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Investigation Of Deviations From Observation Values Of Regression Equation Results Calculated With Some Meteorological Parameters Depending On The Increasing Number Of Data

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Abstract— **In Balıkesir city center, multiple linear regression analysis was performed with the SPSS program using the "monthly averages" calculated from the daily averages of the parameters "wind, amount of sunshine, temperature and humidity" from 4, 7, 10, and 13 years of meteorological data between 2009-2021. Deviations between the regression equations obtained and the observation values were calculated according to the dependent variables of wind and total amount of sunshine, respectively. The analysis determined that the calculated deviations tended to decrease in some equations and increase in others. For this reason, it was determined that obtaining a definitive result was impossible, depending on the increasing data. Meteorological parameters are natural events, and it is known that natural events cannot be predicted, but they are a part of life. It was observed that the equations found with multiple regression analysis using meteorological data can only be used to make future predictions with the possibility of error.**

Keywords—Meteorological data, SPSS and multiple regression, Energy.

I. INTRODUCTION

Many studies have been conducted on energy, especially wind and solar energy. In these studies, the statistical explanation of the relationships between the parameters is quite valuable in determining wind and solar energy potential. Different experiments and their proofs help decide which method suits the system under study.

In a study conducted in 2018 for wind and solar energy, it was announced that Turkey's installed wind energy power was 7370 MW [1]. A study determined that the annual average wind speed and solar energy potential for the Marmara region were measured as 3.29 m/s and 51.91 W/m^2, respectively, and that they had higher values than other geographical regions of Turkey [2]. In a study, it was explained that Turkey has a great potential for electricity generation from wind and solar energy, that wind energy has different values in different regions throughout the year, and that wind speed is difficult to estimate [3]. In a study conducted in Shanghai, China, the highest values were recorded every two hours for the wind speed and direction relationship. With these data, the average wind speed of the location where the measurement was made was calculated [4]. In a study, different statistical methods were used with wind speed and solar amount measurement data, and the data distribution was evaluated. As a result, it was announced that a hybrid renewable energy system installation in Aqaba was suitable [5]. In a study, models were developed to estimate solar amount measurement values. Evaluations were made about the daily amount of sunshine by using meteorological data in the models. The R^2 values of the models (0.87-0.89) were obtained with high accuracy. As a result, it was explained that the amount of sunshine can be accurately estimated using meteorological data [6]. A study explained that different methods could be tried to form a mathematical equation in regression analysis and that multiple linear regression can be used with high accuracy in many statistical evaluations with the support of literature [7]. In a study, the effects of other parameters on the wind were examined using the nonlinear regression analysis method of parameters such as temperature, humidity, wind speed, and pressure measured in Erzincan, Kars, and Van provinces. The results showed that these parameters can be used in studies to determine environmental and energy effects [8]. In a study, declination angle, monthly average external atmospheric insolation amount, and the ratio of insolation duration to day length and insolation amount in the atmosphere, wind speed, and air temperature were used as data of multiple linear regression analysis for Zonguldak province between 1995-2005. When the insolation amount, air temperature, and wind speed were compared with the meteorological data measured between January and December 2005, it was determined that the calculated values were compatible with the measured values [9]. A hybrid power system was created in one study, and an optimization was made. The system combines classical and renewable energy sources and consists of a photovoltaic panel, a wind turbine, and a diesel generator. In optimization, these three elements can work synchronously and be controlled. A biogeographic-based algorithm and a time-weather estimation-based artificial neural network method were used for the optimal design [10]. In one study, a flow diagram based on the literature was prepared to determine the amount of insolation and model the data. ANN (artificial neural networks), linear, fuzzy, and nonlinear modeling techniques were used to evaluate the amount of solar energy. It was explained that the nonlinear model has higher sensitivity in assessing the amount of insolation [11]. In a study conducted in Southern Algeria, different models used to evaluate the amount of insolation were compared. Daily values of daily insolation for 3 years were taken as data. Linear and nonlinear models were studied, as well as both. The calculation determined that the relationship between the amount of daily insolation and the duration of insolation was good. It has been explained that the model chosen in the study can be used for similar climates and regions [12]. A system model has been developed for the energy balance of an energy storage-supported power source in England. The data used for the evaluation belong to the years 1984-2013. The system aims to meet 30% of the electricity of the whole of England with 30-day storage [13]. A study investigated the general status of wind turbine technologies and wind energy resources in Turkey. The inefficient use of wind energy resources and the issue of increasing the use of wind energy potential were discussed [14]. A combined system utilizing solar and tidal energy was modeled in the coastal region of Cochin, India. The efficiency of this system was verified based on the optimization results of traditional, non-renewable, and high-pollution systems. The study optimized the energy system, project duration, project management technique, and critical situations using Homer software [15]. A universal unified data system was studied. The system collects and analyzes Europe's daily insolation data with genetic programming based on an artificial neural network learning model. Although it has different climates, it determines places with high sunshine duration and energy modeling for them [16]. A computer program was prepared based on the multiple regression analysis methods, and regression equations obtained from the SPSS program were used using some meteorological parameters. As a result, it was explained that the differences between the observation and calculation values were very close [17]. In the analysis of the windstorm that occurred in Malaysia in 2017, it was explained that the low correlation between wind speed, humidity, and temperature (-0.256 and 0.278) was one of the factors affecting the storm [18]. In a study conducted in Iraq for aviation or agricultural planning, 36 years of meteorological data from the European Centre for Medium-Range Forecasts were used [19]. In the wind energy potential research of Bitlis province, the Weibull distribution was used to analyze the measured wind data statistically, and it was found that the observed and distribution results of the wind data were close to each other [20].

