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Daily Minimum and Maximum Temperature Estimation by Regression Analysis for Karaman City

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ABSRACT

In this study, it was aimed to be predicted the maximum and minimum air temperature for the province Karaman by using the variables of 850hpa temperature, daily sunshine duration, mean temperature, relative humidity, and mean pressure.

The prediction of maximum and minimum temperature belonging to the first months of four seasons was firstly made by 850hpa temperature and then, adding the variables of daily sunshine duration, mean temperature, relative humidity, and mean pressure to this in order, regression equations were obtained.

In general, in the prediction of minimum and maximum air temperature, regression model, in which the independent variables of 850hpa temperature, daily sunshine duration, and mean temperature, gave better results and, the addition of independent variables of mean pressure and relative humidity to the model did not cause a significant increase in determination coefficients.

1. Introduction

Besides that agricultural sector has critical importance in terms of world population, it has an idiosyncratic structure as an activity area influenced from the economic, social, political, technological, and personal risks at the high level (Bölükbaşı & Pamukçu, 2009). Meteorological data are used in many agricultural areas such as identifying the necessary potential for establishing wind and solar power plant in the region, calculating the cooling desires of vegetables, planning irrigation, planning the land and air transport, predicting harvest season, arranging fertilization time. For future predictions, various methods are used. However, since the air has a very dynamic structure and is also affected from many factors, it is necessary to very well scrutinize the methods used for prediction and factor affecting weather conditions. Following air masses on synoptic meteorological maps, formed by observations of the ground and high altitude level, while the parameters such as temperature, wind and pressure are tried to be predicted, together with today's developing technology, meteorological satellites and meteorological radars have become available. While the people keep living, they need the amounts and adequacies of meteorological data such as wind, temperature and humidity in the living areas (e.g. agriculture, settling, tourism), where they realize their social, cultural and economic activities. However, since the measurements of these parameters are made in certain places, using measurements made in some selected places, these parameters are identified by means of experimentally accepted correlations (Deniz et al., 2006).

Agricultural Meteorology is a sub branch of meteorology examining the relationships between agricultural activities and climate (the relationships of meteorology with agriculture). It is a scientific branch engaging in the physical features of the developing plant and animal organisms, and it can also be defined as a scientific branch examining what physical developments occurring in this environment are and how the development and physical features under consideration are also affected by the findings identified for the benefit of agriculture. It also examines atmosphere and the relationship of environment, in which the parts of plants that are in contact with air develops, with thermal regime and land surface. Helping the plans of soil conservation and irrigation, giving warnings about forest fires, forming a basis regarding the necessary warnings by making frost predictions, planning cultivation and harvest dates, selecting center in rural area and

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designing buildings, supervising the diseases from pests and plants, making some microclimatological evaluations (e.g. planning greenhouses) are of application areas of agricultural meteorology.

The people as well as animals are affected from meteorological factors and suffer from especially temperature and humidity. With global warming, whose impact is more felt in the recent years, temperature stress leads to the important milk losses in dairy cows. In dairy cows, in order to identify the temperature stress, the different indices are used. These indices are generally termed as “Temperature-Humidity” index. Regarding to the index value calculated, the stress level dairy cows expose to and in what rate the fall in milk production may be predicted (Nadaroğlu et al., 2015).

The cold and heat-resistance maps of the plants are used in deciding whether or not a perennial plant considered first time to be cultivated in a region will be cultivated in that region in terms of temperature. The plants survive in the regions, where climatic requirements are met and they can strengthen to the extreme climatic conditions. While the most suitable cultivation area for plants, all plant-climate requirements are together evaluated. In related to resisting of the plants against climactic conditions, their resistance limits for each meteorological factor were determined (Nadaroğlu et al., 2015).

In the determinations made in Karaman and its vicinity by Karaman Provincial Directorate of Agriculture, between the dates of 24.04.2017-28.04.2017 corresponding to inflorescence period, minimum temperature fell to -4.6°C. Due to frost event that occurred in this period, in the red apples, the damage was identified in the rate of 50-100% and in the sorts of Golden and Grammy Smith, in the rate of 20-50%. In the same period, frost damage was identified in the rate of 50-100% in apricot and walnut and in the rate of 40-60% in almond and cherry. The economic value of these damages was about TL 295.373.168.

