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Empirical models for the correlations of the mean monthly values of Speed with meteorological parameters in Ninava Governorate – IRAQ wind

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ABSTRACT: The aim of this paper is to estimate the mean monthly values of wind speed in five meteorological stations (Mosul, Rabea, Sinjar, Talafar, Baag) using different meteorological parameters. Multiple Regression Equations were used to estimate the mean monthly values of wind speed. The performance of this regression models were evaluated by comparing the calculated and measured values of wind speed. Several statistical test were used to control the validation and goodness of the regression models in terms of correlation coefficient, coefficient of determination, Mean Absolute Error, and Root Mean Square Error. The coefficient of determination (R^2) for the regression models using two parameters were ranged between (0.69- 0.96) and (R^2) for the regression models using all the parameters were very high and ranged between (0.94 - 0.98).

INTRODUCTION

Variation in climate is a synergistic of multipleclimatic parameters. Almost every climate variation involves wind variation either directly or indirectly. Wind is an instrumental in the transport of particulates from industrial and mobile sources[(1)] and in the transfer of heat and moisture[(2).] Wind speed affects engineering design and construction [(3)],energy generation [(4)], air dispersion modeling[(5)].Cloud covers show higher correlation with wind speed where higher values of cloud cover corresponding to higher value of wind speed. Pressure can be for the most parts explained by wind speed where high correlation was found between wind speed and air pressure[(6)].Maximum temperature is negatively related to wind speed and significant relationship was found between them .Minimum temperature is positively related to wind speed[(7).] Evaporation shows a highly positive correlation with wind speed. Precipitation shows a little correlation with wind speed [(8).] Humidity and wind speed are negatively related with a strong and significant relationship between them. Multiple Regression Models have been proposed for prediction of wind speed[(6, 7,9).] Almost all these models make use of meteorological parameters such as Sunshine, Cloudiness, Relative Humidity, Atmospheric Pressure, Precipitation, Temperature and Evaporation. In this paper correlations were proposed between the mean monthly values of wind speed with meteorological parameters in (Mosul, Rabea, Sinjar, Talafar, Baag) stations. Then the calculated wind speed was compared with measured values.

MATERIALS AND METHODS

Mean monthly values of wind speed, relative humidity, air temperature, cloudiness, rainfall, evaporation, atmospheric pressure, sunshine are obtained from Iraqi meteorological organization for the period (1980 - 2010) for (Mosul, Rabea, Sinjar, Talafar) stations and for the period (1992-2010) in Baag station according to the date of operation of this station .

. (1). The geographical coordinate of these stations listed in table (1) and displayed in Fig

Mean absolute error (MAE), Root mean square error (RMSE), Coefficient of Determination (R^2), Correlation coefficient (R) were used as the main criteria .The goodness of fit was judged by the size of coefficient of determination . MAE, RMSE were computed as further check on the stability of the multiple regression equations. Tables (2, 3, 4, 5, 6, 7) show the mean monthly values of the different meteorological parameters in all stations.

RESULTS AND DISCUSSION

Table (8) showed the regression models obtained between the mean monthly values of wind speed and the mean monthly values of (T & n) , (T & P) , (P & RH) , (T & E) in Mosul, Rabea, Sinjar, Talafar, Baag stations . The table also showed the summaries of regression statistics obtained from the different models in all stations. All the

models indicate a good correlations between wind speed and other meteorological parameters, where the coefficient of determination (R^2) was ranged between (0.69 – 0.95) for the correlations between V& (T+ n) and between (0.70- 0.96) for the correlations between V& (T +P) and V& (P+ RH), and between (0.74-0.87) for the correlations between V & (T + E). This means that there are statistically significant relationships between wind speed and the other meteorological parameters and the correlations were acceptable for the estimation of wind speed in all stations .

