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Prediction of meteorological parameters of minimum and maximum temperatures in Zayandehrud basin using time series analysis[1]

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Abstract

Introduction: Iran is one of the countries in the world that needs water resources planning. In this research, the maximum and minimum temperatures in seven meteorological stations are analyzed and predicted. Time series analysis is a specific way of analyzing a sequence of data points collected over an interval of time. In time series analysis, analysts record data points at consistent intervals over a set period of time rather than just recording the data points intermittently or randomly. The purpose of this study is to use the time series method in predicting the maximum and minimum temperatures in the Zayandehrud basin, Isfahan, Iran.

Materials and Methods: The Zayandeh Rud River is the main supplier for drinking water to a population of over 4.5 million in the three provinces of Isfahan, Yazd, and Charmahal-Bakhtiari. It provides agricultural water for over 200,000 hectares, supplies water to several large industries, and is and the hub of tourism in the central plateau of Iran. This river used to have significant flow all year long, but today runs dry due to water extraction before reaching the city of Isfahan. Isfahan Province is located in the center of the Islamic Republic of Iran. The total area of the Isfahan province is 106179 square kilometers, approximately 6.25 percent of the total Iran area. The city lies in the lush Zayandeh Roud River plain of foothills of the Zagros Mountains Range. Isfahan is about

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1580 meters high from the sea level. It has a mild climate. ZayandehRud River is the main source and element of the development and beauty of Isfahan. The river rises from the eastern slopes of the Zagros Mountain range. The city is located in the lush plain of the river ZayandehRud, at the foot of the Zagros mountains. Situated at 1.590 meters above sea level on the eastern side of the Zagros Mountains, Isfahan has a dry climate (Köppen BWk). Record Periods include 7 days, 15 days, 30 days, seasonal and daily time steps. The output data were demonstrated by box Diagram, Normal and Grubs Beck. The modeling was performed by examining the autocorrelation and partial autocorrelation diagrams and Akaike, Schwartz and Hanan Quinn criterias. Then normality was test by Kolmogorov-Smirnov and Jarque Bera tests. Durbin Watson and Pert Manto tests were used to check the accuracy of the model. The trend and homogeneity are analysed using MATLAB and the stationery and modeling are done using Minitab, Eviews software.

Results and Discussion: Maximum temperature (meteorological parameter) intervals of 7 days, 15 days, 30 days, seasonal, and daily, and as the number of data decreases, the amount of error increases, the data interval had an increasing trend in daily period. In the R^2 criteria, all of the stations were above 0.7, and in terms of correctness, the model of Kabutarabad station had a better answer than all of the other stations. For this reason, this station was selected. In terms of the test that used for the normality of all of the stations, the results were similar, so that the daily time interval was skewness and kurtosis and the intervals of 7, 15 and 30 days and seasonal were examined for Kolmogorov Smirnov and Jarque bera tests. The percentage error was below than 20%. The models obtained for the intervals were as follows: for the 15 and 30 days intervals of Sarima and for the 7 days, seasonal and daily intervals of Arima.

Conclusions: For validation in the series with daily and 7days time intervals, 5% of data were considered, in 15days and 30days 10% of data, and seasonal 20% of data were considered. Trend was checked by Mann Kendall method and was observed only in daily time interval. The method of estimating the parameters is calculated from the least squares method. Also in modeling the maximum and minimum temperatures, mainly SARIMA model was fitted in 15days and 30days period and ARIMA in 7days and daily period and seasonal period. R^2 was higher than 0.7 and the average squares error and error percentage was below 20%.

The limitations of the project were as follows: One of the hypotheses was that the impact of artificial and human factors on the study data was negligible and the length of the period used is considered as a sample of the total statistical population of that station. It is recommended that firstly the effect of climate change on the prediction of results would be studied, secondly using wavelet in time series analysis, thirdly using and comparing ARCH and GARCH time series models.

The minimum and maximum temperature has a large impact on evapotranspiration and farmland water consumption. Using time series analysis, both minimum and maximum temperatures could be predicted. Therefore, water consumption could be estimated for future crop management and having an efficient water productivity.

Keywords: ARIMA, Time series, Temperature, SARIMA, ZayandehRud, Isfahan.

1. Introduction

Droughts and climate change are the important challenges for majorities of the countries. One of the most important parameters considered by the water resources scientists is temperature. The temperature of the earth has been increased by 0.6°C between 1986 and 2000, which has caused many changes in snowfall, rain, storms and floods (Alshrif *et al.*, 2019) and according to NASA1 data, from 2000 to 2021, it has been increased by 0.46 degrees and this trend is expected to increase. In a sense, Iran is one of the arid and semi-arid countries and the lack of water resources and inadequate water distribution have made it necessary to plan for the optimal use of water resources (Alshrif *et al.,* 2019).

Predicting the meteorological parameters and examining their trends in water resources and optimal use of water are very important and are a key issue in water resources planning. The data used must be stochastic and stationary, the meaning of stochastic in statistics is random, but in hydrology it is used in a special way and refers to a time series that is semi-random, so it can be said that stochastic processes fill the gap between possible and definite processes and stationary means that data is independent of time. Stationary data is a prerequisite for time series data modeling so data should be stationary to analyze by time series method. These features make it possible to use the time series analysis. A set of statistical data that have the equal and regular intervals and statistical methods that examine the data with the mentioned feature is called time series. The aim of this manuscript is time series analysis of temperature data in Zayandehrud basin.

2. Litrature Review

Helmi *et al*. (2020) studied the Sarima model (Seasonal Autoregressive Integrated Moving Average) in different rainfall statistical samples with the aim of predicting drought using Standardized Precipitation Index (SPI). The scale used was 12 months using 7 synoptic stations and was 20 years record length. First, the stationery and seasonality of the data were investigated and the best model was obtained with the Akaike and Schwartz criteria. The results showed that the Sarima model was suitable for all of the stations and the residual graphs were close to the normal distribution and the prediction performance was good (Helmi *et al*., 2020). Kocsi *et al*. (2020) studied the

1. National Aeronautics and Space Administration

climate data in western Hungary, and breakpoints in the annual, seasonal, and monthly rainfall time series were examined, with no breakpoints observed. A significant decreasing trend of 0.2 to 0.7 mm per year was observed with Mann-Kendall test. The results showed that the reduction of seasonal rainfall in autumn is between 0.15 to 0.38 mm per year. It was concluded that the signs of changes in precipitation related to climate change can be detected in a long series (Kocsi, 2020). Polwiang (2020) studied dengue fever and its association with the climatic factors in Bangkok, Thailand, from 2003 to 2017. The time series pattern was obtained seasonally and also the results showed that the amount of rainfall and humidity has a positive effect on the transmission of dengue disease and it was strongly recommended that more variables be considered to increase the accuracy. MAE, RMSE and MAPE criteria were also used for validation analysis (Polwiang,2020). Kalamaras *et al.* (2017) examined the mean, maximum and minimum temperatures on the island of Crete in Greece using a time series. The data used was in daily scale from January 1973 to December 2010. The behavior of the time series models (mean, maximum and minimum daily temperature) with the local climate was almost the same (Kalamaras *et al*., 2017). Asfaw *et al*. (2018) examined the rainfall and temperature data in northern Ethiopia, then the data was analyzed by Mann Kendall trend test and the existence of an increasing trend in mean and minimum temperature was significant at the level of both 5% and 10%. It was then recommended that for the designed strategies in the agricultural sector, the nature of declining and irregular rainfall and the trend of increasing temperature should be considered (Asfaw *et al*., 2018). Latif *et al*. (2020) studied 20 meteorological stations in the basin in the east, west and north of India, China and Afghanistan. The variables included maximum, minimum and average temperature and the result was that the temperature was increasing by 0.26 and 0.13°C in a decade, which leads to a decrease in polar ice if the trend of decreasing precipitation and also increasing the temperature, which in turn will create the dangerous conditions for water resources (Latif *et al*., 2020).