Some researchers (Deniz et al., 2006; Minaz et al., 2012) predicted minimum and maximum air temperature by multiple regression methods; some researchers (Çınar, 2009; Erkaymaz & Yaşar, 2011; Minaz et al., 2013), by YSA method; and some researchers (Beşel & Kayıkçı, 2016) by the method of trend analysis.

In this study, it was aimed to be predicted the minimum (Y_1) and maximum air temperature (Y_2), for the province Karaman by using the variables of 850hpa temperature (X_1), daily sunshine duration (X_2), mean temperature (X_3), relative humidity (X_4) and mean pressure (X_5).

2. Materials and Methods

In this study, meteorological data [mean pressure (mb), mean temperature (°C), relative humidity (%), daily sunshine duration (hours), and 850hpa temperature of Ankara (°C), that is the nearest station to the nearest stations] of the period of 1993-2017 belonging to the province Karaman derived from MEVBİS system of General Directorate of Meteorology, were used to predict maximum and minimum air temperature.

In order to predict minimum (Y_1) and maximum (Y_1) temperature, since more than one independent variables (850hpa temperature, X_1; daily sunshine duration, X_2; average temperature, X_3; relative humidity, X_4; and mean pressure, X_5) are used, multiple regression analysis was used.

3. Results and Discussion

Regression models and determination coefficients, obtained for predicting the minimum and maximum air temperature in the first days of the months belonging to four seasons (Winter, Spring, Summer, Fall), are given in Table 1-4.

Table 1.
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the winter months and determination coefficients

Winter	Variables	Equation	R^2
1 December	X_1	Y_1=-3.02+6.89X_1	29.9**
		Y_2=7.44+11.8X_1	67.6**
	X_1+X_2	Y_1=-0.31+8.67X_1-0.682X_2	46.6**
		Y_2=5.28+10.3X_1+0.543X_2	75.2**
	$X_1+X_2+X_3$	Y_1=-2.94-2.58X_1-0.520X_2+1.19X_3	87.9**
		Y_2=3.77+3.86X_1+0.637X_2+0.684X_3	84.6**
	$X_1+X_2+X_3+X_4$	Y_1=-6.71-2.19X_1-0.463X_2+1.25X_3+0.0449X_4	88.2**
		Y_2=1.48+4.09X_1+0.672X_2+0.725X_3+0.0272X_4	84.1**
	$X_1+X_2+X_3+X_4+X_5$	Y_1=69.5-1.61X_1-0.415X_2+1.16X_3+0.0381X_4-0.0839X_5	88.2**
		Y_2=4+4.11X_1+0.673X_2+0.722X_3+0.0270X_4-0.002X_5	83.2**

Table 1 (Continuation)
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the winter months and determination coefficients

