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MODELING OF WEATHER DATA FOR THE EAST ANATOLIA REGION OF TURKEY

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- Abstract: Monthly average daily data of climatic conditions over the period 1994–2003 of cities in the east Anatolia region of Turkey is presented. Regression methods are used to fit polynomial and trigonometric functions to the monthly averages for nine parameters. The parameters namely temperature, maximum–minimum temperature, relative humidity, pressure, wind speed, rainfall, solar radiation and sunshine duration are useful for renewable energy applications. The functions presented for the parameters should enable determination of specific parameter values and prediction of missing values. They also provide some insight into the variation of these parameters. The models developed can be used in any study related to climatic and its effect on the environment and energy.
- **Keywords:** Energy; environment; temperature, maximum–minimum temperature, relative humidity, wind speed, pressure, rainfall, solar radiation, sunshine duration; weather parameters

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INTRODUCTION

Energy is one of the precious resources in the world. Energy conservation becomes a hot topic around people, not just for deferring the depletion date of fossil fuel but also concerning the environmental impact due to energy consumption (Apple et al., 2006). Performance of environment-related systems, such as heating, cooling, ventilating and airconditioning of buildings (HVAC systems), solar collectors, solar cells, greenhouses, power plants and cooling towers, are dependent on weather variables like solar radiation, dry-bulb temperature, wet-bulb temperature, humidity, wind speed, etc. In order to calculate the performance of an existing system or to predict the energy consumption of a system in design step, the researcher/designer needs appropriate weather data (Üner & İleri, 2000).

Accurate weather data are needed for design optimization and performance prediction of solar technologies and environmental control systems. However, these types of data are not often readily available in easily usable form. Analyzed weather data developed into an atlas provides useful information on renewable energy sources. The modeling of weather data results in mathematical and statistical models, which enable the determination of data and prediction of weather conditions (Dorvlo & Ampratwum, 1999).

A number of studies are found in the literature dealing with the climatic characteristics, solar and wind energy related issues for different region of the World. Global solar irradiation (GSI) had been estimated in a number of studies by the known climatic parameters of bright sunshine duration (Sen, 2007; Abdul-Aziz *et al.*, 1993), cloud fraction (Norris, 1968; Kasten and Czeplak, 1980), air temperature range (Bristow & Campbell, 1984), precipitation status (McCaskill, 1990), both temperature and rainfall (Hansen, 1999) and both sunshine duration and cloud (Tasdemiroglu and Sever, 1991; Ododo, 1996), trends to years of the weather parameters such as temperature, relative humidity, wind speed, dust and fog (Al-Garni *et al.*, 1999).

Climatic differences between urban and suburban have been studied by many other authors (Unger, 1997; Unkasevic, 2001; Roba, 2003; Bernatzky, 1982; Wilmers, 1988; Nowak *et al.*, 1998; Yılmaz *et al.*, 2007). Cañada *et al.* (1997) developed correlation models for global diffuse and tilted irradiation, ambient temperature, sunshine hours and specific humidity for Valencia in Italy. The coefficients of determination of their models were 0.75 or more. Coppolino (1994) developed a polynomial relationship between the clearness index and relative sunshine hours. Raja & Twidell (1994) have carried out statistical analysis of measured global insolation data for up to 15 years from six locations in Pakistan. They obtained cumulative frequency information for application when planning solar installations. Dorvlo & Ampratwum (1999) developed regression models for the weather data of Oman for the period 1987– 1992. However, there is limited information and research dealing with the climatic characteristics, solar and wind energy related issues for different region of the Turkey in the literature (Tatli *et al.*, 2005; Sahin *et al.*, 2006; Sahin 2007; Türkes & Erlat, 2008; Tatli, 2007).

This paper models weather data for the determination of specific climatic parameter values that could be used for developing solar and wind technologies and environmental control systems, and for the calculation of missing data required for the development of a solar and wind atlas for the east Anatolia region of Turkey.

MATERIAL AND METHODS

Features of study area

There are thirteen cities at the east Anatolia region of Turkey. **Table 1** gives the names and locations of the major meteorological stations in the east Anatolia region of Turkey. The east Anatolia region of Turkey has a typical highland climate, in that it is generally cold in winter and hot in summer and there are considerable temperature differences between day and night. Location of cities at the east Anatolia region of Turkey can be shown from Fig. 1. The parameters observed daily at the stations are temperature, maximum-minimum temperature, relative humidity, wind speed, pressure, rainfall, solar radiation and sunshine duration. The measurements have been carried out by conventional meteorological instruments by the Turkish Meteorological State Department (TMSD). The Department produces monthly summaries of this data. The data for the present study is obtained from the summaries of 1994 to 2003.



Fig. 1 Location of cities in the east Anatolia region of Turkey.

Table 1. Geographic location of weather stations in the east Anatolia region of Turkey

Location	Longitude east	Latitude north
Agri	43° 03'	39° 44'
Bingöl	40° 29'	38° 53'
Bitlis	42° 06'	38° 22'
Elazig	39° 14'	38° 41'
Erzincan	39° 29'	39° 44'
Erzurum	41° 17'	39° 55'
Hakkari	43° 45'	37° 34'
Igdir	44° 02'	39° 55'
Kars	43° 05'	40° 36'
Malatya	38° 19'	38° 21'
Muş	41° 30'	38° 44'
Tunceli	39° 33'	39° 07'
Van	43° 20'	38° 28'

Modeling of climatic parameters

Statistical techniques of regression models are frequently used to study a set of experimental data. Adequacy and validity of the model is performed to determine if the model will function in a successful manner in its intended operating field.

Linear regression analysis is a statistical tool by which a line is fitted through a set of experimental data using the least-squares method. Regression is used in a wide variety of applications in order to analyze how a single dependent variable is affected by the values of one or more independent variables. In this study, temperature, maximum temperature, minimum temperature, relative humidity, wind speed, pressure, rainfall, solar radiation and sunshine duration collected for a period of 10 years (1994–2003) is modeled using linear regression analysis with 95% confidence level.

The correlation coefficient (*R*) was primary criterion for selecting the best equation to describe the curve equation. In addition to *R*, the reduced χ^2 as the mean square of the deviations between the observed and calculated values for the models and root mean square error analysis (RMSE) were used to determine the goodness of the fit. The higher the values of the *R*, and lowest values of the χ^2 and *RMSE*, the better the goodness of the fit (Akpinar and Akpinar, 2004; Akpinar *et al.*, 2006). These can be calculated as:

$$R^{2} = \frac{\sum_{i=1}^{n} (Y_{exp,i} - Y_{expmean})^{2} - \sum_{i=1}^{n} (Y_{pre,i} - Y_{exp,i})^{2}}{\sum_{i=1}^{n} (Y_{exp,i} - Y_{expmean})^{2}}$$
(1)

$$\chi^{2} = \frac{\sum_{i=1}^{n} (Y_{\exp,i} - Y_{pre,i})^{2}}{N - n}$$
(2)

$$RMSE = \left[\frac{1}{N} \sum_{i=1}^{N} \left(Y_{pre,i} - Y_{\exp,i}\right)^2\right]^{1/2}$$
(3)

where, $Y_{exp,i}$ is the *ith* experimentally observed value, $Y_{expmean}$, is the mean of experimentally observed value, $Y_{pre,i}$ the *ith* predicted value, N the number of observations and n is the number constants.

Validation of the established model was made by comparing the computed climatic data with the observed climatic data in any particular run under certain conditions. The performance of the models for the climatic data was illustrated. The experimental data are generally banded around the straight line representing data found by computation, which indicates the suitability of the model in describing the computed climatic data.

RESULTS

The monthly daily summaries over the ten years 1994–2003 for the nine meteorological parameters were used in developing the models presented (**Table 2**). The summaries are calculated over all the meteorological stations where possible. Scatter diagrams of the monthly average daily measurements for each year are presented in **Figs 2, 4, 6, 8, 10, 12, 14, 16,** and **18**. Polynomial and trigonometric models were fitted to the data with the months (**m**: 1–12) as the predictor variable. The performance of these models was investigated by comparing the determination of coefficient (*R*), reduced chi-square (χ^2) and root mean square error (RMSE) between the observed and predicted values. Over fitting was avoided by listing only the functions with statistically non-zero coefficients.

The monthly average temperatures

From **Fig. 2**, it can be seen that there is an evident difference at monthly average temperatures between the investigated cities. The overall average temperature for 10 years was found to be about 13.19°C for Elazig, 11.50°C for Erzincan, 5.18°C for Erzurum, 5.58°C for Kars, 6.83°C for Agri, 12.74°C for Igdir, 13.28°C for Tunceli, 10.11°C for Van, 14.14°C for Malatya, 12.56°C for Bingöl, 10.69°C for Muş, 9.87°C for Bitlis, 10.70°C for Hakkari. While the Erzurum city is the coldest area

for the whole period, Malatya city is the hottest area for the whole period. The monthly average temperatures showed changing between -9.4 and 19.4°C for Erzurum city, 1.6 and 27.9°C for Malatya city.

The simple function of the monthly average temperature (AT_1) fit the ambient temperature data very well. The results of statistical analyses undertaken on trigonometric model for the monthly average temperature are given in Table 3. The model was evaluated based on R, χ^2 and RMSE. Generally, R, χ^2 and RMSE values were varied between 0.99660-0.99920, 0.226-0.979 and 0.395-0.823, respectively. The function has coefficients of determination of better than 0.99 and the lowest values of χ^2 and RMSE for all cities. Hence, the trigonometric model (AT_1) satisfactorily described characteristics of the monthly average temperature. Considering trigonometric model (AT_1) , the observed monthly average temperature values were compared with calculated ones. Figure 3 shows the predicted and observed values of monthly average temperature. As seen from Fig. 3, there is a good agreement between predicted and observed values.

Table 2. Models for the weather data

Monthly average	$\Delta T1 = a \pm b \sin(m) \pm c \sin((m/2) \pm d)$
temperature	$A \Pi = u + 0^{2} \operatorname{Sin}(m) + c^{2} \operatorname{Sin}((m/2) + u)$
Monthly average	$\Delta T 2 = a \pm b \sin(m) \pm a \sin((m/2) \pm d)$
maximum temperature	$A T Z = u + v \operatorname{Sin}(m) + v \operatorname{Sin}((m/2) + u)$
Monthly average	$\Delta T_{2}^{2} = a \pm b \sin(m) \pm a \sin((m/2) \pm d)$
minimum temperature	$A I S = u + v \cdot \sin(m) + v \cdot \sin((m/2) + u)$
Monthly average	$\mathbf{D}\mathbf{U} = a + b \sin(m) + a \sin((m/2) + d)$
relative humidity	$KH = u + b \cdot SH(m) + c \cdot SH((m/2) + u)$
Monthly average	$WS = a + b \cdot m + c \cdot (m^2) +$
wind speed	$d \cdot (m^3) + e \cdot (m^4)$
Monthly average	$\mathbf{P} = a + b \cdot m + c \cdot (m^2)
pressure	$d \cdot (m^3) + e \cdot (m^4)$
Monthly average	$RF = a + b \cdot m + c \cdot (m^2) +$
rainfall	$d \cdot (m^3) + e \cdot (m^4)$
Monthly average	$SD = a + b \sin(w) + a \sin(w/2) + d$
solar radiation	$SR = a + o \cdot Sin(m) + c \cdot Sin((m/2) + a)$
Monthly average	$SD = a + b \cdot \sin(m) + c \cdot \sin(2 \cdot m) +$
sunshine duration	$d \cdot \sin(m/2 + e) + f \cdot m$



Fig. 2 Monthly average temperatures during the years 1994–2003 for the cities.



