

# Analyzing and prediction of rainfall trends over Baghdad city

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## Research article

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# Abstract

Rainfall is a key part of the hydrological cycle and alteration of its pattern directly affects the water resources. The changing pattern of rainfall in consequence of climate change is now concerning issues to water resource managers and hydrologists. The present study aims to analyze the trend and forecast annual rainfall in Baghdad. rainfall data for the period of 1979-2019 was analyzed in this study, Statistical trend analysis techniques namely linear and Exponential trend were used to examine and analyze the problem. The result shows that rainfall will decrease in both methods but the liner method gives a higher value. from plotting time series of annual rainfall see that very variation so 5- moving average made to reduce the variance of rain but still variations so second 5- moving average made give less variance for rain then teak liner trend the result show also trend will decrease but reach 125 mm less than liner trend of actual series.

## 1 Introduction

Rain is important climate elements where all world give it special attention for being the basis without which no kind of life in the world can be there. Climate changes have made the amounts of rain change, as some areas have heavy rain, while other areas receive little rain, and sometimes meteorological drought occurs (Abdul-Jabbar& Abdulkareem, 2021) Iraq climate divided to Semi- humid zone in the far north, Semi-dry zone and Dry zone in the middle and south of Iraq (A. G. Mutar et al.,2016).However, this does not mean that the central and southern regions of Iraq do not receive heavy rains. Rather, they receive rains of up to 89 mm per day, and in the southern and southeastern regions are exposed to torrential rains sometimes (Mutar A. G. et al. ,2021). The mean annual rainfall in Iraq is 264.72 mm (Al-Timimi, Y. K. et al.,2020) Rainfall values in Iraq decreased on various time and space scales, especially at northern and middle regions and Northern part of middle Euphrates regions during spring season also a noticeable decrease in the winter rainfall series was observed Middle region towards western part of Iraq the rainfall decreasing was significant (Al-Salihi, A. M. et al.,2014). this variation of rain makes many researchers study the Characteristics and trend of rain. abd al-ghani and mohammed ali (2020) study Trend of Rain in Iraq the result show that rainy season tends to decrease in almost stations but Baghdad station tended to rise, as the rate of change in it reached (21.6+, 10.9 +) mm during the fall and spring seasons respectively((Hichel, M. A. ,2020). Qusai Fadel (2019) Calculating the change in the annual total of rain and the impact of climate change on it Show that in baghdadm the sum of the years in which the annual total exceeded the general total for the period 1918-2010, it reached 39 years only. As for the years whose annual total was lower than the general total for all the time reached 54 years (fadel Abed, Q. ,2019). Ahmad S. H et al ( 2018) used Climatology mean (C M) to separate the amount of normal rainfall from heavy rain over baghdad. The results shown during 30 rainy seasons, have been 12 seasons exceed climatology mean, four of highest extremes rain have been happened in November. The highest extreme rain has been in 2014 (Hassan et al.,2018).

## 2 Methods/experimental

Data have been acquired a mainly monthly average of rainfall data from the Iraqi Meteorological Organization and seismology (IMOS). The long-term data of the monthly average rainfall for the time period 1979-2019 were collected from the Baghdad station located in the center of the country. Monthly rainfall for 39 years for Baghdad city is available which covers 24 years are continuous data from 1979 to 2002, two years missing (2003-2004) and 15 years to 2019 are continuous. The daily rainfall behavior varies widely from the extreme values 89 mm in Baghdad to the minimum 0.2 mm in addition to the persisting of rain for one day and up to more than four days but most of the non-rainy days in the year (Abd& Abdulkareem,2020).

## 2.1 STUDY AREA

The study area is Baghdad city the capital of Iraq, located between latitude (33.452oN and 33.184oN) and longitude (44.189oE and 44.576oE) see Figure 1. The Tigris River passes through the city dividing it into two parts: Karkh (Western part) and Rusafa (Eastern part).

## 3 Results And Discussion

A time series is a set of observations, each of which is recorded at a specific time. the objective of analysis time series are- Forecasting, Control, understanding feature of the data including seasonality, cycle, trend and its nature, description and explanation (Hamilton, J. D. ,2020). ) The annual rainfall series are plotted in figure 2, where its varies widely, with the lowest annual total recorded (50 mm) in 1987, while the highest total was (297 mm) in 2013.the Median of rainfall (108 mm) so 25% of them about (82 mm) and 75% about (153 mm).