1 January	X_1	Y_1=-1.73+10.5X_1	65.1**
		Y_2=6.65+11.8X_1	82.4**
	X_1+X_2	Y_1=0.169+10.6X_1-0.674X_2	73.7**
		Y_2=5.69+11.7X_1+0.340X_2	84.2**
	$X_1+X_2+X_3$	Y_1=-3.06-2.70X_1-0.503X_2+1.21X_3	95.0**
		Y_2=3.44+2.48X_1+0.459X_2+0.842X_3	94.3**
	$X_1+X_2+X_3+X_4$	Y_1=-8.20-2.49X_1-0.392X_2+1.24X_3+0.0660X_4	97.2**
		Y_2=6.52+2.35X_1+0.393X_2+0.821X_3-0.0396X_4	95.0**
	$X_1+X_2+X_3+X_4+X_5$	Y_1=-8.20-2.49X_1-0.392X_2+1.24X_3+0.0660X_4	97.2**
		Y_2=-48.1+2.16X_1+0.367X_2+0.859X_3-0.0371X_4+0.0603X_5	94.9**
1 February	X_1	Y_1=-2.31+9.70X_1	43.0**
		Y_2=8.08+9.73X_1	67.3**
	X_1+X_2	Y_1=2.29+10.6X_1-0.866X_2	57.6**
		Y_2=6.49+9.42X_1+0.299X_2	68.9**
	$X_1+X_2+X_3$	Y_1=-3.08-2.55X_1-0.397X_2+1.25X_3	97.5**
		Y_2=3.35+1.74X_1+0.573X_2+0.728X_3	88.9**
	$X_1+X_2+X_3+X_4$	Y_1=-5.73-2.68X_1-0.365X_2+1.27X_3+0.0333X_4	97.5**
		Y_2=2.65+1.70X_1+0.581X_2+0.736X_3+0.0088X_4	88.4**
	$X_1+X_2+X_3+X_4+X_5$	Y_1=35.6-2.48X_1-0.340X_2+1.25X_3+0.0379X_4-0.0464X_5	97.5**
		Y_2=-18.9+1.60X_1+0.568X_2+0.747X_3+0.0064X_4+0.024X_5	87.9**

**: $P<0.01$

As will also be seen from the Table 1, when 850hpa temperature (X_1) that is a value in average 1500 m high from the sea level is used alone to predict the minimum temperature in the first day of the month December, while determination coefficient is 29.9%, when it is used to predict maximum temperature, it was 67.6%. In the first days of the months January and February, these rates rose to the values of 65.1% and 85.4% and 43.0% and 67.3%, respectively. When daily sunshine duration (X_2) showing the non-cloudy time is added to near 850hpa temperature (X_1), although determination coefficients get higher slightly more, when mean temperature (X_3) is added, determination coefficients almost reached the highest values.

Table 2.
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the spring months and determination coefficients

Spring	Variables	Equation	R^2
1 March	X_1	Y_1=0.21+3.99X_1	7.0
		Y_2=11.0+8.45X_1	36.4**
	X_1+X_2	Y_1=1.91+5.06X_1-0.328X_2	6.6
		Y_2=7.01+5.93X_1+0.775X_2	50.0**
	$X_1+X_2+X_3$	Y_1=-2.68-1.24X_1-0.559X_2+1.13X_3	92.6**
		Y_2=3.39+0.955X_1+0.593X_2+0.894X_3	93.3**
	$X_1+X_2+X_3+X_4$	Y_1=-8.30-1.27X_1-0.536X_2+1.26X_3+0.0760X_4	93.8**
		Y_2=3.63+0.956X_1+0.592X_2+0.888X_3-0.0033X_4	92.9**
	$X_1+X_2+X_3+X_4+X_5$	Y_1=66.6-1.35X_1-0.469X_2+1.24X_3+0.0739X_4-0.0834X_5	94.1**
		Y_2=-58.9+1.02X_1+0.536X_2+0.905X_3-0.0016X_4+0.0697X_5	92.9**

Table 2 (Continuation)
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the spring months and determination coefficients