In literature, multiple linear regression analysis is the most common method used in studies to create equations based on the relationships between parameters related to meteorological data. In studies, using programs that perform statistical calculations that everyone accepts is also a preferred practice. This study aims to determine the deviations of the regression equation results obtained with a commercial-ready statistical program from the observation values and to examine the results, depending on the increasing number of data, using the data of meteorological parameters measured for many years.

II.METHOD

The meteorological parameters used in the study were determined as “wind speed, amount of sunshine, temperature and humidity.” Meteorological parameters are data from latitude 39°37’ and longitude 27°55’ Balıkesir-Turkey. To obtain the regression equations, “monthly averages” calculated from daily averages for the periods of “4, 7, 10 and 13 years” between 2009-2021 were used for the parameters to be used in the calculations [21]. From the data of meteorological parameters, “10-minute average wind speed (m/s) symbolized by W” are monthly averages calculated from daily averages. In the data, “total amount of sunshine (cal/cm^2)” values symbolized by Q, “average temperature (°C) symbolized by T,” and “average relative humidity (%)” values symbolized by H are monthly averages calculated from daily averages. The meteorological data used in the study are given in Table 1 as “monthly averages” according to increasing years.

In the data in Table 1, for 4 years, wind speed observation values were measured as maximum and minimum, with 9.63 m/s in August and 5.93 m/s in December, respectively. Total insolation amount observation values were measured as maximum and minimum, with 653.29 cal/cm² in July and 119.70 cal/cm² in December, respectively. Temperature observation values were measured as maximum and minimum, with 26.05 °C in July and 4.52 °C in January, respectively. Humidity observation values were measured as maximum and minimum, with 81.50% in December-January and 54.50% in August, respectively.

In the data for year 7, wind speed observation values were measured as maximum and minimum, 9.42 m/s in August and 5.48 m/s in December, respectively. Total insolation amount observation values were measured as maximum and minimum, 655.13 cal/cm² in July and 119.67 cal/cm² in December, respectively. Temperature observation values were measured as maximum and minimum, 25.65 °C in July and 5.15 °C in January, respectively. Humidity observation values were measured as maximum and minimum, 83.37% in December and 53.64% in July, respectively.

In the data for year 10, wind speed observation values were measured as maximum and minimum, 9.50 m/s in August and 5.65 m/s in December, respectively. Total insolation amount observation values were measured as maximum and minimum, 631.11 cal/cm² in July and 123.24 cal/cm² in December, respectively. Temperature observation values were measured as maximum and minimum, 25.68 °C in July and 4.68 °C in January, respectively. Humidity observation values were measured as maximum and minimum, 83.27% in December and 54.90% in July, respectively.

In the data for year 13, wind speed observation values were measured as maximum and minimum, 9.40 m/s in August and 5.81 m/s in December, respectively. Total insolation amount observation values were measured as maximum and minimum, 633.27 cal/cm² in July and 123.66 cal/cm² in December, respectively. Temperature observation values were measured as maximum and minimum, 25.60 °C in August and 5.17 °C in January, respectively. The highest and lowest humidity observation values were measured in December, at 83.39%, and in July, at 57.52%, respectively.

Tablo 1. Monthly averages of meteorological 4, 7, 10, and 13-year observation parameter data.

