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Forecasting Temperature in the Coastal Area of Bay of Bengal-An Application of Box-Jenkins Seasonal ARIMA Model

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Abstract
Temperature is one of the most vital elements of the climate system and forecasting of the temperature helps the stakeholders those who are depends on it directly or indirectly to prepare in advance. Country like Bangladesh whose economy mostly geared up by the agricultural product need to know the upcoming pattern of temperature beforehand to take necessary actions. This study has been conducted on the monthly maximum and minimum temperature data (1949-2012) from the second largest and port city of Bangladesh, Chittagong. Non-parametric Mann-Kendall test has been adopted to identify the trend of the series and found that though the maximum temperature is increasing but not significantly but the minimum temperature is increasing significantly. The anomaly plot is just portrait the ups and downs of minimum and maximum temperature and found minimum temperature is increasing from last two decades whereas the maximum temperature has abrupt changes with increase and decrease. The linear trend analysis shows the climate line for maximum and minimum temperature are 35.67 and 10.23 degree Celsius respectively and the rate for significant increase of minimum temperature is 0.07 degree Celsius. The forecasting Seasonal ARIMA model for maximum temperature is SARIMA (1, 1, 1) (2, 0, 0) [12] and for minimum temperature is SARIMA (1, 1, 1) (1, 0, 1) [12]. The resulted outcomes indicate the increasing pattern of temperature in upcoming days in this area of Bangladesh.
Keywords: temperature, Seasonal ARIMA, forecasting, climate, Chittagong

Introduction

Climate change is the most talked about issue now a day's around the globe and at the same time climate research is mostly promoted by the stakeholders universally. It is a huge task to assess the changing pattern of the climatic system since the changing state of the climate is the result of many factors locally and globally. But the most common factors through those the change of climatic system is being assessed are temperature, rainfall, ground and sea water level etc. This study has used maximum and minimum temperature data of the port city Chittagong in order to forecast the changes in temperature.

Coastal area of Bay of Bengal is the most focused area in the world in view of the climate changes and disaster prone based risk. This area demands special attention to any researcher in studying the attributes of Green House Effects. The forecasting of the temperature changes is one of the useful variables in planning the disaster management and combating the challenges thereafter. The coastal area of Bay of Bengal experienced the effects of climate changes more than any part of the world, being a funnel-shaped sea opening. The area had undergone the most dangerous cyclones and natural disasters. The loss of human lives and other living creatures including trees was enormous. The forecasting of temperature changes will set criteria to understand the future shaping of weather changes, agriculture and disaster management issues.

There are many organizations locally and globally like Climate Change Cell (CCC), Intergovernmental Panel on Climate Change (IPCC), United Nations Framework Convention on Climate Change (UNFPCC) etc. are working on climate change issues and doing climate research and providing policies to implement in order to mitigate the adverse effect from the advent circumstance of climate change. These research organizations produce estimate, results and model prediction focusing on global and regional scale. But the changing pattern of climate has deep influence on local level. This study focuses on the changing pattern of temperature, a very vital element of climate system in the context of Bangladesh.

Bangladesh is an agro based country and most of the agricultural products largely depend on the climatic variables and temperature is one of the precedence. Prior perceive about the temperature helps the farmer in their preparedness to imminent circumstances. Authentic forecast of temperature could play a role in this regard for the stakeholders.

Time series analysis has different approaches to analyze the time dependent data and concentration is needed since the events are evolve through time and has a relation successively. The main objective of the time series analysis is to give the thought about the future events by analyzing the lagged events. Many approaches are available in this aspect and one of the most effective and popular approach is Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA) Model.

The study had been carried out keeping the larger Chittagong in view. We shall focus our studies only on

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statistics based forecasting for general use by any user ranging from student to researcher.

Literature review

It is observed that a number of studies have been conducted in the field of climate change around the world in general and within Bangladesh in particular. Islam *et al.,* (2009) shows in his study that the maximum temperature is decreasing at the rate of 0.04 degree Celsius but the minimum temperature increases at the rate of 0.02 degree Celsius around the country whereas Ferdous and Baten (2011) found that annual average temperature was decreased in Rajshahi, Rangpur and Dinajpur by 0.0134^0 Celsius, 0.0262^0 Celsius and 0.0118^0 Celsius per year. But Basak *et al.* (2013) in his study used the data from 1974 to 2008 of 34 weather stations and found both the maximum and minimum temperature has increased around the country. In their fifth assessment report IPCC reported that the global averaged combined land and ocean surface temperature has increased at the rate of 0.85^0 Celsius over the period of 1880 to 2012. Syeda (2012) conducted a study using dry bulb temperature data from six division of Bangladesh using ARIMA model and found temperature is decreasing in Rajshahi and Barisal but increasing others divisions. Nury *et. al.* (2013) in his study forecast the maximum and minimum temperature of Sylhet and Moulovibazar districts using seasonal ARIMA model suggested that this methodology works better in order to forecast the time series data. Karim (undated) in his research study used seasonal ARIMA model to forecast the surface temperature in the north zone of bay of Bangle and found SARIMA (2, 0, 1) (0, 1, 1) [12] as the best candidate model to forecast. Besides, the ARIMA model is widely used by Mohsin *et.al.* (2012), john *et. al.* (2014), Singh *et. al.* (undated), Chowdhury *et. al.* (2008) and many more to forecast the times series data say rainfall, temperature, humidity, rice productions etc. These all justifies the use of Box-Jenkins ARIMA model to forecast the temperature data in this study.

