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Conversion of rain data from surface stations to forecast models data

Ali Mokhles Abdul-Jabbar[1] and Asraa Khtan Abdulkareem[2]

[1]Physicist in National Center for Water Resources Management, Iraq
[2]Department of atmospheric science, College of Science, MustansiriyahUniversity, Iraq.
Corresponding Author:dr.asraa.atmsc@uomustansiriyah.edu.iq

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Abstract

A according to Statistical analysis of daily rainfall values (2007_2016) for the study areas (Baghdad, Karbala, Al-Hay, Mosul, Kirkuk, Khanaqin,Basra, Nasiriya, Diwaniya, and Rutba) could been concluded that the 40% of rainfall very variation and 30% were moderately variable the remaining 30% had little variation, The most variation in (Baghdad, Diwaniyah, Nasiriyah and Karbala) with CV (50) within the study period.

The spatial and temporal variation of rain is one of the reasons that the measured rainfall data from surface stations cannot be directly used in forecasting weather models, they do not give good values for prediction. Therefore, Curve fitting is a good way to convert this data to data calculated from a statistical model without changing the actual value and can use as inputs data in the models of prediction. In this study, more than one function testing and found the best is) waveform-sin 4 parameter) the set data of this function used was used in the prediction model SDSM and gave very good results.

Keywords: rain data, statistical analysis , forecast modal , Iraq.

Introduction

Rain is of important climate elements because it is effect on human activity .A distribution of rainfall is skewed in Iraq and most of world ,where variance between one year and another, and this variation in the amount of rain has made there are years characterized by high quantities of general levels it is a wet year, and other decreases in the amount of rain it is a dry year,for example the seasonal range of rain in Baghdad for the period (1970-2001) record (272.3)mm [1]. There are two precipitation data sources with different features: Rain gauge measurements and satellite-based estimations, Rain networks gauge are usually installed to facilitate the direct measurement of rainfall data that characterize the spatial and temporal variations of local rainfall patterns in a stations the highly variable rainfall patterns and its spatial distribution cannot be represented effectively without having a network of enough spatial density .Therefore, Satellite-based Precipitation Estimates (SPE) are becoming a popular alternative for measuring precipitation, particularly over auge-sparse areas [2]. Due to their different spatial resolutions, the two data sets are not readily comparable. Model data are grid averages, whereas rain gauge measurements are point estimates. Therefore, statistical conversions are used to make rain data from stations with normal distributionSpecial downscaling methods [3].A combination of a stochastic weather generator technique and a transfer function model where used in statistical downscaling model (SDSM) [4].In this study needs two types of daily rainfall data. the local predictands of interest (rainfall) is the first and the data of large-scale predictors (GCM) of a grid box closest to the study area is the second type of data sets to input in (SDSM). the fourth root transformation has been conducted for precipitation in the tropical Langat River Basin as in put data for (SDSM) model by Amirabadizadehetal (2016) [5]. As the distribution of daily rainfall is skewed, also a fourth root transformation was applied to the original series in Nigerian to convert them to a normal distribution, and then used in (SDSM) [6]. Huang etal used the Gamma probability distribution function to describe the rainfall in Peninsular Malaysia as in put in SDSM data to investigate and analyze the severity and extent of drought ([7].

Therefore, this study was conducted to find the best function of curve fitting to convert rainfall data of surface station to a formula that can be entered into prediction models SDSM rather than directly inserted without affecting its true value.

Material and Methods

Study area and data

Iraq is divided into three regions: northern region (Mosul, Kirkuk, and Khanaqin), middle region are (Baghdad, Karbala, and Al-Hay), southern region (Basra, Nasiriya, and Diwaniya) and the western region (Al- Rutba) as shown in Figure(1).The data used are represented by the values of the daily rainfall (mm) for the period (2007-2016) which is taken from the Iraqi Meteorological Organization and Seismology (IMOS).

