TIME SERIES ANALYSIS IN WATER RESOURCES AND CLIMATIC CHANGES

By
Diyaa A. Hassan

Supervisor
Dr. Adnan Al-Salihi

Submitted in the Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

Faculty of Graduate Studies
University of Jordan

August 2003

بسم الله الرحمن الرحيم

(وجعلنا من الماء كل شئ حي)

صدق الله العظيم

This thesis was successfully defended and approved
on: 7 August 2003

<u>Examination Committee</u> | <u>Signature</u>

Dr. Adnan Al-Salihi, Chairman
Associate Prof. of Hydraulic Structures ....

Prof. Omar Rimawi, Member
Prof. of Hydrogeology and Hydrochemistry ....

Dr. Tawfiq Samaneh, Member
Assistant Prof. of Environment ....

Dr. Suleiman Al-Tarawneh, Member
Associate Prof. of Water Resources Planning and Development ....

DEDICATION

This Work Is Dedicated To Iraq

The People, The History, The Land and The Blood

With Best Regards

Diyaa

Acknowledgment

First of all, praise to God who enabled me to do this work and made the completion of this thesis possible.

I wish to express my sincere thanks to my supervisor Dr. Adnan Al-Salihi for his continued enthusiasm, who gave me the full assistance and support to prepare and complete this thesis.

Special thanks to the committee members: Professor Omar Rimawi, Dr. Tawfiq Samaneh, and Dr. Suleiman Tarawneh for their important contribution, advice, and comments.

My gratitude also extends to my family, and my sincere friends for their encouragement and full support through my study.

Table of Contents

List of Abbreviations

Abbreviations	Description
ACF	Autocorrelation Function
a_i	The Slope for Any Unit Time
AIC	Akaike Information Criterion
ANN	Artificial Neural Network
AR	Autoregressive
ARIMA	Autoregressive Integrated Moving Average
ARMA	Auto-Regressive Moving Average
B	Backward Shift Operator
BOD	Biological Oxygen Demand
Cc	Correlation Coefficient
C^o	Centigrade Degree
COD	Chemical Oxygen Demand
Corr	correlation value
d	The Order of Difference
D	The Order of Seasonal Difference
GCEP	General Corporation for Environmental Protection
ITSM	Interactive Time Series Modelling
LBQ	Ljung-Box Q statistics value
LR	Linear Regression
MA	Moving Average
MAD	Mean Absolute Deviation
MAPE	Mean Absolute Percentage Error
mm	Millimeter
MRE	Mean Relative Error
MSD	Mean Standard Deviation
MSE	Mean Square Error
N	The Number of Forecasted Values
Npar	Number of Parameter
p	The Order of Autoregressive
P	The Order of Seasonal Autoregressive
PACF	Partial Autocorrelation Function
PAR	Partial Autoregressive
PARMA	Partial Autoregressive Moving Average
P_i	Normalized to the Mean Value of Precipitation for Any Unit Time (i)
q	The Order of Moving Average
Q	The Order of Seasonal Moving Average
RMSE	Relative Mean Square Error
sq. km.	Kilometer square
SSR	Some of the Square Residual
t	t-test statistics value
T_i	Normalized to the Mean Value of Temperature for Any Unit Time (i)
T-N	Total Nitrogen
T-P	Total Phosphorous
TSS	Total Suspended Solid

Abbreviations	Description
X_t	Variable Value at Time t
X_{t-1}	Variable Value at Time t-1
$X_t^{'}$	First Difference of a Variable
α	Weighted Smoothing Parameter
β_o	Initial Value of a Variable at Time t
β_1	Average Change in Values of Variable from One Period to Next
e_t	Error Term in Time t
$f(\omega)$	The Spectral Density Function
ϕ	Coefficient of Autoregressive
ϕ_j	j^{th} Autoregressive Coefficient
Φ	Coefficient of Seasonal Autoregressive
$\gamma(k)$	The Autocovariance at Lag k
γ_o	The Autocovariance at Time t
l	Moving Average Period Length
ρ	Theoretical Autocorrelation Value
θ	Coefficient of Moving Average
Θ	Coefficient of Seasonal Moving Average
μ	Constant Term
r	Theoretical Autocorrelation Value
Σ	Summation of Variable's Values
λ	The Frequency at the Peak of the Spectral Density Function
ω	The Frequency
y_t	The Actual Reading of the Variable at Time t
$\hat{y}_t$	The Forecasted Value of the Variable at Time t

List of Tables

List of Figures

TIME SERIES ANALYSIS IN WATER RESOURCES AND CLIMATIC CHANGES

By
Diyaa A. Hassan

Supervisor
Dr. Adnan Al-Salihi

Abstract

Jordan is classified as a semi-desert region, which represents a good model of water scarcity. Water in Jordan should be wisely managed and utilized to solve water scarcity problem. An important tool in water management is hydrological information, which can be described as a structure of long series of observations. Continuous update of hydrological databases can be an efficient tool in managing water resources. Through the proper analysis of hydrological information, analysts can predict, with acceptable accuracy, certain water-related parameters such as, precipitation, base flow, etc. One of the methods used to analyze hydrological information is Time Series Analysis.

The main objective of this research was to develop selected procedure to predicting the most efficient forecasting model in order to estimate climatological parameters that represent the mean maximum and mean minimum temperatures, the precipitation for different stations in different climatic regions, and base flow for three different streams in Jordan.

To achieve the objective of the study, the data were analyzed using Simple forecasting methods, Smoothing methods, Correlation analysis methods and ARIMA modeling methods. Data analyses were conducted using four softwares. Those were; Microsoft Excel, Minitab, S-Plus 2000 and (ITSM) for Windows. The analyses revealed that the ARIMA modeling method was the best method for predicting all the variables studied. This was revealed through comparing the three measures of accuracy; MAPE, MAD and MSD obtained from using different methods of modeling.

ARIMA was not efficient with small sample sizes, thus, its needed to correlate limited data to other similar regions with longer data records. The accuracy of Precipitation ARIMA models can be improved by correlating precipitation data with temperature. ARIMA models can be used to validate spatial climatic classifications for different geographic locations. No cyclic trend for precipitation and base flow occurred because the sample sizes were small. Whereas the cyclic trend for temperature was obtained. It was found to be 12 months as expected. There was a direct relationship for base flow with precipitation and reverse relationship for base flow with temperature. But, Zarqa River base flow has reverse relationship with precipitation, this could be attributed to the increase in the treated waste effluent out of As-Samra waste treatment plant due to population growth in Amman-Zarqa Area.

1. INTRODUCTION

1.1 General Information

Jordan is classified as a semi-desert region, with total land area of 92,000-sq. km. located to the East of the Jordan River. Jordan is suffering from both water scarcity and maldistribution. The water shortage in Jordan has been exacerbated by the complexity of hydropolitics in the region, the high rate of population growth, and the forced immigration of hundreds of thousands of Jordanian and Palestinian returnees from the Arab Gulf countries. For the last few years, Jordan cannot meet its increasing demands, even if it uses all conventional and non-conventional local water resources (General Corporation for Environmental Protection, GCEP 2000). The problem of water scarcity is a critical one that has occupied many scientists throughout recent times. Every drop of water in Jordan should be wisely managed and utilized. Jordan represents a good model of water scarcity. Thus, water shortage is a problem that Jordanians have to live with and try to find solutions for (GCEP 2000).

An important tool in water management is the hydrological information. Such information can be described as a structure of long series of numbers. Those numbers may be daily rainfall, stream flow or any other hydrological measures during some time interval. Maintaining and continuous updating of hydrological databases is an efficient tool in managing water resources. Through the proper analysis of hydrological information, analysts can predict, with reasonable accuracy, certain water related parameters such as, *climatological parameters* that represent the mean maximum and mean minimum temperatures and precipitation for different stations in representive different regions in Jordan, which are Mountains region, Aqaba area and Desert region, and *base flow* for three different streams, which are Zarqa River, Wadi Mujib and Wadi

Hisban. With such data, water authorities can better plan and set priorities into the future.

One of the methods used to analyze hydrological data is Time Series Analysis. Time series analysis is the term used for attempts to describe with statistics a sequence of observations taken sequentially in time. Time series analysis and spectral analysis can be used to show the relative magnitude of apparent components such as trends, jumps, periodicities, and autoregression with time series. These analyses are essential for accurate forecasting. Observations analyzed with time series are usually "dependent". Time series analysis is concerned with the techniques for analyzing this dependence. Such analysis is conducted through the development of stochastic and dynamic models for those observations and using such models in important areas of application (Box et al. 1994).

Generally, time series and dynamic models are used in four important areas of application. Those are summarized as follows:

1. The forecasting of future values of a time series from current and past values. The current study did this through the forecasting of precipitation, temperature and base flow from current and past values for the stations taken in different areas in Jordan, which presented in Chapter Four and Appendices B and C.
2. The determination of the transfer function as system subject to inertia - the termination of dynamic input- output model that can show the effect on the output of the system of any given series of inputs. Another important application of transfer function models is forecasting. If, for example, the relationship between two time series (precipitation and temperature) can be determined, past values of both serieses may be used in forecasting

precipitation. This approach can lead to a considerable reduction in the error of the forecast, as presented in Section 5.4 of the current study.

3. The use of indicator input variables in transfer function models represent and assess the effects of unusual intervention events on the behavior of time series.
4. The design of simple control schemes by means of which potential deviations of the system output from a desired target may, so far as possible, be compensated by adjustment of the input series values (Box et al. 1994).

The importance of forecasting in decision-making process is tangible for all planners (Yaffee and McGee, 2000). This is usual, since the ultimate effectiveness of any expected decision depends upon the nature of a sequence of events following the decision to plan accordingly. The ability to predict the uncontrollable aspects of these events prior to making the decision should permit an improved choice over that which would otherwise be made. For this reason, management systems for planning and controlling the operation of an organization typically contain a forecasting function, which could be obtained by mathematical and statistical modeling.

The following are examples where time series analysis and forecasting are effective:

Hydrology: Time series analysis is a major tool in hydrology. It is used for building mathematical models to generate synthetic hydrologic records, estimate missing data not observed, and forecast future values. These are essential for a successful water resources planing and management.

Climate Change: The World Climate Program, initiated by the World Metrological Organization, documented the need for research in the area of climate change. Increasing temperatures and decreasing precipitation in certain areas causes decreasing flows. Therefore, the evidence of a climatic change can be predicted as positive or negative trends in natural time series. This prediction requires time series analysis to develop the proper model(s).

Reservoir Operation: Climate change has important implications on the operation of reservoirs. The operational performance must be evaluated in terms of the reservoirs' ability and effectiveness to meet their purpose of water storage and stream flow regulation. For example, to check the reservoir performance in terms of stream flow regulation, a flow generation model is required to predict future flows and develop solutions for possible problems. The generated data out of climatic conditions can be employed as input to a reservoir operation model. This helps to determine the reservoir response to the inflow resulting from the implementation of the reservoir operating policy.

1.2 Purpose of Current Study

Many methods and approaches exist for formulating forecasting models. Such as linear regression, quadratic regression, exponential smoothing, time series, and many others (Anderson 1984). However, the current study deals exclusively with the time series forecasting model. Specifically, it deals with the Auto-Regressive Integrated Moving Average (ARIMA). These models were described by Box and Jenkins (1994), and details on the approach are presented in Chapter Three of this thesis.

The Box-Jenkins iterative approach allows a manager who only has data on past years' quantities, such as rainfall, to forecast future quantities. This is done through searching for other related time series data, for example temperature. The Box-Jenkins iterative approach allows the use of several time series to explain the behavior of other series if these other time series' data are correlated with the variable of interest.

Knowing the values of the correlated variables, the model can be used to obtain a forecast of the dependent variable.

The main purpose of this research is to develop a general procedure to be used in prediction the most efficient forecasting model in order to estimate important variables, which can help the decision makers for future planning.

1.3 Data Collection

The time series of hydrological data were obtained from two governmental agencies in Jordan. Those are the Ministry of Water and Irrigation and the Ministry of Transport (Department of Meteorology). The obtained data included:

Precipitation

Monthly precipitation rates were obtained for eight stations in Jordan, which represent the mean climatological regions. Those were Amman-Airport station, Irbid station, Aqaba-Airport station, Azraq station, Jafar station, Safawi station, Mafraq station and Shoubak station. Those data are listed in Appendix-A for reference.

Temperatures

Mean maximum, mean minimum and mean monthly temperatures were obtained for five stations in Jordan. Those were Amman-Airport station, Irbid station, Aqaba-Airport station, Azraq station and Jafar station. Those data are also included in Appendix-A.

Base Flow

Monthly base flow rates were obtained for one river and two side wadis in Jordan. Those were Zarqa River, Wadi Mujib and Wadi Hisban. Details about those data are also included in Appendix-A.

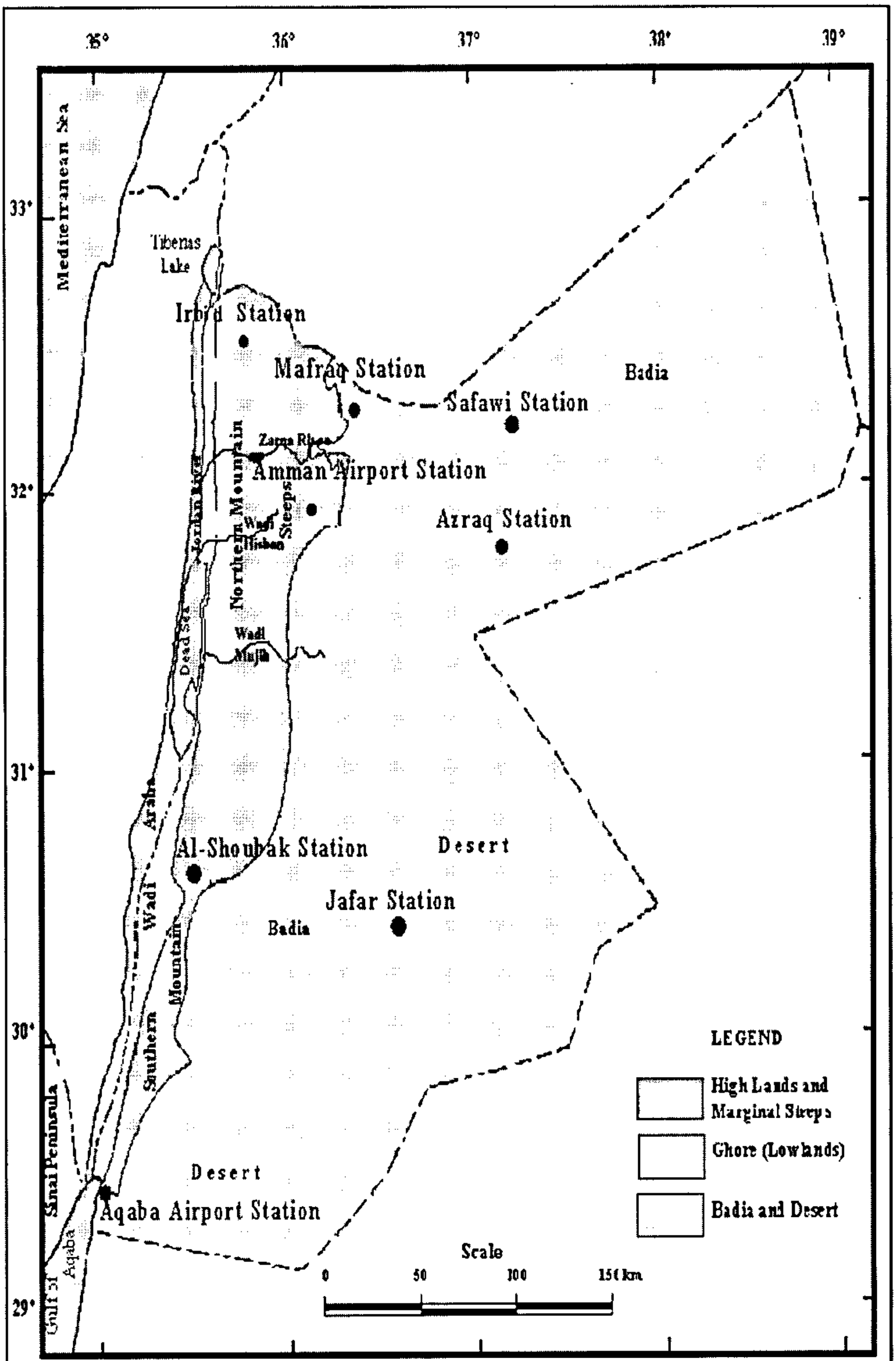


Figure (1.1): Jordan's Map Presents the Stations That Were Taken in the Current Study with Bounded Regions for Each Representative Dominant Area

Forecasting methods

The current study made comparisons between simple forecasting and smoothing methods with correlation analysis ARIMA method to know the best method that used in analyzing the data. Three measures of accuracy were used in this comparison; these were mean absolute percentage error (MAPE), mean absolute deviation (MAD) and mean square deviation (MSD). Minimum values of MAPE, MAD and MSD gave the best method.

General description for the forecasting methods is shown below:

A. Simple forecasting and smoothing methods (Cryer 1986) include:

i. Trend analysis methods, which fit a general model to time series data. This procedure was used to fit the trend when there is no seasonal component in time series data. Some types such as linear, quadratic, exponential growth or decay trends were used.

ii. Decomposition methods were used to separate the time series into trend, seasonal components, and error. In addition, decomposition methods provide forecast. Decomposition calculates the forecast as the trend added to seasonal indices.

iii. Moving average method, which smoothens the data by averaging consecutive observations in a series and providing short-term forecasts. This procedure can be a likely choice when the data do not have a trend or seasonal component. With non-seasonal time series, it is common to use short moving averages to smooth the series, although the selected length may depend on the amount of noise in the series.

iv. Single exponential smoothing method smooths the data by computing the exponentially weighted averages and providing short-term forecasts.

B. Correlation Analysis and ARIMA Modeling Methods

ARIMA is used to model time series behavior and to generate forecasts. ARIMA modeling differs from the other time series methods in that ARIMA modeling uses correlation techniques to the variable with itself or with other variables. ARIMA can be used to model patterns that may not be visible in plotted data. To fit an ARIMA model when there is trend or seasonality present in the data, differencing data is a common step in assessing the likely ARIMA models. Differencing is used to simplify the correlation structure and to help reveal any underlying pattern, and its values depend on the length of the lag. Autocorrelation is the correlation between observations of the time series separated by k time units, and its plot gives indication of Moving Average process. Where partial autocorrelations are correlations between sets of ordered data pairs of a time series, and its plot gives indication of the Autoregressive process (Box, et al. 1994).

Cyclical trends in the data.

Trends in the data are identified through the spectral density of a stationary time series ($X_t, t = 0, \pm 1, \ldots$), with absolutely summable autocovariances. The spectral representation of the variable decomposes the sequence into sinusoidal components, and the relative contributions to the variance of the variable are measured from the components of different frequencies (Brockwell and Davis, 1994).

Spatial distribution model

The current study takes other type of modeling, which depends on the classification of the stations according to the nature of climate. Generalization of estimated ARIMA models have been done in the current study for the stations have the same climatic conditions

Rainfall-temperature modeling

Finally, the current study takes the relationship between the rainfall and the temperature through the rainfall-temperature modeling.

After the application of the above procedure for a given time series, a calibrated model was developed, which encloses the basic statistical properties of the time series into its parameters. The current study was based on data analysis in different fields including water resources such as base flow, and climatological parameters such as precipitation and temperature. Therefore, the thesis will contain details and background information on all data fields.

1.6 Study Outline

The thesis consists of six chapters.

Chapter One, briefly presents general description for Jordan and water shortage in Jordan, then presents general information for time series analysis, and summarizes the purpose of the current study and its procedure.

The second chapter focuses on the basic of time series analysis and introduces some models through the review of similar works.

In the third chapter, a background and theory of time series data is introduced.

The fourth chapter, is concerned with the data analysis and modeling.

The following chapter, introduces the discussion of results. The final chapter, Chapter Six, presents the conclusions and recommendations for further future assessment on this topic.

Appendix-A includes the data for precipitation, temperatures and baseflow for the stations that were taken in the current study. Appendices B and C include the data analysis and results to provide a better understanding of the model. Reference to published work used in the current study is also provided for further inquiries.

2. LITERATURE REVIEW

2.1 Introduction

Several studies have been conducted that address the subject of time series analysis and modeling. Of those, some studies particularly addressed the application of time series in the field of hydrology. In those studies, time series were used to analyze a variety of hydrological and meteorological parameters, such as precipitation, temperature, stream flow, wind velocity and many others. This chapter summarizes the literature that was reviewed for the purposes of conducting the current study. Mainly, literature in three areas was reviewed. The first area covers literature pertaining to time series and modeling in general. The second area covers literature regarding the use of time series to analyze the hydrology and climatic data, with some emphasis placed on the three variables included in the current study. Finally, the third area covers literature pertaining to special issues that arise when conducting time series analysis and modeling, such as noise reduction, aggregation and disaggregation of models, and chaotic behavior.

2.2 Overview on Time Series Analysis and Modeling

1. Box and Jenkins (1976) were pioneers in the field of time series analysis and modeling. In their book, they extensively studied the Autoregressive Integrated Moving Average (ARIMA) models and general ARIMA processes applied to time series analysis, forecasting, and control. They presented, in a comprehensive manner, the relevant information required to understand and use univariate time series ARIMA models. The basis of their approach was summarized in figure (2.1) and mainly consisted of four phases: postulate general classes of the model, identification the model, estimation of parameters, testing the model and application of the model. The

theoretical underpinning described in their book was quite sophisticated, but it was possible for the non-specialist to get a clear understanding of the essence of ARIMA methodology.

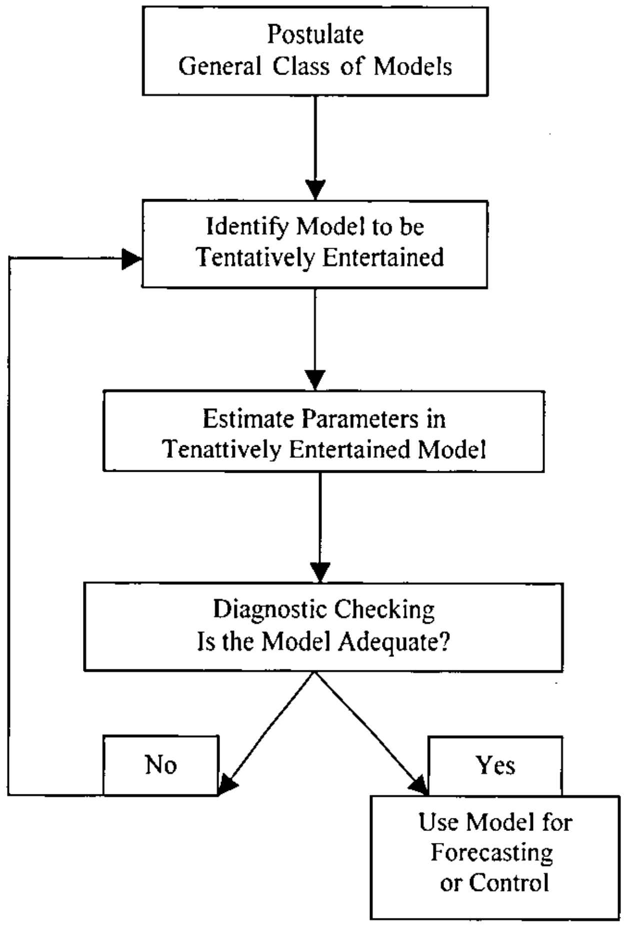


Figure (2.1): Schematic Representation of the Box-Jenkins Approach

2. Box, et al. (1994) authored another book concerned with the building of stochastic (statistical) models for time series and their use in important areas of application. Their work covered the topics of forecasting, model specification, estimation of parameters and checking the model, transfer function modeling of dynamic relationships modeling the effects of intervention events, and process

control. The objective of their study was to provide particular techniques that will be available to most of the wide audience who could benefit from their use.

3. Burroughs (2001) overviewed time series, sampling and harmonic analysis, which can be applied to climatic data. The author indicated that the starting point of any analysis should be the fundamental properties of the data under examination. Ideally, it should consist of an accurate measure of whatever parameter (e.g. precipitation, temperature, flow, pressure, wind etc.) at equal intervals of time, as often as needed for as long as was required. By 'accurate' he meant that errors in the measurement technique are small compared to the changes in the parameter under study. Such a time series would then allow analysts to draw detailed conclusions about the behaviour of the parameter over the period of the observation. He also indicated that for all sorts of reasons the record could be limited by many practical considerations. On the other hand, where the record is complete, there may be far more data than is needed to consider longer-term fluctuations in the climate. In these cases there are good reasons for working with the minimum amount of data required to meet certain criteria to obtain unambiguous information about real changes in the climate.

2.3 Hydrological and Meteorological Parameters Related Research Using Time Series

1. Dahabiyeh (2002) conducted a study in which she analyzed rainfall records in Jordan between the years 1938 through 1999. The purpose of the study was to develop model(s) to predict the future fluctuations in rainfall, and to predict future environmental changes. The study covered 19 stations in three main regions in Jordan;

the Jordan Valley region, the Highlands region and the Badia region. The data were analyzed using time series analysis to estimate precipitation trend in the future. The two main methods used for developing the models were the exponential smoothing method and the autoregressive integrated moving average method. The rainfall data predicted using the developed models generally showed a decreasing trend, which is indicative of a gradual climatic change toward aridity along the Southeast-Northwest direction. This was combined with a cyclical pattern of fluctuations in the Northern and NorthWest parts of Jordan. In the Southern and Eastern parts of Jordan, rainfall was expected to linearly decrease with time. In terms of the expected environmental changes, the results of the study revealed that there is a potential salinization hazard that was expected to increase in the Jordan Valley. In addition, the stresses on the natural vegetation cover and crops grown were expected to increase in the Hilly region. Finally, no indications of soil degradation were revealed in the Badia region.

2. In Jordan, Bani Hani (2002) conducted a detailed analysis of monthly water quality parameters, and water quantities in the Zarqa River, and for the effluent leaving the King Talal Dam Reservoir. Regarding quality, he assessed physical parameters such as total suspended solid (TSS), biological parameters such as biochemical Oxygen demand (BOD) and chemical Oxygen demand (COD), and chemical parameters such as total Nitrogen (T-N) and total Phosphorous (T-P) for the years 1988 through 2000. The quantity was assessed through the flow rates in those two systems. The main objective of the study was to predict the water quantity and quality parameters. The study utilized deterministic and stochastic (ARIMA) forecasting for the six variables studied and the best model selected. Generally, the study revealed that the ARIMA model was an appropriate model for forecasting future values.

3. Elshorbagy, et al. (2001) modeled two cross-correlated rivers as chaotic time series. The existence of chaos in the daily flows of the Little River and the Reed Creek, Virginia, was investigated. Indication of chaotic behaviour was shown using the correlation analysis. Segments of missing data in the Reed Creek were estimated using linear regression (LR) and artificial neural network (ANN) models. Two experiments were conducted with both of the modelling techniques; (a) a single global model was fitted to estimate the missing data and (b) multiple local models were fitted in the direct of the missing data. The locally projective nonlinear noise reduction method was used to reduce the noise of the time series and experiments were repeated with the noise-reduced data. In general, ANN models showed superiority over LR models in estimating the missing data. More significantly, local models were preferred over global models in terms of the mean square error (MSE) and mean relative error (MRE) criteria, which was attributed to the chaotic behaviour of the time series. The noise reduction process was shown to be of little utility and significance to the accuracy of estimating the missing hydrological data. The role that the chaotic behaviour played in this study highlighted the importance of investigating effects of chaoticity on other hydrological applications such as record extension, data generation, and multivariate analysis of chaotic data.

4. Miao-Hsiang and Jin-King (2000) studied groundwater level forecasting using time series analysis. The study site was located in Western Taiwan where serious land subsidence had occurred. A series of monthly groundwater level observations measured during the period 1993 and 1999, which were used for the investigation. Univariate time series models including Autoregressive Integrated Moving Average (ARIMA)

models and the time series decomposition method were applied and the resulting prediction data were compared with the actual data. Empirical results indicated that groundwater level data were cyclic. ARIMA models generated more accurate forecasts than the decomposition model. The forecasting ARIMA models showed the characteristics of trend and seasonal variation because they contain the differencing factor, which treats such variabilities.

5. Solomatine et al. (2000) used time series analysis to predict surge water levels in the coastal waters of the Netherlands. Such predictions are necessary for ship guidance and navigation. It was found that the correlation between data on surde, temperature, air pressure and wind were not sufficient to rely only on the input-output models like neural network.The study found that the surge time series have enough information to make predictions for navigation purposes. The use of linear prediction (autocorrelation and ARIMA models) and non-linear method showed that the latter are much better in predicting surge water levels in the coastal zone. The predictions were quite accurate (RMSE is 3.6 *cm* for 1 hour, and 6.1 *cm* for 3 hours). Possible techniques allowing for increase of the prediction accuracy and horizon (wavelet analysis, data mining techniques) were also identified.

6. Thoms and Sheldon (2000) used time series to study the impact of water resource development projects, such as dams, channel weirs and water extractors in Australia. The study focused on the hydrology of the Berwon-Darling River, which is a large dryland river in the Southeast Australia. Flows in the river had been highly modified through the presence of nine headwater dams, 15 main channel weirs, and 267 licensed water extractors. Median annual runoff had been reduced by 42% over a 60-year period

as a result of those projects. In addition, small flood events had suffered a great impact with reductions in magnitude of between 35% and 70%. The seasonality of flows had also been affected with a distinct shift in seasonal flow peaks relating to irrigation diversions at a number of stations. The results of their analysis showed that flows show marked increase in predictability and consistency. Both long- and short-term hydrological changes in the Berwon-Darling, associated with water resource development projects, were proven critical for the assessment of the ecological health of the system because incorporating such changes make the model as close as possible to reality.

7. Burn and Simonovic (1996) investigated the potential impacts of changing climatic conditions on the operational performance of water resource systems. A multi-site streamflow generation model was used to synthesize potential monthly flow sequences reflecting two different sets of climatic conditions corresponding to a 'cool' and a 'warm' climatic regime. The generated data were subsequently employed as input to a reservoir operation model that was used to determine the reservoir response to the inflow resulting from the implementation of the reservoir operating policy. The performance of an example reservoir system, the Shellmouth Reservoir located in a Canadian province of Manitoba, was evaluated and compared with the two different sets of climatic conditions mentioned earlier. The operational performance was evaluated in terms of the reliability of the systems in meeting the three purposes of the actual reservoir. The reservoir performance was determined to be sensitive to the inflow data.

8. Burn (1994) examined the impacts of climatic change on the timing of the spring runoff events. The impact detection was accomplished using a non-parametric statistical test for trend that was applied to the data sets. The approach was applied to a set of eighty-four rivers in the West-central region of Canada. The results of the study indicated that number of rivers exhibiting early spring runoff was too great to be attributed to chance. Furthermore, the study indicated that impacts on the timing of the spring runoff were more prevalent in the recent portion of the data. The author attributed this trend to the greenhouse gas induced climatic change.

9. Lungu (1993) conducted a study addressing the detection changes in rainfall and runoff patterns. In the study, he searched for significant changes in the components of a number of runoff time series. For this purpose a simple model was assumed for time-series consisting of trend, periodic, autoregressive and random components. He also explored the potential of the topological conjugacy technique to identify changes in the dynamics of hydrologic system. This technique was based on the fact that if two systems are dynamically different, they produce unique graphs. The simple used model and the analysis conducted revealed that runoff was highly stochastic (depending on the analyzing data) and that the residual as most important component in explaining the total variance in a series. The topological conjugacy technique revealed the smaller the drainage area the easier it was to obtain runoff of various magnitudes since the rainfall was usually able to cover the entire drainage area and the initial abstraction was easily exceeded.

10. Kite (1989) studied the impacts of the greenhouse effect climatic changes on society. The purpose of the study was to investigate whether effect of climatic changes

can be identified. The objective of the study was met through the analysis of climate related time series that included series of lake levels and river flows. Those series were analyzed for linear trends, periodicities, autoregressions and random residuals. As a result of the analysis, possible physical causes for the aforementioned components were identified and found to be significant. No statistical components that could be ascribed to greenhouse induced climate change were found. This does not necessarily mean that such a change was not occurring but simply, it has not been detected in these particular time series. This could due to the small sample site and low sensitive data, which could contain error.

2.4 Special Issues Using Time Series Analysis

1. Elshorbagy, et al. (2002) discussed the issues of noise reduction and the reliability of its application to hydrologic time series. It was found that the commonly used algorithm for noise reduction in hydrologic data might also remove a significant part of the original signal and introduce artificial chaoticity to the data. It was recommended that current noise reduction algorithms should be applied with caution and used only for better estimation of chaotic invariant. A case study of the English River in Ontario-Canada is used to support the conclusions.

2. Jayawardena and Lai (1994) examined the time delay embedding method of reconstructing the phase-space diagram of the time series for uncovering possible chaotic behavior and making non-linear predictions. The reliability of various parameters that characterize chaotic time series was verified using; artificially generated data from random, Autoregressive Moving Average (ARMA) series and chaotic series with additive noise. Non-linear predictions were made using a local approximation

method and applied to some daily rainfall and stream flow data in Hong Kong. The study revealed convincing statistical evidence to believe that the streamflow and rainfall data series were better modeled by the time delay embedding approach rather than by the traditional linear ARMA approach since no adequate ARMA model in the range of ARMA (1,0) to ARMA (4,4) was found to fit the series. This was attributed to the fact that the process under study was non-linear.

3. Lin and Lee (1994) examined annual series in general, which was aggregated from a seasonal series. They examined the moments (variance and covariance) associated with annual series and found that the performance of an aggregated series in reproducing the historical moments depends on the type of periodic model and the number of seasons in each year. Only defined annual series can exactly be preserved the historical variance, when the parameters of the periodic model were estimated using the method of moments. To demonstrate the performance of aggregated modeling, they analyzed annual and seasonal streamflow data for the Tanshui River in Taiwan. Two types of seasonal sequences; the two seasons and the three seasons1 were considered. The results indicated that the aggregated modeling has a very limited capability in preserving historical moments. Only annual series aggregated from seasonal series generated by a two-season Partial Autoregressive (PAR (1)) model, two season Partial Autoregressive Moving Average (PARMA (1,1)) model, and three season PARMA (1,1) can reproduce the historical variance, especially when the parameters of the periodic model are estimated using the method of moments.

4. Lin and Lee (1992) developed and applied a new methodology to solve the failure of disaggregation models. Such models were generally used to generate hydrologic time

series that preserved the statistical properties at more than one level (e.g., annual and seasonal). At the time of the study, the most widely used approach was that of Mejia and Rousselle (1976), which was a modification of the Valencia and Schaake (1973) model. The Valencia and Schaake approach can be preserved within seasonal correlations and the correlations between annual and seasonal series-year, while the Mejia and Rousselle was a modification of it that takes into account as many of the seasonal values from the previous year as desired. The purpose of the authors' study was to develop a new approach that could remedy the inconsistent structure of the Mejia and Rousselle approach, in which a problem of parameter estimation arises, thus, does not preserved any of the desired correlations. The proposed new methodology required the identification of the periodic model rather than the annual model. The annual model, which generates input in the disaggregation model, was derived from the fitted periodic model based on the concepts of aggregation. Parameters of the disaggregation model were evaluated completely in terms of the periodic parameters. With the proposed methodology, the modeling can be preserved the additivity and many important historical moments. Among the moments preserved were the over-year seasonal correlations which even existing remedies for the Mejia and Rousselle model were not able to preserved. The number of the moments preserved by the proposed methodology depends slowly on the periodic model chosen to fit the seasonal series. Between the two periodic models considered in the applications, the Partial Autoregressive Moving Average (PARMA (1,1)) model was preferred. The most significant conclusion of this study was that the proposed methodology provides a true linkage between the aggregation and disaggregation approaches for hydrologic time series simulations. The disaggregation model itself was of a disaggregation approach, whereas the parameter estimation of the model was of an aggregation approach.

5. Lin (1990) had also considered a model structure of staged disaggregation using the full Mejia and Rousselle (1976) model and addressed the parameter estimation problem for this model. A technique was developed to derive the corrected parameter estimation equations associated with the use of the Mejia and Rousselle model for a two-stage disaggregation scheme. The technique was based on making the estimation equations mathematically yield consistent parameters. It was found that the corrected parameter estimation equations for the Mejia and Rousselle model were conditional on its key series (input) generation model. With parameters estimated from corrected parameter estimation equations, coupled with the corrected moment estimates for the preservation of additivity, the developed model can be exactly preserved the important moments of interest.

3. BACKGROUND AND THEORY

3.1 Introduction

The time series is a set of data managed sequentially in time. The time serieses tested in this research are:

- Annual Precipitation records.
- Mean monthly temperatures records.
- Monthly and annual baseflow records.

There are two types of series (Granger and Newbold 1986):

1. Continuous for continuous sets, which data are recorded instantaneously and steadily.
2. Discrete for discrete series, which data are recorded at regular intervals.

Probably no phenomenon is totally deterministic, since some factors cannot determine mathematically. Therefore, time dependent phenomenon should be considered for future forecasting. Such sets of time serieses can be called nondeterministic or simply statistical time serieses. A special class of stochastic processes, called stationary processes, is based on the assumption that the process is in a particular state of statistical equilibrium. A stationary process has properties which are unaffected by a change of time origin.

Autoregressive (AR) models were first introduced by Yule in the year 1926 and later generalized by Walker in the year 1931. While Moving Average (MA) models were first used by Slutzky in the year 1937 according to Makridakis, et al. (1983). Wold in the year 1938 provided the theoretical foundations of combined Autoregressive Moving Average (ARMA) processes. Extension to Wold's work, ARMA models were developed in three directions:

- Efficient identification and estimation procedures (for AR, MA and mixed ARMA processes).
- Extension of the results to include seasonal time series.
- Simple extension to include nonstationary processes (ARIMA).

The current study depends on the work of Box and Jenkins (1976), who effectively put together in a comprehensive manner the relevant information required understanding and using univariate time series ARIMA models. The bases of their approach are summarized in Figure (2.1) and consist of four phases: postulate general class of the model, identification of the model, estimating parameters and testing the model and model's application.

3.2 Postulate General Class of Models

Postulate general class of models represents the first phase of Box and Jenkins iterative approach (1976). From the interaction of theory and practice, an initial general class of model for any such variable is considered by analyzing the observed data. Box and Jenkins used the ARIMA program in the analysis of the observed data in their approach, which gives time series plot, autocorrelation function (ACF) and partial autocorrelation function (PACF) plots and spectrum density function analysis (Box, et al. 1994).

3.3 Model Identification

Because the general class of model estimated from the postulate stage was too extensive to be conveniently fitted directly to data, rough meathods for identifying subclasses of thoes models were developed. Such methods of model identification employed data and knowledge of the system to suggest an appropriate parsimonious subclass of models, which may be tentatively entertained. In addition, the identification process can be used to yield rough preliminary estimates of the parameters in the model (Box, et al. 1994).

3.3.1 Stationary and Nonstationary

Time series may be stationary or nonstationary. Stationary series was characterized by a kind of statistical equilibrium around a constant mean level as well as a constant dispersion about that mean level (Box and Jenkins, 1976). Nonstationary series that lack mean stationary have no mean attractor toward which the level trends over time (Yaree and McGee, 2000). Most time series are nonstationary, and the AR and MA aspects of the ARIMA model refer only to a stationary time series. Therefore, it is necessary to have a notational distinction between the original nonstationary time series and its stationary counterpart, after differencing, which was used to simplify the correlation structure in order to be used easily.

A very useful notational device is the backward shift operator, B, which is used as follows:

$$BX_t = X_{t-1} \tag{3-1}$$

where B is operating on X_t, which has the effect of shifting the data back one time period. In the case of monthly data, to shift attention to "the same month last year," B^{12} can be used, and the notation is:

$$B^{12} X_t = X_{t-12} \tag{3-2}$$

The backward shift operator is convenient for describing the process of differencing. For example, if the time series is not stationary, then it can be made more nearly stationary by taking the first difference of the series. Equation (3-3) defines the first difference.

$$X_t^{'} = X_t - X_{t-1} \qquad (3\text{-}3)$$

Using the backward shift operator:

$$X^{'} = (1 - B) X_t \qquad (3\text{-}4)$$

The purpose of taking differences is to achieve stationary, and in general, the d^{th}-order difference to achieve stationary is:

$$d^{th}\text{-order difference} = (1 - B)^d X_t \qquad (3\text{-}5)$$

This model means no Autoregressive (AR) aspect, no Moving Average (MA) aspect, and a d^{th}-order difference of the original data.

If, for a given time series, an analysis of first differences suggests:

(i) The autocorrelations are not significantly different from zero.

(ii) The partial autocorrelations are not significantly different from zero.

(iii) The power spectrum density function is a continuous line, horizontal and roughly uniform.

Then, the original series can be similar to an ARIMA (0,1,0) process. Figure (3.1) shows the graph of n = 48 data points, which were generated to an ARIMA (0,1,0) process.

3.3.2 Autoregressive Processes

In general, for p^{th}*-order*, AR processes could be designated as:

ARIMA (p, 0,0)

$$X_t = \mu^{'} + \phi_1 X_{t-1} + \phi_2 X_{t-2} + ... + \phi_p X_{t-p} + e_t \qquad (3\text{-}6)$$

where $\mu^{'}$ = constant term,

$\phi_j = j^{th}$ Autoregressive parameter,

e_t = the error term at time t.

Note that the range of permissible values for the parameters of stationary AR (ϕ_1, ϕ_2), and MA (θ_1, θ_2), models are shown in Figure (3.2), which stands for ARMA processes that contain AR and MA.

In order to identify an ARIMA (1,0,0) model for any real-word time series, as an example, an empirical analysis for the precipitation in February of Irbid Station was done and look for (i) no significant autocorrelations, (ii) a single significant partial, and (iii) and that there is no frequency for spectrum density function, as shown in Figure (3.3).

If the autocorrelations have no significant, the two significant partial coefficients give indication to second-order autoregressive pattern in the data. An ARIMA (2,0,0) process can be represents in Figures (3.4).

First-order AR and MA models: ϕ_1 and θ_1 must lie between –1 and +1 that is,
For AR (1), $-1 < \phi_1 < +1$, and for MA (1), $-1 < \theta_1 < +1$
Second-order AR and MA models: The following conditions must be satisfied:
For AR (2), $-2 < \phi_2 < +2$ and $-1 < \phi_1 < +1$ and for MA (2), $-2 < \theta_2 < +2$ and $-1 < \theta_1 < +1$

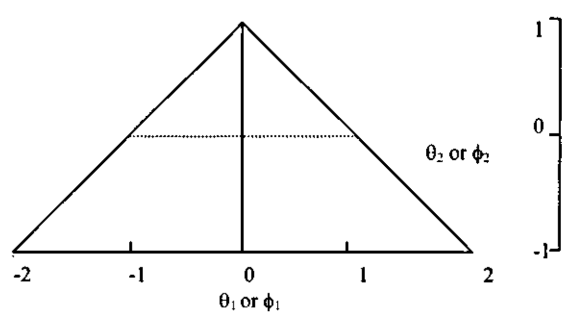


Figure (3.2): Permissible values for the parameters of stationary autoregressive and moving average model

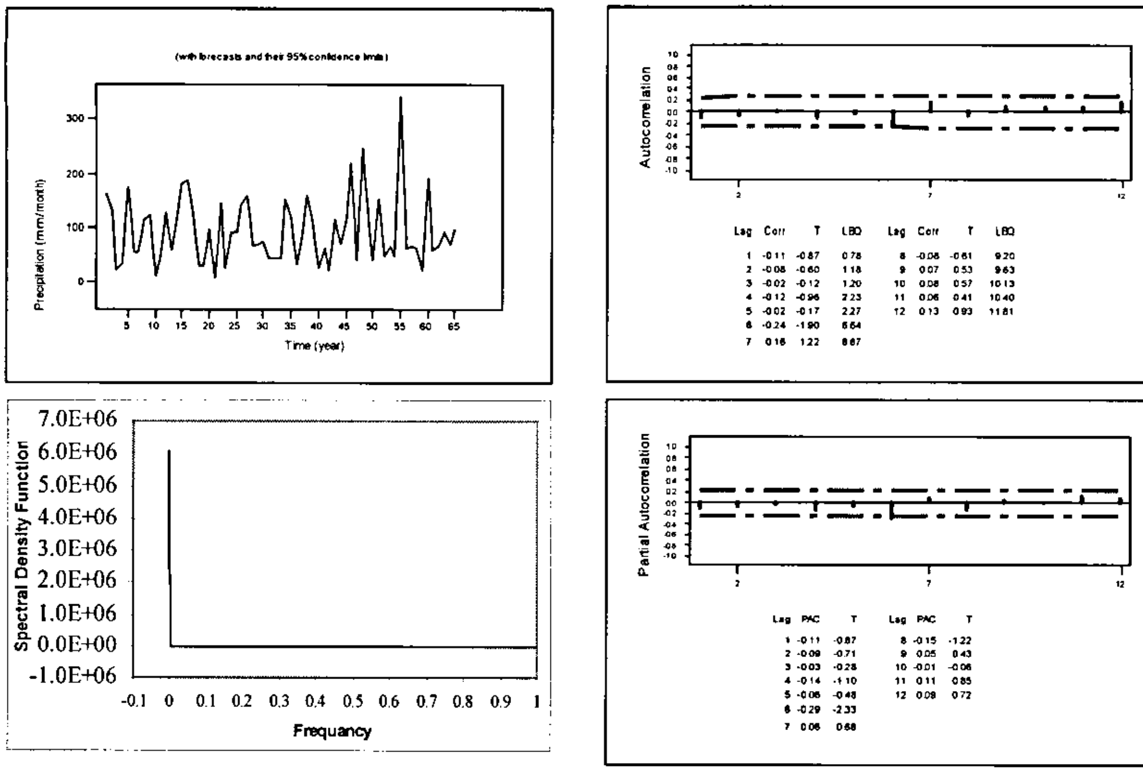


Figure (3.3): ARIMA (1,0,0) for February precipitation of Irbid station with n = 65.

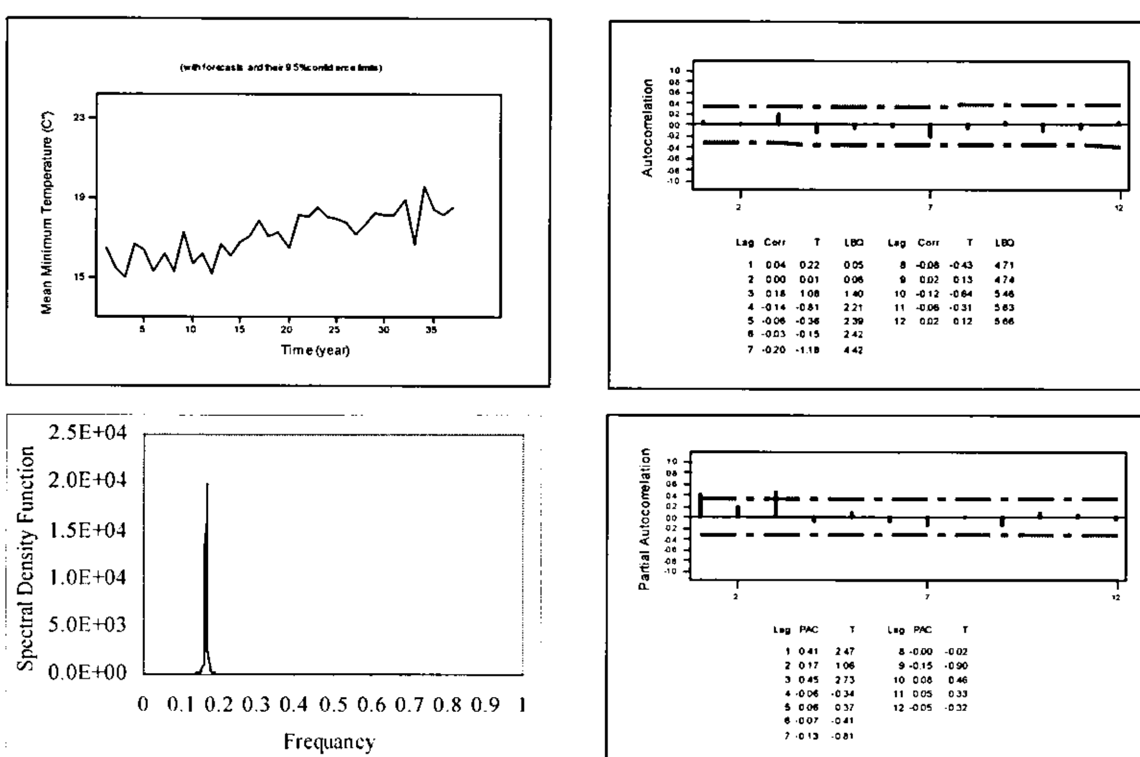


Figure (3.4): ARIMA (2,0,0) for (Jul.-Sep.) Mean Minimum Temperature of Jafar Station with n = 38.

3.3.3 Moving Average Processes

The general MA process of order q can be written as follows:

ARIMA (0,0,q) or MA (q)

$$X_t = \mu + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \ldots - \theta_q e_{t-q} \qquad (3\text{-}11)$$

where $\theta_1\ through\ \theta_q$ are the q Moving Average parameters,

e_{t-k} is the error term at time $t-k$,

μ is a constant.

In practice, the two cases most likely to be encountered are when q = 1,and q = 2, corresponding to the MA (1), and MA (2) models, respectively. These two cases are defined as follows:

ARIMA (0,0,1) or MA (1)

$$X_t = \mu + (1 - \theta_1 B) e_t \qquad (3\text{-}12)$$

In the current study, there is no suggested (0,0,1) ARIMA model. So this model was taken from Makridakis, et al. 1983. Summarizing results for MA (1), single significant autocorrelations, no significant partials, and low frequencies dominate spectrum density function. Figure (3.5) illustrate the theoretical MA (1) processes generating n = 100 data points using the simulation program ARIMA and the model $X_t = 100 + e_t + 0.7e_{t-1}$

ARIMA (0,0,2) or MA (2)

$$X_t = \mu + (1 - \theta_1 B - \theta_2 B^2) e_t \qquad 3\text{-}13)$$

Figure (3.6) illustrates one pure MA (2) processes for the extended precipitation in November of Amman-Airport station. Results show exactly two nonzero autocorrelations for a second-order MA process, no significant partials, and that there is no frequency for spectrum density function.

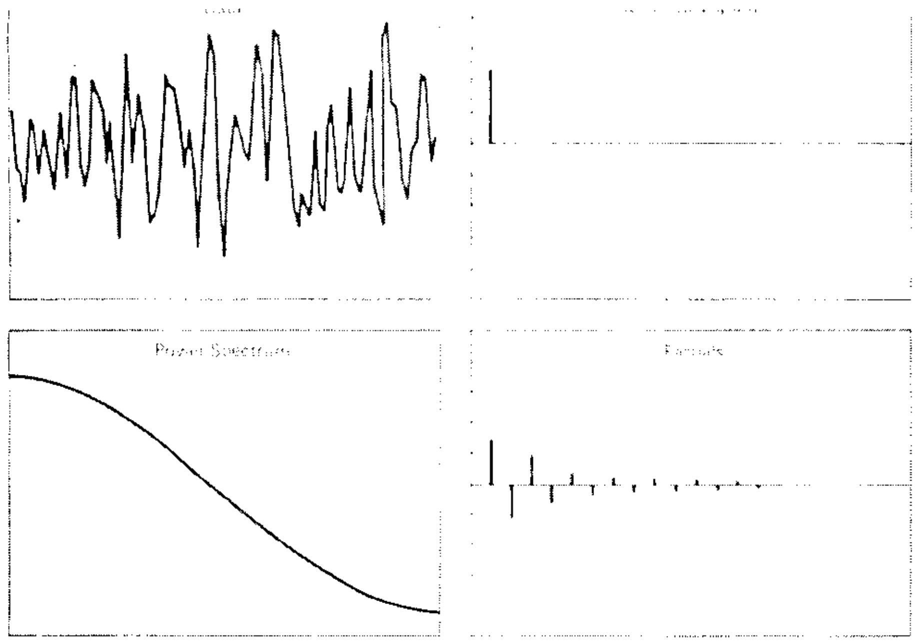


Figure (3.5): ARIMA (0,0,1) with n = 100 Data Points, Using the Model
$X_t = 100 + e_t + 0.7e_{t-1}$

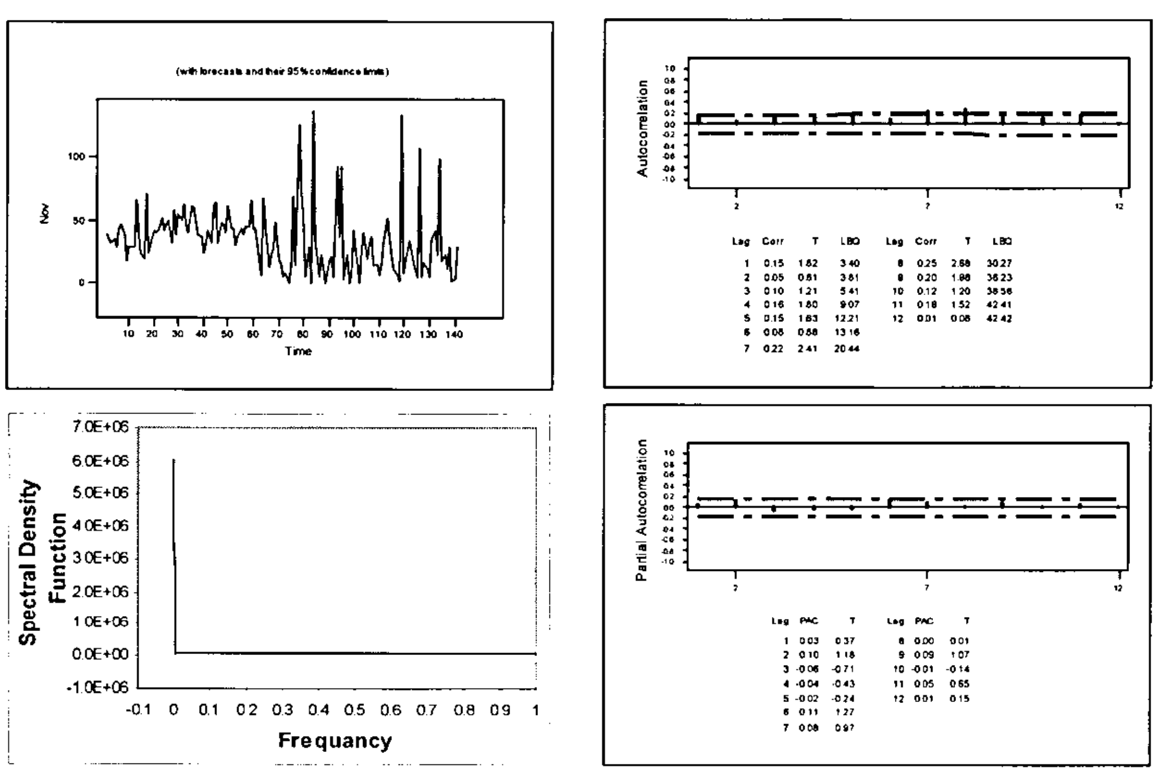


Figure (3.6): ARIMA (0,0,2) for Extended Precipitation in November of Amman-Airport Station with n = 141.

3.3.4 Mixtures: ARMA Processes

A general model for a mixture of a pure AR (1) and a pure MA (1) process would be written as follows:

ARIMA (1,0,1) or ARMA (1,1)

$$X_t = \mu' + \phi_1 X_{t-1} + e_t - \theta_1 e_{t-1}$$

or

$$(1-\phi_1 B)X_t = \mu' + (1-\theta_1 B)e_t \qquad (3\text{-}14)$$

AR (1) MA (1)

Figure (3.7) shows one special case of equation (3-14) where $\phi_1 = 0.99997$, and $\theta_1 = 0.84639$. Autocorrelations and partials both have one significant and no frequency for the spectrum density function.

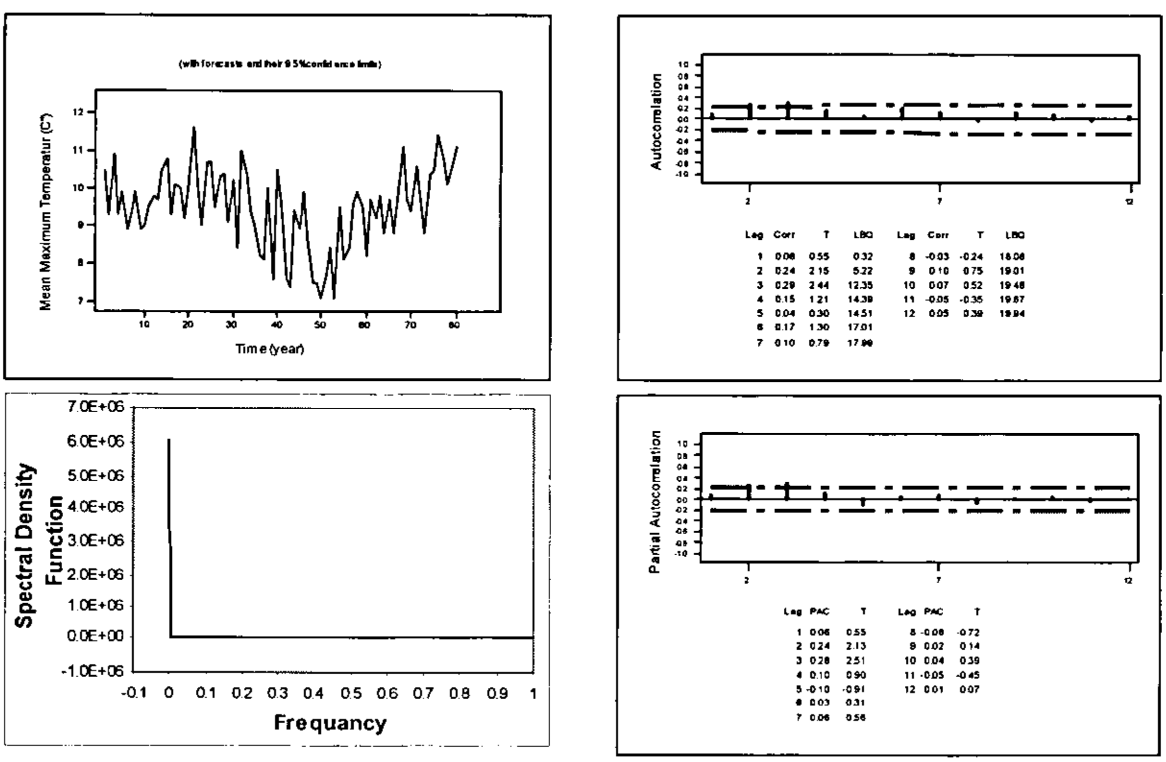


Figure (3.7): ARIMA (1,0,1) for (Oct.-Dec.) Mean Maximum Temperature of Amman-Airport Station with n = 80

3.3.5 Mixtures: ARIMA Processes

If nonstationarity is added to a mixed ARMA process, then the general ARIMA (p,d,q) model is implied. The order of autoregressive, differenced and moving average for the data are representing by p, d and q values respectively. Already it has become clear that the general ARIMA (p,d,q) model involves an enormously large family of model types. Even the simple AR and MA processes show great variety. Thus, it is to be expected that when mixtures are considered, the complexities of identification multiply. The equation for the simplest model ARIMA (1,1,1) is as follows:

ARIMA (1,1,1)

$$(1-B)(1-\phi_1 B)X_t = \mu' + (1-\theta_1 B)e_t \qquad 3\text{-}15)$$

↑ First Difference ↑ AR(1) ↑ MA(1)

or

$$X_t = (1+\phi_1)X_{t-1} - \phi_1 X_{t-2} + \mu' + e_t - \theta_1 e_{t-1} \qquad (3\text{-}16)$$

Note that in this form, the ARIMA model similar to the conventional regression equation, except that there is more than one error term on the right-hand side.

The general ARIMA (p,d,q) model with p = q = 2, and, say, d =1 using parameters with low orders, yields a tremendous variety of patterns in autocorrelations, partials and spectrum density function, so that it is unwise to state the rules for identifying general ARIMA models using autoregressive, differenced and moving average parameters with higher orders (Makridakis, et al. 1983).

3.3.6 Seasonality and ARIMA Models

One final complexity to add to ARIMA models is seasonality. The same way that consecutive data points might exhibit AR, MA, mixed ARMA, or mixed ARIMA properties, so that the data separated by a whole season within a year may exhibit the same properties. For example, consider a data series that is collected quarterly, then seasonal differences could be computed as follows:

$$X_t^{'} = X_t - X_{t-4} = \left(1 - B^4\right)X_t \tag{3-17}$$

For data collected monthly, a full season's (year's) difference would be computed as follows:

$$X_t^{'} = X_t - X_{t-12} = \left(1 - B^{12}\right)X_t \tag{3-18}$$

The ARIMA notation can be extended readily to handle seasonal aspects, and the general shorthand notation is ARIMA (p,d,q) $(P,D,Q)^S$, where (p,d,q) is nonseasonal part of the model, $(P,D,Q)^S$ is seasonal part of the model, and S is the number of periods per season. For illustrative purposes consider the following general ARIMA (1,1,1) $(1,1,1)^4$ model.

[Seasonal AR (1)] Seasonal Difference] Seasonal MA (1)]

$$\left(1-\phi_1 B\right)\left(1-\Phi_1 B^4\right)\left(1-B\right)\left(1-B^4\right)X_t = \left(1-\theta_1 B\right)\left(1-\Theta_1 B^4\right) \tag{3-19}$$

[Nonseasonal AR (1)] [Nonseasonal Difference] [Nonseasonal MA (1)]

All factors can be multiplied out and the general model written in what is called "unscrambled form." Multiplying out equation (3-19) yields the following (Makridakis, et al. 1983):

$$\left.\begin{aligned} X_t = {} & \left(1+\phi_1\right)X_{t-1} + \left(1+\Phi_1\right)X_{t-4} - \left(1+\phi_1+\Phi_1+\phi_1\Phi_1\right)X_{t-5} \\ & + \left(\phi_1+\phi_1\Phi_1\right)X_{t-6} - \Phi_1 X_{t-8} + \left(\Phi_1+\phi_1\Phi_1\right)X_{t-9} \\ & - \phi_1\Phi_1 X_{t-10} + e_t - \theta_1 e_{t-1} - \Theta_1 e_{t-4} + \theta_1\Theta_1 e_{t-5} \end{aligned}\right\} \tag{3-20}$$

In the above form, once the coefficients $\phi_1, \Phi_1, \theta_1, and \Theta_1$ have been estimated from the data, then equation (3-20) can be used for forecasting. The process of identification of a seasonal model depends upon the familiar statistical tools-namely, autocorrelations, partials, and the line spectrum density function- and knowledge of the system (or process) under study

3.4 Estimating the Parameters

After the tentative model identification was finished, the AR and MA parameters, seasonal and nonseasonal have to be determined in the best possible manner. For example, suppose the class of model identified is ARIMA (0,1,1). This is a family of models depending on one MA coefficient θ_1:

ARIMA (0,1,1)

$$(1-B)X_t=(1-\theta_1 B)e_t$$

The best estimate of θ_1 to fit the time series model is required.

There are fundamentally two ways of getting estimates for such parameters, and the 2nd method below is the preferable. These ways are:

1. Trail and error-examine many different values and choose that value (or set of values, for more than one parameter to estimate) that minimizes the sum of squared residuals.

2. Iterative improvement-choose a preliminary estimate and let a computer program refine the estimate iteratively.

3.4.1 Nonseasonal AR (1) and AR (2) processes

Autoregressive of order p, AR (p) are defined as follows:

$$\left.\begin{array}{l} \rho_1=\phi_1 \quad +\phi_2\rho_1 \quad +\dots+\phi_p\rho_{p-1} \\ \rho_2=\phi_1\rho_1 \quad +\phi_2 \quad +\dots+\phi_p\rho_{p-2} \\ . \\ . \\ . \\ \rho_p=\phi_1\rho_{p-1} +\phi_2\rho_{p-2}+\dots+\phi_p \end{array}\right\} \qquad (3\text{-}21)$$

Where $\rho_1,\rho_2,\dots,\rho_p$ are the theoretical autocorrelations for lag 1, 2,..., p, respectively, $\phi_1,\phi_2,\dots,\phi_p$ are the ϕ coefficients of the AR (p) process. Since the theoretical values of ρ are not known, we replace them with their empirical counterparts and then solve for the ϕ values.

Consider an AR (1) process. Rewriting equation (3-21) with p = 1 leaves just one equation

$$\rho_1 = \phi_1 \tag{3-22}$$

Replacing the unknown ρ_1 with the known r_1 (empirical autocorrelation) gives us an estimate for the parameter ϕ_1 in the AR (1) process:

$$\hat{\phi}_1 = r_1 \quad \text{3-23)}$$

Consider an AR (2) process. Rewriting the Yule-Walker equations for p = 2, yields:

$$\left.\begin{aligned}\rho_1 &= \phi_1 + \phi_2\rho_1\\ \rho_2 &= \phi_1\rho_1 + \phi_2\end{aligned}\right\} \tag{3-24}$$

Replacing ρ_1 and ρ_2 with r_1 and r_2 from the autocorrelation diagram, and solving for ϕ_1 and ϕ_2, gives preliminary estimates:

$$r_1 = \hat{\phi}_1 + r_1\hat{\phi}_2 \Rightarrow \hat{\phi}_1 = r_1 - r_1\hat{\phi}_2$$

$$r_2 = r_1\hat{\phi}_1 + \hat{\phi}_2 \Rightarrow \hat{\phi}_2 = r_2 - r_1\hat{\phi}_1$$

$$\hat{\phi}_2 = r_2 - r_1(r_1 - r_1\hat{\phi}_2)$$

$$\hat{\phi}_2 = r_2 - r_1^2 + r_1^2\hat{\phi}_2$$

$$\hat{\phi}_2 = \frac{r_2 - r_1^2}{1 - r_1^2}$$

$$\therefore \hat{\phi}_1 = r_1 - r_1\left(\frac{r_2 - r_1^2}{1 - r_1^2}\right)$$

$$\hat{\phi}_1 = \frac{r_1 - r_1^3 - r_1r_2 + r_1^3}{1 - r_1^2}$$

$$\left.\begin{aligned}\hat{\phi}_1 &= \frac{r_1(1 - r_2)}{1 - r_1^2}\\ \hat{\phi}_2 &= \frac{r_2 - r_1^2}{1 - r_1^2}\end{aligned}\right\} \tag{3-25}$$

3.4.2 Nonseasonal MA (1) and MA (2) processes

The technical details for this section depends on a statistical analysis of the autocovariance function (ACF) for a general MA (q) process. In brief, the theoretical autocorrelations for an MA (q) process can be expressed in terms of the MA coefficients, as follows (Box, et al. 1994):

$$\rho_K = \begin{cases} \dfrac{-\theta_K + \theta_1\theta_{K+1} + \ldots + \theta_{q-K}\theta_q}{1+\theta_1^2 + \ldots + \theta_q^2}, & K = 1,2,\ldots,q, \\ 0, & K > q. \end{cases} \qquad (3\text{-}26)$$

Since the theoretical values, ρ_K, are unknown, preliminary estimates of the coefficients, $\theta_1, \theta_2, \ldots, \theta_q$, can be obtained by substituting empirical autocorrelations, r_K, in equation (3-26), and solving.

Consider an MA (1) process. Here q = 1 and equation (3-27) reduces to

$$\rho_1 = \begin{cases} \dfrac{-\theta_1}{1+\theta_1^2}, & K = 1, \\ 0, & K \geq 2 \end{cases} \qquad (3\text{-}27)$$

Substituting r_1 for ρ_1 and trying to solve for θ_1 yields a quadratic equation, as follows:

$$\hat{\theta}_1^2 + \left(\frac{1}{r_1}\right)\hat{\theta}_1 + 1 = 0, \qquad (3\text{-}28)$$

Which has two solutions. However, θ_1 is restricted to lie between –1 and +1.

Consider an MA (2) process. Now q = 2 and equation (3-26) become

$$\left.\begin{aligned} \rho_1 &= \frac{-\theta_1(1-\theta_2)}{1+\theta_1^2+\theta_2^2}, \\ \rho_2 &= \frac{-\theta_1}{1+\theta_1^2+\theta_2^2}, \\ \rho_K &= 0, \quad K = 3 \end{aligned}\right\} \qquad (3\text{-}29)$$

Substituting r_1 and r_2 for ρ_1 and ρ_2, yields two equations in two unknowns, θ_1 and θ_2, but they are no means easy to solve. Box-Junkins (1976), offered tables and charts to handle preliminary estimates for θ_1 and θ_2.

3.5 Diagnostic Checking

After having estimated the parameters of a tentatively identified ARIMA model, it is necessary to do diagnostic checking to verify that the model is adequate. There are basically two ways of doing this:

1. Study the residuals, to see if any pattern remains unaccounted for.
2. Study the sampling statistics of the current optimum solution, to see if the model could be simplified.

The current study takes the above first way to do diagnostic checking and it is summarized as follows:

The residuals (errors) left over after fitting an ARIMA model are, in most cases, just random noise. Therefore, if the autocorrelations, partials, and the spectral density function of the residuals are obtained, the following could be found: (i) no significant autocorrelations, (ii) no significant partials, and (iii) lower frequency in spectral density function (depending on the observed data).