Table (9) showed the Multiple Regression models between the mean monthly values of wind speed and all the meteorological parameters in all stations. Coefficient of determination (R^2) for these multiple regression models were very high in all stations and ranged between (0.9 4- 0.98). This means that (94 - 98) % of wind speed values can be accounted by using all the meteorological parameters. MAE for these multiple regression models was found in a range of (0.9-3.7)% indicating a very good fitting between the mean monthly wind speed data and the considered meteorological parameters. We can see also from the table (9) that RMSE was lies between (2.2 – 6.5) % in all stations which also shows a very good performance of all the models examined. The values of wind speed calculated by the multiple regression models were compared with the corresponding measured values in all stations. The results are illustrated in fig (2). From this figure the deviation between the measured and calculated values are very small during the months and this mean that these models are suitable to be used in calculating wind speed. Fig (3) shows the correlation between the observed and predicted wind speed for the five stations in Ninava Governorate. The values of (R^2) for these correlations are ranged between (0.936 - 0.991). This means that the multiple regression models give very good results to estimate the mean monthly values of wind speed in all stations.

CONCLUSION

The mean monthly values of wind speed, Mean air temperature, Sunshine hours, Relative humidity, Cloudiness, Rainfall, Evaporation, Atmospheric pressure have been employed to develop several regression models in five stations in Ninava Governorate located in the north of Iraq .

The regression models obtained between the mean monthly values of wind speed and the mean monthly values of (T & n), (T & P), (P & RH), (T & E) give a good results , where the coefficient of determination (R^2) for the regression models were ranged between (0. 69- 0.96) .

The Coefficient of determination for the Multiple Regression models between the mean monthly values of wind speed and all the meteorological parameters in all stations were very high and ranged between (0.9 4- 0.98).MAE and RMSE for these multiple regression models were ranged between (0.9 - 3.7) % and (2 .2 - 6.5)% in all stations respectively indicating a very good fitting between the mean monthly values of wind speed and the considered meteorological parameters . Correlation between the observed and predicted wind speed in all stations gives (R^2) ranged between (0.936 - 0.991). This means that the multiple regression models give very good results to estimate the mean monthly values of wind speed in all stations.

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Table (1): Geographical coordinate of the stations

Stations	Latitude	Longitude	Altitude (m)
Mosul	36° 19'	43° 09'	223
Telafr	36° 22'	42° 28'	273
Sinjar	36° 19'	41° 50'	465
Rabea	36° 48'	42° 06'	382
Baaj	36 °02'	41° 48'	321

