Estimation of clearness index from different meteorological parameters in IRAQ

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Abstract: The aim of this paper is to estimate the mean monthly values of clearness index in five meteorological stations in Iraq (Mosul, Kirkuk, Rutba, Baghdad, Nasiriya) for the period (1970-2000) using different meteorological parameters. Five different models (Linear, Quadratic, Logarithmic, Linear logarithmic, Power) were used to estimate clearness index. The performance of this regression models were evaluated by comparing the calculated clearness index and the measured clearness index. Several statistical tests 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. Results showed that Linear model between (KT & n/N) and between (KT & Rainfall) were the best fit in all stations. Quadratic model were the best fit between (KT & cloudiness), and power model were the best fit between (KT & Quadratic model and Quadratic model were the best fit between (KT & Tmean).

I. Introduction

Clearness index is define as the ratio between the global solar radiation at ground level on horizontal surface and the corresponding extraterrestrial radiation⁽¹⁾. The monthly mean clearness index KT = H/Ho Where H is the monthly mean global solar radiation on horizontal surface Ho is the monthly mean extraterrestrial radiation. clearness index is a parameters of real importance in designing of a renewable energy sources system ; it can provide information concerning the read solar radiation compared with the variable solar radiation^(2,3). Clearness index can describes the attenuation of solar radiation due to clouds and aerosols and it depends on the geographical coordinates of the location for watch calculated^(4,5).

Several methods have been Proposed for prediction of clearness index^(6,7,8). Almost all these models make use of a few meteorological data such as hours of bright sunshine cloudiness, relative humidity, wind speed, altitude precipitation and ambient temperature^(9,10,11).

Iraq in located between 29.5° N and 37.22° N latitude and most of its cites enjoy favorable sunshine whole year around .

In this paper correlations are proposed for monthly mean clearness index (KT) for (Mosul , Kirkuk , Rutba , Baghdad , Nasiriya) stations based on meteorological data for the period (2000-1970) Then calculated KT are compared with measured values.

II. Materials and Methods

Mean monthly values of total solar radiation, relative humidity air temperature, cloudiness, rainfall, evaporation are obtained from Iraqi meteorological organization.

The data obtained covered a period of 31 year (1970-2000) for five stations in Iraq listed in table (1) and displayed in Fig. (1).

The mean monthly values of extraterrestrial radiation (Ho) is calculated from the following equation :

 Φ : is the latitude of the location, Eo is the eccentricity correlation factor, δ is the declination, Ws is the hour angle corresponding to sun-shine or set and Isc is the solar constant having a value of 1367 w/m².

The expressions of Eo , δ and Ws $% \ are given by Iqbal^{(5)}.$

dn is the day number of the year .

Mean monthly values of clearness index were computed for the different stations during the period (1970-2000). A number of regression models (Linear , Quadratic , Logarithmic , Linear logarithmic , Power) were investigated and validated to estimate the mean monthly clearness index using different meteorological parameters in the five stations.

In order to select the best model ,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 and were computed as further check on the stability of the models.

Table(1) : Geographical coordinate of the stations

Stations	Latitude	Longitude	(Altitude(m
Mosul	36° 19′	43° ′09	223
Kirkuk	35° 28′	44° ′25	331
Baghdad	33° 18′	44° ′24	32
Rutba	33° 02'	40° ′17	630
Nasiriya	31° 05′	46° 14	5

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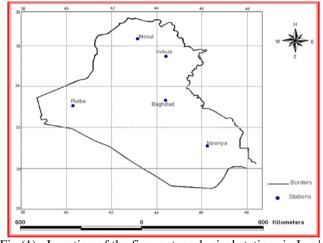


Fig (1): Location of the five meteorological stations in Iraq's

Table (2,3,4,5,6) show the mean monthly meteorological parameters in all stations during the period (1970-2000).

Months Meteo. ele.	JAN	FEB	MA R	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
n/N	0.49	0.56	0.57	0.62	0.73	0.83	0.86	0.88	0.86	0.76	0.64	0.48
Mean air temp.(c°)	7.0	8.8	12.6	18.0	24.5	30.4	34.1	33.1	28.4	21.4	13.8	8.5
RH%	80.2	73.5	67.6	60.2	42.9	27.3	24.1	25.7	30.6	45.7	65.5	79.9
total cloud (octa)	4.3	4.2	4.1	3.9	2.9	1.1	0.4	0.3	0.7	2.3	3.1	4.7
Evaporation(mm)	32.5	51.8	96.4	145.4	247.6	349.8	412.3	373.6	257.1	151.5	68.4	31.4
Rainfall(mm)	63.2	62.1	67.8	43.2	17.0	1.2	0.2	0.0	0.3	11.4	45.1	60.4
H $(w.d/m^2)$	1996	2796	3599	4646	5559	6172	6097	5613	4845	3478	2405	1785
Ho $(w.d/m^2)$	4821	6163	8075	9876	11118	11585	11326	10324	8711	6734	5140	4400
KT	0.41	0.45	0.45	0.47	0.50	0.53	0.54	0.54	0.56	0.52	0.47	0.41

Table (3):Mean Monthly meteorological parameters for Kirkuk station during the period (1970-2000)