Objective

The objective of this study is to build a time series model and use this model to forecast the maximum and minimum temperature of coastal area of the Bay of Bengal. Alongside this objective, this study also attempted to measure the trends and anomalies of maximum and minimum temperature.

Study location & Data

Bangladesh Meteorological Department (BMD) is the government body of all sort of meteorological activities in Bangladesh. BMD has 35 weather stations around the country from where they collect data and Chittagong is one of them. This study has used the monthly maximum and minimum temperature data of Chittagong weather station ranging between 1949 and 2012.

Methodology

This study has used different methodologies to have clear idea about the state of temperature and forthcoming state in this particular region of Bangladesh. The study used Mann-Kendal test to identify whether there is any trend in maximum and minimum temperature in Chittagong, the linear trend analysis facilitates with the rate of change of temperature where as the anomalies for the both the maximum and minimum temperature will shows the changing phenomena with the passes of time. One of the vital concerns of this study is to forecast both the maximum and minimum temperature which has done using widely used Box-Jenkins Seasonal Auto Regressive Moving Average (SARIMA) model.

Non-parametric tests are more suitable than their parametric counterparts when the data do not meet the assumption of normality (Afzal *et al.,* 2011) and the Jarque-Bera normality test for both maximum and minimum temperature shows the non normality of data (appendix table: 1). The formula for rank based Mann-Kendall test is developed by Kendall (1938) and the statistic is,

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign(x_j - x_k)$$

$$sign(x_j - x_k) = \begin{cases} +1 & if\ sign(x_j - x_k) > 0 \\ 0 & if\ sign(x_j - x_k) = 0 \\ -1 & if\ sign(x_j - x_k) < 0 \end{cases}$$

The standard normal variable Z can be calculated based on the value of S using the formula

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & if\ S < 0 \end{cases}$$

Positive value of Z indicate increasing trend and negative value of Z indicates the negative trend whereas zero value of Z signify absence of trend in the series.

Box-Jenkins ARIMA (p, d, q) model is the widely used methodology to analyze the univariate time series data developed by Box and Jenkins in 1970, where p is the autoregressive part, d is the number of differentiation order and q is the order of moving average. The prerequisite for using Box-Jenkins model is that the underlined series must be stationary and if not it has to make stationary by taking necessary differentiations before going to estimation process. To use this method the time series data must be equally spaced and no missing observation is allowed in the series. Basically there are four steps in Box-Jenkins ARIMA model namely, (i) identification, (ii) estimation, (iii) diagnostic, and (iv) forecasting. Since this study has used monthly data of temperature in that case an additional seasonal term is added with the model and the model equation is consisting of autoregressive part which is basically the lagged order of the original series and moving average part, which is nothing but the lagged order of the error term along with the seasonal period of cycling. The mathematical form of ARIMA (p, d, q) model with zero difference order is,

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \dots\dots\dots\dots + \varphi_p y_{t-p} - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \dots\dots\dots\dots - \theta_q e_{t-q} + e_t$$

Where, $\varphi's$ are the autoregressive coefficients and $\theta's$ are the moving order coefficients.

If this model is incorporated with seasonal order say monthly then the equation is written as SARIMA (p, d, q) (P, D, Q) [12] where the capital P, D, and Q are the seasonal autoregressive, difference and moving average order with 12 month period. The mathematical form of the model is more complicated and using backshift notation which can be written as,

$$\emptyset_p(B^s)\varphi_p(B)(1-B)^d(1-B^S)^D y_t = \theta_q(B)\theta_Q(B^S)e_t$$

Where, the small letter notion's indicates the non-seasonal order and the capital letter notions are indicating the seasonal order of the series.

The following schematic diagram describes the process of model building and forecasting of SARIMA model.

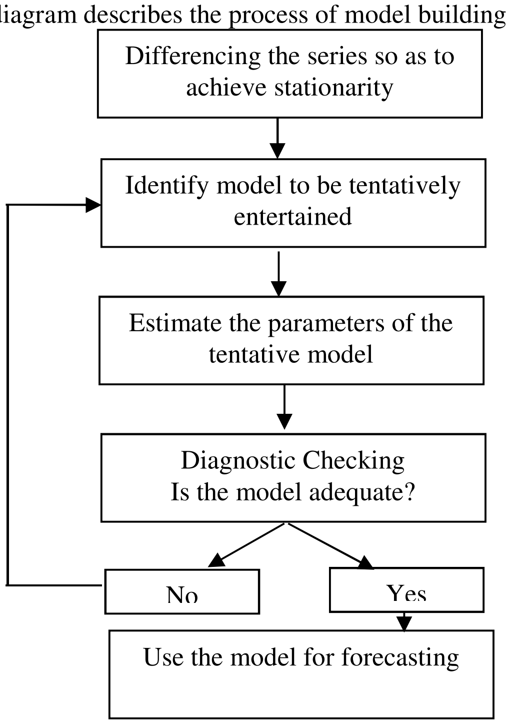

Figure 1: Flow chart for Box-Jenkins ARIMA model building

The stationarity of the model can be checked by constructing correlogram and Augmented Dickey Duller (ADF) test. The correlogram also facilitates to have the idea about the tentative model for estimation. ADF test is based on the hypothesis that the series has a unit root means the series is not stationary. If the series if found non-stationary then the necessary differentiation of the series conforms the stationarity. After settling down the order of all coefficients the least squares method has been applied to estimate the parameter of the seasonal AIRMA model. After accomplishing all the necessary diagnostic test the model is ready to generate future value and this forecast value also been undergone by the validation process.