The purpose of time series analysis is to predict the desired data and obtain a model of changes and identify their trends (Dudangeh *et al*., 2012). and include the recognizing time structure, identifying both stationary and not stationary data, examining the effect of external variables, examining the effect of data correlation structure and their autocorrelation, and identifying the seasonal nature of data and immediately showing the forecast in the next step, but not long. In hydrology, there is no guarantee for exact pridiction and the forecast means estimation.

The novelty of this study is the number of tests that used for the first time for meteorological parameters and the studied basin would be one of the problematic basins that is considered worldwide. Analysis of the mentioned cases is also considered as an innovation and the time periods studied were 7 days, 15 days, 30 days, seasonal and daily.

The time periods used were selected for the following reasons:

1. The more data, the less error and the selected intervals were used due to the accuracy of the results, 2. To use the time series, the more data, the better, and because we were faced with a limited number of data, smaller intervals were considered. 3. One of the innovations of this project was to use different time periods and examine them in the parameter under study.

3. Material and methods

3-1. Case Study Area

The study area is located in Zayandehrud basin in Esfahan province and Iran and the average elevation is about 1466 meters. The total area of the basin is about 41,500 Km^2. It includes 7 synoptic stations of Esfahan, East Esfahan, Kabutarabad, Mobarakeh, Shahreza, Daran and Najafabad because the data records of these stations were available and the measurement unit of of degrees Celsius was considered. All of the stations have the records from 1993. It was received from the Iranian Ministry of Energy in 2019. The number of daily data was 9595 and 7 days was 1371 and 15 days was 640 and 30 days was 313 and seasonal interval was 106 data.

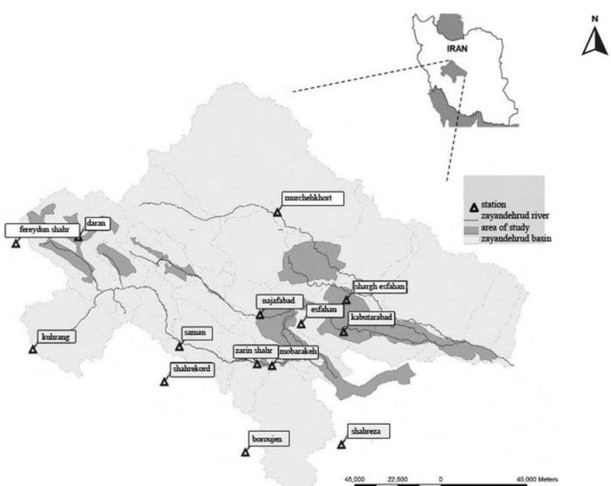

Fig. 1. Selected stations in Zayandehrud basin, Iran

In the beginning, different statistical tests are performed on the data, which are: the trend analysis through non-parametric Mann Kendall test, which, if there is a trend, de-trending should be done. The method of checking the trend is that there is usually a periodic structure in the data. which makes the mean and variance unstable that the seasonal mean in each season is subtracted from the sample mean and thus the seasonality in the variance should be removed. In general, trend elimination is done through several methods: mean trend elimination, variance trend elimination, variance and mean trend elimination, variance displacement elimination, variance displacement and mean displacement. There were also no data mutations and shifts in this study. the trend was observed only in daily time interval and the values in maximum temperature parameter was between 5 to 6°C and at the minimum temperature was between 6 to 8°C.

Homogeneity test was performed with standard normal method, cumulative deviation, Von Neumann ratio test and Buish and range test (Kazemzadeh & Malekian, 2018). which were written the codes in the MATLAB software. The ADF1 unit root test is used to check the stationary of the series of the data, and its null hypothesis is that data has unit root and it is not stationary, which if the null hypothesis is rejected, the result is that the data is stationary, kPSS2, was also used for stationary evaluation. Differentiation was used for unstationary data. After reviewing the mentioned tests, modeling begins. The point is that first the process is eliminated and the homogeneity of the data is checked and the stationary of the data are checked and if they are not stationary, the mentioned tests are used to stationary the data. Akaike, Schwartz and Hanan Quinn criteria were used to evaluate the model and error percentage and MSE3 were also used. The method used in this project is Box Jenkins (Shabani *et al.*, 2013) which is a valid and optimal method in the field of climate parameters modeling. Also, the method of estimating the parameters is calculated from the least squares method. For validation in the series with daily and 7-day time intervals, 5% of data were considered, 15 days and 30 days were considered for 10% of data, and in seasonal time interval, 20% of data were considered. The formulation of ARMA was calculated by equation 1.

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1. Augmented Dickey Fuller
2. Kwaitowski Phillips Schmidt Shin test
3. Mean Square Error

$$Y_t = \sum_{i=1}^{p} \varphi_i Y_{t-i} + \varepsilon_t - \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} \qquad (1)$$

Yt is normally distributed with mean of zero and variance of σ2(Y)

εt is the independent normally distributed noise term with variance of σ2(ε)

{φ1,…, φp} and {θ1,…, θq} are the AR and MA parameters and p, q are Autoregressive and moving average rank respectively and if data has the seasonal properties, it is added to the Arma formula that the P, Q are seasonal autoregressive and seasonal moving average rank, respectively (Eslamian., 2014).

$$\phi_p(B)\Phi_P(B^s)\nabla^d\nabla_s^D X_t = \theta_q(B)\Theta_Q(B^s)a_t \qquad (2)$$

$B(X_t) = X_t - 1$ is operator backward. and p, q is Autoregressive and moving average rank and P, Q is Seasonal autoregressive and seasonal moving average rank. (Khtar & Bahmani, 2015).

3-2. Analysis method

To begin modeling, data autocorrelation diagrams are examined and rankings of p, q, d, P, Q, D are obtained. A model that looks appropriate is obtained to select. Then, for finding the best model, several methods are used, which are Investigation of autocorrelation (ACF) and partial autocorrelation (PACF) diagrams of residues (Nury *et al*., 2017). In this way, no correlation should be observed in the self-correlation diagram until the delay of 3 or 4 which should be replaced if the correlation of the model is observed. The criteria of Akaike, Schwartz and Hanan Quinn (Khatar & Bahmani, 2014) were also used to obtain the optimal model. In this way, according to the number of data, the appropriate criterion is selected from the three mentioned criteria and the performed modeling is compared in terms of the selected criterion (Eslamian, 2014).

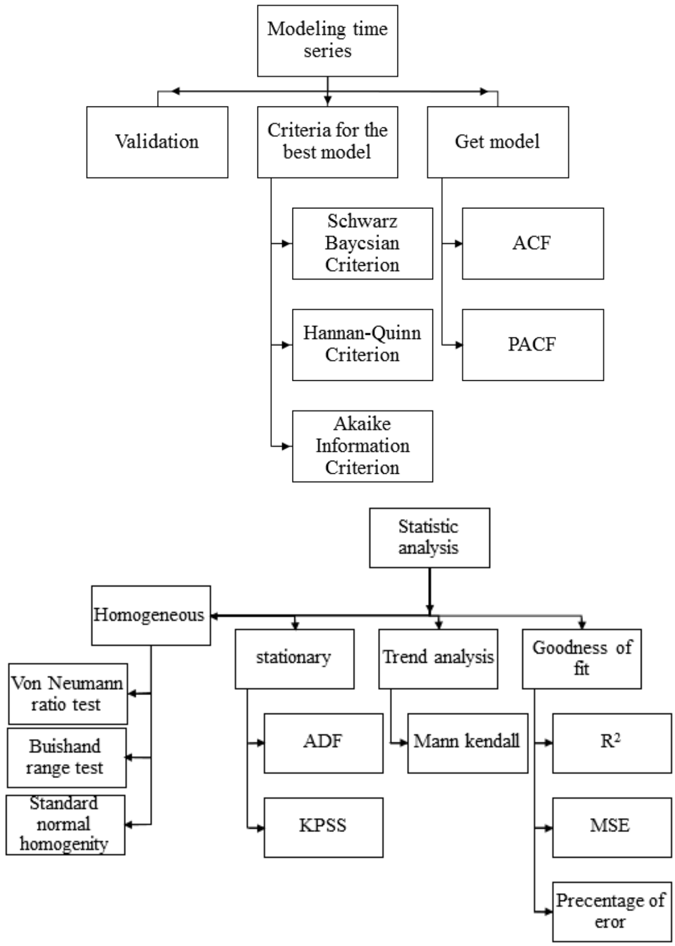


Fig. 2. Methodology flow chart

Table 1. Criteria for estimating the best model

Criterion	Number of data
(AIC)	Up to 200
(HQIC)	200-100
(SBIC)	Under 100

Durbin Watson and Pert Manto test models performed correctly and the results inserted in Table 3.