Fig. 3 Observed and predicted values of the monthly average temperatures.

The monthly average maximum temperatures

The overall average maximum temperature for 10 years was found to be about 19.35°C for Elazig, 18.05°C for Erzincan, 12.64°C for Erzurum, 12.72°C for Kars, 13.7°C for Agri, 19.59°C for Igdir, 19.7°C for Tunceli, 15.05°C for Van, 19.62°C for Malatya, 18.95°C for Bingöl, 16.52°C for Muş, 16.22°C for Bitlis, 15.18°C for Hakkari. While maximum temperatures are at highest values in August and July, at lowest values in January. While Erzurum is coldest city for the whole period, Tunceli is warmest city. Monthly average maximum temperatures changed between -3.2 and 28.1°C for Erzurum city, 4.8 and 35.3°C for Tunceli city at **Fig. 4**.

The simple function of the monthly average maximum temperature (AT_2) fit the maximum temperature data very well. The results of statistical analyses undertaken on trigonometric model for the monthly average maximum temperature are given in **Table 4.** Generally, *R*, χ^2 and *RMSE* values were varied between 0.99380-0.99911, 0.194-1.832 and 0.366-1.126, respectively. The function has coefficients of determination of better than 0.99 and the lowest values of χ^2 and RMSE for all cities. Hence, the trigonometric model (AT₂) satisfactorily described characteristics of monthly average maximum the temperature. Considering trigonometric model (AT₂), the observed monthly average maximum temperature values were



Fig. 4 Monthly average maximum temperatures during the years 1994–2003 for the cities.

Model		Monthly ave	erage temper	ature	
		$= a + b \cdot \sin(m)$	$) + c \cdot \sin((m/2$	(2) + a)	
City	Constant	Model	R	χ^2	RMSE
-		constants		70	
	a	12.611			
Elazığ	b	1.1621	0 99 880	0.284	0 4 4 3
	С	-13.494	0.77 000	0.20.	0.110
	d	7.387			
	а	11.055			
Erzincan	b	0.7980	0.00.812	0.415	0.526
	С	-13.090	0.99 812	0.415	0.550
	d	1.1222			
	а	4.5316			
Erzurum	b	0.1522	0.00 (70	0.007	0.700
	с	-14.733	0.99 6/9	0.897	0.788
	d	1 0937			
	a	4 9791			
Kars	h	-0.1157			
ituis	C	-13.62	0.99 660	0.812	0.750
	d	1 0898			
	u	6 1518			
Acri	u b	0.0052			
Agri	D	-0.0035	0.99 686	0.979	0.823
	C	-13.333			
	а	1.0638			
T 1:	a	12.10//			
Igdir	b	0.7469	0.99 667	0.843	0.764
	С	-14.032			
	d	1.1860			
	а	12.6769			
Tunceli	b	1.08504	0 99 864	0.340	0.485
	С	-13.893	0.99 864	0.540	000
	d	1.1011			
	а	9.5648			
17	b	0.9691	0.00.050	0.205	0.450
van	С	-12.663	0.99 858	0.295	0.452
	d	1.0589			
	a	13.577			
Malatya	b	1.0822			
	C C	-13 473	0.99 890	0.257	0.422
	d	1 1070			
	a	11 947			
Bingöl	h	0.8917			
Diligoi	0	_14 714	0.99 881	0.311	0.464
	c d	-14.214			
	а	1.088			
м	a	9.998/			
Muş	b	0.36/6	0.99 747	0.823	0.755
	С	-15.886		-	
	d	1.0665			
	а	9.3095			
Bitlis	b	0.9693	0 99 863	0 297	0 4 5 4
	С	-12.917	0.99 003	0.491	0.454
	d	1.0696			
	а	10.0726			
Hakkari	b	0.9066	0.00.000	0.226	0.205
	с	-14.744	0.99 920	0.226	0.395
	d	1.0315			

Table 3. The results of statistical analyses according to the model (AT_1) for the monthly average temperature





Table 4. The results of statistical analyses according to the model (AT_2) for the monthly average maximum temperature

