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ANALYSIS OF CLIMATIC PARAMETERS WITH METEOROLOGICAL DATA OF EAST ANATOLIA REGION OF TURKEY

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Abstract

In this study, a 15-years of observation period is examined and modelled by means of using meteorological data and climate parameters such as pressure, temperature, humidity, wind speed, sunshine duration and solar radiation level of 13 provinces in the Eastern Anatolia Region of Turkey. Linear regression analysis was used in modeling climate parameters. With the use of the determined models, it has been determined that i) it can help the studies to be carried out on the effects of climate conditions on the environment and energy, ii) predictions can be made regarding the climate structures of the said provinces for the coming years, iii) solar energy stands out as an alternative energy potential for the cities studied.

Key Words: East Anatolia Region, climatic parameters, meteorological data, energy, temperature

1. Introduction

The need for energy is directly related to climate and weather conditions. It is a need for the climate and meteorology data to be known and analyzed in detail in order to determine the recent and present energy potential and problems of any settlement as much as possible, to carry out studies to improve the potential, as well as to find solutions to problems and to suggest alternatives (Bakirci et al., 2006); (Cobanyildizi & Yuksel, 2013). Climate data can be used in the following scopes: in designing buildings, planning agricultural production, heating houses and industrial areas in cold weather, cooling in hot weather (HVAC systems), solar collectors, solar cells, greenhouses, power plants and cooling towers, are dependent on weather variables like solar radiation, temperature, humidity, wind speed, etc. Global warming, population increase in provinces, green areas, industrialization and lakes or ponds created later lead to changes in climate structures (Bicer, 2019). For this reason, climatic parameters must to be updated over time.

A number of studies have been carried out on the subject and it is possible to divide these studies into two groups. The first group of studies are studies on the climate structures of the region. Some examples of these studies are given below.

Bakirci et al. (2006) conducted energy studies for Erzurum province using meteorological data. Turkey's climate classification structure, was conducted by Turkey State Meteorological Service (TSMS, 2017). Akpinar & Akpinar (2004) investigated the wind energy potential of Elazig province in their study. Akpinar et al. (2005) investigated the weather conditions and wind power of some provinces in the Eastern Anatolia Region. Akpinar & Akpinar (2010) conducted the modeling study of climatic parameters of Elazig Province and neighboring provinces. Emiroglu et al. (1996), Ozkan (1996), Sengun (2007) and Tonbul (1986) investigated the effect of Keban Dam Lake on the climate structure of Elazig in their studies. Bicer (2019) modeled the temperature and humidity parameters of the provinces in the Euphrates Basin using meteorological data. Bicer (2020-a) researched the climate parameters of Tunceli, Bingol and Mus provinces by means of using the related meteorological data. Bicer (2020-b) carried out the modeling study of temperature and humidity parameters of Malatya province. As similar to these studies, there are also studies carried out on the effects of dam lakes at the climate structures of provinces in different regions. Some of these studies are briefly mentioned below;

Studies on the effect of Atatürk Dam Lake on the climate structures of the Southeastern Anatolia Region were carried out by Bicer & Yildiz (1994), Yesilata et al. (2004) and Ekici (2008). Bacanli & Tugrul (2016) examined the effect of Gökpınar Dam Lake on the climate structure of the provinces of the region. Gyau-Boakye (2001) carried out a study on the effects of Akosombo dam on environmental climate change. Ozturk et al. (2015)

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examined the climate structure of the Mediterranean Basin. Apaydin et al. (2011) investigated the topographical and geographical effects using certain climate parameters in the Central Anatolia region of Turkey. Bai et al. (2014) investigated the effect of the Three Gorges Dam on the climate structure in the regions near in Japan.

Cobanyılmaz & Yuksel (2013) gave the Ankara example by examining the damages that cities can suffer from climate change. Fujihara et al. (2008) Seyhan River Basin in Turkey studied the effects of climate change on water resources. Geymen & Dirican (2016) analyzed sea level changes due to climate change. Apple et al. (2006) and Sen (2007) developed weather forecast models using meteorological values. Al-Garni et al. (1999) examined the climate structures of the eastern regions of Saudi Arabia and modeled the wind power of the region. Sahin (2007) developed a new formulation for solar radiation and sunshine duration prediction. Degu et al. (2011) investigated the effects of large dams on the climate and rainfall patterns of the surrounding provinces.

In this study, the climate parameters of the provinces Elazig, Malatya, Bingol, Tunceli, Erzincan, Erzurum, Kars, Agri, Ardahan, Igdir, Mus, Van and Bitlis in Eastern Anatolia Region of Turkey, (pressure, temperature, humidity, wind speed, sun intensity and sunshine duration), meteorological measurement results were updated and analyzed thus being modelled for 15 years (2006-2020) observation period (TMSD, 2020). Here, the objective is to predict the climate structures of the provinces for the coming years.

2. Geographical Location of the Eastern Anatolia Region

Eastern Anatolia Region of Turkey to the east of the country with a field of 164,000 km^2 surface area covers 21% (Fig. 1). Turkey ranks first among geographical regions in terms of the size of the square measurement. It covers the largest area in the north-south direction. The lowest point of the region is Igdir Plain (850m) and its highest point is Ardahan with an altitude of 2200 m (Table 1). The mountains in the region extend in the east-west direction and in three rows. In terms of the diversity of minerals and reserves, Eastern Anatolia region is richest region in Turkey. There are a number of dam lakes built on rivers in the west of the region. Through these dams major part of Turkey's electricity is generated in this region. The reservoirs formed later also affected the climate structure. Table 1 shows the names and locations of important meteorological stations in Eastern Anatolia. Eastern Anatolia region of Turkey has a typical highland climate, often cold in winter, hot in summer and there are significant temperature differences between night and day. In order to make the climatic structures of the cities in the Eastern Anatolia region more conveniently, the region was divided into 3 Zones (Fig. 2). Daily observed parameters at the measurement stations of the provinces in each zone are as follows: pressure, temperature, relative humidity, wind speed, sunshine duration and solar radiation. Measurements were performed by the Turkish Meteorological State Department (TMSD) with conventional meteorological instruments. The Department produces monthly summaries of this data. The data for the present study is obtained from the summaries of 2006 to 2020.

Figure 1. Geographical districts of Turkey ((URL-1, 2021)

Located in the Eastern Anatolia Region of Turkey's, 13 provinces are divided into three zone and climate structures were investigated accordingly. The first zone includes Elazig, Malatya, Bingol, Tunceli and Erzincan, the second

zone includes Erzurum, Kars, Agri, Ardahan and Igdır, and the third zone includes the provinces of Mus, Van, and Bitlis (Fig. 2).