For example, after fitting the seasonal ARIMA (2,1,2) model with seasonal length equal to 12 month, the optimum coefficients of the model were estimated and the sets of residuals were analysed as shown in Figure (3.8). Note that the three points above are largely applied, so that the model appears adequate to describe the data.

One of the procedures for diagnostic checking mentioned by Box and Jenkins is called overfitting that is, for example, using more parameters than necessary, or choosing a second-order AR when a first-order AR is indicated. (Yafee and McGee, 2000)

To avoid this problem, the current study uses the S-PLUS 2000 software to determine the Akaike Information Criterion (AIC), details are mentioned in Chapter Four. The smaller the AIC, the better the fit. (Akaike and Kitagawa, 1999).

For example, Table (3.1) summarizes limiting of the best ARIMA model from the initial (3,1,3) ARIMA modal, which estimated from ACF & PACF plots for mean monthly maximum temperature for Jafar station depending on the minimum value of AIC using S-Plus 2000 software. The (2,1,2) ARIMA was the best model for this station. Then the parameters of the best model were estimated as shown in Table (3.1) using the Minitab software.

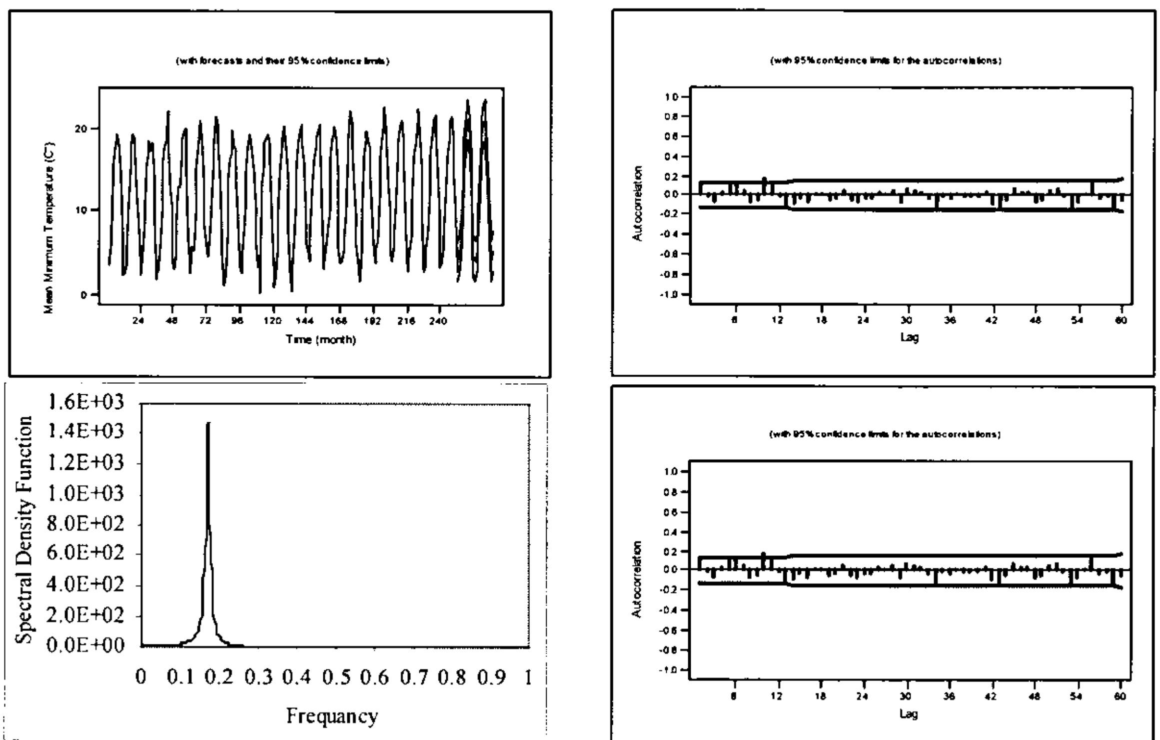


Figure (3.8): Residual Analysis for Mean Monthly Minimum Temperature of Azraq Station.

Table (3.1): Limiting of Best ARIMA Model and Parameters Estimating of Mean Monthly Minimum Temperature for Jafar Station

Model No.	Model (p,d,q)	AIC
1	3,1,3	1677.72
2	3,1,2	1719.37
3	3,1,1	1744.00
4	3,1,0	2040.27
5	2,1,3	2063.59
6	2,1,2	1675.11
7	2,1,1	1910.17
8	2,1,0	2117.99
9	1,1,3	2081.41
10	1,1,2	2099.44
11	1,1,1	2126.72
12	1,1,0	2127.83
13	0,1,3	2095.94
14	0,1,2	2135.99
15	0,1,1	2209.54

Best Model: (2,1,2)	
ϕ , AR Coefficient	θ , MA Coefficient
1.72197	1.7593
-0.98797	-0.79987

3.6 Forecasting with ARIMA Models

After finding the best (p,d,q) ARIMA model for the given observations of the data series, such as mean monthly minimum temperature for Jafar Station, estimating it's parameters, checking the model was done by using backward forecasting type. Predicted future values can be found by using forward forecasting process. These two types of forecasting are shown below:

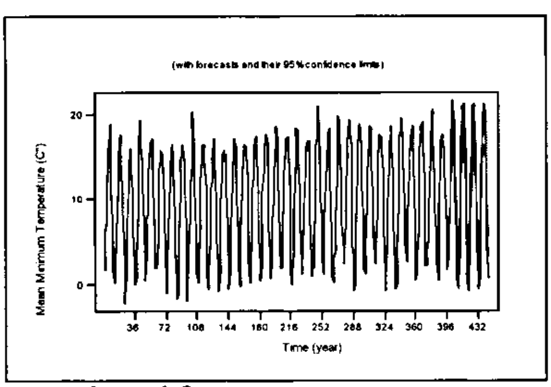
1. Backward forecasting; which is used to check the accuracy of the model in representing the past observations of the data series. Using Microsoft Excel, the current study computes three measures of accuracy of the fitted model. These measures of accuracy are:

- Mean absolute percentage error (MAPE).
- Mean absolute deviation (MAD).
- Mean square deviation (MSD).

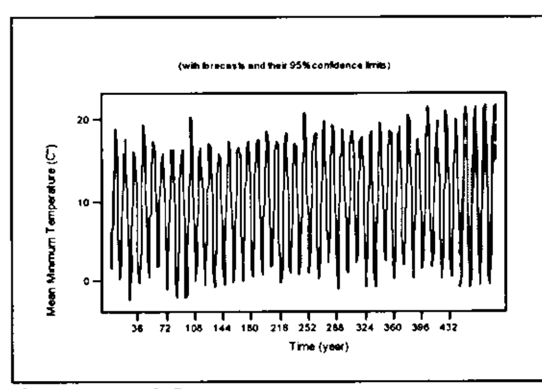
The details of the calculations are shown in Chapter Four and Appendix-C. of this thesis.

Table (3.2) shows the values of the above three measures of accuracy and Figure (3.9.a) shows the backward forecating values for mean minimum temperature of Jafar Station.

2. Forward forecasting; which is used to forecast the future values for the data series. The procedure of forward forecasting process shown in details in Chapter Four and appendix-C of this thesis. Figure (3.9.b) shows the forward forecating values for mean minimum temperature of Jafar Station.



a. Backward forecast



b. Forward forecast

Figure (3.9): Time Series, Forward, and Backward 10% Forecasting of Observed Mean Monthly Minimum Temperature for Jafar Station.

Table (3.2): Determination of MAPE, MAD and MSD of Mean Minimum Temperature for Jafar Station

MAPE	38.69
MAD	1.04
MSD	1.64

4. DATA ANALYSIS AND MODELING

The purpose of this chapter is to present the tools used for the statistical analysis and the modeling procedures as a requirement for time series analysis. This chapter is divided to two sections; the introduction and the analysis of variables. The later section includes; detection of missing data, simple forecasting and smoothing methods, correlation analysis and ARIMA modeling methods and cyclical ternd(s).

4.1 Introduction

The following data analyses are discussed through this chapter as mentioned above:

a) Simple forecasting methods.

b) Smoothing methods.

c) Correlation analysis methods.

d) ARIMA modeling methods.

Simple forecasting and smoothing methods decompose the data into its component parts and then estimates the future components to provide forecasts. The choice of the best smoothing method should be based upon the following (Box, et al. 1994):

- Whether the patterns are constant in time (static) such as trend analysis and decomposition, or vary with time (dynamic) such as moving average and single exponential smoothing.
- The nature of the data components.
- The forecast period. Increasing forecast period caused by decreasing accuracy of forecasting.

Correlation analysis and ARIMA modeling methods. In many statistical analyses, it is very important to examine correlation patterns within a time series or between two time serieses. The correlation analysis is a major tool to help identify an appropriate model in the ARIMA modeling process. The advantage of ARIMA modeling as opposed to the simple forecasting and smoothing methods is that it is more flexible in fitting the data (Box, et al. 1994).

Four softwares were used to rearranging and analyzing the data in the current study. Those were; Microsoft Excel, Minitab, S-Plus 2000 and Interactive Time Series Modeling for Windows (ITSM). Excel was mainly used to tabulate, arrange and organize the data, while the other three softwares were used to conduct the time series analysis. Minitab software was used to analyze the data collected over time. The S-Plus 2000 software was used to determine the Akaike Information Criterion (AIC). This function was calculated for one or several fitted model objects for which a log-likelihood value can be obtained, according to the following equation:

$$AIC = -2 \times \log likelihood + 2 \times npar \tag{4.1}$$

where *npar* represents the number of parameters in the fitted model. When comparing fitted models, the smaller the AIC leads to better the fit (Akaike and Kitagawa 1999). The (ITSM) software is used to determine the cyclic trend(s) in the data of any variable. The spectral density of a stationary time series ($X_t, t = 0, \pm 1, \ldots$), with absolutely summable autocovariances, for an ARIMA process in particular, can be written as:

$$f(\omega) = \frac{1}{2\pi} \sum_{k=-\infty}^{\infty} \gamma(k) e^{-i\omega k} \quad , -\pi \le \omega \le \pi \tag{4.2}$$

where $\gamma(k)$ is the autocovariance at lag k and $i = \sqrt{-1}$. The spectral representation of X_t decomposes the sequence into sinusoidal components and $f(\omega)$ measures the relative contributions to the variance of X_t from the components of different frequencies, measured in radians per unit time. For real-valued series $f(\omega) = f(-\omega)$, therefore, it is necessary to only plot $f(\omega), 0 \le \omega \le \pi$. A peak in the spectral density function at frequency

λ indicates a relatively large contribution to the variance from frequencies near λ. A relatively large part of the variance in the series can be attributed to sinusoidal components in the period (in time-unit) close to $\frac{2\pi}{\lambda}$ (Brockwell and Davis, 1994).

4.2 Analysis of Variables

In this section the data for two main variables were accumulated and analyzed.

The first main variable is *climatological parameters* that represent the mean maximum and mean minimum temperatures and precipitation for different stations in representive different regions in Jordan: a) Mountains region, b) Hill region c) Aqaba area, d) Badia region and e) Desert region.

The Mountains region is represented by Shoubak station. Amman-Airport station and Irbid station represent the Hill region. The Aqaba area is represented by Aqaba-Airport station. The Badia region is represented by Azraq station and Mafraq station. The Desert region is represented by Jafar station and Safawi station.

The second variable is *baseflow* for three different streams, which are: a) Zarqa River, b) Wadi Mujib and c) Wadi Hisban. The analyzed variables are summarized in a Flow Chart, as shown in Figure (4.1).

The precipitation, temperature and baseflow data for the stations mentioned above were obtained from the Ministry of Water and Irrigation.

The results of the analysis for precipitation and mean monthly maximum temperature at Amman-Airport station and monthly baseflow data for Zarqa River station as an example are presented in this chapter. The remaining analysis results are summarized in Appendices B and C.

The following steps were presented to analyze the precipitation, temperature and baseflow data:

4.2.1 Detection of missing data

If some data values are missing, they should replaced. There are many methods to prove that, such as: exponential smoothing method, one-step-ahead forecasting from previous observation, interpolation methods and correlation between stations have the same conditions (Yaffee and McGee, 2000)

Amman-Airport station contains one missing reading for precipitation, which is (October 2001) as shown in Table (4.1) and one missing reading for temperature, which is (April 2002) as shown in Table (4.2). Zarqa River contains one missing reading for baseflow, which is (November 1997) as shown in Table (4.3). All missing readings were estimated by using correlation between observations of the same months for the stations have the same climate conditions. The missing reading for precipitation was estimated to be 9.5 mm/month. The missing reading for temperature was estimated be 22.3 C°. The missing reading for baseflow was estimated by using correlation between observations for the same month (November) for Zarqa River and Wadi Mujib stations. The new calculated value for baseflow was found to be 4.16 m^3/s. By comparing this value with the same month in the pervious and next years, it was noticed that in (November 1996), baseflow was 5.07 m^3/s where its precipitation was 22.2 mm/month and its temperature was 20.2 C°. Also in (November 1998), baseflow was 4.66 m^3/s where precipitation was 29.0 mm/month and its temperature was 23.9 C°. Therefore, the calculated value of baseflow in (November 1997) was adequate because of decreasing its precipitation to 10.7mm/month.

4.2.2 Simple forecasting and smoothing methods

Simple forecasting and smoothing methods include the following methods as listed above:

1. Trend analysis methods: Trend analysis fits a general model to time series data. This procedure was used to fit the trend when there is no seasonal component in time series data. Trend analysis methods used in this research are: a) linear, b) quadratic and c) exponential growth or decay trends.

The linear trend model can be summarized by the following:

$$y_t=\beta_0+\beta_1 t+e_t \tag{4.3}$$

where y_t represents the observed value of the variable (such as precipitation) at time t, β_0 represents the y-intercept (i. e. initial value of y), β_1 represents the average change from one period to the next, t represents the time periods and e_t represents the error term of y at time t (Box, et al. 1994).

The quadratic trend model, which can account for simple curvature in the data, is:

$$y_t=\beta_0+\beta_1 t+\beta_2 t^2+e_t \tag{4.4}$$

The exponential growth trend model is:

$$y_t=\beta_0\beta_1^t+e_t \tag{4.5}$$

Figures (4.2) through (4.10) show linear, quadratic and exponential growth trend analysis for water-year records for Amman-Airport station, mean monthly maximum temperature records for Amman-Airport station and monthly baseflow records for Zarqa River station, respectively.

The Minitab software computes three measures of accuracy for the fitted model. These measures of accuracy are:

- *Mean Absolute Percentage Error* (MAPE), which measures the accuracy of the fitted time series. It expresses accuracy as a percentage:

$$MAPE=\frac{\sum_{1}^{n}\left|(y_t-\hat{y}_t)/y_t\right|}{n}\times 100 \qquad ,(y_t\neq 0) \tag{4.6}$$

where y_t represents the observed value at time t, $\hat{y}_t$ = the forecast value at time t and n = the number forecast.

- *Mean Absolute Deviation* (MAD), which measures the accuracy of the fitted time series values. It expresses accuracy in the same units as the data itself, which helps conceptualize the amount of error:

$$MAD = \frac{\sum_{1}^{n} |y_t - \hat{y}_t|}{n} \tag{4.7}$$

- *Mean Square Deviation* (MSD), which is almost similar to mean square error (MSE). It is a commonly used measure of accuracy for fitted time series values. MSD is computed using the same denominator, n, regardless of the model but not for different degrees of freedom. Therefore, models can be compared.

$$MSD = \frac{\sum_{1}^{n} (y_t - \hat{y}_t)^2}{n} \tag{4.8}$$

Measures of accuracy (MAPE, MAD and MSD) are used to compare the best fit of the different models. The smaller the values of all three measures of accuracy, the better the fit of the model. Forecasts are extrapolations of the trend model fits. The original data are used to fit the trend. According to the three measures of accuracy, the growth curve model was chosen from trend analysis procedure for precipitation, temperature and baseflow as indicated in Tables (4.4), (4.5) and (4.6) respectively.

It was observed from trend analysis for Amman-Airport precipitation and the baseflow of Zarqa River that the baseflow increases in spite of precipitation decreasing. This is attributed to the industrial and domestic sewage thrown in Zarqa River.

2. Decomposition methods are used to separate the time series into trend, seasonal, components and error. In addition, decomposition methods provide forecast by using

Equation (4.9). The additive seasonal component with the trend and cyclic components was chosen because it was more accurate in representing the forecast for variables taken in the current study. Figures (4.11) through (4.16) show the seasonal decomposition fit and residual component analysis for precipitation for water-year records for Amman-Airport station, mean monthly maximum temperature records for Amman-Airport station and monthly baseflow records for Zarqa River station, respectively. Figures (4.17) through (4.22) show seasonal plus trend decomposition fit and residual component analysis for precipitation for water-wear records for Amman-Airport station, mean monthly maximum temperature records for Amman-Airport station and monthly baseflow records for Zarqa River station, respectively. Figures (4.23) through (4.28) show the decomposition fit analysis for precipitation for water-wear records for Amman-Airport station, mean monthly maximum temperature records for Amman-Airport station and monthly baseflow records for Zarqa River station, respectively.

Decomposition calculates the forecast as the trend added to seasonal and cyclic indices. The following steps do this (Makridakis, et al. 1983):

a. For the actual value (y_t), compute a moving average whose length, l, is equal to the length of seasonality. The purpose of this moving average is to estimate seasonality and randomness. Averaging as many periods as the length of the seasonal pattern will estimate seasonality by averaging seasonally high periods with seasonally low periods. Since random errors have no systematic pattern, this averaging reduce randomness as well.

b. Separate the l period moving average (step a above) from the origin data series to obtain trend and cyclically.

c. Isolate the seasonal factor by averaging them for each of the periods making up the complete length of seasonality.

d. Identify the appropriate form of the trend (linear, quadratic, exponential, etc.) and calculate its value for each period, ($Trend_t$).

e. Separate the outcome of step d from that of step b to obtain the cyclic factor.

f. Separate the seasonality, trend and cyclic from the origin data series to isolate the remaining randomness, $Error_t$..

$$y_t = Trend_t + Seasonal + Cyclic + Error_t \tag{4.9}$$

According to the three measures of accuracy, the seasonal plus trend decomposition fit analysis was more accurate from the seasonal decomposition fit analysis for precipitation, temperature and baseflow as indicated in Tables (4.4), (4.5) and (4.6) respectively.

3. Moving average method: One way to modify the influence of past data on the mean as a forecast is to specify the outset just how many past observations will be included in the mean. The term *moving average* is used to describe this procedure because as each new observation becomes available, a new average can be computed by dropping the oldest observation and including the newest one. This Moving Average will then be the forecast for the next period. Each of the observations in the calculation of the moving average is given an equal weight when then the simple average is calculated. (Yaffee and McGee, 2000). The general Moving Average process of order q was defined in Equation (3.11). Moving Average smoothens the data by averaging consecutive observations in a series and provides short-term forecasts. This procedure can be the best choice when the data do not have a trend or seasonal component. With non-seasonal time series, it is common to use short moving averages to smooth the series, although the selected length may depend on the amount of noise in the series. A

longer moving average filters out the noise, but it is also less sensitive to change the series (Cryer 1986).

Figures (4.29) through (4.33) show Moving Averages for different lengths ranging between one and five water-years for precipitation for Amman-Airport station, respectively. Figures (4.34) through (4.43) show Moving Averages for different lengths ranging between one and five months for mean monthly maximum temperature records for Amman-Airport station and monthly baseflow records for Zarqa River station, respectively. Depending upon the three measures of accuracy, as indicated in Table (4.4), two water-years Moving Average (MA (2)) was chosen. As indicated in Tables (4.5) and (4.6), three months Moving Average (MA (3)) was chosen for mean monthly maximum temperature records for Amman- Airport station and for monthly baseflow records for Zarqa River station, respectively.

4. Single exponential smoothing method smooths the data by computing the exponentially weighted averages and providing short-term forecasts. Subsequent smoothed values are calculated from Equation (4.10). The fitted value at time *t* is the smoothed value at time *t-1*. The forecasted value for each time will be the fitted value at the origin.

$$\hat{y}_t = \alpha y_t + (1-\alpha) y_{t-1} \qquad (4.10)$$

where $\hat{y}_t$ is the smoothed value at time *t*, y_t is the observed data at time *t*, y_{t-1} is the smoothed value at time *t-1* and a weight α that provides the desired smoothing is given in Equation (4.11):

$$\alpha = \frac{2}{(l+1)} \qquad (4.11)$$

where l is the unweighted moving average length.

where γ_k is the variance at time $t+k$ and γ_o is the variance at time t. Autocorrelation function (ACF) plot gives indication of MA process. The order of moving average MA (q) was fond by determining the number of significant spikes out of confidence intervals in ACF plot. The partial autocorrelation function (PACF) is a device, which exploits the fact that whereas an AR (p) process has an autocorrelation function, which is infinite in extent, it can by its very nature be described in the term of p nonzero functions of the autocorrelations. Partial autocorrelations are correlations between sets of ordered data pairs of a time series and its plot gives indication of the Autoregressive process. The order of autoregressive AR (p) was fond by determining the number of significant spikes out of confidence intervals in PACF plot (Box, et al. 1994).

For ARIMA modeling process, the following steps could be developed:

1. Model identification. Figures (4.47) and (4.48) show ACF and PACF plots for precipitation of water-year record for Amman-Airport station, respectively. Where Lag represents shifting of data to the k time period, PAC represents partial autocorrelation value, Corr represents correlation value, t represents t-test statistics value and LBQ represents Ljung-Box Q statistics value.

These figures show that the ARIMA model for the recorded data for the period between the year 1922 to 2002, which cannot be obtained because there was no significant spikes out of confidence intervals in ACF and PACF plots that represent the order of MA and AR. Also, no differencing was taken for the observed data. Therefore, correlation with the Jerusalem station rainfall record for the period between the year 1862 to 1963 in order to extend Amman-Airport record. Figures (4.49) and (4.50) show ACF and PACF plots for extended precipitation record of Amman-Airport station, respectively. The initial estimated ARIMA model is (3,0,3). The statistical program S-PLUS 2000 was then used to determine the minimum Akaike Information Criterion

(AIC), which gives the best model. As shown in Table (4.7), the best ARIMA model for extended precipitation of water-year record for Amman-Airport station is ARIMA (3,0,2). Where p = 3, d = 0 and q = 2. Figures (4.51) and (4.52) show the ACF and PACF of residuals for extended precipitation record for Amman-Airport station.

Figures (4.53) and (4.54) show that the data are non-stationary so the differencing of data for mean monthly maximum temperature for Amman-Airport station must be taken before plotting the ACF and PACF. Taking the difference for a lag value of 12 did this because the records had cyclic for this lag period time (i.e. 12 months). Figures (4.55) and (4.56) show ACF and PACF plots for the differenced mean monthly maximum temperature for Amman-Airport station, respectively. It can be seen from the ACF and PACF plots that MA (4) and AR (2) with a differencing value of 1, which results in an ARIMA (2,1,4) model. Using the S-PLUS 2000 software, the minimum AIC was determined and used to estimate the best model. As shown in Table (4.8), the best ARIMA model for mean monthly maximum temperature for Amman-Airport station is ARIMA (2,1,2). Figures (4.57) and (4.58) show the ACF and PACF of residuals for mean monthly maximum temperature for Amman-Airport station.

Figures (4.59) and (4.60) show the ACF and PACF plots for the monthly baseflow for Zarqa River station, respectively. The observation from these Figures gives indication that the differencing of the data record must be taken before plotting the ACF and PACF. Figures (4.61) and (4.62) show the ACF and PACF plots for the differenced monthly baseflow for the Zarqa River station, respectively. It can be seen from the ACF and PACF plots that MA (5) and AR (3) with a differencing value of 1, results in an ARIMA (3,1,5) model. The S-PLUS 2000 software was then used to determine the minimum AIC, which gives the best model. As shown in Table (4.9), the best ARIMA model for the monthly baseflow for Zarqa River station is ARIMA (3,1,1). Figures

(4.63) and (4.64) show the ACF and PACF of residuals for monthly baseflow for Zarqa River station.

2. Estimating the parameters. After choosing the most appropriate model, the AR and MA parameters were estimated as indicated in Tables (4.7), (4.8) and (4.9) for extended precipitation record for Amman-Airport station, mean monthly maximum temperature record for Amman-Airport station and monthly baseflow record for Zarqa River station.

3. Diagnostic checking. Residuals from the fitted model were examined against adequacy, as shown in Figures (4.51), (4.52), (4.57), (4.58), (4.63) and (4.64). These figures give indications that the estimated ARIMA models are accurate if the significant spikes out of confidence intervals are less than 5% of the total spikes in ACF and PACF plots. Afterwards, checking the best model for the same station is conducted using backward forecasting for 10% of the recorded data. Checking these estimated data with the observed data is carriedout using three measures of accuracy from Equations (4.6), (4.7) and (4.8) which is listed in Tables (4.10), (4.11) and (4.12) for extended precipitation record for Amman-Airport station, mean monthly maximum temperature for Amman-Airport station and monthly baseflow for Zarqa River station. Figures (4.65), (4.66) and (4.67) present 10% backward forecasting data, which indicates acceptable accuracy. The ARIMA modeling method is the best one compared to the other methods of time series analysis, depending on the three measures of accuracy, as indicated in Tables (4.4), (4.5) and (4.6). Therefore, the best ARIMA models are used to forward forecasting 10% of the recorded data for precipitation and temperature for Amman-Airport station and of baseflow record for Zarqa River station as indicated in Tables (4.13), (4.14) and (4.15) and shown in Figures (4.68), (4.69) and (4.70).

According to the forward forecasting for Amman-Airport station, the odd years between 2003 and 2015 would be draught years as indicated in Table (4.13).

4.2.4 Cyclic trends in the data

The spectral density function has no frequency for extended precipitation record for Amman-Airport station, as shown in Figure (4.71). This indicates that the precipitation of water-year record for Amman-Airport station cannot indicate cyclic trends in the data depending on the sample size and the frequency of precipitation.

Figure (4.72) shows the spectral density function for mean monthly maximum temperature for Amman-Airport station. It can be observed that the spectral density function has the maximum frequency at $\omega = \lambda = 0.167\pi$, which gives indication that mean monthly maximum temperature for Amman-Airport station has seasonality in the data equal to $\frac{2\pi}{\lambda} = \frac{2\pi}{0.167\pi} = 12 \, months.$

Figure (4.73) shows the spectral density function for the monthly baseflow for Zarqa River station. It can be observed that the spectral density function has low frequency. It was observed from Figures (4.8), (4.9), (4.10) and (4.39) through (4.43) that the monthly baseflow for Zarqa River has cyclic trends in the data.

Table (4.1): Monthly Precipitation Record (mm/month) for Amman-Airport Station

Water-Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Total
22/23	4.4	16.5	58.3	45.3	94.9	18.6	16.5	1.7	0.0	0.0	0.0	0.0	256.2
23/24	26.0	5.4	56.2	43.1	157.6	38.2	0.1	5.0	0.0	0.0	0.0	0.0	331.6
24/25	12.9	68.0	36.9	9.5	14.3	16.1	52.7	0.6	0.6	0.0	0.0	0.0	211.6
25/26	0.2	47.0	35.2	67.4	73.8	46.8	10.4	0.7	0.0	0.0	0.0	0.0	281.5
26/27	0.7	12.0	70.8	47.0	190.8	5.4	36.9	2.1	0.0	0.0	0.0	0.0	365.7
27/28	8.1	22.2	10.9	46.4	109.3	6.0	0.0	0.0	0.0	0.0	0.0	0.0	202.9
28/29	0.0	26.8	48.8	70.3	84.7	15.7	38.0	0.0	0.0	0.0	0.0	0.0	284.3
29/30	0.0	47.3	41.4	86.9	47.6	6.4	26.5	1.0	0.0	0.0	0.0	0.0	257.1
30/31	0.0	17.7	50.6	97.4	50.3	24.9	8.4	0.5	0.0	0.0	0.0	0.0	249.8
31/32	1.9	14.2	91.7	45.4	58.5	7.0	10.4	0.0	0.0	0.0	0.0	0.0	229.1
32/33	9.7	4.5	0.6	53.3	25.2	31.4	13.1	0.0	0.0	0.0	0.0	0.2	138.0
33/34	0.1	7.2	5.1	97.3	45.3	4.1	7.4	1.4	0.0	0.0	0.0	0.0	167.9
34/35	1.5	0.1	87.0	76.9	142.3	17.3	14.8	4.5	0.0	0.0	0.0	0.0	344.4
35/36	14.9	14.0	4.9	13.4	103.1	24.8	11.2	0.9	0.0	0.0	0.0	0.0	187.2
36/37	0.1	68.5	87.3	117.0	16.1	0.0	54.8	3.8	0.0	0.0	0.0	0.0	347.6
37/38	4.6	14.0	1.1	97.0	132.8	66.4	1.3	24.1	0.0	0.0	0.0	0.0	341.3
38/39	0.2	126.5	28.2	24.8	79.4	84.8	4.3	0.0	0.0	0.0	0.0	0.0	348.2
39/40	3.3	71.8	20.4	124.1	5.2	30.0	31.4	0.0	0.0	0.0	0.0	0.0	286.2
40/41	8.4	52.8	59.0	61.6	22.4	24.0	6.2	0.0	0.0	0.0	0.0	0.0	234.4
41/42	2.2	3.5	155.1	56.9	86.6	96.9	0.3	0.0	0.0	0.0	0.0	0.0	401.5
42/43	54.6	27.8	18.6	105.4	50.5	97.6	34.5	2.3	0.0	0.0	0.0	15.4	406.7
43/44	4.5	0.1	18.2	141.7	12.5	19.4	11.7	13.0	0.0	0.0	0.0	0.0	221.1
44/45	0.0	136.8	94.0	100.2	94.5	20.8	4.9	19.6	0.0	0.0	0.0	0.0	470.8
45/46	0.0	33.7	60.4	15.3	120.3	26.1	0.9	30.6	0.0	0.0	0.0	0.0	287.3
46/47	0.3	3.5	31.3	63.1	8.2	21.0	8.6	1.4	0.0	0.0	0.0	0.0	137.4
47/48	0.0	22.2	21.0	92.9	69.1	76.1	12.8	1.3	0.0	0.0	0.0	0.0	295.4
48/49	2.1	12.4	44.3	76.4	123.6	116.0	52.5	2.0	0.0	0.0	0.0	0.0	429.3
49/50	0.0	0.0	92.3	74.1	77.3	31.5	11.5	15.4	0.0	0.0	0.0	0.0	302.1
50/51	7.5	16.7	8.2	28.1	60.3	15.4	0.3	0.0	0.0	0.0	0.0	0.0	136.5
51/52	0.9	19.9	179.8	35.6	79.7	46.9	0.4	0.0	0.0	0.0	0.0	0.0	363.2
52/53	8.5	3.9	12.3	29.3	81.3	168.7	1.8	0.0	0.0	0.0	0.0	0.0	305.8
53/54	1.5	91.3	60.5	17.7	90.3	12.8	16.2	0.0	0.0	0.0	0.0	0.0	290.3
54/55	3.2	37.1	62.5	13.7	15.8	17.4	4.6	0.7	0.0	0.0	0.0	0.0	155.0
55/56	0.4	91.0	62.0	66.2	16.2	68.2	24.4	2.4	0.0	0.0	0.0	0.0	330.8
56/57	1.0	2.4	37.1	101.1	119.1	96.0	8.0	21.0	0.0	0.0	0.0	0.0	385.7
57/58	0.0	21.4	64.0	107.0	15.5	2.7	8.9	0.0	0.0	0.0	0.0	0.0	219.5
58/59	1.0	0.0	0.4	67.3	99.1	34.1	3.1	0.8	0.0	0.0	0.0	6.7	212.5
59/60	0.0	6.2	11.5	30.7	8.0	42.5	5.3	0.2	0.0	0.0	0.0	0.0	104.4
60/61	0.0	41.1	17.6	86.9	80.2	10.5	8.4	4.3	0.0	0.0	0.0	0.0	249.0
61/62	1.8	14.7	149.6	31.8	63.8	0.5	4.2	0.0	0.0	0.0	0.0	0.0	266.4
62/63	4.8	0.0	20.3	6.9	59.0	30.2	13.2	23.3	0.0	0.0	0.0	0.0	157.7
63/64	20.1	24.1	107.7	67.5	76.5	38.1	4.2	1.1	0.0	0.0	0.0	0.0	339.3
64/65	0.0	39.3	30.4	98.5	34.1	25.0	44.8	0.0	0.0	0.0	0.0	0.0	272.1
65/66	12.9	18.6	34.6	21.5	20.4	110.8	0.1	0.0	0.0	0.0	0.0	0.0	218.9
66/67	16.9	31.2	121.8	106.3	26.1	156.2	0.0	0.3	0.0	0.0	0.0	0.0	458.8
67/68	11.1	37.4	42.7	124.3	25.4	11.3	7.0	5.2	0.0	0.0	0.0	0.0	264.4
68/69	1.6	13.6	55.8	73.6	17.4	144.3	16.9	1.6	0.0	0.0	0.0	0.0	324.8
69/70	18.2	13.1	10.5	45.5	24.8	58.0	10.5	0.0	0.0	0.0	0.0	0.0	180.6
70/71	1.5	5.2	37.4	18.4	35.7	52.5	151.3	0.0	0.0	0.0	0.0	0.0	302.0
71/72	0.0	13.8	122.3	31.5	54.5	39.4	43.7	6.6	0.0	0.0	0.0	0.0	311.8
72/73	0.0	31.1	6.2	105.9	19.8	29.4	1.2	0.0	0.0	0.0	0.0	0.0	193.6
73/74	0.4	50.5	31.7	235.2	100.3	11.5	21.4	0.0	0.0	0.0	0.0	0.0	451.0
74/75	0.0	35.9	24.7	17.5	125.7	33.2	5.1	0.0	0.0	0.0	0.0	0.0	242.1
75/76	0.4	21.3	23.7	29.2	42.9	68.6	10.8	6.8	1.1	0.0	0.0	0.0	204.8
76/77	1.2	10.5	1.0	43.4	24.6	52.5	57.6	2.0	0.0	0.0	0.0	0.0	192.8

Table (4.1): Continue

Water-Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Total
77/78	28.2	6.4	73.3	40.4	27.5	67.1	5.5	0.0	0.6	0.0	0.0	0.0	249.0
78/79	1.9	1.4	42.7	42.0	10.7	35.3	3.3	0.6	0.0	0.0	0.0	0.0	137.9
79/80	35.0	133.2	87.4	77.3	76.4	77.8	16.2	0.2	0.0	0.0	0.0	0.0	503.5
80/81	2.0	7.3	173.0	48.2	37.0	20.5	11.1	0.0	0.0	0.0	0.0	0.1	299.2
81/82	0.0	24.5	0.8	57.9	56.3	43.3	12.6	19.8	0.0	0.0	0.0	1.3	216.5
82/83	10.2	33.7	18.6	118.6	129.4	98.5	3.1	1.2	0.0	0.0	0.0	0.0	413.3
83/84	0.0	25.6	3.7	62.0	25.8	79.8	6.4	0.0	0.0	0.0	0.0	0.0	203.3
84/85	6.9	15.3	30.5	24.4	150.8	42.3	2.4	2.1	0.0	0.0	0.0	0.0	274.7
85/86	9.8	4.1	27.4	26.5	58.6	6.2	2.6	8.1	0.0	0.0	0.0	0.0	143.3
86/87	26.5	105.9	32.2	46.4	16.4	38.8	0.0	0.0	0.0	0.0	0.0	0.0	266.2
87/88	33.2	4.8	72.2	50.4	126.3	63.2	13.1	0.0	0.0	0.2	0.0	0.0	363.4
88/89	8.0	14.8	121.2	44.1	26.0	31.8	0.0	0.0	0.0	0.0	0.0	0.0	245.9
89/90	0.1	10.2	13.9	73.9	55.7	65.9	21.3	0.7	0.0	0.0	0.0	0.0	241.7
90/91	1.6	3.7	2.5	90.9	47.2	43.5	6.2	2.1	0.0	0.0	0.0	0.0	197.7
91/92	4.7	35.0	171.6	112.1	199.8	16.4	0.9	6.0	1.2	0.0	0.0	0.0	547.7
92/93	0.0	41.6	72.3	67.6	49.5	18.3	0.0	11.6	0.0	0.0	0.0	0.0	260.9
93/94	24.1	22.1	16.9	75.7	21.0	37.6	0.7	0.8	0.0	0.0	0.0	1.5	200.4
94/95	12.6	97.8	99.5	1.7	36.2	27.3	4.2	0.1	0.0	0.0	0.0	0.0	279.4
95/96	0.0	17.4	11.1	85.4	15.0	64.5	9.8	0.0	0.0	0.0	0.0	0.0	203.2
96/97	9.3	22.2	28.2	66.1	82.4	54.8	3.6	0.8	0.0	0.0	0.0	0.2	267.6
97/98	16.5	10.7	59.4	60.8	34.0	75.0	1.9	0.3	0.0	0.0	0.0	0.0	258.6
98/99	6.7	29.0	50.3	63.6	62.9	44.2	14.2	3.5	0.0	0.0	0.0	0.0	274.3
99/00	6.7	0.5	3.3	117.4	20.8	30.1	14.1	0.0	0.0	0.0	0.0	0.0	193.0
00/01	10.9	2.2	51.8	40.7	37.0	9.6	11.0	13.3	0.0	0.0	0.0	0.0	176.5
01/02	9.5	28.3	49.7	109.8	29.3	38.4	21.2	0.5	0.0	0.0	0.0	0.0	286.7
Average	6.8	28.3	49.7	64.9	61.8	43.5	14.3	3.5	0.0	0.0	0.0	0.3	273.2
Maximum	54.6	136.8	179.8	235.2	199.8	168.7	151.3	30.6	1.2	0.2	0.0	15.4	547.7
Minimum	0.0	0.0	0.4	1.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	104.4
Median	2.0	18.2	37.3	62.6	52.5	33.7	8.5	0.7	0.0	0.0	0.0	0.0	265.3
St. Dev.	9.9	31.2	43.6	38.5	44.7	35.7	20.9	6.5	0.2	0.0	0.0	1.9	90.8
Cv.	1.47	1.10	0.88	0.59	0.72	0.82	1.47	1.87	-	-	-	5.91	0.33
Skew	2.36	1.93	1.26	1.14	0.98	1.44	4.06	2.45	4.84	-	-	7.26	0.71

Table (4.2): Mean Monthly Maximum Temperature Record (C^o) for Amman-Airport Station

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1923	12.7	12.7	17.5	20.8	28.1	32.4	31.0	30.6	33.1	26.2	22.1	15.6	23.6
1924	12.0	13.3	18.0	23.3	26.0	30.5	32.0	31.9	30.8	25.2	19.2	13.6	23.0
1925	9.7	13.8	21.8	20.7	28.3	29.3	32.1	32.7	32.4	27.2	20.8	16.2	23.8
1926	11.7	12.9	15.4	23.5	28.4	31.8	30.5	30.2	28.8	27.4	20.4	15.1	23.0
1927	13.0	9.8	19.2	20.8	30.0	30.7	32.4	32.1	31.7	29.1	21.3	15.2	23.8
1928	13.2	12.1	16.9	26.6	30.0	31.7	33.2	33.7	31.4	27.1	21.1	14.9	24.3
1929	12.1	11.9	16.3	22.9	30.2	30.7	30.8	33.3	31.8	26.1	22.3	13.1	23.5
1930	11.7	13.6	19.6	23.5	27.8	30.9	31.7	34.6	31.6	27.5	21.0	16.7	24.2
1931	13.3	13.9	18.9	22.6	28.1	30.1	32.5	32.7	32.5	28.8	19.3	13.2	23.8
1932	11.1	14.4	19.5	23.1	27.4	32.3	32.6	34.1	31.5	29.8	20.9	13.3	24.2
1933	11.6	15.7	17.4	19.5	26.9	30.7	30.4	31.6	29.1	25.4	24.8	15.4	23.2
1934	11.0	11.8	20.6	24.3	27.7	31.4	32.1	32.5	30.2	27.7	22.6	13.9	23.8
1935	13.4	13.8	19.9	22.7	31.5	33.3	32.2	34.3	31.0	27.9	18.5	16.1	24.6
1936	14.7	15.3	19.5	23.9	26.8	29.2	31.7	33.4	28.9	30.4	22.6	11.6	24.0
1937	9.7	15.5	21.9	24.7	26.9	30.3	31.4	31.8	32.6	27.8	21.4	17.5	24.3
1938	12.4	12.1	13.7	23.5	26.0	30.4	33.2	33.8	30.4	27.9	18.3	15.4	23.1
1939	13.7	12.7	15.3	23.3	31.7	29.9	31.6	30.9	30.9	29.1	18.6	15.6	23.6
1940	12.1	14.8	16.7	22.6	27.5	31.3	31.9	31.2	30.2	27.6	19.6	14.9	23.4
1941	15.1	18.2	16.1	23.1	33.7	30.8	31.8	32.3	29.3	25.2	22.3	12.0	24.2
1942	10.8	14.7	17.3	23.9	28.8	32.9	31.2	31.8	29.0	25.2	20.1	14.2	23.3
1943	11.2	11.2	13.2	18.4	25.9	29.6	31.1	32.4	31.5	28.7	23.8	17.3	22.9
1944	11.4	14.6	19.7	23.9	25.0	31.4	30.7	31.1	31.7	27.8	17.8	13.2	23.2
1945	11.3	10.6	13.3	19.7	29.2	29.7	33.2	33.6	31.2	25.0	20.8	14.0	22.6
1946	11.9	11.9	15.6	22.6	24.2	29.6	31.8	31.5	31.1	26.3	24.3	15.6	23.0
1947	12.8	16.6	20.8	24.4	28.7	30.3	32.2	32.5	29.4	26.7	20.6	16.6	24.3
1948	14.2	12.8	12.4	20.1	26.7	29.5	32.9	32.3	30.3	26.5	20.1	12.1	22.5
1949	10.4	9.7	14.2	17.1	27.9	31.3	31.1	31.3	28.0	27.2	23.7	13.9	22.2
1950	9.5	11.4	16.8	26.2	26.1	29.7	31.2	32.0	30.5	26.1	22.4	17.5	23.3
1951	14.4	14.9	20.3	23.7	28.6	30.1	32.5	33.1	31.1	25.5	20.8	11.1	23.8
1952	13.2	14.3	15.8	22.3	27.5	30.3	30.9	33.2	34.6	29.2	19.9	17.3	24.0
1953	13.4	14.7	12.8	21.8	27.7	30.4	33.1	32.1	30.5	27.9	17.2	11.1	22.7
1954	11.8	13.8	20.1	20.3	29.7	31.2	33.9	34.3	30.1	28.3	20.4	14.0	24.0
1955	15.4	18.2	18.8	23.1	27.6	33.3	31.9	31.6	30.8	29.8	19.4	14.0	24.5
1956	13.3	15.7	14.7	21.6	26.1	31.6	33.1	35.2	30.4	26.5	21.2	13.5	23.6
1957	11.0	13.7	16.4	21.6	26.6	30.4	33.1	35.2	31.3	28.7	20.4	14.6	23.6
1958	12.9	16.0	20.7	26.0	27.5	30.4	32.2	34.0	30.0	26.4	20.8	17.9	24.6
1959	14.3	8.8	16.0	24.6	28.6	31.6	30.3	31.5	28.8	25.9	20.9	16.1	23.1
1960	14.6	17.9	18.4	23.1	31.0	30.7	32.8	33.5	31.5	29.7	21.2	17.9	25.2
1961	12.3	12.0	15.9	23.9	28.8	32.4	32.9	33.3	28.7	27.5	19.6	14.2	23.5
1962	13.5	13.3	21.3	22.0	28.9	33.2	33.2	34.2	33.5	29.3	25.3	16.1	25.3
1963	17.2	16.9	16.9	23.7	26.0	32.5	32.6	34.4	32.9	29.8	22.5	14.2	25.0
1964	9.9	13.2	18.8	21.6	26.4	30.8	32.5	32.6	30.7	29.9	20.8	14.7	23.5
1965	11.8	15.1	20.3	21.3	27.9	33.7	33.3	34.9	32.6	25.3	20.6	15.7	24.4
1966	15.4	16.6	19.3	25.3	28.9	33.7	33.6	35.1	31.0	27.7	23.7	15.2	25.5
1967	11.9	12.6	14.6	21.7	26.9	30.5	32.0	31.3	28.9	25.8	18.0	14.3	22.4
1968	10.3	13.5	16.0	23.0	28.1	30.4	33.6	31.1	29.3	25.2	20.2	14.0	22.9
1969	10.4	15.4	18.7	19.7	27.8	31.5	30.4	32.5	31.7	26.4	20.3	16.2	23.4
1970	14.2	16.2	18.7	24.9	27.6	30.3	30.7	31.1	29.2	25.3	20.5	12.5	23.4
1971	15.2	13.8	18.2	18.7	27.6	29.2	30.5	30.9	31.4	25.7	18.9	11.2	22.6
1972	11.5	12.0	16.4	23.6	25.9	29.3	30.1	31.6	31.2	28.6	19.6	12.1	22.7

Table (4.2): Continue

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1973	12.2	17.0	16.9	21.9	27.4	29.5	32.3	32.3	31.0	28.5	16.8	14.3	23.3
1974	8.9	13.1	17.7	21.4	27.1	30.9	31.7	30.8	29.2	28.9	20.9	12.9	22.8
1975	12.4	12.6	17.8	24.6	26.3	29.5	31.7	30.6	29.7	26.0	20.1	12.6	22.8
1976	12.4	11.8	16.7	21.2	27.0	30.2	30.2	29.9	29.4	27.5	21.4	16.5	22.9
1977	11.3	18.5	17.0	20.8	28.0	30.5	32.5	34.0	29.9	23.7	20.8	12.6	23.3
1978	13.1	15.9	18.0	23.0	29.7	30.5	34.5	30.6	29.4	28.6	17.6	14.7	23.8
1979	13.7	17.0	18.7	24.8	26.6	31.1	31.3	31.9	31.7	26.8	21.5	11.5	23.9
1980	10.3	11.5	16.2	21.5	28.7	31.5	32.1	31.5	28.9	26.2	21.2	14.2	22.8
1981	10.8	12.2	17.6	21.8	25.5	30.1	31.6	31.8	31.8	28.3	17.3	16.4	22.9
1982	13.4	11.2	14.5	23.8	24.8	29.6	29.9	30.8	29.5	25.4	15.7	12.0	21.7
1983	8.7	10.6	15.2	20.0	26.2	29.7	30.9	30.6	29.7	24.6	21.1	15.4	21.9
1984	12.7	16.1	17.6	20.6	28.2	29.5	30.9	29.4	31.3	27.0	18.4	12.4	22.8
1985	15.0	11.8	17.8	21.6	27.6	30.4	31.1	35.0	30.5	24.0	22.0	14.5	23.4
1986	13.2	15.3	19.0	24.8	24.0	29.6	32.1	32.0	32.2	25.8	15.6	12.6	23.0
1987	13.6	16.3	13.8	21.2	28.7	30.4	32.9	32.9	30.9	24.0	21.0	13.4	23.3
1988	11.6	12.7	15.5	22.6	29.0	30.6	33.0	31.7	31.0	24.6	17.3	13.7	22.8
1989	9.6	12.8	16.9	27.4	28.6	29.9	31.9	31.8	30.3	25.3	20.1	14.7	23.3
1990	10.5	11.6	16.5	21.6	26.9	30.3	31.2	31.3	29.7	27.4	22.5	17.2	23.1
1991	12.0	13.8	18.5	24.1	26.5	30.6	30.4	30.5	30.4	26.7	21.0	10.5	22.9
1992	8.1	8.1	14.0	21.1	25.7	29.5	30.6	32.3	29.5	28.7	18.8	10.6	21.4
1993	11.3	11.2	16.6	23.2	25.6	31.4	31.7	33.1	30.8	28.0	18.6	17.3	23.2
1994	13.8	13.4	17.2	26.0	29.1	30.3	30.5	32.4	32.1	28.7	16.6	10.9	23.4
1995	13.5	14.3	18.0	22.0	29.0	31.9	31.2	32.3	31.0	26.1	18.1	14.1	23.5
1996	12.7	15.5	15.6	21.8	30.1	31.0	33.6	33.1	31.1	24.9	20.2	16.0	23.8
1997	13.9	11.4	13.8	20.4	29.1	30.6	31.8	29.7	29.5	27.2	20.4	14.9	22.7
1998	11.6	14.2	15.4	24.3	28.3	31.3	33.4	35.2	31.6	28.3	23.9	16.3	24.5
1999	14.6	15.8	18.7	23.3	30.3	29.9	31.9	33.9	31.1	26.8	21.4	17.1	24.6
2000	11.3	13.2	16.3	24.3	27.5	31.5	36.3	32.5	30.4	24.7	20.5	18.6	23.9
2001	16.2	16.9	22.6	24.6	27.7	32	33.1	32.9	30.2	25.6	20.1	14.4	24.7
2002	10.7	16.2	19.3	22.3	26.4	30.4	32.3	32	30.8	28.8	20.8	13.4	23.6
Average	12.4	13.8	17.3	22.6	27.8	30.8	32.0	32.4	30.7	27.1	20.4	14.5	23.5
Maximum	17.2	18.5	22.6	27.4	33.7	33.7	36.3	35.2	34.6	30.4	25.3	18.6	25.5
Minimum	8.1	8.1	12.4	17.1	24.0	29.2	29.9	29.4	28.0	23.7	15.6	10.5	21.4
Median	12.3	13.8	17.3	22.8	27.7	30.5	31.9	32.3	30.8	27.2	20.6	14.4	23.4
St. Dev.	1.8	2.2	2.3	1.9	1.7	1.1	1.1	1.4	1.2	1.6	2.0	1.9	0.8
Cv.	0.15	0.16	0.13	0.1	0.06	0.04	0.04	0.04	0.04	0.06	0.10	0.13	0.03
Skew	0.10	-0.03	0.02	-0.17	0.54	0.88	0.65	0.24	0.35	0.02	-0.10	-0.07	0.17

Table (4.3): Monthly Baseflow Record (m³/s) for Zarqa River Station

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1970	4.18	3.81	4.40	3.66	3.22	2.96	2.61	4.11	4.33	2.66	2.81	3.48
1971	3.65	2.79	2.63	2.80	1.17	0.77	0.69	0.60	0.85	1.74	2.22	3.35
1972	3.62	4.01	3.31	2.18	1.08	0.64	0.78	1.13	1.09	1.11	1.64	1.58
1973	1.99	1.87	2.00	1.29	1.36	1.42	1.31	1.14	0.95	1.01	1.83	1.98
1974	2.39	2.76	7.90	7.56	4.22	2.52	2.88	1.63	1.60	1.23	2.28	3.57
1975	3.07	3.59	3.59	2.02	1.12	0.73	0.64	0.68	0.73	0.72	1.63	2.70
1976	3.12	3.14	4.00	1.54	1.44	1.13	1.11	1.00	0.87	1.12	1.42	1.84
1977	2.90	2.42	2.73	1.60	1.14	0.43	0.34	0.48	0.66	1.53	1.14	2.96
1978	2.95	2.20	2.93	1.63	0.88	0.19	0.32	0.33	0.39	0.64	0.92	2.22
1979	1.86	1.28	1.35	0.68	0.28	0.33	0.38	0.38	0.40	2.44	2.40	3.12
1980	3.70	5.05	13.85	3.32	2.48	2.33	2.29	2.12	7.79	1.43	1.81	5.23
1981	4.70	4.97	4.58	2.82	2.38	1.69	1.87	2.19	1.87	2.13	2.51	2.51
1982	3.02	4.68	4.52	4.05	3.02	1.78	1.65	1.70	1.50	1.78	2.41	3.18
1983	4.97	4.57	8.11	5.84	4.73	5.03	4.02	5.02	4.64	3.36	3.72	3.52
1984	3.83	3.01	2.70	3.41	3.41	2.49	1.97	2.34	2.35	2.61	3.85	3.70
1985	3.19	5.31	6.44	4.98	2.96	1.30	1.11	1.06	1.75	2.17	2.55	3.32
1986	4.39	4.14	3.63	2.79	2.72	2.18	2.39	2.12	2.48	1.80	3.65	4.25
1987	4.25	4.06	3.51	1.77	2.03	1.97	2.07	1.91	2.00	3.99	3.41	4.76
1988	6.42	9.27	9.54	5.07	4.43	3.23	3.01	3.30	4.01	3.81	3.92	5.49
1989	6.06	4.37	4.73	4.20	3.81	3.33	3.13	3.38	3.53	3.95	4.72	5.20
1990	5.72	5.99	4.72	3.67	3.44	3.03	3.13	3.13	2.90	2.80	2.99	3.52
1991	3.86	4.71	4.22	3.52	3.86	3.33	3.25	3.17	3.01	3.19	4.25	7.31
1992	10.73	9.95	18.12	15.37	11.89	8.99	7.35	5.97	5.60	5.45	5.66	6.40
1993	7.53	9.88	10.37	9.14	8.19	7.17	6.70	6.41	6.05	6.65	7.73	8.44
1994	8.51	8.00	9.15	6.78	5.76	4.90	4.85	4.47	4.74	5.06	5.53	5.43
1995	6.91	6.78	6.73	5.87	5.37	5.16	5.40	5.10	4.71	5.38	6.38	6.64
1996	6.61	6.09	6.69	4.91	6.00	4.96	4.43	4.67	4.87	4.47	5.07	6.78
1997	7.65	7.03	8.68	6.26	5.19	4.03	3.83	4.67	5.00	3.57	**4.16**	5.57
1998	6.62	5.97	6.70	5.30	4.43	3.99	4.27	4.16	4.14	4.64	4.66	5.73
1999	6.27	5.11	4.91	4.48	4.48	4.44	4.56	4.92	5.18	6.10	6.89	8.10
2000	7.90	5.75	5.06	4.07	4.18	3.95	4.36	4.07	3.64	4.22	4.31	5.58
2001	5.25	6.17	5.15	4.10	4.09	3.75	3.99	3.85	3.44	3.57	4.10	6.14
2002	8.25	5.79	5.33	5.43	3.66	3.47	3.35	3.77	3.87	4.27	4.82	6.30
Average	5.0	5.0	5.8	4.3	3.6	3.0	2.8	2.9	3.1	3.0	3.6	4.5
Maximum	10.7	10.0	18.1	15.4	11.9	9.0	7.4	6.4	7.8	6.7	7.7	8.4
Minimum	1.9	1.3	1.4	0.7	0.3	0.2	0.3	0.3	0.4	0.6	0.9	1.6
Median	4.4	4.7	4.7	4.1	3.4	3.0	2.9	3.1	3.0	2.8	3.7	4.3
St. Dev.	2.2	2.2	3.5	2.8	2.3	2.0	1.8	1.8	1.9	1.6	1.7	1.9
Cv.	0.43	0.44	0.60	0.64	0.64	0.68	0.64	0.61	0.62	0.54	0.48	0.41
Skew	0.65	0.66	1.76	2.11	1.53	0.95	0.54	0.18	0.36	0.38	0.55	0.31

Table (4.4): Comparison of Three Measures of Accuracy for Different Time Series Analysis Methods for Water-Year Record for Amman-Airport Station.

Method	MAPE	MAD	MSD
Linear Trend Analysis	29.03	69.25	8140.67
Quadratic Trend Analysis	29.17	69.25	8097.82
Exponential Growth Analysis	27.57	69.44	8349.98
Decomposition (Seasonal)	29.27	69.88	8194.35
Decomposition (Tend + Seasonal)	28.98	69.04	8168.00
Moving Average-MA (1)	43.40	111.60	18981.10
Moving Average-MA (2)	39.30	97.30	14187.80
Moving Average-MA (3)	39.20	98.10	14095.20
Moving Average-MA (4)	33.70	81.50	10733.00
Moving Average-MA (5)	32.80	79.10	10165.70
Single Exponential and Smoothing	35.70	88.00	11892.30
Best Model of ARIMA	21.20	55.79	7413.76

Table (4.5): Comparison of Three Measures of Accuracy for Different Time Series Analysis Methods for Mean Monthly Maximum Temperature Record for Amman-Airport Station.

Method	MAPE	MAD	MSD
Linear Trend Analysis	35.51	6.73	56.00
Quadratic Trend Analysis	35.51	6.73	56.00
Exponential Growth Analysis	34.05	6.86	57.84
Decomposition (Seasonal)	7.1	1.45	4.75
Decomposition (Tend + Seasonal)	7.06	1.47	4.73
Moving Average-MA (1)	18.00	3.58	19.77
Moving Average-MA (2)	32.47	6.34	54.74
Moving Average-MA (3)	32.15	6.28	53.31
Moving Average-MA (4)	43.18	8.35	90.79
Moving Average-MA (5)	41.92	8.11	85.32
Single Exponential and Smoothing	28.14	5.49	40.95
Best Model of ARIMA	7.03	1.47	4.71

Table (4.6): Comparison of Three Measures of Accuracy for Different Time Series Analysis Methods for Monthly Baseflow Record for Zarqa River Station.

Method	MAPE	MAD	MSD
Linear Trend Analysis	67.78	1.40	3.91
Quadratic Trend Analysis	68.24	1.40	3.89
Exponential Growth Analysis	55.10	1.41	4.33
Decomposition (Seasonal)	85.70	1.66	4.69
Decomposition (Tend + Seasonal)	49.49	1.16	2.95
Moving Average-MA (1)	25.27	0.84	1.99
Moving Average-MA (2)	39.71	1.16	2.74
Moving Average-MA (3)	39.33	1.13	2.63
Moving Average-MA (4)	52.09	1.38	3.57
Moving Average-MA (5)	50.86	1.33	3.35
Single Exponential and Smoothing	34.88	1.01	2.19
Best Model of ARIMA	30.18	1.32	2.12

Table (4.7): Limiting of Best ARIMA Model and Parameters Estimating for Extended Precipitation Record for Amman-Airport Station

Model No.	Model (p,d,q)	AIC
1	3,0,3	1654.39
2	3,0,2	1651.80
3	3,0,1	1656.33
4	3,0,0	1674.75
5	2,0,3	1662.73
6	2,0,2	1661.81
7	2,0,1	1666.18
8	2,0,0	1710.83
9	1,0,3	1678.70
10	1,0,2	1677.16
11	1,0,1	1675.47
12	1,0,0	1755.92
13	0,0,3	1843.98
14	0,0,2	1883.30
15	0,0,1	1925.47

Best Model: (3,0,2)	
(ϕ) AR Parameter	**(θ) MA Parameter**
0.00508	-0.11529
0.85072	0.87036
0.14049	

Table (4.8): Limiting of Best ARIMA Model and Parameters Estimating for Mean Monthly Maximum Temperature Record for Amman-Airport Station

Model No.	Model (p,d,q)	AIC
1	2,1,4	4354.37
2	2,1,3	4899.46
3	2,1,2	4354.79
4	2,1,1	5179.24
5	2,1,0	5181.33
6	1,1,4	4981.54
7	1,1,3	5135.19
8	1,1,2	5149.33
9	1,1,1	5187.68
10	1,1,0	5185.85
11	0,1,4	5128.18
12	0,1,3	5148.75
13	0,1,2	5184.97
14	0,1,1	5298.04

Best Model: (2,1,2)	
(ϕ) AR Parameter	**(θ) MA Parameter**
1.688	1.68089
-0.95688	-0.74295

Table (4.9): Limiting of Best ARIMA Model and Parameters Estimating for Monthly Baseflow Record for Zarqa River Station

Model No.	Model (p,d,q)	AIC
1	3,1,5	1339.88
2	3,1,4	1342.49
3	3,1,3	1342.57
4	3,1,2	1346.21
5	3,1,1	1338.92
6	3,1,0	1382.40
7	2,1,5	1341.22
8	2,1,4	1343.76
9	2,1,3	1348.82
10	2,1,2	1347.77
11	2,1,1	1346.77
12	2,1,0	1383.67
13	1,1,5	1341.37
14	1,1,4	1343.86
15	1,1,3	1345.80
16	1,1,2	1348.49
17	1,1,1	1346.63
18	1,1,0	1384.72
19	0,1,5	1342.47
20	0,1,4	1347.49
21	0,1,3	1373.10
22	0,1,2	1388.36
23	0,1,1	1386.88

Best Model: (3,1,1)	
(ϕ) AR Parameter	(θ) MA Parameter
0.69938	0.94903
0.06546	
-0.13171	

Table (4.10): Backward Forecast and Determination of MAPE, MAD and MSD for Extended Precipitation record for Amman-Airport Station

Start Year	End Year	Forecast			Observed
		-5%	0%	+5%	
1987	1988	112.39	292.82	473.26	363.40
1988	1989	65.25	247.08	428.92	245.90
1989	1990	109.17	291.02	472.87	241.70
1990	1991	68.69	255.62	442.55	197.70
1991	1992	99.80	286.73	473.66	547.70
1992	1993	72.27	262.57	452.88	260.90
1993	1994	93.79	284.17	474.54	200.40
1994	1995	75.17	267.83	460.48	279.40
1995	1996	90.02	282.86	475.71	203.20
1996	1997	77.41	271.88	466.35	267.60
1997	1998	87.65	282.40	477.16	258.60
1998	1999	79.11	275.07	471.04	274.30
1999	2000	86.18	282.50	478.81	193.00
2000	2001	80.41	277.67	474.93	176.50
2001	2002	85.31	282.95	480.59	283.70

MAPE	21.21
MAD	55.79
MSD	7413.76

Table (4.11): Backward Forecast and Determination of MAPE, MAD and MSD for Mean Monthly Maximum Temperature Record for Amman-Airport Station

Month	Forecast			Observed
	-5%	0%	+5%	
Dec./1994	10.57	14.21	17.86	10.90
Jan./1995	8.48	12.13	15.77	13.50
Feb./1995	9.84	13.48	17.13	14.30
Mar./1995	13.44	17.08	20.73	18.00
Apr./1995	19.01	22.66	26.30	22.00
May/1995	23.79	27.43	31.08	29.00
Jun./1995	26.93	30.58	34.22	31.90
Jul./1995	28.08	31.72	35.37	31.20
Aug./1995	28.49	32.14	35.78	32.30
Sep./1995	26.84	30.49	34.13	31.00
Oct./1995	23.20	26.85	30.49	26.10
Nov./1995	16.52	20.16	23.81	18.10
Dec./1995	10.59	14.24	17.89	14.10
Jan./1996	8.45	12.10	15.74	12.70
Feb./1996	9.83	13.47	17.12	15.50
Mar./1996	13.41	17.05	20.70	15.60
Apr./1996	18.96	22.61	26.25	21.80
May/1996	23.81	27.45	31.10	30.10
Jun./1996	26.90	30.54	34.19	31.00
Jul./1996	28.07	31.71	35.36	33.60
Aug./1996	28.47	32.12	35.76	33.10
Sep./1996	26.81	30.46	34.11	31.10
Oct./1996	23.19	26.84	30.48	24.90
Nov./1996	16.54	20.19	23.83	20.20
Dec./1996	10.50	14.15	17.80	16.00
Jan./1997	8.41	12.06	15.71	13.90
Feb./1997	9.82	13.47	17.12	11.40
Mar./1997	13.41	17.06	20.71	13.80
Apr./1997	18.89	22.54	26.19	20.40
May/1997	23.75	27.40	31.05	29.10
Jun./1997	26.91	30.56	34.21	30.60
Jul./1997	28.09	31.74	35.39	31.80
Aug./1997	28.46	32.11	35.76	29.70
Sep./1997	26.78	30.43	34.08	29.50
Oct./1997	23.14	26.79	30.44	27.20
Nov./1997	16.60	20.25	23.90	20.40
Dec./1997	10.53	14.18	17.83	14.90
Jan./1998	8.42	12.07	15.72	11.60
Feb./1998	9.82	13.47	17.12	14.20
Mar./1998	13.40	17.05	20.70	15.40
Apr./1998	18.91	22.56	26.21	24.30
May/1998	23.77	27.42	31.07	28.30
Jun./1998	26.89	30.54	34.19	31.30
Jul./1998	28.07	31.72	35.37	33.40
Aug./1998	28.46	32.11	35.76	35.20
Sep./1998	26.78	30.44	34.09	31.60
Oct./1998	23.15	26.80	30.45	28.30
Nov./1998	16.57	20.22	23.87	32.90

MAPE	7.03
MAD	1.47
MSD	4.71

Table (4.11): Continue

Month	Forecast			Observed
	-5%	0%	+5%	
Dec./1998	10.51	14.16	17.81	16.30
Jan./1999	8.41	12.06	15.71	14.60
Feb./1999	9.81	13.46	17.12	15.80
Mar./1999	13.39	17.05	20.70	18.70
Apr./1999	18.89	22.55	26.20	23.30
May/1999	23.75	27.40	31.05	30.30
Jun./1999	26.89	30.54	34.20	29.90
Jul./1999	28.07	31.72	35.38	31.90
Aug./1999	28.45	32.10	35.76	33.90
Sep./1999	26.77	30.43	34.08	31.10
Oct./1999	23.14	26.79	30.44	26.80
Nov./1999	16.58	20.23	23.88	21.40
Dec./1999	10.51	14.17	17.82	17.10
Jan./2000	8.41	12.06	15.71	11.30
Feb./2000	9.80	13.46	17.11	13.20
Mar./2000	13.39	17.04	20.69	16.30
Apr./2000	18.89	22.55	26.20	24.30
May/2000	23.75	27.40	31.06	27.50
Jun./2000	26.88	30.54	34.19	31.50
Jul./2000	28.06	31.72	35.37	36.30
Aug./2000	28.45	32.10	35.75	32.50
Sep./2000	26.77	30.42	34.08	30.40
Oct./2000	23.14	26.79	30.44	24.70
Nov./2000	16.57	20.22	23.87	20.50
Dec./2000	10.50	14.16	17.81	18.60
Jan./2001	8.40	12.05	15.71	16.20
Feb./2001	9.80	13.45	17.11	16.90
Mar./2001	13.38	17.04	20.69	22.60
Apr./2001	18.89	22.54	26.20	24.60
May/2001	23.74	27.40	31.05	27.70
Jun./2001	26.88	30.53	34.19	32.00
Jul./2001	28.06	31.71	35.37	33.10
Aug./2001	28.44	32.10	35.75	32.90
Sep./2001	26.76	30.42	34.07	30.20
Oct./2001	23.13	26.78	30.44	25.60
Nov./2001	16.56	20.22	23.87	20.10
Dec./2001	10.50	14.15	17.81	14.40
Jan./2002	8.39	12.05	15.71	10.70
Feb./2002	9.79	13.45	17.11	16.20
Mar./2002	13.38	17.03	20.69	19.30
Apr./2002	18.88	22.54	26.19	20.70
May/2002	23.74	27.39	31.05	26.40
Jun./2002	26.87	30.53	34.19	30.40
Jul./2002	28.05	31.71	35.37	32.30
Aug./2002	28.44	32.09	35.75	32.00
Sep./2002	26.76	30.41	34.07	30.80
Oct./2002	23.12	26.78	30.44	28.80
Nov./2002	16.56	20.21	23.87	20.80
Dec./2002	10.49	14.15	17.81	13.40

Table (4.12): Backward Forecast and Determination of MAPE, MAD and MSD for Monthly Baseflow Record for Zarqa River Station

Month	Forecast			Observed
	-5%	0%	+5%	
Sep./1999	1.35	4.74	8.14	4.44
Oct./1999	1.27	4.67	8.06	4.56
Nov./1999	1.31	4.70	8.10	4.92
Dec./1999	1.47	4.87	8.26	5.18
Jan./2000	1.95	5.34	8.74	4.22
Feb./2000	2.51	5.91	9.30	4.31
Mar./2000	3.55	6.94	10.34	5.58
Apr./2000	3.47	6.87	10.26	7.9
May/2000	3.21	6.60	10.00	5.75
Jun./2000	3.92	7.32	10.71	5.06
Jul./2000	2.59	5.99	9.38	4.07
Aug./2000	2.04	5.44	8.83	4.18
Sep./2000	1.49	4.96	8.44	3.95
Oct./2000	1.36	4.84	8.32	4.36
Nov./2000	1.41	4.89	8.37	4.07
Dec./2000	1.60	5.08	8.56	3.64
Jan./2001	1.88	5.36	8.84	3.57
Feb./2001	2.42	5.90	9.38	4.1
Mar./2001	3.42	6.90	10.38	6.14
Apr./2001	3.57	7.05	10.53	5.25
May/2001	3.46	6.94	10.42	6.17
Jun./2001	4.30	7.78	11.26	5.15
Jul./2001	2.84	6.32	9.80	4.1
Aug./2001	2.22	5.70	9.18	4.09
Sep./2001	1.62	5.12	8.62	3.75
Oct./2001	1.49	4.99	8.49	3.99
Nov./2001	1.53	5.03	8.53	3.85
Dec./2001	1.73	5.23	8.73	3.44
Jan./2002	1.98	5.47	8.97	4.27
Feb./2002	2.51	6.01	9.51	4.82
Mar./2002	3.50	7.00	10.50	6.3
Apr./2002	3.70	7.20	10.70	8.25
May/2002	3.62	7.12	10.62	5.79
Jun./2002	4.49	7.99	11.49	5.33
Jul./2002	3.01	6.51	10.01	5.43
Aug./2002	2.37	5.87	9.37	3.66
Sep./2002	1.76	5.27	8.78	3.47
Oct./2002	1.62	5.13	8.64	3.35
Nov./2002	1.66	5.17	8.69	3.77
Dec./2002	1.86	5.37	8.88	3.87

MAPE	30.18
MAD	1.32
MSD	2.12

Table (4.13): Forward Forecast for Extended Precipitation Record for Amman-Airport Station