$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Model	M	onthly average $= a + b \cdot \sin(n)$	$e \max imum te$ $m) + c \sin((m/s))$	2 + d	e
Cury Constants X χ KM3E a 18.688 b 1.2062 0.99 873 0.390 0.519 a 17.409 0.99 752 0.692 0.692 0.692 erzincan b 0.9192 0.99 752 0.692 0.692 c -14.693 0.99 618 1.272 0.938 d 7.372 a 1.946 Erzurum b 0.4447 0.99 618 1.272 0.938 d 1.0534 a 12.082 0.99 576 1.212 0.916 Kars b 0.3482 0.99 576 1.212 0.916 d 1.0296 a 18.916 a 18.916 gdir b 0.6014 0.99 698 1.832 1.126 Tunceli b 1.1777 0.99 805 0.625 0.658 d 1.0207 0.99 911 0.194 0.366 d 1.0774 0.99 805	City	Constant	Model	D		DMCE
a 18.688 0.2062 $0.99\ 873$ 0.390 0.519 c -15.392 $0.99\ 873$ 0.390 0.519 d 1.0942 a 17.409 $0.99\ 752$ 0.692 0.692 Erzincan b 0.9192 $0.99\ 752$ 0.692 0.692 0.692 Erzurum b 0.4447 $0.99\ 618$ 1.272 0.938 Kars b 0.3482 $0.99\ 576$ 1.212 0.916 Agri c -16.044 $0.99\ 576$ 1.212 0.916 Agri b 0.4140 $0.99\ 576$ 1.212 0.916 Agri b 0.4140 $0.99\ 698$ 1.189 0.907 Agri b 0.6014 $0.99\ 380$ 1.832 1.126 Igair b 0.6014 $0.99\ 910$ 0.997 Junceli b 1.1777 $0.99\ 805$ 0.625 0.658 d 1.0776 $0.99\ 911$ 0.194 0.366 d 1.0786 </td <td>City</td> <td>Constant</td> <td>constants</td> <td>ĸ</td> <td>χ²</td> <td>RMSE</td>	City	Constant	constants	ĸ	χ²	RMSE
Elazğ b 1.2062 0.99 873 0.390 0.519 d 10942 1.0942 1.0942 0.99 752 0.692 0.692 Erzincan b 0.9192 0.99 752 0.692 0.692 c -14.693 0.99 618 1.272 0.938 d 10.0534 0.99 576 1.212 0.916 Kars b 0.3482 0.99 576 1.212 0.916 Kars c -14.860 0.99 698 1.832 1.126 Agri b 0.4140 0.99 698 1.832 1.126 Igdir b 0.6014 0.99 380 1.832 1.126 Igdir b 0.6014 0.99 805 0.625 0.658 1.0206 a 18.916 0.99 814 0.534 0.608 Van b 1.0786 0.99 814 0.534 0.608 d 1.0194 a 18.739 0.99 884 0.396 0.523 Malatya b 1.0786 0.99 884 0.396 0.523		а	18.688			
c -15.392 0.99 873 0.390 0.319 e -15.392 0.99 873 0.300 0.319 e 17.409 0.99 752 0.692 0.692 e -14.693 0.99 752 0.692 0.692 e -14.693 0.99 618 1.272 0.938 d 0.7372 0.99 618 1.272 0.938 kars b 0.3482 0.99 576 1.212 0.916 d 1.0534 a 12.082 a 1.189 0.907 Agri b 0.4140 0.99 698 1.189 0.907 d 1.0296 a 18.32 1.126 a 19.021 0.99 380 1.832 1.126 Tunceli b 1.1777 0.99 805 0.625 0.658 d 1.0207 0.99 814 0.534 0.608 d 1.0786 0.99 814 0.534 0.608 d 1.0786 0.99 884 0.396 0.523 Mus 0.5124 0.99 753 <	Elazığ	b	1.2062	0.00.972	0.200	0.510
d1.0942 a a 17.409 0.9192 c0.99 7520.6920.692 b 0.1446 		с	-15.392	0.99 8/3	0.390	0.519
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c-14.693 d0.99 732 0.0920.092d7.372 a11.946d0.4447 c-16.044 a0.99 6181.2720.938Karsb0.3482 c-14.860 a0.99 5761.2120.916Agrib0.4140 c-17.455 a0.99 6981.1890.907Agrib0.4140 c-17.455 a0.99 6981.1890.907Igdirb0.6014 c-15.117 a0.99 3801.8321.126Igdirb0.6014 c-15.723 d0.99 8050.6250.658Juncelib1.1777 c-15.723 d0.99 8050.6250.658Vanb1.0207 c-12.956 d0.99 9110.1940.366Malatyab1.2421 c0.99 8840.3960.523Muşb0.5124 c0.99 7531.0480.852 dBitlisb1.299 c0.99 9060.2840.443Hakkarib1.0466 c0.99 8740.4190.538 d	Erzincan	b	0.9192	0.00.752	0.602	0.602
$ \begin{array}{c} d & 7.372 \\ a & 11.946 \\ b & 0.4447 \\ c & -16.044 \\ d & 1.0534 \\ a & 12.082 \\ c & -14.860 \\ c & -14.860 \\ d & 1.0479 \\ a & 12.951 \\ Agri & b & 0.4140 \\ c & -17.455 \\ d & 1.0296 \\ a & 18.916 \\ lgdir & b & 0.6014 \\ c & -15.117 \\ d & 1.0296 \\ a & 18.916 \\ lgdir & b & 0.6014 \\ c & -15.117 \\ d & 1.0296 \\ a & 18.916 \\ lgdir & b & 0.6014 \\ c & -15.172 \\ d & 1.0296 \\ a & 18.916 \\ lgdir & b & 0.6014 \\ c & -15.177 \\ c & -15.723 \\ d & 1.0296 \\ a & 18.916 \\ lgdir & b & 0.6014 \\ c & -15.177 \\ c & -15.723 \\ d & 1.0296 \\ a & 18.916 \\ lgdir & b & 0.6014 \\ c & -15.723 \\ d & 1.0296 \\ a & 18.916 \\ lgdir & b & 0.6014 \\ c & -15.723 \\ d & 1.0700 \\ a & 14.512 \\ Van & b & 1.0207 \\ c & -12.956 \\ d & 1.0194 \\ a & 18.970 \\ Malatya & b & 1.0786 \\ c & -14.898 \\ d & 1.114 \\ a & 18.249 \\ b & 1.2421 \\ c & -16.236 \\ d & 1.0714 \\ a & 15.739 \\ Muş & b & 0.5124 \\ c & -16.236 \\ d & 1.0714 \\ a & 15.739 \\ Muş & b & 0.5124 \\ c & -18.122 \\ d & 1.0546 \\ a & 15.580 \\ Bitlis & b & 1.299 \\ c & -15.252 \\ d & 7.312 \\ a & 14.509 \\ Hakkari & b & 1.0466 \\ c & -15.983 \\ d & 1.0133 \\ \end{array}$		с	-14.693	0.99 /32	0.092	0.092
a11.946 b0.4447 0.99 6181.2720.938Erzurumb0.4447 c0.99 6181.2720.938d1.0534 a12.0820.99 5761.2120.916Karsb0.3482 c0.99 5761.2120.916Agrib0.4140 c-17.455 d0.99 6981.1890.907Agrib0.04140 c0.99 6981.1890.907d1.0296 a1.89160.99 3801.8321.126Igdirb0.6014 c0.99 3801.8321.126Tuncelib1.1777 c0.99 8050.6250.658d1.0207 c0.99 9110.1940.366d1.0207 c0.99 9110.1940.366d1.0194 a1.2421 a0.99 8140.5340.608Malatyab1.0276 c0.99 8140.5340.608d1.2421 a0.99 7531.0480.852Bingölb1.229 c0.99 7531.0480.852Bitlisb1.299 c0.99 9060.2840.443d7.312 a14.5090.99 8740.4190.538Hakkarib1.0466 c0.99 8740.4190.538		d	7.372			
Erzurum b 0.4447 $0.99\ 618$ 1.272 0.938 kars b 0.3482 $0.99\ 576$ 1.212 0.916 Kars b 0.3482 $0.99\ 576$ 1.212 0.916 Agri b 0.4140 $0.99\ 576$ 1.212 0.916 Agri b 0.4140 $0.99\ 576$ 1.212 0.907 Agri b 0.4140 $0.99\ 596$ 1.189 0.907 Agri 0.04140 $0.99\ 698$ 1.189 0.907 d 1.0296 a 18.916 $0.99\ 380$ 1.832 1.126 Igdir b 0.6014 $0.99\ 380$ 1.832 1.126 Tunceli b 1.1777 $0.99\ 805$ 0.625 0.658 Malatya b 1.0207 $0.99\ 911$ 0.194 0.366 Musi b 1.2421 $0.99\ 9184$ 0.534 0.608 c		а	11.946			
c-16.0440.99 618 1.272 0.938d1.0534a12.020.938d1.0534a12.082Karsb0.34820.99 5761.2120.916d1.0479a12.9510.99 6981.1890.907Agrib0.41400.99 6981.1890.907d1.0296a18.9160.99 3801.8321.126Igdirb0.60140.99 3801.8321.126d1.1388a19.0210.99 8050.6250.658Tuncelib1.17770.99 8050.6250.658d1.02070.99 9110.1940.366d1.0194a18.9700.99 8140.5340.608Malatyab1.24210.99 7831.0480.852Bingölb1.24210.99 7531.0480.852d1.0714a15.7800.99 9060.2840.443Muşb0.51240.99 9060.2840.443d1.2990.99 9060.2840.443Hakkarib1.04660.99 8740.4190.538	Erzurum	b	0.4447	0.00 (19	1 272	0.020
d1.0534 aKarsb0.3482 c0.99 5761.2120.916Agrib0.4140 c0.99 6981.1890.907Agrib0.4140 c0.99 6981.1890.907Agrib0.4140 c0.99 6981.1890.907Agrib0.4140 c0.99 6981.1890.907Agrib0.4140 c0.99 6981.1890.907Igdirb0.6014 c0.99 3801.8321.126Igdirb0.6014 c0.99 3801.8321.126Tuncelib1.1777 c0.99 8050.6250.658d1.0700 a14.512 d0.99 9110.1940.366d1.0194 a18.970 d0.99 9110.1940.366d1.0194 a1.0786 c0.99 8140.5340.608Malatyab1.0786 c0.99 8840.3960.523Musb0.5124 c0.99 7531.0480.852Musb0.5124 c0.99 9060.2840.443Bitlisb1.299 c0.99 9060.2840.443Hakkarib1.0466 c0.99 8740.4190.538		С	-16.044	0.99 618	1.272	0.938
Kars a 12.082 b 0.3482 c 0.99 5761.2120.916Agri b 0.4140 c 0.99 6981.1890.907Agri b 0.4140 c 0.99 6981.1890.907Igdir b 0.6014 c 0.99 3801.8321.126Igdir b 0.6014 c 0.99 3801.8321.126Igdir b 0.6014 c 0.99 98050.6250.658Igdir b 1.1777 c 0.99 8050.6250.658Iunceli b 1.1777 c 0.99 9110.1940.366 d 1.0207 c 0.99 9110.1940.366 d 1.0194 a 18.9700.99 8140.5340.608Malatya b 1.0786 c 0.99 8140.5340.608 d 1.114 a 18.2490.99 7531.0480.852 d 1.0714 a 15.7390.99 97531.0480.852 d 1.0546 a 1.229 c 0.99 9060.2840.443 d 1.299 c 0.99 9060.2840.443 d 1.0480.99 8740.4190.538 d 1.0480.99 8740.4190.538		d	1.0534			
Karsb 0.3482 c 0.99576 1.212 0.916 a 1.0479 a 1.0479 a 12.951 0.99698 1.189 0.907 Agrib 0.4140 c 0.99698 1.189 0.907 a 10.296 a 10.296 a 1.0296 a 1.832 1.126 Igdirb 0.6014 c 0.99380 1.832 1.126 d 1.1388 a 19.021 0.999805 0.625 0.658 d 1.0700 a 14.512 d 0.999805 0.625 0.658 d 1.0700 c -15.723 d 0.999805 0.625 0.658 d 1.0700 c -12.956 d 0.999911 0.194 0.366 d 1.0194 a 1.0786 c 0.999814 0.534 0.608 d 1.0786 d 0.999814 0.534 0.608 d 1.0744 a 15.739 0.999753 1.048 0.852 d 1.0546 a 15.580 0.999753 1.048 0.852 d 1.0546 a 15.580 0.999906 0.284 0.443 d 1.0466 c 0.999874 0.419 0.538 d 1.0133 0.99874 0.419 0.538		а	12.082			
c-14.860 d0.99 5761.2120.916Agrib0.4140 c-17.455 d0.99 6981.1890.907Agrib0.6014 c-17.4550.99 3801.8321.126Igdirb0.6014 c-15.117 d0.99 3801.8321.126Tuncelib1.1777 c0.99 8050.6250.658d1.0207 c-15.723 d0.99 9050.6250.658Malatyab1.0207 c-12.956 d0.99 9110.1940.366d1.0194 a18.9700.99 8140.5340.608Malatyab1.0786 c-16.2360.99 8840.3960.523Muşb0.5124 c-16.2360.99 7531.0480.852d1.0546 a1.55800.99 9060.2840.443Hakkarib1.0466 c-15.9830.99 8740.4190.538	Kars	b	0.3482	0.00.57(1 2 1 2	0.01/
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		с	-14.860	0.99 5/6	1.212	0.916
Agri a 12.951 b 0.4140 c 0.99 6981.1890.907 c -17.455 d 1.0296 a 18.9160.99 3801.8321.126Igdir b 0.6014 c $0.99 380$ 1.8321.126Tunceli b 1.1388 a 19.0210.99 805 0.625 0.658 Tunceli b 1.1777 c $0.99 805$ 0.625 0.658 Van b 1.0207 c $0.99 911$ 0.194 0.366 Malatya b 1.0786 c $0.99 814$ 0.534 0.608 d 1.114 a 18.249 $0.99 884$ 0.396 0.523 Muş b 0.5124 c $0.99 753$ 1.048 0.852 d 1.0546 a 1.0546 a $0.99 906$ 0.284 0.443 Bitlis b 1.299 c -15.252 d $0.99 874$ 0.419 0.538 Hakkari b 1.0466 c $0.99 874$ 0.419 0.538		d	1.0479			
Agrib 0.4140 c $0.99\ 698$ 1.189 0.907 d 1.0296 a 1.0296 a 1.8916 $0.99\ 380$ 1.832 1.126 Igdirb 0.6014 c $0.99\ 380$ 1.832 1.126 d 1.1388 a 19.021 $0.99\ 805$ 0.625 0.658 Tuncelib 1.1777 c -15.723 $0.99\ 805$ 0.625 0.658 d 1.0700 a 14.512 $0.99\ 911$ 0.194 0.366 Vanb 1.0207 c -12.956 $0.99\ 911$ 0.194 0.366 d 1.0194 a 18.970 a 18.970 Malatyab 1.0786 c $0.99\ 814$ 0.534 0.608 d 1.114 a a 18.249 a a Bingölb 1.2421 c $0.99\ 884$ 0.396 0.523 d 1.0714 a a 15.739 a 0.5124 c $0.99\ 753$ 1.048 0.852 Bitlisb 1.299 c -15.252 $0.99\ 906$ 0.284 0.443 Hakkarib 1.0466 c $0.99\ 874$ 0.419 0.538		а	12.951			