Months Meteo. ele.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
n/N	0.62	0.67	0.68	0.70	0.76	0.86	0.87	0.91	0.92	0.84	0.76	0.65
Mean air temp.(c°)	9.2	10.8	14.3	20.2	26.8	32.3	35.5	34.9	31.2	24.9	16.9	11.0
RH%	70.9	65.2	59.2	50.6	33.4	22.9	21.1	22.5	24.8	35.9	55.9	70.8
total cloud (octa)	3.8	3.7	3.4	3.3	2.2	0.5	0.3	0.3	0.5	1.9	3.0	3.7
Evaporation(mm)	46.0	61.1	100.2	153.7	260.8	351.8	402.8	374.3	282.1	185.6	83.6	47.0
Rainfall(mm)	68.3	66.4	63.1	47.0	13.8	0.2	0.3	0.1	0.6	12.8	42.9	60.1
H (w.d/m ^{2})	2084	2827	3738	4691	5738	6578	6454	6033	5159	3792	2584	1895
Ho $(w.d/m^2)$	4965	6294	8175	9929	11127	11570	11323	10359	8793	6855	5281	4547
KT	0.42	0.45	0.46	0.47	0.52	0.57	0.57	0.58	0.59	0.55	0.49	0.42

Months Meteo. ele.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
n /N	0.62	0.68	0.67	0.69	0.75	0.87	0.87	0.90	0.86	0.79	0.71	0.62
Mean air temp.(c°)	9.2	11.7	15.5	22.5	28.4	32.3	34.6	33.8	30.1	23.9	16.1	10.6
RH%	73.5	62.2	52.7	42.5	31.8	24.8	24.3	26.8	31.5	40.9	57.3	72.2
total cloud (octa)	3.7	3.3	3.4	3.4	2.7	0.5	0.4	0.5	0.7	2.1	3.1	3.8
Evaporation(mm)	69.7	102.0	177.7	266.3	383.0	500.9	558.1	505.4	369.3	238.9	123.9	70.3
Rainfall(mm)	49.4	35.6	34.2	23.2	8.1	0.2	0.3	0.0	0.3	7.2	26.5	36.9
H $(w.d/m^2)$	2864	3739	4666	5617	6398	7082	6977	6458	5523	4311	3220	2545
Ho (w.d/m ²)	4965	6294	8175	9929	1112 7	1157 0	1132 3	1035 9	8793	6855	5281	4547
KT	0.54	0.56	0.55	0.56	0.57	0.61	0.62	0.62	0.61	0.6	0.57	0.52

Table (4):Mean Monthly meteorological parameters for Baghdad station during the period (1970-2000)

Table (5):Mean Monthly meteorological parameters for Rutba station during the period (1970-2000)

Months Meteo. ele.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
n/N	0.63	0.67	0.69	0.69	0.73	0.86	0.88	0.89	0.87	0.81	0.75	0.62
Mean air temp.(c°)	7.6	9.3	13.0	18.7	23.9	28.1	30.7	30.4	27.5	21.8	14.3	9.3
RH%	70.2	60.7	51.9	42.1	33.6	27.5	26.3	27.7	29.8	41.4	55.6	70.1
total cloud (octa)	3.2	3.1	2.8	2.4	2.0	0.4	0.3	0.4	0.8	2.1	2.8	3.3
Evaporation(mm)	77.5	112.5	186.5	275.2	378.1	470.0	556.1	507.5	371.1	247.3	130.2	78.5
Rainfall(mm)	14.3	20.5	20.2	16.1	6.7	0.1	0.1	0.0	0.4	11.3	16.3	17.8
H (w.d/m ²)	2565	3408	4381	5661	6451	7198	7159	6555	5633	4345	3128	2460
Ho $(w.d/m^2)$	5374	6663	8450	10072	11139	11520	11302	10449	9017	7193	5678	4963
KT	0.48	0.51	0.53	0.56	0.58	0.62	0.63	0.63	0.62	0.6	0.55	0.5

Table (6):Mean Monthly meteorological parameters for Nasiriya station during the period (1970-2000)

Months Meteo. ele.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
n/N	0.63	0.67	0.64	0.65	0.68	0.69	0.71	0.75	0.79	0.76	0.69	0.63
Mean air temp.(c°)	11.7	14.0	18.5	24.9	30.7	34.2	36.0	35.7	32.9	26.9	19.3	13.3
RH%	68.9	59.2	50.4	41.7	31.6	23.7	22.5	23.6	27.2	37.5	53.0	66.9
total cloud	2.8	2.3	2.3	2.4	1.7	0.5	0.3	0.3	0.3	1.5	2.2	2.7
Evaporation(mm)	80.1	110.7	190.1	274.9	404.8	535.4	612.1	554.2	417.8	271.9	140.7	85.3
Rainfall(mm)	29.2	19.2	20.9	10.5	5.0	0.2	0	0	0.8	5.6	15.0	21.2
H (w.d/m ²)	2917	3825	4607	5437	5952	6142	6180	5913	5296	4260	3226	2677
Ho (w.d/m ²)	5699	6951	8660	10174	11138	11469	11273	10508	9185	7456	5993	5295
KT	0.51	0.55	0.53	0.53	0.53	0.54	0.55	0.56	0.58	0.57	0.54	0.51

III. Results and Discussion

Fig (2) show the correlations between the mean monthly values of clearness index and sunshine Ratio (n/N) in all stations. Linear models is the best fit for all stations . The coefficient of determination (R^2) exist between (KT) and (n/N) ranged between (0.89-0.97), this mean that (89%-97%) of KT can be accounted using monthly mean (n/N).

Fig (3) show the correlations between the mean monthly values of KT & Tmean in all stations . The coefficient of determination (R^2) is high for all stations except Nasiriya station. This implies that there are statistically significant relationships between KT & Tmean.