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Figure (1):Study Area

Curve Fitting

Curve fitting, also known as regression analysis, is used to find the "best fit" line or curve for a series of data points. Most of the time, the curve fit will produce an equation that can be used to find points anywhere along the curve. In some cases, you may not be concerned about finding an equation. Instead, you may just want to use a curve fit to smooth the data and improve the appearance of your plot.Curve fitting is a process of constructing a curve that has the best fit for a group of data points possibly subject to given constraints. Curve fitting can involve either interpolation, where an exact fit to the data is required, or smoothing, in which a 'smooth' function is constructed that approximately fits the data The term "curve fitting" is usually used to refer to the process of finding a curve that passes through a set of points [8]

Many types of function are tested (using sigma plot program) in this study as shown in the following equations:

1. Waveform-sin4parameter

$$Rc = d + a\sin(\frac{2\pi x}{b} + c)$$

Where:
(R_c) Rain cumulative, (a) amplitude, (b) period, (c) phase shift, (d) vertical shift, (x) days.

2. Logarithm-3parameter

$$Rc = y_0 + a\ln(x - x_0)$$

Where:
(R_c) Rain cumulative, (x) days, (x_o) primary variable, (a) real number.

3. Weibull-4parameter

$$Rc = a\left[1 - e^{-\left(\frac{x - x_0 + b\ln 2^{\frac{1}{c}}}{b}\right)^{c}}\right]$$

Where:
(R_c) Rain cumulative, (x) days, (x_o) primary variable, (a,b,c) real number.

4. Exponential-single1parameter

$$Rc = e^{ax}$$

Where:
(R_c) Rain cumulative, (x) days, (a) real number.

The Statistical Analysis of Rainfall

The Statistical analysis of rainfall data for period (2007-2016) has revealed that some of the statistical parameters as shown in Table (1), the highest CV (56.2, 53.2, 52.6, 50.9) in (Baghdad, Diwaniya, Nasiriyah, and Karbala) respectively but the lowest CV is (25) in Basrah. Furthermore, the range of annual mean rainfall for the study regions is (206.1) where the max. mean in Mosul (282.6) mm and the min. in Diwaniya (76.5) mm.

40% of the stations have large varianceannual rainfall and the registered SD is more than (70). On the other hand, 30% of the stations have moderately variance annual rainfall with SD nearly estimated as (50). In addition, 30% of the stations have a little variance of the annual rainfall with SD as less than (30).

Table 1. Statistical coefficient for the study area.

Station	C.V	SD	Mean
Baghdad	56.2	73	129.9
Karbala	50.9	50.7	99.6
Hay	41.9	50.9	121.4
Mosul	26.6	75.3	282.6
Kirkuk	29.2	78	266.4
Khanaqin	31.3	78.3	249.8
Nasiriya	52.6	54.7	103.9
Basra	24.9	24	96.4
Diwaniya	53.2	40.7	76.5
Rutba	42.4	38.1	89.9

The max.annual rainfall in Mosul (455.51) mm/year, min. in Diwaniya (9.2) mm/year. Figure (2) show the max. and min. value for all study area.

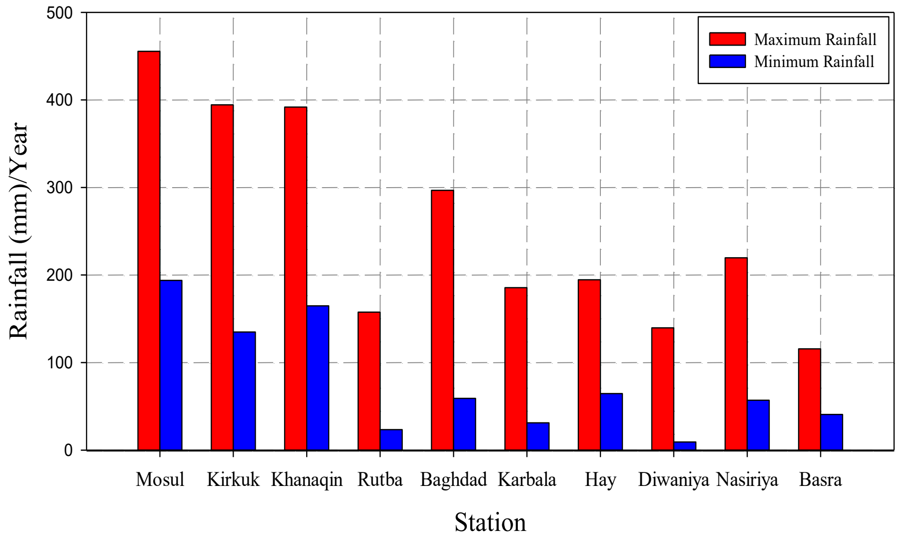

Figure (2): The Max. and Min. annual Rainfall for all station (2007-2016).