c -17.455 0.99 698 1.189 0.907 d 1.0296 a 18.916 0.6014 0.99 380 1.832 1.126 Igdir b 0.6014 0.99 380 1.832 1.126 Tunceli b 1.1777 0.99 805 0.625 0.658 Tunceli b 1.1777 0.99 805 0.625 0.658 d 1.0700 a 14.512 0.99 911 0.194 0.366 Van b 1.0207 0.99 911 0.194 0.366 d 1.0194 a 18.970 0.418 0.608 Malatya b 1.0786 0.99 814 0.534 0.608 d 1.114 a 18.249 0.99 884 0.396 0.523 Muş b 0.5124 0.99 753 1.048 0.852 d 1.0546 a 15.580 0.99 906 0.284 0.443 Bitlis b 1.299 0.99 874 0.419 0.538 d 1.0466 0.99 874 <	Agri	b	0.4140	0.00.609	1 1 2 0	0.007
$ \begin{array}{c} \begin{array}{c} d & 1.0296 \\ a & 18.916 \\ c & -15.117 \\ c & -15.117 \\ d & 1.1388 \\ a & 19.021 \\ \end{array} \\ \begin{array}{c} \text{Tunceli} & b & 1.1777 \\ c & -15.723 \\ d & 1.0700 \\ a & 14.512 \\ \end{array} \\ \begin{array}{c} \text{Van} & b & 1.0207 \\ c & -12.956 \\ d & 1.0194 \\ a & 18.970 \\ \end{array} \\ \begin{array}{c} \text{Malatya} & b & 1.0786 \\ c & -14.898 \\ d & 1.114 \\ a & 18.249 \\ \end{array} \\ \begin{array}{c} \text{Bingöl} & b & 1.2421 \\ c & -16.236 \\ d & 1.0714 \\ a & 15.739 \\ \end{array} \\ \begin{array}{c} \text{Mus} & b & 0.5124 \\ c & -16.236 \\ d & 1.0714 \\ a & 15.739 \\ \end{array} \\ \begin{array}{c} \text{Mus} & b & 0.5124 \\ c & -18.122 \\ d & 1.0546 \\ a & 15.580 \\ \end{array} \\ \begin{array}{c} \text{Bitlis} & b & 1.299 \\ c & -15.252 \\ d & 7.312 \\ a & 14.509 \\ \end{array} \\ \begin{array}{c} \text{Hakkari} & b & 1.0466 \\ c & -15.983 \\ d & 1.0133 \end{array} \\ \begin{array}{c} \text{Mus} & 0.99\ 874 \\ 0.419 \\ 0.538 \\ \end{array} \\ \begin{array}{c} \text{Mus} & 0.99\ 874 \\ 0.419 \\ 0.538 \\ \end{array} $	C C	с	-17.455	0.99 698	1.189	0.907
Igdir a 18.916 b 0.6014 c 0.99 3801.8321.126Iunceli b 1.1388 a 19.0211112611126Tunceli b 1.1777 c 0.99 8050.6250.658 d 1.0700 a 14.5120.99 9110.1940.366Van b 1.0207 c 0.99 9110.1940.366 d 1.0194 a 18.9700.99 8140.5340.608Malatya b 1.0786 c 0.99 8140.5340.608 d 1.114 a 18.2490.99 8840.3960.523Bingöl b 1.2421 c 0.99 8840.3960.523 d 1.0714 a 15.7390.99 7531.0480.852 d 1.0546 a 1.299 c 0.99 9060.2840.443Bitlis b 1.299 c 0.99 8740.4190.538 d 1.01330.99 8740.4190.538		d	1.0296			
Igdirb 0.6014 c $0.99\ 380$ 1.832 1.126 d 1.1388 a 19.021 $0.99\ 380$ 1.832 1.126 Tunceli b 1.1777 c $0.99\ 805$ 0.625 0.658 d 1.0700 a 14.512 $0.99\ 910$ 0.194 0.366 Van b 1.0207 c -12.956 $0.99\ 911$ 0.194 0.366 d 1.0194 a 1.0786 c -12.956 $0.99\ 814$ 0.534 0.608 d 1.0194 a 1.0786 c -14.898 $0.99\ 814$ 0.534 0.608 d 1.114 a 18.249 $0.99\ 884$ 0.396 0.523 Bingöl b 1.2421 c $0.99\ 884$ 0.396 0.523 d 1.0714 a 15.739 $0.99\ 753$ 1.048 0.852 d 1.0546 a 15.580 $0.99\ 906$ 0.284 0.443 Bitlis b 1.299 c -15.252 $0.99\ 906$ 0.284 0.443 Hakkari b 1.0466 c -15.983 $0.99\ 874$ 0.419 0.538		а	18.916			
c -15.117 0.99 380 1.832 1.126 d 1.1388 19.021 1.1388 19.021 b 1.1777 0.99 805 0.625 0.658 d 1.0700 a 14.512 1.126 Van b 1.0207 0.99 911 0.194 0.366 d 1.0194 a 18.970 1.0194 0.366 d 1.0194 a 18.970 1.0194 0.534 0.608 d 1.0194 a 18.970 1.0194 0.534 0.608 d 1.0186 c -16.236 0.99 814 0.534 0.608 d 1.0714 a 15.739 1.048 0.852 d 1.0714 a 15.739 1.048 0.852 d 1.0546 a 15.580 1.048 0.852 d 7.312 a 14.509 0.99 906 0.284 0.443 d 1.0466 c -15.983 0.99 874 0.419 0	Igdir	b	0.6014	0.00.200	1 0 2 2	1.12(
d 1.1388 a19.021 bTunceli b 1.1777 c $0.99\ 805$ 0.625 0.658 d 1.0700 a 14.512 c $0.99\ 911$ 0.194 0.366 Van b 1.0207 c $0.99\ 911$ 0.194 0.366 d 1.0194 a 1.0786 c $0.99\ 814$ 0.534 0.608 Malatya b 1.0786 c -14.898 d $0.99\ 814$ 0.534 0.608 Bingöl b 1.2421 c $0.99\ 884$ 0.396 0.523 Muş b 0.5124 c $0.99\ 753$ 1.048 0.852 d 1.0546 a 1.299 c $0.99\ 906$ 0.284 0.443 Bitlis b 1.299 c -15.252 d $0.99\ 874$ 0.419 0.538 Hakkari b 1.0466 c -15.983 d $0.99\ 874$ 0.419 0.538	-8	с	-15.117	0.99 380	1.832	1.126
Tunceli a 19.021 b 0.99 8050.6250.658Tunceli b 1.1777 c 0.99 8050.6250.658 d 1.0700 a 14.5120.99 9110.1940.366 Van b 1.0207 c 0.99 9110.1940.366 d 1.0194 a 18.9700.99 8140.5340.608 $Malatya$ b 1.0786 c 0.99 8140.5340.608 d 1.114 a 18.2490.99 8840.3960.523 d 1.0714 c -16.236 d 0.99 7531.0480.852 d 0.5124 c 0.99 7531.0480.852 d 1.0546 a 15.5800.99 9060.2840.443 d 1.0546 a 1.0466 c 0.99 8740.4190.538 d 1.0466 c 0.99 8740.4190.538		d	1.1388			
Tuncelib 1.1777 c $0.99\ 805$ 0.625 0.658 a 1.0700 a 14.512 b $0.99\ 911$ 0.194 0.366 Van b 1.0207 c -12.956 d $0.99\ 911$ 0.194 0.366 Malatya b 1.0786 c $0.99\ 814$ 0.534 0.608 Malatya b 1.0786 c $0.99\ 814$ 0.534 0.608 d 1.114 a 18.249 $0.99\ 884$ 0.396 0.523 Bingöl b 1.2421 c $0.99\ 884$ 0.396 0.523 d 1.0714 a 0.5124 c $0.99\ 753$ 1.048 0.852 d 1.0546 a 1.5580 $0.99\ 906$ 0.284 0.443 Bitlis b 1.299 c -15.252 $0.99\ 906$ 0.284 0.443 Hakkari b 1.0466 c -15.983 d $0.99\ 874$ 0.419 0.538		а	19.021			
c -15.723 d $0.99\ 803$ 0.623 0.638 Van b 1.0700 a 14.512 b $0.99\ 911$ 0.194 0.366 Malatya b 1.0207 c -12.956 d $0.99\ 911$ 0.194 0.366 Malatya b 1.0786 c -14.898 $0.99\ 814$ 0.534 0.608 Malatya b 1.0786 c -14.898 $0.99\ 814$ 0.534 0.608 Malatya b 1.2421 c -16.236 $0.99\ 884$ 0.396 0.523 Bingöl b 1.2421 c $0.99\ 884$ 0.396 0.523 Muş b 0.5124 c -16.236 $0.99\ 753$ 1.048 0.852 Bitlis b 1.299 c -15.252 $0.99\ 906$ 0.284 0.443 Hakkari b 1.0466 c -15.983 $0.99\ 874$ 0.419 0.538	Tunceli	b	1.1777	0.00.905	0.625	0 (50
d1.0700 a14.512 1.0207 c0.99 9110.1940.366 b 1.0207 c0.99 9110.1940.366 d 1.0194 a18.9700.99 8140.5340.608 d 1.0786 c0.99 8140.5340.608 d 1.114 a18.2490.99 8840.3960.523 d 1.2421 c0.99 8840.3960.523 d 1.0714 c0.5124 c0.99 7531.0480.852 d 1.0546 a1.55800.99 9060.2840.443Bitlis b 1.299 c0.99 9060.2840.443 d 1.0466 c0.99 8740.4190.538 d 1.0466 c0.99 8740.4190.538		с	-15.723	0.99 803	0.025	0.038
Van a 14.512 b 0.99 9110.1940.366 c -12.956 d 1.0194 a 0.99 9110.1940.366Malatya b 1.0786 c 0.99 8140.5340.608 d 1.114 a 0.99 8140.5340.608 d 1.114 a 0.99 8840.3960.523Bingöl b 1.2421 c 0.99 8840.3960.523 d 1.0714 c 0.99 7531.0480.852 d 1.0546 a 0.99 7531.0480.852 d 1.0546 a 0.99 9060.2840.443 d 1.0546 c -15.252 d 0.99 9060.2840.443 d 1.0466 c 0.99 8740.4190.538 d 1.01330.99 8740.4190.538		d	1.0700			
Van b 1.0207 c $0.99\ 911$ 0.194 0.366 a 1.0194 a 18.970 b 1.0786 c -14.898 $0.99\ 814$ 0.534 0.608 Malatya b 1.0786 c $0.99\ 814$ 0.534 0.608 d 1.114 a 18.249 $0.99\ 884$ 0.396 0.523 Bingöl b 1.2421 c $0.99\ 884$ 0.396 0.523 d 1.0714 a $0.99\ 753$ 1.048 0.852 d 1.0546 a $0.99\ 753$ 1.048 0.852 Bitlis b 1.299 c -15.252 $0.99\ 906$ 0.284 0.443 Hakkari b 1.0466 c -15.983 d $0.99\ 874$ 0.419 0.538		а	14.512			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Van	b	1.0207	0.00.011	0.104	0.200
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		с	-12.956	0.99 911	0.194	0.300
Malatya a 18.970 b 0.99 8140.5340.608 c -14.898 d 0.99 8140.5340.608 d 1.114 a 18.2490.99 8840.3960.523 b 1.2421 c 0.99 8840.3960.523 d 1.0714 a 0.99 7531.0480.852 d 1.0546 a 0.99 9060.2840.443 b 1.299 c 0.99 9060.2840.443 d 1.0466 c 0.99 8740.4190.538 d 1.0466 c 0.99 8740.4190.538		d	1.0194			
Malatya b 1.0786 c 0.99 8140.5340.608 d 1.114 a 18.2490.99 8140.5340.608 b 1.2421 c 0.99 8840.3960.523 d 1.0714 a 0.99 7531.0480.852 d 1.0546 c 0.99 7531.0480.852 d 1.0546 c 0.99 9060.2840.443 d 1.299 c 0.99 9060.2840.443 d 1.0466 c 0.99 8740.4190.538 d 1.0466 c 0.99 8740.4190.538		а	18.970			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Malatya	b	1.0786	0.00.014	0.524	0 (00
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-	с	-14.898	0.99 814	0.334	0.008
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		d	1.114			
Bingöl b 1.2421 c 0.99 8840.3960.523 d 1.0714 a 15.7390.99 7531.0480.852 d 0.5124 c 0.99 7531.0480.852 d 1.0546 a 15.5800.99 9060.2840.443Bitlis b 1.299 c 0.99 9060.2840.443 d 7.312 a 1.0466 c 0.99 8740.4190.538Hakkari b 1.0466 c 0.99 8740.4190.538		а	18.249			
Billgol c -16.236 0.99884 0.396 0.323 d 1.0714 a 15.739 b 0.5124 0.99753 1.048 0.852 d 1.0546 a 15.580 c -15.252 0.999906 0.284 0.443 d 1.299 c -15.252 d 0.999906 0.284 0.443 d 1.299 c -15.252 d 0.443 d 1.299 c -15.252 d 0.443 d 1.0466 c -15.983 0.99874 0.419 0.538 d 1.0133 0.99874 0.419 0.538	Dingäl	b	1.2421	0 00 994	0.206	0 522
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Billgoi	С	-16.236	0.99 884	0.390	0.325
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		d	1.0714			
Muşb 0.5124 c 0.99753 1.048 0.852 d 1.0546 a 15.580 Bitlisb 1.299 c 0.99906 0.284 0.443 d 7.312 a 14.509 Hakkarib 1.0466 c 0.99874 0.419 0.538 d 1.0133 0.99874 0.419 0.538		а	15.739			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Muş	b	0.5124	0.00.752	1 0 4 9	0.952
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		с	-18.122	0.99 / 33	1.048	0.832
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		d	1.0546			
Bitlis b 1.299 0.99 906 0.284 0.443 c -15.252 0.99 906 0.284 0.443 d 7.312		а	15.580			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Bitlis	b	1.299	0.00.007	0.204	0.442
d 7.312 a 14.509 Hakkari b 1.0466 c -15.983 d 1.0133		с	-15.252	0.99 906	0.284	0.443
a 14.509 Hakkari b 1.0466 0.99 874 0.419 0.538 c -15.983 d 1.0133		d	7.312			
Hakkari b 1.0466 0.99 874 0.419 0.538 c -15.983 d 1.0133		а	14.509			
c -15.983 0.99874 0.419 0.538 d 1.0133	Hakkari	b	1.0466	0.00.974	0.419	0.529
d 1.0133		с	-15.983	0.99 8/4		0.538
		d	1.0133			