Start Year	End Year	Forecast		
		-5%	0%	+5%
2002	2003	97.19	277.62	458.06
2003	2004	59.63	241.47	423.30
2004	2005	99.04	280.89	462.74
2005	2006	62.18	249.12	436.05
2006	2007	90.76	277.69	464.62
2007	2008	65.69	255.99	446.30
2008	2009	85.54	275.92	466.29
2009	2010	68.65	261.31	453.97
2010	2011	82.41	275.26	468.10
2011	2012	71.04	265.51	459.98
2012	2013	80.58	275.34	470.09
2013	2014	72.94	268.91	464.88
2014	2015	79.58	275.90	472.21
2015	2016	74.47	271.73	468.99
2016	2017	79.12	276.76	474.40

Table (4.14): Forward Forecasting for Mean Monthly Maximum Temperature Record for Amman-Airport Station

Month	Forecast		
	-5%	0%	+5%
Jan./2003	8.64	12.28	15.93
Feb./2003	10.15	13.79	17.43
Mar./2003	13.62	17.26	20.91
Apr./2003	18.90	22.54	26.19
May/2003	23.94	27.58	31.23
Jun./2003	26.99	30.63	34.28
Jul./2003	28.29	31.93	35.58
Aug./2003	28.56	32.20	35.85
Sep./2003	26.82	30.46	34.11
Oct./2003	23.12	26.76	30.41
Nov./2003	16.85	20.49	24.14
Dec./2003	10.66	14.30	17.95
Jan./2004	8.52	12.17	15.81
Feb./2004	10.05	13.70	17.35
Mar./2004	13.47	17.12	20.76
Apr./2004	18.87	22.51	26.16
May/2004	23.92	27.56	31.21
Jun./2004	26.96	30.61	34.26
Jul./2004	28.30	31.95	35.60
Aug./2004	28.54	32.19	35.84
Sep./2004	26.82	30.46	34.11
Oct./2004	23.12	26.76	30.41
Dec./2004	16.87	20.52	24.16
Jan./2005	10.69	14.33	17.98
Feb./2005	8.60	12.25	15.90
Mar./2005	10.02	13.67	17.32
Apr./2005	13.47	17.12	20.77

Table (4.14): Continue

Month	Forecast		
	-5%	0%	+5%
May/2005	18.91	22.56	26.21
Jun./2005	23.94	27.59	31.24
Jul./2005	26.97	30.62	34.27
Aug./2005	28.28	31.93	35.58
Sep./2005	28.54	32.19	35.84
Oct./2005	26.80	30.45	34.10
Nov./2005	23.06	26.71	30.36
Dec./2005	16.84	20.49	24.14
Jan./2006	10.69	14.34	17.99
Feb./2006	8.55	12.20	15.86
Mar./2006	10.03	13.68	17.33
Apr./2006	13.46	17.11	20.76
May/2006	18.89	22.54	26.19
Jun./2006	23.92	27.57	31.22
Jul./2006	26.96	30.61	34.26
Aug./2006	28.28	31.93	35.58
Sep./2006	28.53	32.18	35.84
Oct./2006	26.80	30.45	34.10
Dec./2006	23.08	26.73	30.38
Jan./2007	16.85	20.50	24.15
Feb./2007	10.68	14.33	17.98
Mar./2007	8.57	12.22	15.87
Apr./2007	10.02	13.67	17.32
May/2007	13.46	17.11	20.76
Jun./2007	18.89	22.54	26.20
Jul./2007	23.92	27.58	31.23
Aug./2007	26.95	30.61	34.26
Sep./2007	28.27	31.92	35.58
Oct./2007	28.53	32.18	35.84
Nov./2007	26.79	30.44	34.10
Dec./2007	23.06	26.71	30.37
Jan./2008	16.84	20.49	24.14
Feb./2008	10.67	14.33	17.98
Mar./2008	8.55	12.21	15.86
Apr./2008	10.01	13.67	17.32
May/2008	13.45	17.10	20.76
Jun./2008	18.88	22.53	26.19
Jul./2008	23.92	27.57	31.22
Aug./2008	26.95	30.60	34.25
Sep./2008	28.27	31.92	35.57
Oct./2008	28.52	32.18	35.83
Dec./2008	26.79	30.44	34.09
Jan./2009	23.06	26.71	30.37
Feb./2009	16.83	20.49	24.14
Mar./2009	10.67	14.32	17.97
Apr./2009	8.55	12.21	15.86
May/2009	10.01	13.66	17.32
Jun./2009	13.45	17.10	20.76
Jul./2009	18.88	22.53	26.19
Aug./2009	23.91	27.57	31.22

Table (4.14): Continue

Month	Forecast		
	-5%	0%	+5%
Sep./2009	26.94	30.60	34.25
Oct./2009	28.26	31.92	35.57
Dec./2009	28.52	32.17	35.83
Jan./2010	26.78	30.43	34.09
Feb./2010	23.05	26.71	30.36
Mar./2010	16.83	20.48	24.14
Apr./2010	10.66	14.32	17.97
May/2010	8.54	12.20	15.86
Jun./2010	10.00	13.66	17.31
Jul./2010	13.44	17.10	20.75
Aug./2010	18.87	22.53	26.18
Sep./2010	23.90	27.56	31.22
Oct./2010	26.94	30.59	34.25
Nov./2010	28.26	31.91	35.57
Dec./2010	28.51	32.17	35.82
Jan./2011	26.77	30.43	34.09
Feb./2011	23.05	26.70	30.36
Mar./2011	16.82	20.48	24.13
Apr./2011	10.66	14.31	17.97

Table (4.15): Forward Forecast for Monthly Baseflow Record for Zarqa River Station

Month	Forecast		
	-5%	0%	+5%
Jan./2003	1.76	5.16	8.55
Feb./2003	2.27	5.67	9.07
Mar./2003	3.44	6.84	10.23
Apr./2003	4.12	7.52	10.91
May/2003	3.50	6.90	10.29
Jun./2003	3.92	7.31	10.71
Jul./2003	2.81	6.20	9.60
Aug./2003	1.98	5.37	8.77
Sep./2003	1.47	4.86	8.26
Oct./2003	1.38	4.78	8.17
Nov./2003	1.49	4.89	8.29
Dec./2003	1.61	5.00	8.40
Jan./2004	1.94	5.42	8.90
Feb./2004	2.46	5.94	9.42
Mar./2004	3.57	7.05	10.53
Apr./2004	4.04	7.52	11.00
May/2004	3.72	7.19	10.67
Jun./2004	4.29	7.77	11.25
Jul./2004	3.00	6.47	9.95
Aug./2004	2.29	5.77	9.25
Sep./2004	1.72	5.20	8.68
Oct./2004	1.63	5.11	8.59
Dec./2004	1.71	5.19	8.66
Jan./2005	1.83	5.31	8.79
Feb./2005	2.10	5.60	9.10
Mar./2005	2.62	6.12	9.61
Apr./2005	3.70	7.20	10.70
May/2005	4.15	7.65	11.15
Jun./2005	3.87	7.37	10.87
Jul./2005	4.50	8.00	11.50
Aug./2005	3.16	6.66	10.16
Sep./2005	2.47	5.97	9.47
Oct./2005	1.89	5.39	8.89
Nov./2005	1.80	5.30	8.80
Dec./2005	1.87	5.36	8.86
Jan./2006	2.00	5.50	9.00
Feb./2006	2.24	5.75	9.27
Mar./2006	2.76	6.27	9.78
Apr./2006	3.83	7.34	10.86
May/2006	4.26	7.77	11.28

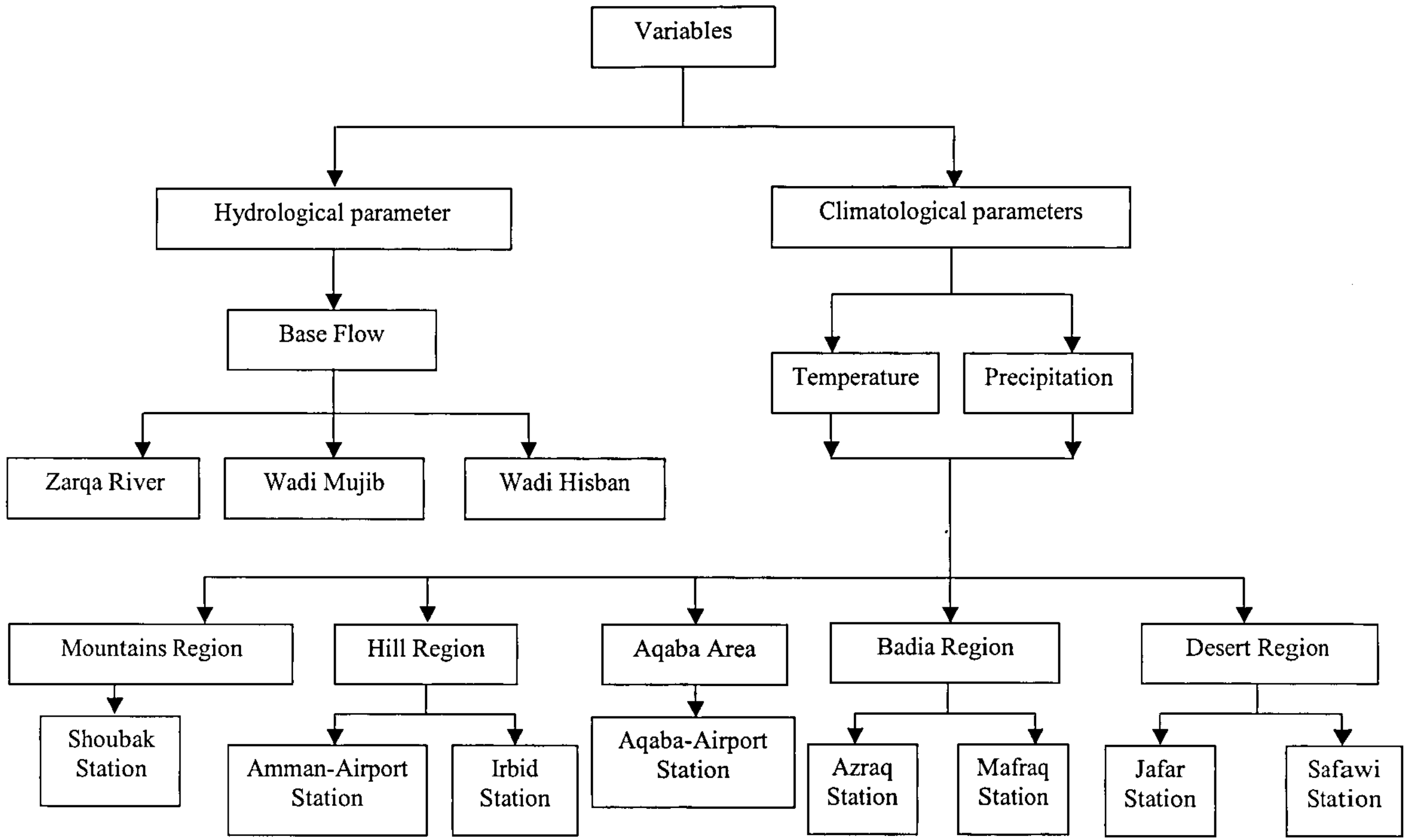


Figure (4.1): Flow Chart for Analyzed Variables

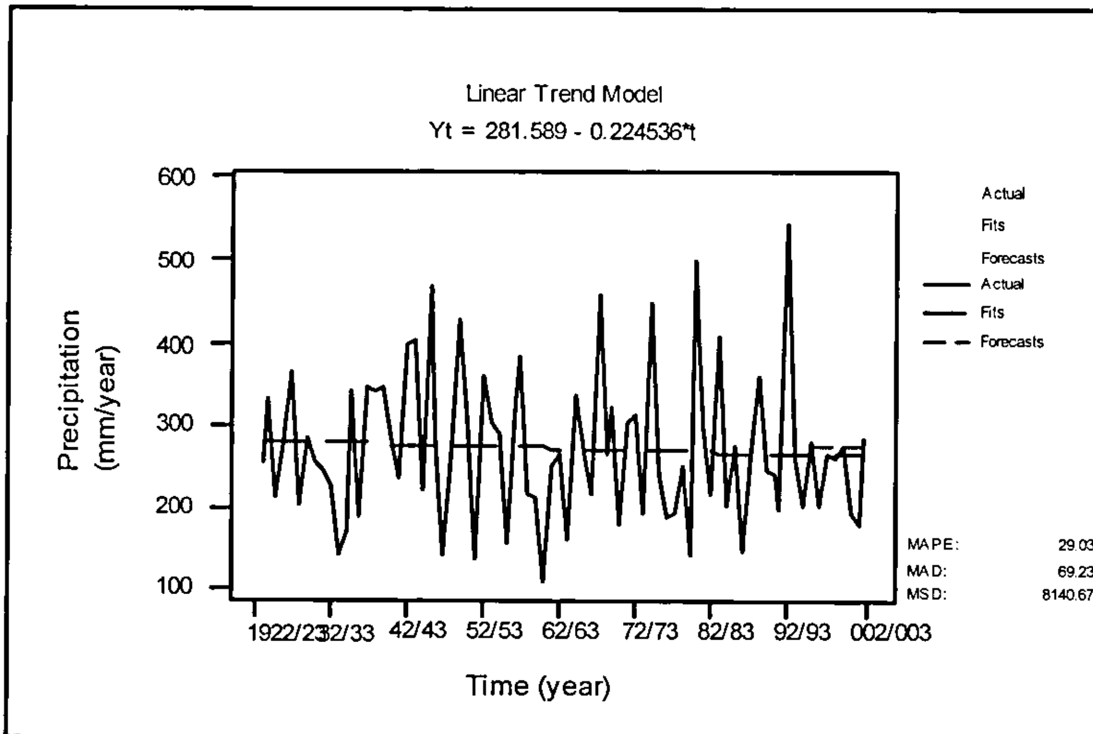


Figure (4.2): Linear Trend Analysis for Precipitation for Water-Year for Amman-Airport Station.

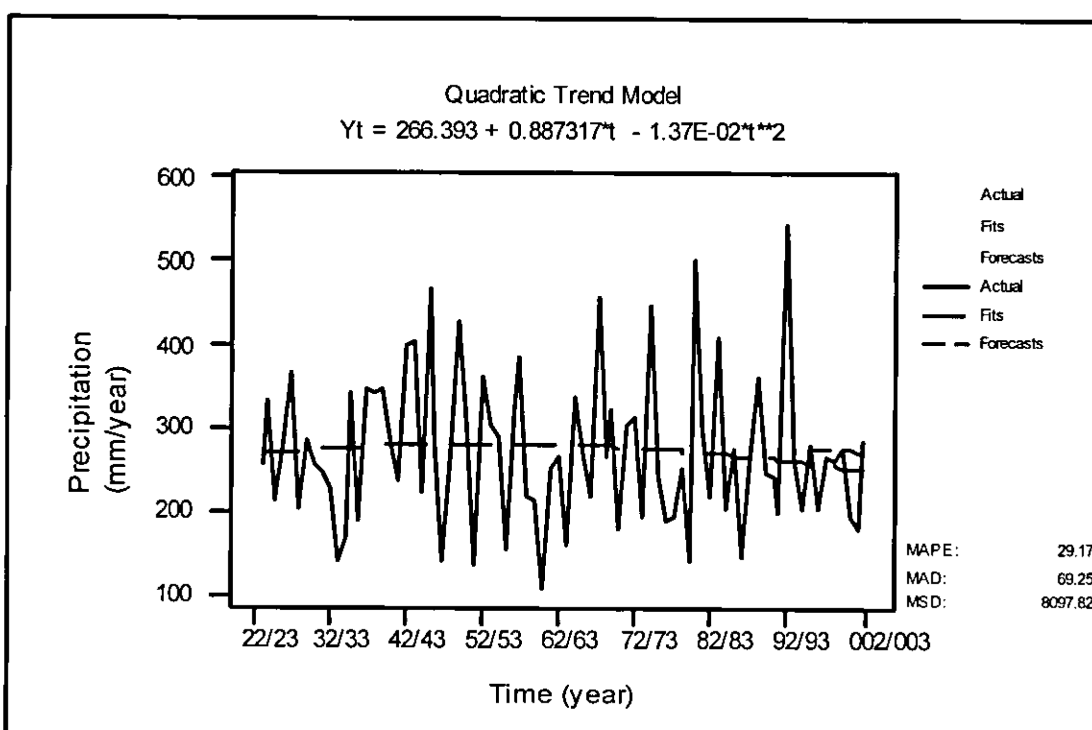


Figure (4.3): Quadratic Trend Analysis for Precipitation for Water-Year for Amman-Airport Station.

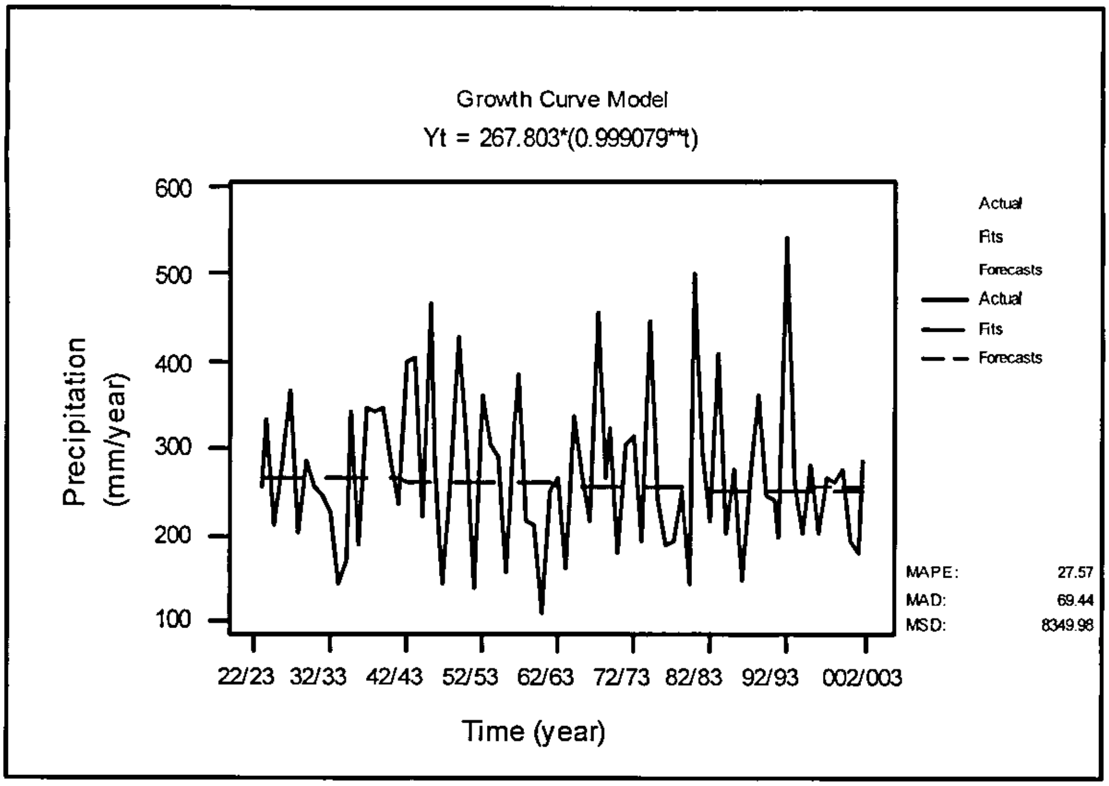


Figure (4.4): Exponential Growth Trend Analysis for Precipitation for Water-Year for Amman-Airport Station.

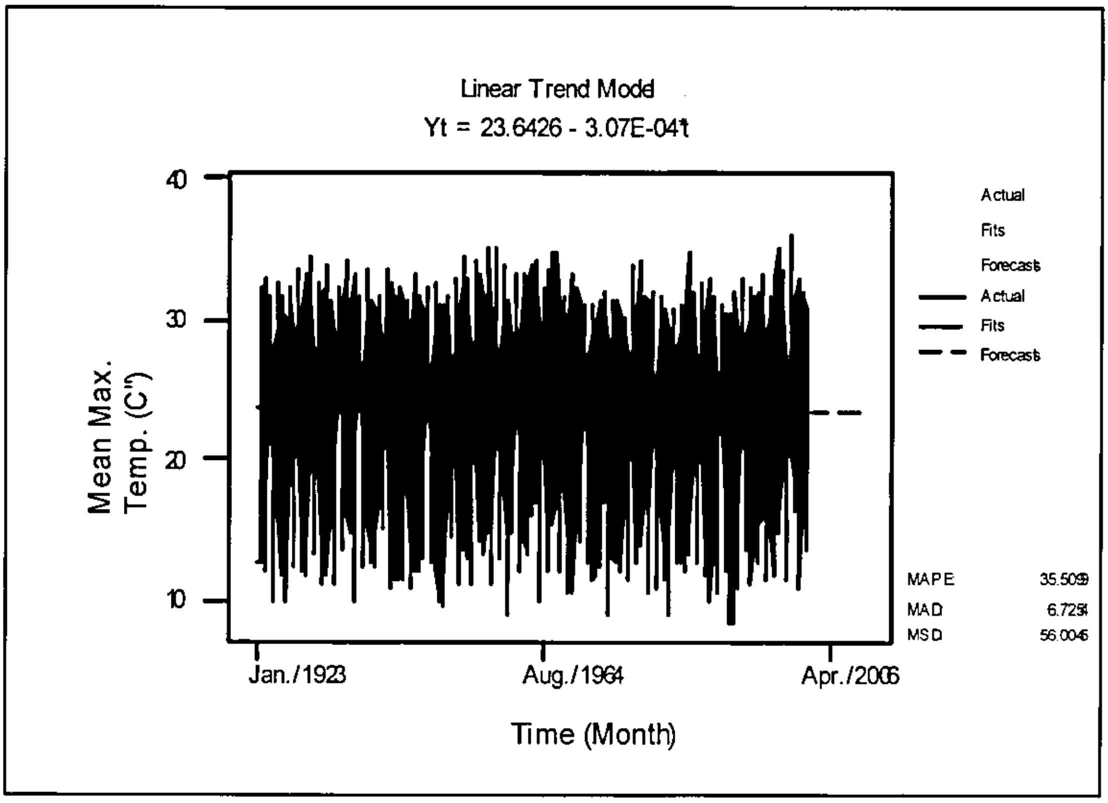


Figure (4.5): Linear Trend Analysis for Mean Monthly Maximum Temperature for Amman-Airport Station.

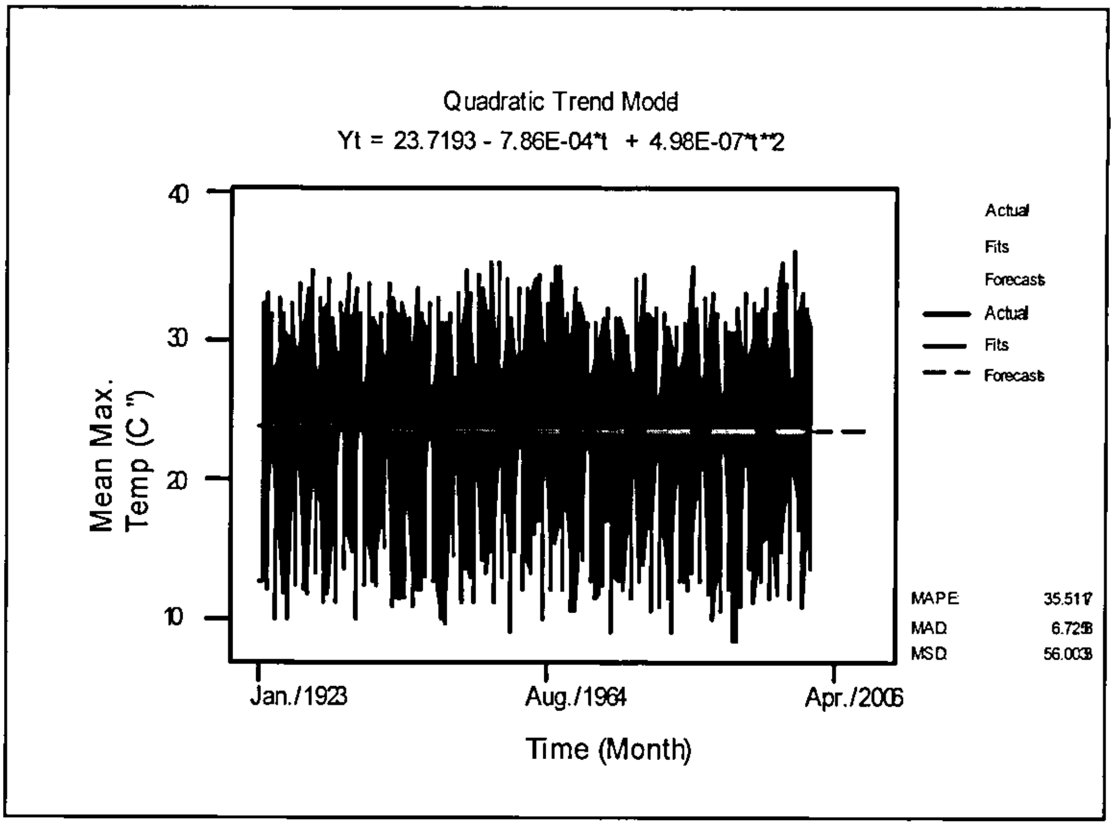


Figure (4.6): Quadratic Trend Analysis for Mean Monthly Maximum Temperature for Amman-Airport Station.

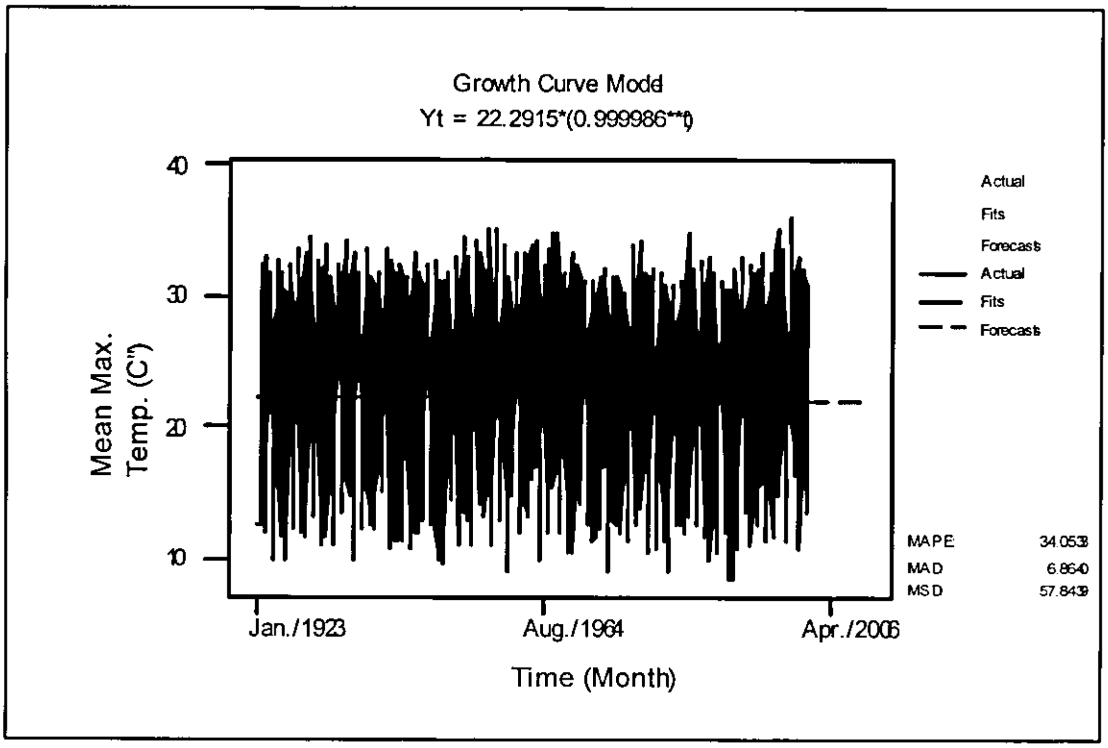


Figure (4.7): Exponential Growth Trend Analysis for Mean Monthly Maximum Temperature for Amman-Airport Station.

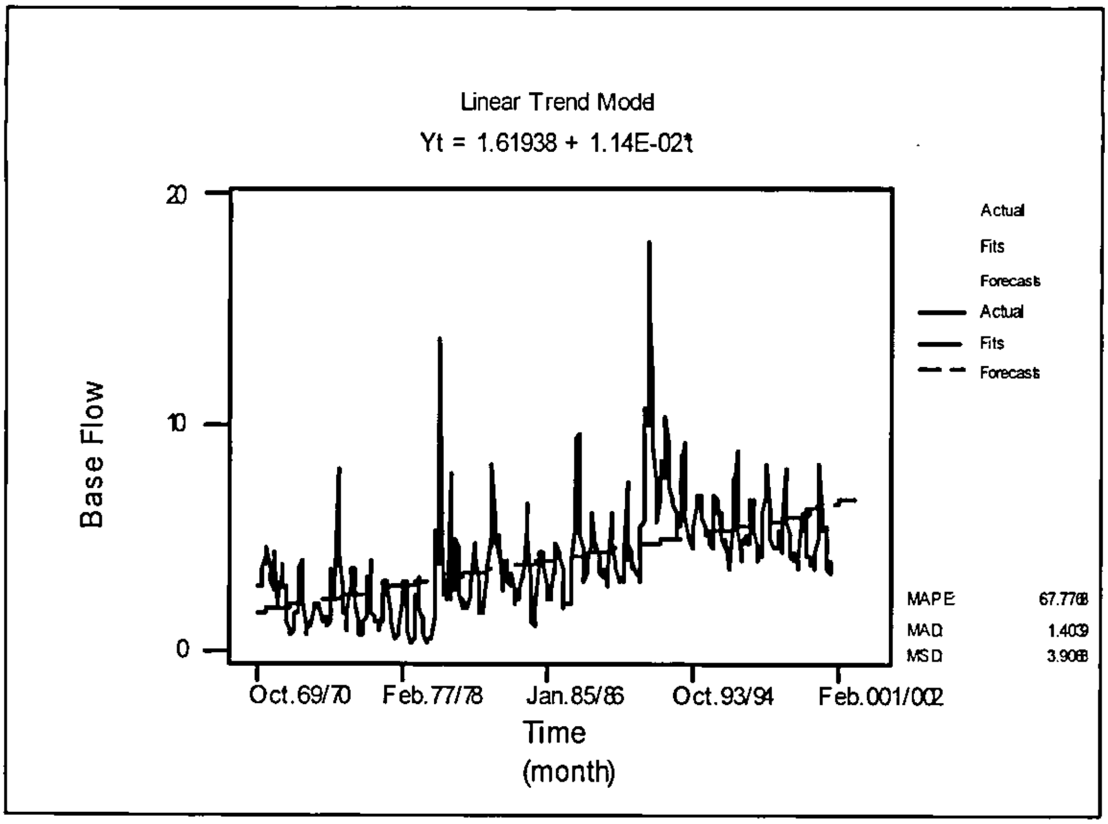


Figure (4.8): Linear Trend Analysis for Monthly Base Flow for Zarqa River Station.

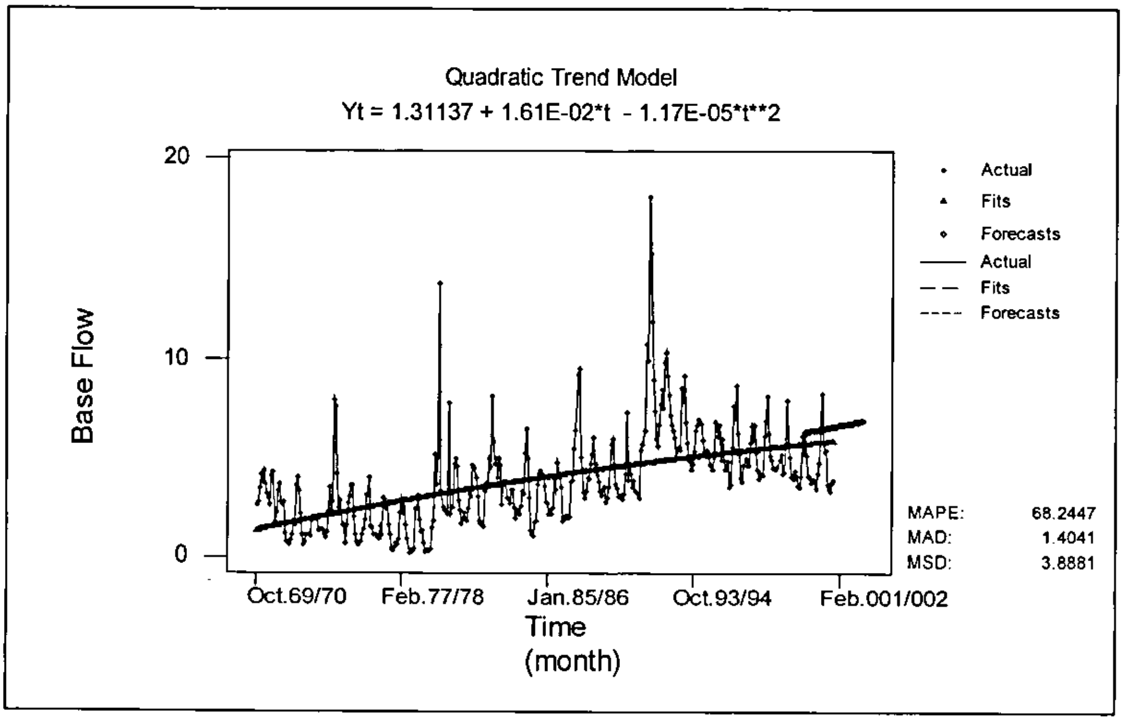


Figure (4.9): Quadratic Trend Analysis for Monthly Base Flow for Zarqa River Station.

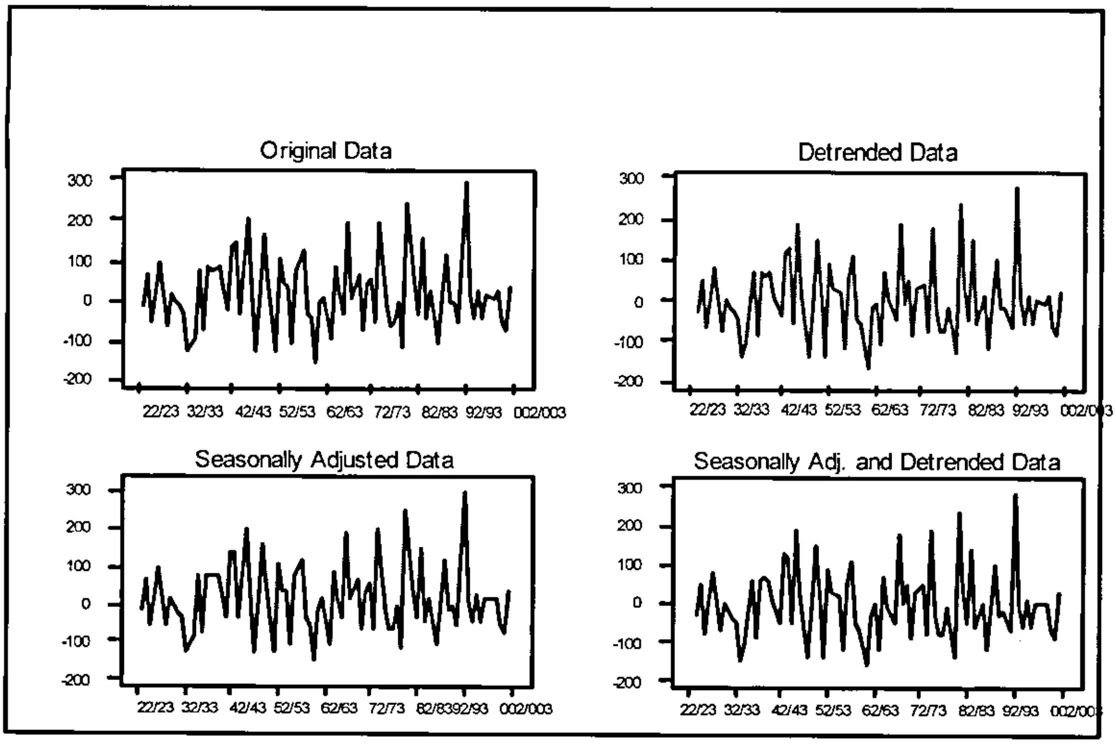


Figure (4.12): Seasonal Component Analysis for Residual Precipitation for Water-Year for Amman-Airport Station.

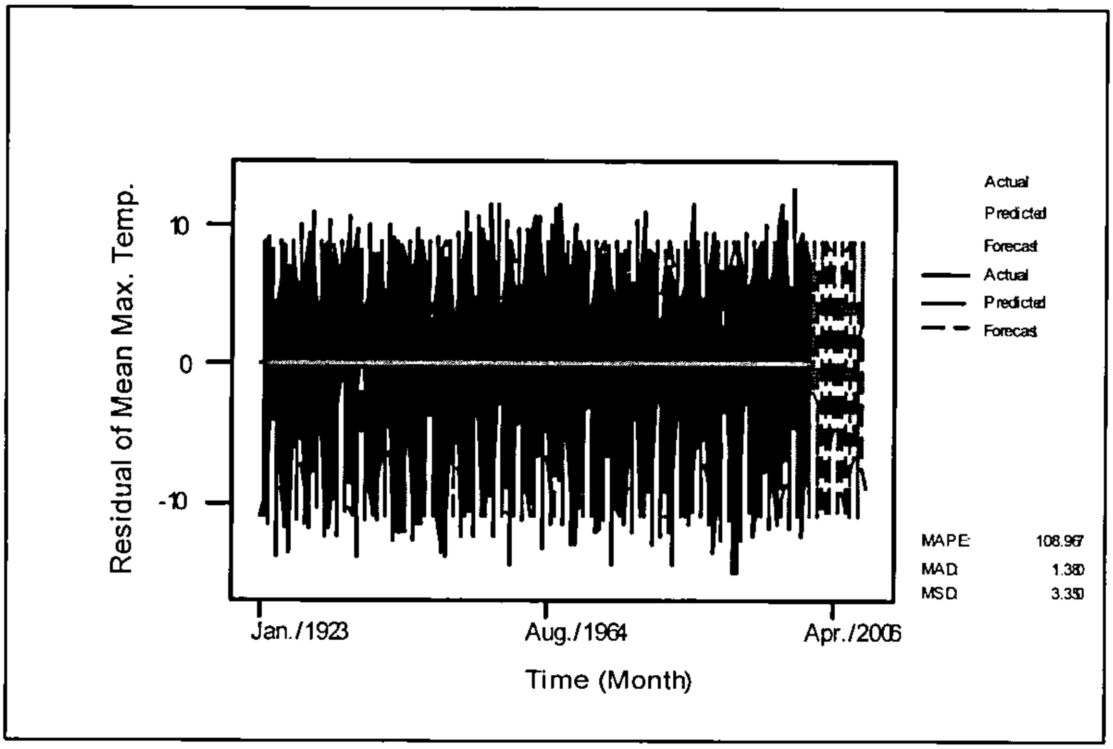


Figure (4.13): Seasonal Decomposition Fit for Residual Mean Monthly Maximum Temperature for Amman-Airport Station.

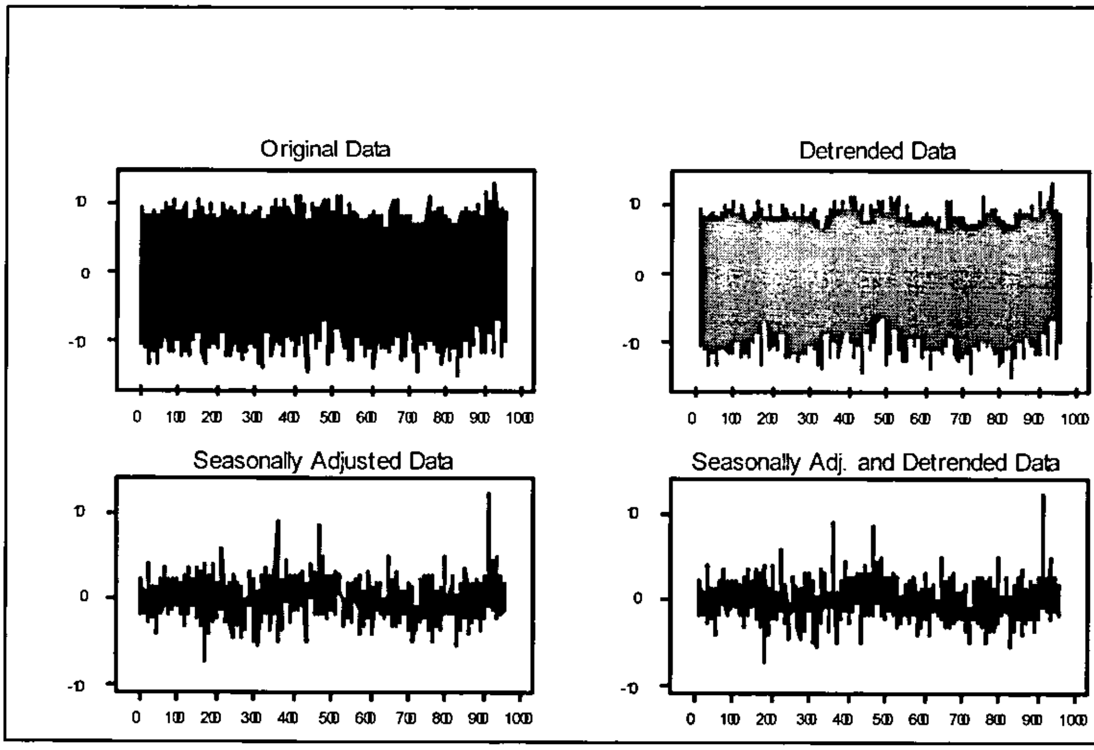


Figure (4.14): Seasonal Component Analysis for Residual Mean Monthly Maximum Temperature for Amman-Airport Station.

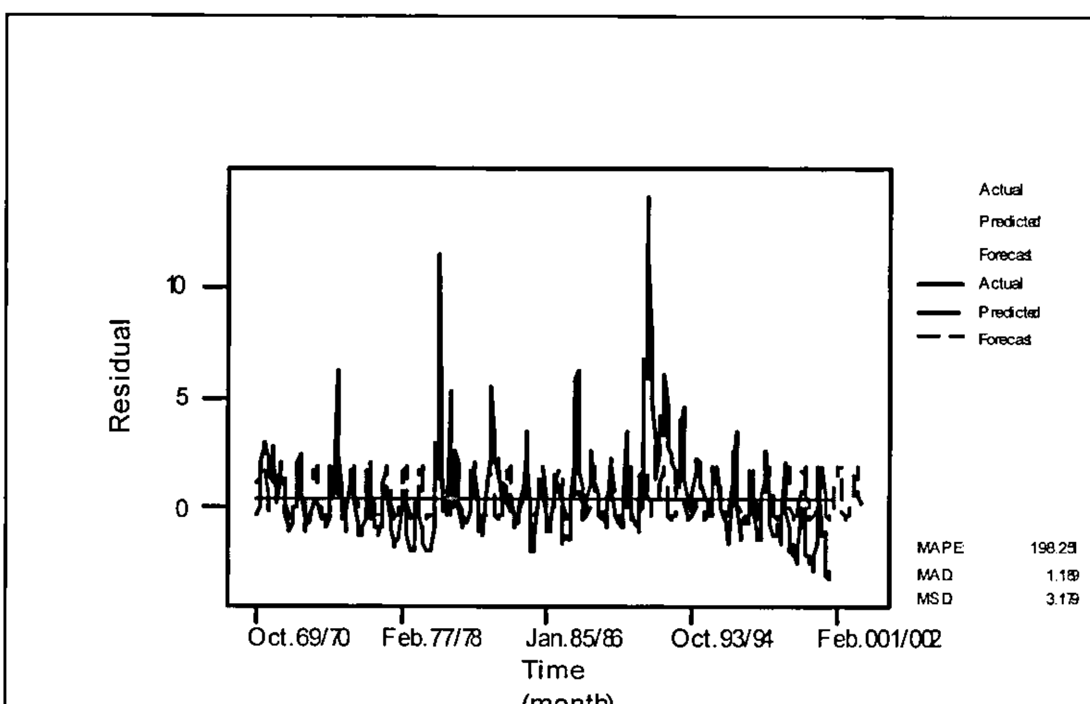


Figure (4.15): Seasonal Decomposition Fit for Residual Monthly Base Flow for Zarqa River Station.

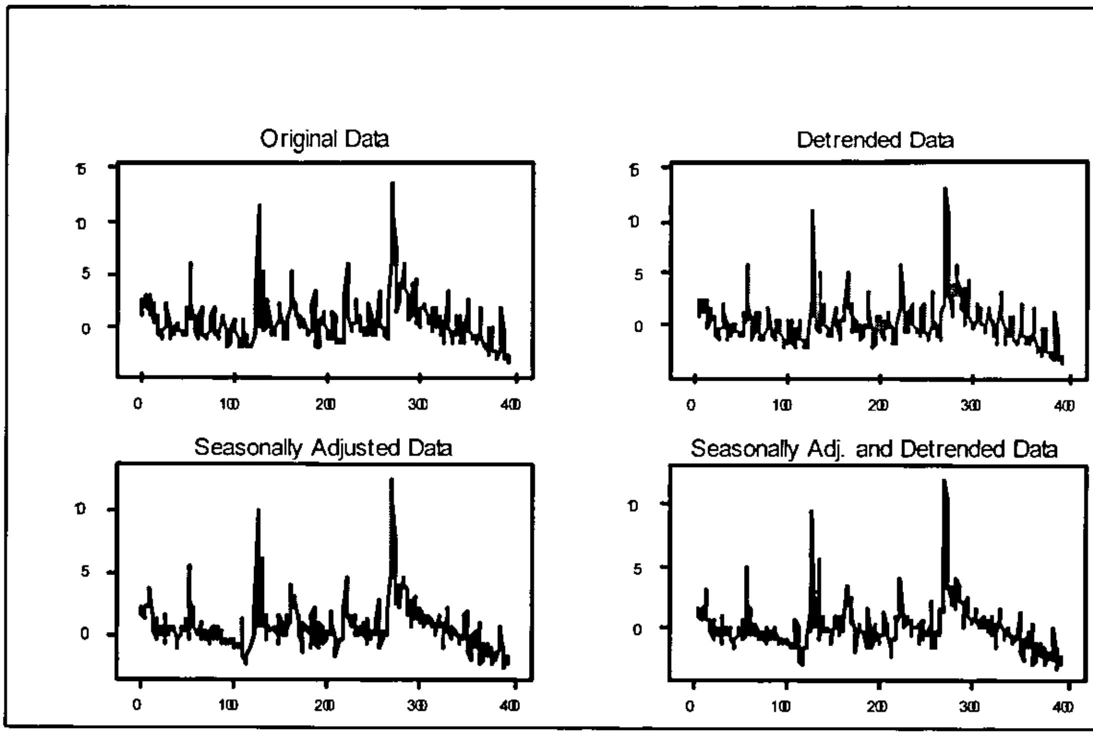


Figure (4.16): Seasonal Component Analysis for Residual Monthly Base Flow for Zarqa River Station.

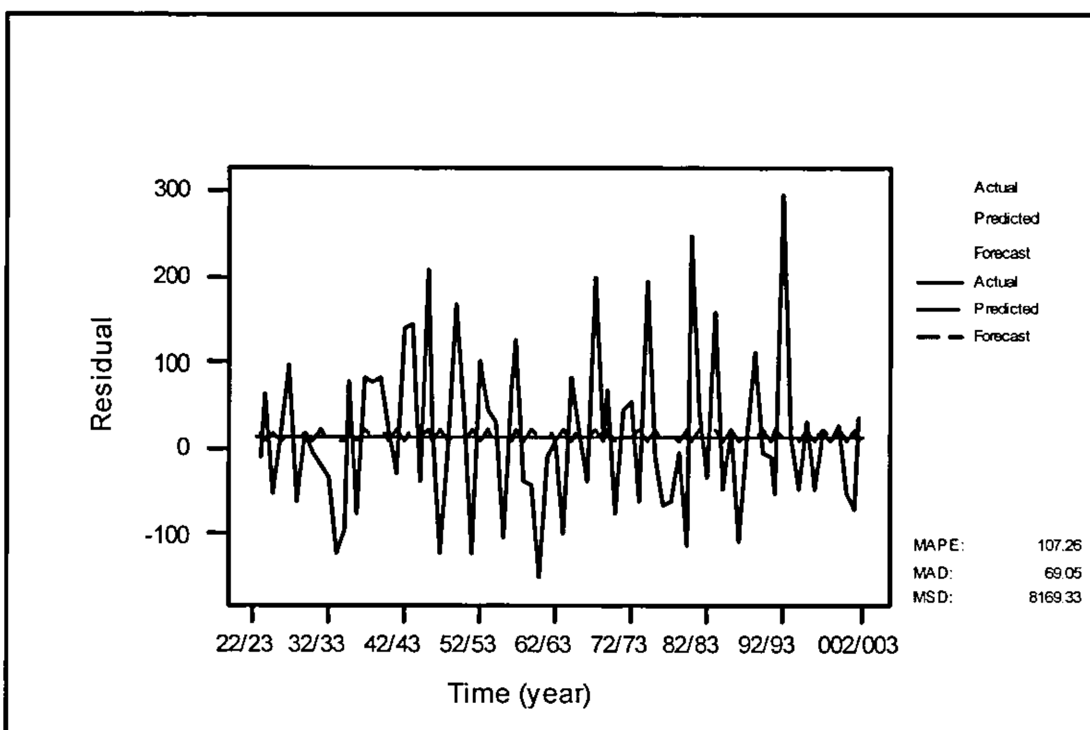


Figure (4.17): Trend plus Seasonal Decomposition Fit for Residual Precipitation for Water-Year for Amman-Airport Station.

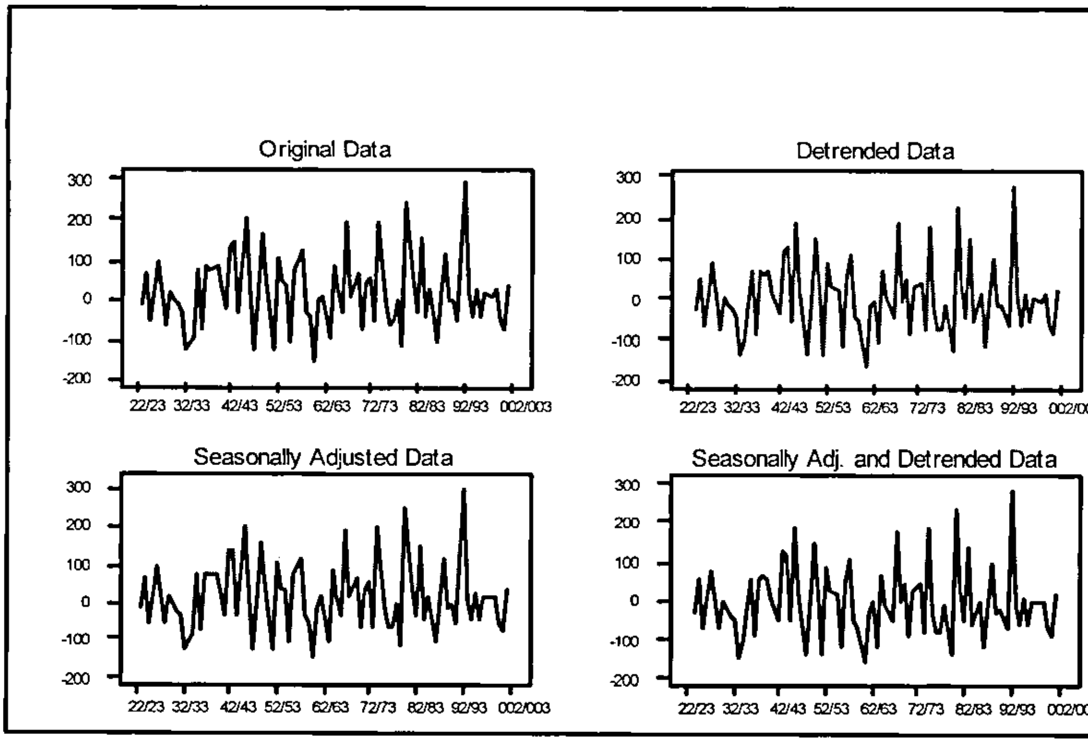


Figure (4.18): Trend plus Seasonal Component Analysis for Residual Precipitation for Water-Year for Amman-Airport Station.

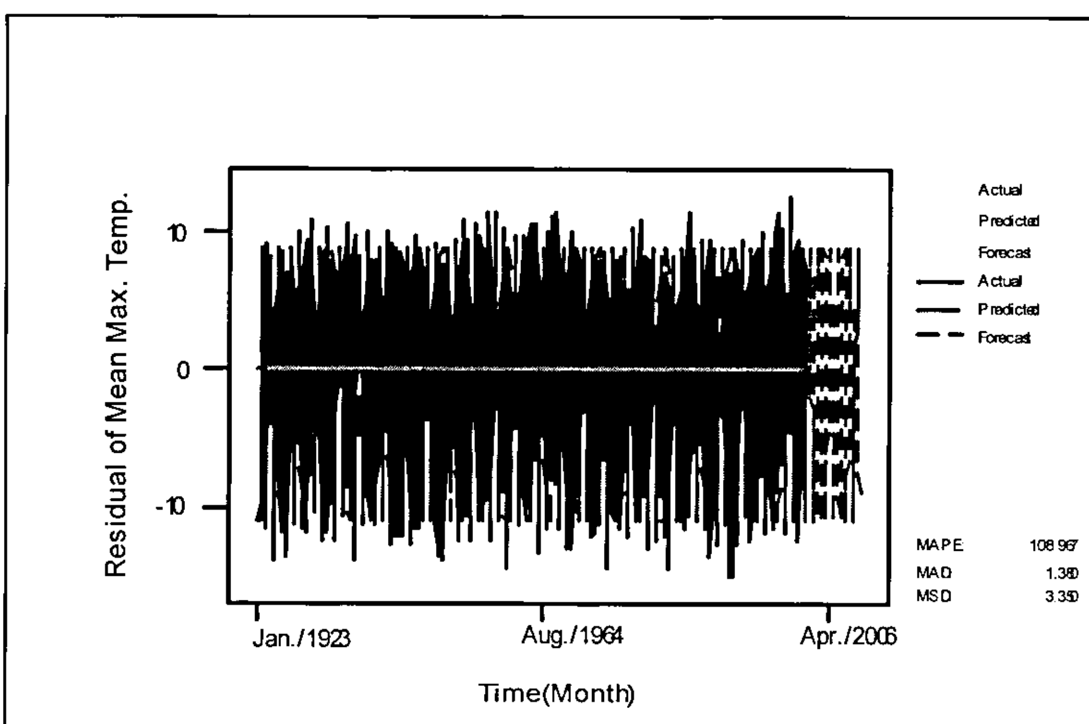


Figure (4.19): Trend plus Seasonal Decomposition Fit for Residual Mean Monthly Maximum Temperature for Amman-Airport Station.

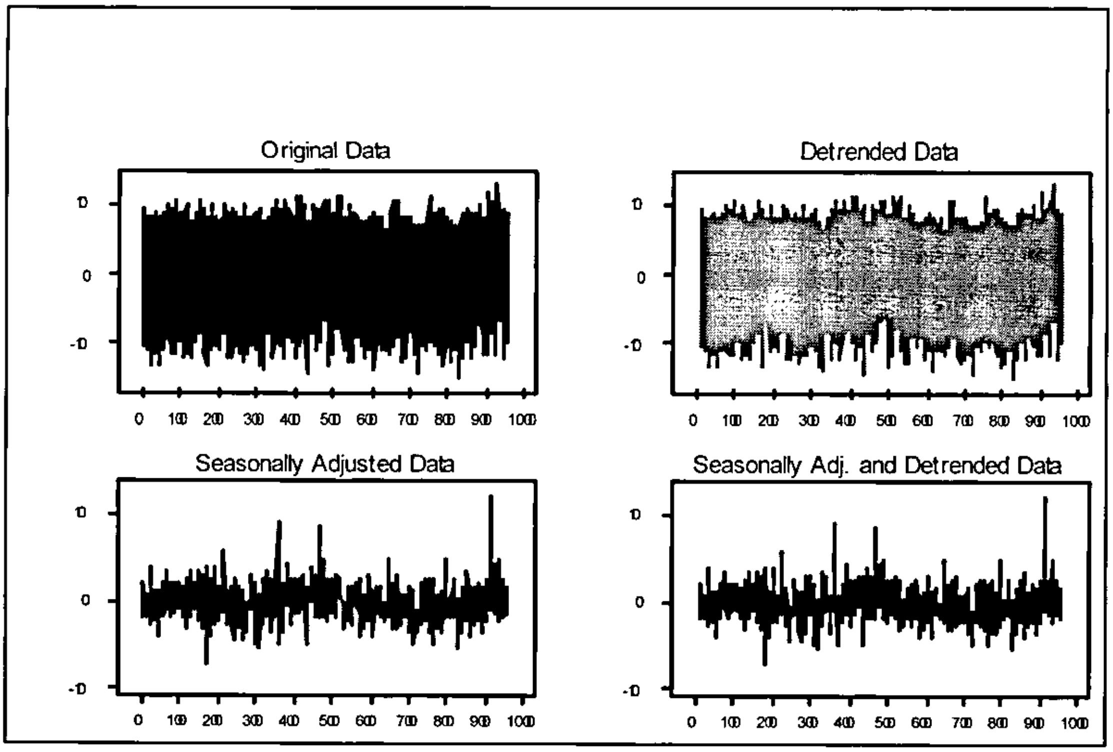


Figure (4.20): Trend plus Seasonal Component Analysis for Residual Mean Monthly Maximum Temperature for Amman-Airport Station.

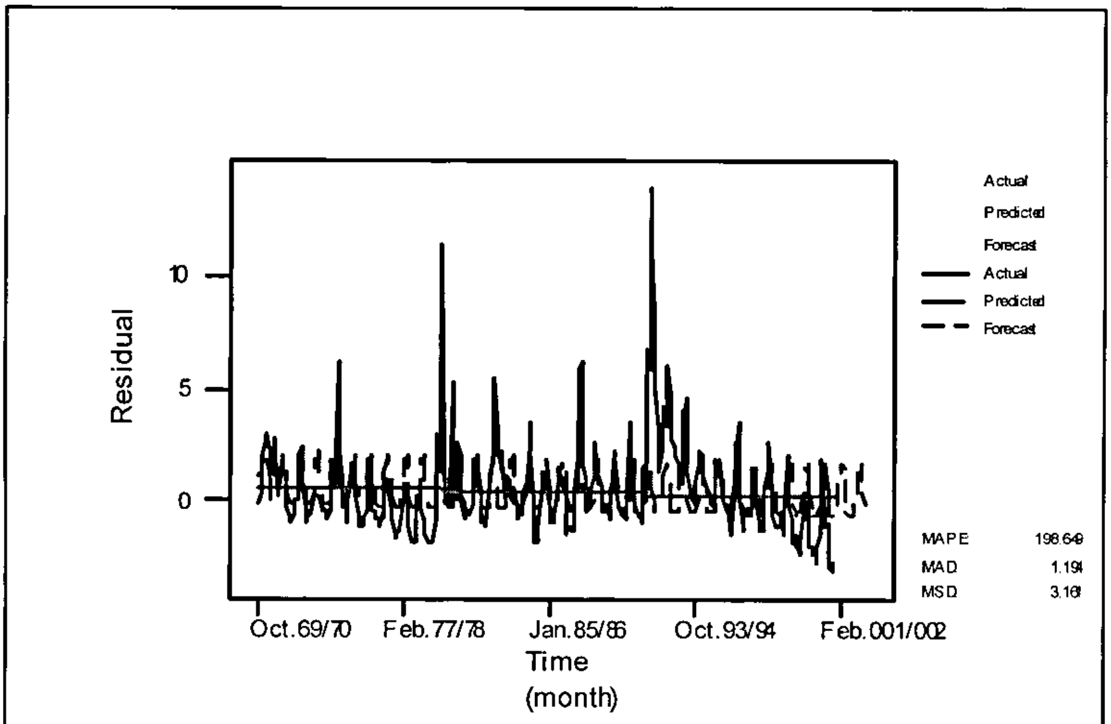


Figure (4.21): Trend plus Seasonal Decomposition Fit for Residual Monthly Base Flow for Zarqa River Station.

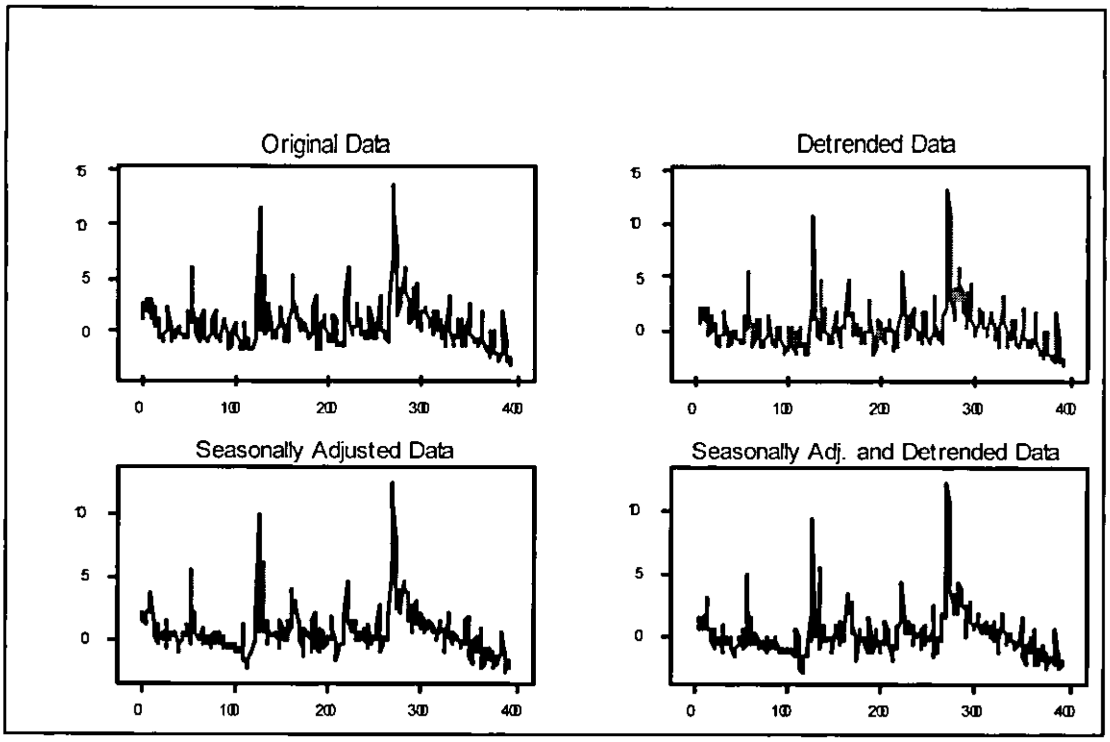


Figure (4.22): Trend plus Seasonal Component Analysis for Residual Monthly Base Flow for Zarqa River Station.

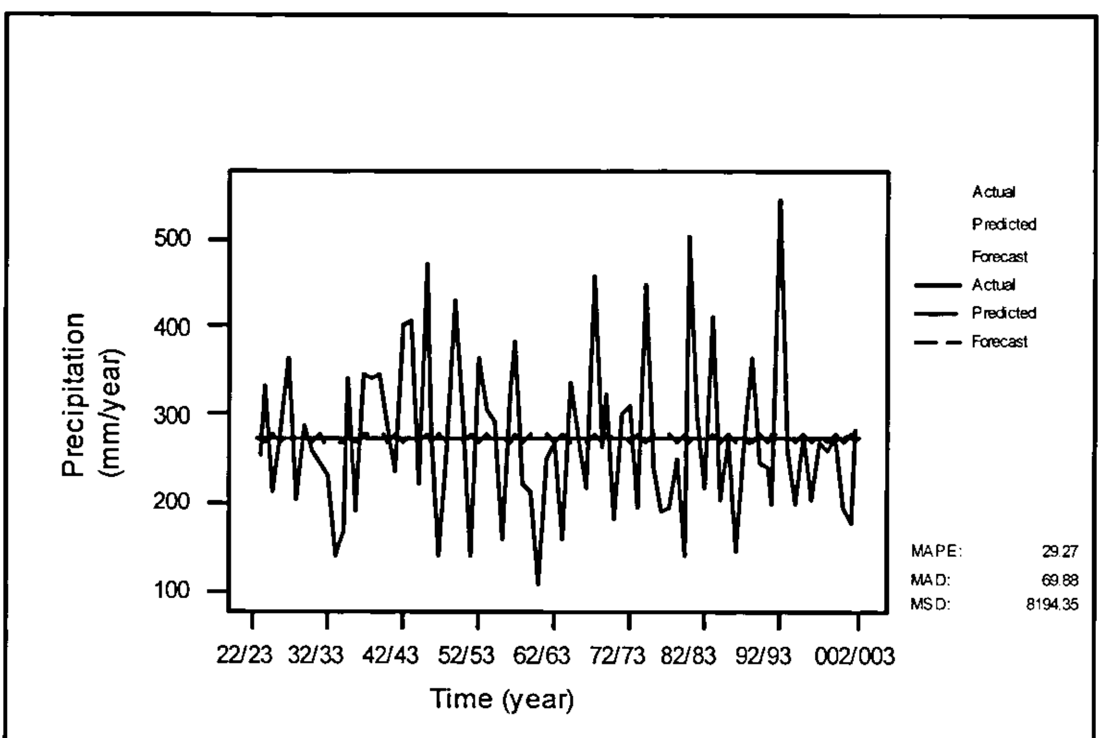


Figure (4.23): Seasonal Decomposition Fit for Precipitation for Water-Year for Amman-Airport Station.

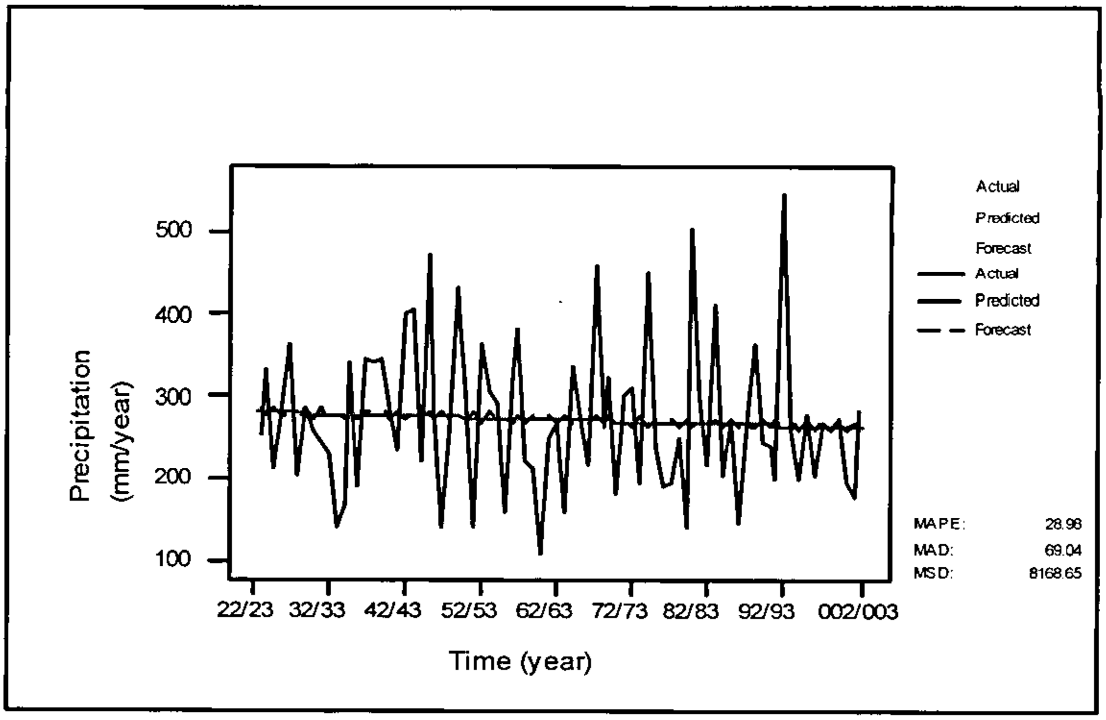


Figure (4.24): Trend plus Seasonal Decomposition Fit for Precipitation for Water-Year for Amman-Airport Station.