Results and Discussion.

The curve fitting applied for each station for daily rainfall value using many types of function(waveform-sin4parameter, Logarithm-3parameter, Weibull-4parameter and Exponential-single1parameter).The general formula of the functions were similar to all stations, but different coefficients would take Baghdad forms in this research as an example.The results of the other stations will be shown in the tables (2,3,4).

The function waveform-sin4parameter divided the data in a sine wave where the months of the season rainfall were represented as a peak and the other months in the case of descent as shown in figure (3 a) the red color represents the curve fitting for each function., this function represented good rainfall variances. In addition, the total sum (318.37) mm is equal to the real sum.It turns out that the waveform represents the nature of the actual data of the daily rain in terms of increasing and decreasing. Where the higher values of rain represented the high peak.

In function Logarithm-3parameter the data are divided approximately equally, seefigure (3 b) by the sum of the total on the number of days and towards from the highest value to the minimum value. The sum of the values is equal to the real total (318.43) mm, but the general distribution didn't represent the real values.

The data period is divided into two equal parts in function Weibull-4parameter the first section gave zero values for all of them, and the second part divided the data into equal parts butwith half the total value as shown in figure (3 c). Therefore, the final sum of the function is(155.22) mm, half the original value (318.37) mm.

Finally, the function Exponential-single1parameter gave equal values for all days with a value of (1), which resulted in the final being much higher than the original (1461) mm, in addition where all data are considered constant, did not represent the nature of the rain, seefigure (3 d).

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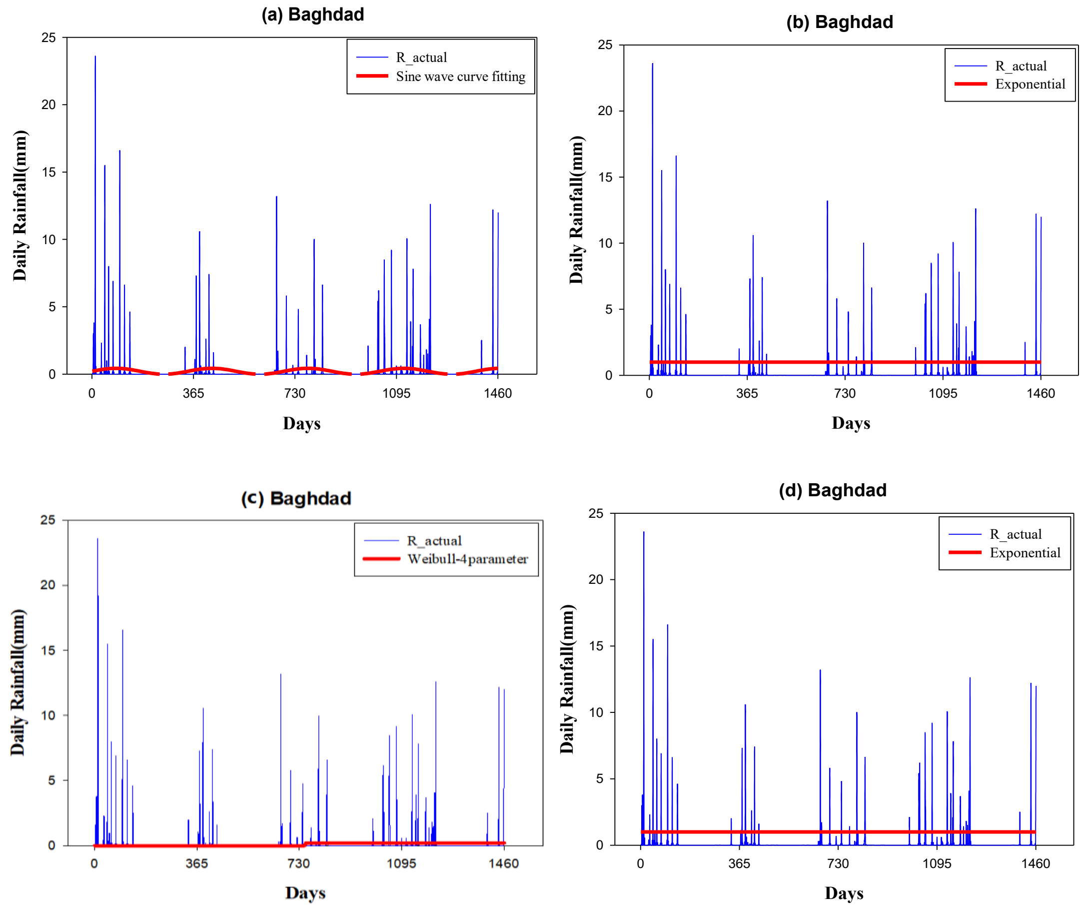