Autocorrelation is a serious problem for the time series data and the autocorrelation can be checked by Ljung-Box test (Ljung, 1978). This test is developed based on the hypothesis that there is no autocorrelation in the series and the statistic is,

$$Q = n(n+2)\left(\frac{\hat{r}_1^2}{n-1} + \frac{\hat{r}_2^2}{n-2} + \dots\dots\dots + \frac{\hat{r}_k^2}{n-k}\right)$$

This test is follows chi-square distribution with p-q-k degrees of freedom where p is the autoregressive order, q is the moving average order and k is the number of order for which the autocorrelation is need to be checked.

Moreover, there are some others test has been incorporated in the model building process such as chow breakpoint test which is the test used to check the stability of the time series model and the test is based on the hypothesis that there is no breakpoint before and after the specified data in the fitted model. The serial correlation also been tested to diagnose the model and the expectation is that there is no serial correlation in the fitted model.

Result and Discussion

The average maximum temperature in Chittagong is found 32.87 degree Celsius and the average minimum temperature is 18.46 degree Celsius. The highest recorded temperature is 39.50 where as the lowest recorded one is found 7.70 degree Celsius. The maximum temperature is less varying (sd=2.20) compare to minimum temperature (sd=4.62).

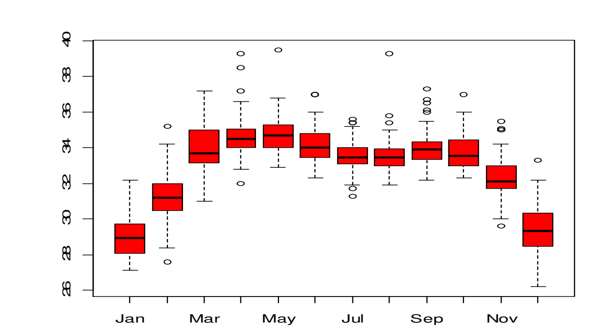

Figure 2: Month wise Box-plot for maximum temperature

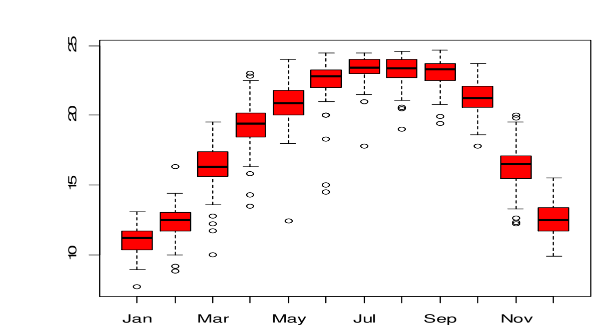

Figure 3: Month wise Box-plot for minimum temperature

It is observed from the month wise Box-Whisker plot that in case of maximum temperature the highest temperature recorded in the month of May. Maximum temperature is more stable in the summer whereas it is very fluctuating in winter though in summer some extreme recorded temperature is observed. Situation is almost similar is case of minimum temperature, fluctuation is higher at winter means not only the maximum temperature but the minimum temperature is also unpredictable in this season.