compared with calculated ones. **Figure 5** shows the predicted and observed values of the monthly average maximum temperature. There is a good agreement between predicted and observed values.

The monthly average minimum temperatures

The overall average minimum temperature for 10 years was determined to be about 7.06°C for Elazig, 5.70°C

Model	1	$= a + b_{ain}$	ge minimum $(m) + continue (m)$	$\frac{1}{2}$	re
	Cana	$-a + b \cdot \sin \theta$	$(m) + c \sin((m))$	(2) + a)	
City	Cons-	Model	R	χ^2	RMSE
	tant	constants		~	
F1 ×	a	6.6105			
Elazig	b	0.9345	0.99 587	0.612	0.651
	С	-10.65			
	d	1.0598			
	а	5.2303			
Erzincan	b	0.4802	0.99 727	0.461	0.554
	С	-10.804			
	d	1.1158			
	а	-2.9692			
Erzurum	b	-0.54468	0 99 206	1 593	1.050
	С	-12.450	0.77 200	1.070	1.000
	d	1.1088			
	а	-1.4663			
Kars	b	-0.4760	0 99 437	1 1 1 9	0.880
	С	-12.415	0.99 437	1.11)	0.000
	d	1.1056			
	а	-0.2878			
Agri	b	-0.6481	0.00.226	1 5 1 0	1 025
C C	С	-13.192	0.99 320	1.519	1.023
	d	1.0772			
	а	6.0989			
Igdir	b	0.7160	0.99 720	0.558	0.622
	С	-12.440			
	d	1.1732			
	а	6.7410			
Tunceli	b	0.8648	0.00.620	0.616	0.653
	С	-11.326	0.99 630		0.033
	d	1.0893			
	а	4.8203			
Van	b	0.7447	0.00.701	0.340	0.485
	с	-10.920	0.99 /81		
	d	1.0275			
	а	8.1937			
Malatya	b	0.9545	0.00.004	0.210	0.460
-	С	-11.172	0.99 804	0.318	0.469
	d	1.0725			
	а	6.6144			
Bingöl	b	0.6555	0.00.725	0.500	0.502
C	С	-11.942	0.99 /25	0.508	0.593
	d	1.0754			
	а	4.4451			
Mus	b	-0.06851	0 00 544	1.000	0.024
Bitlis	С	-13.0715	0.99 544	1.006	0.834
	d	1.0561			
	а	4.3441			
	b	0.6756	0.00.000	0.453	0.511
	с	-10.589	0.99 688	0.454	0.561
	d	1.0588			
	a	4.944			
	b	0.6985	0.00.00.0		0 0
Hakkari	c	-13.086	0.99 906	0.208	0.379
	d	1.0560			

Table 5. The results of statistical analyses according to the model (AT_3) for the monthly average minimum temperature

for Erzincan, -2.40°C for Erzurum, -0.90°C for Kars, 0.3°C for Agri, 6.65°C for Igdir, 7.23°C for Tunceli, 5.28°C for Van, 8.67°C for Malatya, 7.13°C for Bingöl, 5.01°C for Muş, 4.8°C for Bitlis, 5.50°C for Hakkari (**Fig. 6**). While minimum temperatures are at highest values in July, at lowest values in January and February. Minimum temperatures reach the warmest values in the Malatya. The monthly average minimum temperatures demonstrated changing between -1.5 and 20.3°C for Malatya city.

The simple function of the monthly average minimum temperature (AT_3) fit the minimum temperature data very well. The results of statistical analyses undertaken on trigonometric model for the monthly average minimum temperature are given in **Table 5.** Generally, *R*, χ^2 and *RMSE* values were varied between 0.99 206-0.99 906, 0.208-1.593 and 0.379-1.050, respectively. The function has coefficients of determination of better than 0.99 and the lowest values of χ^2 and RMSE for all cities. Hence, the trigonometric model (AT₃) satisfactorily described characteristics of monthly average the minimum temperature. Considering trigonometric model (AT_3) , the observed mean minimum monthly temperature values were compared with calculated ones. Figure 7 shows the predicted and observed values of the monthly average minimum temperature. There is a good agreement between predicted and observed values.



Fig. 6 Monthly average minimum temperatures during the years 1994–2003 for the cities.



Fig. 7 Observed and predicted values of the monthly average minimum temperatures.



Fig. 8 Monthly average relative humidity values during the years 1994–2003 for the cities.

Model		Monthly ave	erage relative	humidity	
widdei		$= a + b \cdot \sin(b \cdot \sin(b \cdot \sin b \cdot $	$(m) + c \cdot \sin((m + c \cdot \sin(m + c \cdot i))))))))))))))))))))))))))))))))))$	(1/2) + d)	
City	Cons-	Model	D	2	DMSE
City	tant	constants	Λ	χ	RIVISE
	а	58.040			
Elazığ	b	-4.347	0.00.772	1 000	0.072
	С	18.755	0.99 //2	1.099	0.872
	d	32.524			
	а	63.721			
Erzincan	b	-1.975	0.00.202	1 0 1 1	0.015
	С	-12.168	0.99 382	1.211	0.915
	d	17.077			
	а	64.193			
Erzurum	b	-2.596	0.00.007	2 1 6 7	1 401
	с	14.599	0.98 907	3.167	1.481
	d	51.322			
	a	72.1167			
Kars	b	-0.5718			
	C	8 7419	0.95 044	5.308	1.917
	d	88 968			
	a	70 881			
Aori	h	-1 754			
71511	C	11 593	0.99 479	0.941	0.807
	d	95 207			
	a	50 135			
Indir	u h	-2 866			
Igair	C	12 /30	0.97 286	5.918	2.024
	d	17 210			
	u	57 018			
Tunceli	u b	1 836			
Tuncen	0	17 522	0.99 545	1.961	1.165
	d	20.028			
	u	20.038			
Von	u b	2 1 4 9			
v all	U C	-3.148	0.98 484	2.795	1.391
	d	11.330			
	u	43.070			
Malatria	u L	35.114			
Malatya	D	-4.430	0.99 415	3.163	1.480
	C	19.897			
	a	7.473			
Din a ⁸¹	а ь	30.892			
Bingoi	D	-4.230	0.99 622	1.572	1.043
	C	17.329			
	а	32.515			
	a	64.806			
Muş	b	-4.973	0.99 549	2.427	1.296
	С	19.633			
	d	/0.1/4			
D	a	69.792			
Bitlis	b	-1.024	0.98 791	2.373	1.282
	С	12.222			
	d	95.400			
	а	54.555			
Hakkari	b	-3.332	0.99 294	3.185	1.485
	С	18.185	0.22 221	2.100	100
	d	0 9574			

Table 6. The results of statistical analyses according to the model

(RH) for the monthly average relative humidity



Fig. 9 Observed and predicted values of the monthly average relative humidity.



Fig. 10 Monthly average wind speed values during the years 1994–2003 for the cities.

The monthly average relative humidity

Kars city is the most humid area almost throughout the period while Igdir is the least humid area. The monthly average relative humidity showed changing between 63 and 81% for Kars city and 38 and 65% for Igdir city (**Fig. 8**). The overall average humidity ratio was about a57.69% for Elazig, 63.52% for Erzincan, 63.58% for Erzurum, 71.75% for Kars, 70.41% for Agri, 49.58% for Igdir, 57.40% for Tunceli, 58.16% for Van, 52.76% for Malatya, 56.59% for Bingol, 64% for Muş, 69.25% for Bitlis, 53.83% for Hakkari. While relative humidity is at highest values in December and January, at lowest values in July and August.

The simple function of the monthly average relative humidity (RH) fit the relative humidity data very well. The results of statistical analyses undertaken on trigonometric model for the monthly average relative humidity are given in **Table 6**. Generally, R, γ^2 and RMSE values were varied between 0.95 044-0.99 772, 1.099–5.308 and 0.872–1.91, respectively. The function has coefficients of determination of better than 0.95 and the lowest values of χ^2 and *RMSE* for all cities. Therefore, the trigonometric model (RH) satisfactorily described characteristics of the monthly average relative humidity. Considering trigonometric model (RH), the observed monthly average relative humidity values were compared with calculated ones. Figure 9 shows the predicted and observed values of the monthly average relative humidity. There is a good agreement between predicted and observed values.



Fig. 11 Observed and predicted values of the monthly average wind speed.



Fig. 12 Monthly average pressure values during the years 1994–2003 for the cities.

The monthly average wind speed

The overall average of wind speed for the same period was obtained to be approximately 2.69 m/s for Elazig, 1.47 m/s for Erzincan, 2.80 m/s for Erzurum, 2.54 m/s for Kars, 1.50 m/s for Agri, 1.11 m/s for Igdir, 1.21 m/s for Tunceli, 2.55 m/s for Van, 1.79 m/s for Malatya, 1.3 m/s for Bingol, 1.15 m/s for Mus, 1.94 m/s for Bitlis, 1.60 m/s for Hakkari. The windiest city is Erzurum. The monthly average wind speed showed changing between 2.3 and 3.5 m/s for Erzurum city.

The simple function of the monthly average wind speed (WS) fit the wind speed data very well. The results of statistical analyses undertaken on polynomial model for the monthly average wind speed are given in **Table 7**. Generally, R, χ^2 and RMSE values were varied between 0.82965-0.98047, 0.007-0.049 and 0.067-0.174, respectively. The function has coefficients of determination of better than 0.82 and the lowest values of χ^2 and RMSE for all cities. Therefore, the polynomial model (WS) satisfactorily described characteristics of the monthly average wind speed. Considering polynomial model (WS), the observed monthly average wind speed values were compared with calculated ones. Figure 11 shows the predicted and observed values of the monthly average wind speed. There is a good agreement between predicted and observed values.

The monthly average pressure

The overall pressure was found to be about 902.74 mbar for Elazig, 878.03 mbar for Erzincan, 822.89 mbar for Erzurum, 820.79 mbar for Kars, 834.63 mbar for Agri, 916.84 mbar for Igdir, 903.79 mbar for Tunceli, 831.53 mbar for Van, 907.19 mbar for Malatya, 886.50 mbar for Bingol, 868.95 mbar for Mus, 841.53 mbar for Bitlis, 827.20 mbar for Hakkari. While pressure values are at highest values in November and December, at lowest values in July. Pressure reaches the highest values in the Igdir. Pressure values are at lowest values in Kars. The monthly average pressure changed between 818 and 823.8 mbar for Kars city and 832.1 and 838.2 mbar for Agri city.

Table 7.	The	results	of	statistical	analyses	according	to	the	model
(WS) for	the n	nonthly	av	erage wind	l speed.				