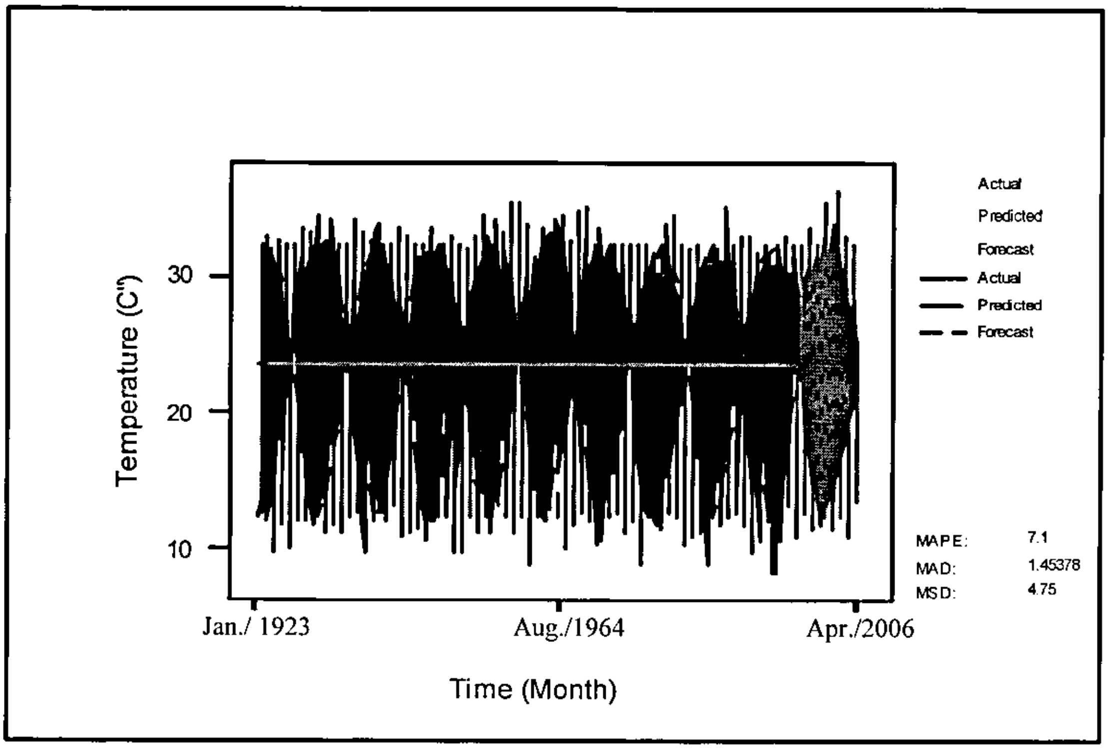


Figure (4.25): Seasonal Decomposition Fit for Mean Monthly Maximum Temperature for Amman-Airport Station.

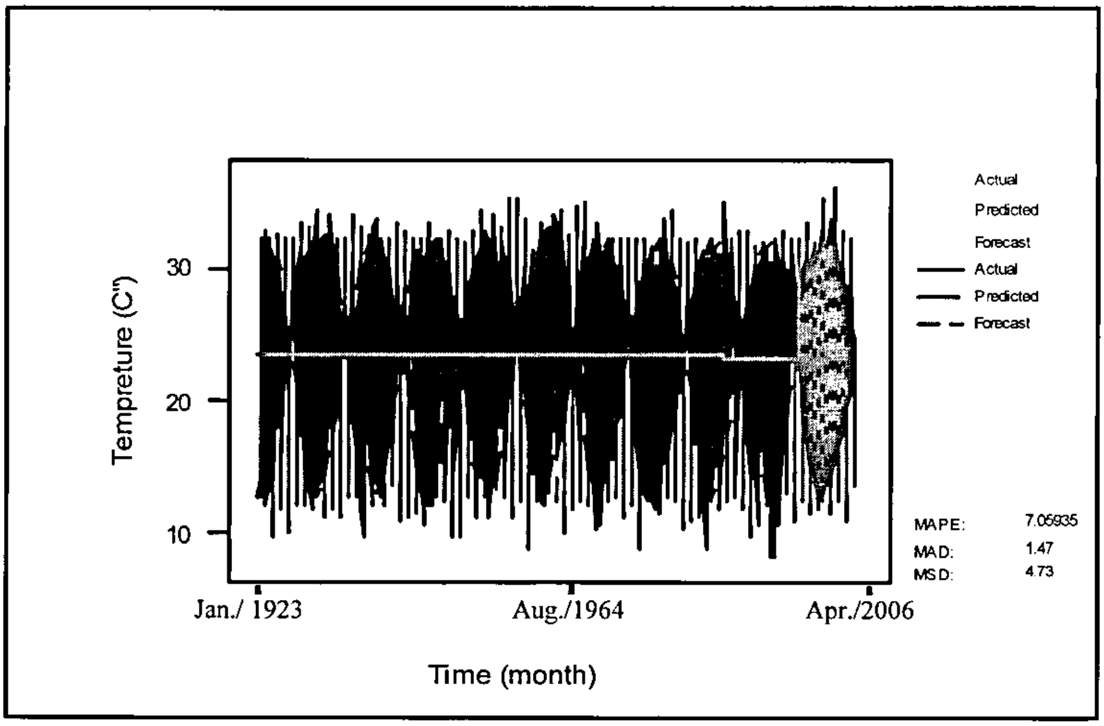


Figure (4.26): Trend plus Seasonal Decomposition Fit for Mean Monthly Maximum Temperature for Amman-Airport Station.

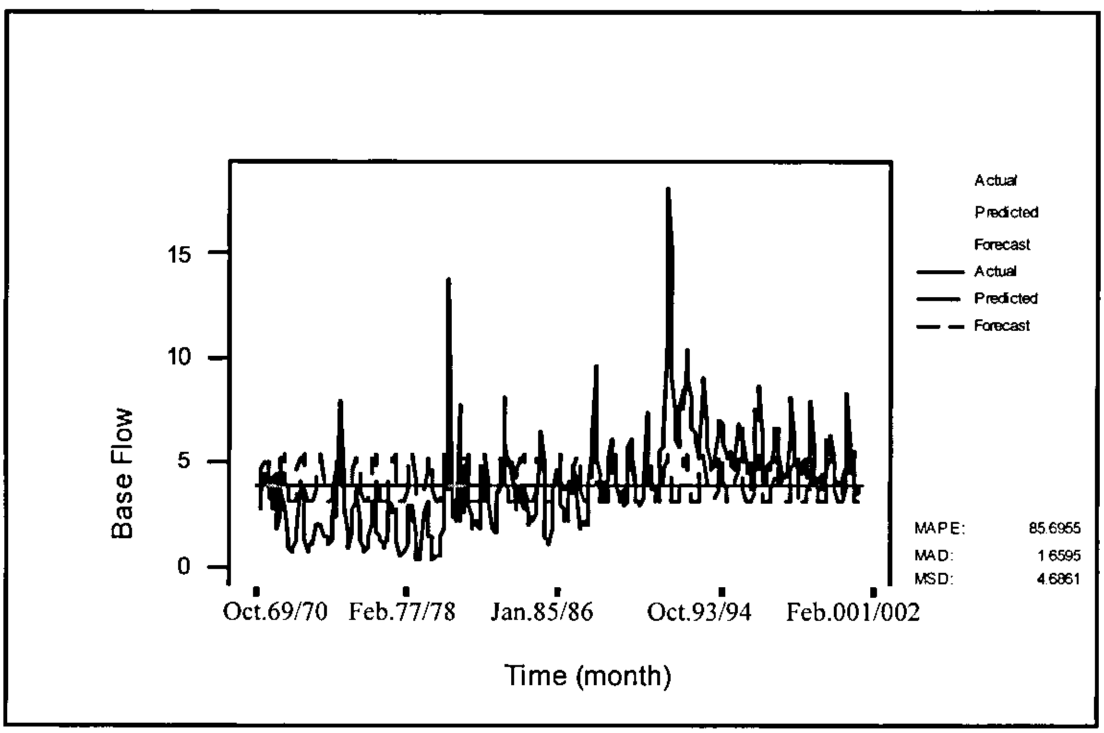


Figure (4.27): Seasonal Decomposition for Monthly Base Flow for Zarqa River Station.

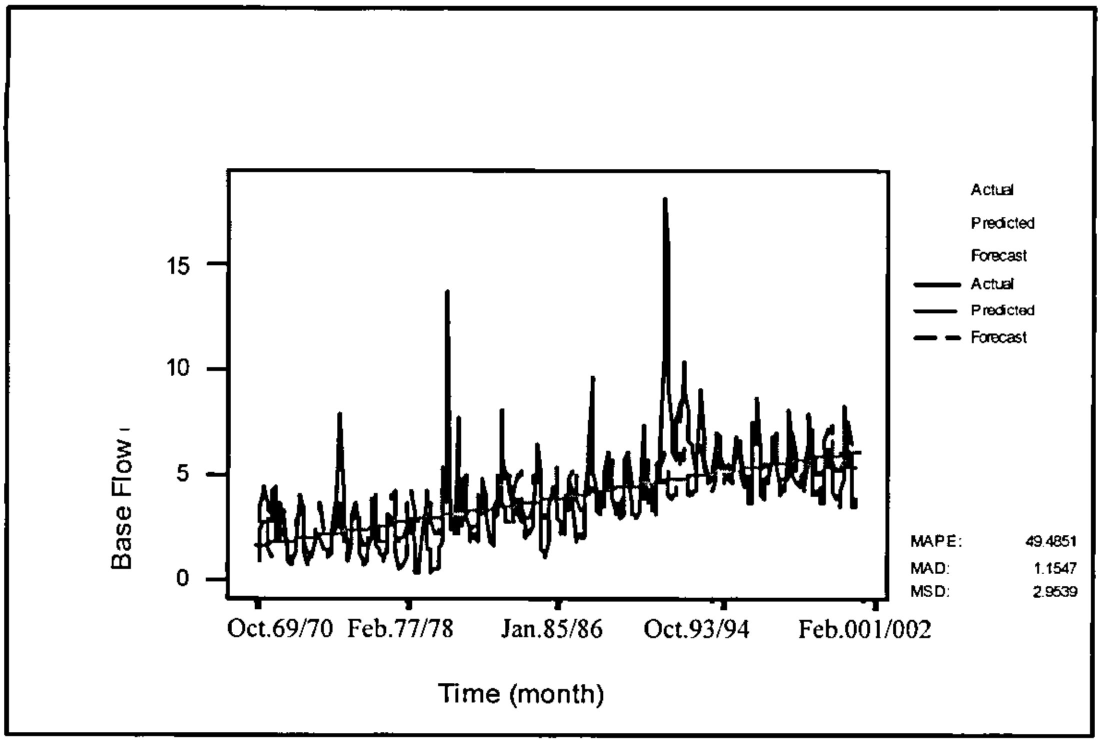


Figure (4.28): Trend plus Seasonal Decomposition for Monthly Base Flow for Zarqa River Station.

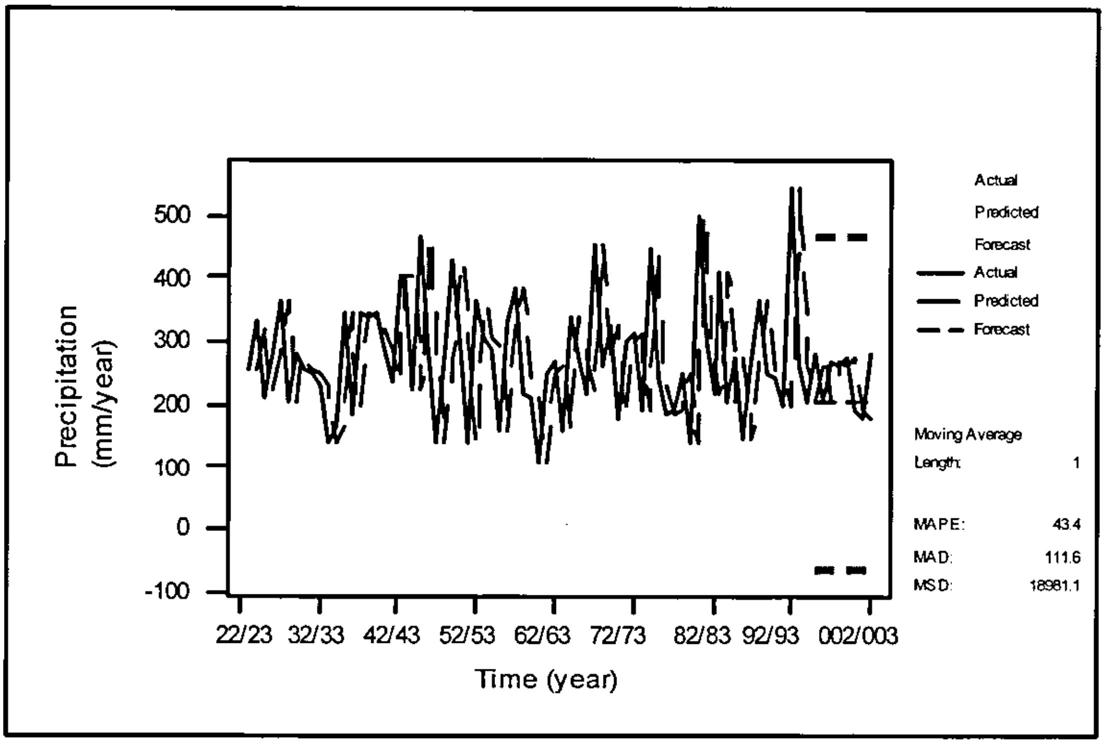


Figure (4.29): Moving Average-MA (1) for Precipitation for Water-Year for Amman-Airport Station.

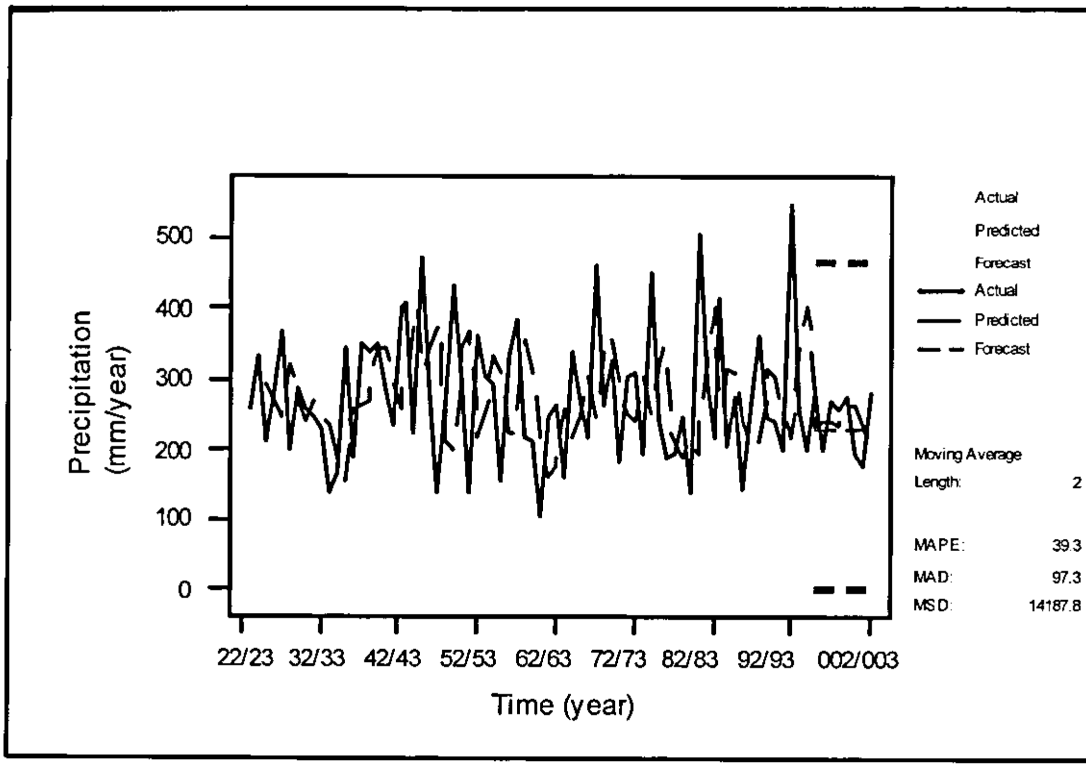


Figure (4.30): Moving Average-MA (2) for Precipitation for Water-Year for Amman-Airport Station.

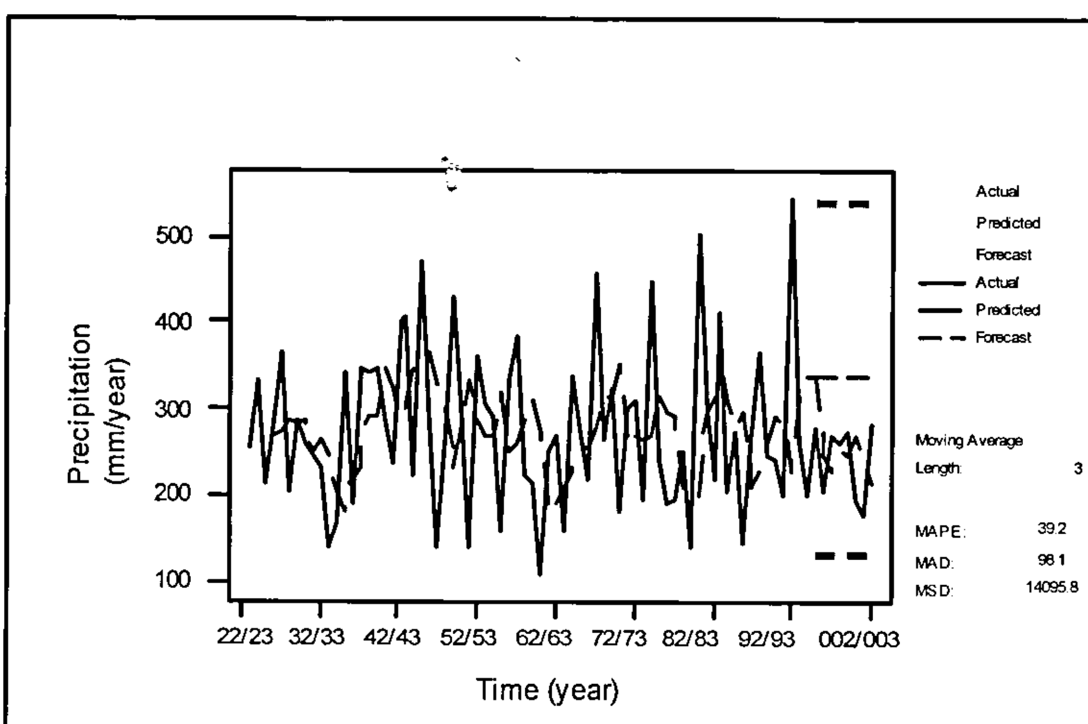


Figure (4.31): Moving Average-MA (3) for Precipitation for Water-Year for Amman-Airport Station.

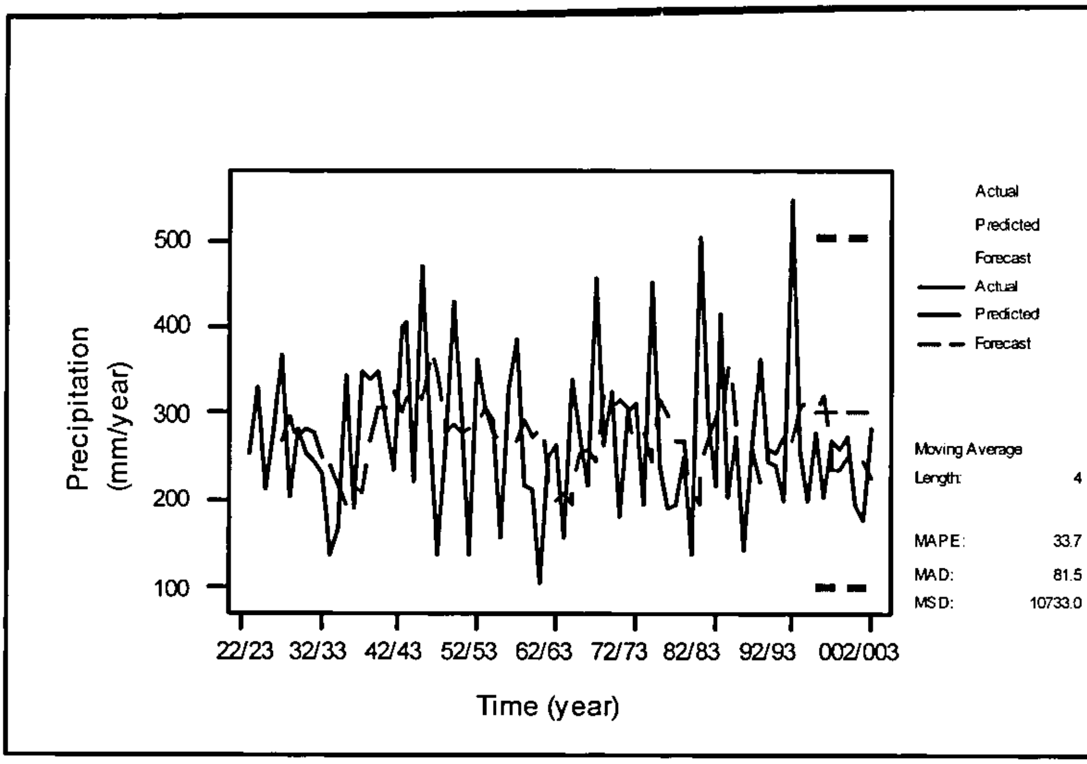


Figure (4.32): Moving Average-MA (4) for Precipitation for Water-Year for Amman-Airport Station.

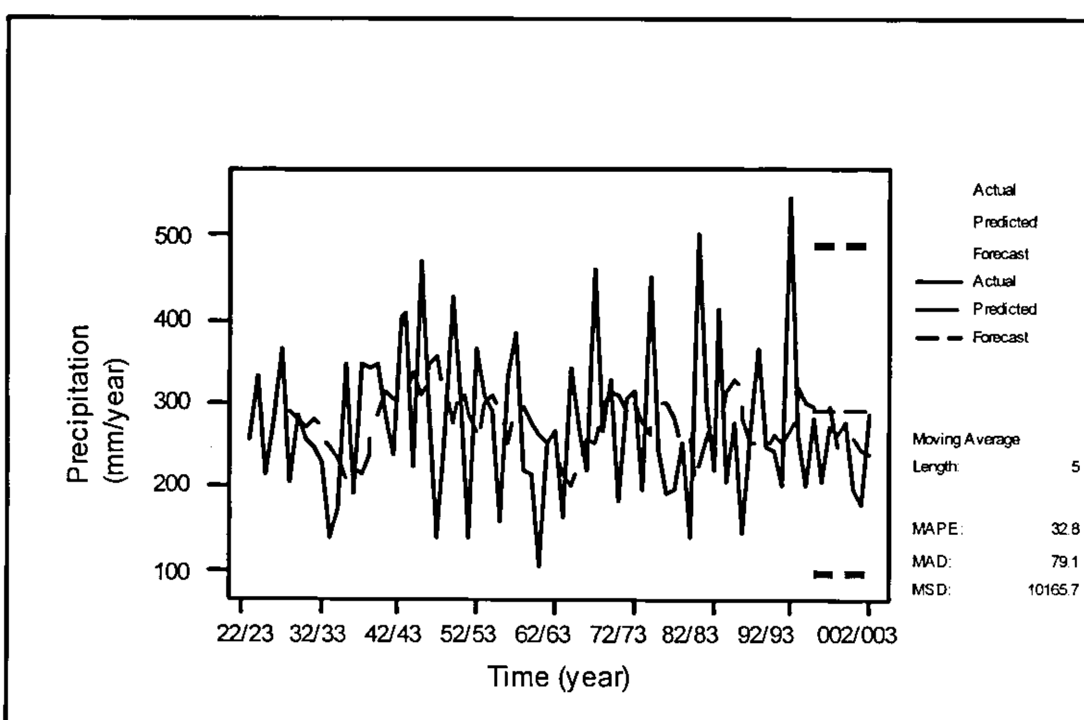


Figure (4.33): Moving Average-MA (5) for Precipitation for Water-Year for Amman-Airport Station.

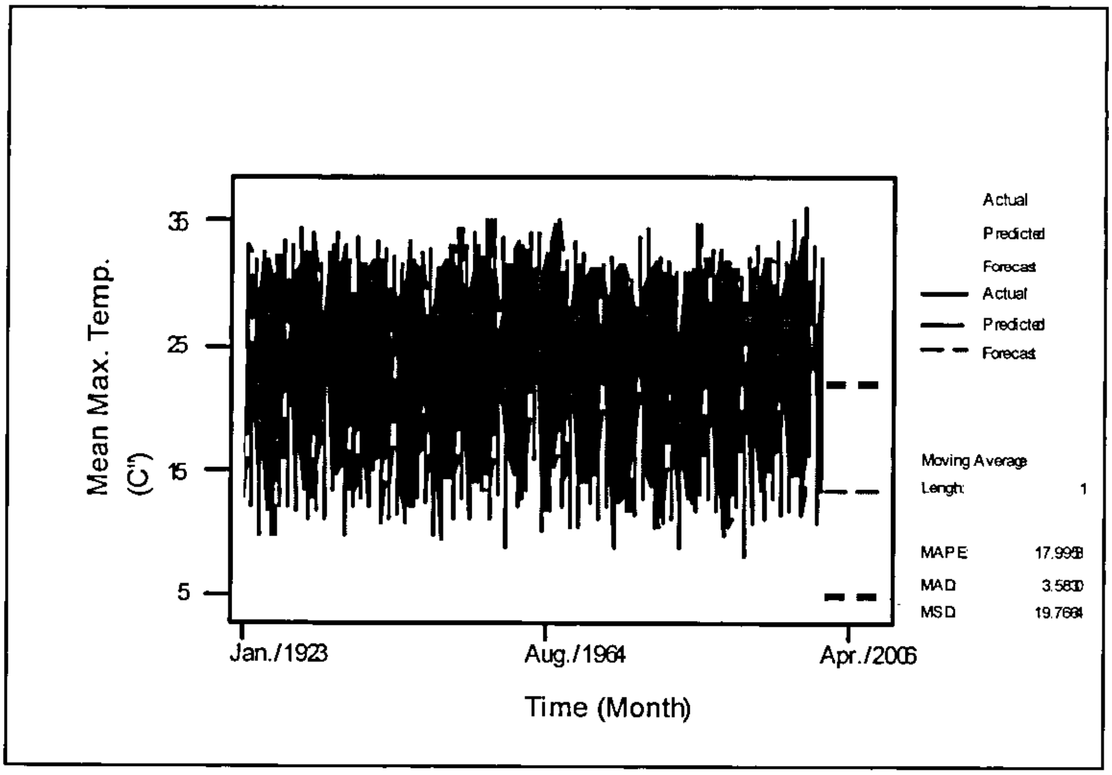


Figure (4.34): Moving Average-MA (1) for Mean Monthly Maximum Temperature for Amman-Airport Station

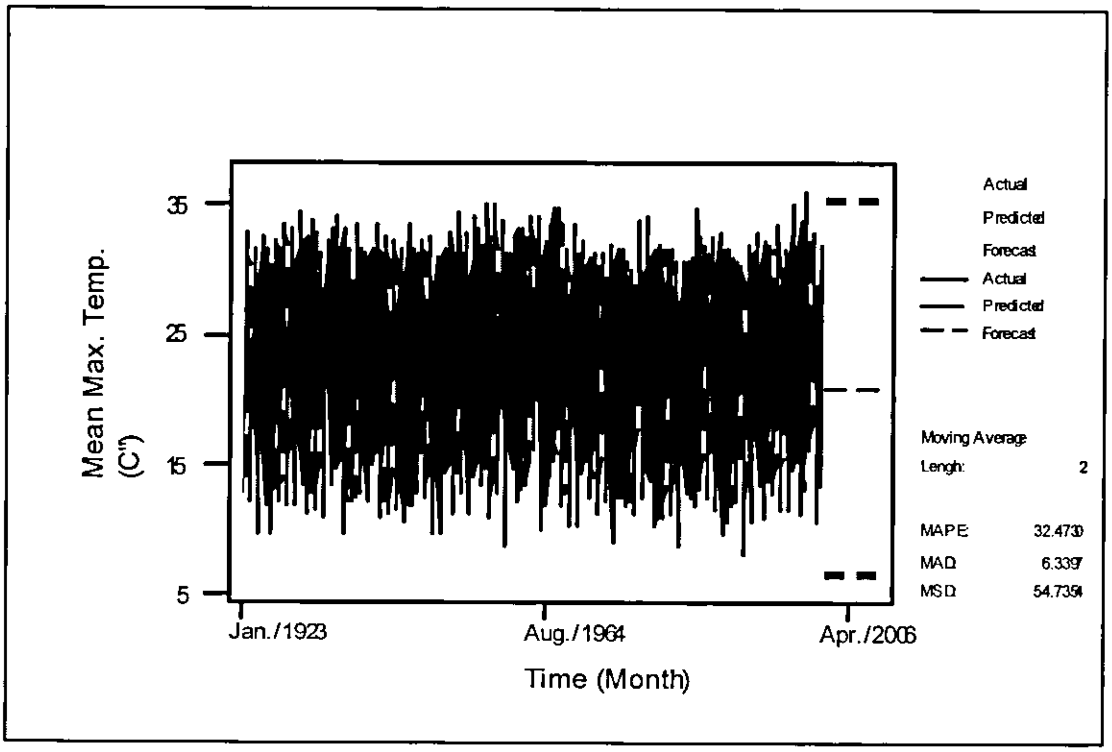


Figure (4.35): Moving Average-MA (2) for Mean Monthly Maximum Temperature for Amman-Airport Station

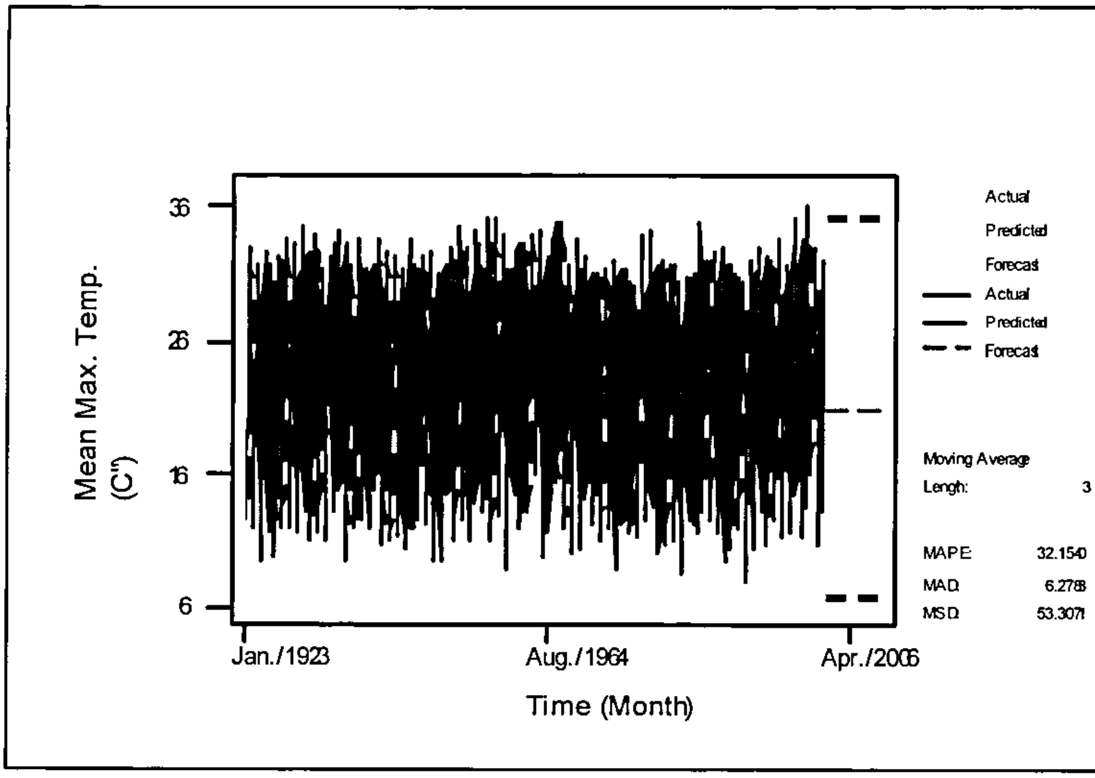


Figure (4.36): Moving Average-MA (3) for Mean Monthly Maximum Temperature for Amman-Airport Station

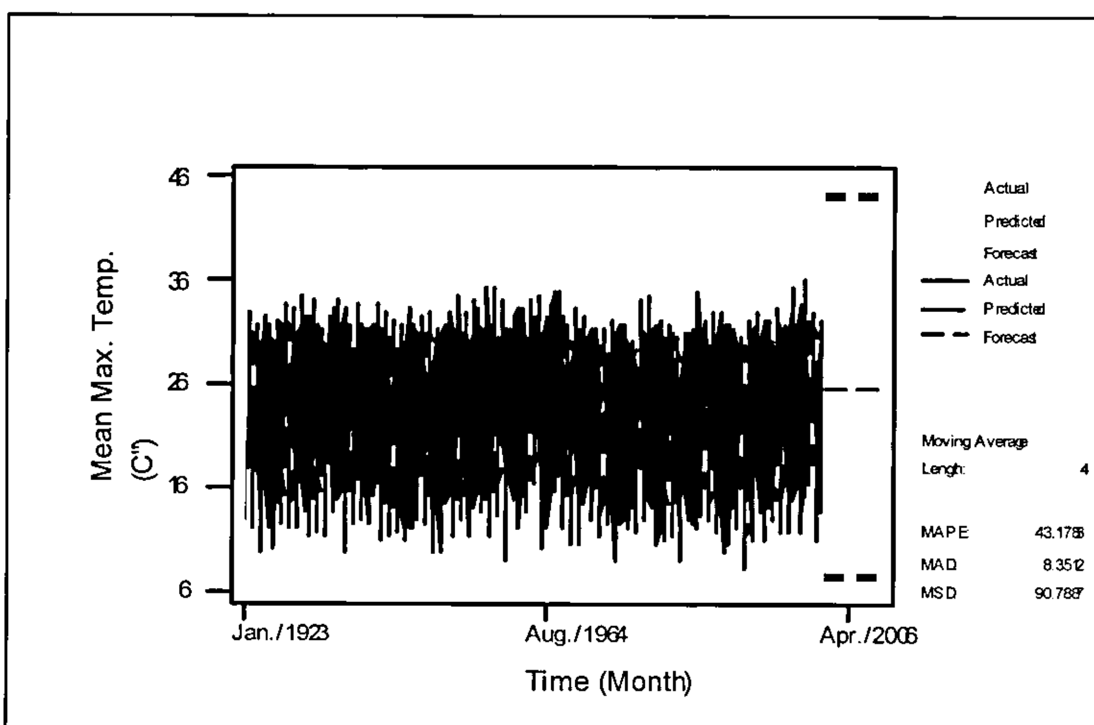


Figure (4.37): Moving Average-MA (4) for Mean Monthly Maximum Temperature for Amman-Airport Station

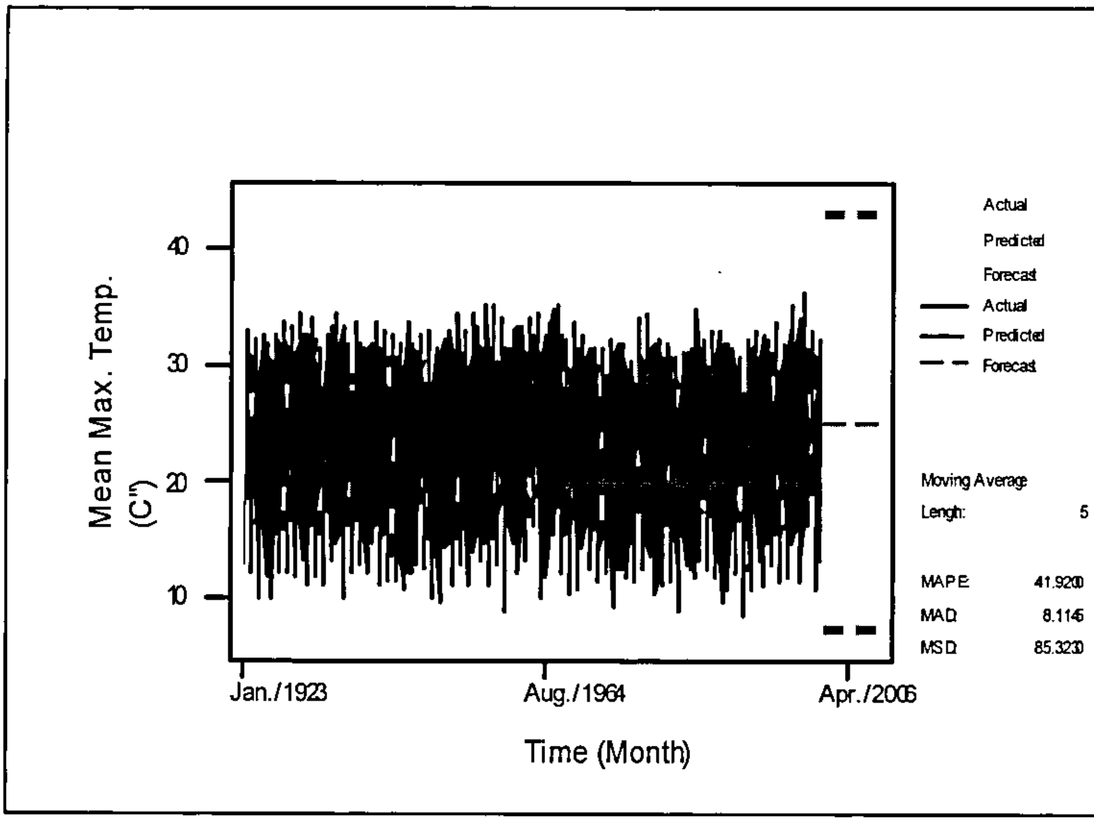


Figure (4.38): Moving Average-MA (5) for Mean Monthly Maximum Temperature for Amman-Airport Station

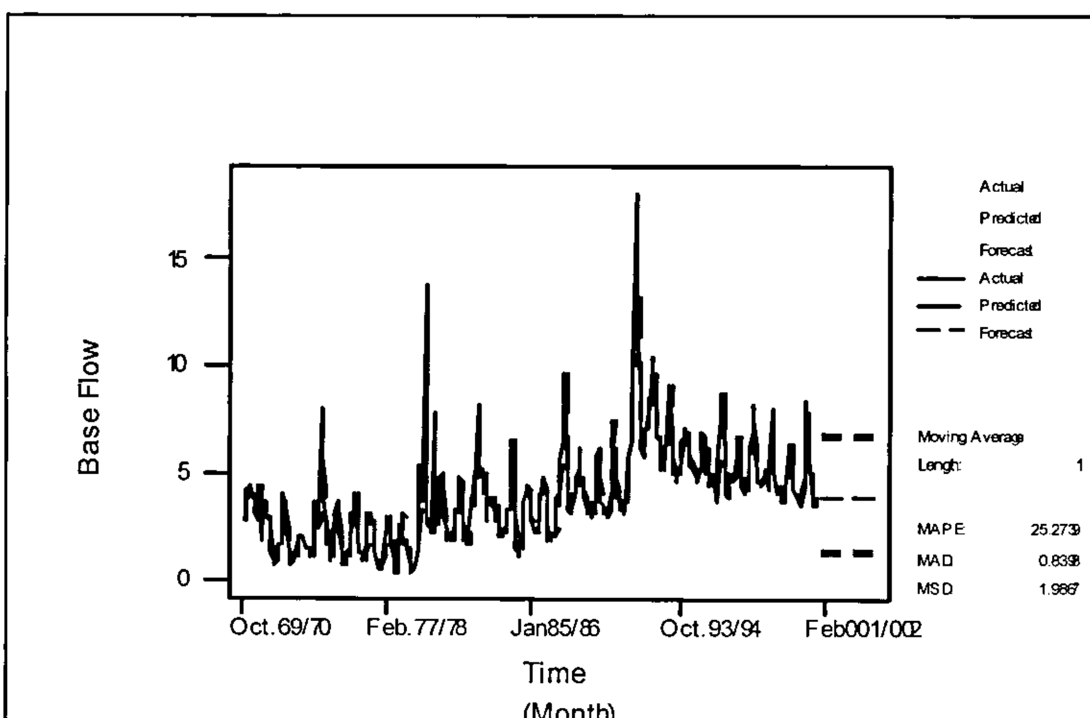


Figure (4.39): Moving Average-MA (1) for Monthly Base Flow for Zarqa River Station.

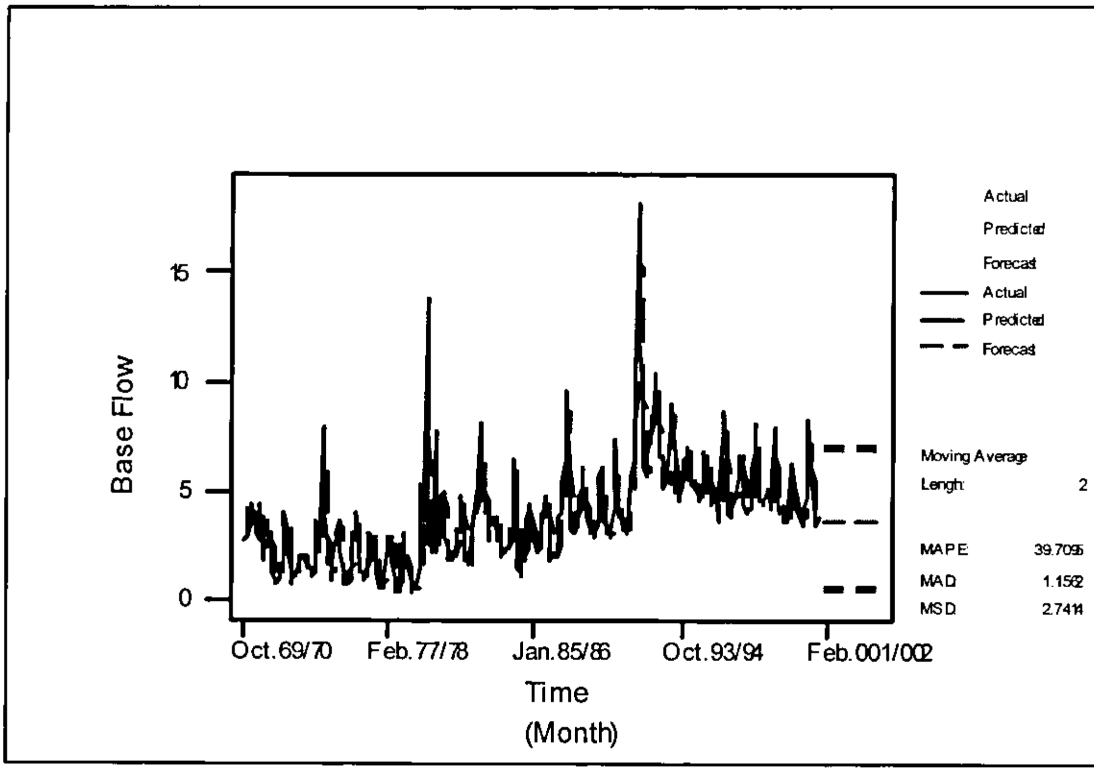


Figure (4.40): Moving Average-MA (2) for Monthly Base Flow for Zarqa River Station.

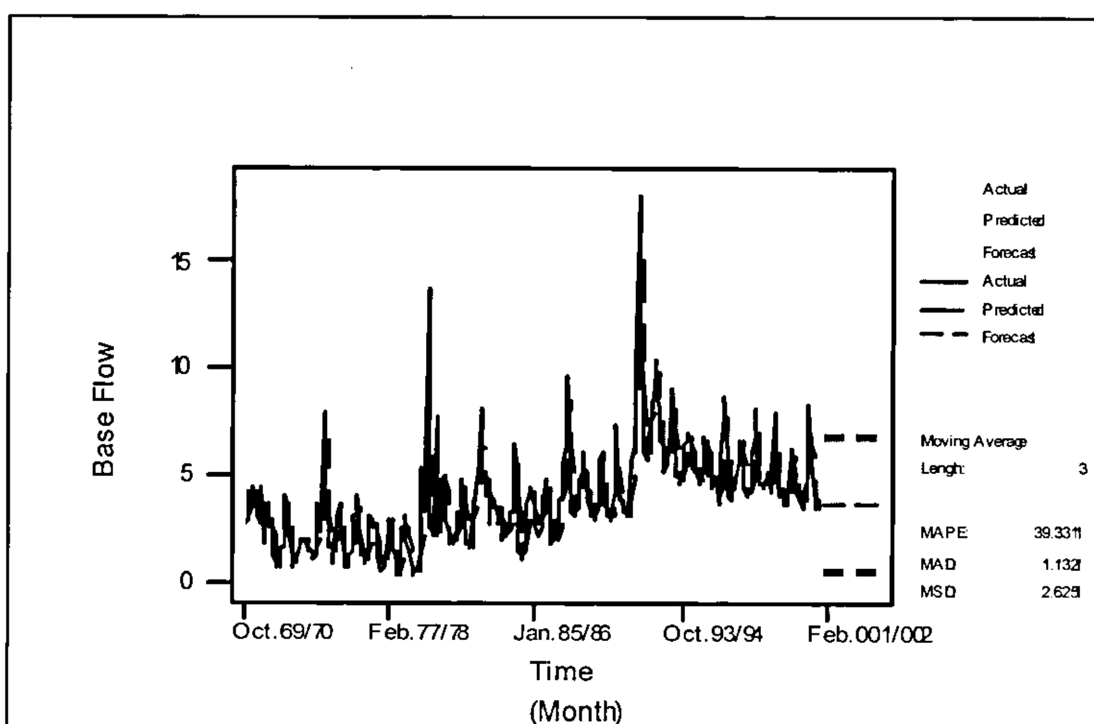


Figure (4.41): Moving Average-MA (3) for Monthly Base Flow for Zarqa River Station.

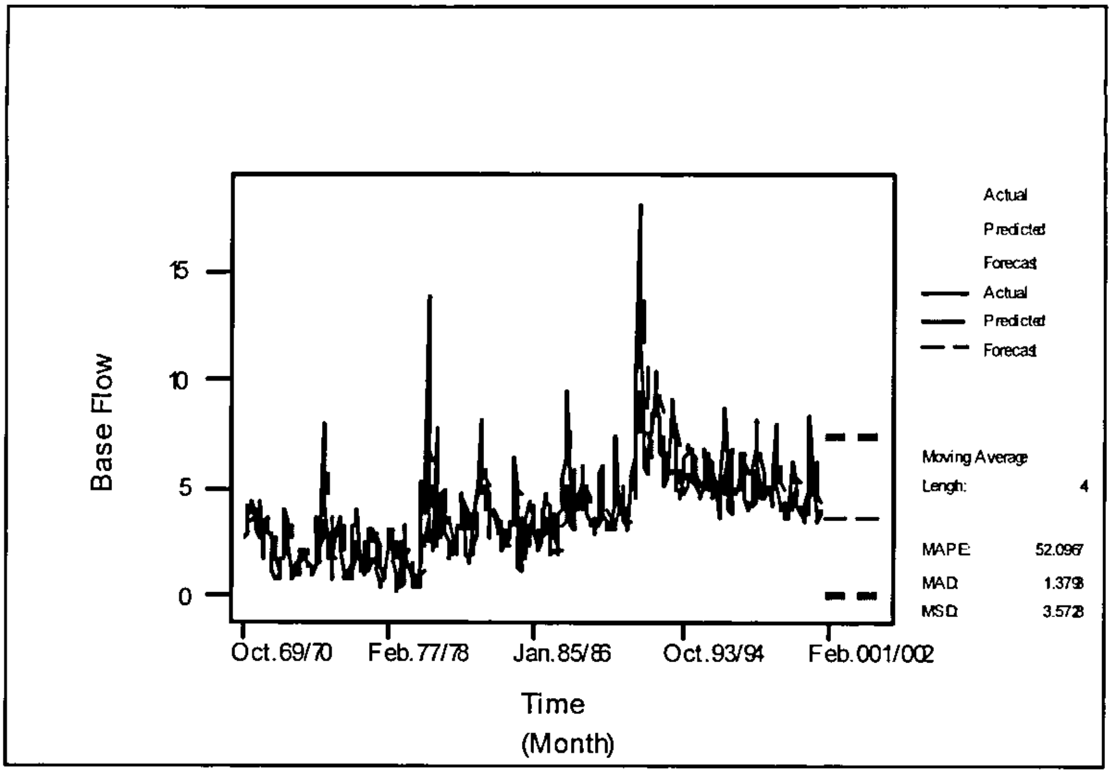


Figure (4.42): Moving Average-MA (4) for Monthly Base Flow for Zarqa River Station.

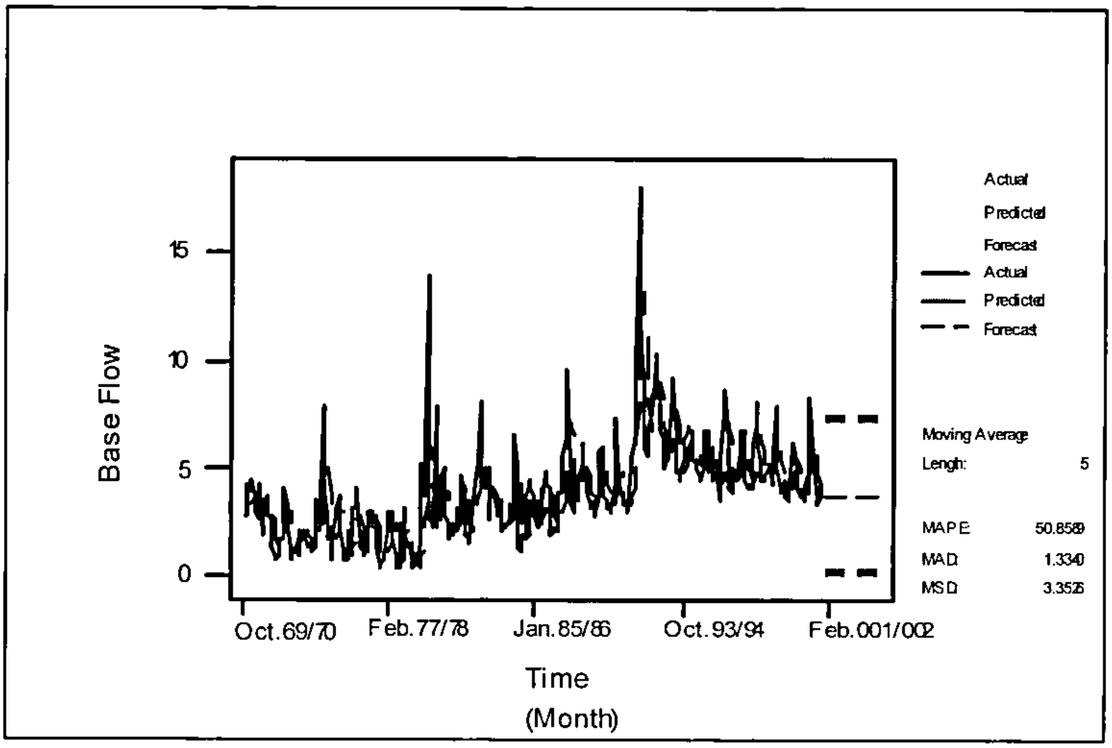


Figure (4.43): Moving Average-MA (5) for Monthly Base Flow for Zarqa River Station.

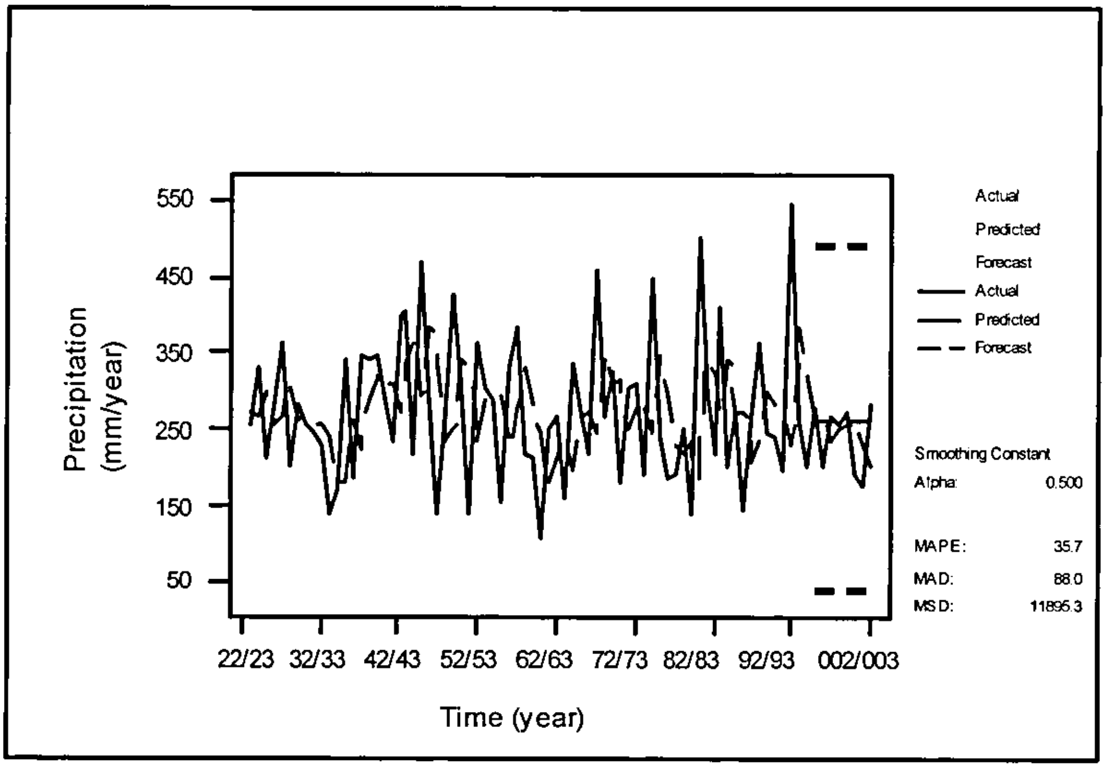


Figure (4.44): Single Exponential Smoothing for Precipitation for Water-Year for Amman-Airport Station.

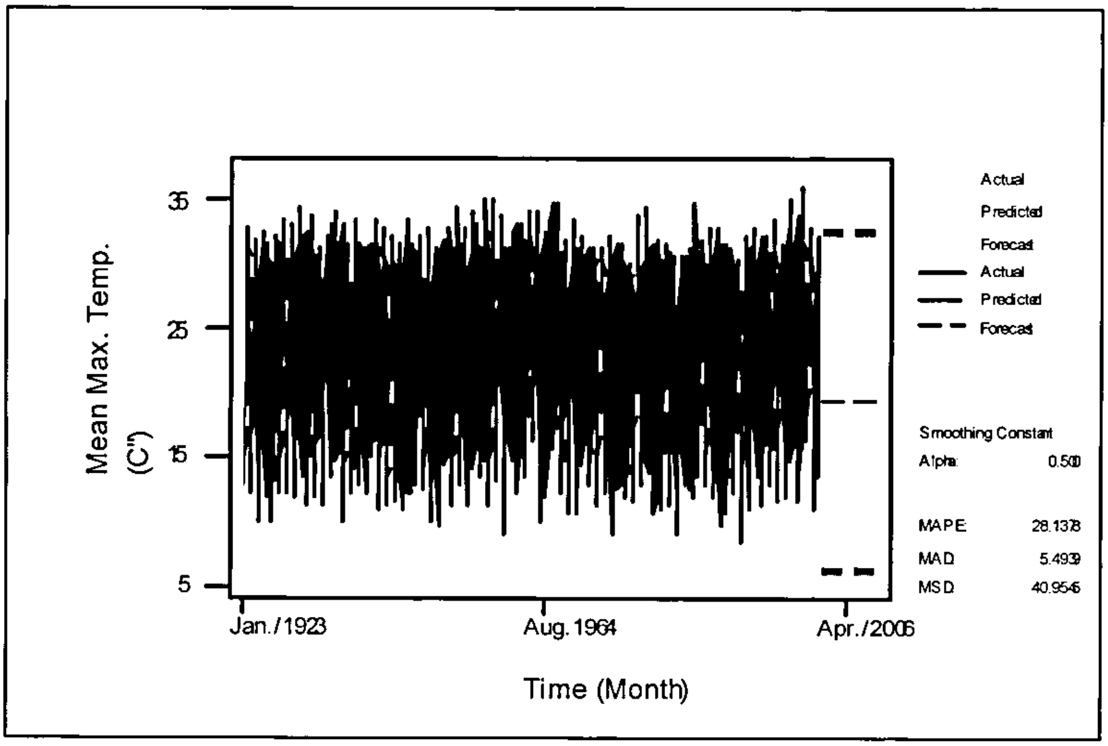


Figure (4.45): Single Exponential Smoothing for Mean Monthly Maximum Temperature for Amman-Airport Station.

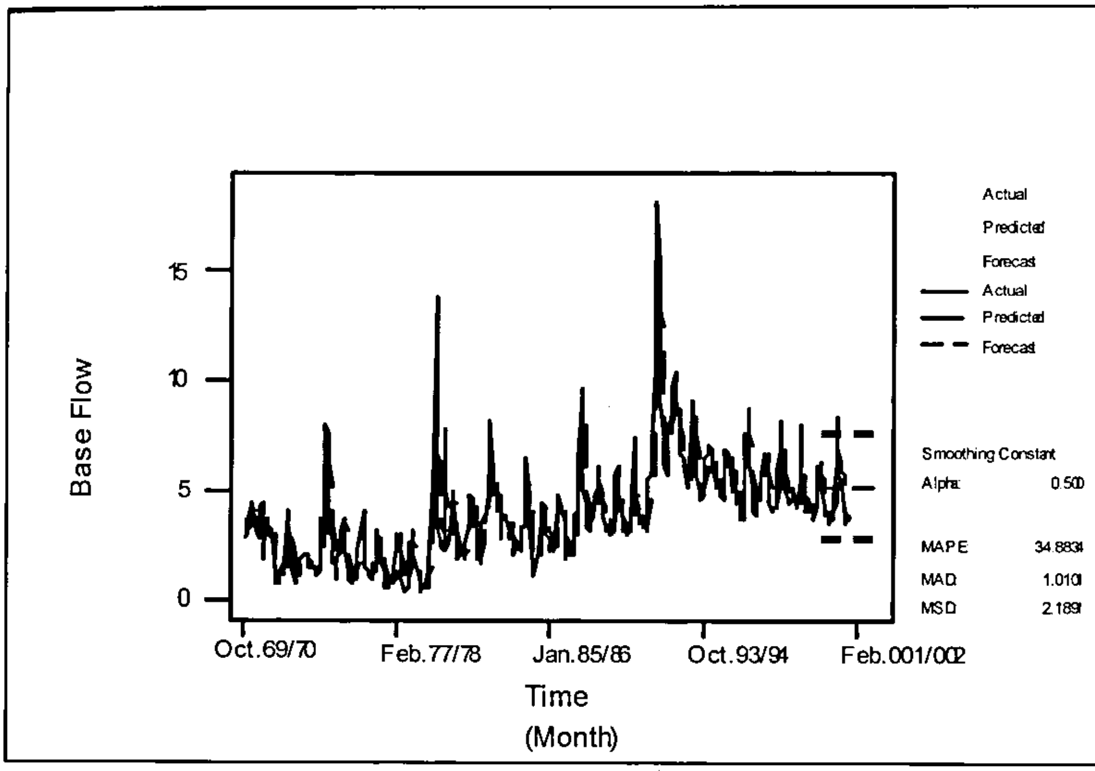
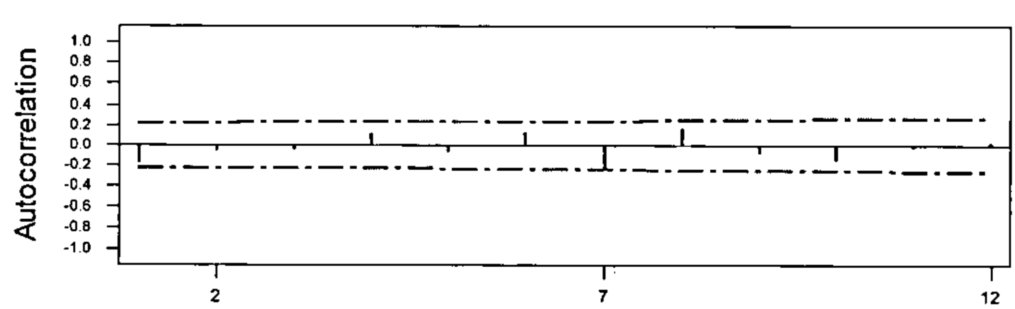
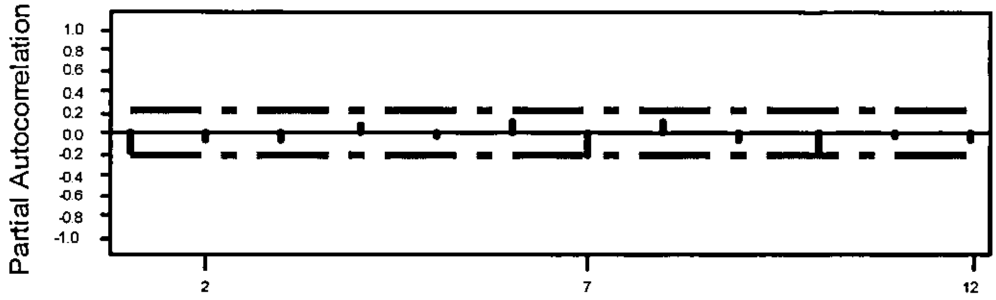


Figure (4.46): Single Exponential Smoothing for Monthly Base Flow for Zarqa River Station.



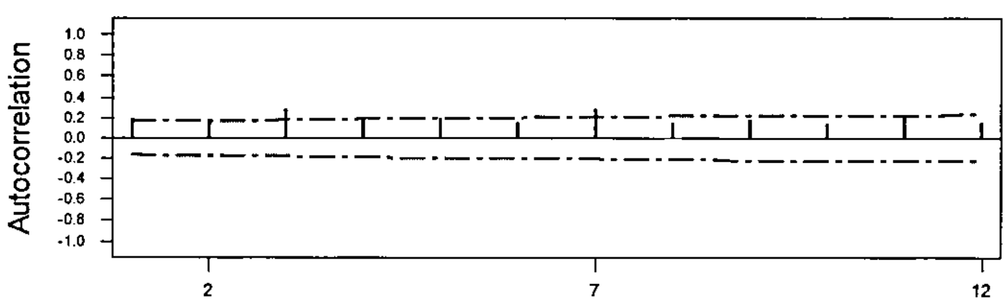
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.17	-1.56	2.54	8	0.17	1.33	13.83
2	-0.05	-0.45	2.76	9	-0.08	-0.60	14.38
3	-0.04	-0.38	2.92	10	-0.14	-1.08	16.20
4	0.11	0.98	4.04	11	-0.02	-0.17	16.24
5	-0.07	-0.57	4.43	12	0.02	0.17	16.29
6	0.13	1.08	5.84				
7	-0.25	-2.07	11.31				

Figure (4.47): Autocorrelation Function for Precipitation of Water-Year record for Amman-Airport Station.



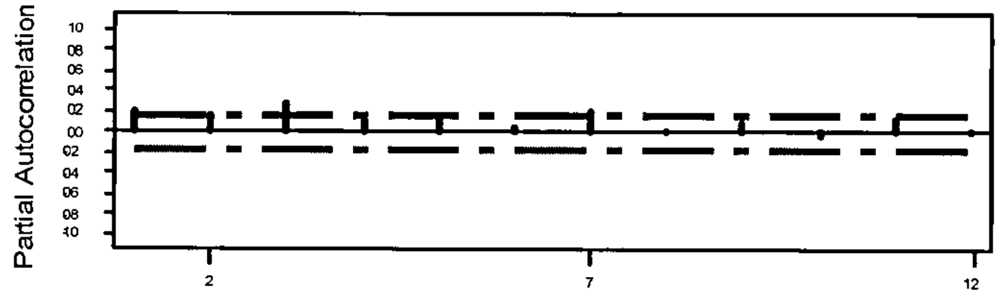
Lag	PAC	T	Lag	PAC	T
1	-0.17	-1.56	8	0.11	0.96
2	-0.08	-0.76	9	-0.07	-0.59
3	-0.07	-0.64	10	-0.19	-1.74
4	0.09	0.82	11	-0.02	-0.18
5	-0.04	-0.33	12	-0.09	-0.81
6	0.13	1.13			
7	-0.21	-1.91			

Figure (4.48): Partial Autocorrelation Function for Precipitation of Water-Year record for Amman-Airport Station.



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.20	2.32	5.48	8	0.15	1.41	55.01
2	0.18	2.08	10.28	9	0.18	1.66	60.21
3	0.29	3.26	22.87	10	0.14	1.23	63.21
4	0.21	2.14	29.13	11	0.21	1.80	69.79
5	0.20	2.04	35.28	12	0.16	1.34	73.67
6	0.16	1.56	39.11				
7	0.29	2.74	51.40				

Figure (4.49): Autocorrelation Function for Extended Precipitation record for Amman-Airport Station.



Lag	PAC	T	Lag	PAC	T
1	0.20	2.32	8	0.01	0.09
2	0.15	1.73	9	0.07	0.82
3	0.25	2.95	10	-0.04	-0.42
4	0.11	1.35	11	0.10	1.17
5	0.10	1.23	12	0.01	0.07
6	0.03	0.31			
7	0.19	2.20			

Figure (4.50): Partial Autocorrelation Function for Extended Precipitation for Amman-Airport Station.

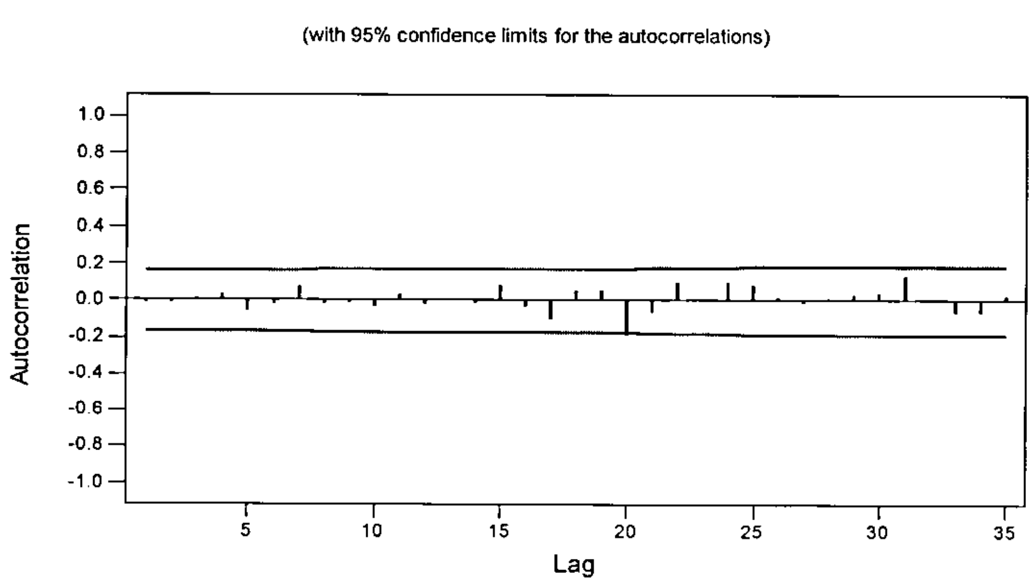


Figure (4.51): Autocorrelation Function of Residuals for Extended Precipitation Record for Amman-Airport Station.

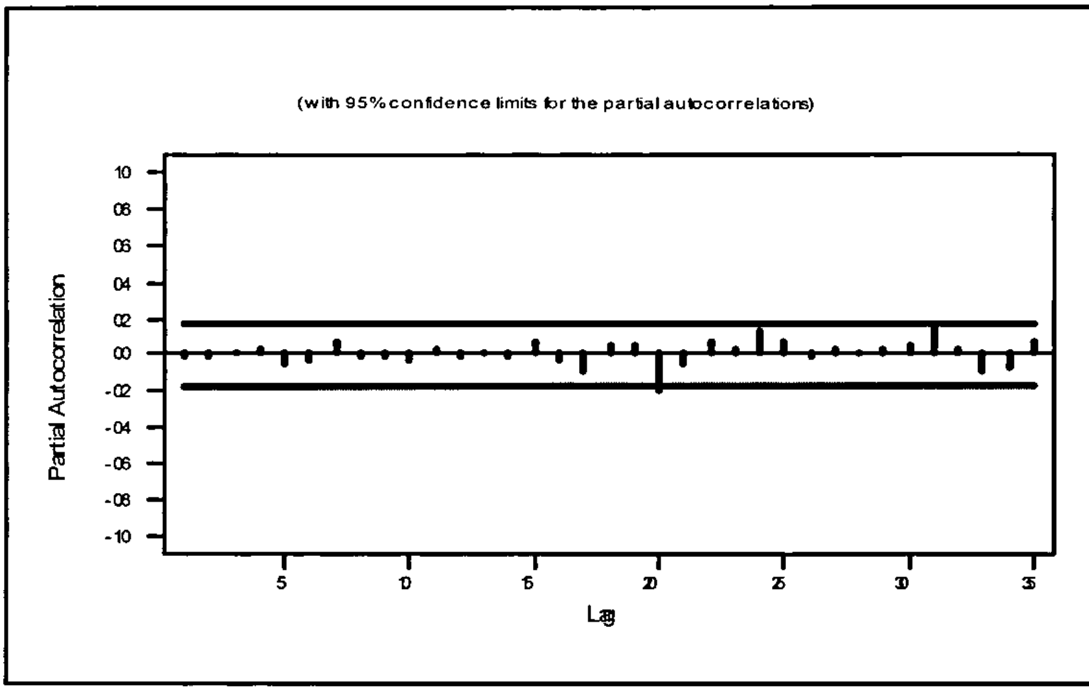
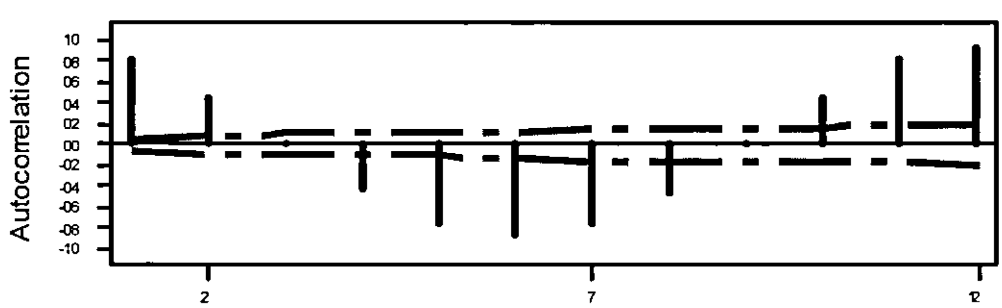
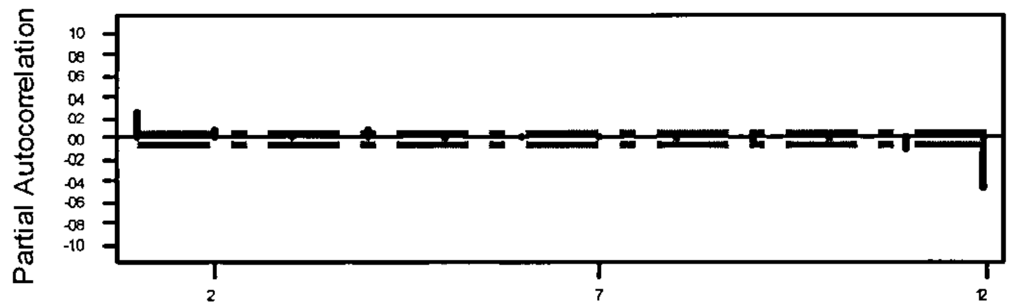


Figure (4.52): Partial Autocorrelation Function of Residuals for Extended Precipitation Record for Amman-Airport Station.