Decomposition of time series data

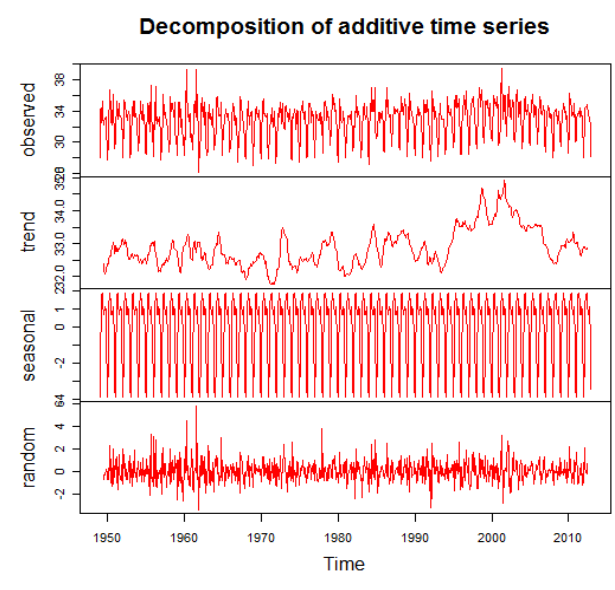

Figure 4: Decomposition of maximum temperature

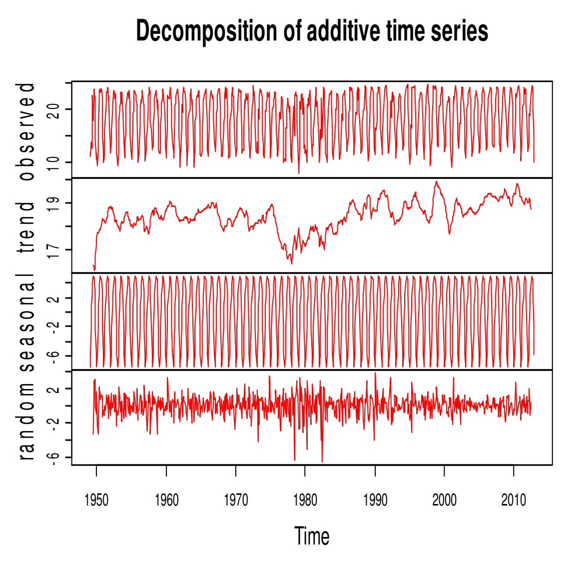

Figure 5: Decomposition of minimum temperature

Intrinsically time series data has four components, (i) trend (ii) seasonal (iii) cyclical, and (iv) random, the above decomposed figure for maximum and minimum temperature shows that both the series has trend, seasonal and random components and also the upward trend is evident.

Mann-Kendall test for trend

Table 1: Mann-Kendall test for detecting trend of maximum and minimum temperature

Variables (Monthly)	Scores (S)	Kendall's (τ)	P-value	Trend
Maximum temperature	84	0.042	0.632	No Significant trend
Minimum temperature	401	0.203	0.021	**Increasing**

It is evident from the positive value of the scores (S) that the maximum temperature is increasing but the trend is not statistically significant. Beside this, the minimum temperature is increasing significantly which imply the lower end of the temperature is shifted to up that is the notion of increasing of temperature over the time.

Anomaly

Anomaly of yearly maximum temperature is the deviation of annual maximum temperature to the average maximum temperature of the period under consideration. Similarly, the anomaly of the yearly minimum temperature is the deviation of annual minimum temperature to the average minimum temperature of the period under consideration. The anomalies for yearly maximum and minimum temperature are shown below:

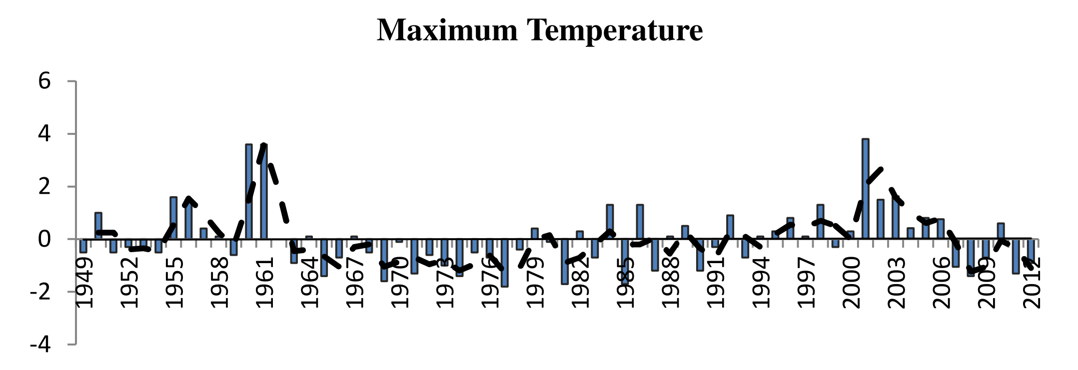

Figure 6: Anomaly of annual maximum temperature

From the anomaly plot it can be assed that maximum temperature is increasing over time though in recent past it is seen to decrease abruptly.

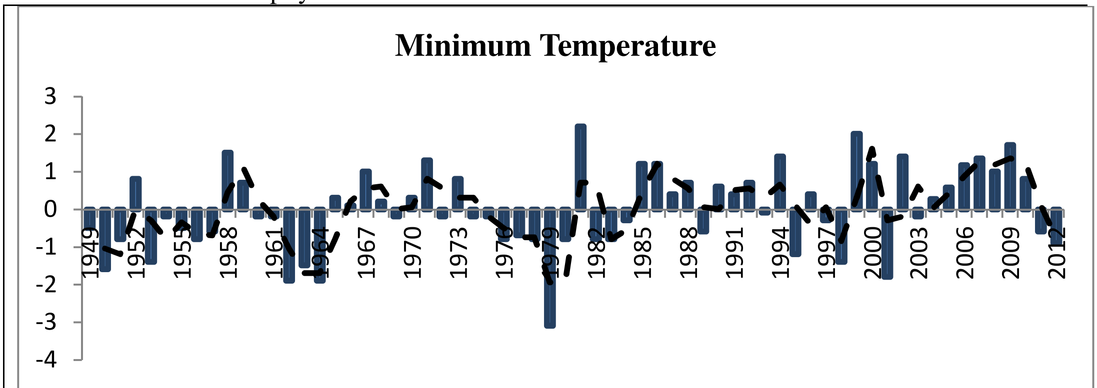

Figure 7: Anomaly of yearly minimum temperature

In case of minimum temperature it is clearly seen that minimum temperature level is increasing in the recent past.