In terms of normality, Kolmogorov-Smirnov, Jarque bera (Alsharif *et al.*, 2019) and Cs-Ck methods (skewness-kurtosis) used, which are inserted in Table 3, and after obtaining the model, in terms of validation of R^2, error percentage, RMSE (Khatab & Bahmani, 2015) and MSE were used, which inserted in Table 5. A number of stations used to validate the model based on the actual data. After validation of the errors, the models are checked and the best model is fitted. Then, using the Kolmogorov-Smirnov test, the normality of the residuals checked, and if the fitted model is normal, the desired model will be acceptable, the results of which are given in Table 4. Finally, the number of the predicted value was insertedin Table6.

$$r(x,y) = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{[n\sum x_i^2 - (\sum x_i)^2]^{\frac{1}{2}}\,[n\sum y_i^2 - (\sum y_i)^2]^{\frac{1}{2}}} \quad (3)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Yi - \hat{Y}i)^2} \quad (4)$$

$$\text{Error percentage} = \frac{\text{actual} - \text{prediction}}{\text{actual}} * 100 \quad (5)$$

$$\text{MSE} = \frac{\sum(\tilde{\hat{y}}_t - y_t)^2}{N} \quad (6)$$

4. Results

Among the stations, the diagrams of Mobarakeh station for the meteorological parameter of maximum temperature and Kabutarabad station for the meteorological parameter of minimum temperature are given as the examples.

Stationary of data determined by drawing autocorrelation and partial autocorrelation diagrams. If the lag of statistically significant is higher than 0.95, it shows that the data is not stationary. Another point is that it can be used from the autocorrelation chart and partial autocorrelation one to check the seasonality of the data. If trend was observed at the specific intervals in autocorrelation and partial autocorrelation diagrams, the data seems to be seasonal.

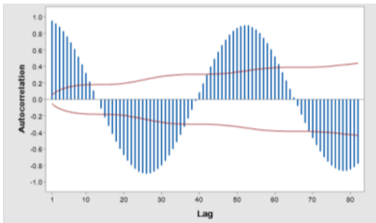
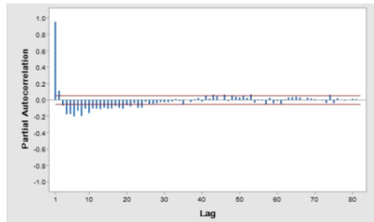
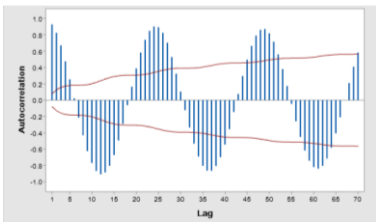
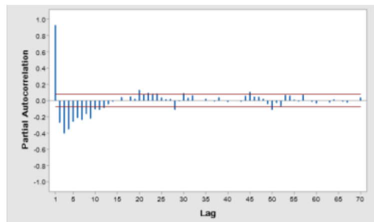
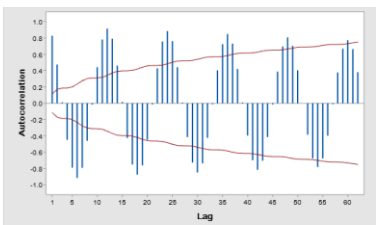
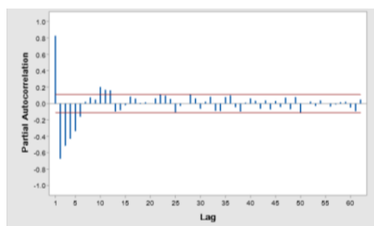
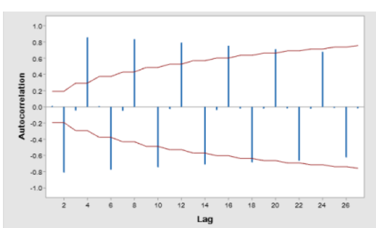
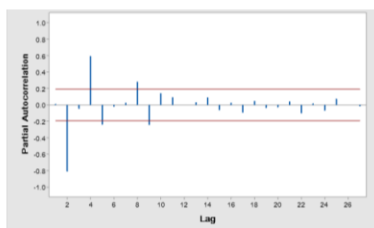
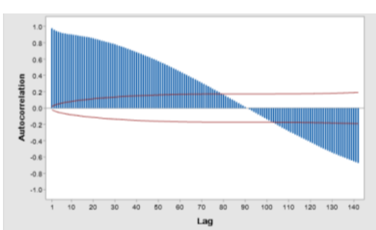
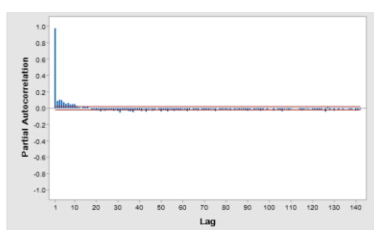
	Acf diagram	Pacf diagram
7 day		
15 day		
30 day		
seasonal		
daily		