### Analysis of the monthly average of troposphere column ozone

In this paper we used the linear and exponential statistical method, to detect the trend in long-term rainfall data series. A trend exists when there is a long-term decrease or increase in the data. General linear or most often nonlinear (damped and exponential) component that changes over time. (Mudelsee, M., 2019).

Two methods of trend taken in this study liner trend, as show in figure.3 and exponential trend in figure.4, the trend( red line) in both methods is decrease with time. MAPT and MAD in exponential lees than in liner because that's mean the accuracy of exponential is the best .also MSD in exponential higher than liner Because outliers have an effect on it. The forecast of annual rainfall for next four years after 2018 made (green line) where in 2022 the amounts of it will be (150 mm ) in liner method but will be (125 mm) in exponential method.

The Simple Moving Average (SMA) method was discovered by G. U. Yule in 1909. The process of computing moving averages smoothens out the fluctuations in the time series data. It 7 can be shown that if the trend is linear and the oscillatory variations are regular (Rahardja, D. ,2020).

the average of a span of series values surrounding and including the current value. The span is the number of series values used to compute the average. If the span is even, the moving average is computed by averaging each pair of uncensored means. The number of cases with the system-missing value at the beginning and at the end of the series for a span of  $n$  is equal to  $n/2$  for even span values and  $(n-1)/2$  for odd span values. (Koutrasetal.,2020).

The 5 moving average (red line) in figure 5 show that rain still variation so we take second 5 moving average to know the liner trend (red line) as show in figure 6. the trend shows that rainfall decrease and in 2020 will be (138 mm)

## 5 Conclusions

The behavior of annual rainfall in Baghdad varies greatly, and it is difficult to determine its trend directly, so using the moving average method is a good but it is better to take the second moving average to give a higher accuracy in determining the trend. By compare between methods used in this study the resulted show that all trend of anuual rainfall will decrease next 4 years to reach more than (125 mm).

## Abbreviations

CMB  
Core-mantle boundary  
GOSAT  
Greenhouse Gases Observing Satellite  
JAXA  
Japan Aerospace eXploration Agency  
TRMM  
Tropical rainfall measuring mission

## Declarations

## Availability of data and material

Data sharing not applicable to this article as no datasets were generated or analysed during the current study. Please contact author for data requests.

## Competing interests

The authors declare that they have no competing interest.

## Funding

no funding

## Authors' contributions

IK proposed the topic, conceived the study. AK analyzed the data and helped in their interpretation. All authors read and approved the final manuscript.