Linear trend has been adopted to have the climate line and slop of maximum and minimum temperature. It is already tested that maximum temperature has no significant trend so the slop is worthless in case of it, the drift or climate line is 35.67 degree Celsius. Minimum temperature has increased at the rate of 0.017 degree Celsius annually and the climate line is 10.23 degree Celsius.

Box-Jenkins Seasonal ARIMA model building

The first step of ARIMA model building process is to identify the tentative order to estimate the parameter of the series and correlogram is an aid to meet this purpose. The corrlogram for both the maximum and minimum temperature shows the annual periodicity indicate that the estimating series should has seasonal autoregressive and seasonal moving average order. And the spikes of the maximum and minimum temperatures outside the confidence interval band indicate that possibly these series are not stationary.

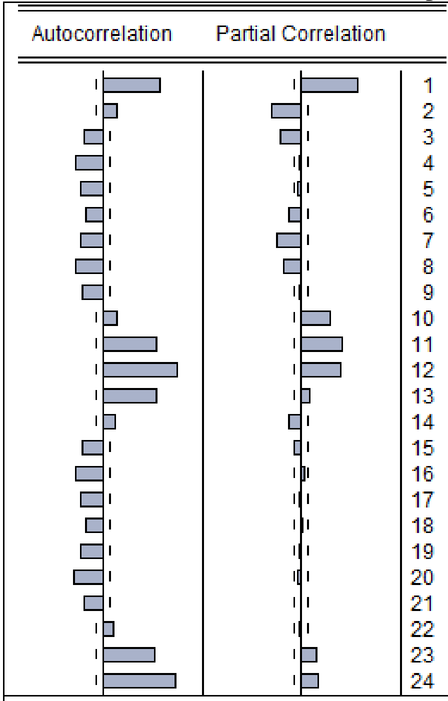

Figure 8: Correlogram for Maximum temperature

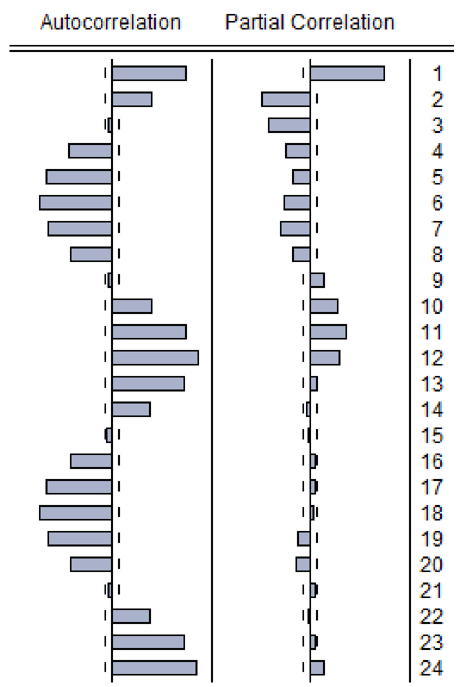

Figure 9: Correlogram for Minimum temperature

Unit root test for stationarity

The stationarity of the series can be tested by unit root test. Among the different test for unit root or stationarity the ADF test is the most useful and widely used. The ADF test for maximum temperature suggested that the series has a unit root (p-value=0.719) that means the series is not stationary and for the minimum temperature it is also found that the original series is not stationary (Appendix table: 2). So, as to achieve the stationarity differentiation has been taken and after taking first difference both the maximum and minimum temperature are found stationary (Appendix table: 3). And Osborn-Chui-Smith-Birchenhall (OCSB) test suggested that these series need not to have any seasonal difference. So, the difference order of the seasonal ARIMA model has been found and which is one for both maximum and minimum temperature.

After lot of experimentation the following models have been found as the best models to produce forecast for both the maximum and minimum temperature. The selection of the models have been done based on the model selection criteria such as Akaike Information Criterion (AIC), Schourtz Information Criterion (SIC) and those whose value are expected to be lower. The goodness of fit of the models are conforms by the r-square value which is expected to closer to one. The final se

Table 2: Parameter estimation for maximum temperature

Variable	Coefficient	Std. Error	t-statistic	P-Value
Drift	0.001	0.002	0.217	0.827
AR(1)	0.167	0.036	4.53	0.000
SAR(12)	0.458	0.034	13.47	0.000
SAR(24)	0.382	0.033	11.28	0.000
MA(1)	-0.995	0.002	-440.95	0.000
R-squared	0.613	**F-statistic**		292.44
Adjusted R-squared	0.611	**p-value**		0.000
Log likelihood	-1207.926	**AIC**		3.26
Durbin-Watson stat	2.01	**SIC**		3.30

Application of least squares method produces the estimate of different lagged parameter in the table 2 and all the parameters are significantly measure the variation of maximum temperature. The R-square value is the measure for goodness of fit and here it is found about 61% of variation has been explained by the regressor's and adjusted R square measure the goodness of the fitted model. Durbin-Watson test confirm that the fitted model is free of auto correlation problem and the minimum value of AIC, SIC ensures the adequacy of the fitted model.