	Months >	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Years > 4	W (m/s)	6.36	6.97	6.89	7.06	6.74	7.97	8.93	9.63	8.11	6.91	5.97	5.93
	Q (cal/cm^2)	131.07	185.45	315.58	404.29	538.55	616.85	653.29	601.96	444.62	286.89	186.54	119.70
	T (°C)	4.52	5.87	8.00	12.37	17.40	22.70	26.05	25.30	21.20	15.80	10.20	7.27
	H (%)	81.50	78.00	72.02	71.05	68.05	58.72	54.62	54.50	61.22	70.32	77.85	81.50
Years > 7	W (m/s)	5.99	6.87	6.82	6.96	6.79	7.94	9.17	9.42	7.78	6.84	5.66	5.48
	Q (cal/cm^2)	136.40	194.00	309.12	421.07	545.84	595.77	655.13	591.81	435.02	280.03	186.67	119.67
	T (°C)	5.15	6.44	8.71	12.45	17.91	22.38	25.65	25.51	21.32	15.50	10.55	6.64
	H (%)	81.84	78.75	71.80	69.97	66.08	59.72	53.64	54.42	60.47	70.61	77.34	83.37
Years > 10	W (m/s)	5.98	6.85	6.83	6.63	6.72	7.78	9.04	9.50	7.80	6.92	5.86	5.65
	Q (cal/cm^2)	139.42	192.90	309.90	444.34	533.33	600.00	631.11	580.85	438.98	288.56	192.23	123.24
	T (°C)	4.68	7.04	9.26	13.00	17.95	22.65	25.68	25.57	21.37	15.48	9.77	6.28
	H (%)	82.36	78.71	72.73	69.78	67.42	60.75	54.90	56.95	60.73	69.44	77.14	83.27
Years > 13	W (m/s)	6.29	7.03	7.20	7.00	6.70	7.71	9.33	9.40	8.42	6.71	6.05	5.81
	Q (cal/cm2)	138.60	213.29	318.44	439.03	535.56	597.13	633.27	583.96	447.73	291.77	194.47	123.66
	T (°C)	5.17	6.82	8.88	12.58	18.19	22.61	25.51	25.60	21.62	16.09	10.62	7.16
	H (%)	82.56	78.86	73.52	70.79	67.44	62.94	57.52	58.04	61.12	71.82	78.70	83.39

When the meteorological parameters in Table 1 are examined, it is determined that the highest values for wind speed, amount of sunshine, and temperature variables were measured in July-August in the 4, 7, 10, and 13-year data. The highest values for humidity were measured in December. The lowest values for wind speed and amount of sunshine were measured in December, January for the temperature parameter, and July-August for humidity.

It was investigated whether the regression equations could represent the observation values by finding the differences of the values calculated from the regression equations obtained with the meteorological observation values determined depending on the increasing number of data, from the observation values and determining the deviations from the observation values. "SPSS Statistics Version 25" was used as the computer program [22]. Multiple linear regression analysis was selected to calculate the regression equations in the SPSS program. The multiple linear regression equation is given by Equation 1. The meanings of the symbols in Equation 1: y_i is the dependent variable, β_0 is the constant number, β_k is the independent variable constant, x_k is the independent variable symbol, ϵ_i is the error symbol, i is the situation index, k is the sub-population index. Equation 2 was used to determine the differences between the observation and the dependent variables' calculated values. The meanings of the symbols in Equation 2: y_i is the dependent variable observation value, y_{ik} is the dependent variable regression equation computed value, and e_i is the difference value.

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} + \epsilon_i \quad (1)$$

$$e_i = y_i - y_{ik} \quad (2)$$

The usability of the regression equations was also evaluated by determining the standard deviation and mean values of the data calculated with the regression equations and calculating the normal distribution

III.CALCULATION AND EVALUATION OF REGRESSION EQUATIONS

In the studies conducted using meteorological parameters, wind speed (W) and total amount of sunshine (Q) data, which are determined as subjects and seen as energy sources, are used as “dependent variables” in this study, respectively. The other three parameters differ from the “dependent variable” and are defined as “independent variables.” In this way, according to the multiple linear regression method, the regression equations obtained with 4, 7, 10, and 13 years of data, where “wind speed” and “total amount of sunshine” are dependent variables and “other parameters” are independent variables, are given from Equation 3 to Equation 10. The numbers next to the indices of the parameters (observation values “W” and “Q”) in the equations indicate years, and the symbol “E” indicates that the value is obtained from the equation. Table 2 gives the resulting values calculated using eight equations, where wind speed and the total amount of sunshine are dependent variables, respectively.

$$y_{WE4} = (26.862) - (0.003).x_{Q4} - (0.096).x_{T4} - (0.245).x_{H4} \quad (3)$$

$$y_{WE7} = (25.022) - (0.002).x_{Q7} - (0.101).x_{T7} - (0.225).x_{H7} \quad (4)$$

$$y_{WE10} = (20.409) - (0.002).\ x_{Q10} - (0.024).\ x_{T10} - (0.173).\ x_{H10} \quad (5)$$

$$y_{WE13} = (29.958) - (0.004).\ x_{Q13} - (0.107).\ x_{T13} - (0.277).\ x_{H13} \quad (6)$$

$$y_{QE4} = (3484.643) - (87.300).\ x_{W4} - (7.581).\ x_{T4} - (34.189).\ x_{H4} \quad (7)$$

$$y_{QE7} = (2707.459) - (43.875).\ x_{W7} - (6.845).\ x_{T7} - (27.824).\ x_{H7} \quad (8)$$

$$y_{QE10} = (2055.138) - (37.143).\ x_{W10} + (2.082).\ x_{T10} - (20.834).\ x_{H10} \quad (9)$$

$$y_{QE13} = (3200.460) - (59.515).\ x_{W13} - (7.720).\ x_{T13} - (32.214).\ x_{H13} \quad (10)$$

Table 2. Wind speed and total insolation values are calculated using equations based on increasing years.