Figure (3): a-Actual daily rainfall and sine wave b- Logarithm-3parameter c- Weibull-4parameter and d- Exponential-single1parameter for Baghdad.

by comparing actual and predicted values, found that all results are in matching with the actual valuesfor waveform-sin4parameter and Logarithm-3parameteras show in table (2). but Weibull-4parameter and Exponential-single1parameter their results were far from actual values of rainfall for all stations. See table (3,4).

Table (2): Actual and Predicted Rainfall value for waveform-sin4parameter and Logarithm-3parameteras

Years	Mosul		Kirkuk		Khanaqin		Diwaniya		Nasiriya	
	Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)	
	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict
2007-2010	874.5	874.5	801.0	801.0	826.6	826.6	183.1	183.1	292.5	292.5
2007-2011	1169.2	1169.2	1022.8	1022.8	993.8	993.8	264.5	264.5	377.6	377.6
2007-2012	1447.8	1447.8	1314.9	1314.9	1295.7	1295.7	363.3	363.3	493.8	493.8
2007-2013	1903.3	1903.3	1709.2	1709.2	1651.1	1651.1	487.4	487.4	668.1	668.1
2007-2014	2244.2	2244.2	2028.2	2028.2	1907.0	1907.0	592.8	592.8	887.8	887.8
2007-2015	2536.9	2536.9	2343.7	2343.7	2298.8	2298.8	732.5	732.5	981.0	981.0
2007-2016	2826.1	2826.1	2664.7	2664.7	2498.5	2498.5	800.8	800.8	1039.3	1039.3

Years	Basra		Baghdad		Karbala		Hay		Rutba	
	Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)	
	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict
2007-2010	312.3	312.3	318.3	318.3	231.7	231.7	317.7	317.7	263.6	263.6
2007-2011	422.1	422.1	414.3	414.3	329.9	329.9	438.0	438.0	351.5	351.5
2007-2012	527.4	527.4	598.8	598.8	408.6	408.6	519.2	519.2	424.5	424.5
2007-2013	643.0	643.0	895.5	895.5	594.1	594.1	707.4	707.4	559.7	559.7
2007-2014	758.7	758.7	1003.5	1003.5	700.9	700.9	896.1	896.1	717.3	717.3
2007-2015	859.3	859.3	1194.4	1194.4	819.8	819.8	1090.7	1090.7	-----	------
2007-2016	964.4	964.4	1299.0	1299.0	996.6	996.6	1214.2	1214.2	-----	------

