T., Gadgil, U. D., Gaddam,K., 2016,Temperature patterns over Northeast and West Coast Regions of India, Bulletin of Geography. Physical Geography Series 2016.

[8] Jhajharia ,D., Yadav, B.K., Maske, S., Chattopadhyay, S.,and Kar, A.K., 2012, Identification of trends in rainfall, rainy days and 24 h maximum rainfall over sub-tropical Assam in northeast India, Comptes Rendus Geoscience. **344**:1–13.

[9] Lim, Y.K., Cai, M., Kalnay, E., Zhou, L., 2005, Observational evidence of sensitivity of surface climate changes to land types and urbanization. Geophysical Research Letters. **32**, L22712.

[10] New, M., Hulme, M., Jones, P.D., 2000, Representing twentieth century space-time climate variability. Part II: Development of 1901–1996 monthly grids of terrestrial surface climate. Journal of Climate. **13**: 2217– 2238.

[11] Parker, D.E., 2006, A demonstration that large-scale warming is not urban. Journal of Climate. **19**: 2882– 2895.

[12] Rathore, L. S., Attri, S. D., Jaswal, A.K., 2013, State Level climate change trends in India, Government of India, Ministry of Earth Sciences, Earth System Science Organisation, India Meteorological Department, Lodi Road, New Delhi- 3 (India), Meteorological Monograph.

[13] Ren, C., Webster, P., Finkel, S.E., Tower, J., 2007, Increased internal and external bacterial load during Drosophila aging without life-span trade-off. Cell Metab. **6**(2): 144-152.

[14] Schaefer, D., Domroes, M., 2009, Recent climate change in Japan – spatial and temporal characteristics of trends of temperature. Climate of the Past. **5**: 13–19.

[15] Zhou, L., Dickinson, R.E., Aiguo, D., Dirmeyer, P., 2010, Detection and attribution of anthropogenic forcing to diurnal temperature range changes from 1950 to 1999: comparing multi-model simulations with observations. Climate Dynamics. **35**: 1289–1307.

[16] Zoran Ivanovski, Ace Milenkovski, and Zoran Narasanov. 2018. Time Series Forecasting Using a Moving Average Model for Extrapolation of Number of Tourist. UTMS Journal of Economics 9 (2): 121–132.