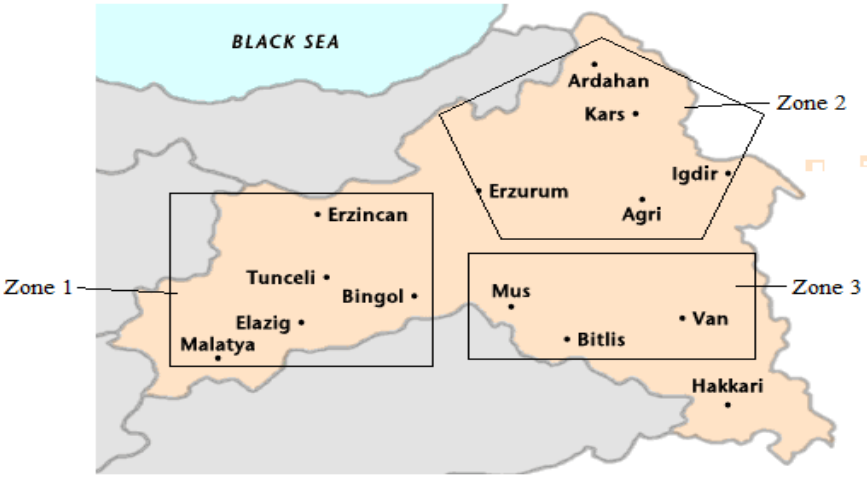
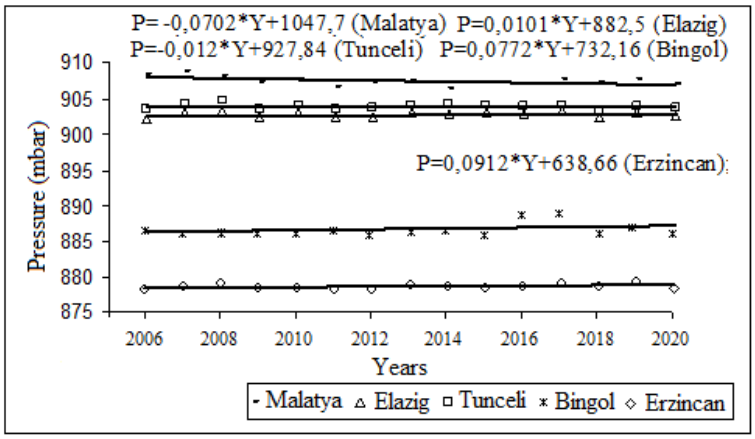


Figure 2. Cities in the Eastern Anatolian Region (URL-2, 2021)

3. Climate Parameters of Region Provinces

3.1. Pressure

The results of pressure parameter measurement obtained during the 15-year observation period (2006-2020) for the provinces of the Eastern Anatolia Region are shown in Figure 3 by years. In this process, the annual average pressure values are in the following range on provincial basis: Malatya 906,3-908,7 mbar, Elazig 902.3-903.3 mbar, Tunceli 903.1-904.6 mbar, Bingol 885.6-888.8 mbar, Erzincan 877.6-878.9 mbar, Erzurum 822.4-824.0 mbar, Kars 819.9-822.6 mbar, Agri 833.6-837.0 mbar, Ardahan 816.5-819.6 mbar, Igdir 915.9-918.5 mbar, Mus 868.1-870.9 mbar, Bitlis 840.7-841.9 mbar and Van 830.9-832.1 mbar.



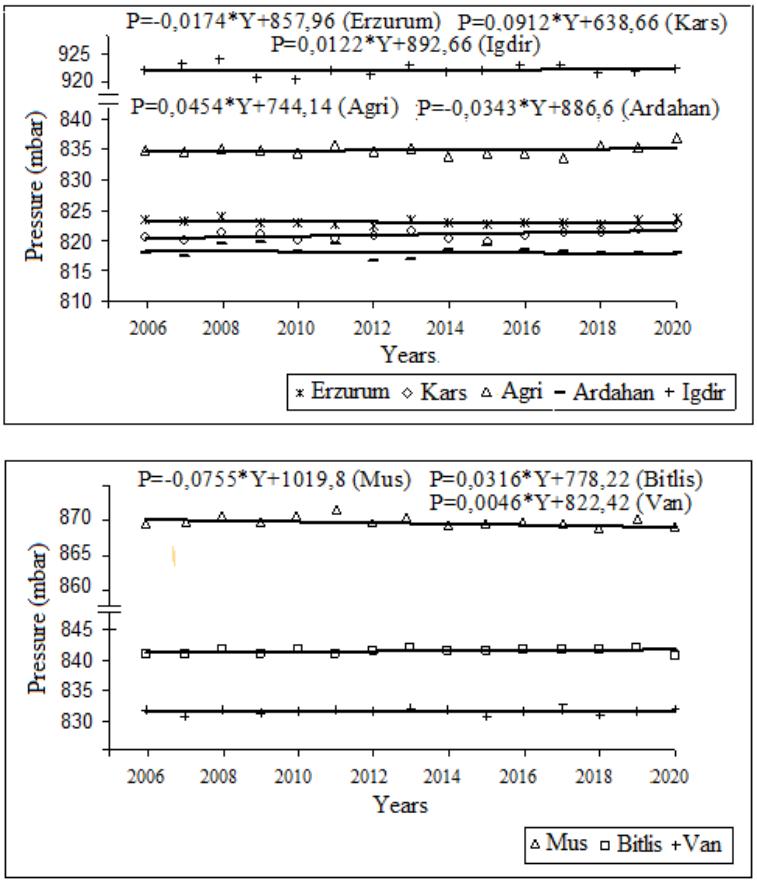
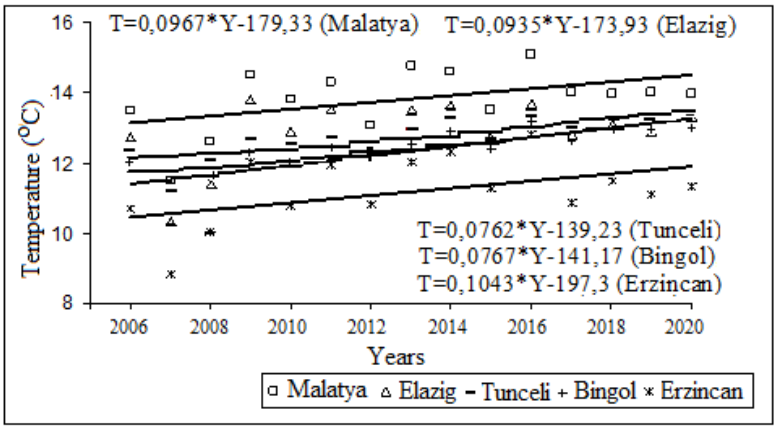


Figure 3. Change of pressure parameters of provinces by years

3.2. Temperature

Annual average temperature parameter in a 15-year observation period (2006-2020) of the provinces of the Eastern Anatolia Region is shown in Figure 4. During the observation process examined, the annual average temperature values were observed in the following range on a provincial basis: Malatya 11.5-15.1 °C, Elazig 10.3-13.8 °C, Tunceli 10.2-14.2 °C, Bingol 9.5-13.5 °C, Erzincan 8.4-12.8 °C, Igdir 10.0-13.5 °C; Agri 3.6-7.6 °C, Erzurum 2.4-6.3 °C, 2.9-6.3 °C for Kars, Ardahan 1.7-5.4 °C, Mus 6.6-12.0 °C, Bitlis 7.4-10.6 °C, Van 7.6-10.8 °C.