Linear model are the best fit for Mosul ,Kirkuk, and Baghdad stations whereas the quadratic model is the best fit in Rutba and Nasiriya stations .

Fig (4) show the correlations between the mean monthly values of KT and RH. The correlations is highly acceptable in all stations except Nasiriya station, where R^2 are ranged between (0.78-0.95).

Linear model are the best fit for Kirkuk, Baghdad and Rutba stations, whereas quadratic model performed the best fit for Mosul and Nasiriya stations.

Fig (5) show the correlations between the mean monthly values of KT & cloudiness in all stations. It can be seen that the coefficient of determination (R^2) implies a good match between the mean monthly values of KT & cloudiness. The values of (R^2) ranged between (0.62-0.98). Quadratic model are the best fit in Mosul ,Kirkuk, Rutba and Nasiriya stations whereas power model is the best fit in Baghdad station.

Fig (6) show the correlations between the mean monthly values of clearness index and Evaporation in all stations. The coefficient of determination (R^2) exist between KT & Evaporation ranged between (0.75-0.89) for all stations except Nasiriya station which give a weak correlation. Power model is the best fit in Mosul ,Kirkuk , Baghdad and Rutba stations whereas quadratic model is the best fit in Nasiriya station.

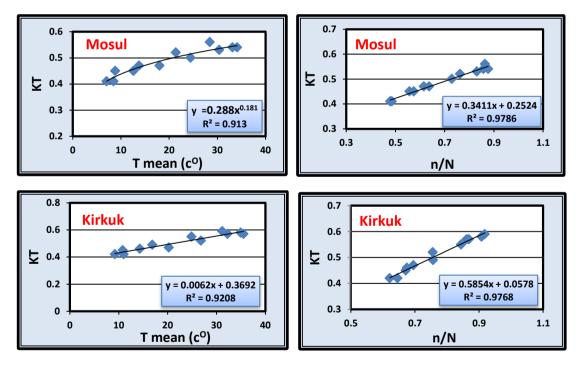
Fig (7) show the correlations between the mean monthly values of clearness index and Rainfall in all stations. The correlations is highly acceptable in Mosul, Kirkuk, Baghdad and Rutba stations where the coefficient of determination are ranged between (0.75-0.94). Nasiriya station show a weak correlation. Linear model is the best fit in Mosul, Kirkuk, Rutba and Nasiriya stations whereas quadratic model is the best fit Baghdad station.

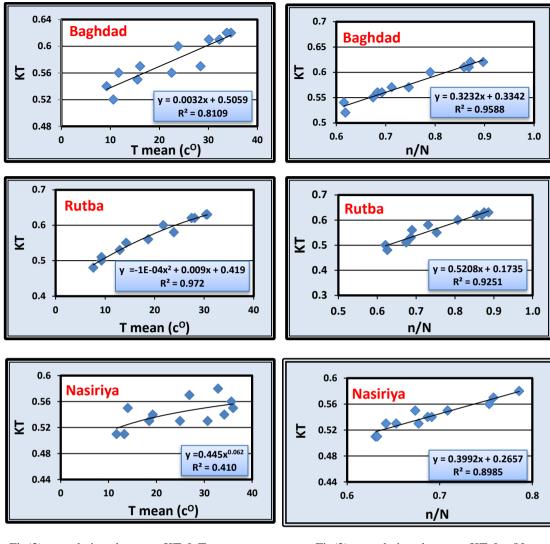
Nasiriya station suffer greatly from duststorm specially during the summer months which attenuate greatly the incoming solar radiation and hence reduce the clearness index during these months. Most of the meteorological parameters and the correlations were affected by this phenomena in Nasiriya station.

Table (7) contain summaries of regression statistics obtained from the different models in all stations. The correlation coefficient (R), coefficient of determination (R^2),Mean absolute Error (MAE) and Root Mean Square Error (RMSE) varies from one station to another , and also vary from one variable to another .

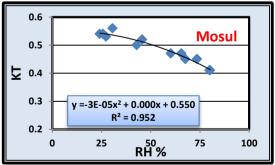
MAE is found in a range of (0.94-9.8)% indicating a fairly good fitting between KT and considered meteorological parameters.

It is quite obvious from the table (7) that RMSE is lies between (1.17,7.86)% in all stations which also shows a good performance of all the models examined .