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## Figures

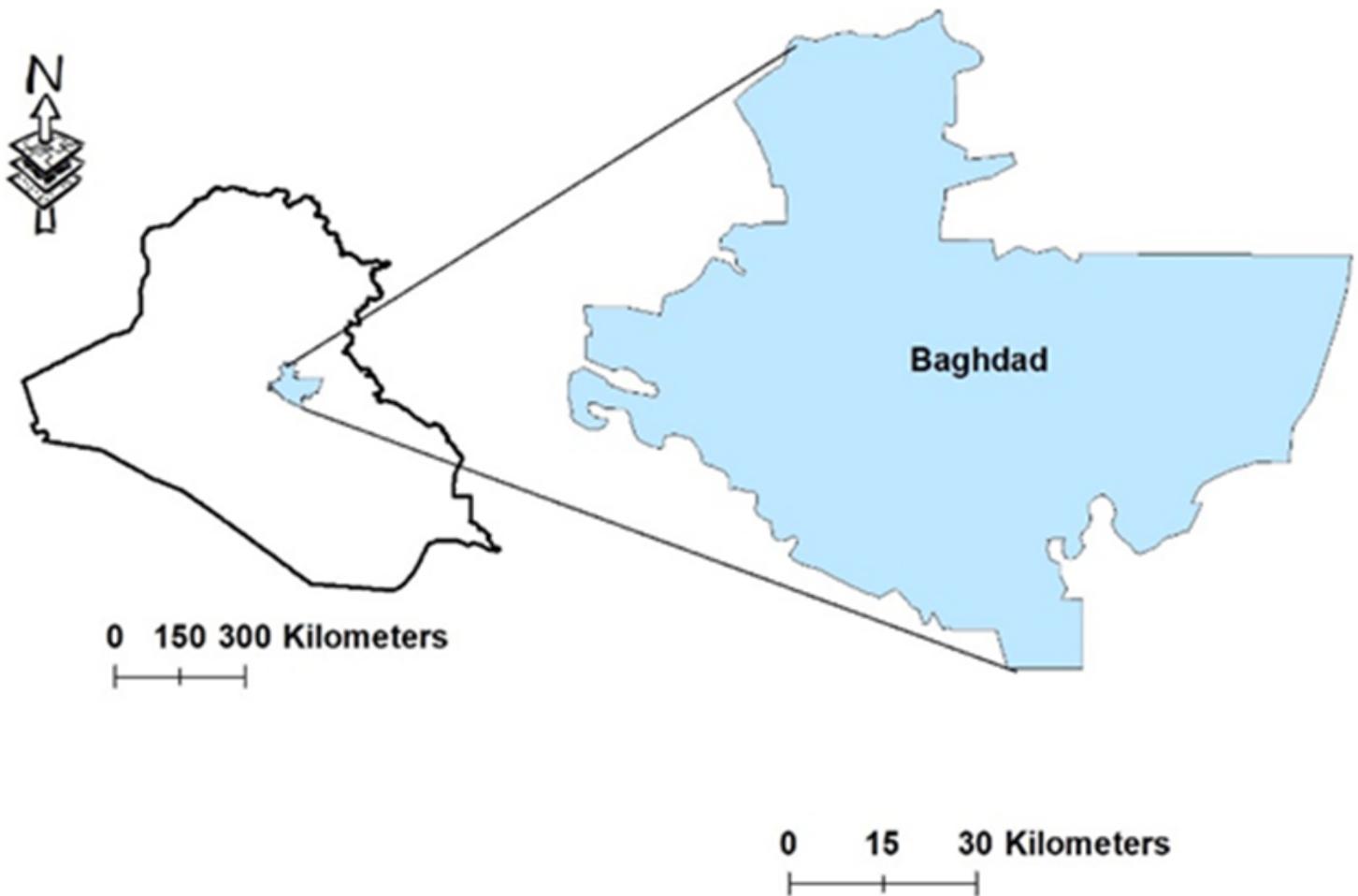


Figure 1

The geographical location of the study area.