Model		Monthly ave $= a+b\cdot m+c(a)$	v average wind speed $r+c(m^2)+d(m^3)+e(m^4)$				
City	Constant	Model	R R	γ^2	RMSE		
City	Constant	constants	K	λ	RMBL		
	u b	0.737					
Elazığ	c	-0.188	0.84 615	0.015	0.097		
	d	0.0178					
	e	-0.00 057					
- ·	u b	0.0634					
Erzincan	с	0.0790	0.92 905	0.017	0.103		
	d	-0.0155					
	e	2 031					
Eastern	b	0.131					
Erzurum	С	0.0969	0.90 236	0.049	0.174		
	d	-0.018					
	e	1 517					
	b	0.391					
Kars	с	0.0244	0.96 062	0.021	0.113		
	d	-0.0111					
	e a	0.00 033					
Agri	b	0.0071					
Agii	С	0.1132	0.92 233	0.027	0.130		
	d	-0.0185					
	a	0.655					
Igdir	b	0.005 955					
igun	С	0.101 663	0.94 967	0.012	0.088		
	d	-0.01 /95					
	a	0.939					
Tunceli	b	0.2319					
Tuncen	С	-0.0277	0.82 965	0.018	0.104		
	a e	-0.00 146					
	a	1.970					
Van	b	0.3716					
	C d	-0.0725	0.88 004	0.010	0.078		
	u e	-0.00 025					
	a	0.953					
Malatva	b	0.5166		0.017			
	c d	-0.063	0.94 573	0.016	0.100		
	u e	0.000 100					
	а	0.9186					
Bingöl	b	-0.112	0.0(.0(0)	0.000	0.072		
e	с d	0.112	0.96 260	0.009	0.073		
	e	0.000 605					
	а	0.6712					
Muş	b	-0.0738	0 07 545	0.007	0.067		
	d	-0.0175	0.97 545	0.007	0.007		
	e	0.000 692					
	а	2.022					
Bitlis	b	0.0392	0.07.077	0.000	0.07.1		
	с d	-0.0117/ 0.0012	0.87 855	0.009	0.074		
	e e	-0.00 006					
	а	0.392 929					
Habbari	b	0.523 326	0 08 047	0 000	0.072		
1 10KKal l	d	0.002 995	0.90 04/	0.009	0.072		
	е	-0.00 013					

The simple function of the monthly average (P) fit the pressure data very well. The results of statistical analyses undertaken on polynomial model for the monthly average pressure are given in Table 7. Generally, R, χ^2 and RMSE values were varied between 0.83 395-0.96 460, 0.728-2.286 and 0.669-1.186, respectively. The function has coefficients of determination of better than 0.83 and the lowest values of χ^2 and RMSE for all cities. The polynomial model (P) satisfactorily described characteristics of the monthly average pressure. Considering polynomial model (P), the observed monthly average pressure values were compared with calculated ones (Fig. 13). As seen from Fig. 13, there is a good agreement between predicted and observed values.

The mean rainfall

The overall average pressure is found to be about 32.65 mm for Elazig, 32.15 mm for Erzincan, 32.53 mm for Erzurum, 41.26 mm for Kars, 41.32 mm for Agri, 20.78 mm for Igdir, 71.61 mm for Tunceli, 31.32 mm for Van, 29.94 mm for Malatya, 79.89 mm for Bingol, 65.03 mm for Mus, 93.49 mm for Bitlis, 61.61 mm for Hakkari. While rainfall values are at highest values in April and May, at lowest values in August. Rainfall reaches the highest values in the Bitlis. Rainfall values are at lowest values in Igdir. The monthly average rainfall showed changing between 3.6 and 196.4 mm for Bitlis city and 6.5 and 46.1 mm for Igdir city.



Fig. 14 Monthly average rainfall values during the years 1994–2003 for the cities.



The simple function of the monthly average rainfall (RF) fit the rainfall data very well. The results of statistical analyses undertaken on polynomial model for the monthly average rainfall are given in **Table 9**. Generally, R, χ^2 and RMSE values were varied between 0.70 915–0.98 088, 115.818–2075.940 and 8.220–34.799, respectively. The function has coefficients of determination of better than 0.70 and the lowest values of χ^2 and RMSE for all cities. Hence, the polynomial model (RF) satisfactorily described characteristics of the monthly average rainfall. Considering polynomial model (RF), the observed the monthly average rainfall values were compared with calculated ones (**Fig. 15**). There is a good agreement between predicted and observed values.

The monthly average direct solar radiation

The overall average of solar radiation for the same period is obtained to be approximately 363.06 cal/cm² for Elazig, 356.69 cal/cm² for Erzincan, 369.72 cal/cm² for Erzurum, 338.37 cal/cm² for Kars, 314.26 cal/cm² for Agri, 344.58 cal/cm² for Igdir, 387.25 cal/cm² for Tunceli, 449.39 cal/cm² for Van, 382.37 cal/cm² for Malatya, 373.01 cal/cm² for Bingol, 339.51 cal/cm² for Mus, 340.99 cal/cm² for Bitlis, 378.92 cal/cm² for Hakkari. While direct solar radiation values are at highest values in June and July, at lowest values in December. Direct solar radiation reaches the highest values in the Tunceli.



Fig. 16 Monthly average solar radiation values during the years 1994–2003 for the cities.