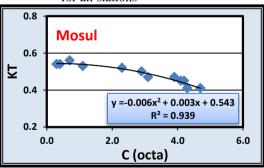


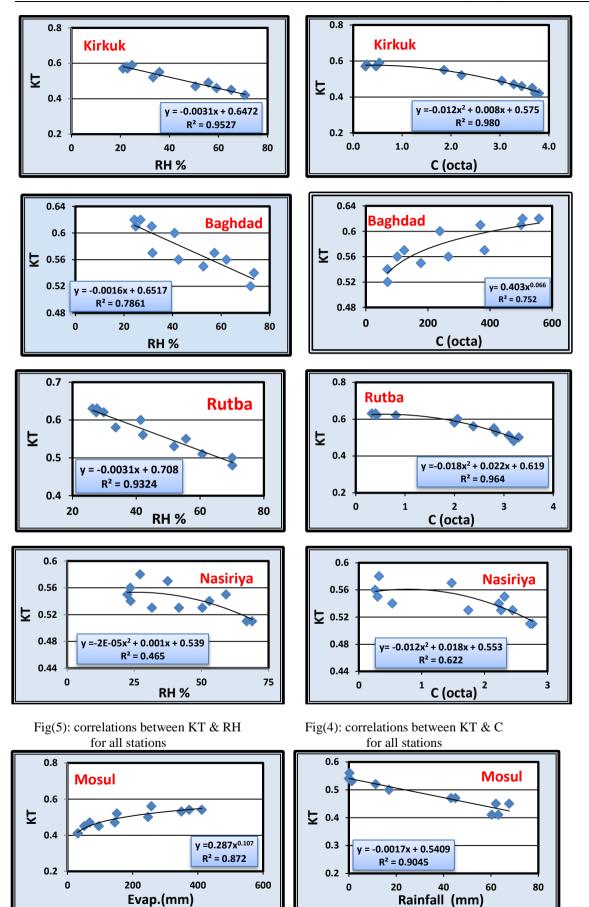


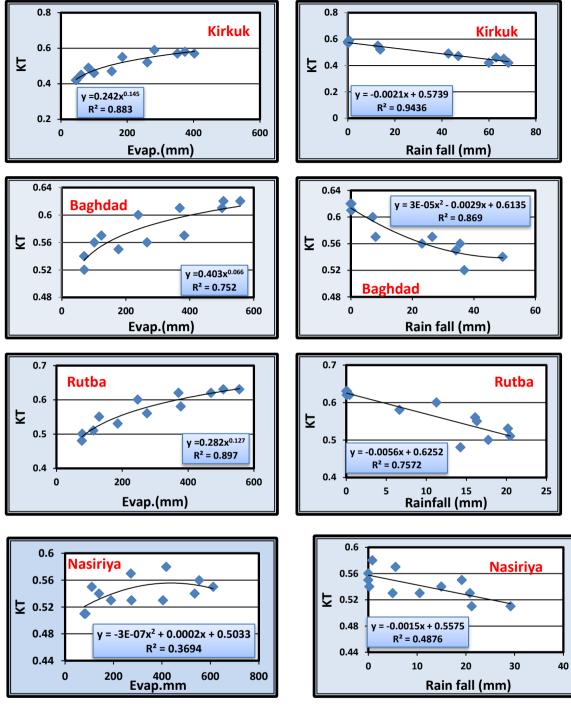
Fig(3): correlations between KT & Tmean for all stations



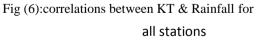
Fig(2): correlations between KT & n/N for all stations