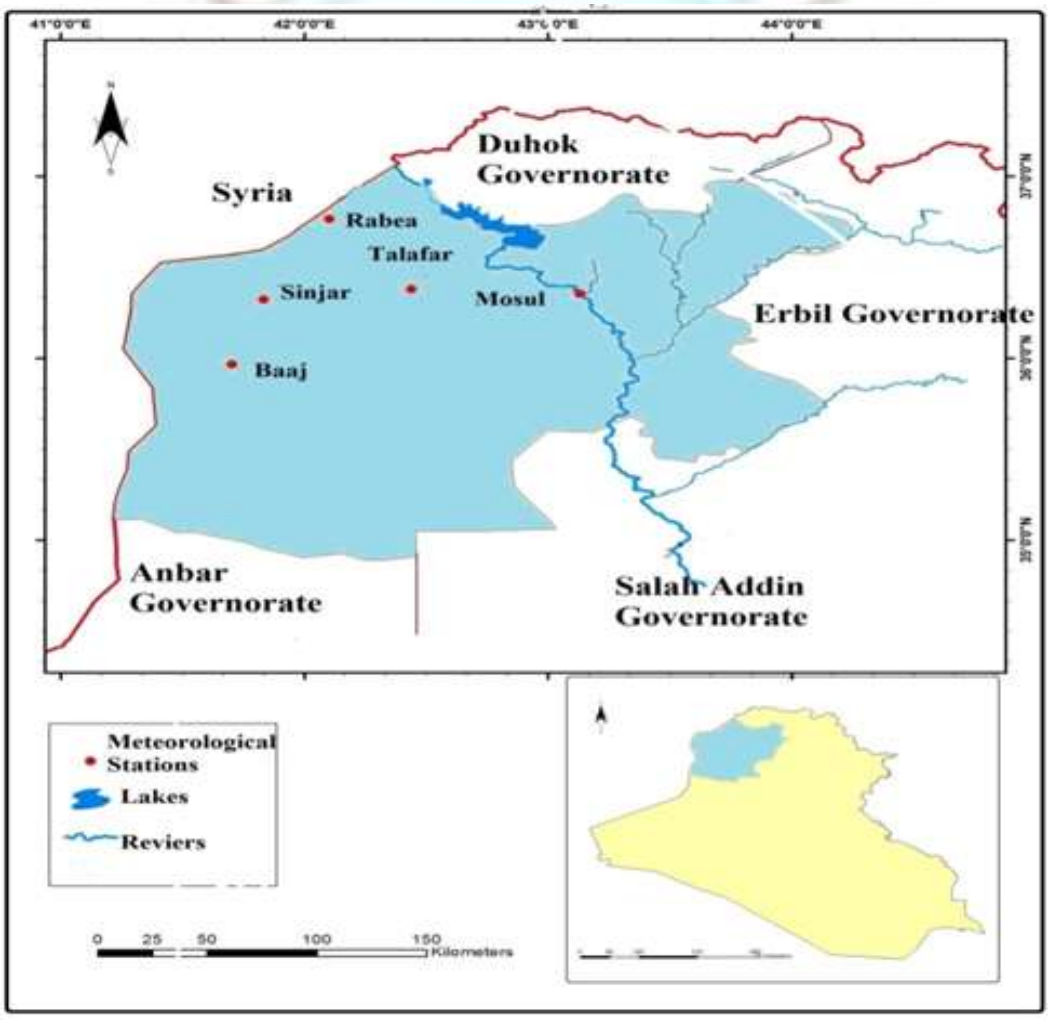

Fig (1) : Location of the five meteorological stations in Ninava Governorate

Table (2) : Mean monthly values of wind speed for all stations during the period (1980-2010) accept Baag station for the period (1992-2010)

Mon. St.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mosul	1.0	1.3	1.4	1.5	1.8	1.8	1.7	1.5	1.1	0.9	0.8	1.0
Sinjar	1.9	2.3	2.8	3.2	4.0	4.4	4.4	4.0	3.3	2.2	1.7	1.7
Talafar	3.8	4.1	4.3	4.5	5.1	5.1	5.4	5.3	4.9	4.3	4.0	3.9
Rabea	1.6	1.7	1.8	1.8	2.1	2.1	2.1	2.0	1.8	1.6	1.4	1.4
Baaj	2.0	2.3	2.7	3.1	3.5	3.9	4.0	3.7	3.2	2.6	2.1	2.0

Table (3): Mean Monthly meteorological parameter for Mosul station during (1980-2010)

Mon. Met.el .	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmean (C^o)	6.9	8.7	12.9	18.1	24.7	31.2	34.6	33.8	28.7	21.7	13.6	8.7
RH%	79	74	68	62	43	28	25	27	31	46	65	78
Evap.(mm)	63	73	129	198	338	495	588	543	411	253	101	59
Rainfall(mm)	63.9	62.9	63.6	28.1	18.5	1.3	0.0	0.0	0.0	16.4	39.4	62.8
Sun shine(hr)	4.7	5.6	6.8	7.9	9.9	12.2	11.9	11.3	10.3	8.1	6.4	4.6
Pressure(mb)	1021.3	1019	1015	1013	1010	1004	999.6	1001.6	1008.4	1014.6	1019	1021
Cloud.(octa)	4.3	4.2	3.9	3.8	2.7	0.9	0.4	0.3	0.6	2.4	3	4.3