Months	Wind Speed (m/s)				Insolation (cal/cm^2)			
	WD4	WD7	WD10	WD13	QD4	QD7	QD10	QD13
Jan	6.050	5.755	5.689	5.981	108.729	132.279	126.624	126.610
Feb	6.595	6.193	6.142	6.531	164.903	170.814	175.306	189.023
Mar	7.419	7.275	6.857	7.369	360.191	350.848	305.337	335.025
Apr	6.940	7.061	6.969	7.247	345.383	370.023	382.052	406.308
Mai	6.743	7.109	7.054	7.189	437.753	448.343	438.037	488.771
Jun	8.254	7.978	7.944	7.716	609.177	544.249	547.417	539.501
Jul	8.813	8.886	8.813	8.762	640.146	637.069	628.881	595.299
Aug	9.086	8.864	8.576	8.806	588.824	605.355	568.929	573.686
Sep	8.354	8.272	8.348	8.924	522.323	537.657	544.649	563.518
Oct	7.180	6.919	7.325	7.715	357.432	336.602	383.416	363.290
Nov	6.211	6.110	6.350	6.244	224.506	235.003	250.659	223.166
Dec	5.823	5.297	5.530	5.598	125.420	101.885	123.551	113.077

Figure 1 (a, b, c, d) shows the change in wind speed depending on increasing years. In Figure 1, August always had the highest value in the W4, W7, W10, and W13 "observation wind speed" value graphs. Absolute decreases became evident in January and December. A slight decrease or a near-linear trend is seen in the February-May period. In the May-August period, a continuously increasing wind speed is seen. In the figures, August's highest value was measured as 9.63 m/s wind speed. It can be said that the regression curve also closely complies with the observation curve. The R2 values of the wind speed regression equations related to increasing data numbers were 0.923 for 4 years, 0.900 for 7 years, 0.845 for 10 years, and 0.879 for 13 years, respectively. It is seen that the minimum and maximum R2 values found vary between 0.787 and 0.923, respectively. R2 values close to 1 indicate that the regression equations agree.

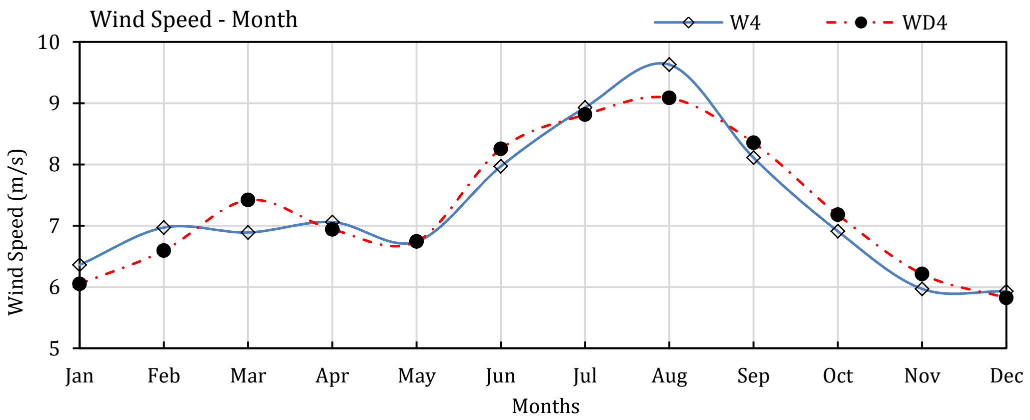

Figure 1.a. Wind speed averages for four years.

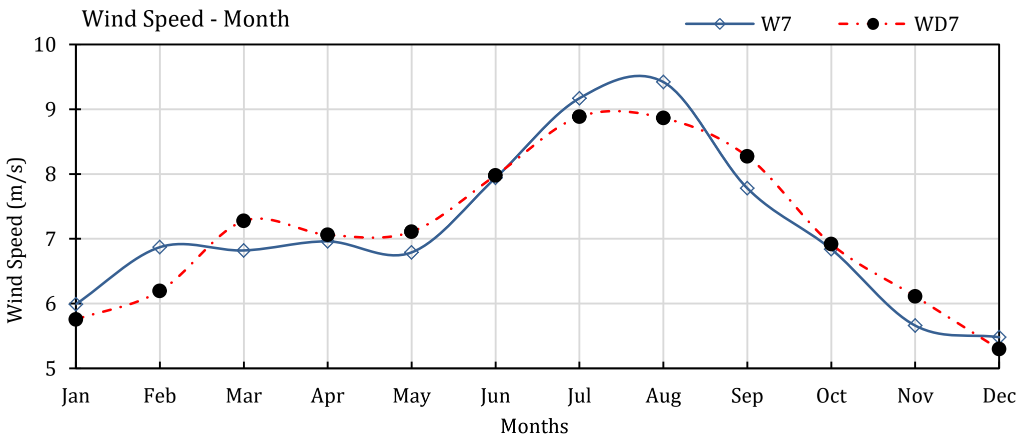

Figure 1.b. Wind speed averages for seven years.