Fig. 3. Data autocorrelation Maximum temperature of Mobarakeh station

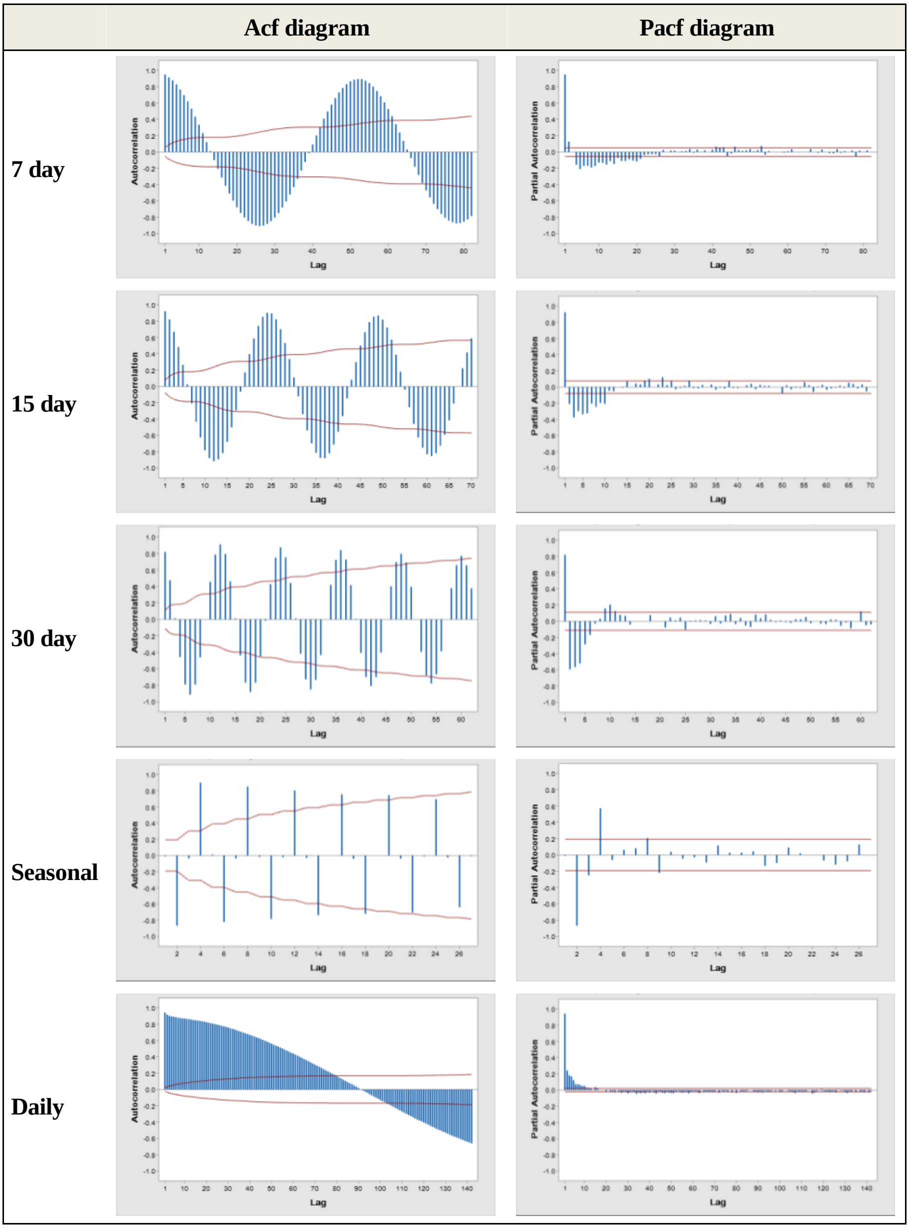


Fig. 4. Data autocorrelation Minimum temperature of Kabutarabad station

It seems that the data in 7 days, 15 days, 30 days intervals are seasonality.

To check the correctness of the model that used, the autocorrelation and partial autocorrelation of residuals are examined. In such a way, so that no correlation should be observed until the intervals 3 to 4, if observed, the obtained model seems that needs to change.

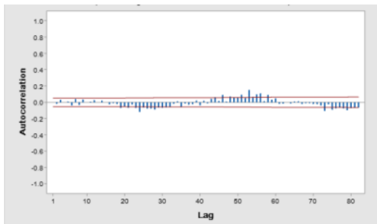
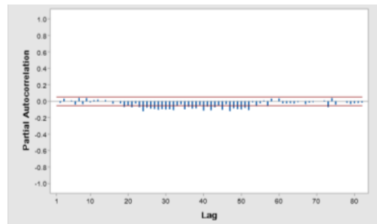
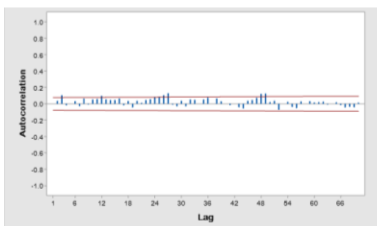
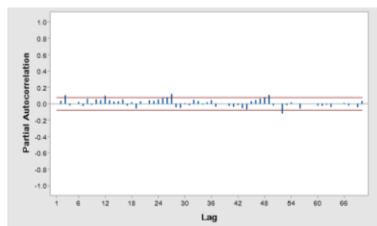
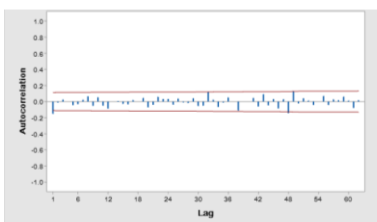
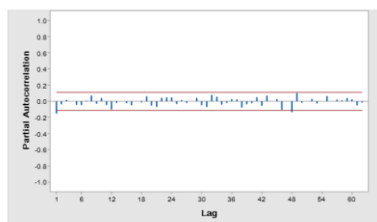
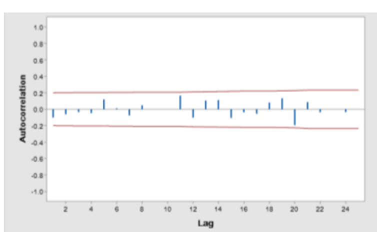
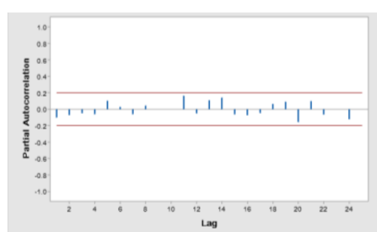
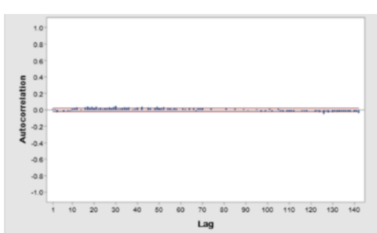
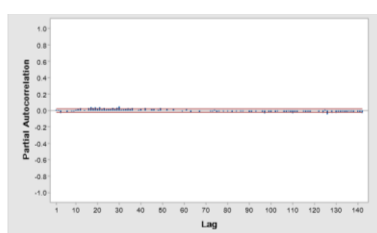
	Acf diagram	Pacf diagram
7day		
15 day		
30 day		
Seasonal		
daily		