Table (4):Mean Monthly meteorological parameters for Rabea station during (1980-2010) |

Mon. Met.el.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmean (C^o)	5.5	7	10.4	15.8	22.6	28.9	32.4	31.5	26.8	20.4	12.6	7.5
RH%	80	76	70	66	50	32.7	30	31	33	4 7	69	81
Evap.(mm)	23	40	72	116	211	323	359	326	252	136	55	27
Rainfall(mm)	54.6	53.7	59.2	37.3	59	4.77	0.0	0.0	0.0	25.1	34.5	59.8
Sun hine(hr)	4.6	5	6.4	7.9	9.8	12.2	12.3	11.5	10	8	5.9	6.4
Pressure(mb)	1020	1017	1014.5	1012	1008.6	1003.5	999.3	1001	1007	1014	1018	1020.7
Cloud.(octa)	4	4.1	4	3.6	2.6	1.34	0.9	0.6	1.2	2.45	3.3	4.3

Table (5): Mean Monthly meteorological parameters for Baag station during (1992-2010)

Mon. Met.el.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmean (C°)	6.7	8.8	12.4	19	25.7	31	33.7	33.2	28.5	22.7	14	9.1
RH%	72.9	65	57	53	35	25	23	24.8	28	39	54	65.3
Evap.(mm)	38.3	66	115	162	288	361	381	386	301	223	87	34
Rainfall(mm)	44.4	37.1	34.8	13.3	9.9	1	0.0	0.0	0.0	11.5	24	36.2
Sun hine(hr)	4.8	5.2	7.3	8.4	9.8	11.8	11.9	11.4	10	8.2	6.5	4.7
Pressure(mb)	1020	1019	1014	1012	1007.5	1002.6	998.8	1001.6	1007.8	1014	1018	1021
Cloud.(octa)	3.7	3.6	3.3	3.2	2.6	1	0.9	0.8	1.1	2.2	2.3	3.5

Table (6): Mean Monthly meteorological parameters for Sinjar station during (1980-2010)

Mon. Met.el .	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmean (C°)	7	8.7	13	18.6	25.2	31.3	35	34.4	30.1	23.8	14.8	9.5
RH%	65.4	62	55.2	47.2	33.1	23.2	20.9	21.8	24.7	37	51.7	65.8
Evap.(mm)	63	73	129	198	338	494	578	543	411	253	101	59
Rainfall(mm)	68.6	62.9	60.9	26	18.5	1.3	0.0	0.0	0.0	19.6	39.3	62.1
SunShine(hr)	4.9	5.6	6.6	7.6	9.1	11.7	11.9	11.4	10.3	8. 4	6	5
Pressure(mb)	1020.5	1018.6	1015	1012	1009	1004	999.4	1000.6	1007.3	1014	1019	1020
Cloud.(octa)	4	4.1	3.7	3.6	2.6	1.2	0.8	0.9	1	2.2	3	3.8

Table (7): Mean Monthly meteorological parameters for Talafar statio (during(1980-2010)

Mon. Met.el .	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmean (C°)	7.1	8.3	12.4	18.6	26.5	30.9	35	32.8	30.4	23.3	14	8.7
RH%	76	70	61	54.6	37	23	22	23.1	24	36	58	73
Evap.(mm)	50	68	123	190	370	539	60 6	587	454	269	118	80
Rainfall(mm)	56.8	51.9	58.5	31	14	1	0.0	0.0	1.4	12.4	37.5	52.4
Sun Shine(n)	5.1	5.5	6.9	7.9	9.8	12.1	12.2	11.4	10	8.1	6.1	5
Pressure(mb)	1024	1021.4	1018.6	1015	1012	1006	1001.6	1003.7	1010	1017	1020	1021
Cloud .(octa)	4.4	4	3.7	7.4	2.8	1.2	0.84	0.6	1	2.4	3.3	4.3