Fig(7): correlations between KT & Evap. for all stations



Т

Meant KT = 0.3411(n(N) + 0.2524 0.989 0.978 1.26 1.45 Kirkuk KT = 0.3532(n/N) + 0.078 0.988 0.976 1.47 1.89 Baghada KT = 0.3232(n/N) + 0.3342 0.979 0.658 0.976 1.17 Rubu KT = 0.3292(n/N) + 0.1735 0.942 0.925 1.92 2.58 Nasiriya KT = 0.3992(n/N) + 0.2657 0.948 0.898 0.944 1.23 Stations correlations R R2 MAE RMSE Moull KT = 0.0027 mean + 0.509 0.90 0.810 6.79 7.48 Ruths KT = -0.0027 mean + 0.509 0.90 0.810 6.79 7.48 Nasiriya KT = -0.4657 mean 0.098 mean + 0.4191 0.966 0.972 4.01 4.85 Mathin KT = -4.0672 + 0.0031 r + 0.5539 0.990 0.390 1.48 1.71 Stations correlations R R2 MAE RMSE Moull KT = -0.0157 c 2 + 0.021 r + 0.6199 0.980 1.48 <th>Stations</th> <th>correlations</th> <th>R</th> <th>R2</th> <th>MAE</th> <th>RMSE</th>	Stations	correlations	R	R2	MAE	RMSE
Baghdal KT = 0.523(µ/N) + 0.3342 0.979 0.958 0.97 1.17 Ruba KT = 0.5238(µ/N) + 0.1735 0.962 0.925 1.92 2.58 Nasiriya KT = 0.392(µ/N) + 0.2657 0.948 0.898 0.944 1.23 Stations correlations R R2 MAE RMSE Mosul KT = 0.2886 Tmean 0.1512 0.956 0.011 2.51 3 Kirkuk KT = 0.0062Tmean + 0.692 0.900 0.920 2.89 3.34 Baghdad KT = 0.4002Tmean + 0.692 0.901 0.911 4.58 Nasiriya KT = 0.4156 Tmean 2 + 0.098 Tmean + 0.4191 0.968 0.972 4.011 4.41 V V Nasiriya KT = 0.4007c2 + 0.031 mean + 0.4191 0.968 0.972 4.011 4.41 V V V 0.641 0.911 4.58 Mastiriya KT = 0.4165 Tmean 0.062 0.644 0.960 0.339 2.08 Mixtast KT = 0.4016 C ± 0.0031 C ± 0.5139 0.960	Mosul	KT = 0.3411(n/N) + 0.2524	0.989	0.978	1.26	1.45
Rutha KT = 0.5208(n/N) + 0.1735 0.962 0.925 1.92 2.58 Nasiriya KT = 0.3992(n/N) + 0.2657 0.948 0.598 0.94 1.23 V Stations Correlations R R.2 MAE RMSE Masail KT = 0.2886 Tmean 0.1812 0.956 0.013 2.51 3 Kirkuk KT = 0.0022 Tmean + 0.569 0.00 0.810 6.79 7.48 Rutba KT = -1E-044 Tmean 2 + 0.0098 Tmean + 0.4191 0.966 0.972 4.01 4.85 Nasiriya KT = 0.4456 Tmean 0.062 0.641 0.010 9.84 4.41 Nasiriya KT = 0.0067c2 + 0.0031 + 0.5439 0.969 0.393 2.08 2.63 Kirkuk KT = -0.0126 c2 + 0.0084 c + 0.5756 0.99 0.980 1.48 1.71 Baghdad KT = -0.012 c 2 + 0.021 c + 0.6199 0.867 0.752 2.49 2.80 Masairy KT = -0.012 c 2 + 0.013 R + 0.517 0.867 0.522 2.31 2.31	Kirkuk	KT = 0.5854(n/N) + 0.0578	0.988	0.976	1.47	1.89
Nasiriya KT = 0.3992(µ/N) + 0.2657 0.948 0.948 0.948 0.948 1.23 Stations correlations R R2 MAE RMSE Mosul KT = 0.2866 Tmean 0.1812 0.956 0.913 2.51 3 Kirkuk KT = 0.0022 Tmean + 0.509 0.90 0.810 6.79 7.48 Baghdad KT = 0.4455 Tmean 0.062 0.641 0.410 9.84 4.41 Visions correlations R R2 MAE RMSE Masal KT = 0.0067c2 + 0.0031c + 0.5439 0.969 0.939 2.08 2.63 Kirkak KT = 0.0187 c 2 + 0.0212 c + 0.5756 0.99 0.938 1.48 1.71 Baghdad KT = 0.0187 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = -0.0187 c 2 + 0.0221 c + 0.5196 0.976 0.952 3.83 4.71 Baghdad KT = -0.0187 c 2 + 0.0218 c + 0.5556 0.976 0.952 2.26 2.61 Mosul KT = -0.0018 RH + 0.6197	Baghdad	KT = 0.3232(n/N) + 0.3342	0.979		0.97	1.17
Stations correlations R R2 MAE RMSE Mosul KT = 0.2866 Tmean 0.1812 0.956 0.913 2.51 3 Baghdad KT = 0.0062Tmean + 0.3692 0.960 0.920 2.89 3.34 Baghdad KT = 0.0032Tmean + 0.569 0.90 0.810 6.79 7.48 Rutba KT = 1.2-04 Tmean + 0.569 0.90 0.810 0.972 4.01 4.85 Nasiriya KT = 0.00572 + 0.0031 mean + 0.4191 0.966 0.972 4.01 4.41 V V V V 0.611 0.410 9.84 4.41 V V V V V 0.90 0.930 1.48 1.71 Baghdad KT = 0.0126 c 2 + 0.0031 mean + 0.5439 0.964 0.480 1.82 0.564 1.48 1.82 Natrinya KT = -0.012 c 2 + 0.0128 mean + 0.5536 0.976 0.952 3.83 4.71 Stations correlations R R2 MAE RMSE	Rutba	KT = 0.5208(n/N) + 0.1735	0.962	0.925	1.92	2.58
Mosal KT = 0.2886 Tmean 0.1812 0.956 0.913 2.51 3 Kirkuk KT = 0.0062Tmean + 0.3692 0.900 0.920 2.89 3.34 Baghdad KT = 0.0032 Tmean + 0.5059 0.90 0.900 0.810 6.779 7.48 Rutba KT = -1.6-04 Tmean 2 + 0.0098 Tmean + 0.4191 0.986 0.972 4.01 4.85 Nasiriya KT = 0.4456 Tmean 0.062 0.641 0.410 9.84 4.41 V Value NAE RMSE 0.969 0.939 2.08 2.63 Kirkuk KT = 0.0067.2 + 0.0031 c + 0.5439 0.969 0.939 0.980 1.48 1.71 Baghdad KT = 0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.980 1.48 1.82 Nasiriya KT = -0.012 c 2 + 0.0188 c + 0.5536 0.789 0.623 1.89 2.31 V Stations correlations R R2 MAE RMSE Massiriya KT = -0.013 R1 + 0.6037 0.976 0.952 3.83 4.71 <td>Nasiriya</td> <td>KT = 0.3992(n/N) + 0.2657</td> <td>0.948</td> <td>0.898</td> <td>0.94</td> <td>1.23</td>	Nasiriya	KT = 0.3992(n/N) + 0.2657	0.948	0.898	0.94	1.23