1 April	X_1	$Y_1=0.06+6.54X_1$	28.4**
		$Y_2=10.8+10.3X_1$	73.4**
	X_1+X_2	$Y_1=1.56+7.71X_1-0.316X_2$	30.4**
		$Y_2=8.10+8.17X_1+0.570X_2$	88.4**
	$X_1+X_2+X_3$	$Y_1=-4.88-2.91X_1-0.532X_2+1.39X_3$	73.0**
		$Y_2=5.76+4.32X_1+0.492X_2+0.504X_3$	93.7**
	$X_1+X_2+X_3+X_4$	$Y_1=-10.8-2.43X_1-0.377X_2+1.47X_3+0.0634X_4$	72.8**
		$Y_2=8.82+4.07X_1+0.412X_2+0.463X_3-0.0329X_4$	93.7**
	$X_1+X_2+X_3+X_4+X_5$	$Y_1=121-1.71X_1-0.272X_2+1.41X_3+0.0702X_4-0.148X_5$	72.6**
		$Y_2=-46.6+3.77X_1+0.368X_2+0.486X_3-0.0358X_4+0.0622X_5$	93.6**
1 May	X_1	$Y_1=4.59+3.17X_1$	15.7*
		$Y_2=15.9+6.13X_1$	39.0**
	X_1+X_2	$Y_1=7.00+2.93X_1-0.245X_2$	21.7*
		$Y_2=12.9+6.44X_1+0.311X_2$	45.5**
	$X_1+X_2+X_3$	$Y_1=-2.99-1.49X_1-0.270X_2+0.986X_3$	81.2**
		$Y_2=2.47+1.82X_1+0.284X_2+1.03X_3$	83.0**
	$X_1+X_2+X_3+X_4$	$Y_1=-7.75-1.49X_1-0.267X_2+1.12X_3+0.0521X_4$	82.3**
		$Y_2=4.08+1.82X_1+0.283X_2+0.982X_3-0.0177X_4$	82.4**
	$X_1+X_2+X_3+X_4+X_5$	$Y_1=15.6-1.37X_1-0.255X_2+1.12X_3+0.0513X_4-0.0262X_5$	81.5**
		$Y_2=-31.2+1.64X_1+0.264X_2+0.982X_3-0.0164X_4+0.0396X_5$	81.6**

*: $P<0.05$; **: $P<0.01$

When 850hpa temperature, which is a value in 1500 m high from sea level (X_1), is used to predict the minimum temperature in the first days of the moths of Mars, April and May, while determination coefficients are rather low, when it is used to predict maximum temperature, this rate rose a slightly more (Table 2). When considered to be predicted either minimum or maximum temperature by using the least variables, dealing with the variables of X_1, X_2 and X_3 together gave better results. That the variables of X_4 and X_5 are included in the model provided a considerable increase in determination coefficients.

Table 3
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the summer months and determination coefficients

Summer	Variables	Equation	R^2
1 June	X_1	$Y_1=6.89+3.89X_1$	31,3**
		$Y_2=15.6+8.15X_1$	71.4**
	X_1+X_2	$Y_1=8,18+4,81X_1-0.228X_2$	39,1**
		$Y_2=13.8+6.85X_1+0.323X_2$	81.1**
	$X_1+X_2+X_3$	$Y_1=1.16-1.63X_1-0.397X_2+1.023X_3$	65,1**
		$Y_2=9.58+3.96X_1+0.247X_2+0.459X_3$	83.1**
	$X_1+X_2+X_3+X_4$	$Y_1=12.32-2.56X_1-0.355X_2+1.410X_3+0.921X_4$	73,2**
		$Y_2=16.0+4.49X_1+0.223X_2+0.238X_3-0.0528X_4$	83.8**
	$X_1+X_2+X_3+X_4+X_5$	$Y_1=10-2.51X_1-0.347X_2+1.396X_3+0.927X_4-0.024X_5$	71,9**
		$Y_2=22+4.51X_1+0.226X_2+0.234X_3-0.0526X_4-0.006X_5$	83.0**

Table 3 (Continuation)
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the summer months and determination coefficients