Fig. 5. Autocorrelation of residues Maximum temperature of Mobarakeh station

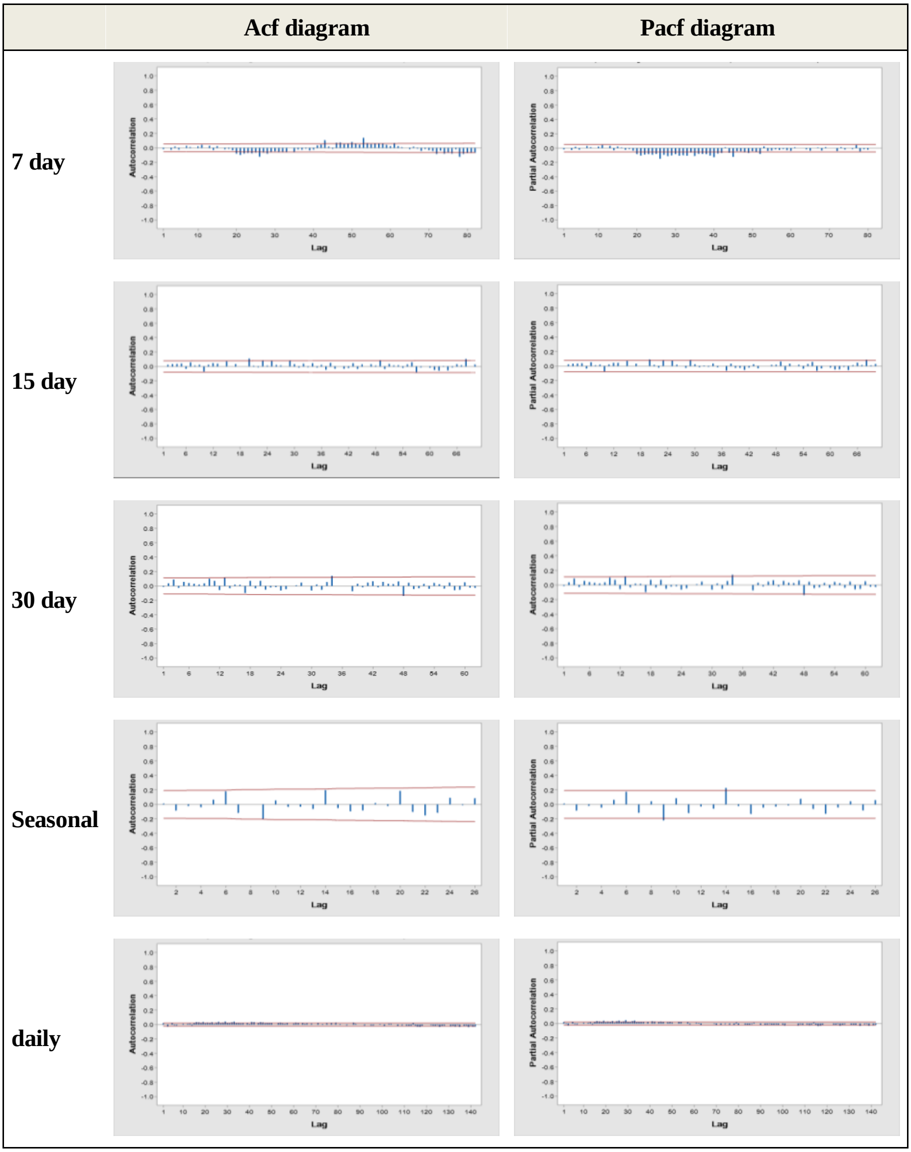


Fig. 6. Autocorrelation of residuals of Minimum temperature of Kabutarabad station

In general, by examining the autocorrelation and partial autocorrelation diagrams, the correct model can be identified.

After modeling, histogram and time series diagrams were drawn with the predicted values and the upper and lower limits of the predicted values were considered in 5% level of significance.

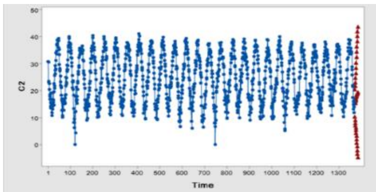
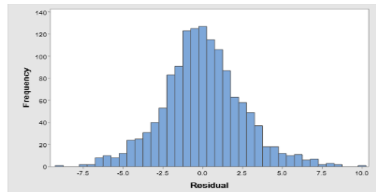
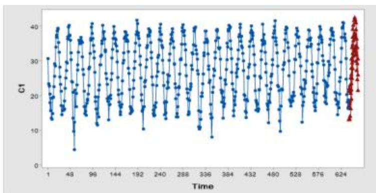
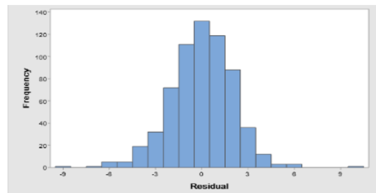
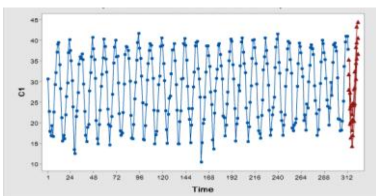
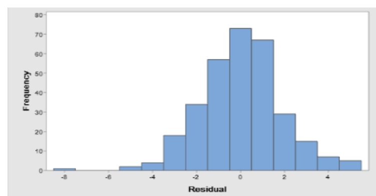
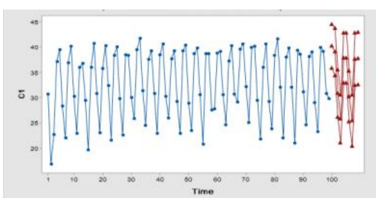
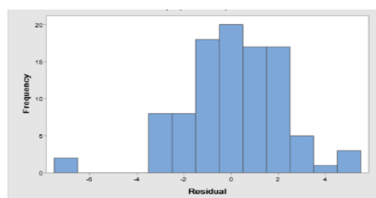
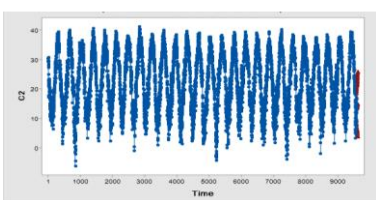
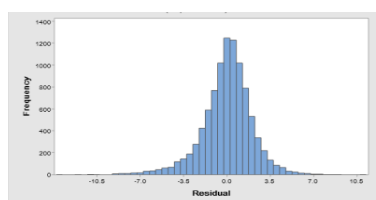
	Time series diagram	Histogram
7 day		
15 day		
30 day		
Seasonal		
daily		

Fig. 7. Correct examination of the maximum temperature model of Mobarakeh station

It seems that there is skewness between 15 days and 30 days, but in reality, it looks like this because the outlier data is not deleted, and the reason for not deleting this data is that the thrown data is observational data and cannot be Deleted it.

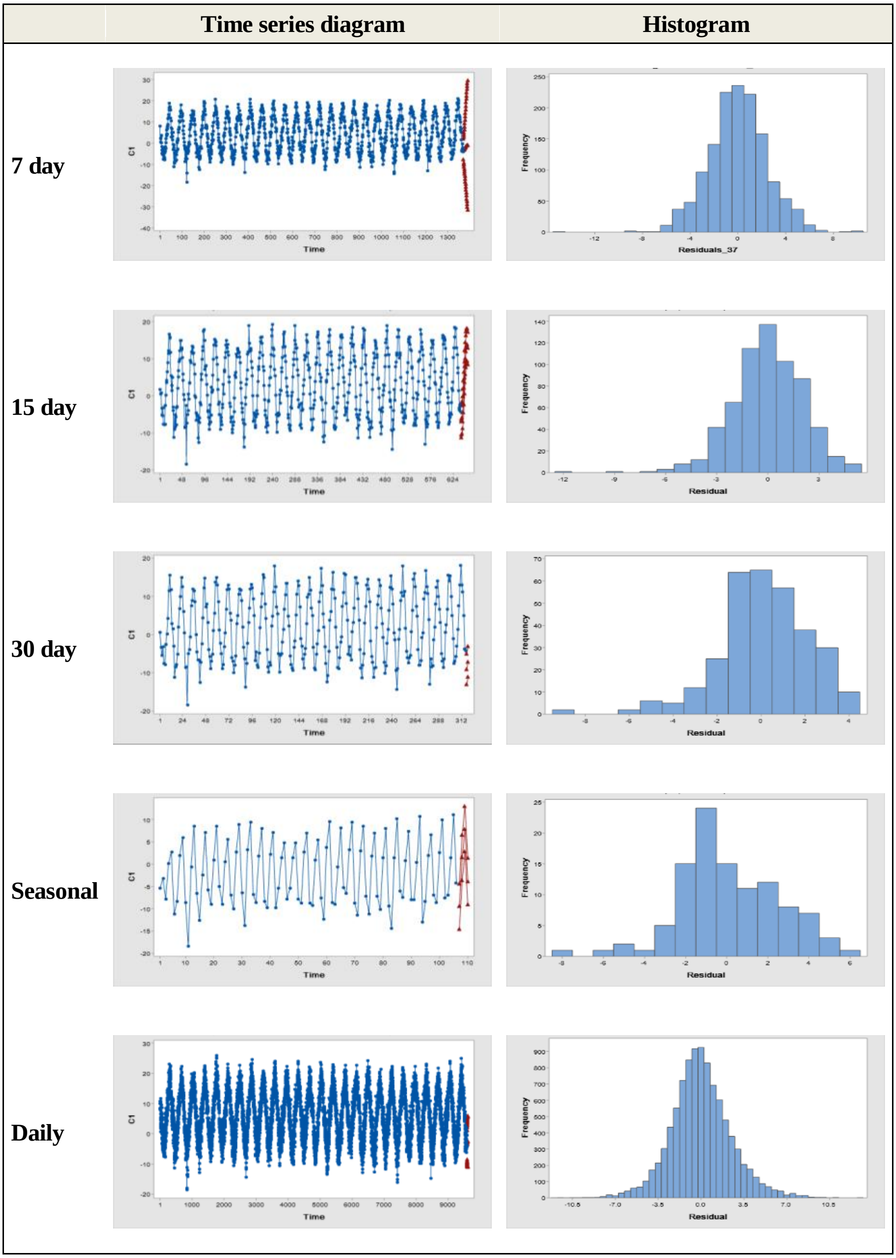


Fig. 8. Correctness of the minimum temperature model of Kabutarabad station

For validation in the series with daily and 7-day time intervals, 5% of data were considered, 15 days and 30 days were considered with 10% of data, and in seasonal time interval, 20% of data were considered.