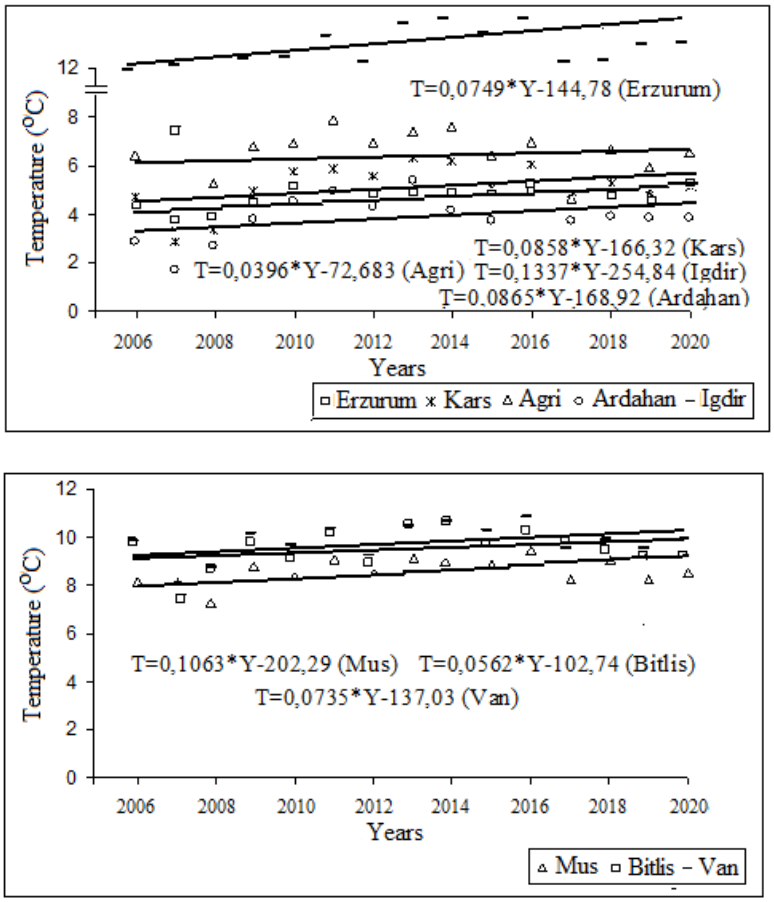
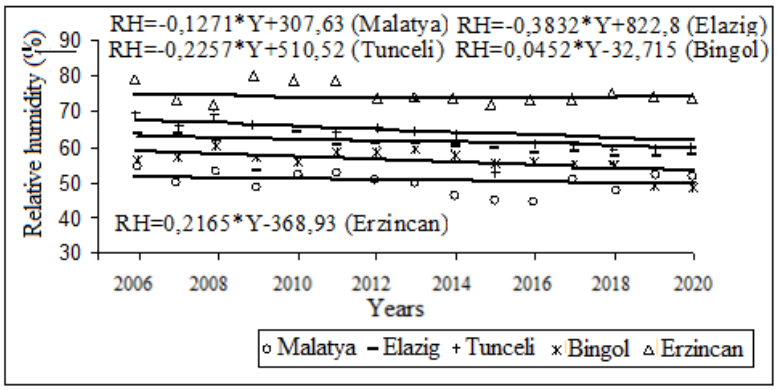


Figure 4. Change of temperature parameters of provinces by years

3.3. Relative Humidity

The relative humidity parameters for the provinces of Eastern Anatolian Region measured within an observation period of 15 years are shown in Figure 5. As can be seen in Figure 5, the annual average relative humidity for the period between 2006-2020 are as follows on provincial basis: Erzincan 59-66%, Tunceli 51-67%, Elazig 51-63%, Bingol 50-61%, Malatya 47-59%, Erzurum 61-71%, Kars 69-79%, Agri 61-80%, Ardahan 63-77%, Igdir 41-58%, Mus 58-68%, Bitlis 61-74%, Van 49-67%.



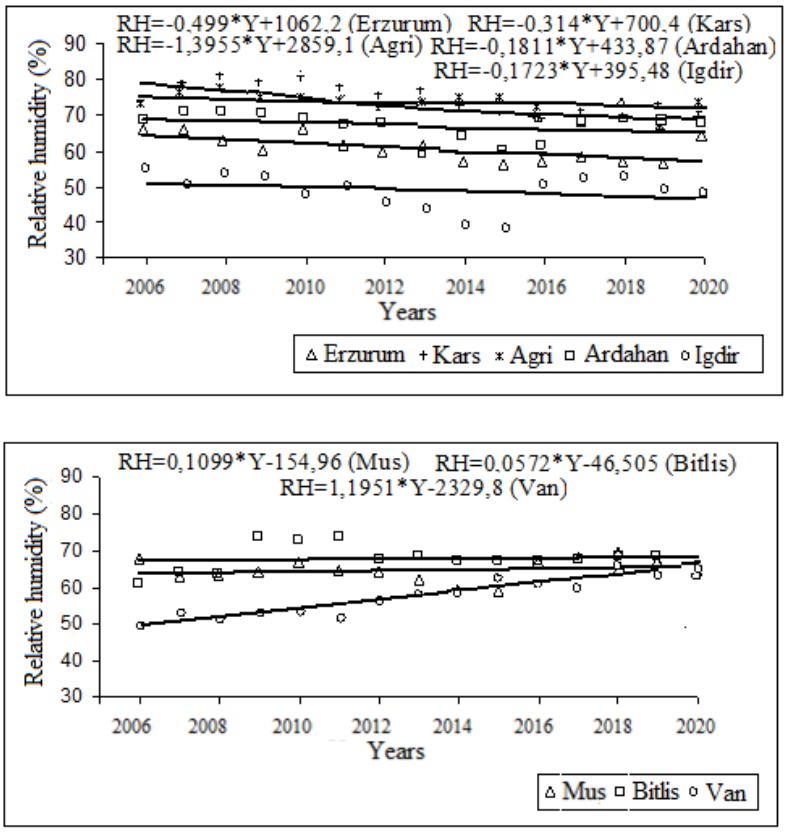
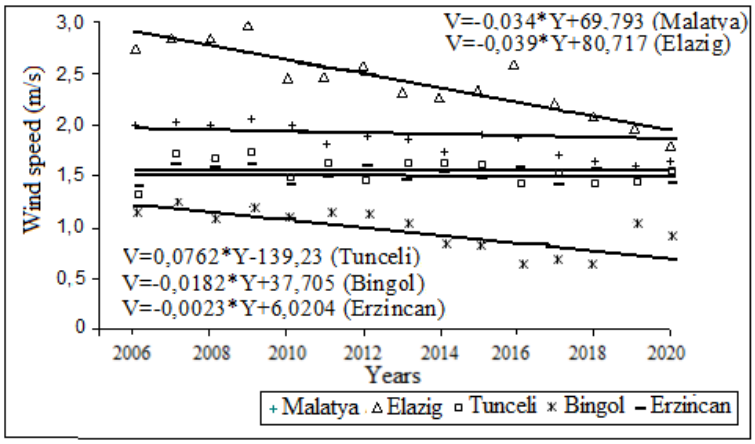


Figure 5. Change of humidity parameters of provinces by years

3.4. Wind Speed

Wind speed is shown in Figure 6 during a 15-year observation period of the provinces of the Eastern Anatolia Region. Wind speeds in the region are as follows on provincial basis: Elazig 2.3-3.0 m/s; Malatya 1.6-2.1 m/s; Erzincan 1.4-1.6 m/s; Tunceli 1.1-1.3 m/s; Bingol 0.8-1.5 m/s; Erzurum 2.4-3.2 m/s; Kars 2.2-2.9 m/s; Ardahan 1.7-2.1 m/s; Agri 0.9-1.9 m/s; Igdir 1.0-1.6 m/s, Mus 0.9-1.5 m/s, Bitlis 1.4-2.5 m/s and Van 2.2-2.9 m/s