1 Jully	X_1	Y_1=12.1+1.53X_1	0.5
		Y_2=21.9+5.69X_1	51.8^{**}
	X_1+X_2	Y_1=18.2+2.11X_1-0.537X_2	3.7
		Y_2=18.9+5.40X_1+0.268X_2	51.4^{**}
	$X_1+X_2+X_3$	Y_1=-9.99-5.03X_1-0.582X_2+1.74X_3	60.4^{**}
		Y_2=7.38+2.48X_1+0.250X_2+0.713X_3	58.0^{**}
	$X_1+X_2+X_3+X_4$	Y_1=-7.50-5.18X_1-0.621X_2+1.71X_3-0.0217X_4	54.2^{**}
		Y_2=8.16+2.44X_1+0.237X_2+0.701X_3-0.0068X_4	56.0^{**}
	$X_1+X_2+X_3+X_4+X_5$	Y_1=65-5.32X_1-0.592X_2+1.74X_3-0.0208X_4-0.082X_5	58.2^{**}
		Y_2=65+2.33X_1+0.260X_2+0.727X_3-0.0060X_4-0.064X_5	54.4^{**}
1 Agust	X_1	Y_1=13.8+1.68X_1	0.0
		Y_2=28.1+2.74X_1	6.1
	X_1+X_2	Y_1=13.4+1.56X_1+0.053X_2	0.0
		Y_2=25.7+1.94X_1+0.335X_2	9.9
	$X_1+X_2+X_3$	Y_1=-4.55-0.20X_1-0.156X_2+0.946X_3	64.9^{**}
		Y_2=6.47+0.062X_1+0.110X_2+1.01X_3	87.2^{**}
	$X_1+X_2+X_3+X_4$	Y_1=-12.0-0.19X_1-0.147X_2+1.12X_3+0.0691X_4	65.9^{**}
		Y_2=7.38+0.062X_1+0.109X_2+0.991X_3-0.0085X_4	86.7^{**}
	$X_1+X_2+X_3+X_4+X_5$	Y_1=206-0.46X_1-0.163X_2+1.13X_3+0.0575X_4-0.242X_5	67.0^{**}
		Y_2=17+0.051X_1+0.109X_2+0.991X_3-0.0090X_4-0.010X_5	86.0^{**}

*: P<0.05; **: P<0.01

It is seen that in the first days of the summer months, there is no relationship between 850hpa temperature (X_1) and daily sunshine duration (X_2) (Table 3). For the other months of summer season a maximum temperature, it is seen that the independent variables of X_1, X_2 and X_3 accounts for the variation in the minimum and maximum temperature at the sufficient level.

Table 4.
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the fall months and determination coefficients

Autumn	Variables	Equation	R^2
1 September	X_1	Y_1=11.5+2.04X_1	5.6
		Y_2=22.5+4.93X_1	47.4^{**}
	X_1+X_2	Y_1=16.0+2.59X_1-0.489X_2	17.5^{*}
		Y_2=20.0+4.63X_1+0.270X_2	49.5^{**}
	$X_1+X_2+X_3$	Y_1=16.0+2.59X_1-0.489X_2+1.134 X_4	65.5^{**}
		Y_2=4.82+1.62X_1+0.312X_2+0.877X_3	75.4^{**}
	$X_1+X_2+X_3+X_4$	Y_1=0.73-1.53X_1-0.506X_2+1.09X_3-0.0504X_4	67.2^{**}
		Y_2=3.29+1.70X_1+0.337X_2+0.892X_3+0.0176X_4	74.6^{**}
	$X_1+X_2+X_3+X_4+X_5$	Y_1=246-2.54X_1-0.502X_2+1.09X_3-0.0734X_4-0.270X_5	71.4^{**}
		Y_2=-211+2.58X_1+0.334X_2+0.892X_3+0.0377X_4+0.236X_5	77.4^{**}

Table 4 (Continuation)
The independent variables used for predicting the minimum (Y_1) and maximum (Y_2) air temperature of the first days of the fall months and determination coefficients