Table (3): Actual and Predicted Rainfall value for Weibull-4parameter

Years	Mosul		Kirkuk		Khanaqin		Diwaniya		Nasiriya	
	Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)	
	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict
2007-2010	874.5	464.4	801.0	486.8	826.6	355.5	183.1	92.6	292.5	110.7
2007-2011	1169.2	670.4	1022.8	618.2	993.8	459.3	264.5	0	377.6	166.9
2007-2012	1447.8	905.9	1314.9	808.4	1295.7	676.0	363.3	81	493.8	256.0
2007-2013	1903.3	1900.7	1709.2	1705.6	1651.1	0	487.4	173.7	668.1	639.3
2007-2014	2244.2	2242.6	2028.2	2025.7	1907.0	1086.2	592.8	0	887.8	873.4
2007-2015	2536.9	2536.9	2343.7	0	2298.8	2282.9	732.5	0	981.0	0
2007-2016	2826.1	2826.1	2664.7	0	2498.5	0	800.8	0	1039.3	1039.3
Years	Basra		Baghdad		Karbala		Hay		Rutba	
	Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)	
	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict
2007-2010	312.3	98.91	318.3	155.2	231.7	113.4	317.7	0	263.6	129.827
2007-2011	422.1	208.7	414.3	227.3	329.9	80.5	438.0	0	351.5	212.0
2007-2012	527.4	244.2	598.8	0	408.6	284.5	519.2	0	424.5	0
2007-2013	643.0	339.3	895.5	193.3	594.1	115.6	707.4	34.6	559.7	554.4
2007-2014	758.7	431.2	1003.5	973.2	700.9	356.7	896.1	697.4	717.3	337.5
2007-2015	859.3	470.2	1194.4	777.2	819.8	0	1090.7	482.3	----	----
2007-2016	964.4	542.2	1299.0	955.7	996.6	0	1214.2	1214.2	-------	-----

Table (4):Actual and Predicted Rainfall value for Exponential-single1parameter

Years	Mosul		Kirkuk		Khanaqin		Diwaniya		Nasiriya	
	Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)	
	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict
2007-2010	874.5	1461	801.0	1461	826.6	355.5	183.1	92.6	292.5	110.7
2007-2011	1169.2	1826	1022.8	1826	993.8	459.3	264.5	0	377.6	166.9
2007-2012	1447.8	2192	1314.9	2192	1295.7	676.0	363.3	81	493.8	256.0
2007-2013	1903.3	2557	1709.2	2557	1651.1	0	487.4	173.7	668.1	639.3
2007-2014	2244.2	2922	2028.2	2922	1907.0	1086.2	592.8	0	887.8	873.4
2007-2015	2536.9	3287	2343.7	3287	2298.8	2282.9	732.5	0	981.0	0
2007-2016	2826.1	3653	2664.7	3653	2498.5	0	800.8	0	1039.3	1039.3
Years	**Basra**		**Baghdad**		**Karbala**		**Hay**		**Rutba**	
	Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)	
	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict	Actual	Predict
2007-2010	312.3	1461	318.3	1461	231.7	113.4	317.7	0	263.6	129.8
2007-2011	422.1	1826	414.3	1826	329.9	80.5	438.0	0	351.5	212.0
2007-2012	527.4	2192	598.8	2192	408.6	284.5	519.2	0	424.5	0
2007-2013	643.07	2557	895.5	2557	594.1	115.6	707.4	34.6	559.7	554.4
2007-2014	758.7	2922	1003.5	2922	700.9	356.7	896.1	697.4	717.3	337.5
2007-2015	859.3	3287	1194.4	3287	819.8	0	1090.7	482.3	----	----
2007-2016	964.4	3653	1299.0	3653	996.6	0	1214.2	1214.2	-------	-----

Conclusions

The spatial variationof the rainfall is significantly different through the calculation of the coefficient of variation where Baghdad, Diwaniyah, Nasiriya and Karbala are considered the most varied areas of rain while Basra is the lowest, where the temporal variabilityof precipitation for each variable station is remarkably significant: 40 % of the study areas are highly variable, and 30% was moderate, and 30% had no significant variation .

From comparing actual and predicted values for all function, it's clear that function (waveform, sin4parameter) is the best one to represented annual rainfall for all study area and it applied to all stations and the results are a very good and Curve fitting is a good way to convert data measured from the IMOS to data calculated from a statistical model without changing the actual value and can use as inputs in the models of prediction.

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