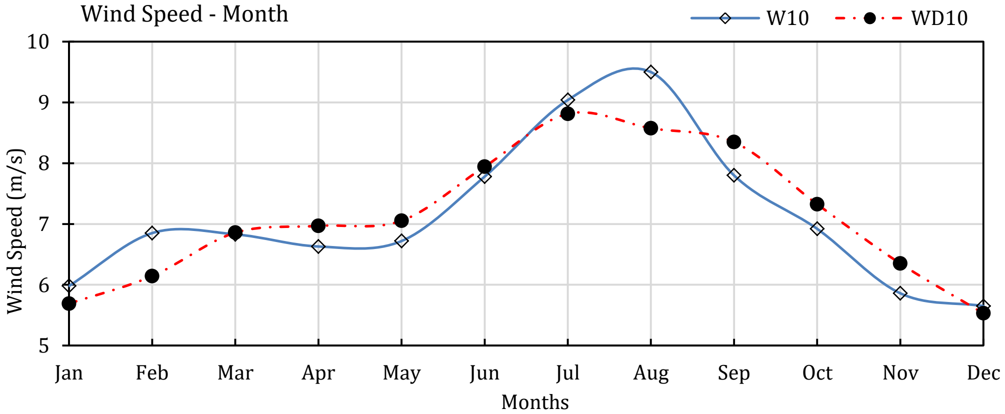

Figure 1.c. Wind speed averages ten years.

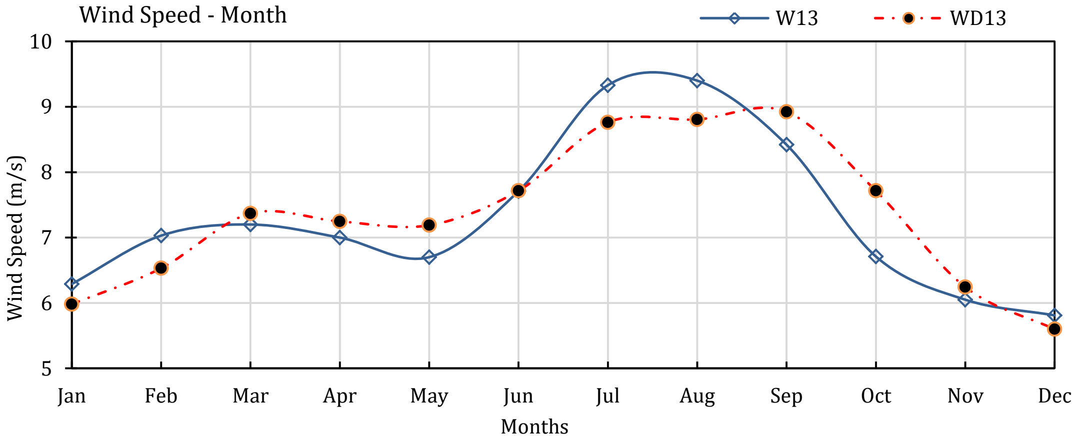

Figure 1.d. Wind speed averages thirteen years.

In Figure 2 (a, b, c, d) the change in the total amount of insolation depending on the increasing years is given. In Figure 2, July always had the most significant values in the Q4, Q7, Q10, and Q13 "observation total amount of insolation" value graphs. Absolute decreases became evident in January and December. Although minimal variability was seen in the four and 7-year data in March and April, this situation is not seen in the curves of the increasing number of years, 10 and 13 years. In the curves of years 4 and 7, it is seen that there is a constantly increasing total amount of insolation in the April-July periods. In the curves of years 10 and 13, there is a tendency first to rise, reach a maximum value, and then decrease. When July is considered in the curves, the most significant value was 655.13 cal/cm2 total insolation in year 7. It can be said that the regression curve has a slope close to the observation curve. The R2 values of the regression equations for the total amount of insolation related to the increasing number of data were found to be 0.931 for 4 years, 0.918 for 7 years, 0.897 for 10 years, and 0.925 for 13 years, respectively. The R2 values vary between the minimum and maximum values of 0.897 and 0.931, respectively. R2 values close to 1 indicate that the regression equations agree.

Regarding the Table 2 data, which includes the results calculated with the regression equations from Equation 2 to Equation 10, the standard deviation (σ) mean (μ) values were determined for Equation 6 and Equation 10, which were obtained with the highest number of data from the equations, and the normal distribution status of the data was examined. Accordingly, for the regression equation of Equation 6 (wind speed), which gives the monthly averages of the 13-year data, the mean was calculated as 7.304 and the standard deviation as 1.118. For the regression equation of Equation 10 (total insolation), the mean was calculated as 179.440 and the standard deviation as 376.409. The normal distributions of both the changes in the regression equations of "wind speed" and "total insolation" were realized as $-2\sigma < \mu < 2\sigma$. It was determined that the values of the regression equations were within the reliable range according to the normal distribution.