1 Octaber	X_1	Y_1=4.26+4.32X_1	27.4**
		Y_2=18.2+5.05X_1	42.9**
	X_1+X_2	Y_1=9.68+3.30X_1-0.509X_2	47.1**
		Y_2=14.6+5.73X_1+0.340X_2	51.4**
	$X_1+X_2+X_3$	Y_1=-1.37-1.97X_1-0.470X_2+1.01X_3	86.3**
		Y_2=4.23+0.783X_1+0.376X_2+0.950X_3	89.3**
	$X_1+X_2+X_3+X_4$	Y_1=1.28-2.44X_1-0.510X_2+0.996X_3-0.0285X_4	86.0**
		Y_2=4.01+0.822X_1+0.380X_2+0.951X_3+0.0023X_4	88.8**
	$X_1+X_2+X_3+X_4+X_5$	Y_1=-38-2.50X_1-0.508X_2+1.02X_3-0.0259X_4+0.043X_5	85.3**
		Y_2=-140+0.599X_1+0.387X_2+1.05X_3+0.0115X_4+0.157X_5	89.8**
1November	X_1	Y_1=1.43+1.22X_1	0.0
		Y_2=14.3+2.00X_1	0.0
	X_1+X_2	Y_1=5.28+0.77X_1-0.508X_2	3.0
		Y_2=7.94+2.76X_1+0.838X_2	20.6*
	$X_1+X_2+X_3$	Y_1=-1.24-1.16X_1-0.680X_2+1.06X_3	87.8**
		Y_2=2.07+1.02X_1+0.683X_2+0.953X_3	82.1**
	$X_1+X_2+X_3+X_4$	Y_1=-3.83-1.16X_1-0.621X_2+1.07X_3+0.0317X_4	87.5**
		Y_2=7.30+1.02X_1+0.563X_2+0.927X_3-0.0641X_4	82.3**
	$X_1+X_2+X_3+X_4+X_5$	Y_1=81.3-1.41X_1-0.585X_2+1.06X_3+0.0206X_4-0.093X_5	87.4**
		Y_2=-97+1.32X_1+0.519X_2+0.940X_3-0.0505X_4+0.114X_5	82.1**

*: P<0.05; **: P<0.01

In the regression models to identify the minimum and maximum temperature in the first days of the months belonging to the fall season, when 850hpa temperature (X_1), daily sunshine duration (X_2) and mean temperature is included in the model (X_3), determination coefficients almost reached to the highest values. Again in the fall season, that the variables of X_4 and X_5 are included in the model, did not result in an important increase in determination coefficients. For the first day of the month November, it was seen that predicting minimum and maximum temperature by only using 850hpa was not suitable.

Human being has found itself in weather conditions since its existence and tried to utilize the positive aspects of aerial events and avoid its negative aspects. Nowadays, the people plan their works, considering the weather condition of today and future. Any sector that not has the relationship with meteorology did not almost remain. All areas such as agriculture, soldiering, transportation, construction, tourism, health and environment are related to meteorology. For preventing total production loss in agricultural production, reducing production costs, using the resource effectively and increasing productivity, it is necessary to predict meteorological parameters in the most zenith ally. In order to be able to make these predictions, it is necessary to collect and record meteorological data. Therefore, it is necessary to establish an observation station, operate these stations, and pay attention to obtain the observation data from scientifically suitable places. However, due to the fact that atmosphere has a structure that is very instable and affected by many factors, the data obtained may not be represent another area very near to them. Since establishing and operating observation station in every area or recording by observing atmosphere with the other methods are costly and even impossible, trying to statistically predict meteorological parameters by utilizing the past values will be less costly.

In this study, it was tried to be predicted the minimum and maximum temperatures, whose effects are more on the plants and animals by making lees expenditures, less laboring, and spending less time. The minimum and maximum air temperatures belonging to the first months of the season was first predicted by means of an independent variable (X_1), and later, regression equations were obtained by adding the variables of X_2, X_3, X_4 and X_5.

It is known that on high temperature, the factors such as southwest wind flows, especially southwester, long sunshine duration, warm-character high pressure effect, high altitude (temperature falls by about 1 °C, while going upward), more sunshine duration, and high sunshine calorie are effective; and that on low temperature, the factors such as north winds, short sunshine duration, overcast and rainy weather (southwester conditions), lower attitude, less sunshine duration, and low sunshine calorie (Çöleri et al., 2007).

As a result of the study, in general, regression model, in which the independent variables of X_1, X_2, and X_3 are used in the prediction of minimum and maximum air temperature, gave better result and the addition of the independent variables of X_4 and X_5 to the model did not result in an important increase in determination coefficients. It is seen that determination coefficients formed to predict minimum temperature in the first days of the months belonging to the summer season remain insufficient. For the predictions of minimum air temperature to be made for summer seasons, some meteorological data such as wind and attitude that are effective on the formation of cold weather conditions can be added to the regression model. In the months of March, April and May, when the late spring frosts are effective, predicting minimum air temperature, it can be possible for the producers to lower the productivity losses that can be formed in plant production by taking actions.

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5. References

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