Table 3: Parameter estimation for minimum temperature

Variable	**Coefficient**	**Std. Error**	**t-statistic**	**P-Value**
C	-0.12	0.21	-0.57	0.56
AR(1)	0.096	0.039	2.45	0.014
SAR(12)	0.998	0.001	1223.6	0.000
MA(1)	-0.94	0.013	-68.90	0.000
SMA(12)	-0.957	0.006	-141.57	0.000
R-squared	0.818	**F-statistic**		841.14
Adjusted R-squared	0.817	**p-value**		0.000
Log likelihood	-1262.16	**AIC**		3.36
Durbin-Watson stat	2.002	**SIC**		3.39

For the minimum temperature one autoregressive and one moving average parameter along with seasonal autoregressive and seasonal moving average parameter has been found significant to measure the variation of minimum temperature. R square and adjusted R square confirms the goodness of fit and the others test also found satisfactory.

Diagnostic test:

Stability test for the forecasting model

Stability test is very important for a forecasting model and chow breakpoint test check the stability of the fitted models at the year 2000. The chow test use F-statistic to test the whether there is any break of series before and after the specified time. Here, chow test found no break in the fitted model that implies the fitter model is stable to forecast (Appendix table 4).

Residual correlogram

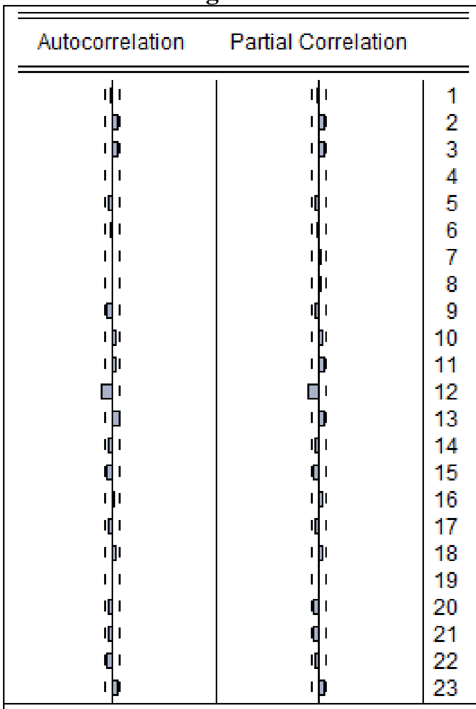

Figure 10: residuals correlogram for maximum temperature

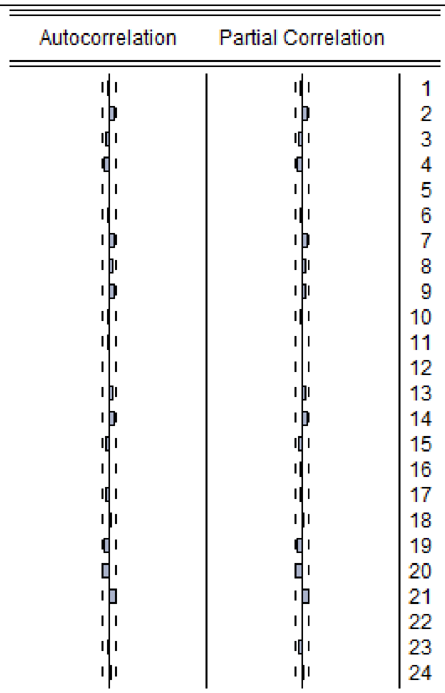

Figure 11: residuals correlogram for minimum temperature

The residual correlogram indicates the residuals of the estimated models are free from autocorrelation which is important conditions of sound fitted forecasting model. The Ljung-Box test for each of the lag order has been done and found insignificant which nullify the presence of autocorrelation in the fitted model.

Serial correlation test

Brush-Godfrey serial correlation test has been adopted to test the serial correlation in the residuals of the fitted model and found both maximum and minimum temperature are free from serial correlation hazard and hence conform the adequacy of the fitted model (Appendix table 5).

Forecast

The main purpose of the univariate time series analysis is to forecast and if the model building process is done adequately then the fitted model is ready to produce forecast value based on that one can assess the upcoming future and which is the target of all sort of effort regarding this analysis. After fitting the model the forecast generation has been done and the following figures shows the scenarios;

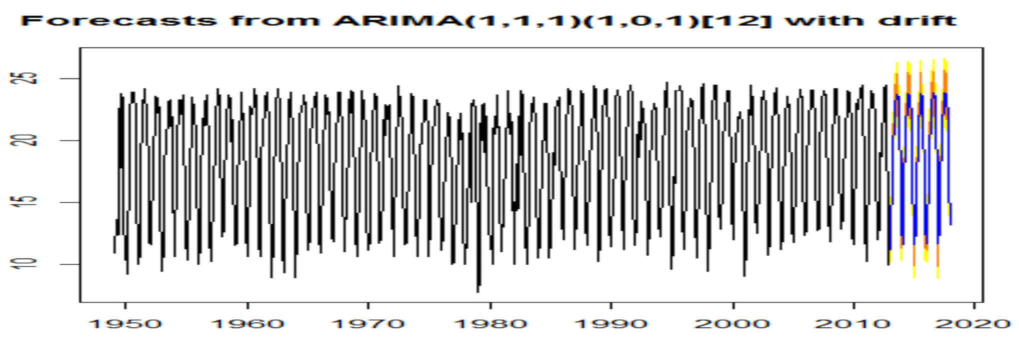

Figure 12: Forecasted values of minimum temperature up to December’17

The colored part is the forecasted temperature.