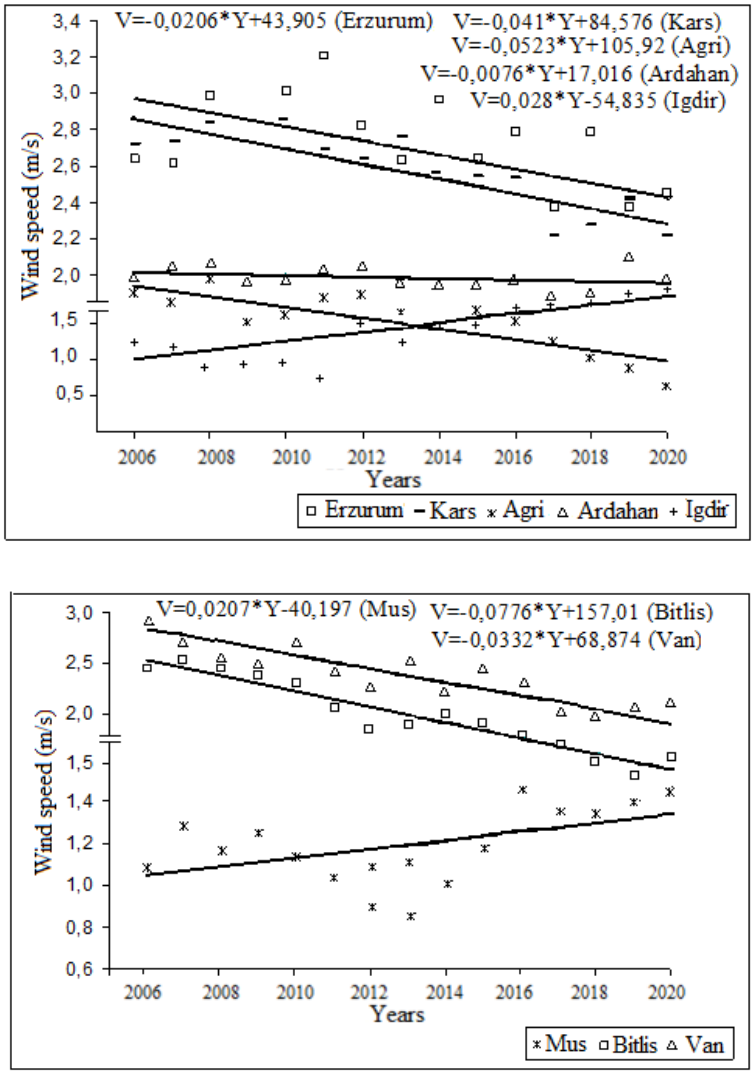


Figure 6. Change of wind speed parameters of provinces by years

3.5. Sunshine Duration

The variation of average sunshine duration during a 15-year observation period for the provinces of the Eastern Anatolia Region is shown in Figure 7. If the figure is examined, the average sunshine duration of the provinces in the region is as follows: Malatya 7.2-8.4 h, Elazig 7.2-8.2 h, Tunceli 6.9-7.9 h, Bingol 6.2-7.5 h, Erzincan 5.0-6.7 h, Igdir 5.7-7.1 h, Kars 5.7-7.0 h, Agri 5.7-6.9 h, Erzurum 6.1-6.8 h, Van 7.8-8.9 h, Mus 6.3-8.3 h, Bitlis 5.0-6.3 h.

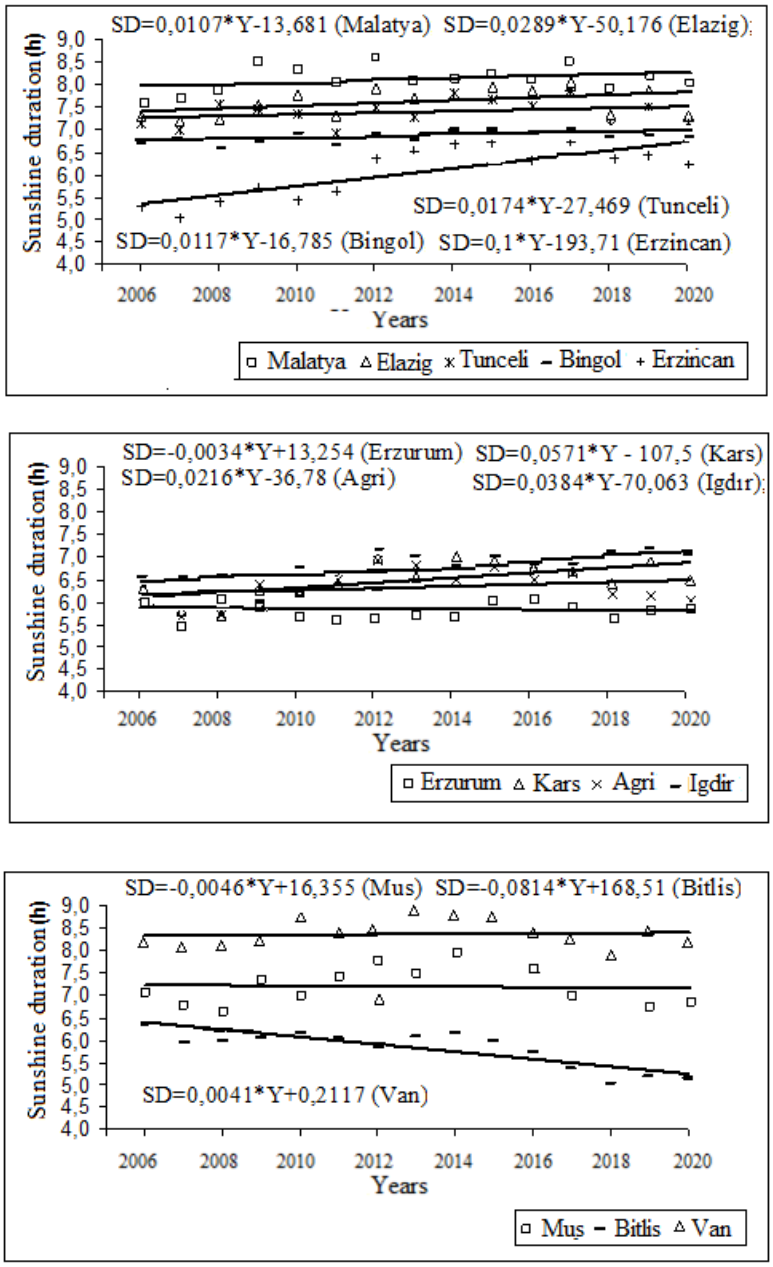


Figure 7. Change of sunshine duration parameters of provinces by years

3.6. Solar Radiation

The average annual solar radiation variation during a 15-year observation period for the provinces of the Eastern Anatolia Region is shown in Figure 8. If the figure is examined, the sunshine duration variation of the provinces in the region is as follows:

Tunceli 366.45-407.98 cal/cm^2, Malatya 344,31-396,29 cal/cm^2, Elazig 350.57-378.33 cal/cm^2, Bingol 345.46-383.77 cal/cm^2, Erzincan 289.24-381.43 cal/cm^2, Erzurum 331.73-410.08 cal/cm^2, Kars 325.02-374.51 cal/cm^2, Igdir 320.36-367.95 cal/cm^2, Agri 284.82-368.86 cal/cm^2, Van 420.01-469.44 cal/cm^2, Bitlis 303.12-358.16 cal/cm^2, Mus 284.02-372.63 cal/cm^2.