Mosal KT = 0.2886 Tmean 0.1812 0.956 0.913 2.51 3 Kirkuk KT = 0.0062Tmean + 0.3692 0.900 0.920 2.89 3.34 Baghdad KT = 0.0032 Tmean + 0.5059 0.90 0.900 0.810 6.779 7.48 Rutba KT = -1.6-04 Tmean 2 + 0.0098 Tmean + 0.4191 0.986 0.972 4.01 4.85 Nasiriya KT = 0.4456 Tmean 0.062 0.641 0.410 9.84 4.41 V Value NAE RMSE 0.969 0.939 2.08 2.63 Kirkuk KT = 0.0067.2 + 0.0031 c + 0.5439 0.969 0.939 0.980 1.48 1.71 Baghdad KT = 0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.980 1.48 1.82 Nasiriya KT = -0.012 c 2 + 0.0188 c + 0.5536 0.789 0.623 1.89 2.31 V Stations correlations R R2 MAE RMSE Massiriya KT = -0.013 R1 + 0.6037 0.976 0.952 3.83 4.71 <td></td> <td></td> <td>_</td> <td></td> <td></td> <td></td>			_			
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Baghad KT = 0.0032 Tmean + 0.5059 0.90 0.810 6.79 7.48 Rutba KT = -1E-04 Tmean 2 + 0.0098 Tmean + 0.4191 0.966 0.772 4.01 4.85 Nasiriya KT = 0.4456 Tmean 0.062 0.641 0.410 9.844 4.41 V Stations correlations R R2 MAE RMSE Mosul KT = 0.0067c2 + 0.0031 c + 0.5439 0.969 0.939 2.08 2.63 Kirkak KT = 0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.960 1.48 1.71 Baghdad KT = 0.0137 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = 0.012 c 2 + 0.0188 c + 0.5536 0.789 0.623 1.89 2.31 Mosul KT = -32-05RH2 + 0.0003RH + 0.5505 0.976 0.952 3.83 4.71 Kirkak KT = 0.0031RH + 0.6472 0.976 0.952 2.26 2.66 Ruba KT = -0.0031RH + 0.517 0.887 0.786 2.25 2.66		KT = 0.2886 Tmean 0.1812		0.913	2.51	3
Rutha KT = -1E-04 Tmean 2 + 0.0098 Tmean + 0.4191 0.986 0.972 4.01 4.85 Nasiriya KT = 0.4456 Tmean 0.062 0.611 0.410 9.84 4.41 Stations correlations R R2 MAE RMSE Mosul KT = 0.0067c2 + 0.0031c + 0.5439 0.969 0.339 2.08 2.63 Kirkuk KT = 0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.960 1.48 1.71 Baghdad KT = 0.013c 0.663 0.867 0.752 2.49 2.80 Rutba KT = 0.0121 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = 0.012 c 2 + 0.003R c + 0.536 0.789 0.623 1.89 2.31 Nasiriya KT = -0.012 c 2 + 0.003R H + 0.505 0.976 0.952 3.83 4.71 Kirkuk KT = -0.003 R H + 0.505 0.976 0.952 2.26 2.61 Baghdad KT = -0.003 R H + 0.517 0.887 0.786 2.26 2.66 Rutba KT = -0.001 R H + 0.6379	Kirkuk	KT = 0.0062Tmean + 0.3692	0.960	0.920	2.89	3.34
Nasiriya KT = 0.4456 Tmean 0.062 0.611 0.611 0.611 0.611 0.611 Stations correlations R R2 MAE RMSE Mosul KT = 0.0067c2 + 0.0031c + 0.5439 0.969 0.939 0.980 1.48 1.71 Baghdad KT = 0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.980 1.48 1.71 Baghdad KT = 0.0137 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = 0.0187 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = 0.012 c 2 + 0.0188 c + 0.5536 0.976 0.952 2.80 Stations correlations R R R R R Mosul KT = -3E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 2.26 2.61 Baghdad KT = -0.0018 RH + 0.6517 0.887 0.786 2.26 2.66 Rutba KT = -0.0011R + 0.6317 0.887 0.795 2.35 2.85 U Mate	Baghdad	KT = 0.0032 Tmean + 0.5059	0.90	0.810	6.79	7.48
Stations correlations R R2 MAE RMSE Mosul KT = -0.0067c2 + 0.0031c + 0.5439 0.969 0.939 2.08 2.63 Kirkuk KT = -0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.960 1.48 1.71 Baghdad KT = 0.0131c 0.0663 0.867 0.752 2.49 2.80 Rutha KT = 0.0137 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = 0.012 c 2 + 0.0188 c + 0.5536 0.789 0.623 1.89 2.31 V V V 0.976 0.952 3.83 4.71 Stations correlations R R R MAE RMSE Mosul KT = -3E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 3.83 4.71 Kirkuk KT = -0.016 RH + 0.6472 0.976 0.952 2.26 2.61 Baghdad KT = -0.0011R + 0.708 0.966 0.932 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.66	Rutba	KT = -1E-04 Tmean 2 + 0.0098 Tmean + 0.4191	0.986	0.972	4.01	4.85
Mosul KT = -0.0067c2 + 0.0031c + 0.5439 0.969 0.339 2.08 2.63 Kirkuk KT = -0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.980 1.48 1.71 Baghdad KT = -0.0126 c 2 + 0.0084 c + 0.5756 0.967 0.752 2.49 2.80 Rutba KT = -0.0187 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = -0.012 c 2 + 0.0188 c + 0.5536 0.789 0.623 1.89 2.31 Mosul KT = -32E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 3.83 4.71 Kirkuk KT = -0.001RH + 0.6472 0.976 0.952 2.26 2.61 Baghdad KT = -0.001RH + 0.6472 0.976 0.952 2.26 2.66 Rutba KT = -0.001RH + 0.6517 0.887 0.786 2.252 2.61 Baghdad KT = -0.001RH + 0.6517 0.887 0.786 2.53 2.85 U V 0.966 0.932 2.12 2.41 Nasiriya KT = -0.0017Rainfall + 0.5739	Nasiriya	KT = 0.4456 Tmean 0.062	0.641	0.410	9.84	4.41
Mosul KT = -0.0067c2 + 0.0031c + 0.5439 0.969 0.339 2.08 2.63 Kirkuk KT = -0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.980 1.48 1.71 Baghdad KT = -0.0126 c 2 + 0.0084 c + 0.5756 0.967 0.752 2.49 2.80 Rutba KT = -0.0187 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = -0.012 c 2 + 0.0188 c + 0.5536 0.789 0.623 1.89 2.31 Mosul KT = -32E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 3.83 4.71 Kirkuk KT = -0.001RH + 0.6472 0.976 0.952 2.26 2.61 Baghdad KT = -0.001RH + 0.6472 0.976 0.952 2.26 2.66 Rutba KT = -0.001RH + 0.6517 0.887 0.786 2.252 2.61 Baghdad KT = -0.001RH + 0.6517 0.887 0.786 2.53 2.85 U V 0.966 0.932 2.12 2.41 Nasiriya KT = -0.0017Rainfall + 0.5739	Station a		D	1	MAE	DMCE