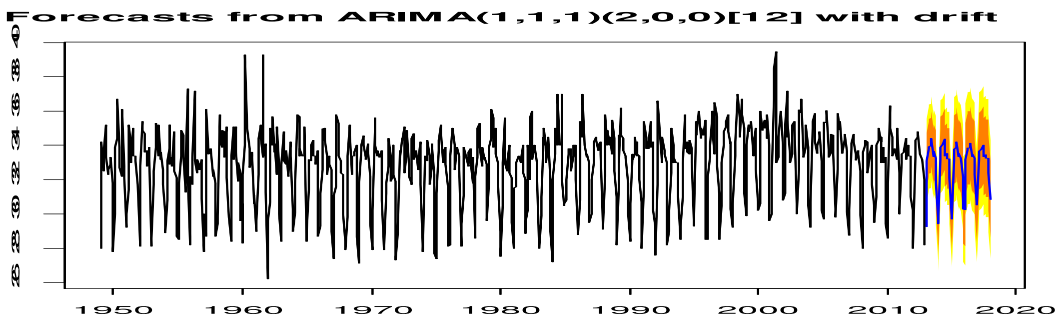

Figure 13: Forecasted values of maximum temperature up to December’17

Validation of forecast

To validate the forecast on the fitted model, we first divide the whole sample into two parts namely test data (January 1949 to December 2000) and validation data (January 2001 to December 2012). Then the fitted model is applied in the test data and noted the root mean square error which is termed as the in sample forecast error. Then using the fitted model forecasting has been done equal to the hold out or validation sample and also noted down the root mean square error termed as out sample forecast error. If the out sample forecast error is less than the in sample forecast error then the forecast value is valid.

Here, In sample forecast error for the maximum temperature based on test data is 1.27 and the out sample forecast error is 1.03 which is clearly less than the former one that confirm the validation of forecasted value using the fitted model. Now in case of minimum temperature the in sample forecast error for the test data is 1.35 where as the out sample forecast error is 0.97 which implies that the forecast produced by the fitted model is also valid enough.

Using the forecasted data the following graphs are prepared and the linear line in the graphs shows the indication of increasing of temperature in the coming future.

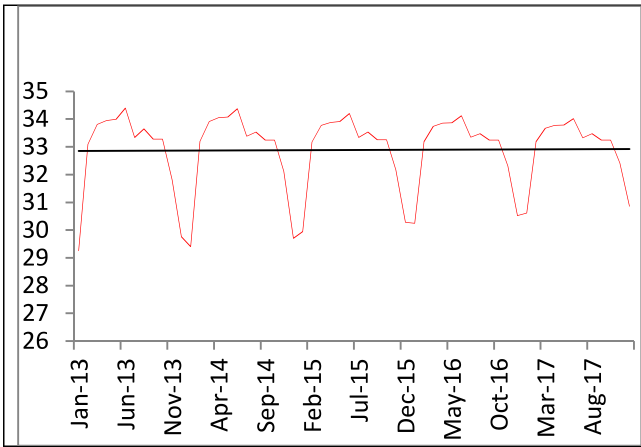

Figure 14: Maximum temperature forecast up to December' 17

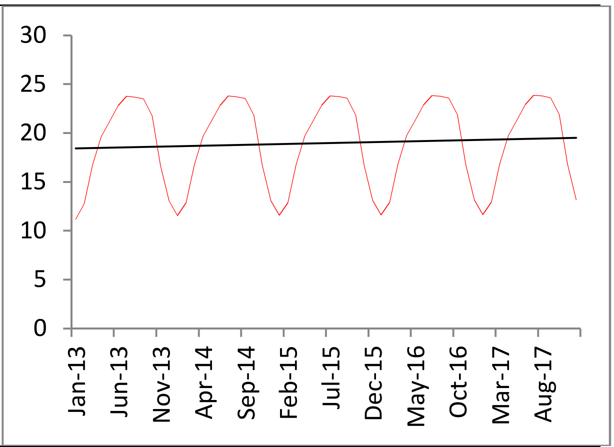

Figure 15: Minimum temperature forecast up to December' 17

Conclusion

Forecasted temperature corroborated the global trend of increasing the temperature and hence evident the increasing trend is more apparent from the beginning of 90th decade and continuing sharply in case of minimum temperature but abruptly for maximum temperature. The fluctuation of temperature is marked more in case of minimum temperature but slightly steady in case of maximum temperature. This is the signature of increasing global warming in terms of temperature. The fitted forecasted model can be used to generate the forecast value of temperature in others area of Bangladesh and the comparison among them would provide better idea about the changing pattern of temperature specifically and would give an idea about the local changing pattern of climate. This is also suggested that this seasonal model can also be used in any other areas of time dependent data with necessary modifications.