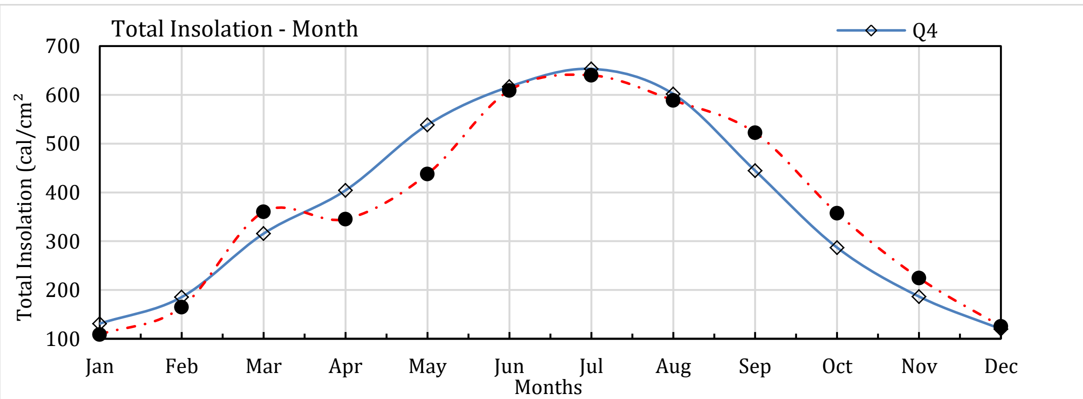

Figure 2.a. Monthly averages of total insolation over four years.

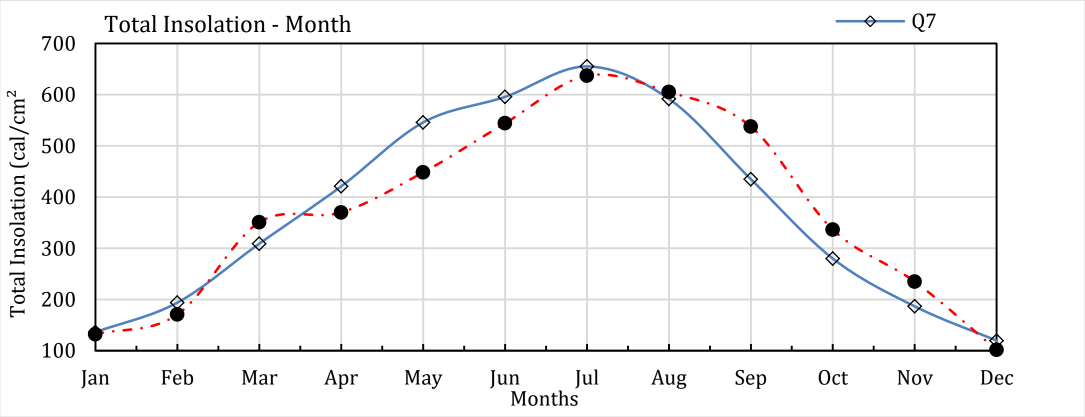

Figure 2.b. Monthly averages of total insolation over seven years.

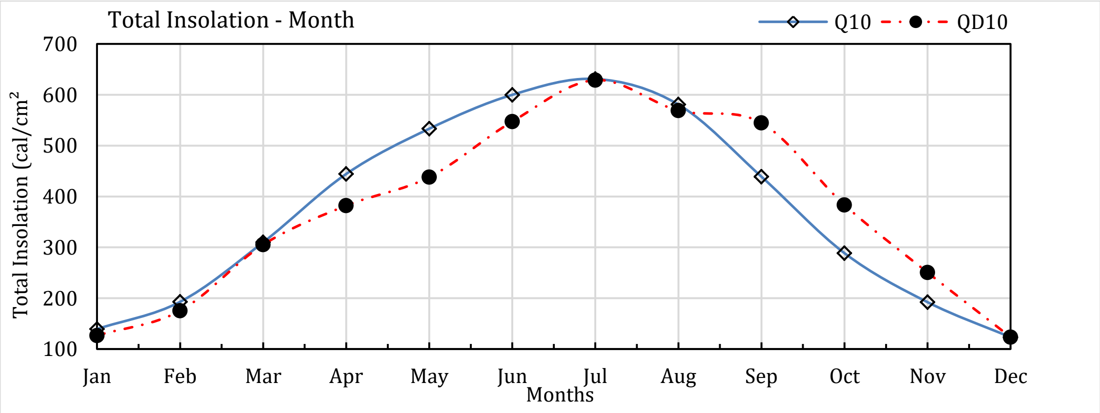

Figure 2.c. Monthly averages of total insolation over ten years.