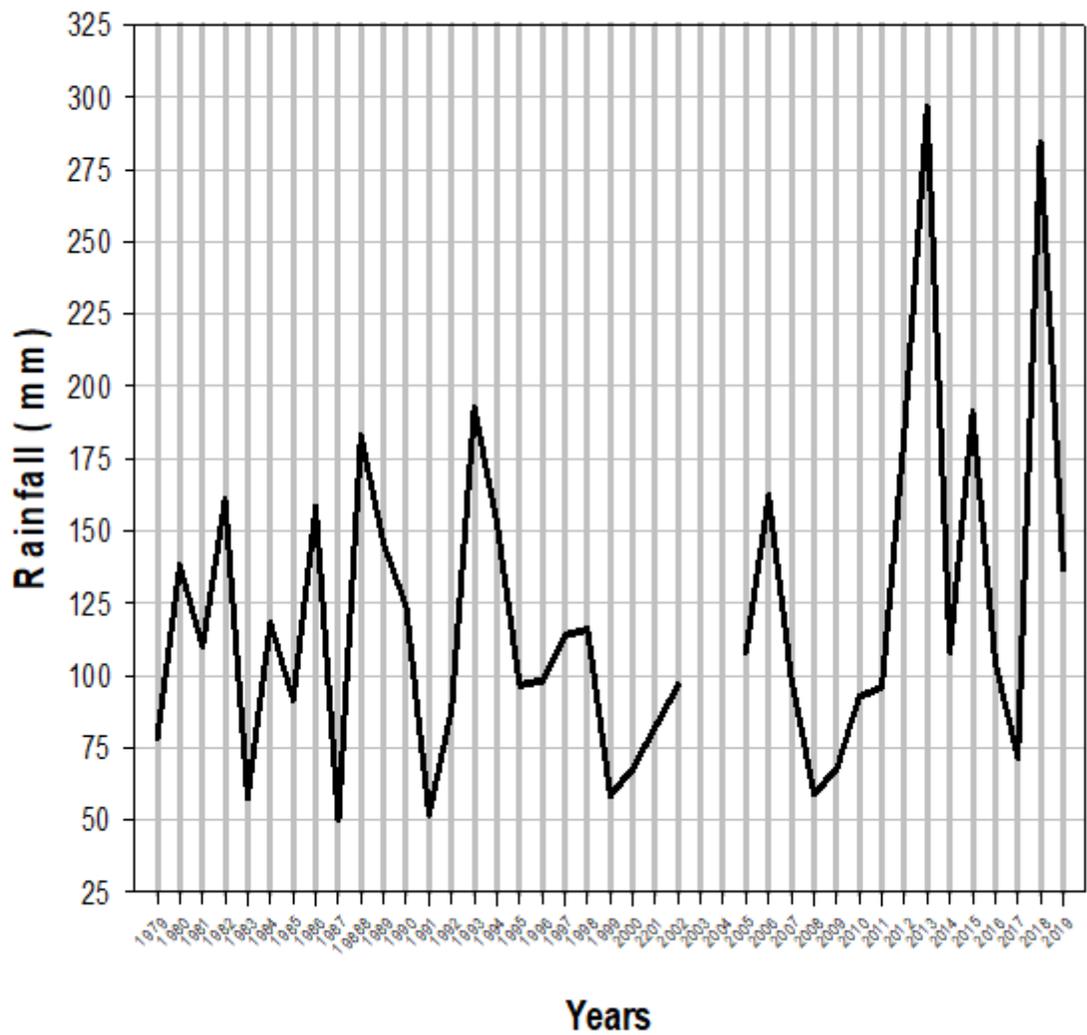


Figure 2

Annual rainfall series for Baghdad city (1979-2019)