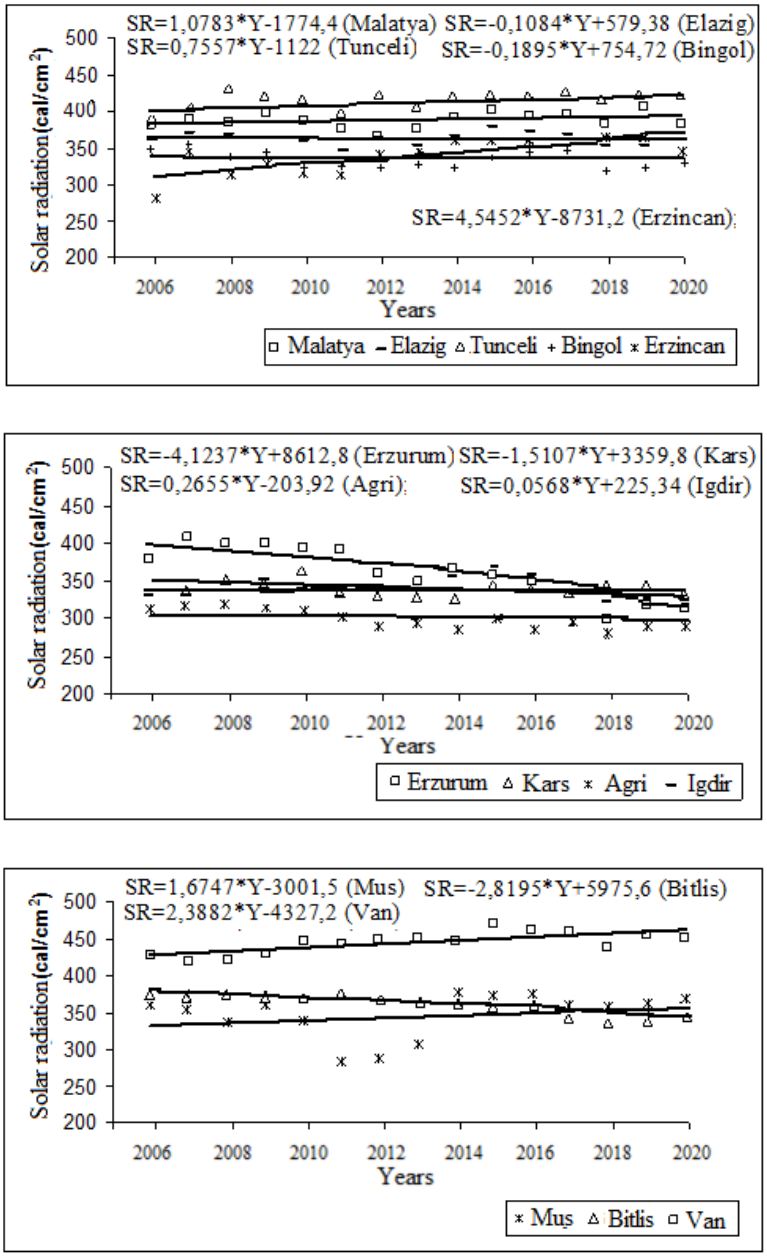


Figure 8. Change of solar radiation parameters of provinces by years

4. Results and Discussions

Examining the Figure 3, it can be seen that the change of annual average pressure values for the observation period determined in all of the provinces examined remains almost constant. The province with the highest pressure value in the region is Igdir (915.9-918.5 mbar) and the smallest is Ardahan (816.5-819.6 mbar).

As can be seen in Figure 4, it is seen that the slopes of the curves consisting of annual average temperature values are increasing, albeit very small. Especially the dams and lake fields (Keban Dam reservoir area and Karakaya Dam and lake area) established on the Firat River affected the climate of Elazig, Malatya, Bingol and Tunceli provinces, causing the temperature parameter to rise significantly in winter and cool slightly in summer. Igdir province is the smallest city in the region and its climate is close to the Mediterranean climate. Therefore, the annual average temperature values are high. There is a slight increase in the average temperatures of the other cities studied. It can be said that the reason for this increase is due to the global warming of the world under the

greenhouse effect. The province with the highest annual temperature averages in the region was determined to be as Malatya (11.5-15.1 °C), and the smallest one Ardahan (1.7-5.4 °C).

Examining Figure 5, the temperature increase caused by the dam lakes especially in the provinces in the 1st zone caused the annual relative humidity averages to decrease slightly in the winter season and increase in the summer season. In brief, as the annual average temperature values of the provinces increase, the annual average relative humidity rates decrease. The province with the highest annual humidity averages in the region was determined as Kars (69-79%) and the smallest as Igdir (41-58%).

As can be seen in Figure 6, the region is not strong in terms of wind speed. The province with the highest annual wind speed averages in the region was determined as Erzurum (2.4-3.2 m/s) and the smallest was Bingol (0.8-1.5 m/s). It has been determined that wind power is almost negligible in provinces of Tunceli, Bingol, Agri, Igdir and Mus. In Erzurum, Kars (2.2-2.9 m/s), Elazig (2.3-3.0 m/s), and Van (2.2-2.9 m/s), it has been determined that it can be used for pumping water and for meeting the electricity needs of small businesses.

Examining Figure 7, it can be seen that Eastern Anatolia Region provinces are quite suitable for solar energy applications in terms of sunshine duration, especially Tunceli, Malatya, Elazig, Van and Mus provinces. The province with the longest sunshine duration in the region is Van (7.8-8.9 h) and the shortest one is Bitlis (5.0-6.3 h). As the sunshine duration time increases, the temperature increases, as well. Temperature values are high due to the long insolation period in summer. Again, the fact that the highest temperatures during the day are not exactly at noon but a few hours in the afternoon is related to the sunshine duration time. At night, on the other hand, cooling is observed as no energy is taken from the sun. Therefore, the coldest moment of the day is the moment before sunrise in the morning.

In the provinces of the Eastern Anatolia Region, the solar radiation was highest in Van, Tunceli, Malatya and Elazig, but it was found to be high in all provinces (Fig. 8). When the 15-year average values of insolation intensity were calculated, it was determined that Van province (420.01-469.44 cal/cm^2) had the highest value and Agri province (284.82-368.86 cal/cm^2) had the lowest average value.

The monthly and annual air parameters change of the regional provinces are shown in Figure 9, Figure 10 and Figure 11. In the provinces, sunshine duration and solar radiation as well as wind speed values has the minimum in winter and maximum values in summer. It shows an increasing trend from spring to summer, and a decreasing trend from autumn to winter.

The main sources of income in the Eastern Anatolia Region are agriculture and animal husbandry. A number of agricultural products are grown in this region. Most of these products, which are consumed fresh during the production period, are dried. With the development of the ready-made food production industry, the demand for dried products is increasing day by day. Due to the potential of the region for solar energy, it is possible to use renewable energy sources such as the sun as an energy source in dryers designed to dry agricultural products in closed systems. In addition, it will be possible to use solar energy for heating water, houses and greenhouses. Solar energy can be used to obtain the necessary cooling for both air conditioning and the preservation of products such as foodstuffs and medicines without deterioration.

The models of climate parameters of the studied provinces were determined on the computer together with linear regression correlations in Excel and are shown collectively in Table 2. With these models, it will be possible to predict the climate parameters of these provinces in the coming years and to determine the effects of these predicted weather conditions on the environment.