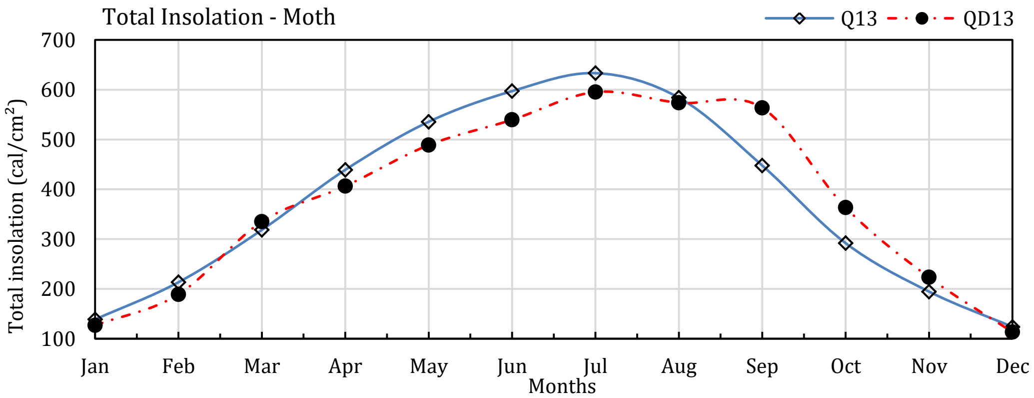

Figure 2.d. Monthly averages of total insolation over thirteen years.

Tablo 3. Deviations of regression equation calculation values from observation values.

Months	Wind Speed (m/s)				Insolation (cal/cm^2)			
	ei_{W4}	ei_{W7}	ei_{W10}	ei_{W13}	ei_{Q4}	ei_{Q7}	ei_{Q10}	ei_{Q13}
Jan	0,049	0,039	0,050	0,049	0,170	0,030	0,092	0,087
Feb	0,054	0,098	0,104	0,071	0,111	0,120	0,091	0,114
Mar	-0,077	-0,067	-0,004	-0,023	-0,141	-0,135	0,015	-0,052
Apr	0,017	-0,015	-0,051	-0,035	0,146	0,121	0,140	0,075
Mai	0,000	-0,047	-0,049	-0,073	0,187	0,179	0,179	0,087
Jun	-0,036	-0,005	-0,020	-0,001	0,012	0,086	0,088	0,097
Jul	0,013	0,031	0,025	0,061	0,020	0,028	0,004	0,060
Aug	0,056	0,059	0,097	0,063	0,022	-0,023	0,021	0,018
Sep	-0,030	-0,063	-0,070	-0,060	-0,175	-0,236	-0,241	-0,259
Oct	-0,039	-0,012	-0,058	-0,150	-0,246	-0,202	-0,329	-0,245
Nov	-0,040	-0,080	-0,084	-0,032	-0,204	-0,259	-0,304	-0,148
Dec	0,018	0,033	0,021	0,036	-0,048	0,146	-0,003	0,086

In Table 3, deviation values calculated using the differences between “observation values” and “regression equation calculation values” according to the equation given in Equation 2 are shown. “Wind speed” and “total amount of sunshine” data are different parameters used as deviation values. Since the various parameters will be expressed with a specific scale by knowing the deviation values, comparing them with each other will be possible. In Table 3, “wind speed” values were calculated as the smallest and largest values as (year 13, October) -0.150 and (year 10, February) 0.104, respectively. “Total amount of sunshine” was calculated as the smallest and largest values as (year 10, November) -0.304 and (year 4, May) 0.187, respectively. The values obtained are variable, and when examined in general, the most significant deviation absolute value calculated in the positive and negative directions was obtained at 0.304. When the table data is reviewed, a regression equation belonging to a specific group of years did not stand out with low deviation values. Similarly, it is difficult to talk about a regression equation with low deviation values depending on the increasing number of data.

IV.CONCLUSION

*For statistical analyses to be performed using a large number of meteorological parameters, it was determined that regression equations suitable for normal distribution and meaningful for the data can be obtained using the multiple linear regression method. It was observed that the shapes obtained from the values found from the observation values of the meteorological parameters selected in the study and the regression equations calculated depending on the increasing data numbers have similar trends. Although there was variability in the values calculated as R^2, it was observed that the regression curves were compatible with the observation curves because the values of the observation values and the regression equations represented the situation well. It was determined that the results of the regression equations were reliable by remaining within the limits of an accepted normal distribution with increasing years and data numbers.

*When the deviation values calculated from the regression equation values obtained depending on the increasing data numbers and the measurement values of the observation values for 4, 7, 10, and 13 years were examined, increasing or decreasing variability was observed in all equations. Therefore, it was impossible to conclude that the deviation of the multiple regression equation belonging to a particular year group is lower than the other.

*Unless there are exceptional natural events, it can be said that the changes in the values of meteorological parameters will generally occur with similar trends depending on the seasons and will be measured with a similar convergence for the measurement location taken as the basis for the study. However, these estimates will be insufficient when unexpected natural events occur for meteorological events or when significant seasonal variations may occur. It is known that the regression equations obtained using meteorological parameters can be used for future estimates, regardless of the number of data and with certain margins of error.

REFERENCES

[1] GWEC, “European Wind Energy Council,” 80 Rue d’Arlon, Brussels, Belgium, Report. 2019.