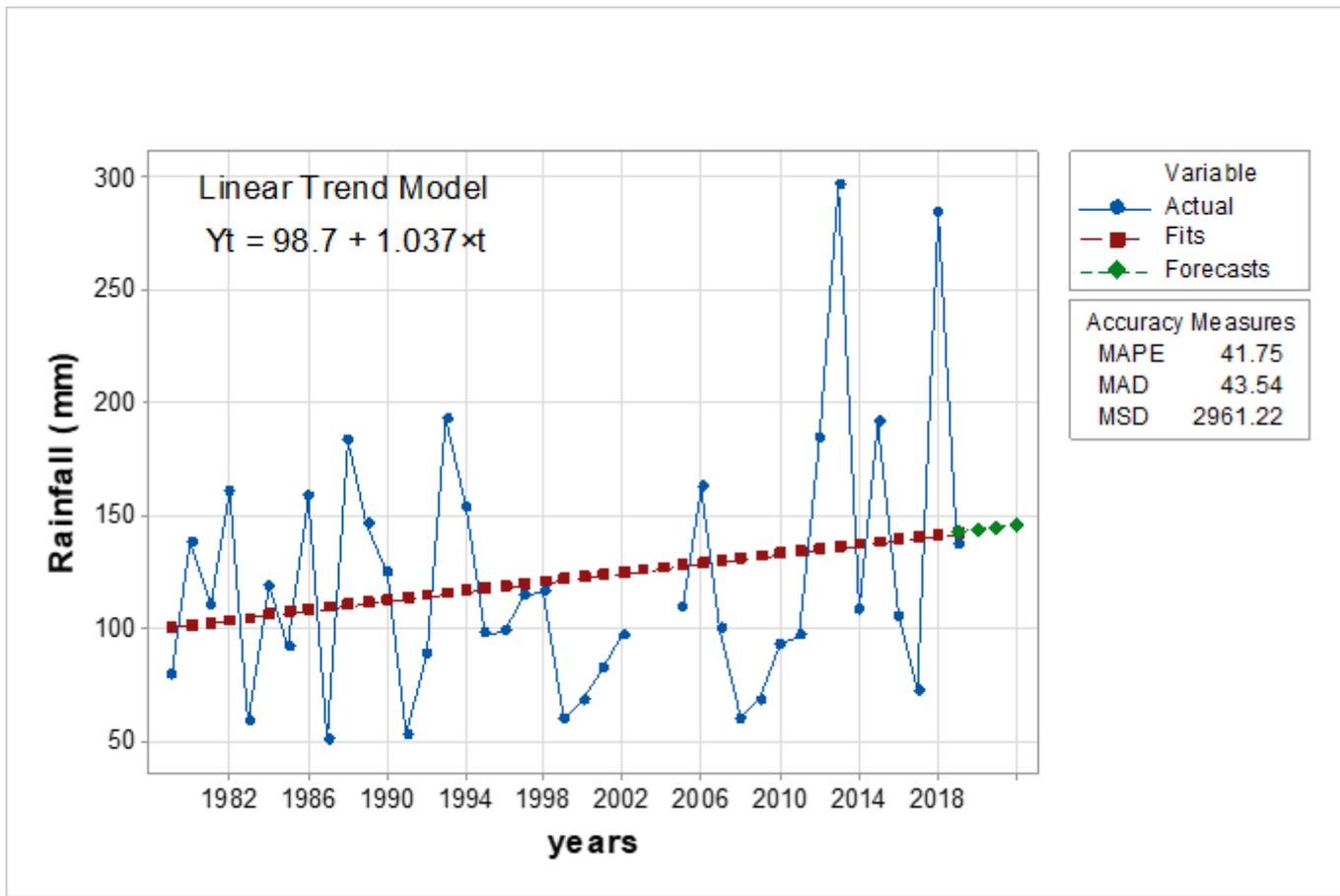
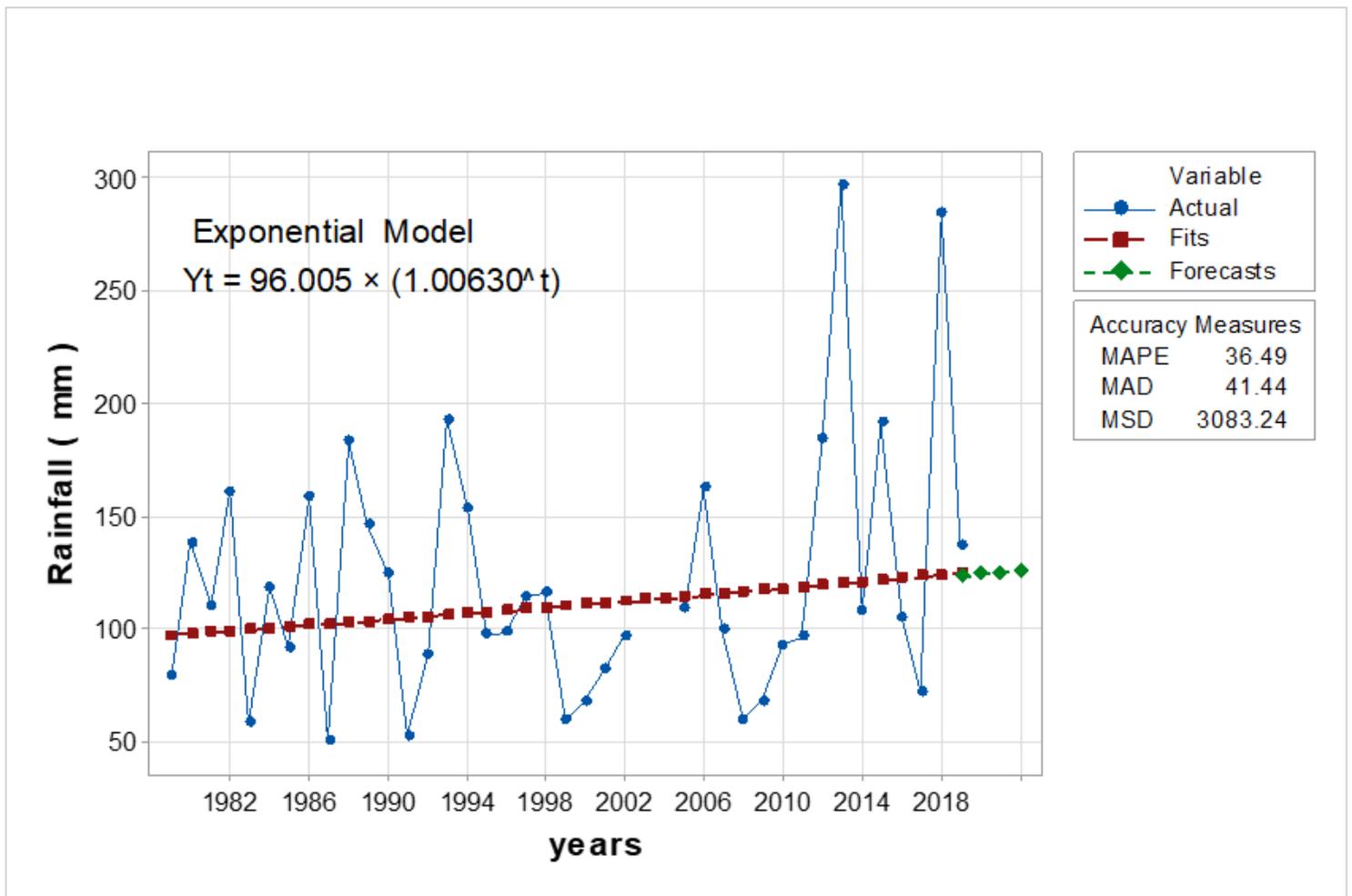