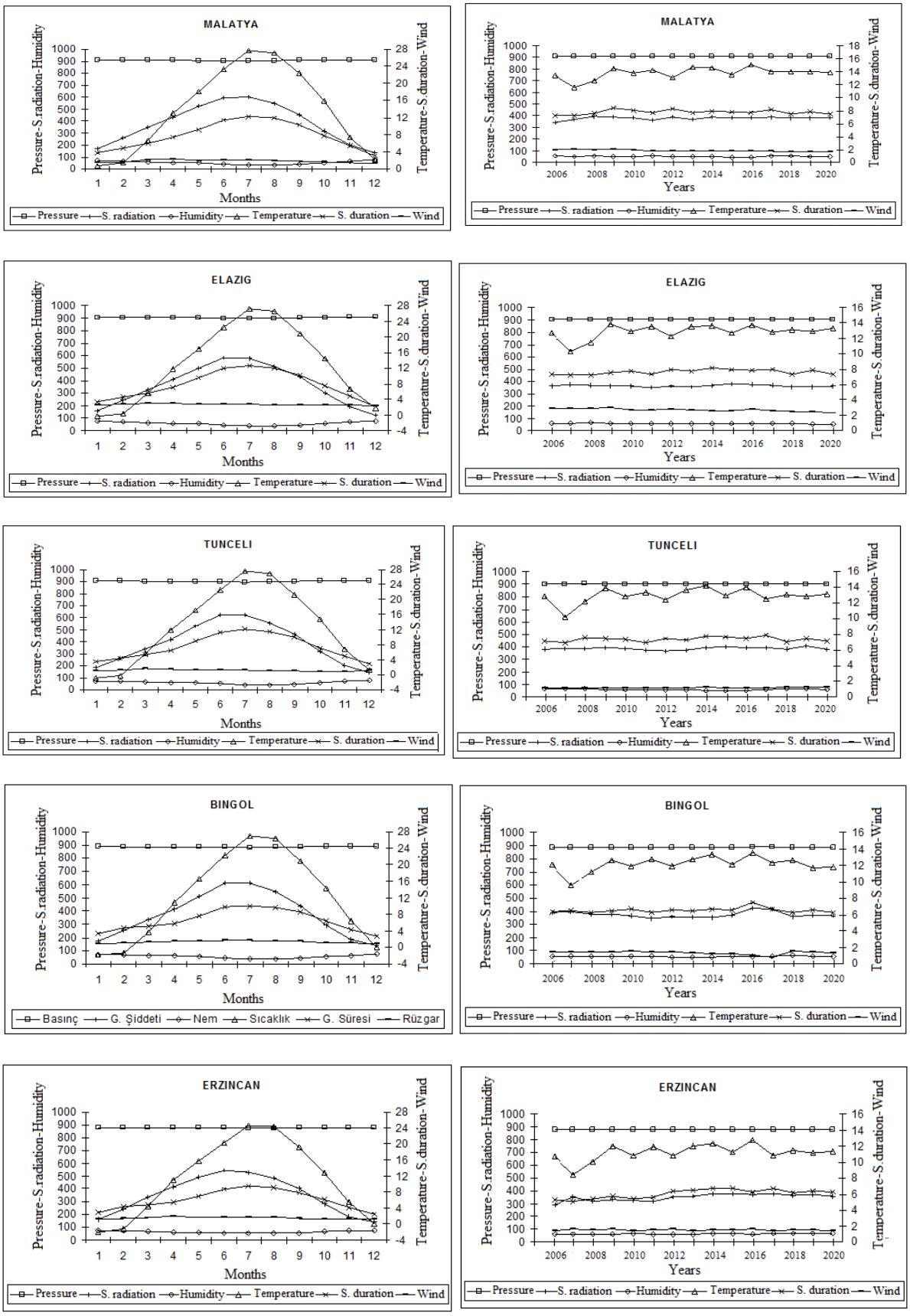


Figure 9. Monthly and yearly change of weather parameters of province in Zone-1

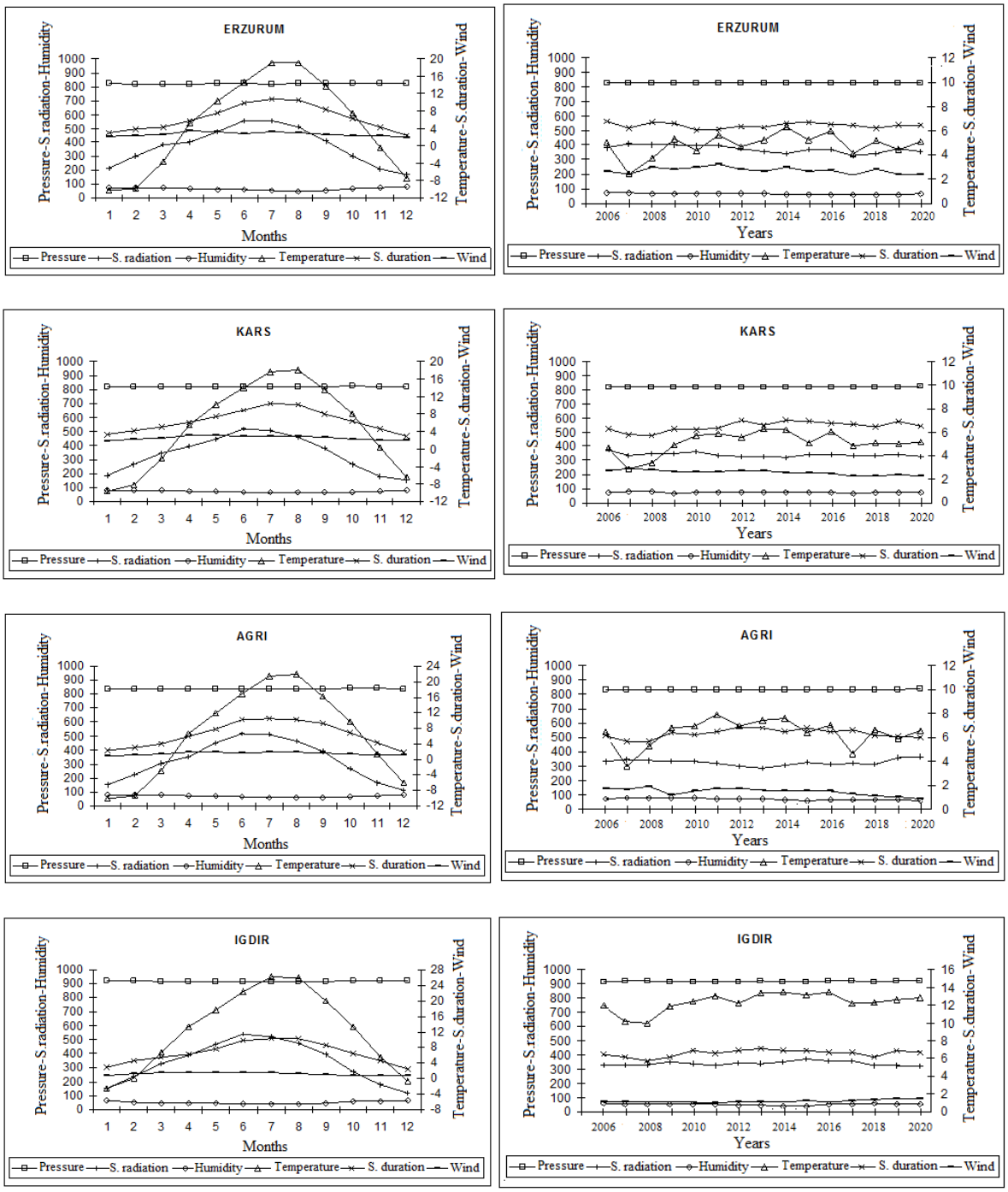


Figure 10. Monthly and yearly change of weather parameters of province in Zone-2

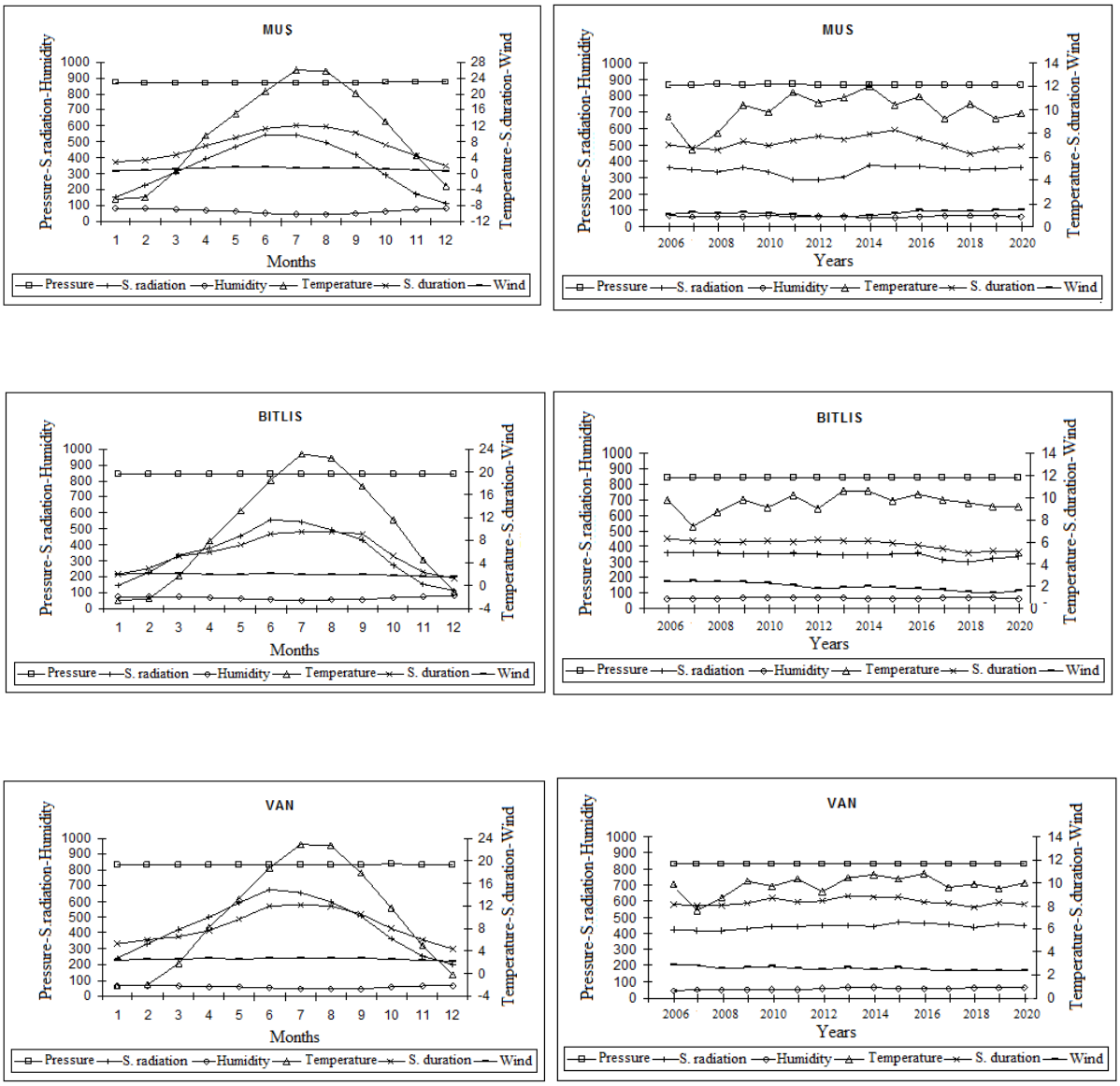


Figure 11. Monthly and yearly change of weather parameters of province in Zona-3

Table 2. Regression equations of climate parameters of provinces

Climate parameters						
City	Pressure	Temperature	Relative humidity	Wind speed	Sunshine duration	Solar radiation
Zone1						
Malatya	P=-0,07*Y+105 R^2=0,9472	T=0,097*Y-179 R^2=0,4641	RH=0,127*Y+307,63 R^2=0,4456	V=0,034*Y+69 R^2=0,3936	SD=0,0107*Y-13,681 R^2=0,4142	SR=1,078*Y-177 R^2=0,7538
Elazig	P=0,01*Y+882 R^2=0,9514	T=0,094*Y-173 R^2=0,3763	RH=-0,3832*Y+822,8 R^2=0,5262	V=0,039*Y+80 R^2=0,4041	SD=0,0289*Y-50,176 R^2=0,4238	SR=-0,11*Y+579 R^2=0,7623
Tunceli	P=0,011*Y+727 R^2=0,9278	T=0,073*Y-133 R^2=0,2736	RH=0,218*Y+485,25 R^2=0,5146	V=0,073*Y-121 R^2=0,4033	SD=0,0165*Y -26,458 R^2=0,4026	SR=0,657*Y-101 R^2=0,6738
Bingol	P=0,063*Y+62 R^2=0,9342	T=0,078*Y-128 R^2=0,4838	RH = 0,0425*Y - 34,5 R^2=0,4631	V=0,018*Y+35 R^2=0,3928	SD=0,0123*Y - 18,57 R^2=0,3937	SR=0,176*Y+744 R^2=0,4930
Erzincan	P=0,09*Y+638 R^2=0,9715	T=0,104*Y-197 R^2=0,2139	RH=0,2165*Y-368,93 R^2=0,6141	V=0,0023*Y+6 R^2=0,4022	SD=0,1*Y-193,71 R^2=0,3822	SR=4,545*Y-873 R^2=0,4641
Zone 2						
Erzurum	P=-0,017*Y+85 R^2=0,9415	T=0,074*Y-144 R^2=0,3827	RH=-0,499*Y+1062,2 R^2=0,4827	V=-0,02*Y+43 R^2=0,2033	SD=-0,0034*Y+13,2 R^2=0,4140	SR=-4,1*Y+8612 R^2=0,6836
Kars	P=0,09*Y+638 R^2=0,9527	T=0,086*Y-166 R^2=0,2323	RH=-0,314*Y+700,4 R^2=0,4035	V=-0,04*Y+84 R^2=0,2326	SD = 0,0571*Y – 107 R^2=04038	SR=-1,5*Y+3359 R^2=0,6012

Agri	P=0,045*Y+74 R^2=0,9478	T=0,0396*Y-72 R^2=0,1538	RH=-1,3955*Y+2859 R^2=0,5138	V=-0,05*Y+10 R^2=0,2138	SD=0,0216*Y-36,78 R^2=0,4228	SR=0,265*Y-203 R^2=0,7033