Kirkuk KT = -0.0126 c 2 + 0.0084 c + 0.5756 0.99 0.980 1.48 1.71 Baghdad KT = 0.4031c0.0663 0.867 0.752 2.49 2.80 Rutha KT = -0.0187 c 2 + 0.0221 c + 0.6199 0.982 0.964 1.48 1.82 Nasiriya KT = -0.012 c 2 + 0.0188 c + 0.5536 0.795 0.623 1.89 2.31 Stations correlations R R2 MAE RMSE Mosul KT = -3E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 2.26 2.61 Baghdad KT = -0.016 RH + 0.6517 0.887 0.786 2.26 2.66 Rutha KT = -2E-05 RH 2 + 0.0011 x + 0.539 0.662 0.932 2.12 2.41 Nasiriya KT = -2.003 1 RH + 0.6517 0.887 0.786 2.26 2.66 Rutha KT = -0.0013 RH + 0.6517 0.682 0.466 2.53 2.85 U Stations correlations R R2 MAE RMSE Mosul KT = -0.017Rainfall + 0.5739				R2		
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Number No.52 No.53 No.53 No.53 No.53 No.53 <t< td=""><td></td><td>KT = -0.0126 c 2 + 0.0084 c + 0.5756</td><td>0.99</td><td>0.980</td><td>1.48</td><td>1.71</td></t<>		KT = -0.0126 c 2 + 0.0084 c + 0.5756	0.99	0.980	1.48	1.71
NasiriyaKT = -0.012 c 2 + 0.0188 c + 0.55360.7890.6231.892.31O0.7890.6231.892.31StationscorrelationsRR2MAERMSEMosulKT = -3E-05RH2 + 0.0003RH + 0.55050.9760.9523.834.71KirkukKT = -0.0031RH + 0.64720.9760.9522.262.61BaghdadKT = -0.0016 RH + 0.65170.8870.7860.2262.66RutbaKT = -0.0031RH + 0.7080.9660.9322.122.41NasiriyaKT = -2E-05 RH 2 + 0.0011x + 0.5390.6820.4662.532.85CStationscorrelationsRR2MAERMSEMosulKT = -0.0017Rainfall + 0.57390.9510.9055.737.86KirkukKT = -0.0017Rainfall + 0.57390.9710.9442.453.08BaghdadKT = -0.0017Rainfall + 0.57390.9710.9442.453.08MosulKT = -0.0017Rainfall + 0.57390.9710.9442.453.08BaghdadKT = -0.0017Rainfall + 0.57390.9320.8691.552.15RutbaKT = -0.0017Rainfall + 0.62520.8770.3354.96MasiriyaKT = -0.0017Rainfall + 0.63750.9320.8870.3332.70WireKT = 0.2874E vap.0.10730.9440.9340.8723.153.63Masiriya </td <td>Baghdad</td> <td>KT = 0.4031c0.0663</td> <td>0.867</td> <td>0.752</td> <td>2.49</td> <td>2.80</td>	Baghdad	KT = 0.4031c0.0663	0.867	0.752	2.49	2.80
Stations correlations R R2 MAE RMSE Mosul KT = -3E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 3.83 4.71 Kirkuk KT = -0.0031RH + 0.6472 0.976 0.952 2.26 2.61 Baghdad KT = -0.0031RH + 0.6517 0.887 0.786 2.26 2.66 Rutha KT = -0.0031RH + 0.708 0.966 0.932 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85	Rutba	KT = -0.0187 c 2 + 0.0221 c + 0.6199	0.982	0.964	1.48	1.82
Mosul KT = -3E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 3.83 4.71 Kirkuk KT = -0.0031RH + 0.6472 0.976 0.952 2.26 2.61 Baghdad KT = -0.0016 RH + 0.6517 0.887 0.786 2.26 2.66 Rutba KT = -0.0031 RH + 0.708 0.966 0.932 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85 U U U U U U 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85 U U U U U NAE RMSE Mosul KT = -0.0017Rainfall + 0.5409 0.951 0.905 5.73 7.86 Kirkuk KT = -0.0021x Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = 0.02874 Evap.0.1073	Nasiriya	KT = -0.012 c 2 + 0.0188 c + 0.5536	0.789	0.623	1.89	2.31
Mosul KT = -3E-05RH2 + 0.0003RH + 0.5505 0.976 0.952 3.83 4.71 Kirkuk KT = -0.0031RH + 0.6472 0.976 0.952 2.26 2.61 Baghdad KT = -0.0016 RH + 0.6517 0.887 0.786 2.26 2.66 Rutba KT = -0.0031 RH + 0.708 0.966 0.932 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85 U U U U U U 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85 U U U U U NAE RMSE Mosul KT = -0.0017Rainfall + 0.5409 0.951 0.905 5.73 7.86 Kirkuk KT = -0.0021x Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = 0.02874 Evap.0.1073	Stations	correlations	D		MAE	DMSE
Kirkuk KT = -0.0031RH + 0.6472 0.976 0.952 2.26 2.61 Baghdad KT = -0.0016 RH + 0.6517 0.887 0.786 2.26 2.66 Rutba KT = -0.0031 RH + 0.708 0.966 0.932 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85 Constrained R R2 MAE RMSE Stations correlations R R2 MAE RMSE Mosul KT = -0.0017Rainfall+ 0.5409 0.951 0.905 5.73 7.86 Kirkuk KT = -0.0021x Rainfall + 0.5739 0.971 0.944 2.45 3.08 Baghdad KT = -0.0056 Rainfall - 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Correlations R R2 MAE RMSE Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 <td< td=""><td></td><td></td><td></td><td>R2</td><td></td><td></td></td<>				R2		