Figure 3

liner trend of annual rainfall for Baghdad station



**Figure 4**

exponential trend of annual rainfall for Baghdad station

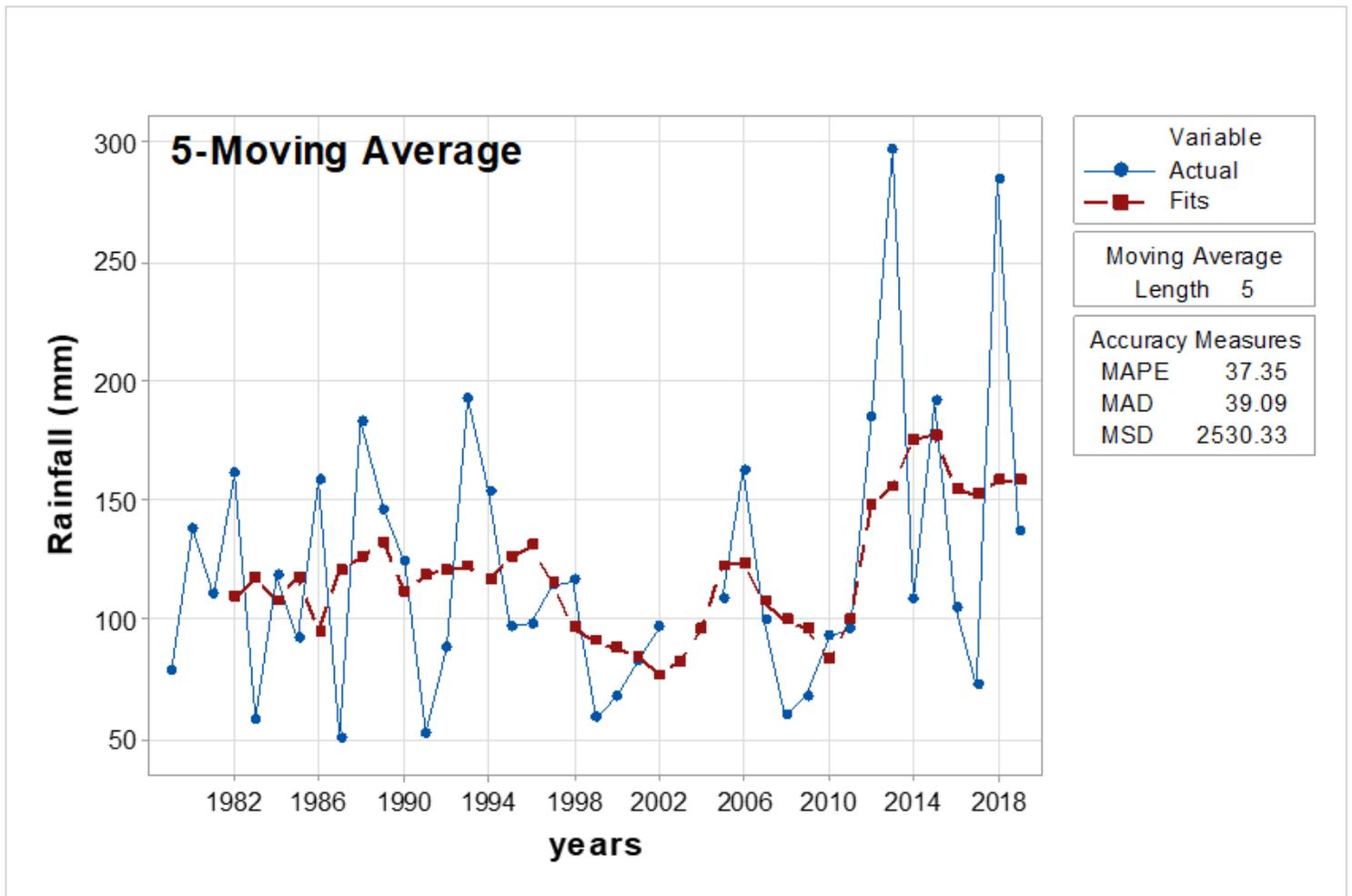