Ardahan	P=-0,034*Y+88 R^2=0,8777	T=0,086*Y-168 R^2=0,1827	RH=-0,1811*Y+433,8 R^2=0,3742	V=-0,07*Y+17 R^2=0,3926	-	-
Igdir	P=0,012*Y+89 R^2=0,9515	T=0,134*Y-254 R^2=0,2033	RH=-0,1723*Y+395,4 R^2=0,3521	V=0,028*Y-54 R^2=0,2522	SD=0,0384*Y-70,063 R^2=0,4023	SR=0,057*Y+225 R^2=0,7122
Zone 3						
Mus	P=0,057*Y+97 R^2=0,9617	T=0,094*Y-220 R^2=0,2039	RH=0,0898*Y-145,69 R^2=0,4952	V=0,024*Y- 38 R^2=0,2036	SD=-0,0046*Y+16,35 R^2=0,4631	SR=1,54*Y- 2002 R^2=0,4238
Bitlis	P=0,032*Y+78 R^2=0,9813	T=0,056*Y-102 R^2=0,2742	RH=0,0572*Y-46,505 R^2=0,3846	V=0,07*Y+157 R^2=0,3926	SD=-0,0814*Y+168 R^2=0,5150	SR=-2,82*Y+597 R^2=0,6822
Van	P=0,005*Y+82 R^2=0,9839	T=0,074*Y-137 R^2=0,2928	RH=1,1951*Y -2329,8 R^2=0,4752	V=0,033*Y+68 R^2=0,2837	SD=0,0041*Y+0,2117 R^2=0,4542	SR=2,388*Y-432 R^2=0,7020

5. Conclusions

In this study, the Eastern Anatolia Region of Turkey's meteorological data available for the 15-year observation period of 13 provinces in the Eastern Anatolia Region of Turkey was used. Accordingly, the climate parameters of the provinces were examined and the following results were obtained by determining the change models.

- ✓ While Malatya province is the warmest region of the entire period, Ardahan city is the coldest region. During this period, Kars province was determined as the one with highest humidity and Igdir province with the least humidity. Highest wind speed values are in Erzurum and the lowest in Bingol and Mus. The pressure is the highest in Igdir and lowest in Ardahan. The highest values of direct sunlight were in Tunceli and the lowest values were in Agri. The insolation duration is the highest in Van and the lowest in Bitlis.
- ✓ Regression models for the thirteen provinces in the 2006-2020 period on the weather data for the Eastern Anatolia region of Turkey is presented. With these models, it will be possible to predict the climate parameters of these provinces in the coming years and to determine the effects of these predicted weather conditions on the environment.