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.82	25.46	650.22	8	-0.46	-5.29	3216.14
2	0.46	9.25	852.13	9	-0.01	-0.12	3216.25
3	-0.01	-0.15	852.19	10	0.45	5.06	3414.33
4	-0.46	-8.52	1054.41	11	0.80	8.75	4039.69
5	-0.78	-13.54	1643.51	12	0.93	9.42	4882.10
6	-0.90	-13.23	2421.63				
7	-0.78	-9.86	3011.35				

Figure (4.53): Autocorrelation Function for Mean Monthly Maximum Temperature for Amman-Airport Station.



Lag	PAC	T	Lag	PAC	T
1	0.24	7.44	8	-0.04	-1.35
2	0.06	1.94	9	-0.03	-0.98
3	0.05	1.68	10	-0.04	-1.28
4	0.07	2.09	11	-0.10	-3.10
5	-0.02	-0.70	12	-0.48	-14.91
6	-0.00	-0.05			
7	0.02	0.55			

Figure (4.56): Partial Autocorrelation Function for Differenced Mean Monthly Maximum Temperature for Amman-Airport Station.

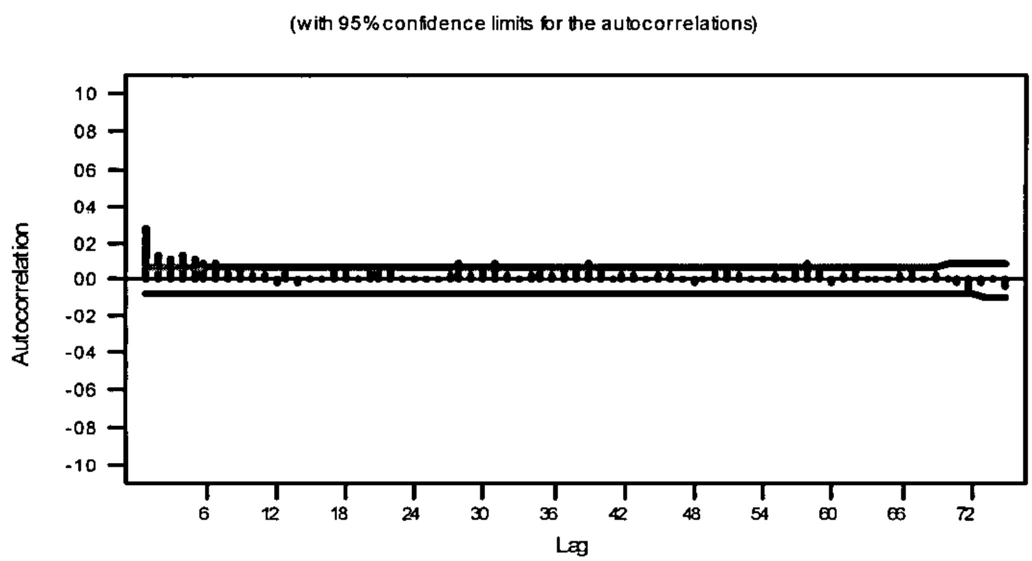
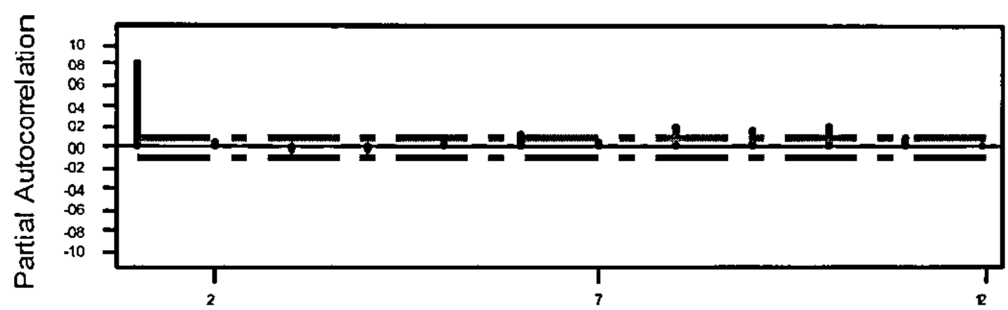
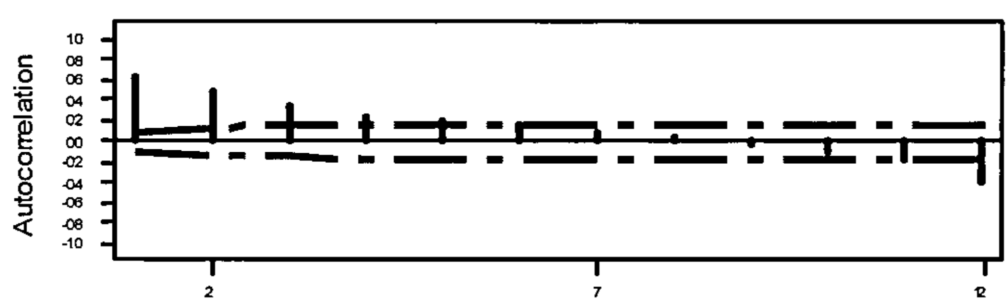


Figure (4.57): Autocorrelation Function of Residuals for Differenced Mean Monthly Maximum Temperature for Amman-Airport Station.



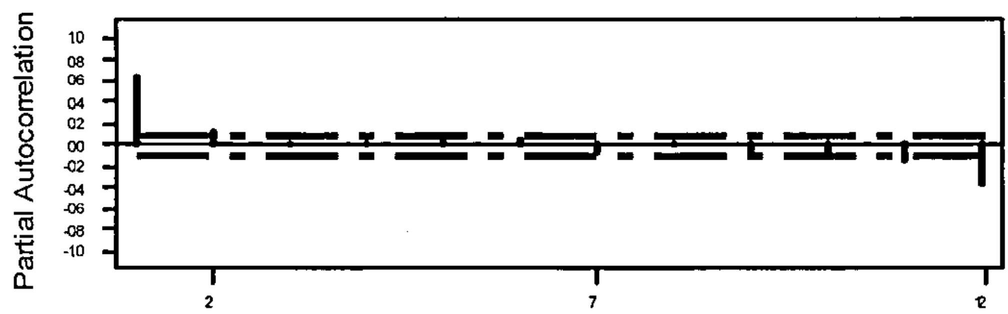
Lag	PAC	T	Lag	PAC	T
1	0.82	16.38	8	0.19	3.71
2	0.05	0.94	9	0.16	3.27
3	-0.05	-0.99	10	0.17	3.30
4	-0.04	-0.89	11	0.09	1.71
5	0.07	1.49	12	0.01	0.24
6	0.13	2.54			
7	0.03	0.70			

Figure (4.60): Partial Autocorrelation Function for Monthly Base Flow for Zarqa River Station.



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.62	12.24	150.93	8	0.04	0.46	312.42
2	0.46	6.74	232.67	9	-0.03	-0.31	312.69
3	0.32	4.23	272.53	10	-0.09	-1.14	316.21
4	0.22	2.75	291.06	11	-0.20	-2.44	332.34
5	0.17	2.09	302.17	12	-0.42	-4.96	401.65
6	0.14	1.73	310.02				
7	0.07	0.83	311.85				

Figure (4.61): Autocorrelation Function for Differenced Monthly Base Flow for Zarqa River Station.



Lag	PAC	T	Lag	PAC	T
1	0.62	12.24	8	-0.00	-0.07
2	0.11	2.22	9	-0.07	-1.36
3	-0.01	-0.15	10	-0.09	-1.68
4	-0.01	-0.28	11	-0.16	-3.19
5	0.03	0.60	12	-0.36	-7.04
6	0.03	0.60			
7	-0.07	-1.43			

Figure (4.62): Partial Autocorrelation Function for Differenced Monthly Base Flow for Zarqa River Station.

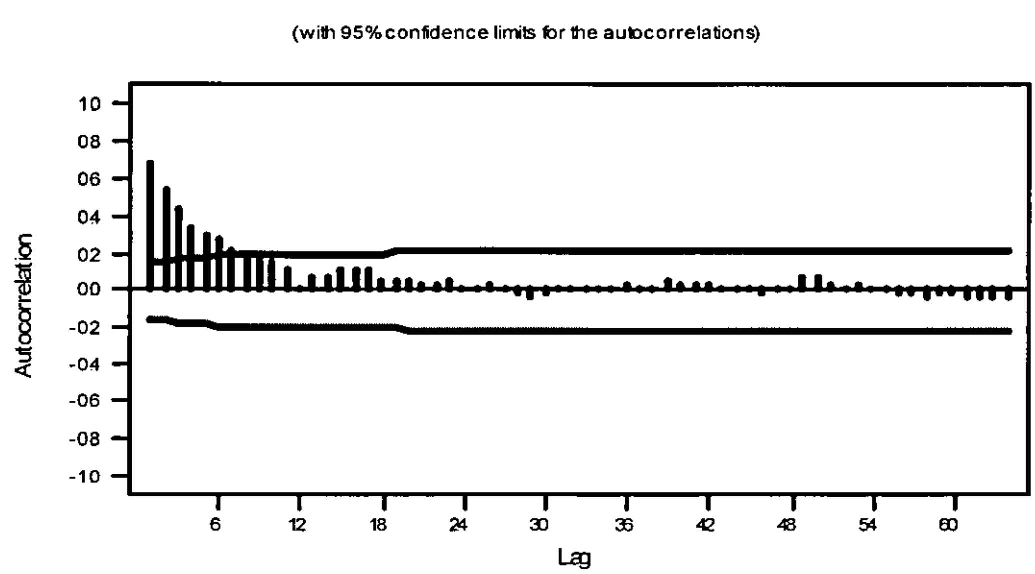


Figure (4.63): Autocorrelation Function of Residuals for Differenced Monthly Base Flow for Zarqa River Station.

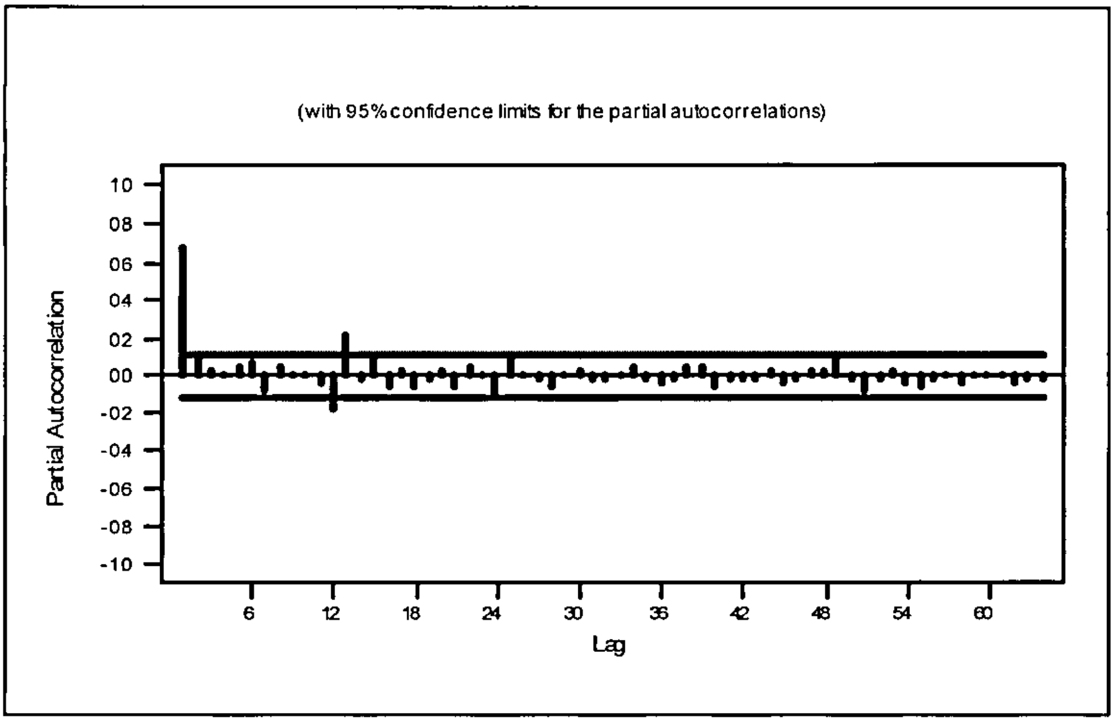


Figure (4.64): Partial Autocorrelation Function of Residuals for Differenced Monthly Base Flow for Zarqa River Station.

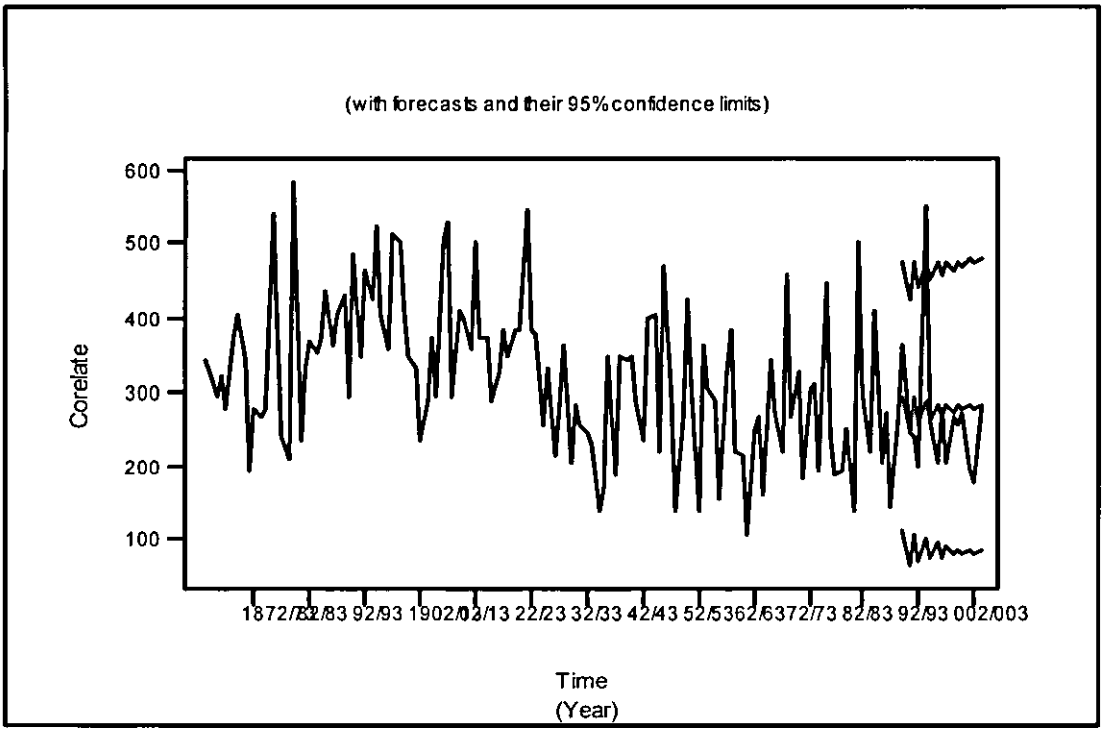


Figure (4.65): Backward Forecasting for 10% of Recorded Data for Extended Precipitation Record for Amman-Airport Station.

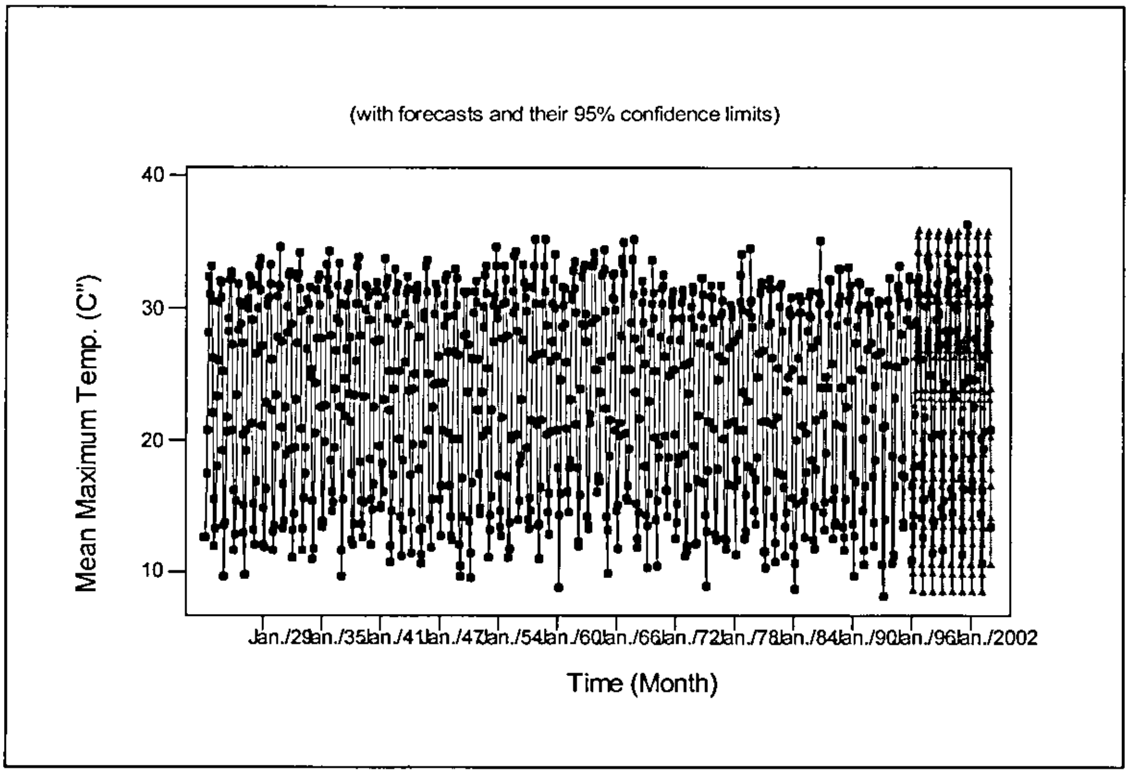


Figure (4.66): Backward Forecasting for 10% of Recorded Data for Mean Monthly Maximum Temperature for Amman-Airport Station.

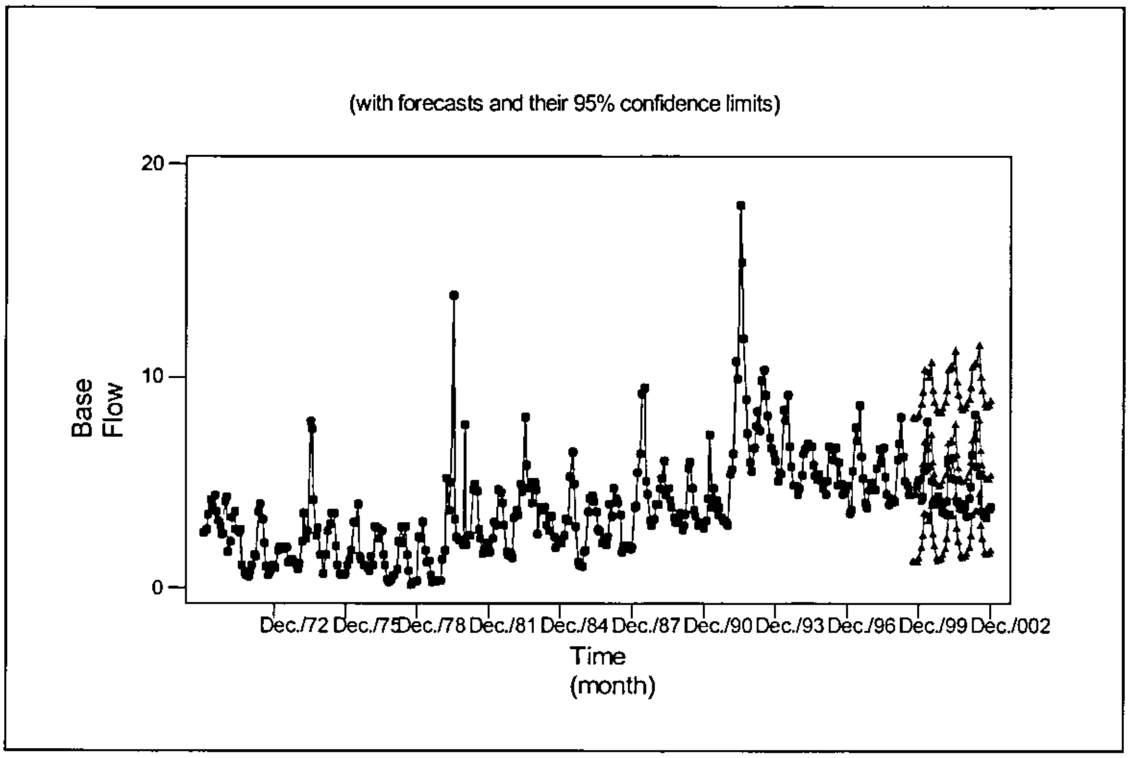


Figure (4.67): Backward Forecasting for 10% of Recorded Data for Monthly Base Flow Record for Zarqa River Station.

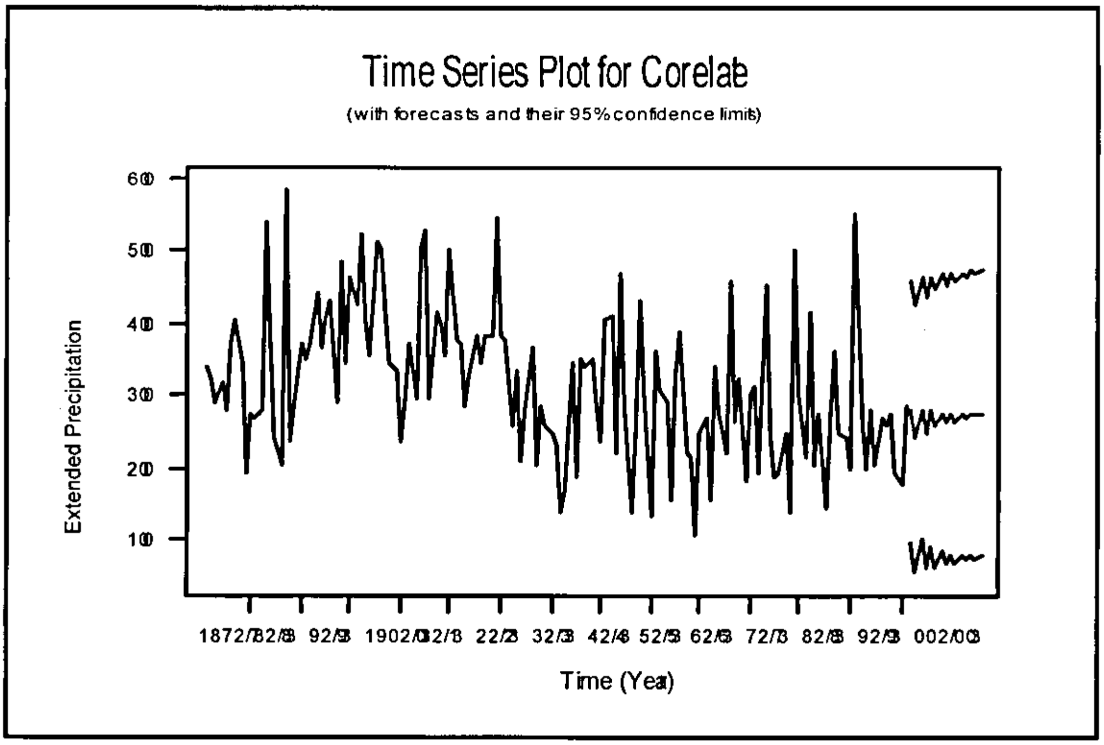


Figure (4.68): Time Series and Forward Forecasting for 10% of Recorded Data for Extended Precipitation Record for Amman-Airport Station.

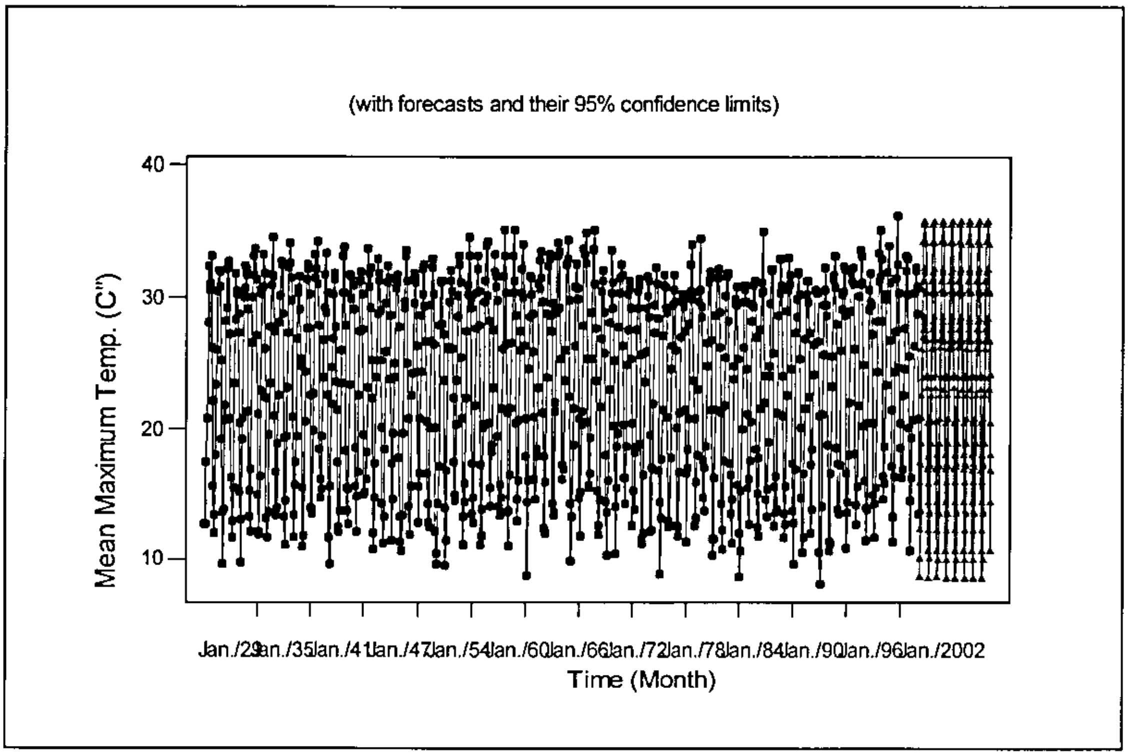


Figure (4.69): Time Series and Backward Forecasting for 10% of Recorded Data for Mean Monthly Maximum Temperature for Amman-Airport Station.

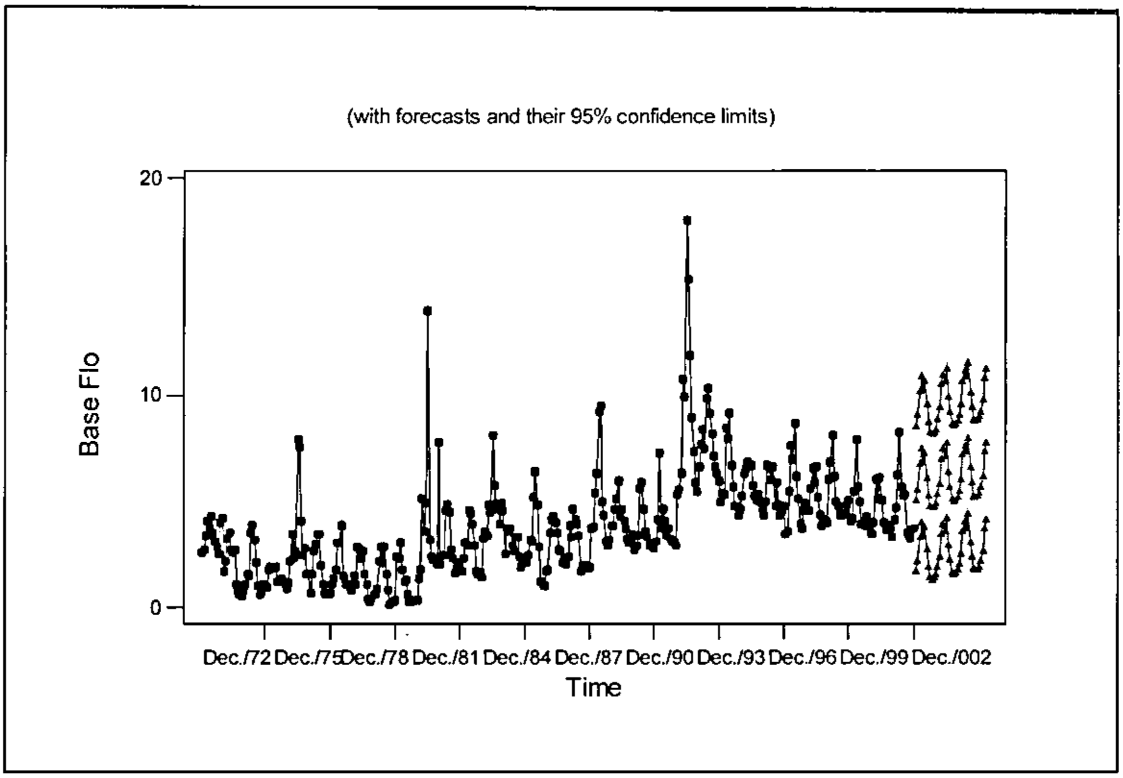


Figure (4.70): Time Series and Backward Forecasting for 10% of Recorded Data for Monthly Base Flow for Zarqa River Station.

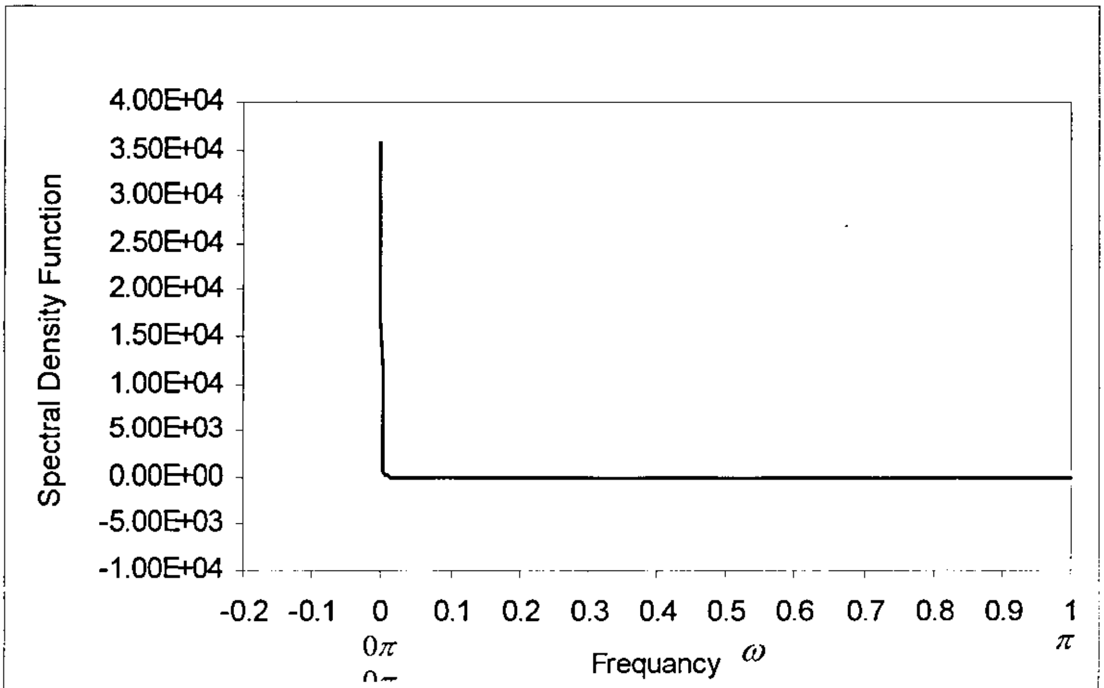


Figure (4.71): The Spectral Density Function for Precipitation of Water-Year Record for Amman-Airport Station.

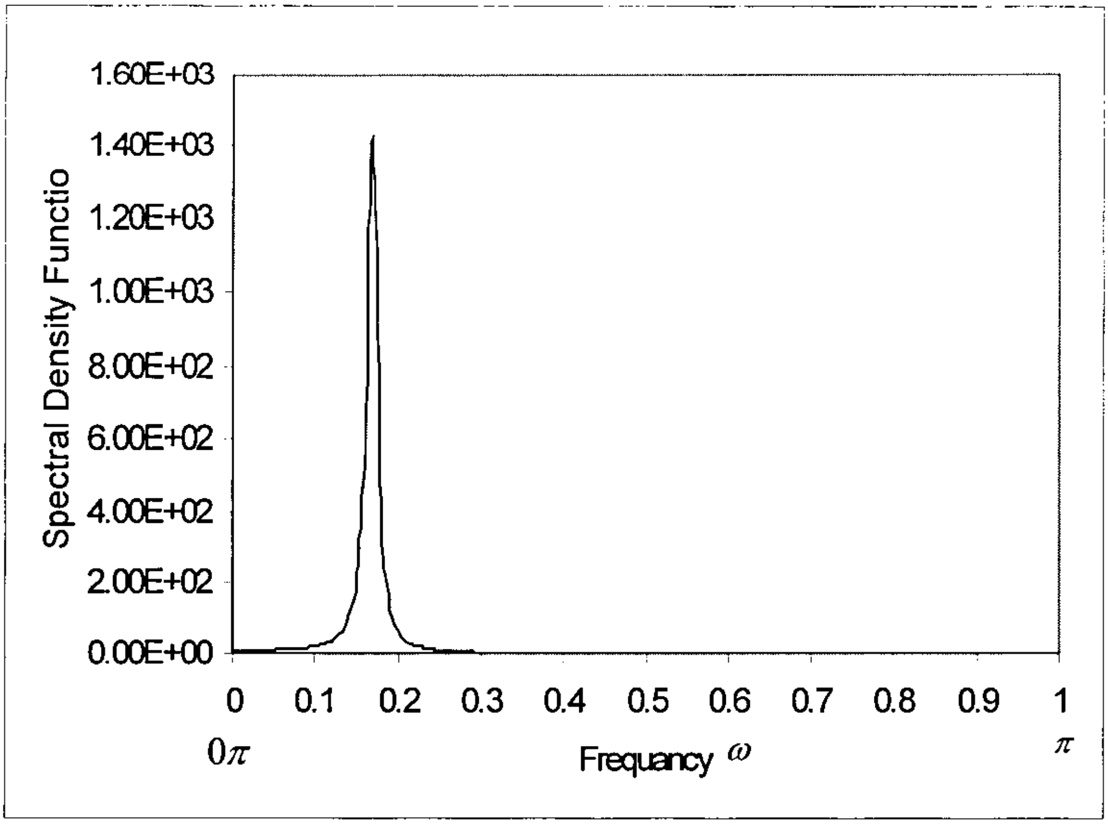


Figure (4.72): The Spectral Density Function for Mean Monthly Maximum Temperature for Amman-Airport Station.

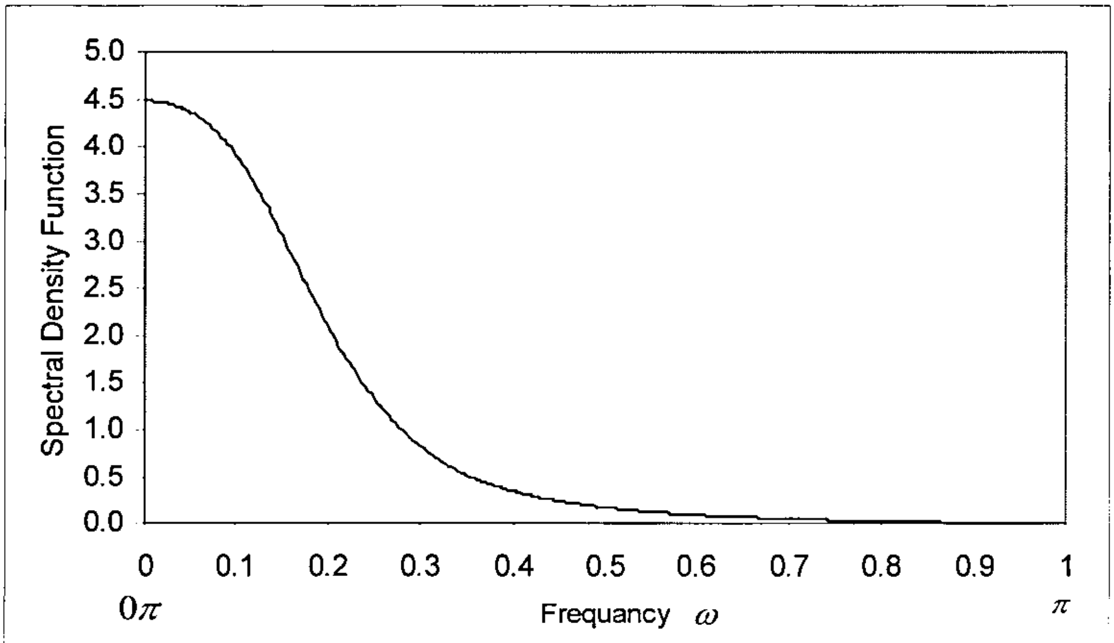


Figure (4.73): The Spectral Density Function for Monthly Base Flow for Zarqa River Station.

5. ANALYSES OF RESULTS

5.1 Introduction

The results are subjected to three types of analysis:

- *10% Forecasting*, which depends on the comparison between the actual observations and 10% of the forecasted data using the best methods.
- *Spatial distribution*, which depends on the classification of the stations according to the nature of climate.
- *Rainfall-Temperature modeling,* which represents the establishing of a relationship between Rainfall and Temperature records.

5.2 Forecasting Analysis

The three measures of accuracy; MAPE, MAD and MSD indicate important results. It was observed from the analyses of time series for all variables shown in Chapter Four of the current study that the ARIMA is the best method and the decomposition (trend plus seasonal) is the second best method in comparison with the other methods, such as trend analysis methods, moving average methods and single exponential smoothing method. This result was in accordance with conclusions of Miao-Hsiang and Jin-King (2000), who used time series models including (ARIMA) modeling and decomposition methods. The result was ARIMA models, which generated more accurate forecasts than the decomposition models. Also, Dahabiyeh (2002) used two main methods for developing the models to predict the future fluctuations in rainfall, and to predict future environmental changes. Those were the exponential smoothing method and the ARIMA method. The predicted rainfall data using the developed models generally showed a decreasing trend. The study of Bani Hani (2002) also utilized deterministic and stochastic (ARIMA) models. The study revealed that the ARIMA model was an appropriate model for forecasting future values.

Figures (5.1) and (5.2) show the comparison between actual and forecasted 10% of the data for Amman-Airport Station. Figure (5.3) show the comparison between actual and forecasted 10% of the data for Zarqa River base flow. Due to the ARIMA modeling behavior in smoothing the data through containing integrated part (Box, et al. 1994), it was observed that the predicted value of precipitation in the water year 2000/2001 increases with respect to its value in the water year 1999/2000,while the observed value decreases.

The main constrain in the analysis of the variables was the length of the records. This resulted in the difficulty of having the best model representing the data. The problem and the suggested solution are discussed below.

For precipitation analyses, there was no suggested ARIMA model in all stations taken in the current study (due to sample size), for example, Amman-Airport station, as shown in Figures (4.16) and (4.17). Therefore, correlations between the precipitation data for Amman-Airport and Irbid with the data for Jerusalem were conducted The precipitation data of the two stations were extended backward to the year 1862, as shown in Table (C.1). Amman-Airport extended data was used to extend Azraq and Shoubak as listed in Table (C.1). But, there was no correlation for precipitation data of Safawi, Mafraq, Jafar and Aqaba-Airport Stations.

Most authors recommended a sample size of at least 50 observations. This can be verified with other researchers such as; Box and Jenkins, (1976), Cook and Campbell, (1979), McCain and McCleary, (1979) and McCleary, et al., (1980). According to Yaffee and McGee, (2000), the minimum number of observations is between 100 and 250.

The three measures of accuracy; MAPE, MAD and MSD estimated from the backward forecast for 10% of the precipitation data were affected by the correlation. Good correlation gives accurate ARIMA model. Table (5.1) summarizes the results of the best ARIMA models. AIC values and model parameters are listed in Table (5.1) for the precipitation before data extension. Table (5.2) summarizes the results of the best ARIMA models, AIC values and model parameters for extended precipitation data.

5.3 Spatial Distribution Modeling

Generalization of estimated ARIMA models was carried out through the current study for the stations have the same climatic conditions. Table (5.3) was developed according to climate regains bounded by Abandah (1993). As an example, both Amman-Airport and Shoubak Stations have the same ARIMA model (3,0,2).

Good accuracy could be achieved through the application of Amman-Airport precipitation ARIMA model on the extended data of Irbid station, as shown in Figure (5.4) and Table (5.4).

Figures (B.91), (B.129) and (B.139) show no ARIMA model for the stations Jafar, Mafraq and Safawi, respectively. The extended precipitation data for Azraq station was used to develop ARIMA model (5,1,1), which was proposed the stations Mafraq and Safawi. A good representation to the above two stations was detected as shown in Figures (5.5) and (5.6) and the results were summarized in Table (5.4).

Figure (5.7) presents a prediction for water year precipitation data for Aqaba-Airport station using ARIMA model (1,0,1), which indicates low accuracy. Application of ARIMA model (1,0,1) on Jafar station also gives low accuracy prediction, as shown in Figure (5.8) and Table (5.4). Aqaba-Airport and Jafar data have short records with high variance, which explains the low accuracy in the prediction. Therefore, it was proposed to use ARIMA models (1,1,1) and (2,1,1) in the precipitation due to the nonstationary of observed data. The results of these applications were summarized in the Table (5.4). It was observed that ARIMA model (2,1,1) is more accurate than ARIMA model (1,1,1) especially for Aqaba-Airport station according to the three measures of accuracy. Figures (5.9) and (5.10) show the comparison between the observed and 10% backward forecasted precipitation for Jafar and Aqaba-Airport stations, respectively.

Table (5.5) summarizes the best ARIMA models for water year precipitation records for the stations considered according to the climate region. Irbid station could be classified as Dry Forest similar to Amman-Airport and Shoubak. Mafraq could be classified as Arid Badia similar to Safawi and Azraq.

The mean monthly maximum temperature analyses were summarized in Table (5.6). Using ARIMA model (1,1,2) indicates high accuracy to represent the mean monthly maximum temperature for Amman-Airport, Irbid and Azraq stations, as shown in Figures (5.11), (5.12) and (5.13), respectively. High accuracy was obtained from using ARIMA model (3,1,4) to represent the mean maximum temperature for Aqaba-Airport and Jafar stations, as shown in the Figures (5.14) and (5.15), respectively.

The mean monthly minimum temperature analyses were summarized in Table (5.7). Using ARIMA model (3,1,2) shows high accuracy in the representing the record for Amman-Airport and Irbid stations, as shown in Figures (5.16) and (5.17), respectively. High accuracy was obtained from using ARIMA model (2,1,2) for Azraq station, as shown in Figure (5.18). ARIMA model (1,1,0) presents high accuracy for Aqaba-Airport station, as shown in the Figures (5.19). Low accuracy was obtained from using ARIMA model (2,1,2) to represent Jafar records, as shown in Table (5.7) and Figure (5.20).

5.4 Rainfall-Temperature Modeling

Precipitation and Temperature are investigated together through a linear correlation between both observed data. Normalization to the mean was considered and the linear regression slope was developed as related variable to both. The procedure of rainfall-temperature modeling for Irbid station is summarizes in the following:

1. Finding the average yearly temperature and the yearly precipitation for all time periods for the station data, as shown in Table (5.9).
2. The mean of average yearly temperature and yearly precipitation was determined as (17.89 C°) and (464.96 mm/year), respectively.
3. The standard deviation of mean yearly temperature and yearly precipitation was determined as (0.66) and (142.22), respectively. Normalization to the mean for average yearly temperature and yearly precipitation was proposed to avoid the difference in units for both variables. The negative values indicate that the values are less than the mean. Equation (5.1) was used to propose normalization:

$$Normalized\ Value = \frac{Observed\ Value - Mean}{Standard\ Deviation} \qquad (5.1)$$

(T_i) and (P_i) represented normalized values of yearly mean temperature and yearly precipitation, respectively.

4. The linear regression between (T_i) and (P_i) was done as shown in Figure (5.21) to determine the value of coefficient (b) in the formula estimated from the linear regression, which is shown as follows:

$$(P_i) = -0.4814\ (T_i) - 0.0015 \qquad (5.2)$$

In this case the value of (b) was equal to (– 0.0015) and correlation coefficient (Cc) is equal to (- 0.4781). The negative sign of Cc gives indication that the relationship between temperature and precipitation is reversible.

5. The values of slop *(a_i)* for any unit time (year) were determined, as shown in the Table (5.9), from the following formula:

$$a_i = \frac{(P_i) - b}{-(T_i)} = \frac{(P_i) - (-0.0015)}{-(T_i)} = \frac{0.0015 - (P_i)}{(T_i)} \tag{5.3}$$

Table (5.9) indicates mean yearly temperature, yearly precipitation, *(T_i)*, *(P_i)* and *(a_i)* for Irbid station.

6. The ARIMA model for the estimated values of slop *(a_i)* was found using Minitab software. In this case, ARIMA model (1,0,0) was estimated from Figures (5.22) and (5.23).
7. The 10% backward forecasting of yearly precipitation was done using two ARIMA models. The first model was estimated from the previous step (i.e. ARIMA model. (1,0,0)) and the second model was estimated from the analysis of extended yearly precipitation for Irbid station (i.e. ARIMA model (2,0,1)), as shown in the Table (5.10). The three measures of accuracy (MAPE, MAD, and MSD) for the two models were estimated and compared with each others, as shown in the Table (5.11), there was a clear effect of temperature on the precipitation. It was observed that ARIMA model (1,0,0) is more accurate than ARIMA model (2,0,1).

Figure (5.24) shows the observed and 10% predicted precipitation for Irbid station using the two ARIMA models mentioned above in step seven.

Table (5.1): Best ARIMA Models, AIC Values and Estimated Parameters for Precipitation Data before Extension.

a. Irbid Station

Observed Data for	Best Model	AIC Values	AR Coefficient ϕ_1	MA Coefficient θ_1
February	(1,0,0)	748.58	0.65251	NA
March	(1,0,1)	693.58	0.99662	0.99598

b. Aqaba-Airport Station

Observed Data for	Best Model	AIC Values	AR Coefficient ϕ_1	MA Coefficient θ_1
Water Year	(1,0,1)	377.06	0.99127	0.99679
Season (Jan. - Mar)	(1,0,0)	360.45	0.45276	NA

c. Azraq Station

Observed Data for	Best Model	AIC Values	AR Coefficient ϕ_1	MA Coefficient θ_1
October	(1,0,1)	412.01	0.81440	0.55103

d. Shoubak Station

Observed Data for	Best Model	AIC Values	AR Coefficient ϕ_1	MA Coefficient θ_1
Water Year	(1,0,1)	805.98	0.98782	0.86351
January	(1,0,1)	714.29	0.99715	0.99786

Table (5.2): Best ARIMA Models, AIC Values and Estimated Parameters for Extended Precipitation Data.

a. Amman Airport Station

Extended Data for	Best Model	AIC Values	AR Coefficients					MA Coefficients	
			ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	θ_1	θ_2
Water Year	(3,0,2)	1651.80	0.00508	0.85072	0.14049	NA	NA	-0.11529	0.87036
Season (Oct. - Dec)	(1,0,1)	1506.68	0.99674	NA	NA	NA	NA	0.96498	NA
Season (Jan. - Mar)	(2,0,1)	1556.56	1.01811	-0.02046	NA	NA	NA	0.95484	NA
November	(0,0,2)	1397.84	NA	NA	NA	NA	NA	-0.32910	-0.38637
December	(1,0,1)	1414.32	0.99623	NA	NA	NA	NA	0.99596	NA
January	(5,1,1)	1463.21	0.00930	-0.12709	-0.06151	-0.05990	-0.13942	0.81994	NA
February	(3,0,2)	1490.20	-0.02515	0.84575	0.17125	NA	NA	0.06317	0.87926

b. Irbid Station

Extended Data for	Best Model	AIC Values	AR Coefficients		MA Coefficient
			ϕ_1	ϕ_2	θ_1
Water Year	(2,0,1)	1774.13	1.07844	-0.93093	0.93093
Season (Jan. - Mar)	(2,0,1)	1663.43	1.10862	-0.10993	0.92960
January	(1,0,1)	1485.20	0.99704	NA	0.99429
February	(2,0,1)	1475.67	0.97547	0.02169	0.99420

Table (5.2): Continue

c. Azraq Station

Extended Data for	Best Model	AIC Values	AR Coefficients					MA Coefficients	
			ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	θ_1	θ_2
Water Year	(5,1,1)	134419.00	-0.10593	-0.11337	-0.11644	-0.19867	-0.10767	0.61465	NA
Season (Oct. - Dec)	(2,0,1)	1243.07	0.95371	NA	NA	NA	NA	0.92673	NA
Season (Jan. - Mar)	(1,0,2)	1203.56	0.99625	NA	NA	NA	NA	0.83346	0.16322
November	(1,0,1)	1054.35	0.99429	0.80067	NA	NA	NA	0.93647	NA
December	(3,0,2)	1045.13	-0.06256	0.80067	0.25114	NA	NA	-0.06313	0.91077
January	(3,0,2)	982.33	0.42761	0.64902	-0.08179	NA	NA	0.08655	0.88628
February	(1,0,1)	1024.03	0.99752	NA	NA	NA	NA	0.99706	NA
March	(1,0,1)	983.43	0.99526	NA	NA	NA	NA	0.99626	NA

d. Shoubak Station

Extended Data for	Best Model	AIC Values	AR Coefficients			MA Coefficients	
			ϕ_1	ϕ_2	ϕ_3	θ_1	θ_2
Water Year	(3,0,2)	1685.93	0.12843	0.67522	0.18532	-0.20290	0.62896
Season (Oct. - Dec)	(2,0,1)	1518.60	0.98280	0.03110	NA	0.99729	NA
Season (Jan. - Mar)	(3,0,1)	1602.73	1.17176	-0.21455	0.03976	0.88584	NA
November	(1,0,1)	1308.72	0.99509	NA	NA	0.93046	NA
December	(1,0,1)	1477.90	0.99648	NA	NA	0.99392	NA
January	(3,0,1)	1484.34	1.02926	-0.03374	0.00103	0.91488	NA
March	(1,0,1)	1449.34	0.98712	NA	NA	0.78088	NA

Table (5.3): Stations According to the Climate Region

Station	The Nature of Climate Region
Amman-Airport	Dry Forest
Shoubak	Dry Forest
Irbid	Semi-Wet
Mafraq	Semi-Arid (Steep)
Safawi	Arid Badia
Azraq	Arid Badia
Jafar	True Desert
Aqaba-Airport	True Desert

Table (5.4): Applications of ARIMA Models and Three Accuracy Measures (MAPE, MAD and MSD) for 10% Backward Forecasting of Water Year Precipitation

ARIMA Model Identification	MAPE	MAD	MSD
Extended Precipitation for Amman-Airport Station Using ARIMA Model (3,0,2)	21.21	55.79	7413.76
Extended Precipitation for Shoubak Station Using ARIMA Model (3,0,2)	43.93	106.56	13618.75
Extended Precipitation for Irbid Station Using ARIMA Model (2,0,1)	22.24	97.86	20533.00
Extended Precipitation for Irbid Station Using ARIMA Model (3,0,2) out of Extended Precipitation for Amman-Airport Station	22.27	97.97	20471.83
Mafraq Station Using ARIMA Model (5,1,1) out of Extended Precipitation for Azraq Station	24.66	36.24	1756.37
Safawi Station Using ARIMA Model (5,1,1) out of Extended Precipitation for Azraq Station	19.83	10.52	247.87
Aqaba-Airport Station Using ARIMA Model (1,0,1)	86.94	12.38	207.71
Aqaba-Airport Station Using ARIMA Model (1,1,1)	71.47	9.78	138.62
Aqaba-Airport Station Using ARIMA Model (2,1,1)	49.26	9.12	87.69
Jafar Station Using ARIMA Model (1,0,1) out of Aqaba-Airport Station	95.02	16.40	316.23
Jafar Station Using ARIMA Model (1,1,1)	97.22	16.34	333.78
Jafar Station Using ARIMA Model (2,1,1)	74.88	13.88	229.72

Table (5.5): Best ARIMA Model According to Climate Regions

Station	Climate Region	The Best ARIMA MODEL
Amman-Airport	Dry Forest	(3,0,2)
Shoubak		
Irbid	Semi-Wet*	(3,0,2)
Mafraq	Semi-Arid (Steep)*	(5,1,1)
Safawi	Arid Badia	(5,1,1)
Azraq		
Jafar	True Desert	(2,1,1)
Aqaba-Airport		

* As classified by Abandah (1993).

Table (5.6): ARIMA Models and Three Accuracy Measures (MAPE, MAD and MSD) for 10% Backward Forecasting for Mean Monthly Maximum Temperature

ARIMA Model Identification	MAPE	MAD	MSD
Amman-Airport Using ARIMA Model (2,1,2)	7.03	1.47	4.71
Amman-Airport Using ARIMA Model (1,1,2) out of Irbid	6.82	1.45	4.68
Irbid Using ARIMA Model (2,1,2) out of Amman-Airport	10.23	2.38	9.84
Irbid Using ARIMA Model (1,1,2)	10.00	2.34	9.50
Azraq Using ARIMA Model (1,1,2)	3.48	0.79	1.38
Aqaba-Airport Using ARIMA Model (3,1,4)	3.55	1.09	1.91
Aqaba-Airport Using ARIMA Model (1,1,2)	3.64	1.12	1.97
Jafar Using ARIMA Model (3,1,4)	4.63	1.20	2.92
Jafar Using ARIMA Model (1,1,2)	5.05	1.33	3.17

Table (5.7): ARIMA Models and Three Accuracy Measures (MAPE, MAD and MSD) for 10% Backward Forecasting for Mean Monthly Minimum Temperature

ARIMA Model Identification	MAPE	MAD	MSD
Amman-Airport Using ARIMA Model (3,1,2)	13.00	1.24	2.25
Amman-Airport Using ARIMA Model (2,1,2) out of Irbid	12.99	1.24	2.25
Irbid Using ARIMA Model (3,1,2) out of Amman-Airport	8.52	1.01	1.67
Irbid Using ARIMA Model (2,1,2)	8.90	1.05	1.78
Azraq Using ARIMA Model (2,1,2)	9.00	0.52	0.46
Aqaba-Airport Using ARIMA Model (2,1,2)	7.36	1.38	2.71
Aqaba-Airport Using ARIMA Model (1,1,0)	6.21	1.23	2.42
Jafar Using ARIMA Model (2,1,2)	38.69	1.04	1.64
Jafar Using ARIMA Model (1,1,0)	41.43	1.16	2.11

Table (5.8): Best ARIMA Model for Mean Monthly Maximum and Minimum Temperature

<table>
<tr><th rowspan="2">Station</th><th colspan="2">Best ARIMA MODEL</th></tr>
<tr><th>Mean Max. Temp.</th><th>Mean Min.. Temp.</th></tr>
<tr><td>Amman-Airport</td><td rowspan="3">(1,1,2)</td><td rowspan="4">(2,1,2)</td></tr>
<tr><td>Irbid</td></tr>
<tr><td>Azraq</td></tr>
<tr><td>Jafar</td><td rowspan="2">(3,1,4)</td></tr>
<tr><td>Aqaba-Airport</td><td>(1,1,0)</td></tr>
</table>

Table (5.9): Mean Yearly Temperature, Yearly Precipitation, *(T_i)*, *(P_i)* and Determination of *(a_i)* Values for Irbid Station.

Year	Mean Yearly Temperature (C°)	Yearly Precipitation (mm / year)	Normalized Value of Temperature (T_i)	Normalized Value of Precipitation (P_i)	a_i
22/23	18.75	445.7	1.31	-0.14	0.10
23/24	18.14	536.4	0.37	0.50	-1.34
24/25	17.60	389.9	-0.44	-0.53	-1.19
25/26	17.71	476.3	-0.28	0.08	0.28
26/27	17.82	578.2	-0.11	0.80	7.33
27/28	18.55	378.6	0.99	-0.61	0.61
28/29	17.78	479.7	-0.16	0.10	0.63
29/30	17.98	446.8	0.14	-0.13	0.94
30/31	18.25	433.4	0.55	-0.22	0.41
31/32	17.97	412.2	0.12	-0.37	3.17
32/33	17.35	287.6	-0.82	-1.25	-1.53
33/34	17.94	331.1	0.08	-0.94	11.54
34/35	18.69	552.0	1.21	0.61	-0.50
35/36	18.24	357.7	0.53	-0.75	1.43
36/37	18.46	555.9	0.87	0.64	-0.73
37/38	18.08	490.1	0.29	0.18	-0.60
38/39	17.94	748.4	0.07	1.99	-27.19
39/40	17.97	531.0	0.13	0.46	-3.64
40/41	18.67	536.0	1.19	0.50	-0.42
41/42	17.94	816.0	0.07	2.47	-35.18
42/43	16.89	756.9	-1.51	2.05	1.36
43/44	18.44	352.0	0.83	-0.79	0.95
44/45	17.38	579.9	-0.77	0.81	1.05
45/46	17.37	331.8	-0.78	-0.94	-1.20
46/47	18.83	192.5	1.43	-1.92	1.34
47/48	17.84	276.2	-0.08	-1.33	-17.10
48/49	16.68	608.9	-1.84	1.01	0.55
49/50	17.81	508.5	-0.12	0.31	2.44
50/51	18.73	312.0	1.27	-1.08	0.84

Table (5.9): Continue

Year	Mean Yearly Temperature (C°)	Yearly Precipitation (mm / year)	Normalized Value of Temperature (T_i)	Normalized Value of Precipitation (P_i)	a_i
51/52	17.93	685.0	0.06	1.55	-23.85
52/53	18.04	654.2	0.23	1.33	-5.86
53/54	17.91	375.5	0.04	-0.63	16.78
54/55	18.64	231.3	1.14	-1.64	1.45
55/56	18.28	487.3	0.60	0.16	-0.26
56/57	17.73	447.2	-0.24	-0.12	-0.53
57/58	18.19	422.2	0.46	-0.30	0.66
58/59	17.37	300.6	-0.79	-1.16	-1.47
59/60	18.68	211.7	1.19	-1.78	1.50
60/61	18.19	368.6	0.45	-0.68	1.51
61/62	18.18	470.3	0.44	0.04	-0.08
62/63	18.76	386.4	1.32	-0.55	0.42
63/64	17.27	523.1	-0.94	0.41	0.43
64/65	17.96	464.8	0.11	0.00	0.02
65/66	17.79	398.4	-0.15	-0.47	-3.15
67/68	17.68	519.1	-1.46	2.03	1.39
68/69	17.80	576.1	-0.31	0.38	1.21
69/70	18.04	474.1	-0.13	0.78	6.00
70/71	17.40	603.5	0.23	0.06	-0.27
71/72	16.78	486.1	-0.75	0.97	1.30
72/73	17.54	348.5	-1.68	0.15	0.09
73/74	17.04	628.9	-0.53	-0.82	-1.54
74/75	17.52	350.7	-1.29	1.15	0.89
75/76	16.54	442.9	-0.56	-0.80	-1.44
76/77	18.00	415.7	-2.05	-0.16	-0.08
77/78	17.82	427.0	0.16	-0.35	2.17
78/79	18.33	241.3	-0.11	-0.27	-2.42
79/80	17.40	742.7	0.66	-1.57	2.39
80/81	17.76	427.4	-0.74	1.95	2.65
81/82	17.43	411.5	-0.20	-0.26	-1.33
82/83	16.43	617.4	-0.70	-0.38	-0.54
83/84	17.34	446.7	-2.21	1.07	0.48
84/85	17.55	484.8	-0.83	-0.13	-0.16
85/86	18.02	395.8	-0.52	0.14	0.27
86/87	17.30	597.8	0.20	-0.49	2.46
87/88	17.76	565.4	-0.90	0.93	1.04
88/89	17.53	305.9	-0.19	0.71	3.65
89/90	17.23	463.6	-0.55	-1.12	-2.03
90/91	18.12	403.5	-1.01	-0.01	-0.01
91/92	16.38	912.9	0.35	-0.43	1.24
92/93	17.25	460.8	-2.30	3.15	1.37
93/94	18.73	356.6	-0.98	-0.03	-0.03

Table (5.9): Continue

Year	Mean Yearly Temperature (C°)	Yearly Precipitation (mm / year)	Normalized Value of		a_i
			Temperature (T_i)	Precipitation (P_i)	
94/95	17.95	427.1	0.09	-0.27	2.94
95/96	17.77	386.6	-0.19	-0.55	-2.96
96/97	17.33	506.4	-0.84	0.29	0.34
97/98	18.26	525.2	0.56	0.42	-0.76
98/99	19.33	216.8	2.18	-1.74	0.80
99/000	19.01	353.8	1.70	-0.78	0.46
000/001	19.95	294.3	3.13	-1.20	0.38
001/002	19.08	497.4	1.81	0.23	-0.13

Table (5.10): Observed and 10% Backward Forecasting for Precipitation for Irbid Station Using Two Different ARIMA Models

Year	Actual Precipitation (mm / year)	Forecasted Precipitation Using (2,0,1) Model (mm / year)	Forecasted Precipitation Using (1,0,0) Model (mm / year)
92/93	460.80	473.68	464.68
93/94	356.60	469.92	464.95
94/95	427.10	467.67	464.97
95/96	386.60	466.44	464.97
96/97	506.40	465.77	464.97
97/98	525.20	465.41	464.97
98/99	216.80	465.21	464.97
99/000	353.80	465.10	464.97
000/001	294.30	465.05	464.97
001/002	497.40	465.01	464.97

Table (5.11): Comparison between Three Accuracy Measures for 10% Backward Forecasting Precipitation for Irbid Station Using Two Different ARIMA Models

Measures of Accuracy	Type of ARIMA	
	(2,0,1)	(1,0,0)
MAPE	29.47	29.04
MAD	90.99	89.26
MSD	13055.11	12880.44

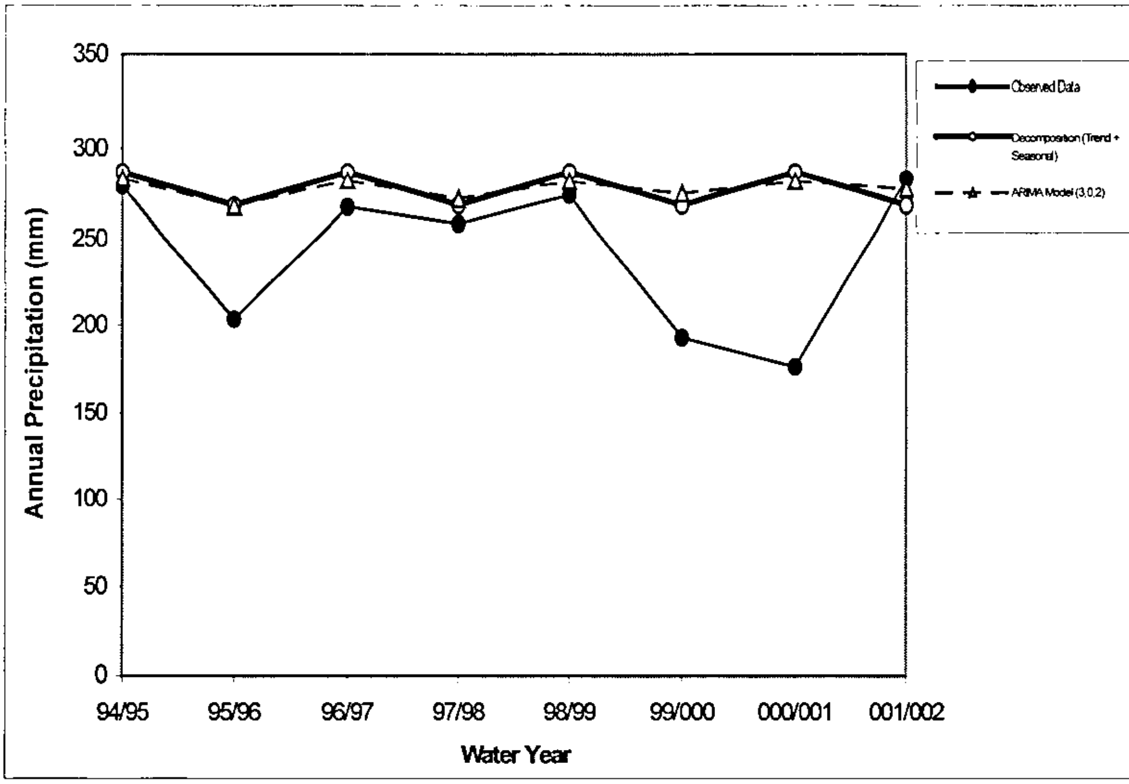


Figure (5.1): Comparison between Original and Predicted 10% of Data for Amman-Airport Precipitation.

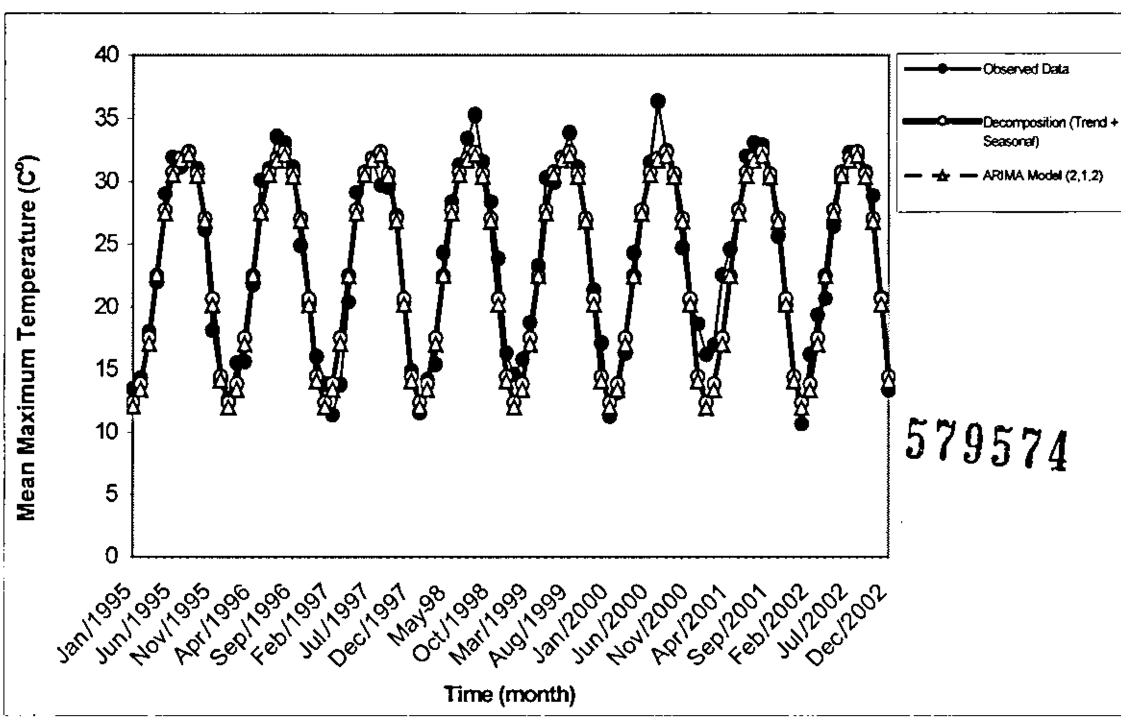


Figure (5.2): Comparison between Original and Predicted 10% of Mean Monthly Maximum Temperature for Amman-Airport Station.