The predicted values of Mobarakeh and Kabutarabad stations in the meteorological parameter of maximum and minimum temperature were collected as a sample in Table 6.

Table 2. Predicted values of maximum and minimum temperature (degrees Celsius) of Mobarakeh and Kabutarabad stations

daily			seasonal			30 day			15 day			7 day		
n	t_{max}	t_{min}	n	t_{max}	t_{min}	n	t_{max}	t_{min}	n	t_{max}	t_{min}	n	t_{max}	t_{min}
1	13.09	-3.78	1	40.15	-9.55	1	31.61	-9.17	1	17.01	-6.48	1	15.18	-3.01
2	13.18	-3.62	2	39.01	1.434	2	23.38	-7.19	2	17.71	-7.03	2	15.10	-3.458
3	13.29	-3.53	3	30.72	7.843	3	20.16		3	17.47	-5.94	3	15.32	-3.33
4	13.36	-3.47	4	25.76	-3.91	4	18.11		4	18.42	-4.58	4	15.72	-3.25
5	13.43	-3.41	5	37.84		5	20.67		5	20.63	-2.61	5	16.19	-3.14
6	13.49	-3.36	6	37.79		6	24.10		6	23.39	-0.25	6	16.69	-2.96
7	13.55	-3.31	7	30.16		7	28.39		7	26.02	2.01	7	17.16	-2.76
8	13.60	-3.26				8	34.36		8	29.37	4.86	8	17.59	-2.55
9	13.66	-3.21				9	39.36		9	32.27		9	17.98	-2.35
10		-3.16							10	34.73		10	18.31	-2.15
11		-3.11							11	35.84		11	18.60	-1.97
12		-3.07							12	37.18		12	18.85	-1.81
13		-3.02							13	37.96		13	19.05	-1.66
14		-2.97							14	37.38		14	19.22	-1.52
15		-2.92							15	37.29		15	19.35	-1.41
16		-2.88							16	36.47		16	19.46	
17		-2.83							17	34.39		17	19.55	
18		-2.78							18	31.75		18	19.62	
19		-2.74							19	29.21		19	19.68	
20		-2.69							20	25.93		20	19.72	

Table Guide: n refers to the number of predicted data.

The maximum temperature data in the daily time interval had an increasing trend, which was eliminated for modeling by time series method. The models were evaluated normal in Table 3 and the R^2 values in Table 5 were very good and high.

Table 3. Check the normality, accuracy of the model from two methods (Durbin Watson and Pert Manto) and error percentage of all stations

Station & Period		Normality					
		t_{max}			t_{min}		
		k	j	S	k	j	S
Daran	7day		0.08				1.1
							0.1
	15 day	0.05			0.1		
	30 day	0.11			>0.15		
	seasonal	>0.15			>0.15		
	daily			1.42			1.4
				0			-0.1
Isfahan	7day		0.21		0.1		
	15 day	0.06			>0.15		
	30 day	>0.15			>0.15		
	seasonal	>0.15			0.1		
	daily			2.32			1.3
				-0.6			0.2
Kabutar abad	7day		0.05			0.8	
	15 day		0.1		0.1		
	30 day	0.05				0.3	
	seasonal	0.06			0.1		
	daily			1.5			1.4
				-0.3			0.2
Mobarakeh	7day		0.23		0.1		
	15 day	0.07			0.1		
	30 day	>0.15				0.1	
	seasonal	>0.15			0.1		
	daily			1.3			1.5
				-0.4			0.3
Najaf abad	7 day		0.07			0.1	
	15 day	0.06			>0.15		
	30 day	>0.15			0.1		
	seasonal	>0.15			0.1		
	daily			2.61			1.3
				-0.7			0.2
Shahreza	7day	0.14				0.1	
	15 day	0.05			>0.15		
	30 day	0.13				0.1	
	seasonal	>0.15			0.1		
	daily			4			0.9
				-0.5			0.1

Station & Period		Model Accuracy				Eror%		Number	
		t_{max}		t_{min}					
		d	l	d	l	t_{max}	t_{min}	t_{max}	t_{min}
Daran	7 day	×		×		-4	-3.2	20	15
	15 day	×	×	×		-1.3	-2.2	20	10
	30 day	×	×	×	×	-2.5	0.78	9	4
	seasonal		×			-0.4	7.48	7	3
	daily	×	×		×	-0.24	0.27	6	20
Isfahan	7 day		×		×	-4	-1.8	20	15
	15 day	×				-0.4	2.08	20	13
	30 day	×	×	×		-2.4	-8.8	11	3
	seasonal		×	×	×	-1.6	-5.5	7	7
	daily					-8.2	5.5	12	20
Kabutar abad	7 day		×		×	-6.2	-4.8	20	15
	15 day	×		×	×	0.32	2.48	28	8
	30 day	×		×	×	-2.8	6.65	11	2
	seasonal	×	×	×	×	1.41	-3.8	7	4
	daily			×		4.7	-0.79	10	20
Mobarakeh	7 day		×			-5.4	-4.3	20	13
	15 day	×		×		0.19	0.32	20	10
	30 day		×	×	×	-8	-18.7	9	2
	seasonal	×	×	×	×	-9.5	13.9	7	4
	daily			×		5.8	-1.2	9	20
Najaf abad	7 day					5.4	-2.01	20	15
	15 day	×		×		1.3	-1.3	20	10
	30 day	×	×	×		-4.6	0.08	10	3
	seasonal		×		×	-0.6	-9.97	10	2
	daily	×		×		-1.4	-2.2	13	20
Shahreza	7 day				×	4.2	-0.4	20	13
	15 day	×			×	-0.99	4.75	20	8
	30 day		×		×	1.74	5.9	13	3
	seasonal		×	×	×	-5.9	-0.87	7	3
	daily	×		×		-1.4	-4.7	7	20
Shargh Isfahan	7 day		×		×	-4.3	-3.9	20	15
	15 day	×		×		-4.8	-7.8	20	8
	30 day	×	×	×		-4.3	-13.1	8	4
	seasonal		×		×	-13	-16.6	7	5
	daily					-3.4	1.6	12	20

Station & Period		Normality						Station & Period	Model Accuracy				Eror%		Number	
		t_{max}			t_{min}				t_{max}		t_{min}					
		k	j	S	k	j	S		d	l	d	l	t_{max}	t_{min}	t_{max}	t_{min}
Shargh Isfahan	7day		0.14			0.1										
	15 day	0.07			0.1											
	30 day	>0.15			0.1											
	seasonal	>0.15			>0.15											
	daily			2.5			1.2									
				-0.5			0.2									

Table guide: k -means the Kolmogorov-Smirnov method. J-means Jark bera method. S- means a statistical method in which the first parameter means kurtosis and the second parameter means skewness. d- Durbin Watson method. L: the method of Pert Manto.