[2] C. İlkılıc, , H. Aydın, R. Behcet, “The current status of wind energy in Turkey and in the world,” Energy Policy, vol. 39, pp. 961–967. 2011. https://doi.org/10.1016/j.enpol.2010.11.021

[3] M. Patel. Wind and Solar Power Systems, Taylor & Francis Group, 2nd edition, Book. 2006. https://doi.org/10.1201/9781420039924

[4] Y. Ge, H. Xiang. "Statistical study for mean wind velocity in Shanghai area," Journal ofWind Engineering and Industrial Aerodynamics, vol. 90, no. 12-15, pp. 1585-1599, 2002. https://doi.org/10.1016/S0167-6105(02)00272-6

[5] Y. Anagreh, A. Bataineh, M. Al-Odat. "Assessment of renewable energy potential, at Aqaba in Jordan," Renewable and Sustainable Energy Reviews, vol. 14, no. 4, pp. 1347–1351, 2010. https://doi.org/10.1016/j.rser.2009.12.007

[6] J. Almorox, M. Bocco, E. Willington. "Estimation of daily global solar radiation from measured temperatures at Canada de Luque, Cordoba, Argentina," Renewable Energy, vol. 60, pp. 382–387, 2013. https://doi.org/10.1016/j.renene.2013.05.033

[7] D. C. Montgomery, G.C. Runger. ''Statistical, Applied Statistics and Probability for Engineers'', John Wiley & Sons, 5th edition. Book. 2010.

[8] Kavakakpınar E., Biçer Y., Erdoğan B."Modeling of Weather Conditions and Wind Power of Some Provinces in Eastern Anatolia Region." *Journal of Plumbing Engineering*, n:89, p:.58-64, 2005.

[9] Deniz E., Atik K., Buğutekin A. "Prediction of Some Meteorological Data Using Regression Analysis Method." *Technology*, Cilt 9, Sayı 4, 271-276, 2006.

[10] R.A.Gupta, Kumar R., Bansal A. K.''BBO-based small autonomous hybrid power system optimization incorporating wind speed and solar radiation forecasting''. *Renewable and Sustainable Energy Reviews* 41, 1366–1375, 2015. http://dx.doi.org/10.1016/j.rser.2014.09.017

[11] Teke A., Yıldırım H.B., Çelik Ö. ''Evaluation and performance comparison of different models for the estimation of solar radiation'', Renewable and Sustainable *Energy Reviews*. 50, 1097–1107, 2015. http://dx.doi.org/10.1016/j.rser.2015.05.049

[12] Rabehi A., Guermoui M., Lalmi D. "Hybrid models for global solar radiation prediction: a case study'', International Journal of Ambient Energy, 2018. https://doi.org/10.1080/01430750.2018.1443498

[13] Fragaki A., , Markvart T., Laskos G. "All UK electricity supplied by wind and photovoltaics-The 30-30 rule", Energy, 169, 228e237, 2019. https://doi.org/10.1016/j.energy.2018.11.151

[14] Kaplan Y. A., Agalar A., Bıldırcın H. "General situation of wind energy source in Turkey and wind turbine Technologies". International Journal of Renewable Energy Tecnology, Volume:10 Issue: 1-2, 2019. https://doi.org/10.1504/IJRET.2019.097004

[15] Khare V. "Prediction, investigation, and assessment of novel tidal–solar hybrid renewable energy system in India by different techniques". International Journal of Sustainable Energy, Vol. 38, No. 5, 447–468, 2019. https://doi.org/10.1080/14786451.2018.1529034

[16] Ghimire S., Deo R. C., Downs N. J., Raj N. "Global solar radiation prediction by ANN integrated with European Centre for medium range weather forecast fields in solar rich cities of Queensland Australia". Journal of Cleaner Production, 216 288e310. 2019. https://doi.org/10.1016/j.jclepro.2019.01.158

[17] Yüksel B., Ates E. Determining Balıkesir's Energy Potential Using a Regression Analysis Computer Program. Journal of Renewable Energy. Vol. 2014. Article ID 975403, 8 pages. 2014. http://dx.doi.org/10.1155/2014/975403

[18] Zakaria N. H. et al. "Analysis of Wind Speed, Humidity and Temperature: Variability and Trend in 2017". IOP Conf. Series: Earth and Environmental Science 489 012013. 2020. http://doi.org/10.1088/1755-1315/489/1/012013

[19] Abdulkareem I. H., Nemah H. A. "Variation of weather elements during different seasons in Iraq". Journal of Engineering Science and Technology. Vol. 16. Is. 6. P. 5000- 5012. 2021.

[20] Oral F. "Statistical analysis of wind energy potential of Bitlis province." *DUMF Engineering Journal*.11:2. PP.671-678. 2020.

[21] T.C. Ministry of Environment, Urbanization and Climate Change, General Directorate of Meteorology, Ankara. Türkiye.

[22] IBM SPSS Statistics, Version 25. IBM, Licensed Software, Balıkesir University, Balıkesir, Türkiye. 2019.