$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Model		Monthly	y average pr	essure		Model		Month	ly average r	ainfall	
$ \begin{array}{c c \ c \ c \ c \ c \ c \ c \ c \ c \ c $		~	$= a + b \cdot m +$	$-c(m^2)+d(m^3)$	$+e(m^{-})$				$= a + b \cdot m$	$+c(m^2)+d(m)$	$e(m^{\tau})$	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	City	Cons-	Model	R	χ^2	RMSE	City	Constant	Model	R	χ^2	RMSE
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		tant	constants		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~				constants		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		a b	902.284					a	-30.982			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Elazığ	U	2.0378	0.04.263	1 868	1.072	Elazığ	U G	21 250	0 86 088	100 420	10 786
Firzincan $\left(\begin{array}{c} a & -0.013 \\ b & 0.2036 \\ c & -0.7429 \\ c & -0.0501 \\ c & -0.00501 \\ c & -0.00050 \\ c & -0.00000 \\ c & -0.$		c d	-2.327	0.94 203	1.000	1.072		d	3 221	0.80 088	199.420	10.780
$ \begin{array}{c} & 880 768 \\ c & 0.7429 \\ d & 0.107 \\ c & 0.7229 \\ d & 0.107 \\ c & 0.7229 \\ c & 0.00501 \\ c & 0.0050 \\ c & 0.0078 \\ c & 0.0078 \\ c & 0.0078 \\ c & 0.0078 \\ c & 0.0051 \\ c & 0.0078 \\$		u o	-0.0112					u	-0 1086			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		e	880 768					e	-52 909			
		h	0 2636					h h	87 434			
$ \begin{array}{c} \mathbf{r} & -0.1207 & 0.0001 & 1.16 & 0.000 & 1.46 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0.0071 & 0$	Erzincan	C	-0 7429	0 90 961	1 518	0.966	Erzincan	C	-24 342	0 70 915	2075 940	34 799
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		d	0.12.07	0.90 901	1.010	0.900		d	2 5168	0.70 910	2075.910	51.777
$ \begin{array}{c} a & 822 rg 3 & a & 51 482 \\ b & -0.1523 & 0.97 859 & 0.931 & 0.757 & Erzurum & c & -17.286 & 0.72 121 & 205.650 & 1 \\ d & 0.05768 & a & 821.693 \\ e & -0.00292 & e & -0.0514 \\ a & 821.693 & 0.91 362 & 0.728 & 0.669 & Kars & c & 6.288 & 0.88 245 & 125.651 & 4 \\ d & -0.0054 & a & 7.777 \\ c & -0.0054 & e & -0.0054 \\ e & -0.0054 & a & 7.777 \\ d & -0.0054 & e & -0.0054 \\ e & -0.0054 & e & -0.0054 \\ e & -0.0054 & e & -0.0054 \\ e & -0.0054 & e & 0.0054 \\ e & -0.0054 & e & 0.0054 \\ e & -0.0054 & e & -0.0054 \\ e & -0.0054 & e & -25.801 & 0.71 498 & 388.614 & 1 \\ d & 0.10181 & 0.96 460 & 1.399 & 0.928 & Igdir & c & -32.801 \\ e & -0.00785 & e & -0.01527 \\ a & 920.707 & a & -28.995 \\ d & 0.2048 & 0.93 011 & 1.831 & 1.061 & Tunceli & b & 4.1956 \\ e & -0.00785 & e & -0.01527 \\ a & 903.710 & 0.93 911 & 1.831 & 1.061 & Tunceli & b & -31.217 \\ Tunceli & b & 4.1956 & 0.93 011 & 1.831 & 1.061 & Tunceli & b & -31.234 \\ d & 0.2376 & e & -0.0057 & e & -0.01527 \\ e & -0.0078 & e & -0.01527 \\ a & 903.710 & 0.93 946 & 1.801 & 1.053 & Malatya & c & -25.494 \\ d & 0.2576 & e & -0.0057 & e & -0.01527 \\ e & -0.00691 & e & -51.424 & 0.95 607 & 306.989 1 \\ d & 0.2576 & e & -0.00691 & e & -51.424 \\ d & 0.2576 & e & -0.0057 & e & -0.01527 \\ e & -0.00691 & e & -51.624 & 0.95 607 & 306.989 1 \\ d & 0.2587 & e & -0.0177 & a & -51.714 \\ d & 0.2576 & e & -0.0057 & e & -0.0157 \\ e & -0.00691 & e & -0.0057 & e & -0.0157 \\ e & -0.00691 & e & -0.0057 & e & -0.0177 \\ a & 829.202 & a & -51.714 \\ b & 8.0094 & a & -29.728 \\ b & 8.0904 & a & -29.728 \\ b & 8.0912 & -2.728 & 0.91 95 2.286 & 1.186 & Bingol & c & -25.495 & 0.87 435 128.233 86 \\ e & -0.01065 & e & -0.01847 \\ a & 885.310 & 0.20776 & 6.081 & 0.017 & Mu5 & C & -25.432 & 0.99 0.98 0.88 195.252 10 \\ d & 0.2677 & e & -0.01847 \\ e & -0.01065 & e & -0.01847 \\ e & -0.01847 & e & -0.01847 \\ e & -0.01847 & e & -0.01847 \\ e & -0.01847 & e & -0.01847 \\ e & -0.0057 & e & -0.01847 \\ e & -0.0057 & e & -0.01847 \\ e & -0.01847 & e & -0.01847 \\ e & -0.0187 & e$		ρ	-0.00501					e	-0.0871			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		a	822 793					a	-51 482			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	_	h	-0 1523				_	h	71 919			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Erzurum	c	-0.2463	0.87 859	0.931	0.757	Erzurum	c	-17.286	0.72 121	205.650	10.953
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		d	0.05768					d	1.604			
		е	-0.00292					е	-0.0514			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		а	821.693					а	7.777			
Kars c 0.3053 0.91 362 0.728 0.669 Kars c 6.258 0.88 245 125.651 4 d -0.0005 d -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10 -1.10	17	b	-1.808				17	b	1.091			
$ \begin{array}{c} \mbox{d} & -0.0054 & \ & \ & \ & \ & \ & \ & \ & \ & \ & $	Kars	С	0.3053	0.91 362	0.728	0.669	Kars	С	6.258	0.88 245	125.651	8.561
$ \begin{array}{c} e & -0.00058 \\ a & 833.869 \\ b & 0.7709 \\ c & -0.6021 \\ d & 0.10181 \\ e & -0.00459 \\ a & 920.707 \\ c & -1.4437 \\ e & -0.00459 \\ c & -1.4437 \\ e & -0.00459 \\ c & -1.4437 \\ d & 0.2048 \\ e & -0.00785 \\ a & 903.710 \\ c & -1.4437 \\ d & 0.2048 \\ e & -0.00785 \\ a & 903.710 \\ c & -1.9108 \\ d & 0.2376 \\ e & -0.00785 \\ a & 903.710 \\ d & 0.2376 \\ e & -0.00785 \\ a & 903.710 \\ c & -1.9108 \\ d & 0.2376 \\ e & -0.0087 \\ a & 829.202 \\ d & 0.2376 \\ e & -0.0087 \\ a & 829.202 \\ c & -1.2465 \\ a & 903.710 \\ c & -1.2465 \\ e & 0.0067 \\ a & 829.202 \\ c & 0.0087 \\ a & 853.10 \\ c & 0.0686 \\ e & 0.0681 \\ c & 0.0686 \\ e & 0.0681 \\ c & 0.0686 \\ e & 0.00691 \\ a & 907.553 \\ a & 885.310 \\ c & -1.2465 \\ c & 0.0087 \\ c & -2.1285 \\ c & 0.0094 \\ c & -2.1285 \\ c & 0.0094 \\ c & -2.1285 \\ c & -2.1285 \\ c & 0.01995 \\ c & -2.1285 \\ c & 0.0094 \\ c & -2.1285 \\ c & 0.0097 \\ c & -2.1285 \\ c & -2.1285 \\ c & 0.0097 \\ c & -2.1285 \\ c & -2.1285 \\ c & -2.1285 \\ c & -2.1285 \\ c & -2.1287 \\ c & -$		d	-0.0054					d	-1.110			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		е	-0.00058					е	0.0494			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		а	833.869					а	-61.609			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	A ~~~;	b	0.7709				A ~~;;	b	100.500			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Agri	С	-0.6021	0.88 911	1.324	0.902	Agri	С	-25.801	0.71 498	388.614	15.056
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		d	0.10181					d	2.451			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		е	-0.00459					е	-0.0782			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		а	920.707					a	-28.595			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Indir	b	1.5712				Indir	b	40.091			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	igun	С	-1.4437	0.96 460	1.399	0.928	igun	С	-8.296	0.74 827	117.670	8.285
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		d	0.2048					d	0.6222			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		е	-0.00785					е	-0.01527			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		а	903.710					а	-32.314			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Tunceli	b	4.1956				Tunceli	b	163.579			
$ {\rm Van} \begin{array}{ccccccccccccccccccccccccccccccccccc$	Tuncen	С	-1.9108	0.93 011	1.831	1.061	runcen	С	-51.424	0.95 607	306.989	13.382
$ Van \qquad \begin{array}{ccccccccccccccccccccccccccccccccccc$		d	0.2376					d	5.375			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		е	-0.0087					е	-0177			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		а	829.202					а	-51.714			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Van	b	2.9758					Ь	89.996		100 000	0 (10
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		С	-1.2465	0.83 395	1.567	0.982	Van	c	-25.495	0.87 435	128.233	8.649
$ Malatya = \begin{cases} e & -0.00691 \\ a & 907.553 \\ b & 4.0417 \\ c & -1.9701 & 0.93 946 & 1.801 & 1.053 \\ d & 0.2521 \\ e & -0.00944 \\ a & 885.310 \\ c & -2.1285 & 0.91 095 & 2.286 & 1.186 \\ c & -2.1285 & 0.91 095 & 2.286 & 1.186 \\ d & 0.2677 \\ e & -0.01008 \\ a & 867.718 \\ e & -0.01008 \\ a & 867.718 \\ b & 4.8704 \\ c & -2.1587 & 0.92 736 & 1.680 & 1.017 \\ b & 4.8704 \\ c & -2.1587 & 0.92 736 & 1.680 & 1.017 \\ d & 0.2768 \\ e & -0.0184 \\ a & 839.499 \\ b & 2.8874 \\ c & -1.2416 & 0.86 872 & 1.346 & 0.910 \\ e & -0.0825 \\ a & -0.184 \\ a & -0.1847 \\ a & -0.1847 \\ a & -120.213 \\ b & 2.8874 \\ c & -1.2416 & 0.86 872 & 1.346 & 0.910 \\ e & -0.0676 \\ e & -0.023 \\ e & -0.023 \\ e & -0.0676 \\ e & -0.293 \\ e & -0.292 \\ c & -86.801 & 0.96 716 & 460.725 & 1 \\ c & -86.801 & 0.96 716 & 460.725 & 1 \\ c & -86.801 & 0.96 716 & 460.725 & 1 \\ c & -86.801 & 0.96 716 & 460.725 & 1 \\ c & -86.801 & 0.96 716 & 460.725 & 1 \\ c & -86.801 & 0.96 716 & 460.725 & 1 \\ c & -86.801 & 0.96 716 & 460.725 & 1 \\ c & -80.607 \\ c & -0.06676 \\ e & -0.293 \\ c & $		d	0.1686					d	2.5873			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		е	-0.00691					е	-00855			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		a	907.553					a	-29.828			
$Bingöl = \begin{bmatrix} c & -1.9701 & 0.93946 & 1.801 & 1.053 & c & -24.104 & 0.89638 & 113.818 & 4 \\ d & 0.2521 & d & 2.479 \\ e & -0.00944 & e & -0.0825 \\ a & 885.310 & a & -29.922 \\ b & 4.8864 & c & -2.1285 & 0.91095 & 2.286 & 1.186 & Bingöl & b & 183.345 \\ c & -2.1285 & 0.91095 & 2.286 & 1.186 & Bingöl & c & -56.892 & 0.98088 & 195.252. 1 \\ d & 0.2677 & e & -0.01008 & e & -0.184 \\ a & 867.718 & a & -49.587 \\ e & -0.01008 & e & -0.184 \\ a & 867.718 & b & 4.8704 \\ c & -2.1587 & 0.92736 & 1.680 & 1.017 & Muş & b & 172.713 \\ d & 0.2768 & e & -0.1847 \\ d & 0.2768 & e & -0.1847 \\ a & 839.499 & b & 2.8874 \\ c & -1.2416 & 0.86872 & 1.346 & 0.910 & Bitlis & b & 291.074 \\ c & -86.801 & 0.96716 & 460.725 & 1 \\ d & 8.895 & e & -0.293 \\ e & -0.00676 & e & -0.293 \\ e & -0.00676 & e & -0.293 \\ e & -0.00676 & e & -0.293 \\ e & -0.0293 \\ e & -0.029 \\ e & -0.0293 \\ e & -0.029 \\ e & -0$	Malatya	b	4.041/	0.02.046	1 001	1.052	Malatya	В	80.942	0.00 (50	115 010	0.220
$Bingöl \begin{pmatrix} a & 0.2521 \\ e & -0.00944 \\ a & 885.310 \\ b & 4.8864 \\ c & -2.1285 & 0.91 095 & 2.286 & 1.186 \\ c & -2.1285 & 0.91 095 & 2.286 & 1.186 \\ c & -2.1285 & 0.91 095 & 2.286 & 1.186 \\ c & -2.1285 & 0.91 095 & 2.286 & 1.186 \\ a & 867.718 \\ c & -2.1587 & 0.92 736 & 1.680 & 1.017 \\ c & -2.1587 & 0.92 736 & 1.680 & 1.017 \\ d & 0.2768 \\ e & -0.01065 \\ a & 839.499 \\ b & 2.8874 \\ c & -1.2416 & 0.86 872 & 1.346 & 0.910 \\ b & 2.8874 \\ c & -1.2416 & 0.86 872 & 1.346 & 0.910 \\ d & 0.16710 \\ e & -0.00676 \\ e & -0.00676 \\ e & -0.0293 \\ e & -0.293 \\ e & $,	C	-1.9701	0.93 946	1.801	1.053	2	c	-24.104	0.89 658	115.818	8.220
$Bingöl \begin{pmatrix} e & -0.00944 \\ a & 885.310 \\ b & 4.8864 \\ c & -2.1285 & 0.91095 & 2.286 & 1.186 \\ d & 0.2677 \\ e & -0.01008 \\ a & 867.718 \\ b & 4.8704 \\ c & -2.1587 & 0.92736 & 1.680 & 1.017 \\ d & 0.2768 \\ e & -0.01065 \\ a & 839.499 \\ b & 2.8874 \\ c & -1.2416 & 0.86872 & 1.346 & 0.910 \\ Bitlis \begin{pmatrix} e & -0.0823 \\ a & -29.922 \\ c & -56.892 \\ d & 5.789 \\ e & -0.184 \\ a & -49.587 \\ c & -53.263 \\ d & 5.546 \\ e & -0.1847 \\ a & -120.213 \\ b & 291.074 \\ c & -86.801 \\ d & 0.96716 & 460.725 \\ 1 & d & 8.895 \\ e & -0.00676 \\ e & -0.093 \\ 1 & 0.6710 \\ e & -0.00676 \\ e & -0.0910 \\ 1 & 0.6710 \\ e & -0.00676 \\ e & -0.293 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.757 \\ 1 & 0.7$		a	0.2521					a	2.4/9			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		e	-0.00944					e	-0.0825			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		u h	1 9961					u h	-29.922			
$Bitlis = \begin{bmatrix} c & -2.1283 & 0.91093 & 2.286 & 1.186 & c & -30.892 & 0.98088 & 193.232. & 1 \\ d & 0.2677 & d & 5.789 \\ e & -0.01008 & e & -0.184 \\ a & 867.718 & a & -49.587 \\ b & 4.8704 & b & 172.713 \\ c & -2.1587 & 0.92736 & 1.680 & 1.017 & Muş & c & -53.263 & 0.97455 & 153.141 & 9 \\ d & 0.2768 & d & 5.546 \\ e & -0.01065 & e & -0.1847 \\ a & 839.499 & b & 2.8874 \\ c & -1.2416 & 0.86872 & 1.346 & 0.910 \\ b & 2.8874 & c & -1.2416 & 0.86872 & 1.346 & 0.910 \\ d & 0.16710 & e & -0.00676 \\ e & -0.00676 & e & -0.293 \\ e & -0.00676 & e & -0.293 \\ e & -0.00676 & e & -0.293 \\ \end{bmatrix}$	Bingöl	D	4.0004	0.01.005	2 286	1 1 9 6	Bingöl	D Q	165.545	0 08 088	105 252	10 672
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		c d	-2.1263	0.91 095	2.280	1.180		c d	-30.892	0.98 088	195.252.	10.072.
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		u	0.2077					u	0.184			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		e	867 718					e	40 587			
Muş b 4.8704 Muş b 172.713 c -2.1587 0.92736 1.680 1.017 Muş c -53.263 0.97455 153.141 9 d 0.2768 d 5.546 d 5.546 e -0.1847 a 839.499 b 2.8874 a -120.213 b 2.8874 b 291.074 c -86.801 0.96716 d 0.16710 d 8.895 e -0.293 e -0.00676 e -0.297		u b	4 8704					u b	172 713			
$Bitlis \begin{array}{cccccccccccccccccccccccccccccccccccc$	Muş	U C	-2 1587	0 92 736	1 680	1.017	Muş	U C	-53 263	0 97 455	153 141	9 4 5 2
$Bitlis \begin{array}{cccccccccccccccccccccccccccccccccccc$		d	0.2768	0.72 750	1.000	1.017		d	5 546	0.97 433	155.141	7.452
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		u 0	-0.01065					a	-0 1847			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		a	839 499					e	-120 213			
Bitlis c -1.2416 0.86 872 1.346 0.910 Bitlis c -86.801 0.96 716 460.725 1 d 0.16710 d 8.895 e -0.293 e		h	2 8874					h h	291 074			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Bitlis	c	-1 2416	0 86 872	1 346	0.910	Bitlis	c	-86 801	0 96 716	460 725	16 394
e -0.00676 $e -0.293$		d	0 16710	0.00 072	1.540	0.910		d	8 895	0.90 /10	400.725	10.574
		e	-0.00676					e.	-0 293			
a = 825.666 $a = -10.777$		a	825 666					a	-10 777			
b = 5.2156 $b = 131.047$		h	5.2156					h	131 047			
Hakkari c -2.1874 0.92 909 1.352 0.912 Hakkari c -39 702 0.95 756 292 439 1	Hakkari	c	-2.1874	0.92 909	1.352	0.912	Hakkari	с	-39.702	0.95 756	292.439	13.061
d 0.27324 d 3.869		d	0.27324					d	3.869			
e -0.01035 e -0.116		e	-0.01035					e	-0.116			