- ✓ Climate parameters are to be updated, both due to the dam lakes created in the region and global warming. This study will surely help update the climatic parameters of the provinces, on which the related studies are carried out.

- ✓ Such meteorological studies will be a guide in the use of renewable energy sources. With this study, solar energy use comes to the forefront when temperature, insolation duration and solar radiation parameters are considered as an alternative energy source for the provinces of the region. Therefore, it will be able to benefit from solar energy as an energy source for hot water production, residential and greenhouse heating, and drying of agricultural products in technical dryers in the region. The wind energy potential of the provinces of the region is almost nonexistent.

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References

1. **Akpinar, E.K. & Akpinar, S. (2004).** An Analysis of the Wind Energy Potential of Elazig. Turkey. *Int. J. Green Energy* 1(2), 193–207.
2. **Akpinar, E.K., Bicer, Y., Erdogan, B. & Cetinkaya, F. (2005).** Investigation of Weather Conditions and Wind Power of Some Provinces in the Eastern Anatolia Region. *15. Thermal Science and Technology Congress* 7-9 September 2005, Trabzon, Turkey.
3. **Akpinar, S. & Akpinar, E.K. (2010).** Modeling of Climatic Parameters and Determination of Climatic Differences in the City of Elazig-Turkey and its Close Regions *Journal of Environmental Protection*, 1: 41-52.
4. **Al-Garni, A.Z. & Sahin, A.Z. (1999).** A. Modelling of Weather Characteristics and Wind Power in the Eastern Part of Saudi Arabia, *International Journal of Energy Research*, 23, 805-812.

5. **Apaydin, H., Anli, A.S. & Ozturk, F. (2011).** Evaluation of Topographical and Geographical Effect on some Climatic Parameters in the Central Anatolia Region of Turkey. *International Journal of Climatology*, 31, 1264-1279.
6. **Apple, L.S.C., Chow, T.T., Square, K.F.F. & Lin, J.Z. (2006).** Generation of a typical meteorological year for Hong Kong. *Energy Conversion and Management*, 47, 87–96.
7. **Bacanli, U.G. & Tugrul, A.T. (2016).** A Climate Impact of Dam Lake and Recep Yazicioglu Gokpinar Dam Lake Sample, *Pamukale University Journal of Engineering Sciences*, 22(3), 154-159.
8. **Bai, Y., Xu, Z., Zhang, J., Mao, D., Luo, C., He, Y., Liang, G., Lu, B., Bisesi, M.S., Sun, Q., Xu, X., Yang, W. & Liu, Q. (2014).** Regional Impact of Climate on Japanese Encephalitis in Areas Located near the Three Gorges Dam. *PLoS ONE*, 9(1), 1-9.
9. **Bakirci, K., Ozyurt, O., Yilmaz, M. & Erdogan, S. (2006).** Climate and Meteorological Data for Energy Studies in Erzurum Province, *Journal of Plumbing Engineering*, 9(5), 19-26.
10. **Bicer, A. (2019).** Temperature and Relative Humidity Models of the Region Cities in Firat Basin, Bartın.
11. **Bicer, A. (2020-a).** Analysis of Climatic Parameters of Tunceli, Bingol and Mus Provinces with Meteorological Data, *International Journal of Eastern Anatolia Science Engineering and Design*, 2(1), 120-133.
12. **Bicer, A. (2020-b).** Temperature and Relative Humidity Models of the Malatya City, *MTU Journal of Engineering and Natural Sciences* 1(1), 11-18.
13. **Bicer, Y. & Yildiz, C. (1994).** Investigation of the Effect of Atatürk Dam Reservoir on Sanlıurfa's External Temperature Parameter, *3. National Refrigeration and Air Conditioning Congress*, 333-340, 4-6 May 1994, Adana, Turkey.
14. **TSMS, (2017).** Climate Classifications, Turkey State Meteorological Service (TSMS), Research Department, climatological division, 1-16, Ankara, Turkey.
15. **Cobanyilmaz, P. & Yuksel, U.D. (2013).** Determination of Vulnerability of Cities to Climate Change: The Case of Ankara. *Suleyman Demirel University Journal of Natural and Applied Science*, 17(3): 39-50.
16. **Degu, A.M., Hossain, F., Niyogi, D., Pielke, R., Hepherd, J.M., Voisin, N. & Chronis, T. (2011).** The Influence of Large Dams on Surrounding Climate and Precipitation Patterns. *Geophysical Research Letters*, 38(4), 1-7.
17. **Ekici, A. (2008).** Climate Impacts of GAP on Southeast Anatolia. *MSc Thesis*, Istanbul Technical University, İstanbul, Turkey.
18. **Emiroglu, M.E., Ozkan, F. & Ozturk, M. (1996).** A Research on the Effect of Keban Dam Reservoir on Elazig Province Climate Conditions, *GAP I. Engineering Congress*, 6-7 May 1996, PP: 167-174, Sanliurfa, Turkey.
19. **Fujihara, Y., Tanaka, K., Watanabe, T., Nagan, T. & Kojiri, T. (2008).** Assessing the Impacts of Climate Change on the Water Resources of the Seyhan River Basin in Turkey: Use of Dynamically Downscaled Data for Hydrologic Simulations". *Journal of Hydrology*, 353(1-2), 33-48.
20. **Geymen, A. & Diricana, A.Y. (201**6). Analyzing Sea Level Change due to Climate Change Using Geographic Information Systems. *Journal of Map Technologies*, 8(1), 65-74.
21. **Gyau-Boakye, P. (2001).** Environmental Impacts of the Akosombo Dam and Effects of Climate Change on the Lake Levels. *Environment, Development and Sustainability*, 3(1), 17-26.
22. **Ozkan, F. (1996).** Investigation of the Effect of Keban Dam Lake on the Climate Conditions of Elazig Region, *MSc Thesis*, Firat University, Elazig, Turkey.
23. **Ozturk, T., Ceber, Z.P., Turkes, M. & Kurnaz, M.L. (2015).** Projections of Climate Change in the Mediterranean Basin by Using Downscaled Global Climate Model Outputs, *International Journal of Climatology*, 35, 4276-4292.
24. **Sahin, A.D. (2007).** A New Formulation for Solar Irradiation and Sunshine Duration Estimation. *Int. J. Energy Res.* 31(2), 109–118.
25. **Sen, Z. (2007).** Simple Nonlinear Solar Irradiation Estimation Model. *Renewable Energy*, 32:342–350.
26. **Sengun, M.T. (2007).** The Effect of Keban Dam on Elazig Climate. *Eastern Anatolia Region Studies*, PP: 116-121.
27. **TMSD (2020).** Turkish Meteorological State Department, Climatological Service, Ankara, Turkey.
28. **Tonbul, S. (1986).** Climate Characteristics of Elazig and its Surroundings and the Effects of Keban Dam on the Local Climate. *Geography Congress*, 14-15 April 1986, Elazig, Turkey.
29. **URL-1, (2021),** https://www.mapsofworld.com/turkey/geography, April, 04, 2021
30. **URL-2, (2021),** https://www.allaboutturkey.com/eastern-anatolia, April, 04, 2021
31. **Yesilata, B., Bulut, H. & Yesilnacar, M.I. (2004).** Investigation of the Change Trend in Temperature and Humidity Parameters Originating from the Reservoir in the GAP Region, *Journal of Plumbing Engineering*, 83, 21-31.