Table (8): Correlations between wind speed & the different variables

Stations	Correlations between V& (T+ n)	R	R^2	MAE	RMSE
Mosul	V= - o.313 - 0.090 T + 0.416 n	0.83	0.69	12	15
Sinjar	V= - 1.78 - 0.196 T+1. 078 n	0.92	0.85	7.5	9.8
Talaf.	V= 2.605 – 0.023 T + 0.292 n	0.93	0.86	3	3.8
Rabea	V = 0.523 – 0. 77 T + 0.327 n	0.91	0.83	3.5	4.3
Baag	V = 0.344 – 0.032 T + 0.387 n	0.97	0.95	4.4	5
Stations	Correlations between V & (T+ P)	R	R^2	MAE	RMSE
Mosul	V= 117.6 – 0.061 T – 0.114 P	0.84	0.7	19.8	23
Sinjar	V=203.22 – 0.062 T – 0.197 P	0.89	0.8	12	19
Talaf.	V= 69.015 + 0.010 T – 0.64 P	0.91	0.84	8.8	13
Rabea	V= 96.66 – 0.049 T – 0.093 P	0.94	0.89	6.5	8.6
Baag	V = 108.14 – 0.007 T – 0.104 P	0.98	0 .96	3.9	5
Stations	Correlations between V & (P+RH)	R	R^2	MAE	RMSE
Mosul	V = 90.68 – 0.089 P + 0.021 RH	0.85	0.7	27	32
Sinjar	V =150.57 -0.146 P + 0.014 RH	0.88	0.78	20	25
Talaf.	V = 80.421 – 0.075 P + 0.001RH	0.92	0.84	5.3	6.8
Rabea	V= 72.424 - 0.071 P+ 0.016 RH	0.90	0.82	19	22.6
Baag	V =107.148 -0.103 P + 0.004 RH	0.98	0.96	6.7	10.6
Stations	Correlations Between V & (T +E)	R	R^2	MAE	RMSE
Mosul	V = 1.618 – 0.093 T + 0.001 E	0.86	0.74	10	13
Sinjar	V = 2.428 – 0.087 T + 0.009E	0.86	0.74	12	16.7
Talaf.	V = 3.768 + 0.011T + 0.002 E	0.89	0.76	9.3	11.8
Rabea	V = 1.939 + 0.070 T + 0.007 E	0.88	0.78	4.9	6.9
Baag	V= 1.565 + 0.047 T + 0.002 E	0.93	0.87	5.7	7.9

Table (9): Meteorological Parameters in all stationsSpeed and all theWindValues of Multiple Regression models between the Mean Monthly:

Stations	Multiple Regression models	R	R^2	%MAE	%RMSE
Mosul	V= - 28.629 – 0.005T+0.129 n+ 0.320C - 0.014RH+0.006E+0.027P+0.016R	0.99	0.98	2.0	3.0
Sinjar	V=21.985 – 0.226T+0.488 n+0.900C – 0.083RH+0.006E – 0.018P – 0.007 R	0.98	0.96	3.7	6.5
Talafar	V=21.744+ 0.057T +0.068 n +0.444C – 0.013RH +0.002 E – 0.020 P + 0.020 R	0.97	0.94	2.5	3.2
Rabea	V=67.311-0.086T+0.135 n-0.037C -0.008 RH+0.001E - 0.064P+0.004R	0.98	0.96	0.9	2.2
Baaj	V=108.807 – 0.115T+0.019 n+0.194C – 0.003RH+0.005E – 0.103P – 0.034R	0.99	0.98	3.0	3.5

, RH =Relative Humidity , C =Cloudiness T = Mean Air Temp. , n = Sun Shine hour
E = Evaporation, P= Atmospheric Pressure, R= Rainfal