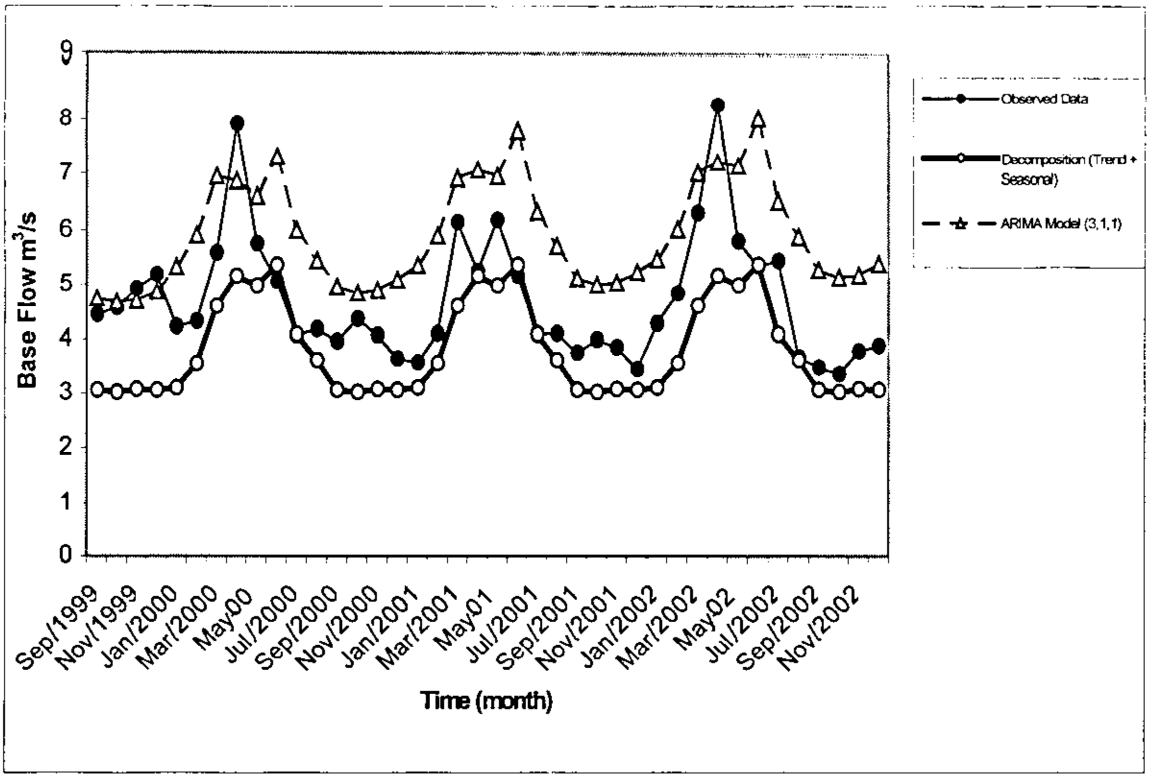


Figure (5.3): Comparison between Original and Predicted 10% Monthly Base Flow of Zarqa River Station

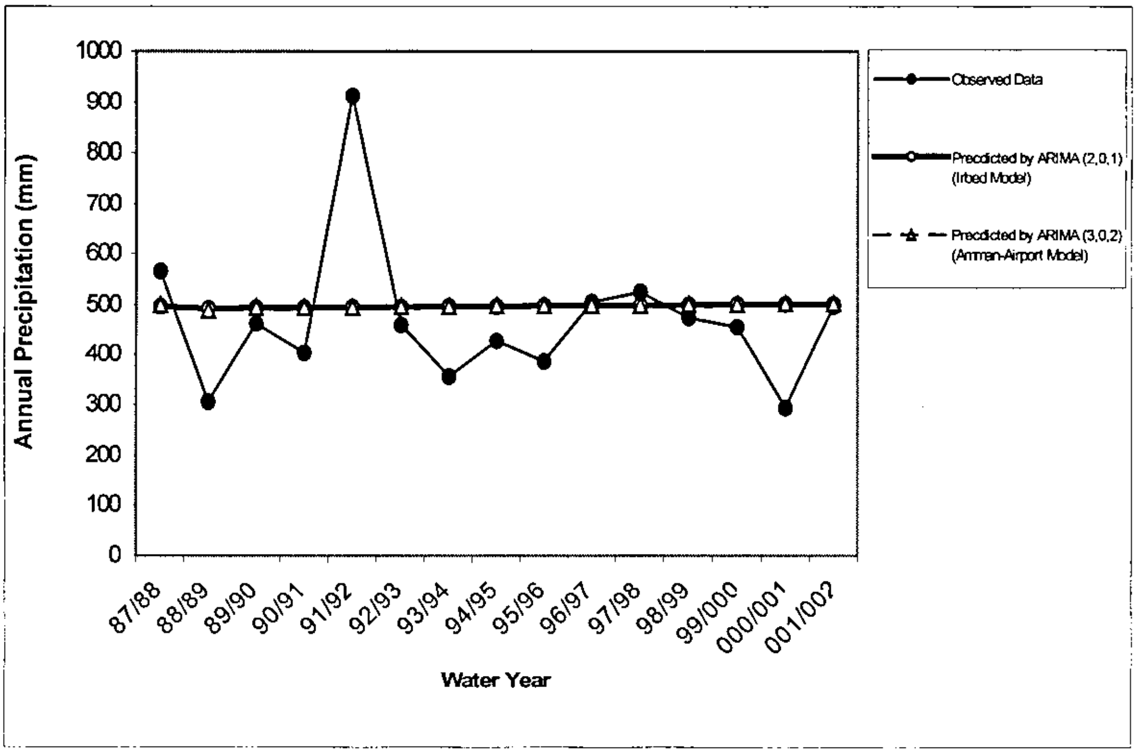


Figure (5.4): Observed and 10% Predicted Precipitation of Irbid Station Using Two Different ARIMA Models

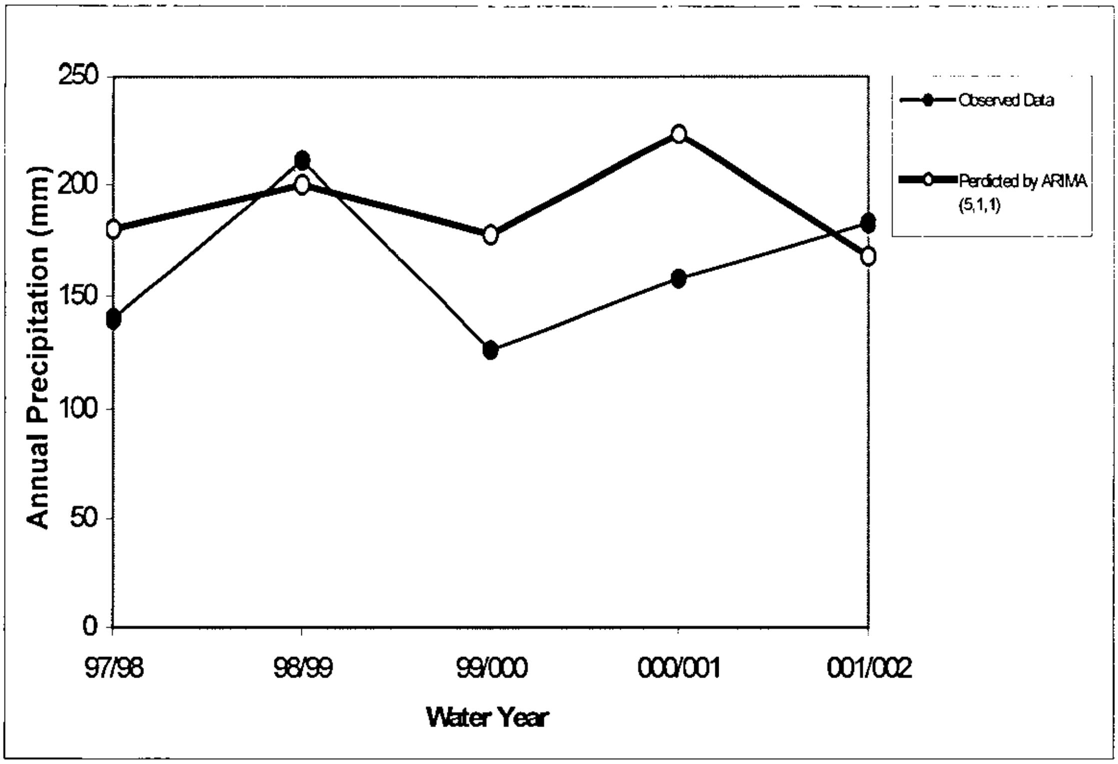


Figure (5.5): Observed and 10% Predicted Precipitation for Mafraq Station Using ARIMA Model (5,1,1,)

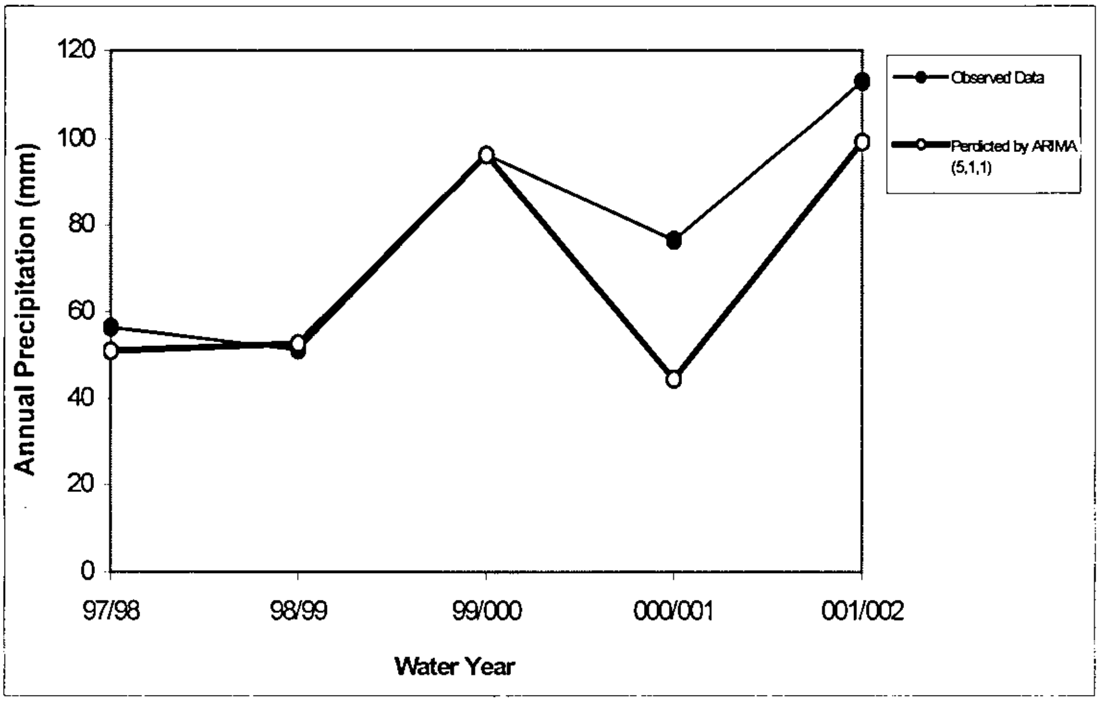


Figure (5.6): Observed and 10% Predicted Precipitation for Safawi Station Using ARIMA Model (5,1,1,)

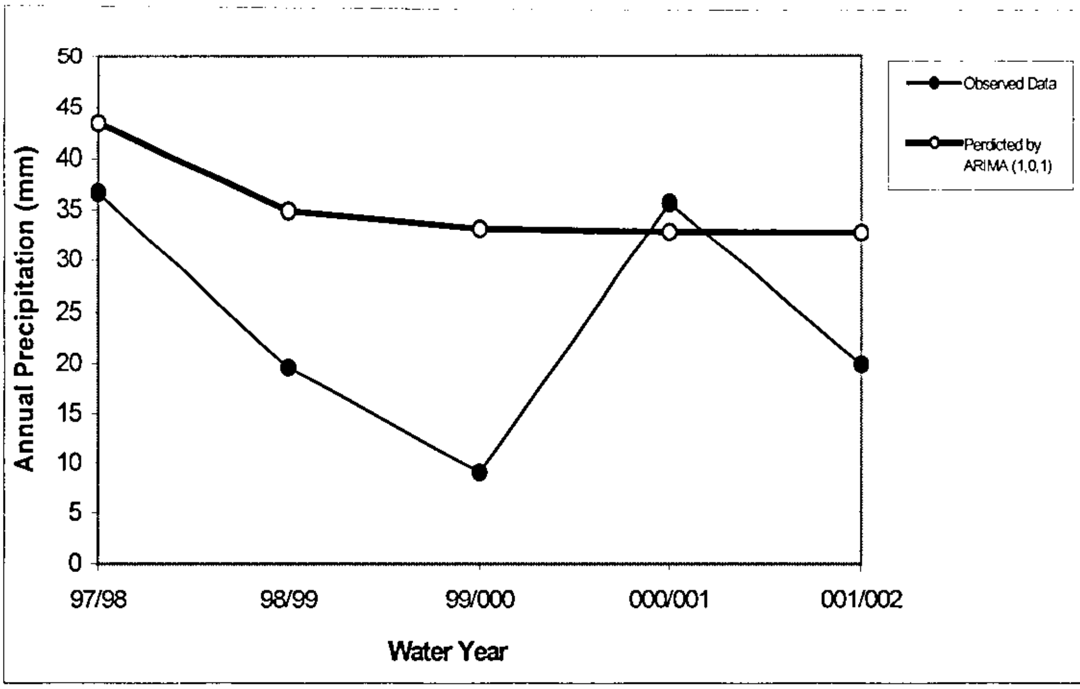


Figure (5.7): Observed and 10% Predicted Precipitation for Aqaba-Airport Station Using ARIMA Model (1,0,1)

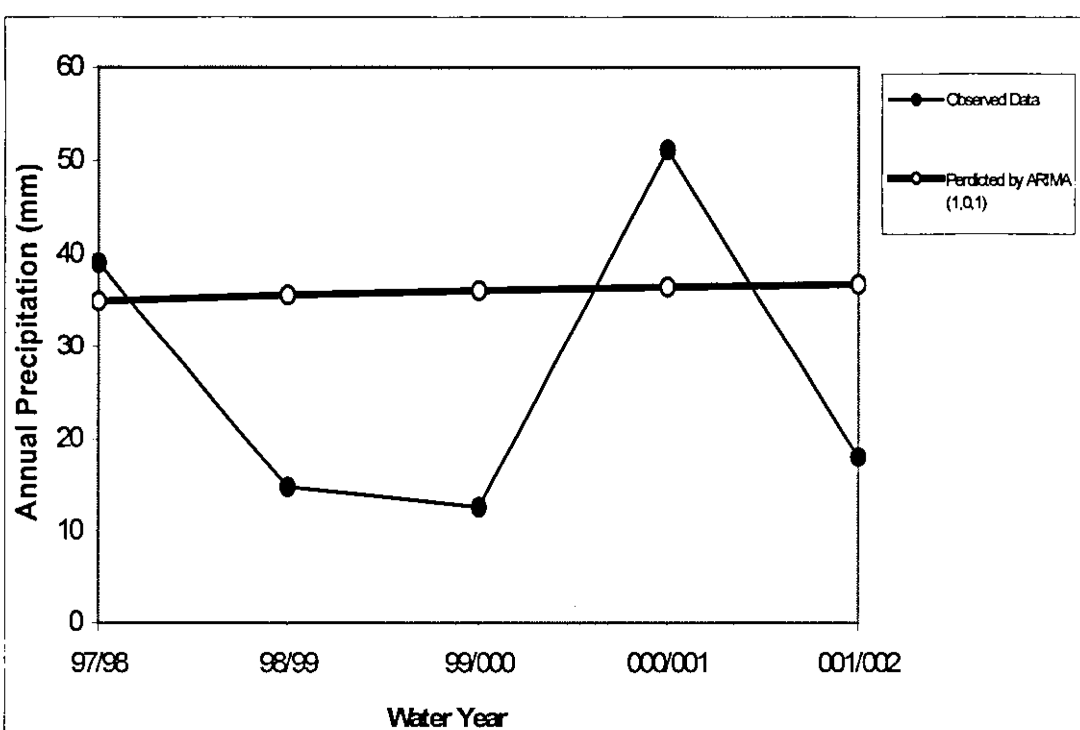


Figure (5.8): Observed and 10% Predicted Precipitation for Jafar Station Using ARIMA Model (1,0,1)

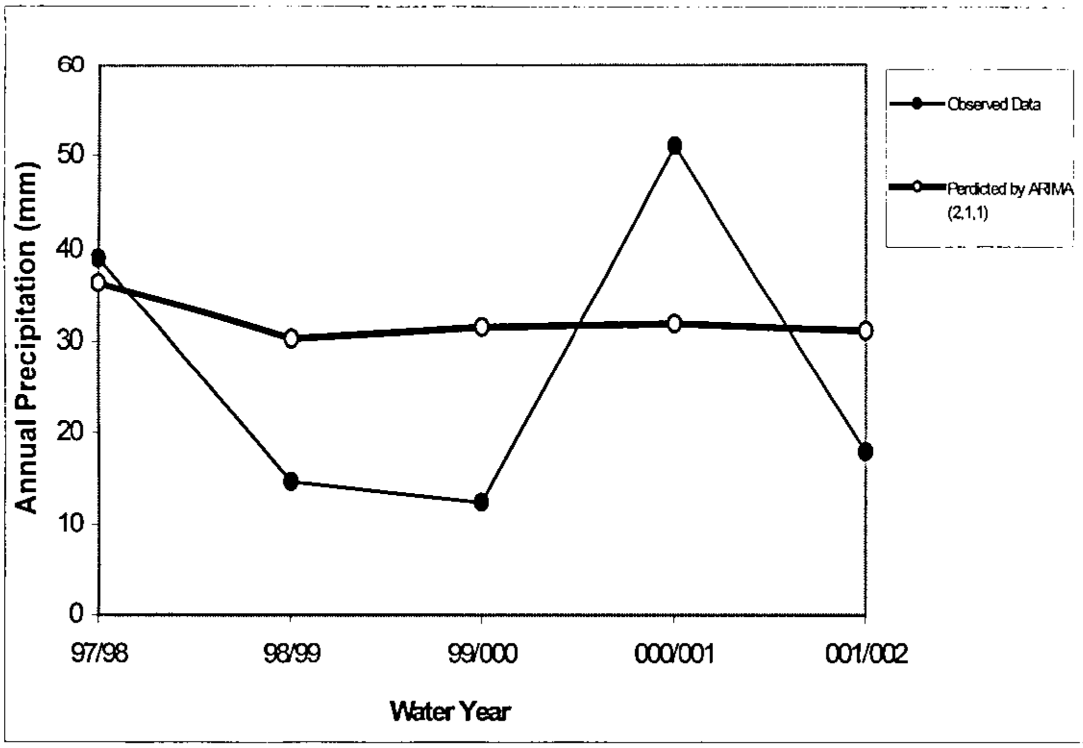


Figure (5.9): Observed and 10% Predicted Precipitation for Jafar Station Using ARIMA Model (2,1,1)

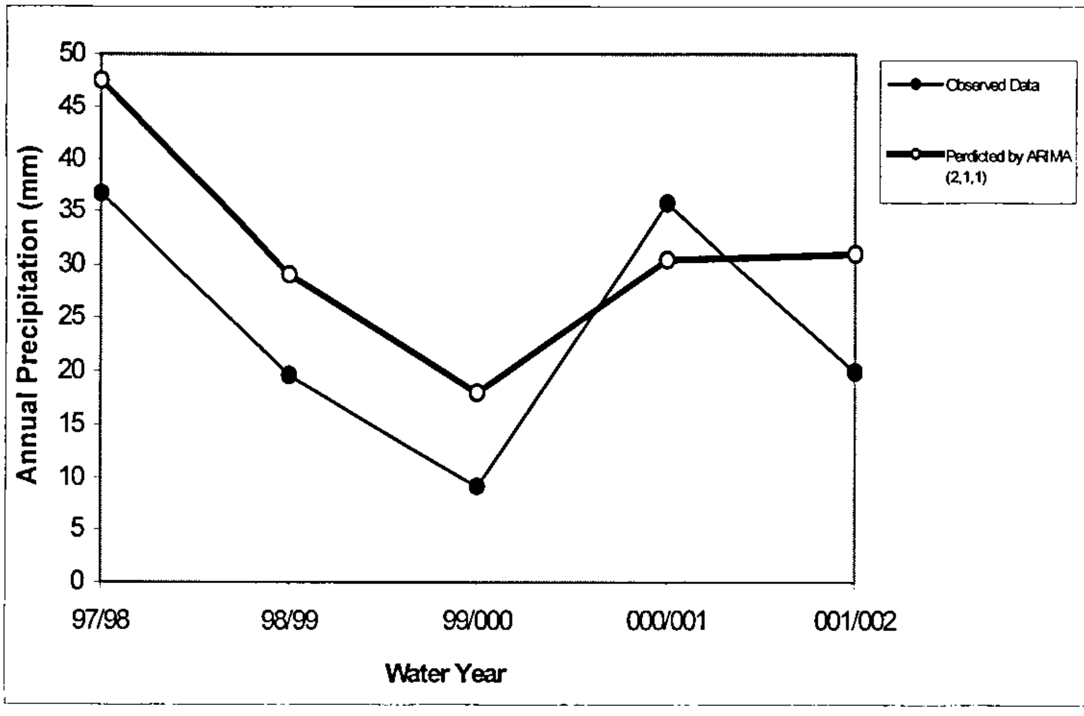


Figure (5.10): Observed and 10% Predicted Precipitation for Aqaba-Airport Station Using ARIMA Model (2,1,1)

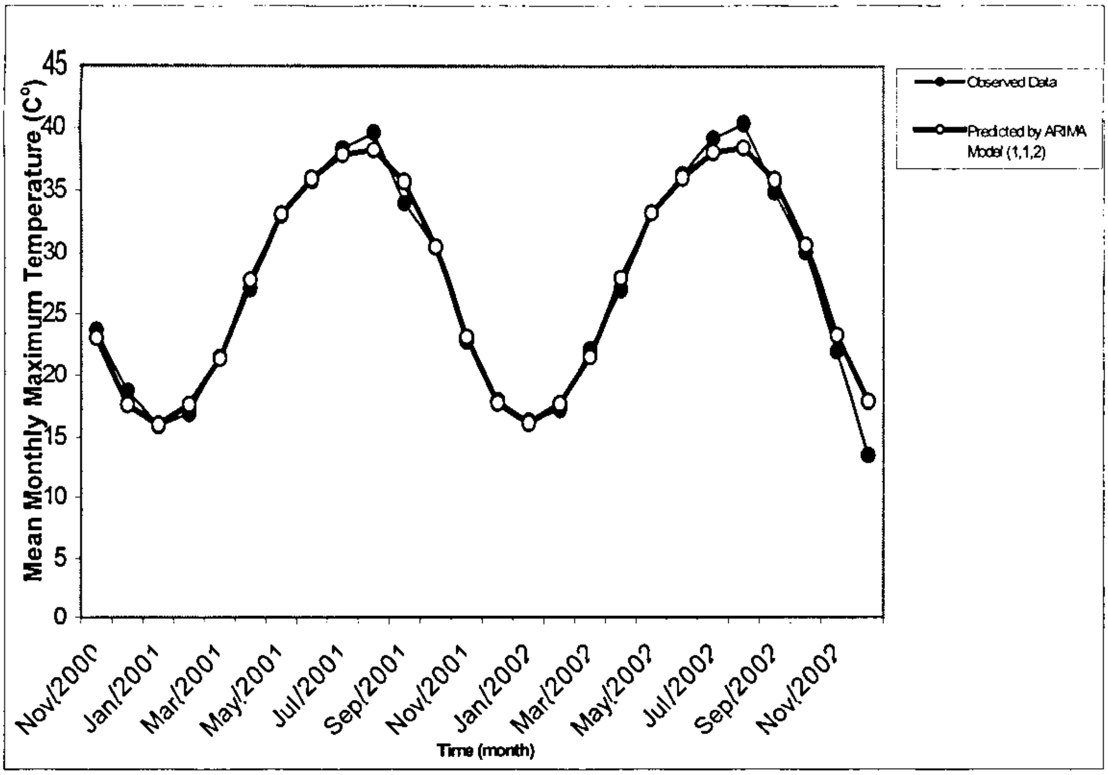


Figure (5.13): Observed and 10% Predicted Mean Monthly Maximum Temperature for Azraq Station Using ARIMA Model (1,1,2)

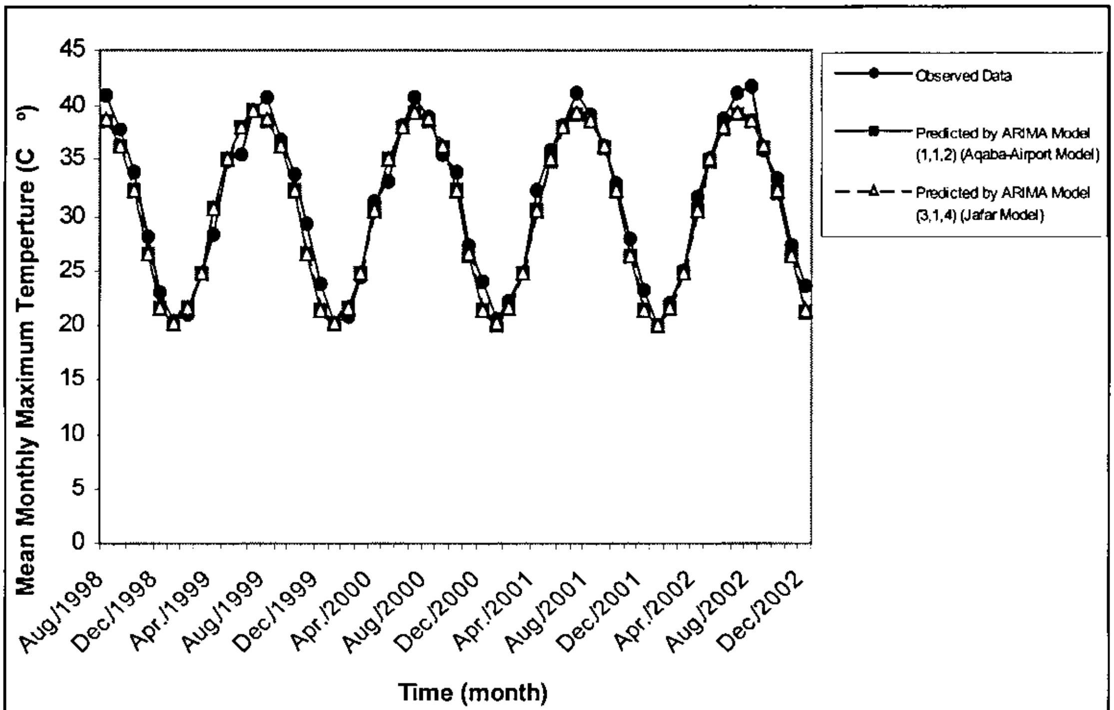


Figure (5.14): Observed and 10% Predicted Mean Monthly Maximum Temperature for Aqaba-Airport Station Using Two Different ARIMA Models

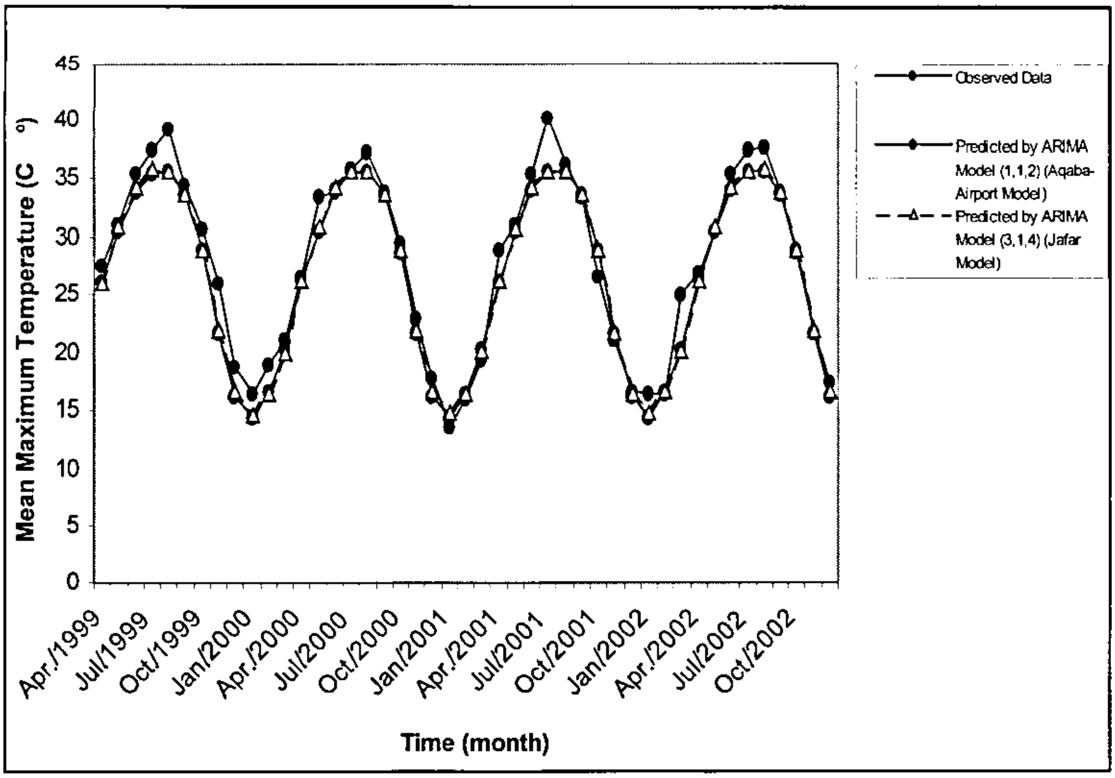


Figure (5.15): Observed and 10% Predicted Mean Monthly Maximum Temperature for Jafar Station Using Two Different ARIMA Models

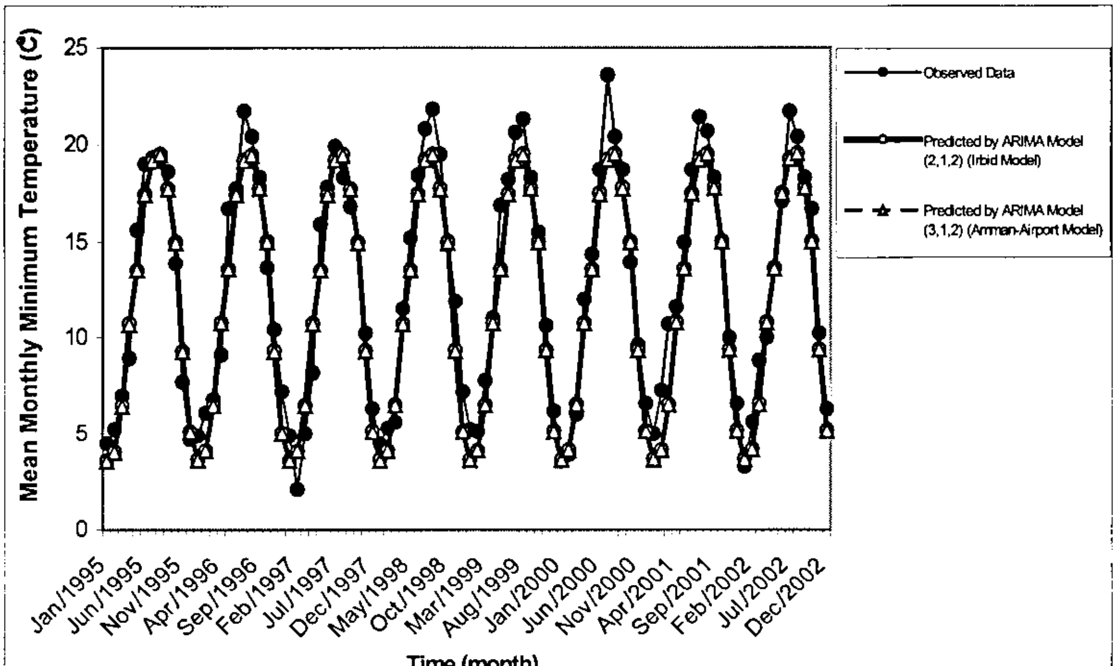


Figure (5.16): Observed and 10% Predicted Mean Monthly Minimum Temperature for Amman-Airport Station Using Two Different ARIMA Models

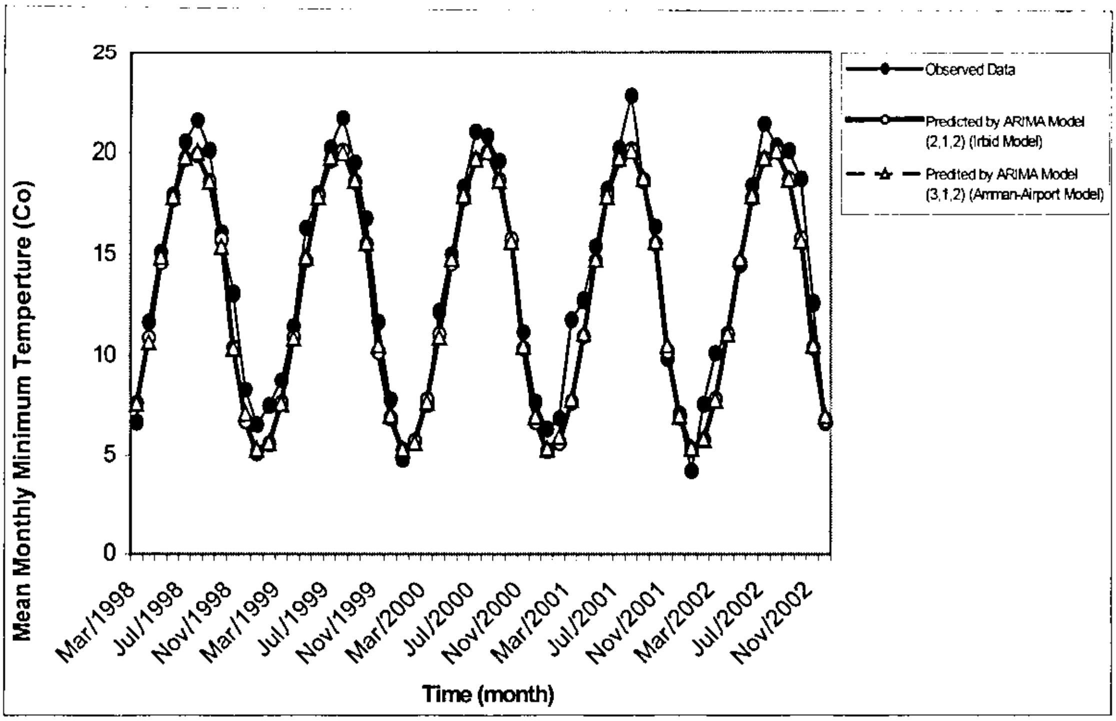


Figure (5.17): Observed and 10% Predicted Mean Monthly Minimum Temperature for Irbid Station Using Two Different ARIMA Models

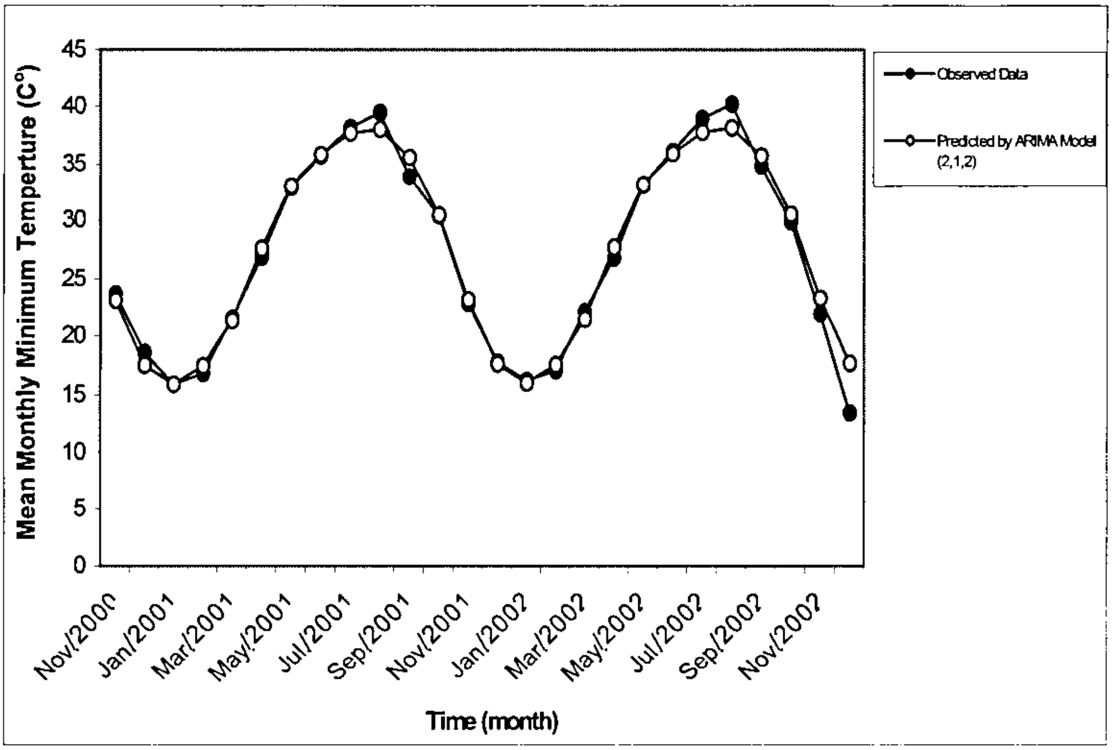


Figure (5.18): Observed and 10% Predicted Mean Monthly Minimum Temperature for Azraq Station Using ARIMA Model (2,1,2)

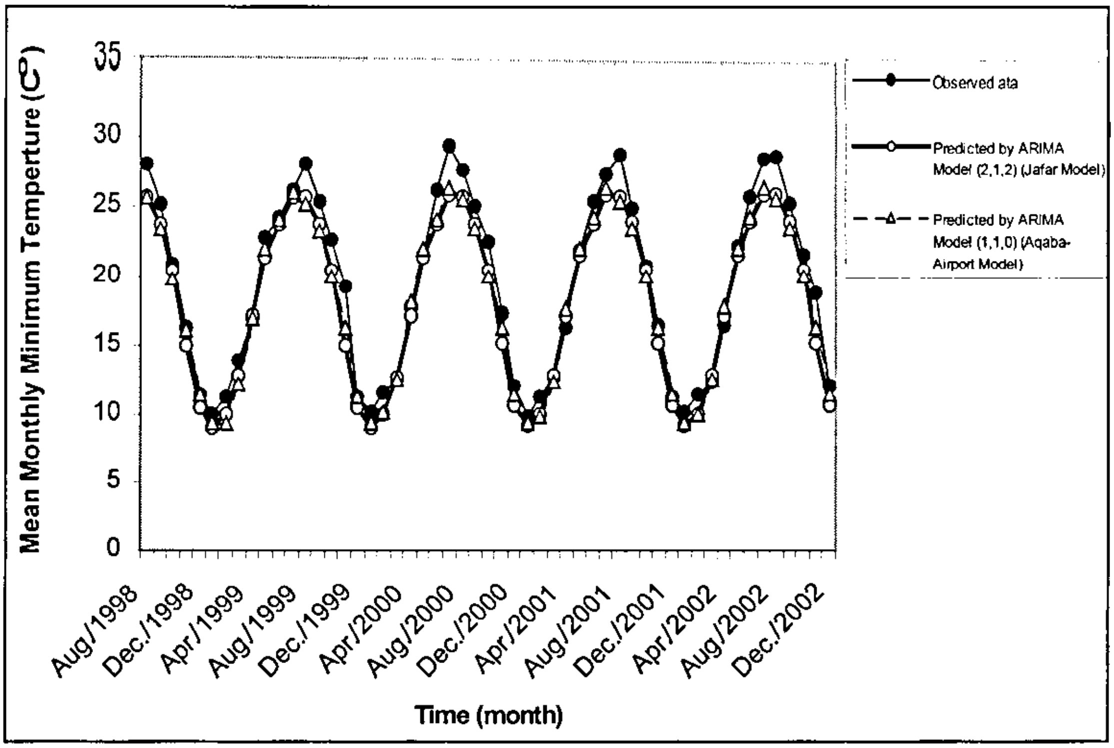


Figure (5.19): Observed and 10% Predicted Mean Monthly Minimum Temperature for Aqaba-Airport Station Using Two Different ARIMA Models

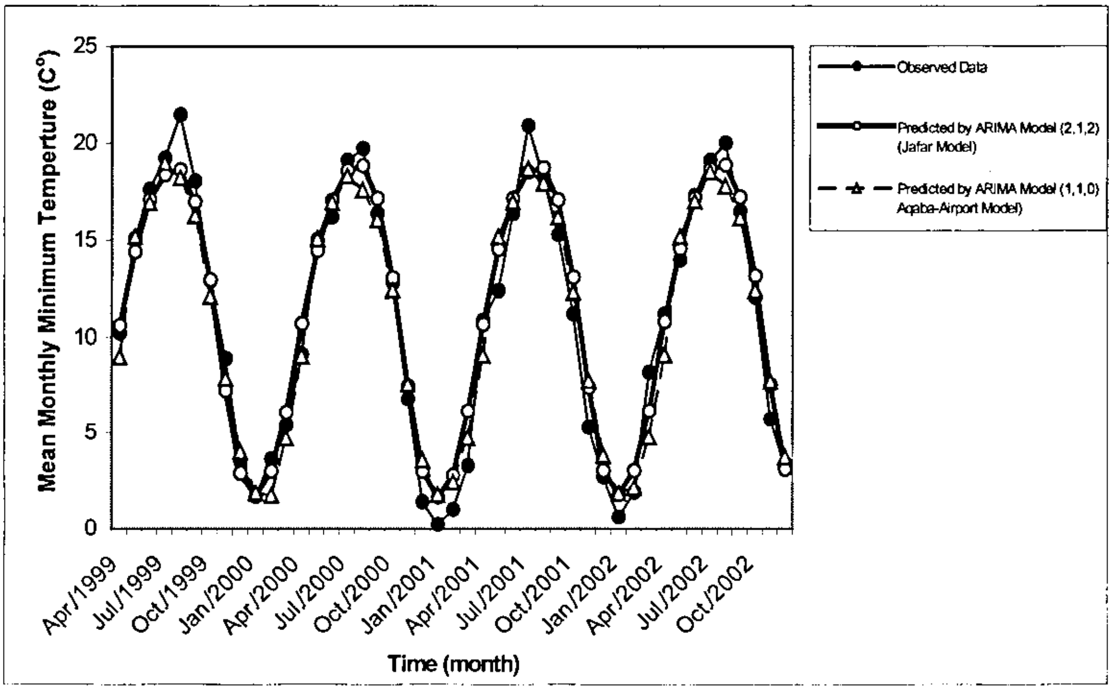


Figure (5.20): Observed and 10% Predicted Mean Monthly Minimum Temperature for Jafar Station Using Two Different ARIMA Models

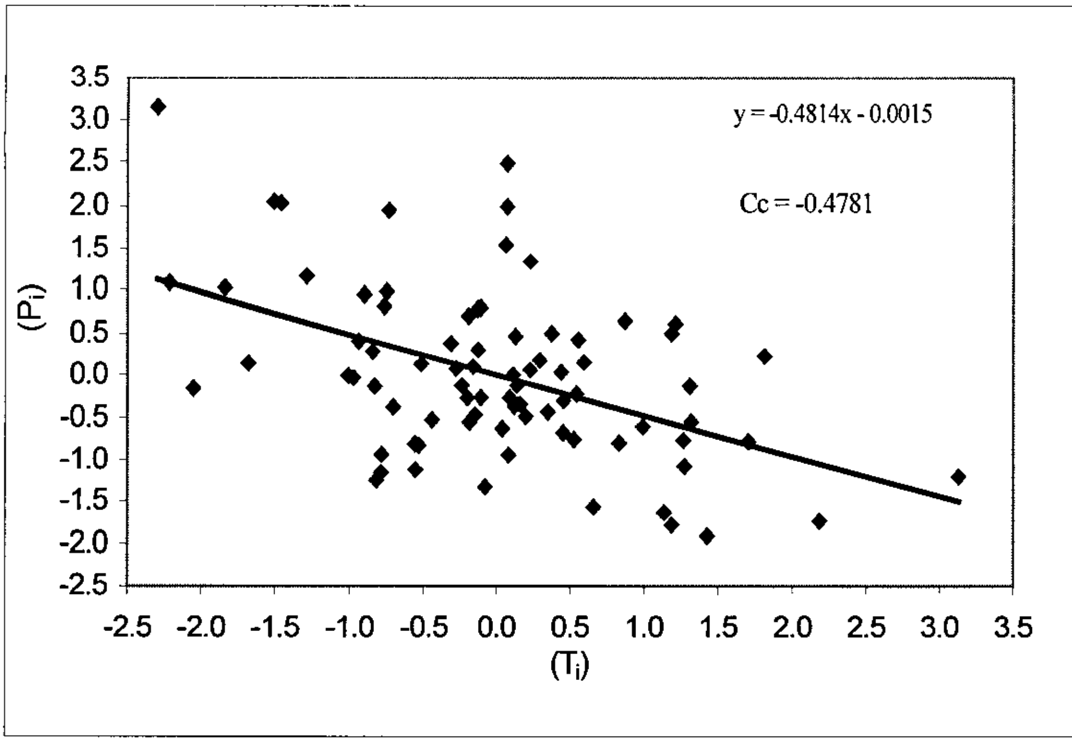
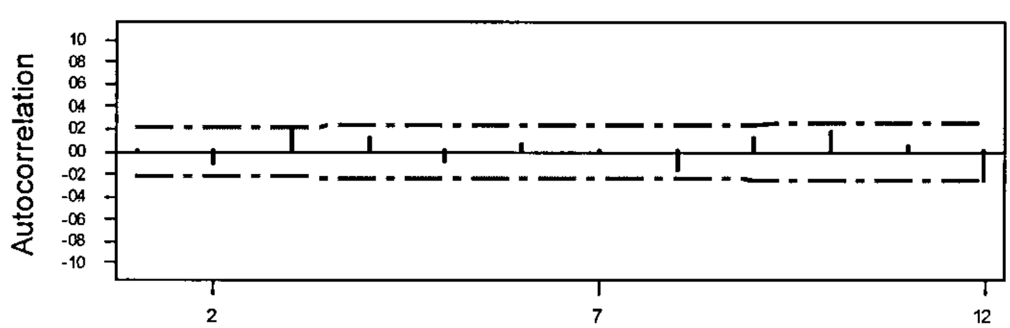
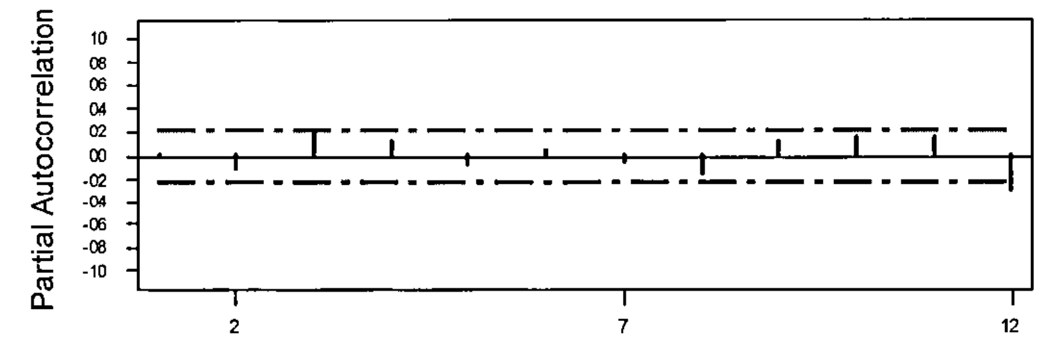


Figure (5.21): Linear Regression between Normalized Yearly Precipitation (P_i) and Mean Yearly Temperature (T_i) for Irbid Station



Lag	Cor	T	LBQ	Lag	Cor	T	LBQ
1	0.01	0.09	0.01	8	-0.17	-1.39	9.96
2	-0.10	-0.86	0.78	9	0.12	0.95	11.24
3	0.22	1.91	4.74	10	0.18	1.43	14.25
4	0.13	1.09	6.17	11	0.05	0.36	14.45
5	-0.09	-0.79	6.94	12	-0.27	-2.07	21.29
6	0.07	0.57	7.36				
7	0.02	0.13	7.38				

Figure (5.22): Autocorrelation Function for the Slop *(a_i)* for Irbid Station.



Lag	PAC	T	Lag	PAC	T
1	0.01	0.09	8	-0.15	-1.37
2	-0.10	-0.86	9	0.13	1.14
3	0.22	1.96	10	0.15	1.38
4	0.12	1.04	11	0.15	1.38
5	-0.06	-0.54	12	-0.30	-2.68
6	0.05	0.44			
7	-0.06	-0.50			

Figure (5.23): Partial Autocorrelation Function for the Slop *(a_i)* for Irbid Station..

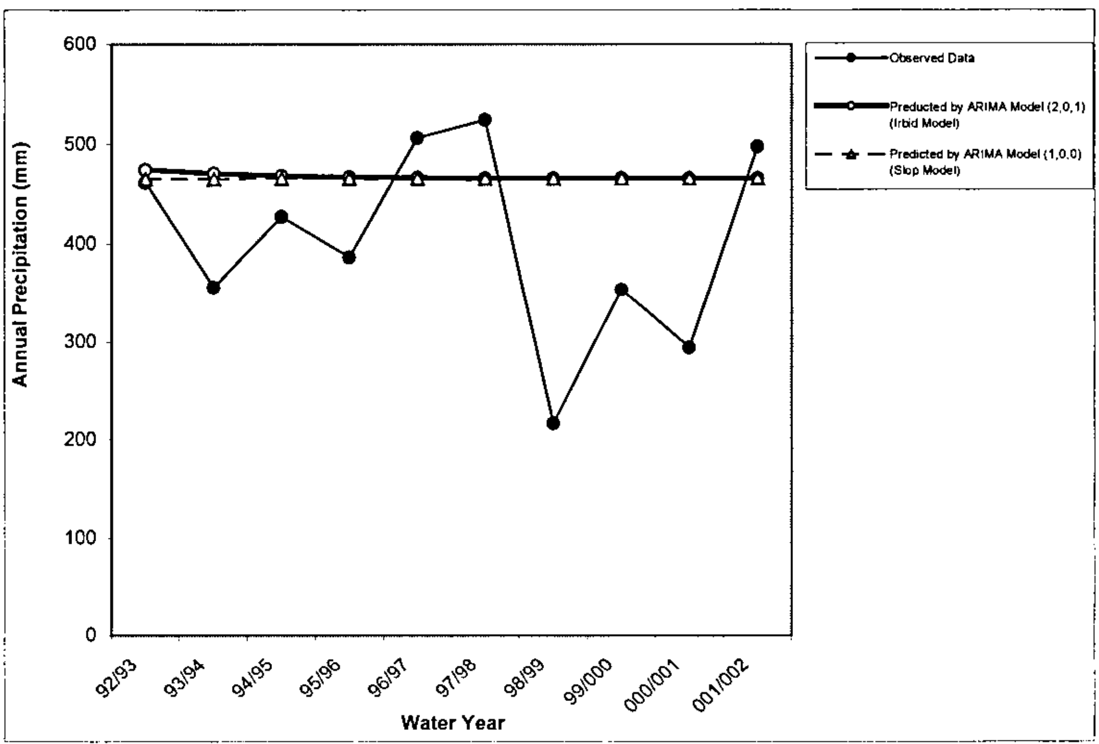


Figure (5.24): Comparison between Observed and Predicted 10% of Data for Irbid Precipitation.

6. CONCLUSIONS AND RECOMMENDATIONS

The important points raised by this research were discussed through this chapter and important conclusions as a result were listed. Recommendations for future studies were developed and according to priority were listed.

6.1 Conclusions

1. It should be mentioned that the precipitation data sample sizes were small compared to those of the other variables (temperature and base flow). The largest sample size was that for the Amman-Airport station, which consisted of 80 data points, and the smallest sample size was that for the Jafar station, which consisted of 22 data points. Due to this, ARIMA models for precipitation could not obtained. To overcome this, correlation between Amman-Airport and Irbid data was conducted with Jerusalem data, which was available for the years 1862 to 1962. The correlation was conducted for the coinciding periods between the three stations. The model developed using this correlation was used to extend the Amman-Airport and Irbid station data backward to the year 1862. The extended data was used to develop ARIMA models for precipitation. The developed ARIMA model was also found to be superior to the models developed from the other methods.

2. Precipitation and temperature for Irbid station were investigated together through a linear correlation between both observed data. Normalization to the mean was considered to avoid the difference in units for both variables. The negative values of normalized data indicated that the values are less than the

mean. The linear regression slope was developed as related variable to both. It was observed that the correlation coefficient has a negative sign, which indicated a reverse relationship between the two variables mentioned above. Furthermore, ARIMA model for the estimated values of this slope was found to be (1,0,0). This ARIMA model was applied to the Irbid precipitation data and compared to the ARIMA model (2,0,1) developed earlier. It was observed that ARIMA model (1,0,0) is more accurate than ARIMA model (2,0,1).

3. The developed ARIMA models were compared for the stations with similar climatic conditions. The current analysis was classified Amman-Airport and Shoubak stations as Dry Forest climate and Irbid could be classified with same classification rather than a Semi-Wet climate. The same was found for Mafraq, which had been classified as Semi-Arid (Steep), while the ARIMA models indicated that its climate is similar to that of Safawi and Azraq (Arid Badia).

4. The trend analysis of Zarqa River base flow indicated a steady increase in flow with time, even though the trend analysis for precipitation in that area indicated a steady decrease with time. This could be attributed to the increase in the treated waste effluent out of As-Samra waste treatment plant due to population growth in Amman-Zarqa Area.

5. The trend of Wadi Mujib and Wadi Hisban base flow decreases with time as the trend of precipitation. Therefore, the relationship between base flow and

precipitation was direct. A reverse relationship between base flow and temperature occurred.

6. No cyclic trend for precipitation occurred, because the sample sizes were small. This can be verified with other researchers such as; Box and Jenkins, (1976), Cook and Campbell, (1979), McCain and McCleary, (1979) and McCleary, et al., (1980) according to Yaffee and McGee, 2000. Whereas the cyclic trend for temperature was obtained. It was calculated to be 12 months.

7. Using the three measures of accuracy; MAPE, MAD and MSD, a comparison was made between simple forecasting, smoothing methods, correlation analysis, and ARIMA methods. The method that gives the minimum values of the three accuracy measures indicates that it is the best method to be used in prediction. It was observed from the analyses of time series for all variables that the ARIMA is the best method.

8. One of the procedures for diagnostic checking is called overfitting that is, for example, using more parameters than necessary, or choosing a second-order AR when a first-order AR is indicated. (Yafee and McGee, 2000). Testing the initial ARIMA models by using AIC test was done to find the best ARIMA model, which was accurate in representing the data.

6.2 Recommendations

Based on the findings of this study, several recommendations can be made.

1. Regarding time series analysis, better accuracy of prediction can be accomplished if longer periods of time are studied. Therefore, it is highly recommended that using large sample size with minimum amount of missing data to reduce nonstationary, especially for ARIMA modeling.

2. If data record is small, it was found that correlation between similar conditioned data could be a reasonable method for extending the record to longer period.

3. Precipitation is a combination of dynamic, thermodynamic and microphysics process, so using other parameters beside rainfall data such as temperature, humidity and pressure is really important to reduce the residual values and give better understanding of the flocculation movements. It was clear by using Rainfall-Temperature modeling, which enhanced the accuracy of forecasting through, minimize the three measures of accuracy; (MAPE, MAD and MSD).

7. REFERFNCES

Abandah, A., 1993. *Agro – Climatic Features of Jordan, Strengthening Forest and Range Management.* Food and Agriculture Organization of the United Nations, United Nations Development Program and Ministry of Agriculture, Amman, Jordan.

Akaike, H., and Kitagawa, G. 1999. *The Practice of Time Series Analysis.* Springer-Verlag, NewYork

Anderson, T.W. 1978. *An Introduction to Multivariate Statistical Analysis, Second Edition.* Wiley, New York.

Bani Hani, A.A. 2002. *Analysis and Projection of the Influent Rate and Quality Parameters of Water in King Talal Dam.* Master Thesis, University of Jordan, Amman, Jordan.

Box, G.E., and Jenkins, G.M. 1976. *Time-Series Analysis, Forecasting and Control, rev. Edition.* Holden-Day, San Francisco.

Box, G.E., Jenkins, G.M., and Reinsel, G.C. 1994. *Time Series Analysis Forecasting and Control, Third Edition.* Prentice Hall, New Jersey.

Brockwell, P.J., and Davis, R.A. 1994. *ITSM for Windows a User Guide to Time Series Modeling and Forecasting.* Springer-Verlag, New York.

Burn, D.H. 1994. Hydrologic effects of climatic change in west-center Canada. *Journal of Hydrology,* 160: 53-70.

Burn, D.H., and Simonovic, S.P. 1996. Sensitivity of reservoir operation performance to climatic change. *Water Resources Management,* 10: 463-478.

Burroughs, W.J. 2001. *Statistics, Climate Change a Multidisciplinary Approach.* Cambridge University Press.

Cryer, J.D. 1986. *Time Series* Analysis. Duxbury Press, United State.

Dahabiyeh, M.H. 2002. *Rainfall Analysis during the Twentieth Century and Associated Environmental Impacts in Jordan.* Master Thesis, University of Jordan, Amman, Jordan.

Elshorbagy, A., Panu, U.S. and Simonovic, S.P. 2001. Analysis of cross-correlated chaotic stream flow. *Hydrological Sciences-Journal-des Sciences Hydrologiques,* 46 (5): 1-14.

Elshorbagy, A., Simonovic, S.P., and Panu, U.S. 2002. Noise reduction in chaotic hydrologic time series: facts and doubts. *Journal of Hydrology,* 256: 147-165.

Granger, C.W.J., and Newbold, P.1977. *Forecasting Economic Time Series.* Academic Press. New York.

Jayawardena, A.W., and Lai, F. 1994. Analysis and prediction of chaos in rainfall and stream flow time series. *Journal of Hydrology*, 153: 23-52.

Kite, G. 1989. Use of time series analysis to detect climatic change. *Journal of Hydrology,* 111: 259-279.

Lin, G.F. 1990. Parameter estimation for seasonal to sub seasonal disaggregating. *Journal of Hydrology*, 120: 65-77.

Lin, G.F., and Lee, F.C. 1992. An aggregation-disaggregating approach for hydrologic time series modeling. *Journal of Hydrology.* 138: 543-557.

Lin, G.F., and Lee, F.C. 1994. Assessment of aggregated hydrologic time series modeling. *Journal of Hydrology,* 156: 447-458.

Lungu, E.M. 1993. Detection of changes in rainfall and runoff patterns. *Journal of Hydrology,* 147: 153-167.

Makridakis, S., Wheelwright, S.C., and McGee, V.E. 1983. *Forecasting Methods and Applications, Second Edition.* John Wiley and Sons, Inc. USA

Mejia, J.M. and Rosselle, J.D. 1976. Disaggregation models in hydrology revisited. Water Resource Res., 12(2): 185-186.

Miao-Hsiang, P., and Jin-King, L. 2000. Ground Water Level Forecasting with Time Series Analysis. HSIN-Chu, Taiwan. Available at http://www.gisdevelopment.net

Montgomery, D.C., and Johnson, L.A. 1976. *Forecasting and Time Series Analysis.* McGraw-Hill Company, USA.

Solomatine, D. P., Rojas, C. J., Velickov S. and Wust, J. C. 2000. Chaos Theory in Predicting Surge Water Levels in the North Sea. Proc. *fourth International Conference on Hydro informatics*, Iowa, USA, 1-8. www.ihe.nl/hi/sol/papaers/hi2000_chaos.pdf.

The General Corporation for Environment Protection (GCEP), 2000. Vulnerability and Adaptation to Climate Change, Final Report. United Nations Development Program (UNDP), Jordan. 3:4-35.

Thoms, M.C., and Sheldon, F. 2000. Water resources development and hydrological change in large dryland river: the Barwon-Darling River, Australia. *Journal of Hydrology, 228*: 10-21.

Valencia, R.D. and Schaake, J.C. 1973. Disaggregation processes in stochastic hydrology. Water Resource Res., 9(3): 580-585.

Yaffee, R., and McGee, M. 2000. *Introduction to Time Series Analysis and Forecasting with Application of SAS and SPSS.* Academic Press, New York.