Modeling was performed based on the criteria and review of partial autocorrelation diagrams and the results were inserted in Table 4

Table 4. Models obtained from other stations

Station	Period	Fitted Model of t_{min}	Fitted Model of t_{max}
Daran	7 day	SARIMA(4,1,1)(0,1,1)	ARIMA(3,1,2)
	15 day	SARIMA(4,0,2)(1,0,1)	SARIMA (2,0,3)(1,2,1)
	30 day	SARIMA(2,0,3)(1,0,1)	SARIMA (2,0,3)(2,0,1)
	seasonal	ARIMA(2,1,2)	ARIMA(4,1,2)
	daily	ARIMA(2,0,2)	ARIMA(1,1,3)
Isfahan	7 day	ARIMA(2,1,2)	ARIMA(3,1,2)
	15 day	SARIMA(2,0,3)(1,0,1)	SARIMA(5,0,2)(1,0,1)
	30 day	SARIMA(1,0,1)(1,0,0)	SARIMA(2,1,1)(1,0,1)
	seasonal	ARIMA(4,0,3)	ARIMA(4,1,3)
	daily	ARIMA(2,0,2)	ARIMA(4,1,5)
Kabutar abad	7 day	ARIMA(4,1,2)	ARIMA(3,1,3)
	15 day	SARIMA(2,0,5)(1,0,1)	SARIMA(3,1,4)(1,0,1)
	30 day	SARIMA(2,0,3)(1,0,1)	SARIMA(2,0,2)(1,0,0)
	seasonal	ARIMA(4,0,3)	ARIMA(4,1,1)
	daily	ARMA(2,0,1)	ARIMA(4,1,2)
Mobarakeh	7 day	ARMA(3,5)	ARIMA(3,1,2)
	15 day	SARIMA(4,0,2)(1,0,0)	SARIMA(2,0,4)(1,0,1)
	30 day	SARIMA(4,0,3)(1,0,1)	SARIMA(2,1,3)(1,0,2)
	seasonal	AR (4)	ARIMA(4,0,3)
	daily	ARMA(2,1)	ARIMA(3,0,2)

Station	Period	Fitted Model of t_{min}	Fitted Model of t_{max}
Najaf abad	7 day	ARMA(3,4)	SARIMA(4,1,1)(1,0,0)
	15 day	SARIMA(3,0,2)(1,0,1)	SARIMA(2,0,4)(1,0,1)
	30 day	SARIMA(1,0,1)(1,0,0)	SARIMA(2,0,3)(1,0,0)
	seasonal	ARIMA(4,1,2)	ARIMA(4,1,3)
	daily	ARIMA(2,0,1)	ARMA(4 ,1)
Shahreza	7 day	ARIMA(4,1,2)	SARIMA(2,1,2)(1,1,0)
	15 day	SARIMA(1,0,1)(1,0,1)	SARIMA(3,0,3)(1,0,0)
	30 day	SARIMA(3,0,3)(1,0,0)	SARIMA(3,1,2)(1,1,0)
	seasonal	ARIMA(4,1,1)	ARIMA(5,1,2)
	daily	ARIMA(3,0,1)	ARIMA(3,0,1)
Shargh Isfahan	7 day	ARIMA(4,1,2)	ARIMA(3,2,5)
	15 day	SARIMA(2,0,4)(0,0,1)	SARIMA(2,0,1)(1,0,1)
	30 day	SARIMA(4,0,4)(1,0,0)	SARIMA(0,0,1)(1,0,2)
	seasonal	ARIMA(4,1,0)	ARIMA(4,1,3)
	daily	ARIMA(2,0,2)	ARMA(4,4)

The observational and predicted data had a good determination coefficient that is given in Table 5 and also the model was examined in terms of criteria and the results are presented in Table 5.

Table 5. Criteria obtained by other stations

Station	Criteria	7day		15day		30day		Seasonal		Daily	
		t_{max}	t_{min}	t_{max}	t_{min}	t_{max}	t_{min}	t_{max}	t_{min}	t_{max}	t_{min}
Daran	R^2	0.96	0.95	0.942	0.87	0.763	0.77	0.932	0.76	0.96	0.87
	AIC	3.94	4.26	4.39	5.31	5.69	5.9	4.15	4	3.77	5
	SBIC	3.96	4.29	4.4	5.32	5.7	5.93	4.28	4.2	3.78	5
	HQIC	3.95	4.27	4.4	5.32	5.7	5.93	4.2	4.1	3.78	5
	MSE	0.069	0.07	0.113	0.1	0.112	0.13	0.23	0.3	0.024	0.02
	RMSE	2.58	3.05	2.67	3.41	4.08	4.55	2.53	2.63	2.4	2.95
Isfahan	R^2	0.86	0.9	0.88	0.99	0.94	0.78	0.93	0.87	0.91	0.88
	AIC	5.27	4.9	5.04	1.71	4.3	5.79	4.27	5.13	5.1	5
	SBIC	5.29	5	5.088	1.75	4.4	5.84	4.3	5.23	5.1	5
	HQIC	5.28	4.9	5.06	1.72	4.3	5.81	4.3	5.17	5.1	5
	MSE	0.069	0.06	0.087	0.09	0.102	0.15	0.238	0.21	0.2	0.02
	RMSE	5.05	4.37	2.98	0.56	3.07	4.29	2.7	2.94	3.12	2.99
Kabutar abad	R^2	0.83	0.84	0.97	0.88	0.74	0.78	0.96	0.85	0.94	0.89
	AIC	5.47	5.29	3.6	5.03	5.8	5.6	3.5	5.01	4.5	4.82
	SBIC	5.49	5.31	3.7	5.07	5.8	5.67	3.7	5.02	4.5	4.82
	HQIC	5.48	5.3	3.7	5.04	5.8	5.63	3.6	5.12	4.5	4.82
	MSE	0.07	0.06	0.09	0.08	0.11	0.11	0.24	0.24	0.02	0.02
	RMSE	5.58	4.28	2.27	2.96	4.34	3.91	1.85	2.82	3.52	2.69

Station	Criteria	7day		15day		30day		Seasonal		Daily	
		t_{max}	t_{min}	t_{max}	t_{min}	t_{max}	t_{min}	t_{max}	t_{min}	t_{max}	t_{min}
Mobarakeh	R^2	0.86	0.82	0.88	0.88	0.83	0.78	0.85	0.82	0.89	0.89
	AIC	5.2	5.37	4.9	4.96	5.3	5.6	4.9	5.24	5.1	4.7
	SBIC	5.2	5.38	4.9	4.99	5.3	5.7	5	5.32	5.1	4.7
	HQIC	5.2	5.37	4.9	4.97	5.3	5.6	4.9	5.27	5.1	4.7
	MSE	0.06	0.05	0.08	0.1	0.1	0.11	0.21	0.28	0.02	0.02
	RMSE	4.89	3.53	2.83	2.86	5.01	3.94	2.62	3.19	3.12	2.64
Najaf abad	R^2	0.92	0.81	0.88	0.88	0.79	0.79	0.93	0.93	0.92	0.92
	AIC	4.05	5.52	5.02	5.1	5.5	5.7	4.2	4.43	4.8	4.63
	SBIC	4.07	5.54	5.06	5.15	5.6	5.76	4.3	4.55	4.8	4.63
	HQIC	4.06	5.53	5.04	5.12	5.5	5.73	4.3	4.48	4.8	4.63
	MSE	0.07	0.05	0.08	0.09	0.1	0.15	0.22	0.27	0.02	0.02
	RMSE	2.7	3.82	2.94	3.08	3.78	4.12	2.68	3.02	2.73	2.45
Shahreza	R^2	0.96	0.83	0.87	0.87	0.94	0.72	0.76	0.96	0.91	0.79
	AIC	3.9	5.39	5	5	4.27	5.92	5.3	3.94	4.9	5.4
	SBIC	3.9	5.41	5	5.1	4.36	5.98	5.4	4.07	4.9	5.4
	HQIC	3.9	5.4	5	5.1	4.31	5.94	5.39	3.99	4.9	5.4
	MSE	0.08	0.07	0.08	0.09	0.11	0.12	0.21	0.3	0.02	0.03
	RMSE	2.62	4.5	2.98	3.12	2.99	4.61	4.72	2.3	2.88	3.76
Shargh Isfahan	R^2	0.82	0.88	0.81	0.86	0.8	0.77	0.93	0.94	0.9	0.87
	AIC	5.6	5.09	6	5.26	5.5	5.73	4.3	4.34	5.2	5.1
	SBIC	5.6	5.11	6.1	5.29	5.6	5.79	4.4	4.44	5.2	5.1
	HQIC	5.6	5.1	6.1	5.27	5.6	5.75	4.3	4.38	5.2	5.1
	MSE	0.07	0.07	0.09	0.08	0.11	0.12	0.23	0.28	0.001	0.02
	RMSE	4.51	4.62	4.77	3.33	3.88	4.16	2.76	2.94	3.31	3.1

The number of predicted data and the average error of the predicted data are given in Table 6.