Table 8. The results of statistical analyses according to the model

 (P) for the monthly average pressure

Table 9. The results of statistical analyses according to the model (RF) for the monthly average rainfall

Model		Monthly ave	rage solar ra	adiation =	
		$a+b\cdot\sin(r)$	n)+ c ·sin((m /	(2)+d)	
City	Constant	Model	R	γ^2	RMSE
eny	Constant	constants	n	λ.	IUNDL
	а	352.441			
Elazığ	b	15.083	0 00 782	142 642	0.027
	С	227.146	0.99 /85	142.045	9.957
	d	-158.72			
	а	347.345			
Erzincan	b	10.931	0.00.060	71 530	7 027
	с	202.003	0.99 862	71.532	7.037
	d	142,948			
	a	361 205			
Erzurum	b b	26 720			
Lizaian	C	-186.07	0.99 617	173.440	10.958
	d	45 543			
	a	330 177			
Kars	u b	18 630			
Kais	U C	178 110	0.99 678	132.002	9.560
	c d	1/0.119			
	u	205 221			
A	<i>u</i> <i>L</i>	21 500			
Agri	D	21.509	0.99 689	149.901	10.187
	C	193.157			
	d	-20.477			
· ··	a	334.978			
Igdır	b	11.145	0.99 767	125.225	9.311
	С	205.287			
	d	-114.693			
	а	376.126			
Tunceli	b	23.556	0 99 719	207 375	11 982
	С	239.240	0.77 / 17	201.010	11.902
	d	61.156			
	а	438.504			
Van	b	20.299	0 99 823	124 832	9 296
	С	-234.433	0.77 825	124.032	1.270
	d	-11.019			
	а	371.562			
Malatya	b	18.861	0 00 802	72 750	7 1 4 5
-	С	231.646	0.99 893	/3./30	7.143
	d	36.048			
	а	361.769			
Bingöl	b	24.394	0.00.705	222 525	10 410
U	С	242.097	0.99 /05	222.535	12.412
	d	-246.684			
	a	329.416			
Mus	h	17 294			
ining	c	-216 399	0.99 836	98.421	8.255
	d	-42 496			
	a	330,900			
Ritlie	u b	26 0458			
Dittis	C	_218 20/	0.99 537	286.837	14.092
	d	-210.234			
	u	-+2.409 270 262			
Haldson	u 1-	370.203			
паккап	0 C	106 007	0.99 658	153.909	10.322
	C	-180.98/			
	d	51.843			

 Table 10. The results of statistical analyses according to the model (SR) for the monthly average solar radiation

Direct solar radiation values are at lowest values in Agri. The monthly average direct solar radiation demonstrated changing between 139.78 and 628.3 cal/cm^2 for Tunceli city, 102.01 and 504.6 cal/cm² for Agri city.

The simple function of the monthly average solar radiation (SR) fit the solar radiation data very well. The results of statistical analyses undertaken on trigonometric model for the monthly average solar







Fig. 18 Monthly average sunshine duration values during the years 1994–2003 for the cities.

radiation are given in **Table 10**. Generally, R, χ^2 and RMSE values were varied between 0.99 537–0.99 893, 71.532–286.837 and 7.037–14.092, respectively. The function has coefficients of determination of better than 0.99 and the lowest values of χ^2 and RMSE for all cities.

Hence, the trigonometric model (SR) satisfactorily described characteristics of the monthly average solar radiation. Considering trigonometric model (SR), the observed monthly average solar radiation values were compared with calculated ones (Fig. 17). As seen from Fig. 17, there is a good agreement between predicted and observed values.

The mean sunshine duration

The overall average sunshine duration for 10 years is found to be about 464.76 min for Elazig, 369.48 min for Erzincan, 381.33 min for Erzurum, 396.75 min for Kars, 389.83 min for Agri, 393.25 min for Igdir, 441.33 min for Tunceli, 506.08 min for Van, 476 min for Malatya, 391.33 min for Bingol, 439.58 min for Mus, 347.58 min for Bitlis, 468.66 min for Hakkari. While sunshine duration values are at highest values in August and July, at lowest values in December. Sunshine duration reaches the highest values in the Van. Sunshine duration values are at lowest values in Bitlis. The monthly average sunshine duration displayed changing between 266 and 729 min for Van, 79 and 569 min for Bitlis. The simple function of the monthly average sunshine duration (SD) fit the sunshine duration data very well. The results of statistical analyses undertaken on

Model	Monthly average sunshine duration =						
	a-	$b \cdot \sin(m) + c \cdot$	$sin(2m) + d \cdot s$	$\sin(m/2+e) +$	-f·m		
City	Cons-	Model	R	χ^2	RMSE		
	a	550 849					
	b	9.476					
Elazığ	С	-17.66	0 00 606	560 581	17 374		
	d	309.566	0.99 000	500.561	17.374		
	e	29.334					
	J a	-15.503					
	u h	17 0438					
Erzincan	c	-12.181	0.00.004	140 070	15 554		
	d	194.336	0.99 224	449.272	15.554		
	е	41.901					
	f	-8.9174					
	a b	414.286					
	C C	-5 732					
Erzurum	d	242.411	0.99 382	578.584	17.651		
	е	431.515					
	f	-6.719					
	a	395.491					
Vore	b	25.163					
Kais	c d	4.144	0.99 126	577.074	17.628		
	e	167.760					
	f	-1.168					
	а	467.961					
	b	-3.520					
Agrı	c d	-13.659	0.99 874	140.660	8.703		
	u P	481 627					
	f	-13.875					
	a	417.268					
	b	21.314					
lgdır	С	-9.135	0.98 664	927.253	22.345		
	a	206.320					
	f f	-5.136					
	a	556.415					
	b	6.835					
Tunceli	С	-16.133	0.99 521	602.599	18.013		
	d	299.924					
	e f	412.314 -19.677					
	a	580.767					
	b	15.243					
Van	С	-25.283	0 99 757	216 658	10 801		
	d	244.779	0.337 101	210.000	10.001		
	e f	242.953					
	J	-13.192 527.667					
	b	16.933					
Malatya	С	-15.242	0 99 520	522 681	16 776		
	d	266.057	0.99 520	522.084	10.770		
	e	280.692					
	J	-9./80					
	u h	3.722					
Bingöl	c	-27.953	0.00.002	860 125	21 525		
-	d	243.847	0.98 983	000.435	21.323		
	e	85.825					
	f	-17.382					
	a h	-8 0482					
Mus	c	-15.795	0.00.001	00.510	7.000		
3	d	321.562	0.99 931	99.569	7.322		
	e	211.469					
	f	-19.343					

Table 11. The results of statistical analyses according to the model

(SD) for the monthly average sunshine duration

Table 11. Cor	itinuation				
City	Cons-	Model	P	~ ²	PMSE
City	tant	constants	Λ	λ	RIVISE
	а	402.781			
	b	30.753		1278.975	26.243
Bitlis	с	-23.861	0.00.010		
	d	257.439	0.98 818		
	е	16.897			
	f	-10.337			
	а	522.847			
	b	-10.204			
Hakkari	с	25.971	0.00 (25	426 125	15 140
	d	-19.386	0.99 623	420.123	13.148
	е	269.957			
	f	268.132			



trigonometric model for the monthly average sunshine duration are given in Table 11. The model was evaluated based on R, χ^2 and RMSE. Generally, R, χ^2 and RMSE values were varied between 0.98 664-0.99 931. 99.569-1278.975 and 7.322-26.243 respectively. The function has coefficients of determination of better than 0.98 and the lowest values of χ^2 and *RMSE* for all cities. Hence, the trigonometric model (SD) satisfactorily described characteristics of the monthly average sunshine duration. Considering trigonometric model (SD), the observed the monthly average sunshine duration values were compared with calculated ones. Figure 19 shows the comparison of the predicted and observed values of the monthly average sunshine duration. There is a good agreement between predicted and observed values.

CONCLUSION

In the study, it was attempted to determine and model how much the climatic elements for the period 1994– 2003 of thirteen cities in the east Anatolia region of Turkey. These data can be seen that:

 Malatya city is the hottest area whole period, while the Erzurum city is the coldest area. Maximum temperatures are at highest values in Tunceli. Minimum temperatures reach the warmest values in the Malatya. Minimum temperatures reach the

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coldest values in the Erzurum. Kars city is the most humid area almost throughout the period while Igdir is the least humid area. Wind speed reaches the highest values in the Erzurum and the lowest values in the Igdir. Pressure reaches the highest values in the Igdir and the lowest values in the Kars. Bitlis city is the most rainfall almost throughout the period while Igdir is the least rainfall area. Direct solar radiation reaches the highest values in the Tunceli and the lowest values in the Agri. Sunshine duration reaches the highest values in the Van and the lowest values in the Bitlis.

- (2) Regression models are presented for the weather data at the period 1994-2003 of thirteen cities in the east Anatolia region of Turkey. The best fits were for the monthly average temperature, maximum-minimum temperature, relative humidity, wind speed, solar radiation and sunshine duration. The model for the monthly average pressure and rainfall is also adequate. As seen from Figs 3, 5, 7, 9, 11, 13, 15, 17, 19, there are good agreements between predicted and observed values. In other words the new equations are able to predict effectively the monthly average variations of observed values. The three good indicators of solar and wind energy potential, temperature, maximum-minimum temperature, global radiation and sunshine hours have very high averages. These high values are maintained for a considerable part of the year. The functions presented for the parameters should enable the determination of specific parameter values and the prediction of missing values.
- (3) The factors thought to be effective on the climatic differences mentioned above may result from the features of the investigated cities. The factors thought to be effective on the differences determined in the present study are briefly canopy and evapotranspiration effects, elevation difference between the areas and surface roughness, radiation and reflection factors, smoke and dust, the duration and color of snow cover on the ground, wind direction and other anthropogenic effects of the investigated city. Depending on the location of the city center, prevalent easterly and northerly winds in this area is effective on temperatures and humidity, which can decrease temperatures and increase humidity. As is known, there is a true relationship between the population and temperature in a city center. This effect may be smaller compared to those aforementioned, because of the relatively low population and the city lacks of any industrial facilities that may influence the temperature in the city.

This study is expected to be useful in analyzing and interpreting the environmental and energy related issues.

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