APPENDIX A
PRECIPITATION, TEMPERATURE AND BASE FLOW DATA

Table (A.1): Monthly Precipitation (mm/month) for the Irbid Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
37/38	17.7	31.7	16.2	156.5	159.0	72.5	6.5	30.0	0.0	0.0	0.0	0.0	490.1
38/39	0.0	174.3	101.2	66.0	124.9	204.0	78.0	0.0	0.0	0.0	0.0	0.0	748.4
39/40	0.0	133.5	39.0	301.5	24.0	25.0	8.0	0.0	0.0	0.0	0.0	0.0	531.0
40/41	3.5	90.5	98.0	165.0	34.5	134.0	10.5	0.0	0.0	0.0	0.0	0.0	536.0
41/42	16.5	11.0	276.0	121.5	174.5	216.5	0.0	0.0	0.0	0.0	0.0	0.0	816.0
42/43	126.0	108.2	12.0	230.7	58.0	126.5	95.5	0.0	0.0	0.0	0.0	0.0	756.9
43/44	3.0	9.0	25.5	198.5	56.5	35.0	10.5	14.0	0.0	0.0	0.0	0.0	352.0
44/45	0.0	173.4	129.5	93.9	109.8	38.3	26.0	9.0	0.0	0.0	0.0	0.0	579.9
45/46	0.0	82.8	49.3	14.2	116.3	43.4	0.0	25.8	0.0	0.0	0.0	0.0	331.8
46/47	0.0	0.5	30.5	103.3	10.7	29.0	18.5	0.0	0.0	0.0	0.0	0.0	192.5
47/48	0.0	39.7	13.0	52.5	43.5	103.5	24.0	0.0	0.0	0.0	0.0	0.0	276.2
48/49	0.0	49.5	44.5	82.0	119.5	166.9	146.5	0.0	0.0	0.0	0.0	0.0	608.9
49/50	0.0	0.0	133.5	179.0	62.0	66.5	29.0	38.5	0.0	0.0	0.0	0.0	508.5
50/51	23.0	7.0	24.0	49.5	119.5	66.5	22.5	0.0	0.0	0.0	0.0	0.0	312.0
51/52	30.0	53.0	236.5	63.5	182.5	119.5	0.0	0.0	0.0	0.0	0.0	0.0	685.0
52/53	38.0	4.5	45.2	174.0	191.0	190.5	11.0	0.0	0.0	0.0	0.0	0.0	654.2
53/54	0.3	91.5	51.5	51.8	112.5	21.6	46.3	0.0	0.0	0.0	0.0	0.0	375.5
54/55	0.0	44.5	53.4	2.6	28.6	72.4	25.9	3.9	0.0	0.0	0.0	0.0	231.3
55/56	16.0	152.0	97.3	88.6	32.2	85.2	15.1	0.9	0.0	0.0	0.0	0.0	487.3
56/57	0.0	7.8	113.1	88.3	95.4	109.1	18.4	15.1	0.0	0.0	0.0	0.0	447.2
57/58	2.7	46.6	115.0	173.0	7.7	8.2	28.6	40.4	0.0	0.0	0.0	0.0	422.2
58/59	4.2	0.0	12.9	72.5	140.7	29.5	12.4	5.3	0.0	0.0	0.0	23.1	300.6
59/60	0.6	14.3	8.5	45.1	24.8	91.4	26.0	1.0	0.0	0.0	0.0	0.0	211.7
60/61	0.0	84.3	68.3	74.2	89.4	34.0	15.8	2.6	0.0	0.0	0.0	0.0	368.6
61/62	3.4	23.2	250.9	82.6	90.9	3.7	15.6	0.0	0.0	0.0	0.0	0.0	470.3
62/63	0.4	0.0	73.6	52.6	135.7	73.6	26.7	23.8	0.0	0.0	0.0	0.0	386.4
63/64	37.5	22.7	97.5	87.1	156.0	104.6	4.9	12.8	0.0	0.0	0.0	0.0	523.1
64/65	0.0	107.7	55.0	145.8	67.9	43.8	44.2	0.4	0.0	0.0	0.0	0.0	464.8
65/66	52.1	20.0	68.2	49.3	70.9	127.3	6.9	3.7	0.0	0.0	0.0	0.0	398.4
66/67	38.3	32.5	191.3	188.1	74.8	215.0	5.5	8.7	0.0	0.0	0.0	0.0	754.2
67/68	13.3	76.2	78.5	236.9	46.8	31.8	20.9	14.7	0.0	0.0	0.0	0.0	519.1
68/69	15.8	28.3	162.5	162.2	43.9	143.2	14.6	0.0	0.0	0.0	0.0	5.6	576.1
69/70	29.8	44.3	29.8	140.3	46.4	154.2	28.6	0.7	0.0	0.0	0.0	0.0	474.1
70/71	11.2	18.9	87.0	74.9	146.4	70.5	192.6	1.0	1.0	0.0	0.0	0.0	603.5
71/72	0.0	26.4	164.7	81.6	112.3	60.0	35.2	5.0	0.9	0.0	0.0	0.0	486.1
72/73	6.6	28.5	16.5	156.1	33.0	96.4	4.4	7.0	0.0	0.0	0.0	0.0	348.5
73/74	9.0	88.2	56.9	270.5	94.7	69.5	40.1	0.0	0.0	0.0	0.0	0.0	628.9
74/75	0.0	20.5	49.5	38.4	154.6	78.7	6.1	0.1	0.0	0.0	0.0	2.8	350.7
75/76	1.0	54.1	92.6	61.4	103.5	83.3	31.6	15.4	0.0	0.0	0.0	0.0	442.9
76/77	16.8	58.5	28.8	103.4	26.2	102.7	75.7	3.3	0.3	0.0	0.0	0.0	415.7
77/78	17.0	11.9	131.5	64.0	66.3	121.9	13.5	0.7	0.2	0.0	0.0	0.0	427.0
78/79	25.1	3.4	46.6	64.0	21.7	73.6	6.9	0.0	0.0	0.0	0.0	0.0	241.3
79/80	40.6	111.8	198.1	116.9	109.6	142.8	19.3	3.6	0.0	0.0	0.0	0.0	742.7
80/81	21.2	10.0	147.1	111.4	71.6	47.2	18.8	0.1	0.0	0.0	0.0	0.0	427.4
81/82	0.0	55.3	28.1	71.5	114.3	95.7	5.7	38.5	0.0	0.0	0.0	2.4	411.5
82/83	4.1	62.1	47.9	148.7	219.1	110.0	20.5	5.0	0.0	0.0	0.0	0.0	617.4
83/84	2.4	44.7	15.9	117.6	42.9	146.0	77.2	0.0	0.0	0.0	0.0	0.0	446.7
84/85	30.6	52.0	73.9	48.1	245.9	22.5	11.2	0.6	0.0	0.0	0.0	0.0	484.8
85/86	18.9	35.0	30.7	103.5	106.3	37.3	35.2	28.9	0.0	0.0	0.0	0.0	395.8
86/87	31.0	214.5	103.4	89.7	43.0	114.4	1.8	0.0	0.0	0.0	0.0	0.0	597.8
87/88	15.5	8.2	126.6	133.9	149.3	115.2	16.7	0.0	0.0	0.0	0.0	0.0	565.4

Table (A.1): Continue

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
88/89	6.4	35.3	107.0	30.3	47.6	59.1	0.0	0.0	20.2	0.0	0.0	0.0	305.9
89/90	10.2	54.0	50.3	152.2	68.4	97.7	30.2	0.6	0.0	0.0	0.0	0.0	463.6
90/91	4.2	22.9	22.3	165.7	48.4	91.2	45.9	2.9	0.0	0.0	0.0	0.0	403.5
91/92	0.0	58.3	233.3	214.6	336.0	36.2	4.4	12.1	18.0	0.0	0.0	0.0	912.9
92/93	0.0	58.9	197.5	73.4	62.8	34.6	0.0	33.2	0.0	0.0	0.0	0.4	460.8
93/94	17.3	17.0	20.8	118.1	69.5	102.8	2.0	1.4	0.0	0.0	0.0	7.7	356.6
94/95	12.7	152.3	119.8	17.8	63.7	37.8	21.4	1.6	0.0	0.0	0.0	0.0	427.1
95/96	5.5	77.3	27.7	110.1	21.4	126.5	18.1	0.0	0.0	0.0	0.0	0.0	386.6
96/97	25.0	26.1	53.0	86.2	191.9	93.8	21.0	5.2	0.0	0.0	0.0	4.2	506.4
97/98	17.4	43.1	95.5	122.8	60.8	170.6	10.8	3.7	0.0	0.0	0.0	0.5	525.2
98/99	2.0	2.1	27.1	69.0	66.9	41.9	7.8	0.0	0.0	0.0	0.0	0.0	216.8
99/000	0.0	7.6	21.2	109.8	92.7	88.2	26.1	6.8	0.7	0.0	0.0	0.8	353.8
000/001	14.6	3.7	99.8	45.2	72.8	4.7	22.7	30.8	0.0	0.0	0.0	0.0	294.3
001/002	14.9	48.5	86.5	115.4	94.0	89.4	25.6	23.1	0.0	0.0	0.0	0.0	497.4
Average	13.13	50.39	83.21	108.90	92.44	86.90	26.02	7.41	0.64	0.00	0.00	0.73	469.77
Maximum	126.00	214.50	276.00	301.50	336.00	216.50	192.60	40.40	20.20	0.00	0.00	23.10	912.90
Minimum	0.00	0.00	8.50	2.60	7.70	3.70	0.00	0.00	0.00	0.00	0.00	0.00	192.50
Median	6.40	39.70	68.20	93.90	72.80	85.20	18.50	1.40	0.00	0.00	0.00	0.00	460.80
St. Dev.	19.14	48.06	64.90	61.87	61.50	51.48	32.56	11.33	3.33	0.00	0.00	3.12	152.26
Cv.	1.46	0.95	0.78	0.57	0.67	0.59	1.25	1.53	5.24	-	-	4.27	0.32
Skew	3.52	1.45	1.17	0.91	1.38	0.61	3.22	1.67	5.57	-	-	6.22	0.60

Table (A.2): Monthly Precipitation (mm/month) for the Aqaba Airport Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
60/61	0.0	1.8	1.4	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5
61/62	5.0	0.0	21.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.8
62/63	0.0	0.0	0.2	0.6	3.4	3.0	39.9	0.8	0.0	0.0	0.0	0.0	47.9
63/64	1.0	0.6	8.8	7.3	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	19.9
64/65	0.0	0.0	19.5	27.0	0.0	4.8	1.8	0.0	0.0	0.0	0.0	0.0	53.1
65/66	0.2	1.0	0.0	36.8	12.1	3.5	0.0	0.0	0.0	0.0	0.0	0.0	53.6
66/67	0.0	0.4	0.2	0.4	1.3	0.0	0.3	1.0	0.0	0.0	0.0	0.0	3.6
67/68	8.9	1.5	0.0	0.8	5.5	4.2	6.1	10.0	0.0	0.0	0.0	0.0	37.0
68/69	0.0	27.2	0.8	15.1	0.0	29.0	5.7	0.0	0.0	0.0	0.0	0.0	77.8
69/70	0.7	3.4	0.0	1.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5.6
70/71	0.0	0.5	0.0	17.8	0.7	6.1	21.7	0.0	0.0	0.0	0.0	0.0	46.8
71/72	0.0	2.6	20.9	5.6	1.6	8.4	1.0	0.0	0.0	0.0	0.0	0.0	40.1
72/73	0.0	17.6	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	18.8
73/74	0.0	12.8	0.3	9.0	6.4	5.5	0.0	0.0	0.0	0.0	0.0	0.0	34.0
74/75	0.0	1.5	14.1	1.0	67.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	84.2
75/76	0.0	0.0	17.3	0.0	0.0	6.3	0.0	3.4	0.0	0.0	0.0	0.0	27.0
66/67	0.1	0.0	1.5	0.7	0.0	0.1	12.0	0.0	0.0	0.0	0.0	0.0	14.4
77/78	0.0	0.0	13.5	7.6	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5
78/79	0.0	0.0	17.3	0.0	19.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5
79/80	0.0	1.3	1.8	1.2	2.2	3.7	0.2	0.0	0.0	0.0	0.0	0.0	10.4
80/81	0.0	2.0	43.3	1.8	0.0	1.6	0.6	0.0	0.0	0.0	0.0	0.0	49.3
81/82	8.3	0.0	0.0	9.7	12.0	4.6	6.0	7.3	0.0	0.0	0.0	0.2	48.1
82/83	0.0	6.8	0.0	0.0	5.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	15.7
83/84	0.0	0.0	1.2	2.8	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	9.1
84/85	0.0	0.0	0.0	1.1	0.8	11.6	0.2	1.5	0.0	0.0	0.0	0.0	15.2
85/86	0.0	0.0	22.2	0.0	2.2	3.0	11.5	14.1	0.0	0.0	0.0	0.0	53.0
86/87	0.0	8.7	1.0	0.0	11.7	9.0	0.0	0.0	0.0	0.0	0.0	0.0	30.4
87/88	21.8	0.0	17.5	20.6	3.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	69.0
88/89	1.1	0.1	6.8	4.5	2.2	5.0	1.0	0.0	0.0	0.0	0.0	0.0	20.7
89/90	0.0	15.2	0.0	0.0	0.0	9.0	12.4	0.0	0.0	0.0	0.0	0.0	36.6
90/91	8.4	0.0	18.5	4.5	0.0	30.6	0.0	0.0	0.0	0.0	0.0	0.0	62.0
91/92	0.2	0.0	3.6	6.4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8
92/93	0.0	7.0	0.2	0.4	1.8	0.0	0.0	0.2	0.0	0.0	0.0	0.0	9.6
93/94	9.3	0.0	35.2	34.7	1.0	4.7	0.2	0.0	0.0	0.0	0.0	0.8	85.9
94/95	7.2	4.1	0.0	0.0	6.4	0.0	4.7	0.0	0.0	0.0	0.0	0.0	22.4
95/96	0.0	0.0	0.0	0.8	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.5
96/97	0.0	0.2	0.4	9.0	0.5	3.3	0.0	0.0	0.0	0.0	0.0	0.0	13.4
97/98	28.0	0.0	0.3	0.8	0.3	1.3	0.3	5.7	0.0	0.0	0.0	0.0	36.7
98/99	2.6	0.0	7.6	0.0	4.8	0.0	3.4	1.2	0.0	0.0	0.0	0.0	19.6
99/000	0.0	3.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
000/001	2.6	1.5	5.7	4.5	0.0	4.4	17.0	0.0	0.0	0.0	0.0	0.0	35.7
001/002	0.0	3.0	2.0	5.0	5.3	0.0	3.4	1.2	0.0	0.0	0.0	0.0	19.9
Average	2.51	2.95	7.24	6.07	4.62	4.25	3.64	1.10	0.00	0.00	0.00	0.02	32.41
Maximum	28.00	27.20	43.30	36.80	67.20	30.60	39.90	14.10	0.00	0.00	0.00	0.80	85.90
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
Median	0.00	0.45	1.30	2.30	1.15	3.15	0.20	0.00	0.00	0.00	0.00	0.00	31.10
St. Dev.	5.83	5.68	10.51	9.03	10.92	6.55	7.63	2.93	0.00	0.00	0.00	0.13	22.14
Cv.	2.32	1.93	1.45	1.49	2.36	1.54	2.10	2.65	-	-	-	5.31	0.68
Skew	3.15	2.79	1.68	2.21	4.89	2.99	3.26	3.26	-	-	-	5.98	0.77

Table (A.3): Monthly Precipitation (mm/month) for the Azraq Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
42/43	4.0	10.3	24.0	4.2	6.9	31.4	4.7	0.4	0.0	0.0	0.0	0.0	85.9
43/44	2.3	0.0	16.6	42.3	2.4	15.4	0.5	21.9	0.0	0.0	0.0	0.0	101.4
44/45	0.0	43.2	62.9	35.5	11.8	12.1	2.5	25.7	0.0	0.0	0.0	0.0	193.7
45/46	0.0	16.2	18.2	1.5	36.3	1.5	0.0	8.3	0.0	0.0	0.0	0.0	82.0
46/47	0.0	10.4	0.6	3.0	14.9	4.5	1.0	0.0	0.0	0.0	0.0	0.0	34.4
47/48	0.0	0.0	0.0	0.0	2.0	0.0	15.4	0.0	0.0	0.0	0.0	0.0	17.4
48/49	5.0	0.0	10.4	2.2	32.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.9
49/50	0.0	0.0	44.4	7.6	10.1	12.0	9.8	12.5	0.0	0.0	0.0	0.0	96.4
50/51	0.0	2.6	8.2	0.7	3.6	0.0	0.7	0.0	0.0	0.0	0.0	0.0	15.8
51/52	0.0	0.0	44.1	5.3	20.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	73.6
52/53	1.5	0.2	8.9	6.7	20.1	27.0	10.7	0.0	0.0	0.0	0.0	0.0	75.1
53/54	0.0	8.0	3.0	1.7	18.1	7.2	11.3	0.0	0.0	0.0	0.0	0.0	49.3
54/55	2.8	17.3	32.8	0.0	2.0	4.6	0.6	0.0	0.0	0.0	0.0	0.0	60.1
55/56	0.0	13.2	10.2	1.5	1.5	11.4	0.0	0.0	0.0	0.0	0.0	0.0	37.8
56/57	0.0	0.0	12.1	7.6	22.1	23.9	5.0	10.1	0.0	0.0	0.0	0.0	80.8
57/58	0.0	0.0	7.0	4.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	13.5
58/59	0.0	0.0	1.0	2.5	3.8	24.2	2.2	0.0	0.0	0.0	0.0	0.0	33.7
59/60	0.0	8.4	9.5	3.0	0.0	2.5	0.0	3.0	0.0	0.0	0.0	0.0	26.4
60/61	0.0	11.0	6.0	6.9	24.3	0.0	1.5	0.0	0.0	0.0	0.0	0.0	49.7
61/62	5.0	37.0	37.5	17.0	11.0	0.0	12.0	3.0	0.0	0.0	0.0	0.0	122.5
62/63	8.0	0.0	3.5	8.0	53.0	4.5	18.0	11.0	0.0	0.0	0.0	0.0	106.0
63/64	1.0	0.0	20.0	11.5	19.0	2.0	0.0	0.0	0.0	0.0	0.0	0.2	53.5
64/65	0.0	2.5	24.5	44.0	2.5	5.4	4.0	0.0	0.0	0.0	0.0	0.0	82.9
65/66	12.0	11.0	2.0	11.0	18.2	14.2	0.2	0.0	0.0	0.0	0.0	0.0	68.6
66/67	16.7	27.5	26.5	22.8	12.5	15.9	0.0	16.2	0.0	0.0	0.0	0.0	138.1
67/68	39.0	3.0	0.0	30.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.0
68/69	3.3	4.7	14.9	19.0	2.5	28.1	3.3	2.0	0.0	0.0	0.0	0.0	77.8
69/70	12.2	0.0	3.7	13.5	13.5	8.8	0.5	0.0	0.0	0.0	0.0	0.0	52.2
70/71	0.0	0.0	4.4	23.7	8.3	5.4	31.2	2.2	0.0	0.0	0.0	0.0	75.2
71/72	0.0	0.4	34.3	0.9	15.2	15.7	31.6	1.7	0.0	0.0	0.0	0.0	99.8
72/73	0.0	25.5	0.0	18.2	1.7	2.2	0.4	0.0	0.0	0.0	0.0	0.0	48.0
73/74	0.9	17.4	14.5	35.3	73.4	29.2	4.2	0.0	0.0	0.0	0.0	0.0	174.9
74/75	0.0	26.8	0.1	2.9	42.1	2.1	0.5	0.0	0.0	0.0	0.0	0.0	74.5
75/76	0.0	0.4	7.8	3.9	25.5	27.5	7.9	0.0	0.0	0.0	0.0	0.8	73.0
76/77	4.7	1.0	0.6	13.2	2.5	4.4	1.2	0.0	0.0	0.0	0.0	0.0	27.6
77/78	0.0	1.2	14.0	4.0	2.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	25.6
78/79	0.0	0.0	0.0	4.0	6.7	3.7	0.0	2.8	0.0	0.0	0.0	0.0	17.2
79/80	0.0	49.0	12.4	1.2	17.6	10.3	0.0	0.0	0.0	0.0	0.0	0.0	90.5
80/81	3.1	0.0	48.4	11.7	10.3	6.7	9.2	0.0	0.0	0.0	0.0	0.0	89.4
81/82	0.0	5.4	0.0	21.5	7.5	1.9	23.1	8.4	0.0	0.0	0.0	0.0	67.8
82/83	3.0	6.4	10.7	11.0	9.2	4.5	1.2	3.0	0.0	0.0	0.0	0.0	49.0
83/84	0.0	7.0	6.8	9.8	3.0	10.3	0.8	0.0	0.0	0.0	0.0	0.0	37.7
84/85	4.1	8.6	8.1	1.3	7.8	27.2	0.0	0.0	0.0	0.0	0.0	0.0	57.1
85/86	0.0	30.0	30.5	0.2	5.4	0.0	39.3	0.0	0.0	0.0	0.0	0.0	105.4
86/87	0.2	30.3	1.2	1.4	2.3	0.0	31.5	0.0	0.0	0.0	0.0	0.0	66.9
87/88	4.9	0.0	15.3	40.1	10.9	28.7	5.4	0.0	0.0	0.0	0.0	0.0	105.3
88/89	32.8	60.8	56.7	25.8	1.5	11.1	0.0	0.0	0.0	0.0	0.0	0.0	188.7
89/90	0.0	3.5	0.3	10.4	43.8	14.3	11.9	0.0	0.0	0.0	0.0	0.0	84.2
90/91	25.1	0.0	0.5	35.5	2.8	51.6	1.0	0.0	0.0	0.0	0.0	0.0	116.5
91/92	0.0	5.8	14.9	5.0	16.2	1.8	0.0	3.0	0.0	0.0	0.0	0.0	46.7
92/93	0.0	9.3	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5

Table (A.3): Continue

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
93/94	1.0	2.1	6.1	16.3	2.6	8.0	0.0	0.0	0.0	0.0	0.0	0.0	36.1
94/95	6.0	40.1	20.5	0.0	26.7	1.9	1.5	1.1	0.0	0.0	0.0	0.0	97.8
95/96	0.0	1.0	4.2	11.7	3.8	3.3	0.2	0.0	0.0	0.0	0.0	0.0	24.2
96/97	0.0	4.8	8.1	22.3	9.9	5.1	0.2	0.0	0.0	0.0	0.0	0.0	50.4
97/98	9.5	7.4	15.4	27.2	9.5	11.5	0.2	3.4	0.0	0.0	0.0	0.0	84.1
98/99	0.0	0.0	0.7	13.0	12.6	0.1	4.2	0.0	0.0	0.0	0.0	0.0	30.6
99/000	0.0	8.1	10.8	4.2	14.9	4.0	0.8	0.0	0.0	0.0	0.0	0.0	42.8
000/001	2.5	0.0	5.3	1.7	6.4	3.0	25.0	2.0	0.0	0.0	0.0	0.0	45.9
001/002	4.1	5.7	3.3	17.7	8.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	43.0
Average	3.58	9.74	13.58	11.80	13.09	9.45	5.61	2.36	0.00	0.00	0.00	0.02	69.20
Maximum	39.00	60.80	62.90	44.00	73.40	51.60	39.30	25.70	0.00	0.00	0.00	0.80	193.70
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.50
Median	0.00	4.75	8.55	7.60	9.70	4.55	0.90	0.00	0.00	0.00	0.00	0.00	67.35
St. Dev.	7.61	13.88	14.89	12.01	13.96	10.68	9.46	5.30	0.00	0.00	0.00	0.11	40.13
Cv.	2.13	1.43	1.10	1.02	1.07	1.13	1.69	2.25	-	-	-	6.36	0.58
Skew	3.24	1.89	1.59	1.18	2.16	1.68	2.09	2.92	-	-	-	7.16	1.15

Table (A.4): Monthly Precipitation (mm/month) for the JAfar Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
80/81	0.0	0.0	39.1	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.1
81/82	0.0	0.0	0.3	3.9	4.9	0.0	0.0	2.7	0.0	0.0	0.0	2.6	14.4
82/83	0.0	1.3	0.0	2.1	5.3	7.4	3.3	0.0	0.0	0.0	0.0	0.0	19.4
83/84	0.0	0.0	1.6	2.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6
84/85	24.0	0.0	2.6	0.6	1.0	9.2	0.0	13.5	0.0	0.0	0.0	0.0	50.9
85/86	0.0	0.0	28.8	0.2	6.7	2.6	0.0	6.5	0.0	0.0	0.0	0.0	44.8
86/87	0.0	1.2	0.1	0.3	0.2	6.5	19.3	0.0	0.0	0.0	0.0	0.0	27.6
87/88	78.4	0.0	7.5	17.5	2.7	19.5	0.0	2.3	0.0	0.0	0.0	0.0	127.9
88/89	9.7	0.0	18.1	4.7	7.1	8.1	6.9	0.0	0.0	0.0	0.0	0.0	54.6
89/90	0.0	11.4	1.8	3.9	0.4	7.3	0.0	0.0	0.0	0.0	0.0	0.0	24.8
90/91	7.0	0.0	2.7	15.9	0.2	22.4	3.6	0.0	0.0	0.0	0.0	0.0	51.8
91/92	0.6	0.0	3.9	3.3	1.5	1.4	0.0	0.2	0.0	0.0	0.0	0.0	10.9
92/93	0.0	8.5	1.5	1.7	0.8	1.5	0.0	5.6	0.0	0.0	0.0	0.0	19.6
93/94	9.3	0.0	8.8	48.6	0.6	4.0	0.0	0.0	0.0	0.0	0.0	2.2	73.5
94/95	8.4	4.0	1.1	0.0	3.1	13.6	0.6	0.0	0.0	0.0	0.0	0.0	30.8
95/96	0.0	0.0	0.3	7.6	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	11.0
96/97	0.0	31.3	0.7	12.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	46.0
97/98	19.5	1.1	1.0	2.6	6.1	3.7	3.5	1.5	0.0	0.0	0.0	0.0	39.0
98/99	0.0	0.0	0.0	1.1	12.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7
99/000	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5
000/001	1.0	0.0	1.7	7.0	4.9	1.5	34.0	1.0	0.0	0.0	0.0	0.0	51.1
001/002	0.0	2.0	0.0	9	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.0
Average	7.18	2.76	5.53	6.58	3.63	5.13	3.24	1.60	0.00	0.00	0.00	0.22	35.86
Maximum	78.40	31.30	39.10	48.60	12.60	22.40	34.00	13.50	0.00	0.00	0.00	2.60	127.90
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.60
Median	0.00	0.00	1.55	3.05	2.10	2.85	0.00	0.00	0.00	0.00	0.00	0.00	29.20
St. Dev.	17.28	7.03	10.21	10.66	3.82	6.33	8.11	3.23	0.00	0.00	0.00	0.71	27.47
Cv.	2.41	2.54	1.85	1.62	1.05	1.24	2.51	2.01	-	-	-	3.25	0.77
Skew	3.68	3.58	2.50	3.21	1.16	1.61	3.22	2.81	-	-	-	3.10	1.88

Table (A.5): Monthly Precipitation (mm/month) for the Shoubak Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
37/38	0.5	61.0	67.0	144.0	96.0	98.0	3.5	1.0	0.0	0.0	0.0	0.0	471.0
38/39	0.0	58.3	48.8	24.3	97.5	93.7	39.7	0.0	0.0	0.0	0.0	0.0	362.3
39/40	0.0	117.0	7.0	79.0	19.0	49.0	53.5	0.0	0.0	0.0	0.0	0.0	324.5
40/41	15.0	7.6	63.0	1.0	51.3	208.0	0.0	0.0	0.0	0.0	0.0	0.0	345.9
41/42	0.0	5.0	317.5	143.5	53.0	172.5	4.0	0.0	0.0	0.0	0.0	0.0	695.5
42/43	25.0	37.0	18.0	78.5	167.0	315.5	61.0	0.0	0.0	0.0	0.0	0.0	702.0
43/44	0.0	0.0	59.5	186.4	25.6	62.8	51.5	50.0	0.0	0.0	0.0	0.0	435.8
44/45	0.0	74.4	132.7	91.0	86.0	51.3	14.0	180.0	0.0	0.0	0.0	0.0	629.4
45/46	0.0	38.5	76.5	109.5	56.5	12.0	0.0	5.0	0.0	0.0	0.0	0.0	298.0
46/47	0.0	7.0	9.0	51.0	0.0	155.5	10.0	0.0	0.0	0.0	0.0	0.0	232.5
47/48	0.0	32.0	10.0	85.5	50.0	124.5	24.0	0.0	0.0	0.0	0.0	0.0	326.0
48/49	0.0	9.5	32.0	50.0	170.5	58.0	16.0	0.0	0.0	0.0	0.0	0.0	336.0
49/50	0.0	14.0	121.0	51.5	163.5	10.5	0.5	30.5	0.0	0.0	0.0	0.0	391.5
50/51	0.5	1.5	34.0	53.0	169.5	19.0	0.0	0.0	0.0	0.0	0.0	0.0	277.5
51/52	0.0	7.0	12.0	36.5	149.0	40.0	8.0	0.0	0.0	0.0	0.0	0.0	252.5
52/53	0.0	0.0	4.7	2.0	55.3	52.3	23.0	0.0	0.0	0.0	0.0	0.0	137.3
53/54	0.0	30.4	116.1	3.5	129.7	48.3	50.0	0.0	0.0	0.0	0.0	0.0	378.0
54/55	0.0	13.5	132.3	51.7	19.7	10.0	7.5	0.0	0.0	0.0	0.0	0.0	234.7
55/56	0.0	30.7	80.7	75.3	13.8	54.7	19.2	0.0	0.0	0.0	0.0	0.0	274.4
56/57	0.0	12.3	55.3	70.5	53.9	85.5	24.5	15.5	0.0	0.0	0.0	0.0	317.5
57/58	0.0	22.0	2.0	98.5	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	128.4
58/59	0.0	3.0	23.0	22.6	192.2	21.5	21.8	1.5	0.0	0.0	0.0	0.0	285.6
59/60	0.0	54.0	23.0	48.9	0.0	47.5	2.0	0.0	0.0	0.0	0.0	0.0	175.4
60/61	0.0	18.2	40.8	72.3	74.0	19.6	12.4	5.2	0.0	0.0	0.0	0.0	242.5
61/62	9.6	28.2	82.0	78.8	8.9	0.0	24.5	0.0	0.0	0.0	0.0	0.0	232.0
62/63	0.0	0.0	11.5	2.3	48.4	29.5	23.0	0.0	0.0	0.0	0.0	0.0	114.7
63/64	0.0	9.0	352.3	85.3	78.6	29.1	13.0	0.0	0.0	0.0	0.0	0.0	567.3
64/65	0.0	27.7	75.0	350.5	0.0	48.8	26.5	0.2	0.0	0.0	1.2	0.0	529.9
65/66	3.6	3.0	4.6	31.3	68.8	72.6	0.0	0.0	0.0	0.0	0.0	0.0	183.9
66/67	16.6	19.0	16.2	85.0	82.0	99.9	1.6	59.5	0.0	0.0	0.0	0.0	379.8
67/68	8.7	38.9	16.2	92.9	61.5	27.7	22.3	16.4	0.0	0.0	0.0	0.0	284.6
68/69	15.7	45.3	61.6	55.8	5.2	120.9	51.7	3.2	0.0	0.0	0.0	0.0	359.4
69/70	2.5	22.7	0.2	45.5	2.0	95.9	8.2	0.0	0.0	0.0	0.0	0.0	177.0
70/71	0.3	4.4	71.7	56.7	22.5	5.7	98.2	0.0	0.0	0.0	0.0	0.0	259.5
71/72	0.0	5.0	200.8	10.3	77.0	143.0	21.6	0.5	0.0	0.0	0.0	0.0	458.2
72/73	18.0	43.3	16.0	57.2	0.5	2.0	1.1	0.0	0.0	0.0	0.0	0.0	138.1
73/74	0.0	11.9	16.0	238.0	107.0	22.0	15.2	0.0	0.0	0.0	0.0	0.0	410.1
74/75	0.0	13.0	77.4	35.2	159.3	23.0	2.0	0.2	2.3	0.0	0.0	0.0	312.4
75/76	0.0	2.1	64.7	15.3	25.6	72.0	3.7	2.7	0.0	0.0	0.0	0.0	186.1
76/77	4.8	5.3	2.4	102.2	22.2	27.1	104.0	2.4	0.0	0.0	0.0	0.0	270.4
77/78	0.0	75.2	76.2	22.7	21.1	34.5	0.0	0.0	0.0	0.0	0.0	0.0	229.7
78/79	0.2	3.4	43.8	143.6	61.6	46.9	0.0	10.0	0.0	0.0	0.0	0.0	309.5
79/80	2.7	63.5	100.3	32.0	135.3	32.6	6.5	1.7	0.0	0.0	0.0	0.0	374.6
80/81	8.7	0.0	146.2	13.8	31.0	76.3	18.4	0.4	0.0	0.0	0.0	0.0	294.8
81/82	0.0	14.2	7.6	63.2	95.2	74.8	8.8	18.1	0.0	0.0	0.0	2.5	284.4
82/83	0.4	95.2	84.6	98.0	72.7	94.1	2.0	0.3	0.0	0.0	0.0	0.0	447.3
83/84	0.0	2.0	8.1	35.2	7.5	42.4	0.0	0.0	0.0	0.0	0.0	0.0	95.2.0
84/85	11.4	1.0	49.0	9.8	104.8	42.5	21.7	6.2	0.0	0.0	0.0	0.0	246.4
85/86	8.0	0.8	126.0	17.1	44.0	5.6	67.6	9.2	0.0	0.0	0.1	0.0	278.4
86/87	0.0	50.7	14.5	6.9	49.3	88.5	0.0	0.0	0.0	0.0	0.0	0.0	209.9

Table (A.5): Continue

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
87/88	2	0.0	47.7	125.7	129.5	145.7	5.3	0.0	0.0	0.0	0.0	0.0	455.9
88/89	2.3	0.0	97.7	89.9	80.9	35.9	0.0	0.0	0.0	0.0	0.0	0.0	306.7
89/90	0.0	5.5	11.8	37.1	16	63.4	90.3	0.0	0.0	0.0	0.0	0.0	224.1
90/91	13.6	0.0	0.0	142.7	44.7	279.6	0.0	1.3	0.0	0.0	0.0	0.0	481.9
91/92	10.5	4.7	59	154	162.3	29.9	0.0	0.4	0.0	0.0	0.0	0.0	420.8
92/93	0.0	30.4	96.5	30.8	57.6	7.3	3	4.1	0.0	0.0	0.0	0.0	229.7
93/94	22.5	0.9	32.3	121.8	56.7	41.8	2	0.0	0.0	0.0	0.0	2.5	280.5
94/95	22.9	185.5	70	0.0	107	4.9	34.7	0.0	0.0	0.0	0.0	0.0	425
95/96	0.0	18.8	1.8	96.1	24.3	69.3	4.5	0.0	0.0	0.0	0.0	0.0	214.8
96/97	0.0	17.4	17.8	140.5	24.4	37	7.7	0.4	0.0	0.0	0.0	0.0	245.2
97/98	18	0.3	56.7	93.2	56.3	45.3	5.4	4.8	0.0	0.0	0.0	0.0	280.0
98/99	0.5	0.7	12.6	35.4	90.1	5.5	1.4	0.0	0.0	0.0	0.0	2.5	146.2
99/000	2.7	0.0	2.2	32	83	29	4.8	0.0	0.0	0.0	0.0	0.0	153.7
000/001	16	24	34	58	92	27	11	0.0	0.0	0.0	0.0	0.0	262.0
001/002	21	31	45	62	99	24	5.9	0.0	0.0	0.0	0.0	0.0	287.9
Average	4.37	23.97	58.40	71.29	67.92	61.73	17.90	6.63	0.04	0.00	0.02	0.12	315.73
Maximum	25.00	185.50	352.30	350.50	192.20	315.50	104.00	180.00	2.30	0.00	1.20	2.50	702.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	114.70
Median	0.00	13.00	45.00	57.20	56.70	45.30	8.00	0.00	0.00	0.00	0.00	0.00	285.10
St. Dev.	7.19	32.30	65.83	60.31	51.22	61.42	24.20	24.27	0.29	0.00	0.15	0.53	129.10
Cv.	1.64	1.35	1.13	0.85	0.75	0.99	1.35	3.66	8.06	-	7.46	4.58	0.41
Skew	1.53	2.66	2.54	1.98	0.65	2.16	2.02	6.14	8.06	-	7.98	4.43	1.06

Table (A.6): Monthly Precipitation (mm/month) for the Mafraq Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
60/61	0.8	35.3	16.9	42.4	33.2	18.5	7.1	2.6	0.0	0.0	0.0	0.0	156.8
61/62	2.0	8.2	44.4	17.9	25.3	1.0	1.8	0.0	0.0	0.0	0.0	0.0	100.6
62/63	2.1	0.0	9.4	6.1	39.0	6.1	5.7	10.3	0.0	0.0	0.0	0.0	78.7
63/64	7.0	5.4	31.6	31.9	46.5	35.7	3.5	0.0	0.0	0.0	0.0	0.0	161.6
64/65	0.0	15.5	50.5	85.7	9.7	6.6	18.5	0.0	0.0	0.0	0.0	0.0	186.5
65/66	23.4	2.9	8.8	21.6	17.8	67.8	0.5	0.8	0.0	0.0	0.0	0.0	143.6
66/67	15.0	15.9	75.1	53.7	23.2	59.7	0.0	18.3	0.0	0.0	0.0	0.0	260.9
67/68	28.7	26.7	11.3	38.1	15.2	18.7	15.9	4.3	0.0	0.0	0.0	0.0	158.9
68/69	1.4	7.7	32.2	46.7	10.6	51.0	10.8	3.8	0.0	0.0	0.0	0.3	164.5
69/70	13.9	15.3	4.4	28.5	18.9	33.9	7.5	0.0	0.0	0.0	0.0	0.0	122.4
70/71	2.9	8.2	20.0	36.0	21.7	21.7	52.6	0.0	0.0	0.0	0.0	0.0	163.1
71/72	0.1	16.9	51.8	18.1	45.4	29.3	14.4	1.2	0.0	0.0	0.0	0.0	177.2
72/73	0.5	24.7	2.4	32.5	3.2	19.4	5.7	0.5	0.0	0.0	0.0	0.0	88.9
73/74	0.6	24.6	9.2	99.3	57.5	22.2	12.7	0.0	0.0	0.0	0.0	0.0	226.1
74/75	0.0	11.4	22.5	8.6	76.2	21.4	20.5	0.0	0.0	0.0	0.0	1.0	161.6
75/76	0.2	11.2	22.1	13.2	32.8	56.1	5.0	10.0	0.0	0.0	0.0	0.0	150.6
66/67	4.3	4.5	2.2	35.6	8.3	18.5	15.1	0.2	0.0	0.0	0.0	0.0	88.7
77/78	9.1	2.0	38.9	21.2	13.7	19.5	4.5	0.0	0.4	0.0	0.0	0.0	109.3
78/79	4.2	1.1	21.9	17.0	19.0	11.2	0.5	0.0	0.0	0.0	0.0	0.0	74.9
79/80	24.4	71.1	59.6	37.9	44.0	52.9	11.5	0.0	0.0	0.0	0.0	0.0	301.4
80/81	2.6	2.6	97.1	14.5	26.1	27.0	6.1	0.0	0.0	0.0	0.0	0.7	176.7
81/82	0.0	19.5	3.6	41.9	25.4	11.7	28.8	20.8	0.0	0.0	0.0	3.4	155.1
82/83	8.4	35.5	11.8	30.6	51.7	36.4	1.5	2.0	0.0	0.0	0.0	0.0	177.9
83/84	1.6	16.6	3.9	34.2	9.7	50.6	2.1	0.0	0.0	0.0	0.0	0.0	118.7
84/85	20.0	16.1	26.8	16.3	76.1	28.9	5.8	2.1	0.0	0.0	0.0	0.0	192.1
85/86	1.6	2.5	13.2	11.6	39.1	4.4	3.3	1.9	0.0	0.0	0.0	0.0	77.6
86/87	7.6	97.8	17.9	27.7	17.8	35.4	0.0	0.0	0.0	0.0	0.0	0.0	204.2
87/88	22.7	6.1	37.2	82.6	70.6	42.2	11.7	0.0	0.0	0.0	0.0	0.0	273.1
88/89	4.7	9.0	68.4	33.4	9.2	15.4	0.0	0.0	0.2	0.0	0.0	0.0	140.3
89/90	12.0	13.7	32.8	45.4	31.7	38.9	17.0	0.0	0.0	0.0	0.0	0.0	191.5
90/91	0.5	10.7	2.0	64.6	15.3	41.7	5.9	0.0	0.0	0.0	0.0	0.2	140.9
91/92	20.7	17.3	79.9	46.2	102.0	14.2	0.4	3.2	1.6	0.0	0.0	0.0	285.5
92/93	0.0	19.2	50.2	27.5	19.3	17.3	0.1	9.6	0.0	0.0	0.0	0.1	143.3
93/94	4.2	12.9	7.7	52.5	20.9	32.4	1.1	0.0	0.6	0.0	0.0	7.8	140.1
94/95	7.4	96.6	48.0	0.7	40.1	15.3	2.0	0.2	0.0	0.0	0.0	0.0	210.3
95/96	0.2	11.4	9.0	41.2	9.6	49.6	5.0	0.2	0.0	0.0	0.0	0.0	126.2
96/97	9.3	20.7	18.1	44.6	35.1	25.4	3.6	1.2	0.0	0.0	0.0	0.0	158.0
97/98	11.8	24.1	33.9	41.2	11.5	54.8	5.4	0.2	0.0	0.0	0.0	0.0	182.9
98/99	7.7	21.4	31.1	21.1	18.2	20.9	3.4	1.2	0.0	0.0	0.0	0.0	19.6
99/000	7.7	21.1	30.7	20.8	18.0	20.7	0.0	0.0	0.0	0.0	0.0	0.0	9.1
000/001	7.5	20.3	29.8	20.0	17.3	20.2	17.0	0.0	0.0	0.0	0.0	0.0	35.7
001/002	0.0	3.0	2.0	5.0	5.3	0.0	3.4	1.2	0.0	0.0	0.0	0.0	19.9
Average	7.11	19.21	28.34	33.70	29.31	27.97	8.03	2.28	0.07	0.00	0.00	0.32	148.93
Maximum	28.70	97.80	97.10	99.30	102.00	67.80	52.60	20.80	1.60	0.00	0.00	7.80	301.40
Minimum	0.00	0.00	2.00	0.70	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.10
Median	4.25	15.40	22.30	32.20	21.30	21.95	5.20	0.20	0.00	0.00	0.00	0.00	155.95
St. Dev.	7.92	21.56	23.35	21.29	21.85	17.00	9.77	4.73	0.27	0.00	0.00	1.30	67.56
Cv.	1.11	1.12	0.82	0.63	0.75	0.61	1.22	2.07	4.01	-	-	4.06	0.45
Skew	1.24	2.67	1.08	1.17	1.48	0.51	2.68	2.80	5.07	-	-	5.16	0.03

Table (A.8): Monthly Mean Minimum Temperature (C°) for the Amman Airport Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1923	3.9	4.6	5.8	7.3	14.0	16.2	17.8	16.9	17.3	13.9	10.2	7.3	11.3
1924	4.6	5.6	7.6	9.5	12.5	17.2	18.5	18.6	16.8	13.5	9.6	4.8	11.6
1925	1.2	2.6	8.9	8.2	13.1	15.8	17.8	18.8	17.2	14.6	10.9	7.2	11.4
1926	5.1	4.9	6.3	9.4	13.5	16.4	17.1	16.1	14.1	13.3	8.6	6.1	10.9
1927	3.8	2.7	6.6	8.6	13.6	16.6	18.9	18.0	16.6	15.2	10.3	4.2	11.3
1928	4.1	4.6	4.5	11.1	14.8	16.2	19.3	19.6	16.4	12.6	8.8	5.4	11.5
1929	3.0	3.8	4.9	8.6	14.6	16.0	17.4	19.3	17.6	12.4	10.6	5.0	11.1
1930	2.8	4.6	6.3	9.8	12.1	16.1	18.0	19.5	16.5	13.4	9.3	6.9	11.3
1931	4.6	4.1	6.8	9.3	12.3	15.8	18.6	18.6	17.6	14.6	8.6	3.6	11.2
1932	3.3	4.1	6.3	9.2	12.4	17.4	18.4	18.6	16.1	15.4	9.1	2.6	11.1
1933	3.7	5.4	6.1	7.2	12.6	16.3	16.3	17.3	15.1	12.1	11.1	5.3	10.7
1934	2.9	2.0	6.1	9.8	13.6	16.9	17.9	18.2	16.2	14.0	9.9	5.4	11.1
1935	4.6	5.3	7.6	8.6	15.4	17.8	17.9	18.8	16.8	14.6	8.4	6.1	11.8
1936	4.8	5.9	7.6	10.7	13.4	15.4	18.6	20.1	15.2	16.0	11.8	3.8	11.9
1937	2.0	5.2	8.3	11.3	13.6	16.1	18.9	17.9	18.2	15.1	11.3	6.1	12.0
1938	5.1	3.8	4.6	10.4	12.6	16.1	19.7	19.2	16.5	13.7	8.6	5.6	11.3
1939	3.6	5.0	5.8	9.9	15.8	15.3	19.1	17.7	17.3	15.3	8.8	6.1	11.6
1940	4.5	5.3	5.9	10.3	12.8	16.6	19.2	17.5	16.0	14.7	9.1	6.1	11.5
1941	5.8	6.6	6.6	10.0	17.4	16.4	18.2	18.2	16.3	11.9	10.6	5.0	11.9
1942	3.1	4.8	7.5	11.0	14.6	18.4	18.8	18.1	15.2	14.4	10.1	5.4	11.8
1943	3.8	2.9	3.9	6.9	12.1	14.6	18.1	19.2	16.7	16.3	11.4	7.1	11.1
1944	3.9	4.6	6.8	10.6	12.6	16.9	18.1	17.5	16.8	14.0	10.2	6.2	11.5
1945	3.8	2.9	3.0	7.2	15.6	15.7	18.9	19.6	17.0	12.5	9.6	4.8	10.9
1946	3.8	3.8	5.7	9.6	13.3	16.5	18.5	18.6	17.7	13.7	11.7	6.7	11.6
1947	5.2	5.9	8.7	10.4	15.2	16.5	18.8	19.2	16.0	13.8	10.6	7.6	12.3
1948	5.8	5.3	4.4	8.7	13.5	16.2	19.6	19.4	16.3	13.4	9.9	5.2	11.5
1949	2.2	2.6	6.1	6.9	14.8	16.0	17.4	17.7	14.6	13.3	10.8	6.8	10.8
1950	3.1	2.6	6.5	12.1	13.4	15.7	18.3	18.0	16.8	13.9	10.4	6.8	11.5
1951	3.8	5.2	8.1	10.6	14.8	16.1	18.7	18.7	17.6	13.4	9.4	4.4	11.7
1952	4.3	5.5	6.4	9.7	13.2	15.8	17.7	20.0	19.5	15.2	8.9	6.4	11.9
1953	4.0	5.5	4.6	9.3	13.6	16.4	20.1	18.8	15.9	14.5	7.7	2.9	11.1
1954	3.6	5.1	7.6	8.5	14.2	16.7	19.5	20.4	16.3	14.3	12.8	5.8	12.1
1955	4.2	6.7	6.3	10.1	14.1	18.2	18.2	16.9	16.6	14.9	9.8	6.5	11.9
1956	4.3	5.9	4.9	9.3	11.4	16.4	19.1	20.8	16.4	12.6	11.3	4.2	11.4
1957	1.8	4.0	8.4	11.2	11.8	15.7	17.7	19.0	15.9	14.2	8.9	4.0	11.1
1958	4.6	3.3	6.1	11.0	11.8	15.4	16.5	17.9	14.7	12.2	7.4	4.9	10.5
1959	3.5	0.1	4.5	9.3	12.8	16.8	16.7	15.6	13.8	11.6	8.2	4.4	9.8
1960	3.9	5.0	5.4	9.0	15.0	15.9	17.5	17.8	15.5	13.6	9.6	6.7	11.2
1961	2.7	2.7	3.9	7.9	12.6	16.6	17.8	18.4	13.4	11.0	6.9	4.8	9.9
1962	4.0	3.1	6.6	7.6	12.6	16.5	17.1	18.6	15.9	14.7	11.0	5.7	11.1
1963	5.3	5.8	4.5	9.5	11.2	15.9	18.3	19.1	14.4	15.2	9.6	4.3	11.1
1964	0.5	3.2	6.4	7.5	9.8	15.2	16.4	16.3	13.8	11.1	7.9	3.7	9.3
1965	3.0	3.0	5.4	7.1	11.2	16.8	17.3	18.2	15.7	11.1	6.8	4.4	10.0
1966	3.1	3.8	4.7	9.1	11.8	16.2	17.6	17.9	14.7	12.5	10.0	5.6	10.6
1967	1.8	2.0	3.1	7.5	10.7	13.9	17.5	17.6	15.5	13.0	8.1	5.6	9.7
1968	2.7	3.5	5.7	10.5	14.6	16.9	19.5	18.0	15.8	14.0	9.6	6.2	11.4
1969	3.5	5.3	8.1	8.3	14.4	18.7	17.5	18.3	18.1	13.7	7.3	4.8	11.5
1970	4.0	4.2	7.2	10.3	12.2	15.5	17.7	17.9	15.6	11.1	8.4	2.9	10.6
1971	4.5	4.0	5.5	7.2	12.9	15.4	17.0	18.0	16.4	11.2	7.7	3.7	10.3
1972	1.8	1.8	5.5	10.1	11.6	15.6	16.7	17.6	15.8	13.4	7.4	0.6	9.8
1973	1.0	4.7	5.4	8.2	13.1	15.0	18.6	17.6	15.6	13.4	6.0	3.7	10.2
1974	1.9	3.2	6.7	8.4	10.7	16.3	18.4	17.3	15.0	13.6	8.5	3.0	10.3
1975	2.0	3.0	4.7	9.8	11.6	15.8	17.7	17.2	15.6	10.5	7.7	3.1	9.9
1976	2.2	2.1	4.6	8.3	13.0	15.4	16.9	16.8	15.9	14.2	8.9	5.3	10.3

Table (A.8) Continue

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1977	2.6	6.4	5.9	8.6	13.6	16.4	18.9	18.7	15.7	11.6	8.1	4.7	10.9
1978	3.4	4.8	6.3	8.1	14.5	16.1	19.8	15.7	15.6	14.0	5.7	5.5	10.8
1979	3.7	5.4	7.0	10.6	13.3	17.2	17.6	17.6	17.3	14.0	10.5	4.2	11.5
1980	2.5	4.0	5.7	8.7	13.5	17.9	19.5	18.9	15.3	14.2	10.0	5.5	11.3
1981	3.3	4.4	7.7	10.0	12.8	17.5	19.3	19.3	18.1	15.0	7.5	5.9	11.7
1982	4.3	3.6	5.5	11.7	12.8	17.2	18.1	18.7	17.0	14.0	6.6	3.9	11.1
1983	1.9	3.4	5.5	9.1	13.7	16.9	18.5	18.1	16.9	12.9	10.5	5.6	11.1
1984	4.7	5.1	7.8	9.3	15.1	17.1	18.8	17.7	17.3	14.9	9.4	3.3	11.7
1985	5.8	3.6	6.1	9.6	14.7	16.7	18.6	21.1	17.4	12.7	10.8	5.8	11.9
1986	4.0	5.7	7.9	12.5	12.0	17.4	19.0	19.1	19.4	14.5	7.6	4.2	11.9
1987	4.3	6.1	4.4	8.6	13.9	16.9	20.1	19.9	17.7	13.3	8.8	7.1	11.8
1988	4.7	4.8	6.6	10.3	15.1	17.8	20.5	19.7	17.8	13.7	7.1	5.7	12.0
1989	1.5	3.0	6.5	13.1	14.8	16.3	18.8	19.1	16.8	13.8	10.1	5.1	11.6
1990	3.3	4.0	5.9	9.8	13.7	17.0	19.6	18.8	16.5	15.0	11.3	6.9	11.8
1991	3.8	4.7	8.7	11.8	7.0	17.9	18.6	18.5	17.6	15.1	10.0	3.9	11.5
1992	1.4	2.0	4.6	8.7	13.4	17.4	18.0	19.6	17.0	15.1	9.1	3.9	10.9
1993	2.0	2.6	6.0	10.3	13.5	18.2	19.3	20.5	17.5	15.9	8.8	7.2	11.8
1994	5.9	4.9	6.9	12.5	15.9	17.3	19.6	20.0	19.6	16.9	9.2	3.1	12.7
1995	4.5	5.2	7.0	8.9	15.6	19.0	19.3	19.3	18.6	13.9	7.7	4.7	12.0
1996	4.9	6.1	6.8	9.1	16.7	17.7	21.7	20.4	18.3	13.7	10.4	7.2	12.8
1997	4.9	2.1	5.0	8.2	15.9	17.8	19.9	18.3	16.8	15.0	10.2	6.3	11.7
1998	4.5	5.3	5.6	11.5	15.2	18.4	20.8	21.8	19.5	15.0	11.9	7.2	13.1
1999	5.2	5.1	7.8	11	16.9	18.2	20.6	21.3	18.3	15.5	10.6	6.2	13.1
2000	3.6	3.9	6	12	14.4	18.7	23.6	20.4	18.7	14	9.6	6.6	12.6
2001	5	7.3	10.7	11.6	15	18.7	21.4	20.7	18.3	15	10	6.6	13.4
2002	3.3	5.6	8.8	10	13.7	17.1	21.7	20.4	18.3	16.7	10.2	6.3	12.7
Average	3.61	4.28	6.23	9.54	13.48	16.64	18.62	18.63	16.60	13.84	9.35	5.24	11.35
Maximum	5.90	7.30	10.70	13.10	17.40	19.00	23.60	21.80	19.60	16.90	12.80	7.60	13.40
Minimum	0.50	0.10	3.00	6.90	7.00	13.90	16.30	15.60	13.40	10.50	5.70	0.60	9.30
Median	3.80	4.60	6.10	9.50	13.50	16.50	18.55	18.60	16.55	13.95	9.60	5.40	11.40
St. Dev.	1.22	1.37	1.42	1.44	1.66	1.02	1.29	1.25	1.35	1.36	1.46	1.38	0.80
Cv.	0.34	0.32	0.23	0.15	0.12	0.06	0.07	0.07	0.08	0.10	0.16	0.26	0.07
Skew	-0.37	-0.37	0.30	0.19	-0.57	0.23	0.99	0.07	0.04	-0.36	-0.25	-0.56	-0.07

Table (A.9): Monthly Mean Maximum Temperature (C^0) for the Irbid Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1955	15.9	17.8	18.4	23.4	28.0	33.0	32.8	31.3	30.5	28.3	20.0	14.5	24.5
1956	13.2	14.7	15.2	20.4	26.5	31.8	33.3	34.6	30.9	27.6	22.0	13.7	23.7
1957	11.4	13.1	16.0	21.1	26.0	30.9	32.3	33.3	30.6	29.0	21.8	16.0	23.5
1958	13.1	14.9	19.2	24.7	25.6	28.5	30.6	33.2	28.9	24.7	21.2	17.4	23.5
1959	14.5	8.5	15.7	22.3	28.0	29.9	28.8	30.9	27.9	25.0	21.0	16.2	22.4
1960	14.8	17.6	17.1	22.1	30.7	30.8	32.9	33.4	31.0	30.1	21.5	18.4	25.0
1961	12.5	12.7	16.4	23.3	28.8	32.4	32.7	32.7	28.7	27.3	20.6	15.5	23.6
1962	13.4	13.5	20.7	22.2	28.2	32.4	32.9	33.7	32.5	28.8	24.4	16.4	24.9
1963	16.8	16.9	16.4	23.2	25.7	31.8	32.6	33.8	32.0	28.9	22.9	15.9	24.7
1964	10.7	13.3	18.3	20.9	25.7	30.5	31.4	31.6	29.8	29.9	21.6	15.4	23.3
1965	12.4	15.7	19.8	20.5	27.5	33.1	32.5	31.5	29.9	23.3	20.3	15.7	23.5
1966	14.9	15.4	17.7	23.0	26.3	31.0	31.2	31.6	28.6	26.2	23.7	15.0	23.7
1967	12.1	11.4	13.9	20.3	24.8	28.9	30.5	30.8	28.3	26.2	18.8	15.3	21.8
1968	11.5	14.0	16.0	22.9	28.3	30.0	32.2	31.6	28.8	25.0	20.9	15.3	23.0
1969	11.2	15.9	18.4	19.6	27.5	30.9	29.7	31.3	31.0	25.4	20.9	16.7	23.2
1970	14.1	15.8	18.7	23.8	26.9	29.3	30.0	30.7	29.0	26.1	21.3	13.4	23.3
1971	15.9	14.1	17.7	18.2	27.4	29.0	29.3	30.5	29.9	25.5	19.4	11.8	22.4
1972	12.0	12.5	16.5	23.3	25.3	28.5	29.1	30.5	30.6	27.7	19.7	13.2	22.4
1973	13.1	17.4	16.9	21.8	26.7	28.9	31.5	30.7	30.4	27.8	17.4	14.8	23.1
1974	9.7	13.6	17.7	20.9	26.3	29.7	30.9	29.9	29.0	28.4	20.8	13.5	22.5
1975	12.6	12.9	17.7	24.1	25.8	28.6	30.6	29.3	28.8	25.6	20.2	12.9	22.4
1976	12.8	11.6	16.2	20.6	26.7	28.9	29.2	29.1	28.2	26.5	22.4	16.2	22.4
1977	11.6	18.1	16.7	20.5	27.0	29.6	31.4	32.5	28.9	24.0	21.5	13.3	22.9
1978	13.9	16.1	18.0	22.3	29.2	29.6	32.1	29.7	28.5	27.9	18.4	15.5	23.4
1979	14.2	17.0	18.5	24.2	26.2	30.6	30.4	30.7	29.9	26.6	22.6	12.8	23.6
1980	11.6	12.5	16.2	21.2	28.0	30.3	30.2	30.4	28.0	26.5	21.7	15.3	22.7
1981	12.3	13.0	17.7	21.8	25.0	29.5	30.5	30.4	30.8	27.7	17.9	16.8	22.8
1982	13.7	12.2	14.9	23.5	24.9	29.0	29.4	30.3	29.2	26.0	16.6	12.6	21.9
1983	9.3	11.4	15.1	19.8	25.5	29.0	30.2	30.1	28.6	24.7	21.4	15.8	21.7
1984	13.5	16.1	17.5	19.8	27.3	28.4	29.9	29.1	30.0	26.7	19.2	13.0	22.5
1985	14.9	11.9	18.1	21.6	26.7	28.9	30.2	32.6	29.8	24.0	22.6	15.3	23.1
1986	13.6	15.4	18.5	24.2	23.0	28.8	30.4	30.5	31.0	25.8	16.0	13.2	22.5
1987	14.9	16.5	13.5	19.9	27.1	29.0	31.4	31.6	30.3	24.4	21.0	14.6	22.9
1988	12.0	12.9	15.1	21.8	28.2	29.7	32.2	30.9	30.4	24.6	17.9	14.2	22.5
1989	10.2	13.7	16.7	27.4	28.2	28.8	31.0	30.8	29.4	24.9	20.7	15.0	23.1
1990	10.8	12.4	16.3	21.5	26.0	29.4	30.8	30.7	28.8	27.5	23.2	17.5	22.9
1991	12.6	14.2	18.0	23.3	25.8	29.3	29.5	29.8	29.3	27.1	21.2	11.8	22.7
1992	9.2	8.8	14.3	20.6	24.9	28.5	29.6	31.3	29.1	28.2	19.7	11.3	21.3
1993	12.0	11.4	16.6	22.8	24.8	30.4	30.8	31.8	29.7	28.5	19.1	17.8	23.0
1994	14.4	14.0	16.6	25.5	28.4	29.4	30.6	31.6	31.7	29.1	17.6	12.1	23.4
1995	13.7	14.6	17.7	21.6	27.6	30.5	30.7	31.4	30.2	25.5	18.7	14.6	23.1
1996	13.0	15.4	15.7	20.8	28.5	29.8	31.7	32.0	30.0	24.7	20.9	16.7	23.3
1997	14.7	11.9	14.1	19.6	28.5	29.8	31.3	29.2	28.5	26.7	20.6	15.4	22.5
1998	12.2	14.0	15.3	23.1	27.5	29.7	31.9	33.6	30.9	27.6	23.5	17.0	23.9
1999	14.8	15.7	18.9	23.4	29.0	30.0	31.8	33.6	31.5	27.5	21.9	21.9	25.0
2000	11.9	14.1	16.8	24.2	28.2	31.5	34.9	32.0	30.3	24.7	24.7	21.1	24.5
2001	15.6	15.4	23.1	25.3	29.1	30.9	33.0	32.9	30.7	27.9	27.9	19.4	25.9
2002	10.8	16.4	20.0	20.9	26.5	30.7	32.9	32.1	31.8	29.7	29.7	22.1	25.3
Average	12.92	14.13	17.09	22.15	26.95	30.00	31.16	31.41	29.85	26.70	21.02	15.40	23.23
Maximum	16.80	18.10	23.10	27.40	30.70	33.10	34.90	34.60	32.50	30.10	29.70	22.10	25.90
Minimum	9.20	8.50	13.50	18.20	23.00	28.40	28.80	29.10	27.90	23.30	16.00	11.30	21.30
Median	12.90	14.05	16.85	21.95	26.95	29.70	30.95	31.30	29.90	26.65	20.95	15.30	23.10
St. Dev.	1.78	2.19	1.84	1.84	1.49	1.22	1.33	1.37	1.14	1.73	2.54	2.44	0.97
Cv.	0.14	0.15	0.11	0.08	0.06	0.04	0.04	0.04	0.04	0.06	0.12	0.16	0.04
Skew	-0.06	-0.34	0.59	0.40	-0.09	0.89	0.39	0.36	0.27	0.06	0.96	0.88	0.72

Table (A.10): Monthly Mean Minimum Temperature (C°) for the Irbid Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1955	5.1	7.4	6.9	9.5	13.5	17.9	18.8	19.7	18.3	16.7	11.5	7.8	12.8
1956	6.7	7.3	6.9	9.9	13.1	16.5	19.7	21.0	18.3	14.0	11.2	5.5	12.5
1957	3.7	5.6	8.5	10.7	13.0	17.6	19.2	20.2	18.4	11.8	10.9	6.8	12.2
1958	6.6	5.6	8.7	12.8	14.2	17.0	18.3	20.5	17.9	15.0	10.1	8.3	12.9
1959	6.5	2.3	7.4	10.8	14.8	17.4	18.1	19.1	17.3	13.7	10.8	7.0	12.1
1960	7.4	7.0	8.1	11.8	16.8	17.5	18.7	20.1	16.7	17.4	11.6	7.4	13.4
1961	4.4	4.3	5.2	9.8	14.1	18.0	18.8	19.3	16.0	13.1	8.6	7.1	11.6
1962	5.2	6.2	7.9	8.9	13.0	17.2	18.3	20.0	17.9	15.7	12.0	7.0	12.4
1963	6.7	7.2	5.9	10.1	12.4	17.0	19.1	19.9	18.4	16.2	10.4	5.2	12.4
1964	1.3	5.1	8.5	9.0	10.9	16.1	17.4	18.2	16.3	14.0	10.1	5.5	11.0
1965	4.4	5.0	6.9	8.8	12.3	18.2	18.5	19.2	18.4	13.2	9.1	7.2	11.8
1966	6.2	6.8	6.9	10.6	13.5	18.1	19.3	19.3	17.8	15.6	11.7	6.8	12.7
1967	3.6	3.4	5.4	9.1	13.0	16.3	18.5	19.3	17.6	14.6	9.0	7.1	11.4
1968	3.8	4.6	6.5	12.0	15.8	18.1	20.3	19.7	17.3	14.8	11.1	7.7	12.6
1969	5.0	5.7	8.7	8.7	14.6	18.3	18.0	19.0	19.0	15.1	9.5	7.0	12.4
1970	5.9	6.8	8.7	11.4	13.9	17.3	18.7	19.2	18.2	13.9	11.4	4.3	12.5
1971	5.7	5.4	7.3	9.3	14.8	17.2	18.1	19.3	18.0	13.7	10.1	4.6	12.0
1972	3.0	2.0	7.1	11.4	13.2	16.6	18.2	19.3	18.6	16.0	9.7	2.9	11.5
1973	2.9	6.7	6.8	9.6	14.9	16.7	19.3	19.1	18.3	15.9	6.9	6.2	11.9
1974	2.6	4.9	8.5	9.6	13.2	17.4	19.3	18.8	17.9	16.9	10.9	5.6	12.1
1975	4.5	5.0	6.7	12.2	13.3	16.9	19.1	18.7	17.6	13.5	10.3	4.6	11.9
1976	4.4	3.6	6.0	9.6	13.4	16.3	18.1	18.2	16.9	15.6	10.2	7.1	11.6
1977	3.2	7.5	7.0	9.9	14.8	17.5	19.6	20.2	17.9	12.8	10.5	5.9	12.2
1978	5.8	6.0	8.1	10.1	15.4	17.6	21.1	18.5	17.6	16.2	7.5	8.0	12.7
1979	5.6	7.8	9.2	11.8	14.2	19.4	19.2	19.1	18.3	15.6	11.8	5.4	13.1
1980	4.2	5.1	6.6	10.6	14.6	17.7	19.3	19.5	16.9	15.0	10.4	7.4	12.3
1981	5.0	6.0	8.5	11.1	13.0	17.5	19.7	19.5	18.6	16.3	8.5	7.9	12.6
1982	5.8	4.1	6.2	12.2	13.9	17.3	18.7	19.4	18.4	15.7	8.2	5.0	12.1
1983	2.2	4.2	6.8	10.1	14.2	17.2	19.0	19.3	18.2	14.2	2.7	7.0	11.3
1984	6.4	5.6	8.6	10.4	15.2	17.0	18.8	18.5	18.3	15.1	10.1	3.4	12.3
1985	7.0	3.9	5.8	10.8	16.1	17.5	18.5	20.9	18.5	13.9	11.5	7.3	12.6
1986	5.5	7.2	8.9	12.6	12.3	17.6	19.0	19.5	19.9	15.6	8.3	5.3	12.6
1987	6.4	6.9	4.9	9.3	13.7	17.0	19.8	20.2	18.5	14.6	9.1	7.7	12.3
1988	5.7	5.5	7.4	10.6	15.2	17.6	20.4	20.2	19.1	14.9	8.7	6.6	12.7
1989	2.4	4.2	7.7	14.0	15.6	16.7	19.4	19.4	18.1	14.6	11.4	6.8	12.5
1990	3.6	4.9	6.8	10.3	14.1	17.1	19.5	19.2	17.8	16.1	12.1	7.7	12.4
1991	5.1	5.5	9.1	11.7	14.5	17.0	18.6	19.5	18.0	16.7	11.2	5.4	12.7
1992	2.6	2.8	5.4	9.9	9.0	17.2	18.5	20.0	17.9	16.2	9.7	4.8	11.2
1993	3.2	3.7	6.4	10.8	13.5	17.9	19.4	20.3	18.5	17.0	9.1	7.9	12.3
1994	7.1	6.2	8.3	13.1	16.0	17.4	19.5	19.9	20.3	17.9	10.2	4.0	13.3
1995	6.0	5.8	7.7	9.9	15.1	18.2	19.7	20.5	19.0	14.8	8.6	5.1	12.5
1996	5.2	7.0	7.6	9.6	15.9	17.6	20.5	20.0	18.8	14.1	10.1	8.3	12.9
1997	5.2	3.0	5.7	8.9	15.8	17.8	20.3	19.1	17.8	15.3	10.9	7.5	12.3
1998	4.8	5.3	6.6	11.7	15.1	17.9	20.5	21.6	20.1	16.1	13.0	8.2	13.4
1999	6.5	7.4	8.7	11.5	16.3	18.0	20.2	21.7	19.5	16.8	11.7	7.7	13.8
2000	4.8	5.7	7.5	12.2	15.0	18.3	21.0	20.8	19.6	15.7	11.2	7.6	13.3
2001	6.3	6.8	11.8	12.7	15.4	18.2	20.2	27.9	18.6	16.4	9.8	7.0	14.3
2002	4.2	7.5	10.1	11.1	14.4	18.4	21.4	20.3	20.1	18.7	12.6	6.6	13.8
Average	4.90	5.49	7.44	10.68	14.17	17.46	19.24	19.84	18.24	15.26	10.13	6.46	12.44
Maximum	7.40	7.80	11.80	14.00	16.80	19.40	21.40	27.90	20.30	18.70	13.00	8.30	14.30
Minimum	1.30	2.00	4.90	8.70	9.00	16.10	17.40	18.20	16.00	11.80	2.70	2.90	11.00
Median	5.10	5.60	7.35	10.60	14.20	17.50	19.20	19.50	18.30	15.45	10.25	7.00	12.40
St. Dev.	1.48	1.48	1.36	1.29	1.44	0.64	0.89	1.42	0.91	1.39	1.72	1.36	0.68
Cv.	0.30	0.27	0.18	0.12	0.10	0.04	0.05	0.07	0.05	0.09	0.17	0.21	0.05
Skew	-0.43	-0.46	0.57	0.48	-1.00	0.23	0.45	4.03	0.09	-0.06	-1.77	-0.76	0.33

Table (A.11): Monthly Mean Maximum Temperature (C°) for the Aqaba Airport Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1959	26.0	22.2	28.5	35.4	38.9	41.4	40.3	41.4	36.0	31.6	27.9	23.7	32.8
1960	22.1	25.4	26.8	30.9	37.3	38.2	40.5	40.5	37.3	36.0	29.3	25.7	32.5
1961	21.4	21.1	24.5	31.3	35.3	40.8	40.3	40.1	35.2	32.5	26.9	22.7	31.0
1962	22.1	22.0	29.4	30.1	35.3	40.6	38.1	40.4	38.2	34.6	32.3	23.8	32.2
1963	23.8	24.9	25.9	30.3	33.3	39.5	40.2	41.0	38.3	35.8	28.9	22.8	32.1
1964	19.0	22.4	27.4	30.2	33.8	38.8	39.1	39.6	35.8	35.3	27.8	22.4	31.0
1965	19.8	23.2	27.4	29.2	34.7	40.2	40.6	40.0	37.7	31.8	27.4	24.0	31.3
1966	22.2	23.5	26.2	31.9	36.0	40.0	40.4	40.3	36.5	34.2	31.1	23.6	32.2
1967	21.0	21.9	24.1	30.8	33.8	38.2	39.4	39.3	36.0	32.2	25.8	22.5	30.4
1968	20.1	22.1	24.6	30.2	35.7	38.8	40.3	39.0	36.4	31.3	26.9	22.6	30.7
1969	20.0	23.8	26.8	28.0	35.5	39.6	38.3	39.9	38.2	32.9	28.1	23.6	31.2
1970	22.5	24.0	27.3	32.2	35.5	37.9	38.8	39.4	36.2	31.9	26.5	20.6	31.1
1971	23.1	22.5	26.5	28.0	35.5	37.6	38.5	38.4	36.7	31.8	26.4	19.6	30.4
1972	19.7	21.9	24.9	31.3	33.8	37.0	37.7	38.5	37.1	33.3	25.4	19.3	30.0
1973	20.2	24.5	25.5	30.2	34.9	37.0	39.8	38.2	36.3	33.2	24.4	21.8	30.5
1974	18.0	21.8	25.4	30.5	34.4	37.6	39.4	38.0	35.7	33.5	26.7	19.9	30.1
1975	19.4	21.0	26.1	32.3	33.8	37.1	38.9	37.2	35.3	31.6	26.3	20.4	30.0
1976	19.4	19.9	25.0	29.4	34.9	37.2	38.1	37.4	36.0	33.7	28.1	22.4	30.1
1977	19.6	25.4	26.6	29.2	35.4	38.3	40.0	39.9	35.7	30.5	27.1	20.4	30.7
1978	20.7	23.7	26.3	31.3	37.4	37.8	40.3	37.7	35.2	33.7	24.2	21.8	30.8
1979	20.8	24.4	27.4	32.1	34.7	38.5	38.7	38.8	35.9	32.6	28.0	20.4	31.0
1980	19.7	20.5	25.6	30.6	36.1	38.6	39.3	39.1	34.9	32.8	27.9	21.2	30.5
1981	19.6	21.1	26.5	30.9	33.9	38.2	39.1	38.8	35.8	33.4	24.5	23.1	30.4
1982	20.9	19.8	23.6	31.3	32.8	37.8	38.4	36.1	35.7	32.8	23.4	19.9	29.4
1983	17.4	20.2	23.5	28.4	34.5	37.4	39.0	38.1	35.7	30.8	27.6	21.7	29.5
1984	20.2	23.4	25.7	29.8	36.3	37.1	38.4	37.4	36.4	32.8	25.9	20.0	30.3
1985	22.4	21.0	25.5	30.1	35.1	38.5	38.3	39.7	36.3	30.2	28.0	21.6	30.6
1986	21.1	23.6	26.5	31.3	32.0	37.7	39.5	38.9	37.9	32.1	24.2	20.3	30.4
1987	21.9	24.5	23.4	29.0	35.5	37.4	40.2	39.5	36.2	30.4	26.6	21.1	30.5
1988	19.3	21.5	24.7	30.7	36.8	38.7	40.5	39.5	37.1	30.8	24.8	21.1	30.5
1989	17.1	20.5	25.0	34.0	35.9	37.7	39.5	39.1	36.4	31.6	26.9	21.5	30.4
1990	19.6	20.7	25.1	30.8	34.2	37.9	39.5	38.5	35.2	33.2	29.4	23.5	30.6
1991	19.9	22.7	26.9	32.1	34.6	38.4	38.2	38.0	35.2	32.6	27.0	19.6	30.4
1992	17.4	18.3	23.5	29.2	33.9	38.1	38.5	39.4	35.7	33.7	26.2	19.5	29.5
1993	18.2	19.7	24.7	31.0	33.7	38.9	39.5	40.4	36.6	34.1	26.8	22.7	30.5
1994	20.9	21.8	25.3	32.7	36.0	37.6	39.2	39.5	37.7	34.5	25.4	19.6	30.9
1995	20.6	22.0	26.2	29.3	35.1	39.8	39.4	39.1	37.4	31.6	24.8	21.3	30.6
1996	20.4	23.0	24.9	30.2	36.6	37.6	40.1	39.6	37.7	31.9	27.7	23.7	31.1
1997	21.8	20.2	23.8	28.9	36.4	38.6	40.0	38.3	35.8	32.5	27.6	22.1	30.5
1998	20.7	22.6	24.6	32.7	35.2	38.2	41.0	41.1	37.9	33.9	28.2	22.9	31.6
1999	20.5	21.1	24.8	28.4	34.9	35.5	39.6	40.9	36.9	33.7	29.4	23.7	30.8
2000	20.2	20.9	24.3	31.4	33.2	38.2	40.8	39.0	35.5	33.8	27.3	24.0	30.7
2001	20.7	22.2	24.8	32.3	35.8	38.2	41.2	39.3	36.2	32.9	28.0	23.1	31.2
2002	20.1	22.1	25.0	31.7	35.1	38.9	41.2	41.9	35.9	33.3	27.4	23.6	31.4
Average	20.49	22.16	25.60	30.72	35.08	38.34	39.50	39.23	36.40	32.80	27.06	21.93	30.78
Maximum	26.00	25.40	29.40	35.40	38.90	41.40	41.20	41.90	38.30	36.00	32.30	25.70	32.80
Minimum	17.10	18.30	23.40	28.00	32.00	35.50	37.70	36.10	34.90	30.20	23.40	19.30	29.40
Median	20.30	22.05	25.45	30.75	35.10	38.20	39.50	39.30	36.20	32.80	27.05	21.95	30.60
St. Dev.	1.69	1.64	1.35	1.54	1.31	1.13	0.92	1.19	0.93	1.37	1.79	1.59	0.74
Cv.	0.08	0.07	0.05	0.05	0.04	0.03	0.02	0.03	0.03	0.04	0.07	0.07	0.02
Skew	0.60	0.09	0.54	0.54	0.30	0.60	-0.02	-0.13	0.56	0.21	0.40	0.04	0.79