Table 6. Number of predicted values and error of stations in the maximum and minimum temperature parameter

Parameter	Station Name	Period	Error	Num.	Parameter	Error	Num
t_{max}	Daran	7 day	-4	20	t_{min}	-3.2	15
t_{max}	Daran	15 day	-1.3	20	t_{min}	-2.2	10
t_{max}	Daran	30 day	-2.5	9	t_{min}	0.78	4
t_{max}	Daran	seasonal	-0.4	7	t_{min}	7.48	3
t_{max}	Daran	daily	-0.24	6	t_{min}	0.27	20
t_{max}	Isfahan	7 day	-4	20	t_{min}	-1.8	15
t_{max}	Isfahan	15 day	-0.4	20	t_{min}	2.08	13
t_{max}	Isfahan	30 day	-2.4	11	t_{min}	-8.8	3

Parameter	Station Name	Period	Error	Num.	Parameter	Error	Num
t_{max}	Isfahan	seasonal	-1.6	7	t_{min}	-5.5	7
t_{max}	Isfahan	daily	-8.2	12	t_{min}	5.5	20
t_{max}	Kabutar abad	7 day	-6.2	20	t_{min}	-4.8	15
t_{max}	Kabutar abad	15 day	0.32	28	t_{min}	2.48	8
t_{max}	Kabutar abad	30 day	-2.8	11	t_{min}	6.65	2
t_{max}	Kabutar abad	seasonal	1.41	7	t_{min}	-3.8	4
t_{max}	Kabutar abad	daily	4.7	10	t_{min}	-0.79	20
t_{max}	Mobarakeh	7 day	-5.4	20	t_{min}	-4.3	13
t_{max}	Mobarakeh	15 day	0.195	20	t_{min}	0.32	10
t_{max}	Mobarakeh	30 day	-8	9	t_{min}	-18.7	2
t_{max}	Mobarakeh	seasonal	-9.5	7	t_{min}	1.13	2
t_{max}	Mobarakeh	daily	5.8	9	t_{min}	-1.2	20
t_{max}	Najaf abad	7 day	5.4	20	t_{min}	-2.01	15
t_{max}	Najaf abad	15 day	1.1	20	t_{min}	-0.73	10
t_{max}	Najaf abad	30 day	-4.6	10	t_{min}	0.08	3
t_{max}	Najaf abad	seasonal	-0.6	10	t_{min}	-9.97	2
t_{max}	Najaf abad	daily	-1.4	13	t_{min}	-2.2	20
t_{max}	Shahreza	7 day	4.2	20	t_{min}	-0.4	13
t_{max}	Shahreza	15 day	-0.99	20	t_{min}	4.75	8
t_{max}	Shahreza	30 day	1.74	13	t_{min}	5.9	3
t_{max}	Shahreza	seasonal	-5.9	7	t_{min}	-0.87	3
t_{max}	Shahreza	daily	-1.4	7	t_{min}	-4.7	20
t_{max}	Shargh Isfahan	7 day	-4.3	20	t_{min}	-3.9	15
t_{max}	Shargh Isfahan	15 day	-4.8	20	t_{min}	-7.8	8
t_{max}	Shargh Isfahan	30 day	-4.3	8	t_{min}	-13.1	4
t_{max}	Shargh Isfahan	seasonal	-13	7	t_{min}	-16.6	5
t_{max}	Shargh Isfahan	daily	-3.4	12	t_{min}	1.6	20

5. Discussions

The trend determination was checked by Mann-Kendall non-parametric test and had an increasing linear trend in the daily interval. The method that used in this project was box Jenkins and the steps were: to get the initial and the best model model, the acf and pacf diagrams should be examined. to check the correctness of the model that used, the autocorrelation and partial autocorrelation of residuals are examined. In such a way, so that no correlation should be observed until the intervals 3 to 4, if observed, the obtained model seems that needs to change. and criteria Akaike, Schwartz and Hanan Quinn criteria were used, then the normality of the data was checked and for evaluation, using durbin Watson and Pert manto tests. The lowest error in the meteorological parameters of the maximum and minimum temperature is related to the period of 15 days because the error in this interval is less and the the R^2 values are more and the number of the predicted values is also higher.

Maximum temperature (meteorological parameter) interval was evaluated in 7 days, 15 days, 30 days, seasonal and daily time intervals, and as the number of data decreases, the amount of estimate error increases. Box Cox conversion was not used because the number the obtained ones was outside the desired range. For validation, The R^2, MSE and percentage error are used. The R^2 values were above 0.7, percentage error was below than 20%. In terms of normality, all of the stations were similar (in terms of the tests used in different time periods). All data were analyzed at 7 days, 15 days, 30 days, and seasonal periods by Kolmogorov-Smirnov and Jarque bera tests. The models obtained in the intervals were as follows: for the 15 and 30days intervals of Sarima and for the 7days, seasonal and daily intervals of Arima. Mobarakeh station had the least error in the 15 days period and the most in the 30 days period, which is why this station was selected to show the modeling steps and diagrams.

Maximum temperature (meteorological parameter) intervals of 7 days, 15 days, 30 days, seasonal, and daily, and as the number of data decreases, the amount of error increases, the data interval had an increasing trend in daily period. In the R^2 criteria, all of the stations were above 0.7, and in terms of correctness, the model of Kabutarabad station had a better answer than all of the other stations. For this reason, this station was selected. In terms of the test that used for the normality of all of the stations, the results were similar, so that the daily time interval was skewness and kurtosis and the intervals of 7, 15 and 30 days and seasonal were examined for Kolmogorov Smirnov and Jarque bera tests. The percentage error was below than 20%. The models obtained for the intervals were as follows: for the 15 and 30days intervals of Sarima and for the 7 days, seasonal and daily intervals of Arima.

6. Conclusion

At the maximum temperature of the obtained models for all of the stations in a period of 7 days, Arima was obtained and for 15 days and for 30 days intervals, Sarima was obtained and for seasonal and daily intervals as Arima.

Trend evaluation showed that only in daily interval, the data have an increasing trend and the value obtained in Mann Kendall test at maximum temperature parameter is generally between 5 to 6 and at the minimum temperature parameter is generally between 6 to 8. At the minimum temperature, the obtained models were obtained as Arima for a period of 7 days and for the period of 15 and 30 days as Sarima and in the seasonal and daily intervals as Arima. They had an increasing trend on a daily interval. With the performed studies, it seems that the models obtained at maximum and minimum temperatures in different time intervals were obtained in terms of the same model type. Also, in evaluating and validating the data, R^2 was higher than 0.7 and the error percentage was less than 25%

The Mann Kendall method was used to study the trend in Khatar, Asfaw and Nury studies. In Khatar and Nury studies, the RMSE method was used for validation. Khatar *et al*. used the Sarima method to predict the soil temperature at monthly intervals. Khatar and et al also used Sarima model in their monthly model. In this study, the Sarima model was obtained for a monthly period, and thus the Sarima model was obtained in a period of 15 days.

7. Conflict Interest

The authors declare no competing financial interests associated with this manuscript.

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