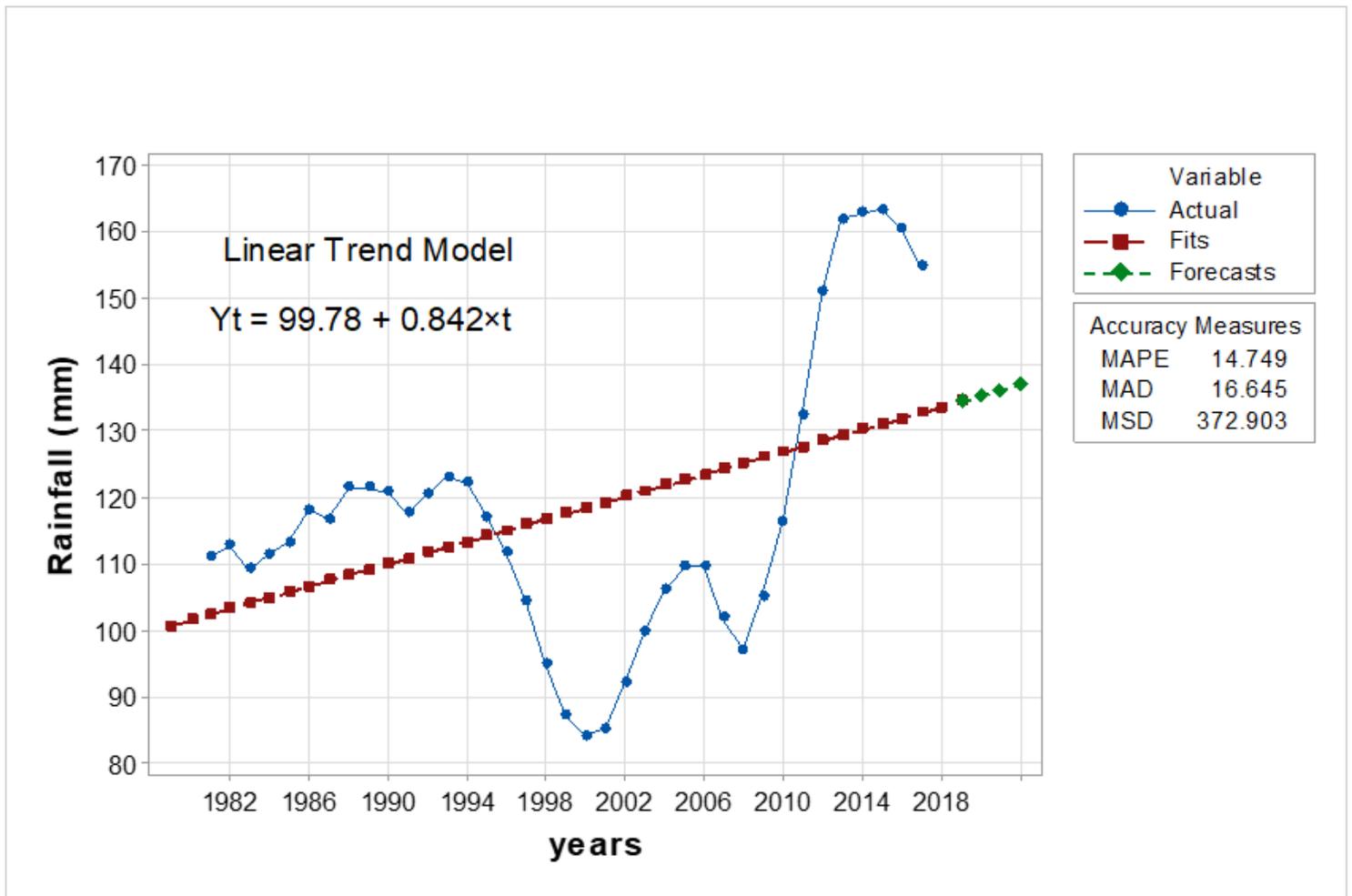


Figure 5

5 -moving average of annual rainfall in Baghdad



**Figure 6**

second 5-moving average with trend of annual rainfall in Baghdad