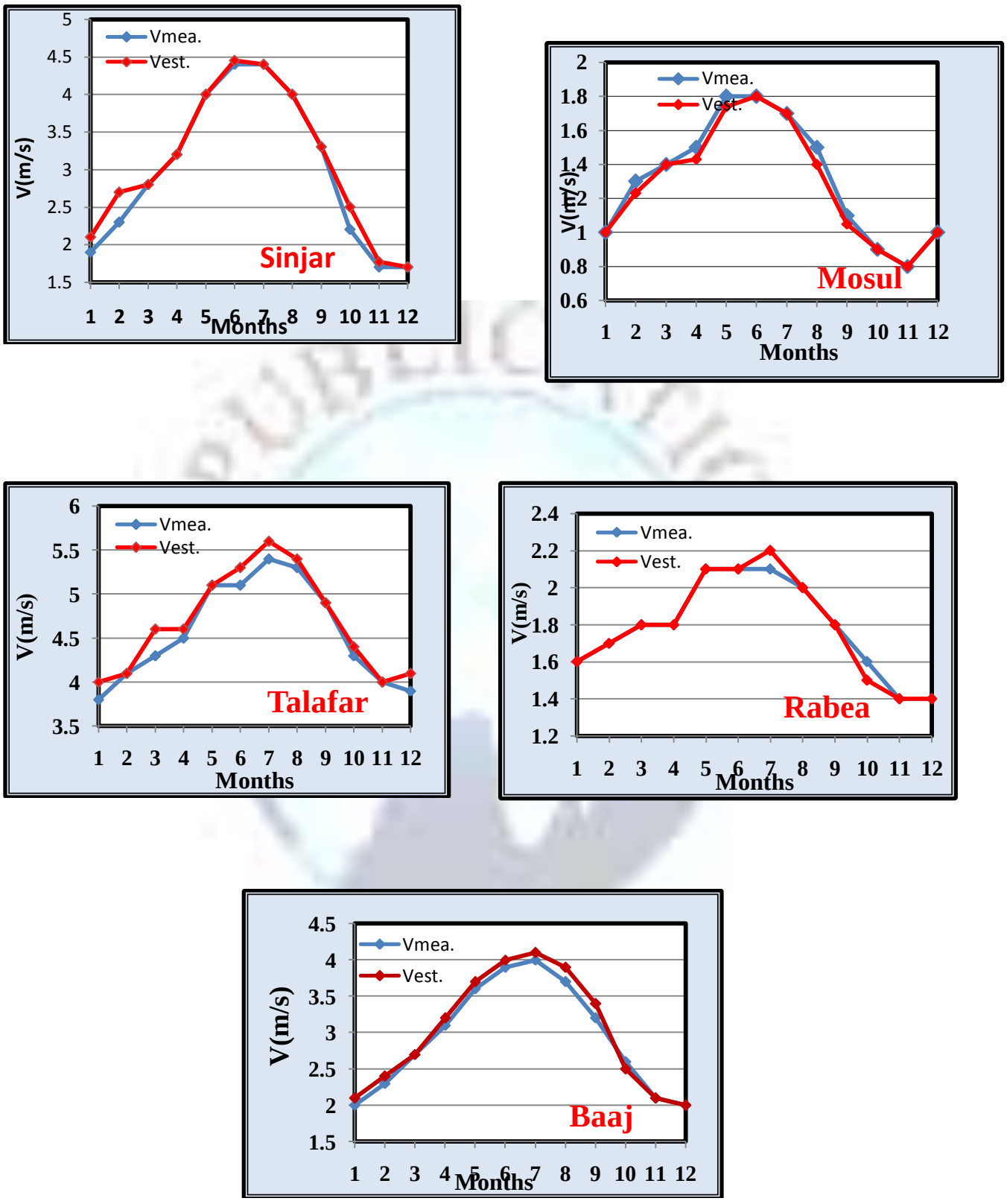

Fig. (2): comparison between the measured and estimated values of wind speed in all stations