Baghdad KT = -0.0016 RH + 0.6517 0.887 0.786 2.26 2.66 Rutba KT = -0.0031 RH + 0.708 0.966 0.932 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85 U V 0.905 0.466 2.53 2.85 U V V 0.905 0.466 2.53 2.85 V V V V 0.951 0.905 5.73 7.86 Mosul KT = -0.0017Rainfall+ 0.5739 0.971 0.944 2.45 3.08 Baghdad KT = 3E-05 Rainfall 2 · 0.0029 Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 V V V V V V V V V V V V V V<				0.952		
Rutba KT = -0.0031 RH + 0.708 0.966 0.932 2.12 2.41 Nasiriya KT = -2E-05 RH 2 + 0.0011x + 0.539 0.682 0.466 2.53 2.85 Stations correlations R R2 MAE RMSE Mosul KT = -0.0017Rainfall + 0.5409 0.951 0.905 5.73 7.86 Kirkuk KT = -0.0021x Rainfall + 0.5739 0.971 0.944 2.45 3.08 Baghdad KT = 3E-05 Rainfall - 0.0029 Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations correlations R R2 MAE RMSE Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Mosul KT = 0.2827Evap.0.1274 0.947 0.887 2.49 2.80 Mosul KT = 0.2827 Evap.0.1274 0.947 <				0.952		
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Image: Constraint of the second sec		KT = -0.0031 RH + 0.708	0.966	0.932	2.12	2.41
Mosul KT = -0.0017Rainfall+ 0.5409 0.951 0.905 5.73 7.86 Kirkuk KT = -0.0021x Rainfall + 0.5739 0.971 0.944 2.45 3.08 Baghdad KT = 3E-05 Rainfall 2 - 0.0029 Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Mosul KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.2827 Evap.0.1663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Nasiriya	KT = -2E-05 RH 2 + 0.0011x + 0.539	0.682	0.466	2.53	2.85
Mosul KT = -0.0017Rainfall+ 0.5409 0.951 0.905 5.73 7.86 Kirkuk KT = -0.0021x Rainfall + 0.5739 0.971 0.944 2.45 3.08 Baghdad KT = 3E-05 Rainfall 2 - 0.0029 Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Mosul KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.2827 Evap.0.1663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Stations	correlations	R		MAE	RMSE
Kirkuk KT = -0.0021x Rainfall + 0.5739 0.971 0.944 2.45 3.08 Baghdad KT = 3E-05 Rainfall 2 - 0.0029 Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall - 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations correlations R R2 MAE RMSE Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Kutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94						
Baghdad KT = 3E-05 Rainfall 2 - 0.0029 Rainfall + 0.6135 0.932 0.869 1.55 2.15 Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.6252 0.698 0.487 2.33 2.70 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations correlations R R2 MAE RMSE Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94						
Rutba KT = -0.0056 Rainfall + 0.6252 0.87 0.757 3.35 4.96 Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations KT = 0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations correlations R R2 MAE RMSE Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94						
Nasiriya KT = -0.0015 Rainfall + 0.5575 0.698 0.487 2.33 2.70 Stations correlations R R2 MAE RMSE Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Rutba	KT = -0.0056 Rainfall + 0.6252				
Stations correlations R R2 MAE RMSE Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Nasiriya	KT = -0.0015 Rainfall + 0.5575	0.698		2.33	2.70
Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94				0.407		
Mosul KT = 0.2874Evap.0.1073 0.934 0.872 3.15 3.63 Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Stations	correlations	R	R2	MAE	RMSE
Kirkuk KT = 0.2428 Evap.0.1458 0.94 0.883 3.36 4.14 Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Mosul	KT = 0.2874Evap.0.1073	0.934		3.15	3.63
Baghdad KT = 0.4031 Evap.0.0663 0.867 0.752 2.49 2.80 Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Kirkuk	KT = 0.2428 Evap.0.1458	0.94		3.36	4.14
Rutba KT = 0.2827 Evap.0.1274 0.947 0.897 2.48 2.94	Baghdad	KT = 0.4031 Evap.0.0663	0.867		2.49	2.80
	Rutba	KT = 0.2827 Evap.0.1274	0.947		2.48	2.94
	Nasiriya	KT = -3E-07 Evap.2 + 0.0002 Evap. + 0.5033	0.608		3.60	4.44

able (7) : Models with Regression and statistical Indicators for all Stations

IV. Conclusion

The clearness index for five meteorological stations in Iraq has been expressed of (sunshine ratio , relative humidity , cloudiness , mean air temperature , rain fall , evaporation) applying a variety of regression models . The significance and performance characteristic of the models have been viewed using several statistical tests (R, R^2 , MAE, MBE).

The result showed that linear model gave the best fit for the relation between (KT & n/N), (KT & Rainfall) in all stations.

Quadratic model and power model gave the best fit for the relation between (KT & c) , (KT & Evap.) respectively , while linear , power and quadratic models gave the best fit between (KT & Tmean) , (KT & RH).

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