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Appendix

Appendix Table 1: Normality test

	Maximum temperature	**Minimum temperature**
Jarque-Bera statistic	**46.98**	**72.13**
p-value	**0.000**	**0.000**

Appendix table 2

ADF test for Stationary (before difference)	**Maximum temperature**	**Minimum temperature**
t-statistic	0.117	0.341
p-value	0.719	0.783

Appendix table 3

ADF test for Stationary (after difference)	**Maximum temperature**	**Minimum temperature**
t-statistic	-15.71	0.000
p-value	-23.81	0.000

Appendix table 4

Chow breakpoint test	**Maximum temperature**	**Minimum temperature**
F-statistic	**1.17**	**0.063**
p-value	**0.318**	**0.997**

Appendix table 5

Brush-Godfrey test	Maximum temperature	Minimum temperature
F-statistic	**1.60**	**2.55**
p-value	**0.201**	**0.079**

Appendix table 6

Forecasted maximum and minimum temperature

Month	Maximum Temperature	95% Confidence Interval		Minimum temperature	95% Confidence Interval	
		lower	Upper		Lower	Upper
Jan-13	29.26	26.84	31.69	11.16	8.55	13.78
Feb-13	33.1	30.65	35.56	12.78	10.13	15.43
Mar-13	33.81	31.35	36.27	16.74	14.08	19.4
Apr-13	33.95	31.49	36.41	19.64	16.98	22.3
May-13	33.99	31.53	36.45	21.18	18.51	23.84
Jun-13	34.4	31.94	36.86	22.8	20.13	25.46
Jul-13	33.34	30.88	35.8	23.75	21.08	26.42
Aug-13	33.65	31.19	36.11	23.68	21	26.35
Sep-13	33.28	30.82	35.74	23.5	20.82	26.18
Oct-13	33.28	30.82	35.74	21.78	19.09	24.46
Nov-13	31.81	29.35	34.27	16.69	14.01	19.38
Dec-13	29.76	27.3	32.22	13.04	10.35	15.73
Jan-14	29.4	26.7	32.1	11.56	8.86	14.26
Feb-14	33.2	30.49	35.9	12.85	10.15	15.55
Mar-14	33.91	31.2	36.61	16.77	14.07	19.48
Apr-14	34.05	31.34	36.76	19.67	16.96	22.37
May-14	34.07	31.36	36.77	21.2	18.49	23.92
Jun-14	34.37	31.66	37.08	22.82	20.1	25.54
Jul-14	33.38	30.68	36.09	23.78	21.06	26.5
Aug-14	33.53	30.82	36.23	23.7	20.98	26.43
Sep-14	33.24	30.53	35.95	23.52	20.8	26.25
Oct-14	33.24	30.54	35.95	21.8	19.07	24.53
Nov-14	32.11	29.4	34.81	16.72	13.98	19.45
Dec-14	29.7	27	32.41	13.07	10.33	15.81
Jan-15	29.95	26.88	33.02	11.59	8.84	14.33
Feb-15	33.17	30.09	36.25	12.87	10.12	15.62
Mar-15	33.77	30.69	36.84	16.8	14.04	19.55
Apr-15	33.88	30.8	36.96	19.69	16.93	22.45
May-15	33.91	30.83	36.99	21.23	18.47	23.99
Jun-15	34.2	31.12	37.28	22.85	20.08	25.61
Jul-15	33.34	30.27	36.42	23.8	21.03	26.57
Aug-15	33.53	30.45	36.61	23.73	20.96	26.5
Sep-15	33.26	30.18	36.34	23.55	20.77	26.32
Oct-15	33.26	30.18	36.34	21.83	19.05	24.61
Nov-15	32.17	29.09	35.25	16.75	13.96	19.53
Dec-15	30.28	27.2	33.36	13.09	10.3	15.88
Jan-16	30.25	26.99	33.52	11.61	8.82	14.41
Feb-16	33.19	29.92	36.47	12.9	10.1	15.69
Mar-16	33.74	30.46	37.01	16.82	14.02	19.62
Apr-16	33.85	30.57	37.12	19.72	16.91	22.52
May-16	33.87	30.59	37.14	21.25	18.44	24.06
Jun-16	34.12	30.84	37.39	22.87	20.06	25.68
Jul-16	33.35	30.07	36.62	23.83	21.01	26.65
Aug-16	33.48	30.21	36.76	23.75	20.93	26.58
Sep-16	33.25	29.98	36.52	23.57	20.75	26.4
Oct-16	33.25	29.98	36.52	21.85	19.02	24.68
Nov-16	32.31	29.04	35.59	16.77	13.94	19.6
Dec-16	30.52	27.25	33.8	13.12	10.28	15.95
Jan-17	30.61	27.17	34.05	11.64	8.79	14.48
Feb-17	33.19	29.75	36.64	12.92	10.07	15.77
Mar-17	33.67	30.23	37.12	16.85	14	19.7
Apr-17	33.77	30.32	37.22	19.74	16.89	22.6
May-17	33.79	30.34	37.23	21.28	18.42	24.14
Jun-17	34.02	30.57	37.46	22.9	20.03	25.76
Jul-17	33.33	29.88	36.78	23.85	20.99	26.72
Aug-17	33.47	30.02	36.91	23.78	20.91	26.65
Sep-17	33.25	29.81	36.7	23.6	20.72	26.47
Oct-17	33.25	29.81	36.7	21.88	19	24.76
Nov-17	32.41	28.96	35.85	16.8	13.91	19.68
Dec-17	30.86	27.41	34.31	13.14	10.26	16.03