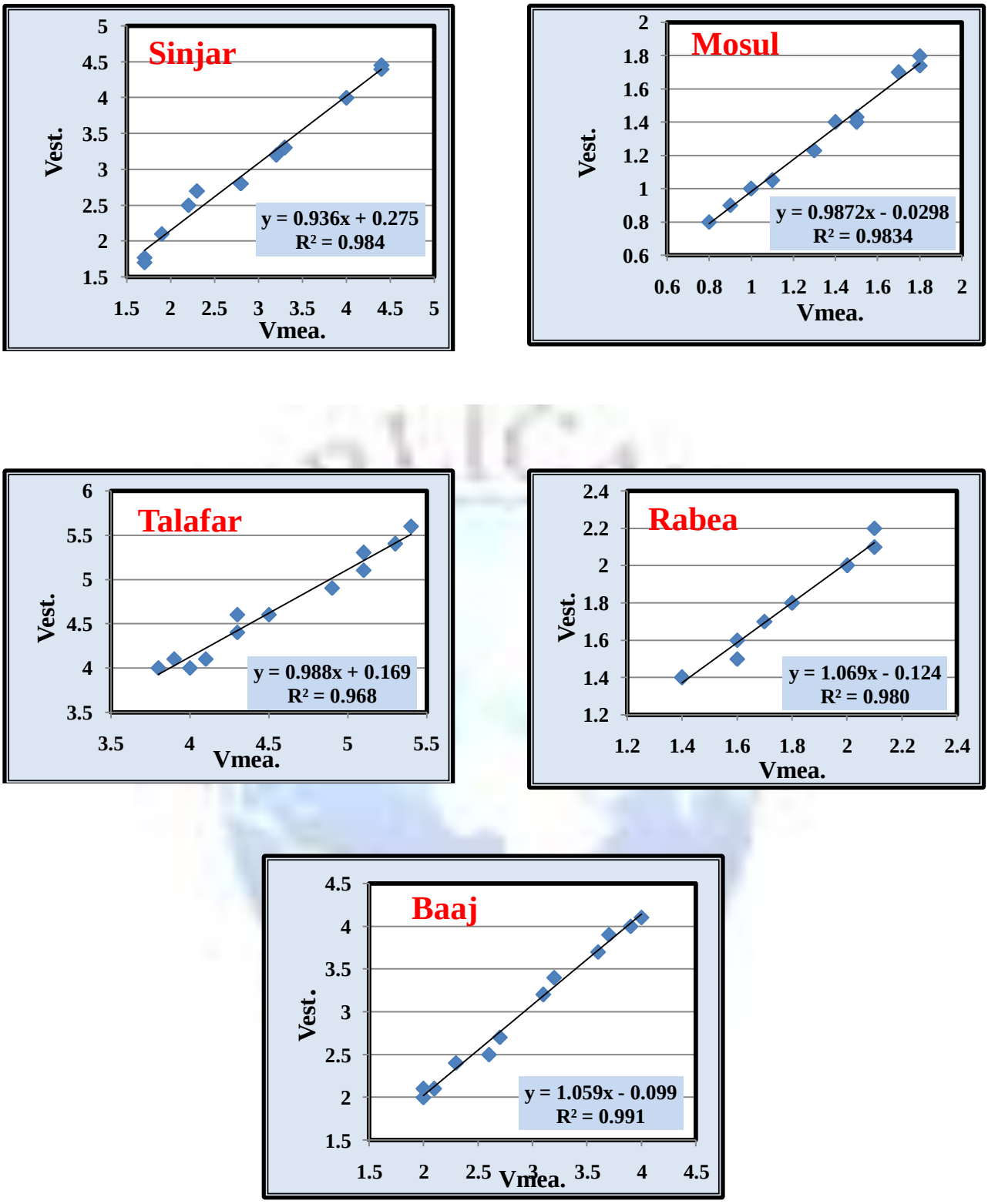

Fig (3) : correlations between measured and estimated wind speed in all stations