Table (A.12): Monthly Mean Minimum Temperature (C⁰) for the Aqaba Airport Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1959	12.2	9.4	13.8	18.8	22.6	25.5	25.9	25.4	21.3	17.8	14.0	10.5	18.1
1960	9.2	10.6	12.4	16.4	21.7	21.8	24.4	25.4	23.2	20.7	16.6	13.3	18.0
1961	9.4	9.3	10.6	15.9	19.7	24.6	25.4	24.2	21.3	18.7	13.9	10.4	17.0
1962	9.9	10.1	14.5	15.4	20.3	24.0	24.7	26.3	23.7	20.8	17.4	11.2	18.2
1963	10.0	12.4	11.8	17.5	20.1	24.0	25.8	25.5	24.3	21.6	16.5	10.3	18.3
1964	6.5	9.6	14.0	16.0	18.8	23.3	24.5	25.0	22.3	19.3	14.7	11.2	17.1
1965	10.0	10.8	13.8	15.6	19.2	24.7	24.9	26.0	22.9	18.9	14.4	10.3	17.6
1966	9.4	10.9	12.3	16.5	20.3	23.5	23.9	25.4	22.8	20.4	18.6	11.4	18.0
1967	7.4	8.3	10.5	15.4	19.5	22.1	24.0	24.8	22.7	19.7	14.8	10.2	16.6
1968	8.7	9.7	12.0	17.3	21.5	24.4	26.0	24.6	22.6	19.3	14.5	11.5	17.7
1969	8.8	11.0	14.8	15.5	21.7	24.1	23.3	25.0	24.0	20.4	15.3	10.7	17.9
1970	10.1	11.1	14.8	18.0	20.3	22.5	24.7	24.7	22.9	18.6	15.5	8.5	17.6
1971	11.1	9.7	13.7	15.4	21.3	23.0	24.0	25.1	23.6	18.3	14.0	8.6	17.3
1972	7.9	9.0	12.9	17.7	19.3	21.9	23.1	24.6	23.6	20.8	15.1	7.9	17.0
1973	8.1	12.3	12.2	16.2	19.9	22.3	25.5	24.8	23.4	20.3	13.5	10.5	17.4
1974	8.6	10.1	13.9	17.3	19.8	22.9	25.1	24.8	22.6	20.3	14.7	9.2	17.4
1975	7.9	10.1	13.5	19.4	20.2	32.1	25.2	24.4	22.9	18.6	14.5	9.9	18.2
1976	8.9	8.8	13.0	16.8	20.9	22.7	24.3	23.5	22.8	20.3	15.7	10.8	17.4
1977	8.0	12.1	12.5	16.3	21.0	23.5	25.5	26.5	23.2	18.2	13.6	9.5	17.5
1978	8.4	10.9	13.4	16.6	21.8	23.0	26.5	24.4	22.5	20.9	12.1	10.7	17.6
1979	8.9	11.9	14.3	19.0	20.8	24.3	24.7	25.2	23.9	21.0	17.0	10.0	18.4
1980	7.7	9.7	13.2	17.1	21.2	23.6	24.7	25.0	22.2	19.9	15.5	10.6	17.5
1981	8.6	10.4	13.8	17.0	19.9	22.4	25.2	25.1	24.1	20.4	13.1	10.3	17.5
1982	9.3	9.6	11.7	17.9	19.2	23.1	24.5	24.8	23.4	20.2	12.3	9.0	17.1
1983	7.1	8.9	11.6	15.2	20.2	23.0	25.0	25.0	22.7	18.3	14.6	9.9	16.8
1984	8.9	10.3	13.9	16.3	20.6	22.5	23.9	23.5	23.1	20.4	14.5	8.6	17.2
1985	10.3	8.9	12.9	17.9	21.5	22.5	24.1	26.5	23.3	18.2	16.5	11.1	17.8
1986	10.0	11.1	13.8	18.5	18.7	23.2	25.0	25.1	24.9	20.4	13.1	9.2	17.8
1987	8.5	12.2	11.7	15.3	20.5	23.4	25.9	26.0	23.7	19.3	14.7	11.6	17.7
1988	9.5	10.6	12.9	17.7	22.2	23.9	26.6	25.8	23.7	19.3	12.3	10.2	17.9
1989	6.4	7.3	12.3	18.3	21.5	22.6	24.8	25.4	23.3	19.1	15.1	9.3	17.1
1990	8.6	9.0	12.3	17.8	19.6	23.0	25.2	24.8	22.6	20.4	16.9	12.5	17.7
1991	8.8	10.2	14.7	18.5	20.9	23.7	24.8	24.7	22.9	20.7	14.9	8.9	17.8
1992	6.7	8.5	11.4	15.7	20.0	23.4	24.6	25.5	23.1	20.0	14.2	8.9	16.8
1993	7.3	8.1	12.1	16.6	20.6	23.8	24.7	25.9	23.3	21.3	14.9	12.1	17.6
1994	11.1	9.7	12.3	18.7	21.2	23.0	25.3	25.7	24.7	22.8	14.4	8.3	18.1
1995	8.4	10.4	13.7	15.4	20.7	24.5	25.7	25.8	24.5	19.6	13.1	9.9	17.6
1996	9.3	11.4	12.6	16.2	22.3	22.8	26.7	26.3	24.0	19.2	16.1	11.4	18.2
1997	9.4	7.8	11.5	15.0	21.9	24.2	25.4	24.8	22.9	20.2	16.2	11.2	17.5
1998	9.2	10.9	12.8	18.9	22.0	24.0	26.6	28.1	25.2	20.9	16.3	11.4	18.9
1999	9.9	11.3	13.9	17.0	22.8	24.2	26.1	28.1	25.3	22.7	19.1	11.3	19.3
2000	10.1	11.6	12.5	17.7	21.6	26.1	29.3	27.5	25.0	22.5	17.2	12.0	19.4
2001	9.8	11.3	12.6	16.3	21.9	25.3	27.3	28.7	24.8	20.8	16.4	11.3	18.9
2002	10.2	11.4	12.4	16.4	22.2	25.7	28.4	28.5	25.2	21.6	18.7	12.1	19.4
Average	8.97	10.20	12.89	16.92	20.77	23.73	25.25	25.50	23.42	20.07	15.15	10.40	17.77
Maximum	12.20	12.40	14.80	19.40	22.80	32.10	29.30	28.70	25.30	22.80	19.10	13.30	19.40
Minimum	6.40	7.30	10.50	15.00	18.70	21.80	23.10	23.50	21.30	17.80	12.10	7.90	16.60
Median	8.90	10.25	12.85	16.70	20.75	23.45	25.05	25.15	23.30	20.30	14.85	10.45	17.65
St. Dev.	1.24	1.26	1.08	1.21	1.06	1.63	1.21	1.19	0.96	1.20	1.66	1.22	0.66
Cv.	0.14	0.12	0.08	0.07	0.05	0.07	0.05	0.05	0.04	0.06	0.11	0.12	0.04
Skew	0.02	-0.24	-0.12	0.27	-0.05	3.26	1.19	1.16	0.17	0.22	0.41	-0.03	0.83

Table (A.13): Monthly Mean Maximum Temperature (C°) for the Azraq Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1982	15.6	14.3	18.5	28.2	29.2	34.2	34.7	35.4	33.5	28.0	17.6	13.8	25.3
1983	11.8	14.3	19.6	24.5	30.7	34.1	35.9	35.2	33.5	27.8	23.9	17.4	25.7
1984	15.9	19.2	21.2	25.4	31.9	34.1	35.3	33.7	35.4	29.8	21.5	14.8	26.5
1985	17.1	15.4	20.7	26.0	31.5	35.2	35.2	39.6	34.3	27.5	23.7	16.7	26.9
1986	16.0	18.9	22.6	28.0	28.2	33.8	37.0	36.8	36.5	29.9	18.7	15.5	26.8
1987	17.1	20.0	17.7	25.5	33.0	35.0	37.5	37.4	35.0	27.2	23.1	16.7	27.1
1988	14.2	16.6	19.4	20.1	32.8	35.0	37.9	36.1	34.9	28.2	19.9	15.5	25.9
1989	11.2	15.3	20.7	31.1	32.9	34.7	37.1	36.9	34.3	29.1	22.4	17.0	26.9
1990	13.1	15.1	20.2	25.6	31.0	35.4	38.4	36.1	34.3	30.1	24.6	19.2	26.9
1991	14.0	16.8	22.1	28.2	30.5	35.8	35.6	35.4	34.5	29.5	23.7	13.9	26.7
1992	11.2	12.5	17.9	25.5	30.5	34.1	35.7	37.0	33.7	31.8	21.5	13.5	25.4
1993	13.6	14.9	20.7	27.6	30.1	36.0	36.8	37.5	35.3	30.4	21.4	19.1	27.0
1994	16.4	16.9	21.6	29.5	33.2	35.0	34.9	37.0	36.2	31.4	19.5	12.9	27.0
1995	16.5	16.9	22.0	26.5	33.3	36.7	35.9	37.2	35.1	29.5	20.9	15.8	27.2
1996	15.3	18.9	20.4	26.0	34.7	36.1	39.0	38.3	35.2	28.2	22.2	18.7	27.8
1997	16.0	14.6	18.0	25.0	33.5	35.4	37.0	34.5	33.7	29.8	22.3	16.9	26.4
1998	13.8	17.0	19.2	27.9	32.1	35.9	38.4	40.3	35.3	30.9	26.0	18.6	28.0
1999	16.6	18.7	22.0	27.6	34.0	34.7	37.0	38.3	34.5	30.1	23.4	18.5	28.0
2000	16.5	17.6	21.7	27.7	33.5	34.6	37.8	38.7	35.4	30.5	23.7	18.6	28.0
2001	15.9	16.8	21.5	26.9	32.9	35.7	38.2	39.5	33.9	30.4	22.8	17.8	27.7
2002	16.2	17.1	22.1	26.8	33.1	36.1	39.0	40.2	34.8	29.9	21.9	13.5	27.6
Average	14.95	16.56	20.47	26.65	32.03	35.12	36.87	37.20	34.73	29.52	22.13	16.40	26.90
Maximum	17.10	20.00	22.60	31.10	34.70	36.70	39.00	40.30	36.50	31.80	26.00	19.20	28.00
Minimum	11.20	12.50	17.70	20.10	28.20	33.80	34.70	33.70	33.50	27.20	17.60	12.90	25.30
Median	15.90	16.80	20.70	26.80	32.80	35.00	37.00	37.00	34.80	29.80	22.30	16.70	26.90
St. Dev.	1.89	1.93	1.53	2.19	1.68	0.81	1.35	1.83	0.83	1.28	2.02	2.06	0.82
Cv.	0.13	0.12	0.07	0.08	0.05	0.02	0.04	0.05	0.02	0.04	0.09	0.13	0.03
Skew	-0.89	-0.10	-0.52	-0.93	-0.65	0.09	-0.02	0.04	0.31	-0.28	-0.48	-0.27	-0.46

Table (A.14): Monthly Mean Minimum Temperature (C^o) for the Azraq Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1982	3.5	3.8	5.7	13.2	15.1	17.7	18.9	19.2	18.2	14.5	6.4	2.3	11.5
1983	2.5	3.6	5.8	11.1	15.3	17.9	19.3	18.8	17.5	12.0	8.3	3.9	11.3
1984	2.3	4.8	8.1	9.5	15.3	17.2	18.5	17.3	18.3	14.1	9.2	1.8	11.4
1985	4.1	2.9	5.9	10.1	15.3	17.8	18.5	22.3	18.0	12.7	10.3	4.0	11.8
1986	3.1	4.8	8.4	13.0	12.9	17.7	18.7	19.9	20.1	15.1	7.1	2.8	12.0
1987	2.6	5.8	5.3	10.0	15.1	17.6	20.6	20.9	18.6	13.5	8.4	6.3	12.1
1988	4.4	4.8	7.0	12.1	16.3	18.3	21.4	20.6	18.6	14.4	6.3	4.7	12.4
1989	1.2	2.4	7.5	13.8	16.5	17.1	19.7	17.8	17.6	13.8	8.8	3.4	11.6
1990	2.5	4.0	7.3	11.3	14.9	18.0	19.4	19.1	17.3	14.9	10.5	6.1	12.1
1991	3.3	4.4	0.2	13.4	15.3	18.4	18.9	19.3	18.0	15.7	8.9	3.0	11.6
1992	0.9	2.2	5.5	10.0	15.2	17.8	18.7	20.2	17.7	14.2	8.0	2.7	11.1
1993	0.4	2.4	6.3	11.1	14.6	18.3	19.8	20.4	18.2	16.0	8.2	6.2	11.8
1994	5.2	3.9	7.7	12.9	16.3	17.8	18.7	19.7	20.4	17.8	9.5	3.1	12.8
1995	3.7	5.4	7.8	10.2	16.3	18.9	19.6	20.3	18.8	14.6	5.8	3.8	12.1
1996	4.0	5.3	6.5	9.9	17.6	18.8	22.1	20.8	18.4	12.9	9.3	6.0	12.6
1997	3.9	1.7	5.3	9.8	16.9	18.7	19.9	18.6	17.9	14.8	9.5	5.2	11.9
1998	3.7	5.5	6.5	12.2	16.3	18.7	20.9	22.8	19.9	14.0	10.6	5.4	13.0
1999	3.9	5.5	7.0	10.9	17.1	18.4	20.2	21.1	18.2	15.2	7.2	2.7	12.3
2000	3.8	5.4	7.2	11.3	16.8	18.3	20.9	22.4	19.2	15.1	9.7	2.9	12.8
2001	3.6	5.5	7.1	12.1	16.7	18.7	21.3	21.7	19.3	14.8	9.8	3.4	12.8
2002	3.7	5.4	6.9	11.8	17.2	18.9	21.1	21.6	18.8	14.7	10.2	2.8	12.8
Average	3.16	4.26	6.43	11.41	15.86	18.14	19.86	20.23	18.52	14.51	8.67	3.93	12.09
Maximum	5.20	5.80	8.40	13.80	17.60	18.90	22.10	22.80	20.40	17.80	10.60	6.30	13.00
Minimum	0.40	1.70	0.20	9.50	12.90	17.10	18.50	17.30	17.30	12.00	5.80	1.80	11.10
Median	3.60	4.80	6.90	11.30	16.30	18.30	19.70	20.30	18.30	14.60	8.90	3.40	12.10
St. Dev.	1.19	1.29	1.69	1.33	1.10	0.54	1.10	1.49	0.85	1.23	1.43	1.42	0.56
Cv.	0.38	0.30	0.26	0.12	0.07	0.03	0.06	0.07	0.05	0.08	0.17	0.36	0.05
Skew	-0.90	-0.67	-2.57	0.26	-0.73	-0.26	0.44	-0.12	0.81	0.40	-0.57	0.52	0.05

Table (A.15): Monthly Mean Maximum Temperature (C°) for the Jafar Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1965	14.5	18.5	23.4	24.1	29.8	35.4	35.5	37.2	34.4	25.7	21.9	17.3	26.5
1966	17.1	17.7	20.6	27.6	31.2	35.8	35.7	37.8	33.5	28.7	25.1	17.8	27.4
1967	14.7	15.1	17.9	25.5	29.2	32.2	35.2	34.5	32.0	27.8	19.5	16.4	25.0
1968	13.9	16.6	19.9	25.5	30.7	34.4	37.5	35.3	33.1	28.0	22.0	17.5	26.2
1969	14.2	20.1	24.5	24.4	31.0	35.6	35.1	36.6	34.6	28.3	22.0	18.2	27.1
1970	16.1	18.7	21.8	28.7	30.7	34.7	34.9	34.6	32.6	28.5	22.0	15.0	26.5
1971	16.9	17.1	21.8	22.2	31.1	32.8	35.0	34.2	34.4	27.9	21.1	13.9	25.7
1972	14.1	15.4	20.1	27.1	29.5	32.7	34.4	34.7	34.0	30.4	20.4	13.9	25.6
1973	14.9	20.5	20.8	25.9	30.4	33.0	35.6	36.0	33.5	30.5	19.4	17.1	26.5
1974	11.6	16.0	20.4	27.2	30.7	34.7	35.5	35.0	31.9	30.3	22.4	14.3	25.8
1975	13.8	15.6	20.4	26.9	29.3	33.3	35.2	34.3	33.1	28.0	22.1	15.4	25.6
1976	14.6	15.1	19.7	24.7	29.4	34.0	34.2	34.1	33.5	30.1	22.5	14.5	25.5
1977	14.7	15.6	19.9	25.8	30.1	33.6	34.3	34.9	33.6	30.5	22.7	15.2	25.9
1978	13.8	16.1	20.5	26.7	30.5	33.9	36.1	35.4	33.1	30.7	21.9	16.3	26.3
1979	14.9	18.3	21.1	26.3	30.1	34.2	35.8	35.8	34.2	29.9	22.0	17.1	26.6
1980	13.7	15.4	20.3	26.2	29.9	35.7	35.4	36.2	34.7	30.2	22.3	17.5	26.5
1981	13.6	15.8	21.9	25.8	29.6	33.9	35.9	36.0	34.8	30.8	19.9	19.3	26.4
1982	16.7	14.2	17.9	28.2	28.8	33.8	34.3	34.5	32.7	27.4	18.1	13.8	25.0
1983	11.2	13.7	18.2	23.5	29.9	33.0	35.4	34.6	32.7	27.0	23.0	16.6	24.9
1984	14.8	18.9	21.5	25.2	31.2	32.3	34.3	33.3	34.0	28.8	20.5	15.2	25.8
1985	18.0	15.6	20.9	25.4	30.5	34.1	34.9	38.1	32.8	26.5	22.5	16.0	26.3
1986	15.3	18.0	21.0	26.0	27.0	32.5	36.2	35.6	35.1	28.3	18.3	14.3	25.6
1987	17.1	20.1	17.7	24.8	31.7	33.8	36.4	36.2	33.5	26.0	22.5	15.8	26.3
1988	13.9	15.3	19.3	25.7	32.0	34.2	35.9	34.8	33.8	27.3	19.8	15.7	25.6
1989	11.1	14.2	19.7	29.3	31.4	33.9	35.9	35.7	34.3	27.6	21.9	16.5	26.0
1990	12.7	14.3	19.6	25.6	29.8	34.0	35.2	35.0	33.4	29.4	24.7	20.2	26.2
1991	13.2	16.8	21.5	27.9	29.7	34.9	34.3	34.3	33.2	28.2	23.0	13.4	25.9
1992	11.0	11.9	17.9	25.0	29.4	32.8	34.5	35.6	32.3	30.7	21.0	13.7	24.7
1993	13.0	14.7	19.7	26.8	29.2	34.6	35.2	36.2	34.3	29.3	22.0	19.4	26.2
1994	15.6	16.0	19.9	28.1	31.5	33.7	33.0	35.3	34.0	30.3	19.8	13.9	25.9
1995	16.8	17.1	21.1	25.5	32.1	35.6	35.3	36.8	34.7	29.4	20.8	16.2	26.8
1996	15.5	18.4	19.6	26.0	33.6	34.6	37.9	36.4	33.8	27.9	21.7	18.8	27.0
1997	16.3	13.7	17.7	24.7	31.7	34.5	35.8	34.3	33.1	28.6	21.7	16.5	25.7
1998	13.9	17.2	18.8	27.6	31.2	35.5	37.5	39.3	34.4	30.7	25.9	18.8	27.6
1999	16.4	19.1	21.3	26.6	33.5	33.8	35.8	37.3	33.8	29.6	22.9	17.9	27.3
2000	13.6	16.1	19.4	28.9	31.2	35.4	40.2	36.3	33.6	26.6	21.3	16.6	26.6
2001	16.4	16.5	25.0	27.0	30.5	35.5	37.4	37.7	33.8	28.7	21.9	17.5	27.3
Average	14.58	16.47	20.34	26.17	30.52	34.12	35.59	35.67	33.63	28.77	21.69	16.31	26.16
Maximum	18.00	20.50	25.00	29.30	33.60	35.80	40.20	39.30	35.10	30.80	25.90	20.20	27.60
Minimum	11.00	11.90	17.70	22.20	27.00	32.20	33.00	33.30	31.90	25.70	18.10	13.40	24.70
Median	14.60	16.10	20.30	26.00	30.50	34.00	35.40	35.60	33.60	28.70	21.90	16.40	26.20
St. Dev.	1.77	1.99	1.70	1.53	1.27	1.03	1.28	1.31	0.79	1.45	1.65	1.80	0.71
Cv.	0.12	0.12	0.08	0.06	0.04	0.03	0.04	0.04	0.02	0.05	0.08	0.11	0.03
Skew	-0.24	0.16	0.70	-0.11	0.12	-0.07	1.38	0.72	-0.32	-0.29	0.13	0.19	0.04

Table (A.16): Monthly Mean Minimum Temperature (C°) for the Jafar Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1965	1.6	2.4	6.0	7.2	11.0	16.2	15.5	18.7	15.3	11.2	6.6	1.3	9.4
1966	0.2	2.5	4.8	6.9	12.3	15.8	15.0	17.5	14.0	10.9	8.4	2.6	9.2
1967	-2.1	-1.0	1.1	6.3	11.0	13.2	15.9	15.1	14.0	11.0	6.2	1.6	7.7
1968	-0.1	0.6	3.5	9.0	13.3	15.7	19.2	16.5	14.4	11.4	5.7	2.9	9.3
1969	0.5	3.0	7.8	8.5	13.7	16.7	16.3	17.2	15.7	13.1	6.0	1.7	10.0
1970	1.7	2.0	5.1	9.9	13.3	14.6	15.7	15.3	14.9	9.7	7.5	-1.0	9.1
1971	1.6	2.3	5.9	7.1	13.4	14.0	16.3	16.3	15.9	9.2	4.7	0.3	8.9
1972	-1.8	-1.0	4.4	10.3	12.1	14.7	15.2	16.3	14.5	12.5	6.2	-2.0	8.5
1973	-1.6	3.4	3.9	8.3	11.6	14.1	16.3	20.3	15.2	11.9	3.6	1.1	9.0
1974	0.1	2.0	6.4	9.8	12.4	15.4	16.5	16.5	14.2	11.6	6.5	1.1	9.4
1975	-0.5	1.7	4.7	11.1	12.2	15.1	17.1	16.5	15.0	9.9	5.2	1.3	9.1
1976	-0.7	1.4	4.6	9.3	13.0	15.3	15.8	14.6	15.3	10.6	5.6	1.5	8.9
1977	-0.5	1.5	4.9	10.9	13.2	15.6	17.2	16.8	16.1	11.3	5.7	2.1	9.6
1978	-0.3	1.9	5.3	11.2	12.6	16.1	16.5	16.1	15.8	12.1	6.3	1.9	9.6
1979	0.1	2.1	6.1	11.3	12.8	16.0	16.2	17.3	16.9	11.9	6.1	2.5	9.9
1980	0.5	2.3	5.9	10.9	13.2	15.9	17.1	17.6	16.7	11.8	6.7	3.8	10.2
1981	0.7	2.7	7.0	10.0	13.1	16.3	17.8	18.5	17.0	12.4	4.5	1.9	10.2
1982	1.7	2.0	4.0	11.4	13.0	16.1	17.1	17.3	16.8	12.6	4.7	1.6	9.9
1983	-0.1	1.4	3.8	8.9	14.1	16.8	18.3	18.0	15.6	10.6	7.1	1.8	9.7
1984	1.1	2.8	7.3	8.8	13.8	16.0	17.0	15.7	16.8	12.7	7.1	0.9	10.0
1985	3.4	1.8	5.4	8.9	14.4	16.3	17.4	20.8	16.2	10.8	8.2	2.7	10.5
1986	1.0	3.8	6.4	11.7	11.9	15.9	17.8	18.1	18.2	12.8	5.2	0.8	10.3
1987	0.2	3.1	3.8	8.0	13.6	16.7	19.7	19.1	16.8	12.0	6.8	4.5	10.4
1988	2.2	3.1	6.4	11.0	15.0	17.1	19.2	18.2	16.7	12.3	4.6	3.3	10.8
1989	-0.9	0.2	5.6	12.6	15.3	16.1	18.6	18.7	16.3	11.9	7.7	1.8	10.3
1990	1.5	1.1	5.0	9.9	13.4	16.9	18.5	18.2	16.5	13.6	9.5	5.3	10.8
1991	2.2	3.4	7.7	11.8	14.0	17.3	17.7	17.3	16.5	13.6	7.4	0.9	10.8
1992	-0.7	1.0	4.1	9.1	13.5	16.3	17.7	18.6	16.5	12.8	6.7	0.7	9.7
1993	-0.6	-0.1	4.7	10.0	13.8	17.4	18.1	19.4	17.0	14.1	7.9	5.0	10.6
1994	4.3	2.6	6.1	12.3	15.0	16.6	17.4	18.6	18.2	16.0	7.5	0.3	11.2
1995	1.1	3.2	6.1	9.1	15.1	18.0	18.5	18.9	17.0	12.2	4.9	2.0	10.5
1996	2.1	4.0	5.3	8.9	15.4	16.9	20.4	19.6	16.8	11.4	8.5	5.0	11.2
1997	2.1	0.3	4.6	9.0	14.9	16.9	17.5	16.8	15.7	12.7	7.2	3.0	10.1
1998	1.6	3.1	4.7	10.2	15.1	17.6	19.2	21.5	18.0	12.9	8.9	3.5	11.4
1999	1.7	3.6	5.4	9.1	15.0	16.2	19.1	19.7	16.4	12.8	6.8	1.4	10.6
2000	0.2	1.0	3.3	10.9	12.4	16.4	20.9	18.2	15.3	11.2	5.3	2.7	9.8
2001	0.6	1.9	8.2	11.2	14.0	17.3	19.1	20.0	16.5	12.1	5.7	3.2	10.8
2002	3.7	5.4	6.9	11.8	17.2	18.9	21.1	21.6	18.8	14.7	10.2	2.8	12.8
Average	0.73	2.07	5.32	9.81	13.53	16.17	17.63	17.93	16.14	12.06	6.56	2.05	10.01
Maximum	4.30	5.40	8.20	12.60	17.20	18.90	21.10	21.60	18.80	16.00	10.20	5.30	12.80
Minimum	-2.10	-1.00	1.10	6.30	11.00	13.20	15.00	14.60	14.00	9.20	3.60	-2.00	7.70
Median	0.55	2.05	5.30	9.90	13.40	16.20	17.45	18.05	16.35	12.05	6.55	1.85	10.00
St. Dev.	1.46	1.35	1.42	1.56	1.32	1.12	1.55	1.71	1.16	1.34	1.47	1.54	0.93
Cv.	1.99	0.65	0.27	0.16	0.10	0.07	0.09	0.10	0.07	0.11	0.22	0.75	0.09
Skew	0.33	-0.26	-0.31	-0.31	0.33	-0.37	0.41	0.24	0.06	0.46	0.37	0.00	0.30

Table (A.17): Monthly Base Flow (mm/month) for Wadi Al-Mujib Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
69/70	0.19	0.27	0.60	0.55	0.37	0.73	0.35	0.04	0.03	0.03	0.03	0.03	3.20
70/71	0.03	0.26	1.45	0.92	0.47	0.46	1.25	1.20	0.13	0.13	0.13	0.13	6.57
71/72	0.03	0.29	1.79	1.41	0.93	1.13	0.81	0.55	0.03	0.03	0.03	0.03	7.05
72/73	0.08	0.42	0.16	1.27	0.35	0.37	0.41	0.27	0.12	0.11	0.11	0.10	3.77
73/74	0.12	0.18	0.44	0.72	0.68	0.70	0.43	0.40	0.31	0.23	0.19	0.18	4.58
74/75	0.54	0.52	0.54	0.58	0.51	0.58	0.52	0.27	0.13	0.05	0.05	0.05	4.33
75/76	0.24	0.32	0.45	0.54	0.45	0.56	0.50	0.35	0.26	0.27	0.21	0.21	4.37
76/77	0.24	0.26	0.31	0.62	0.46	0.34	0.46	0.43	0.32	0.23	0.20	0.23	4.11
77/78	0.24	0.27	0.37	0.36	0.35	0.40	0.45	0.39	0.33	0.27	0.22	0.22	3.87
78/79	0.00	0.00	0.58	0.62	0.51	0.63	0.47	0.30	0.10	0.05	0.03	0.03	3.32
79/80	0.00	0.01	0.30	0.87	0.78	0.76	0.43	0.10	0.01	0.01	0.01	0.00	3.28
80/81	0.00	0.01	0.02	0.36	0.42	0.58	0.15	0.10	0.02	0.02	0.00	0.00	1.68
81/82	0.01	0.20	0.52	0.29	0.38	0.11	0.10	0.02	0.02	0.01	0.01	0.11	1.79
82/83	0.14	0.13	0.43	0.69	0.93	0.50	0.16	0.01	0.01	0.00	0.00	0.00	3.02
83/84	0.00	0.48	0.96	0.43	0.68	1.20	0.96	0.62	0.45	0.34	0.21	0.16	6.50
84/85	0.21	0.27	0.37	1.44	1.42	1.54	1.44	1.23	0.58	0.27	0.21	0.13	9.11
85/86	0.14	0.28	0.31	0.43	0.42	0.48	0.45	0.43	0.29	0.21	0.13	0.13	3.71
86/87	0.29	0.13	0.14	0.26	0.21	0.41	0.46	0.38	0.30	0.24	0.19	0.18	3.19
87/88	0.24	0.31	0.32	0.44	0.44	0.47	0.28	0.14	0.08	0.02	0.02	0.08	2.82
88/89	0.00	0.00	0.01	0.37	0.34	0.38	0.34	0.32	0.25	0.24	0.24	0.19	2.69
89/90	0.05	0.13	0.02	0.30	0.46	0.48	0.46	0.07	0.00	0.00	0.00	0.00	1.98
90/91	0.00	0.00	0.00	0.08	0.09	0.10	0.10	0.11	0.09	0.05	0.00	0.00	0.63
91/92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
93/94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
94/95	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
95/96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
96/97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
97/98	1.19	0.52	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90
98/99	0.00	0.00	0.00	0.23	0.22	0.25	0.16	0.14	0.13	0.14	0.13	0.10	1.50
99/00	0.02	0.10	0.05	0.18	0.21	0.31	0.11	0.09	0.09	0.10	0.07	0.08	1.41
00/01	0.00	0.01	0.07	0.02	0.17	0.07	0.02	0.01	0.11	0.07	0.02	0.09	0.67
01/02	0.03	0.12	0.19	0.20	0.26	0.01	0.03	0.04	0.07	0.03	0.09	0.08	1.15
Average	0.12	0.17	0.32	0.44	0.38	0.41	0.34	0.24	0.13	0.10	0.08	0.08	2.80
Maximum	1.19	0.52	1.79	1.44	1.42	1.54	1.44	1.23	0.58	0.34	0.24	0.23	9.11
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Median	0.03	0.13	0.19	0.36	0.37	0.40	0.34	0.11	0.09	0.05	0.03	0.08	2.82
St. Dev.	0.23	0.17	0.41	0.40	0.32	0.38	0.36	0.31	0.15	0.11	0.09	0.08	2.27
Cv.	1.87	1.01	1.29	0.91	0.85	0.92	1.04	1.28	1.16	1.13	1.13	1.01	0.81
Skew	3.53	0.66	2.14	1.10	1.15	1.10	1.47	1.99	1.32	0.85	0.70	0.56	0.83

Table (C.18): Monthly Base Flow (mm/month) for Wadi Al-Hisban Station

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
81/82	0.27	0.27	0.35	0.37	0.72	1.91	1.24	1.61	0.65	0.45	0.37	0.32	8.52
82/83	0.41	0.41	0.53	0.40	0.78	2.05	1.38	1.20	0.75	0.54	0.49	0.39	9.34
83/84	0.19	0.26	0.34	0.48	0.61	0.58	0.50	0.38	0.32	0.28	0.18	0.15	4.29
84/85	0.16	0.12	0.31	0.35	0.53	0.45	0.32	0.24	0.22	0.21	0.14	0.14	3.19
85/86	0.09	0.30	0.33	0.36	0.35	0.37	0.20	0.25	0.12	0.11	0.11	0.08	2.68
86/87	0.20	0.34	0.34	0.40	0.49	0.37	0.29	0.26	0.19	0.12	0.12	0.13	3.26
87/88	0.24	0.29	0.33	0.49	0.55	0.95	0.56	0.87	0.47	0.27	0.22	0.25	5.50
88/89	0.16	0.33	0.33	0.35	0.33	0.39	0.40	0.33	0.30	0.28	0.24	0.19	3.64
89/90	0.24	0.25	0.27	0.66	0.52	0.50	0.38	0.29	0.23	0.19	0.14	0.21	3.89
90/91	0.18	0.16	0.68	0.33	0.33	0.42	0.29	0.20	0.17	0.18	0.18	0.19	3.31
91/92	0.12	0.00	0.00	0.44	0.37	2.46	1.26	0.84	0.51	0.33	0.40	0.46	7.19
92/93	0.08	0.09	0.10	0.00	0.78	0.00	0.98	0.33	0.05	0.17	0.15	0.21	2.95
93/94	0.14	0.29	0.44	0.16	0.15	0.12	0.13	0.10	0.08	0.09	0.10	0.09	1.91
94/95	0.07	0.42	0.13	0.31	0.36	0.20	0.10	0.26	0.12	0.37	0.10	0.08	2.50
95/96	0.09	0.11	0.12	0.16	0.14	0.12	0.11	0.10	0.11	0.14	0.15	0.12	1.47
96/97	0.09	0.07	0.10	0.13	0.12	0.12	0.11	0.10	0.08	0.11	0.10	0.09	1.20
97/98	0.10	0.13	0.10	0.11	0.10	0.10	0.08	0.09	0.11	0.09	0.07	0.09	1.19
98/99	0.12	0.14	0.13	0.11	0.14	0.11	0.09	0.08	0.07	0.08	0.11	0.09	1.27
Average	0.16	0.22	0.27	0.31	0.41	0.62	0.47	0.42	0.25	0.22	0.19	0.18	3.74
Maximum	0.41	0.42	0.68	0.66	0.78	2.46	1.38	1.61	0.75	0.54	0.49	0.46	9.34
Minimum	0.07	0.00	0.00	0.00	0.10	0.00	0.08	0.08	0.05	0.08	0.07	0.08	1.19
Median	0.15	0.26	0.32	0.35	0.37	0.38	0.31	0.26	0.18	0.19	0.15	0.15	3.23
St. Dev.	0.09	0.12	0.17	0.17	0.23	0.74	0.44	0.43	0.21	0.13	0.12	0.11	2.44
Cv.	0.53	0.55	0.64	0.54	0.55	1.19	0.94	1.03	0.83	0.59	0.63	0.61	0.65
Skew	1.44	-0.06	0.55	-0.04	0.19	1.67	1.18	1.79	1.27	1.03	1.57	1.33	1.20

APPENDIX B
FIGURES OF ANALYSIS, MODELING AND FORECAST FOR PRECIPITATION, TEMPERATURE, AND BASE FLOW

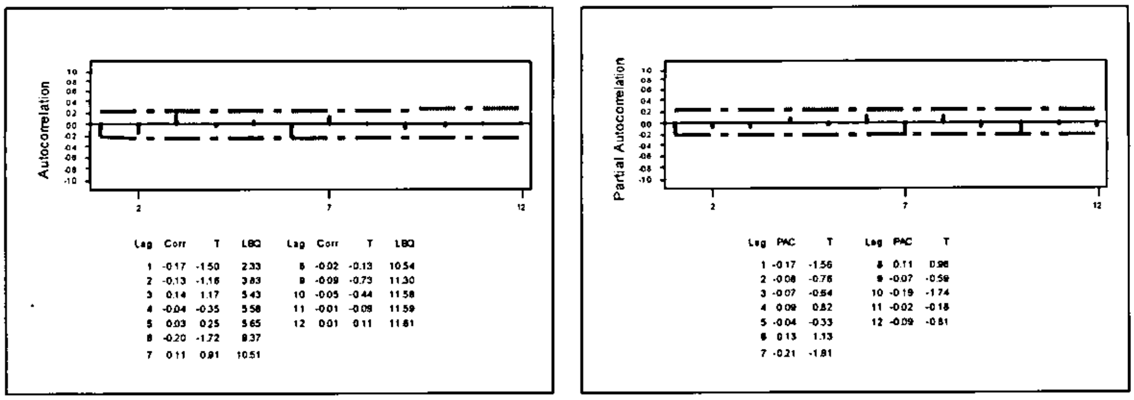


Figure (B.1): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Season from (Oct. to Mar.) for Amman Airport Station

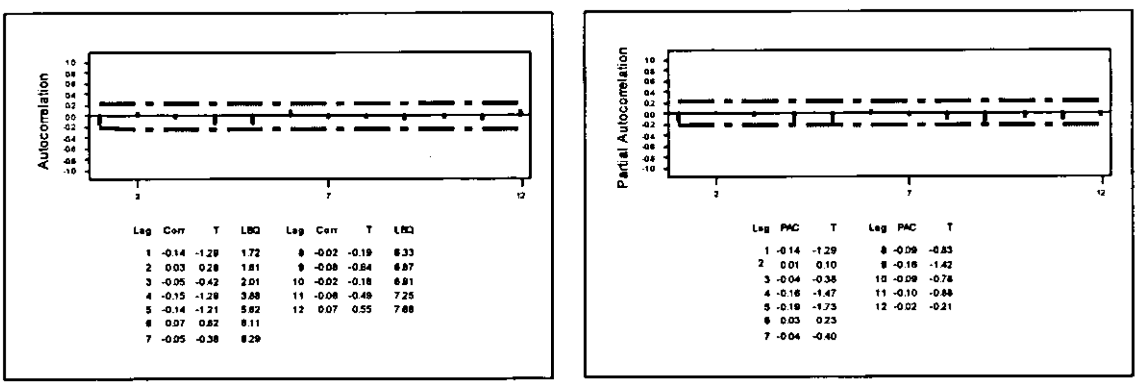


Figure (B.2): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Amman Airport Station

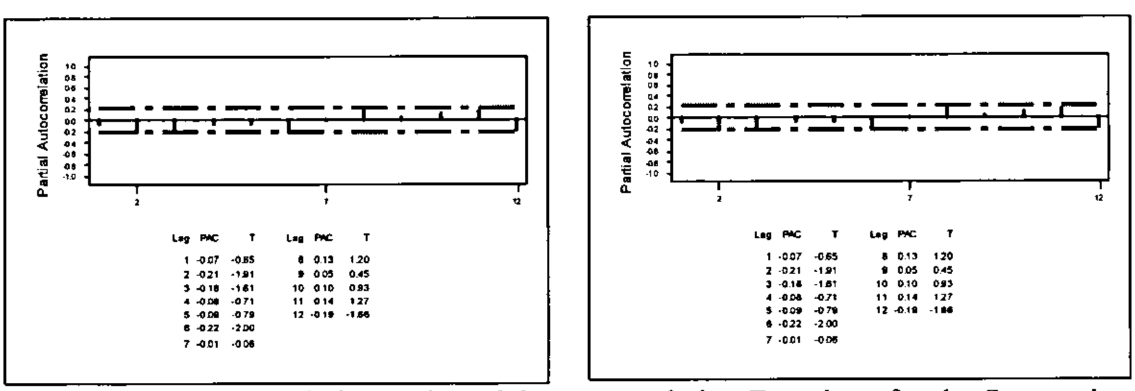


Figure (B.3): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Jan. to Mar.) for Amman Airport Station

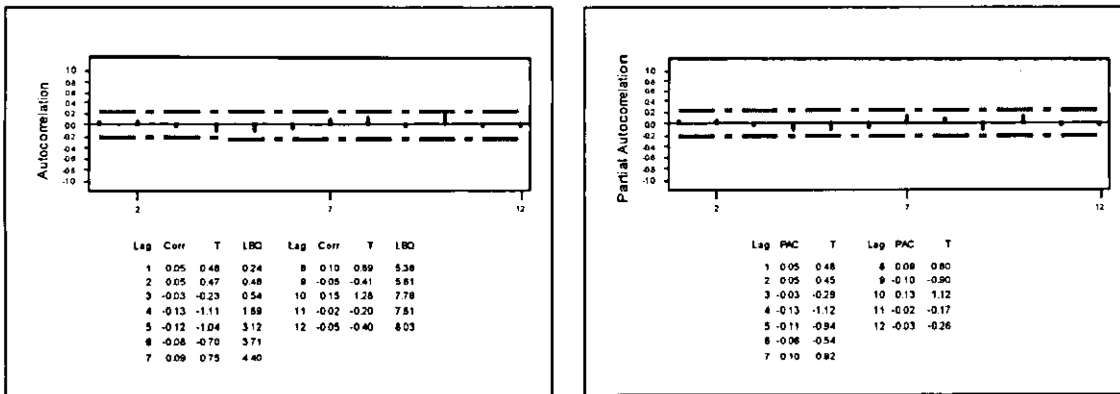


Figure (B.4): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Amman Airport Station

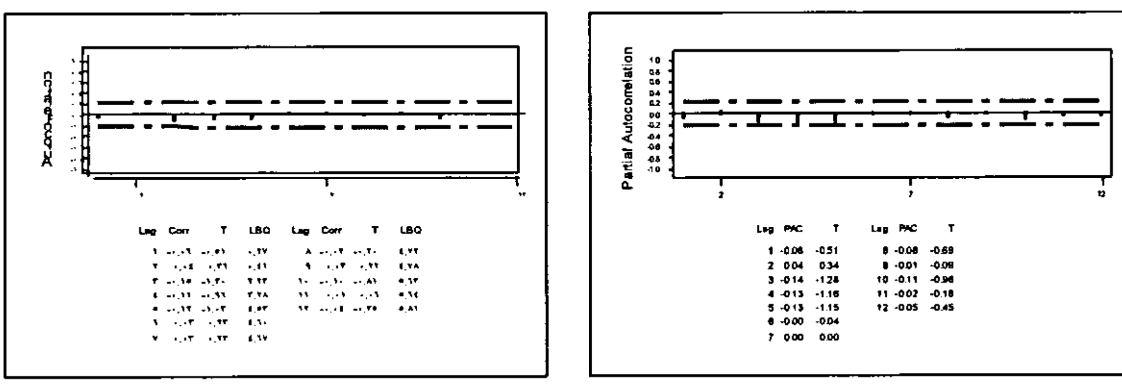


Figure (B.5): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Amman Airport Station

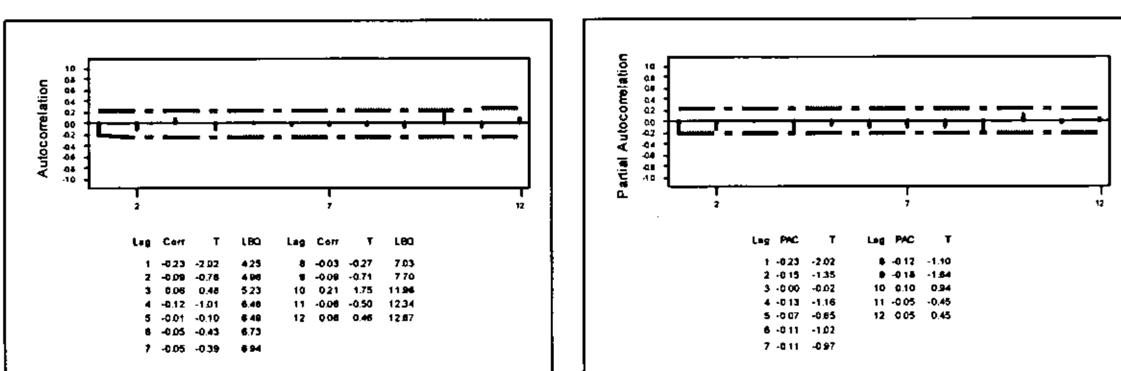


Figure (B.6): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Amman Airport Station

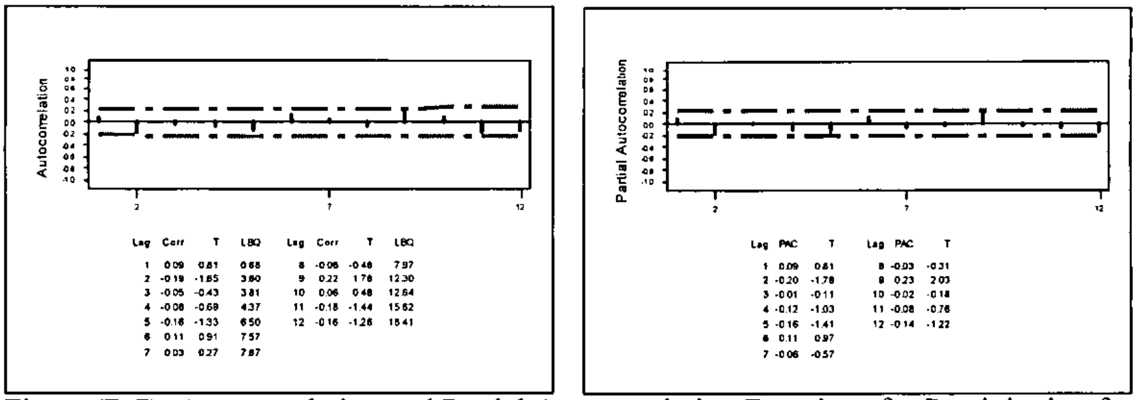


Figure (B.7): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Amman Airport Station

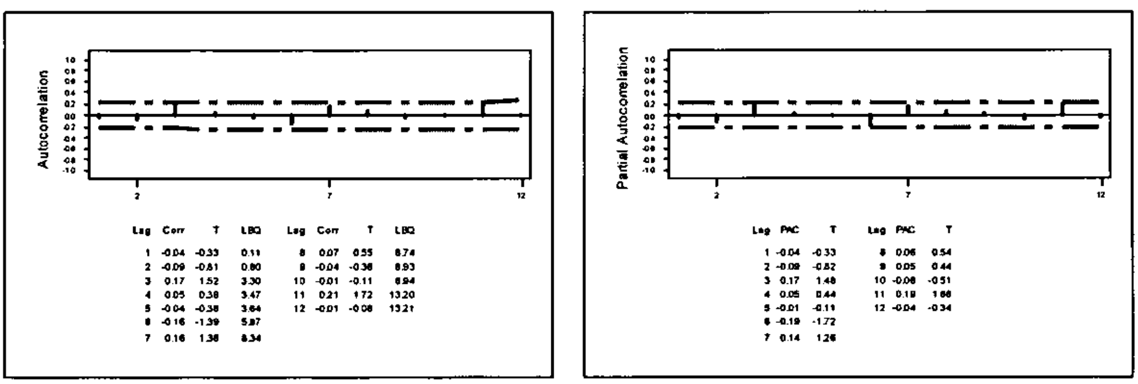


Figure (B.8): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Amman Airport Station

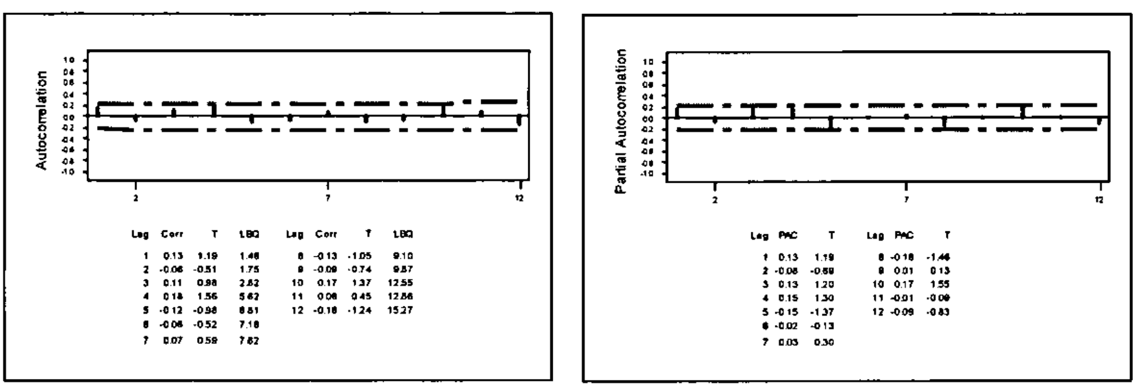
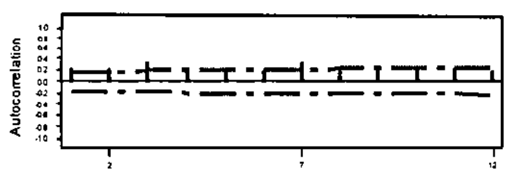
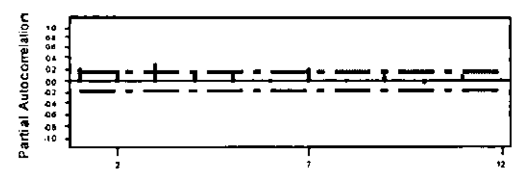


Figure (B.9): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Amman Airport Station

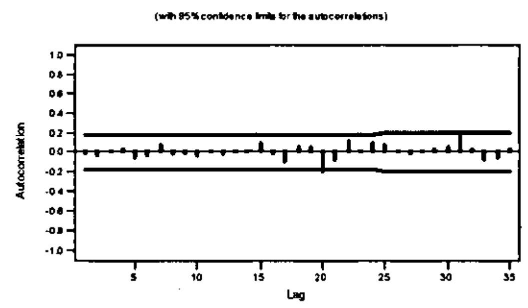


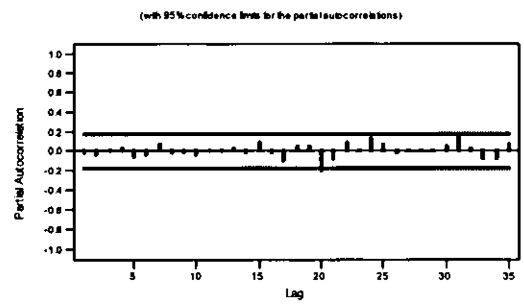
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.17	2.07	4.38	8	0.14	1.34	49.79
2	0.17	1.95	8.52	9	0.18	1.67	54.87
3	0.29	3.26	20.80	10	0.14	1.23	57.75
4	0.19	2.03	26.32	11	0.18	1.68	63.34
5	0.20	2.00	32.07	12	0.18	1.37	67.21
6	0.14	1.43	35.21				
7	0.28	2.69	46.85				



Lag	PAC	T	Lag	PAC	T
1	0.17	2.07	8	0.01	0.09
2	0.14	1.70	9	0.08	0.95
3	0.25	3.00	10	-0.03	-0.36
4	0.11	1.32	11	0.09	1.05
5	0.11	1.26	12	0.01	0.14
6	0.02	0.20			
7	0.18	2.17			

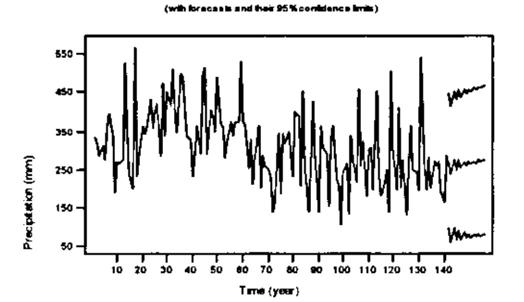
One. Extended Data





Two. Residuals for Extended Data

Figure (B.10): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation in the Season form (Oct. to Mar.) for Amman Airport Station



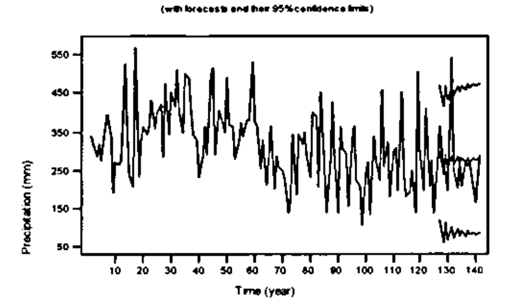
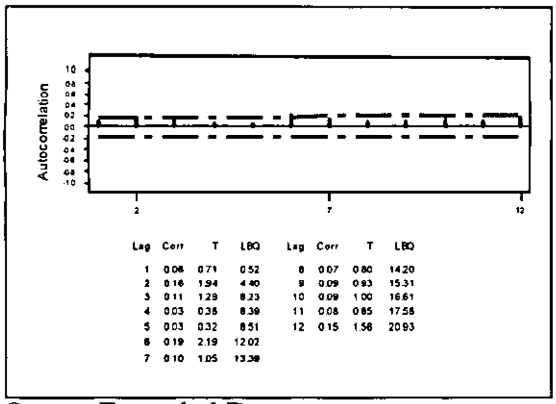
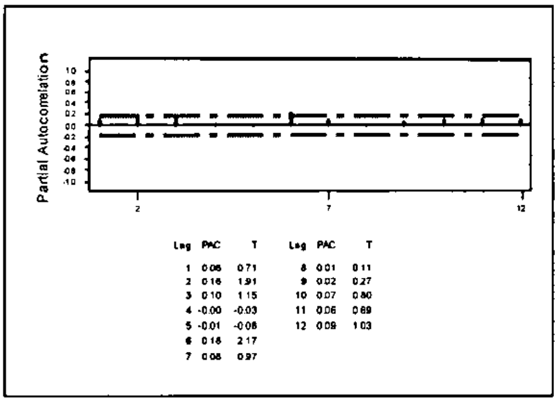
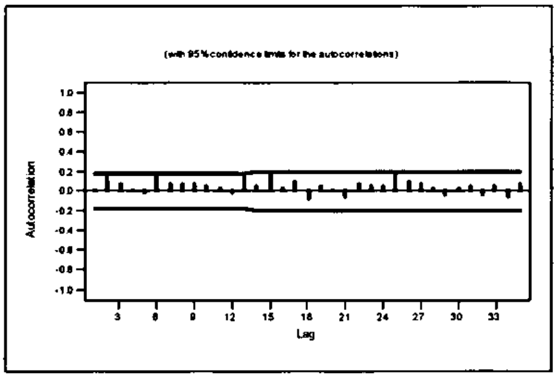


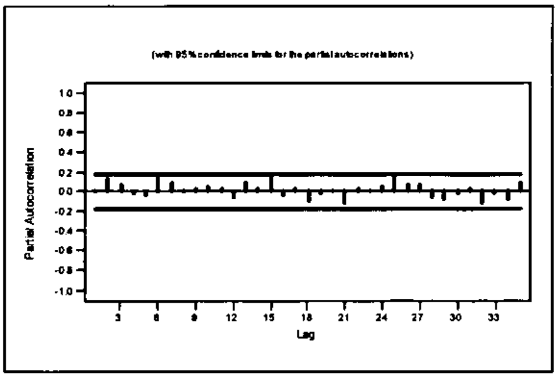
Figure (B.11): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation in the Season form (Oct. to Mar.) for Amman Airport Station





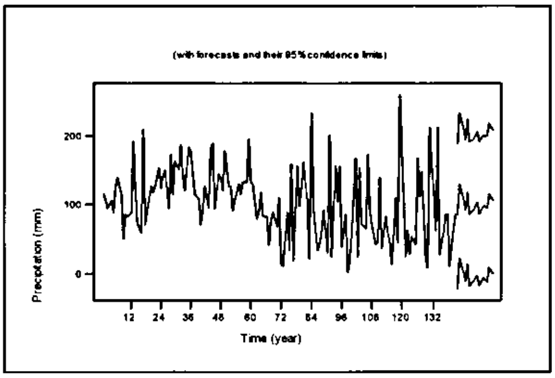
One. Extended Data





Two. Residual for Extended Data

Figure (B.12): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Oct. to Dec.) for Amman Airport Station



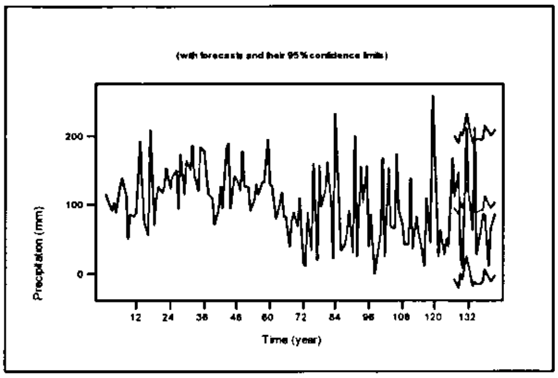
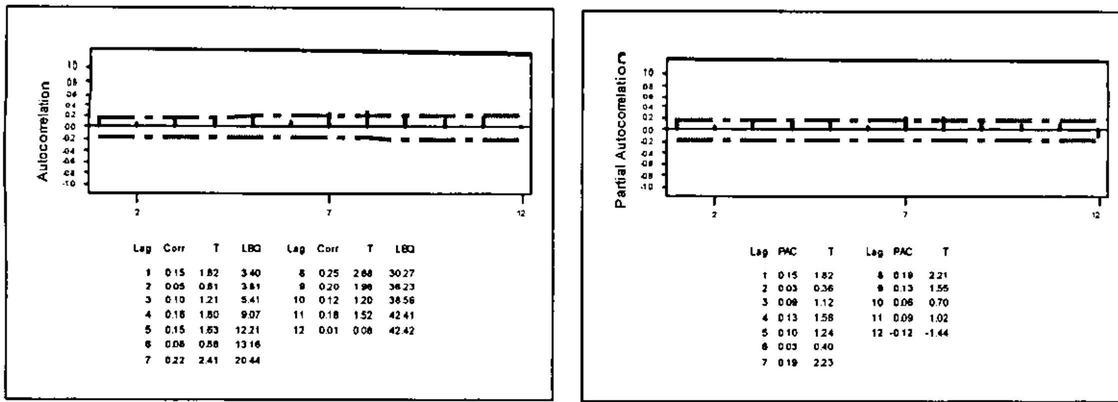
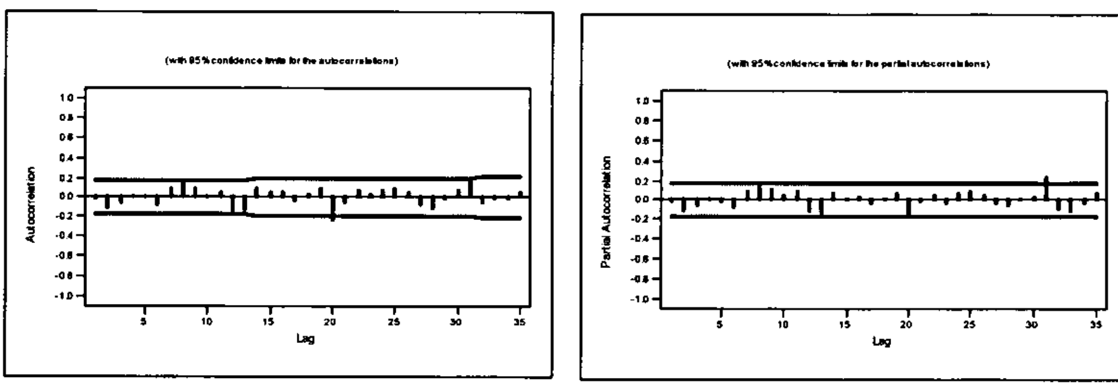


Figure (B.13): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Oct. to Dec.) for Amman Airport Station



One. Extended Data



Two. Residual for Extended Data

Figure (B.14): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Jan. to Mar.) for Amman Airport Station

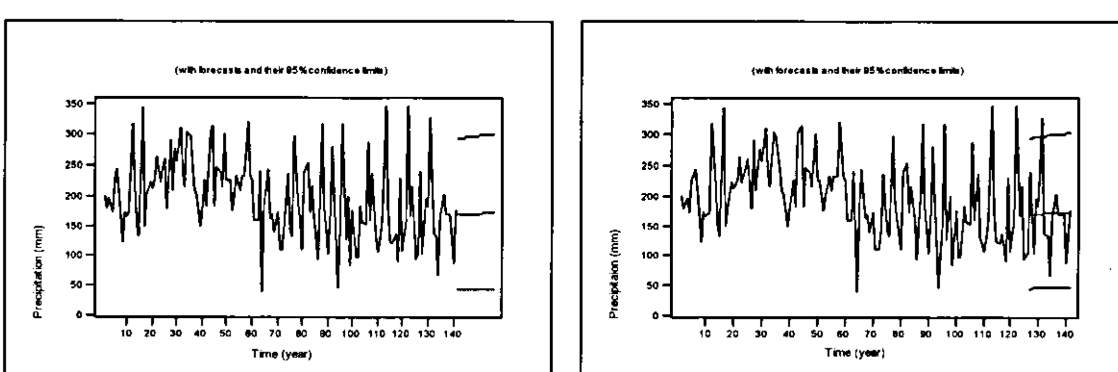
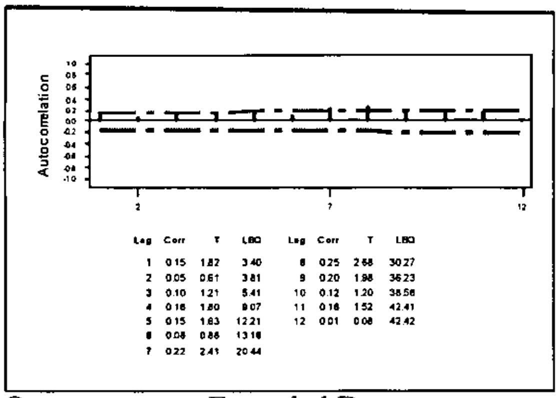
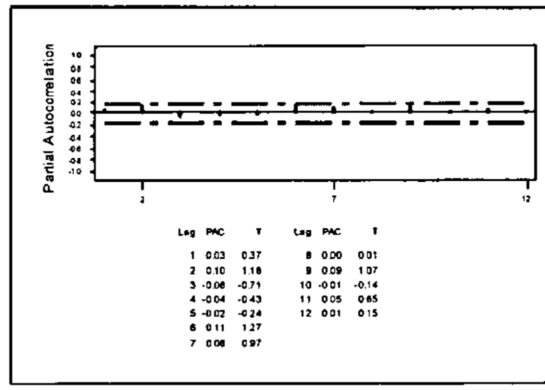
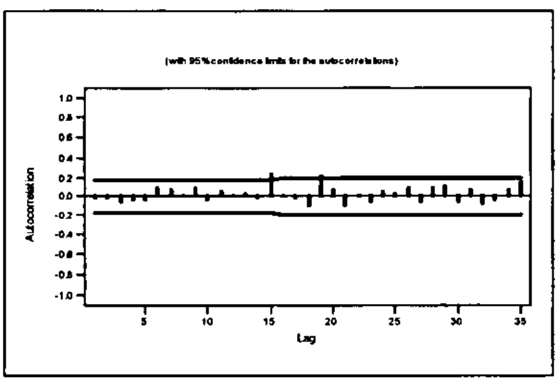


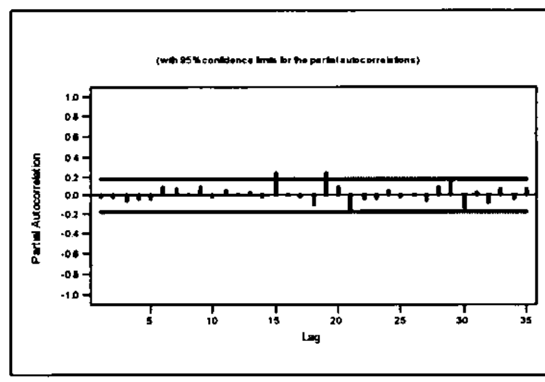
Figure (B.15): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Jan. to Mar.) for Amman Airport Station





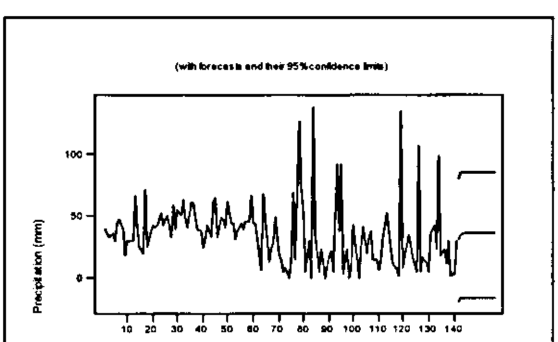
One. Extended Data





Two. Residual for Extended Data

Figure (B.16): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Nov.) for Amman Airport Station



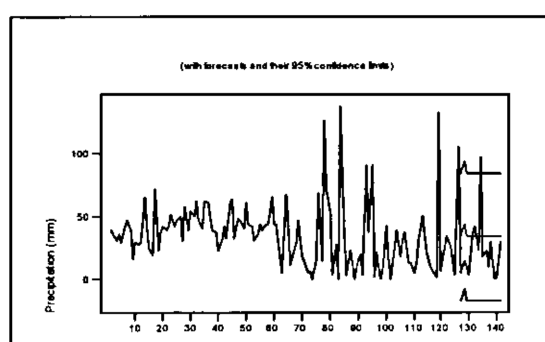
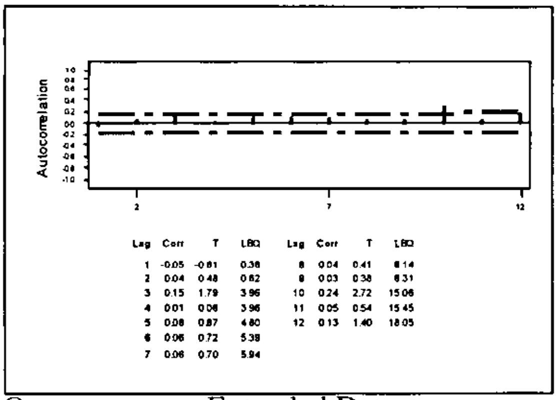
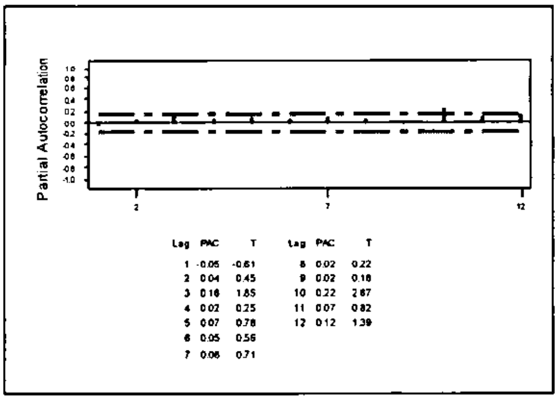
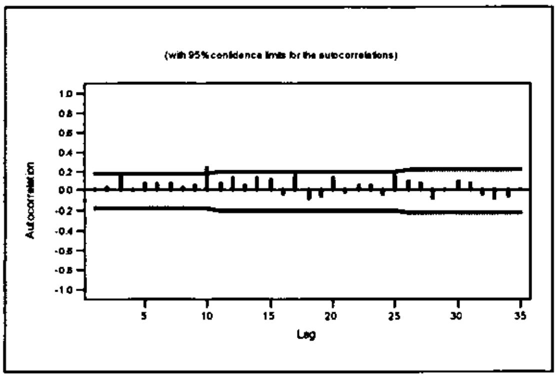


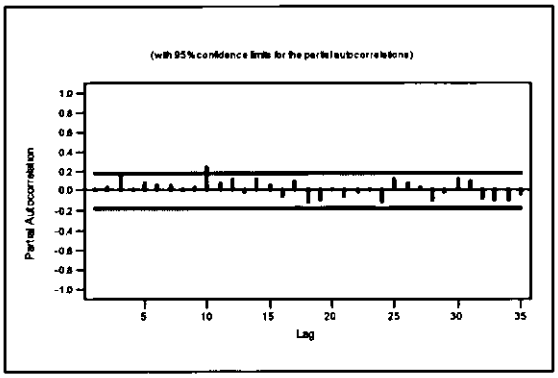
Figure (B.17): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Nov.) for Amman Airport Station





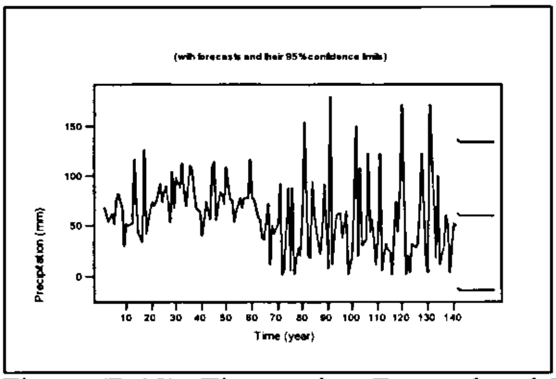
One. Extended Data





b. Residual for Extended Data

Figure (B.18): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Dec.) for Amman Airport Station



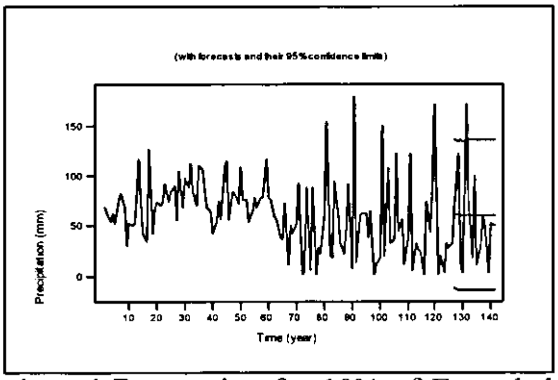
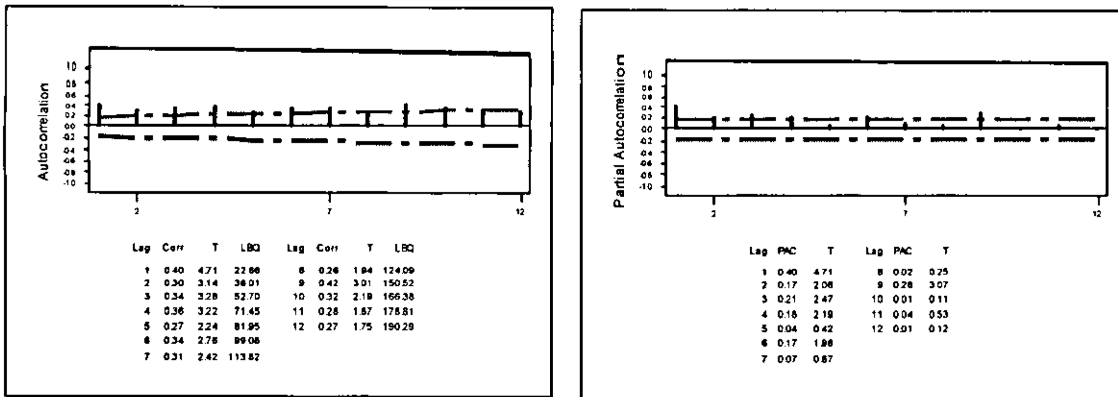
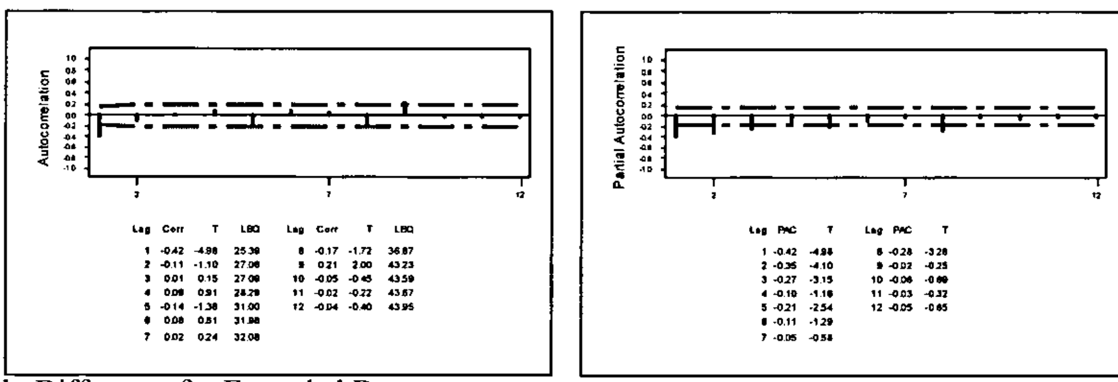


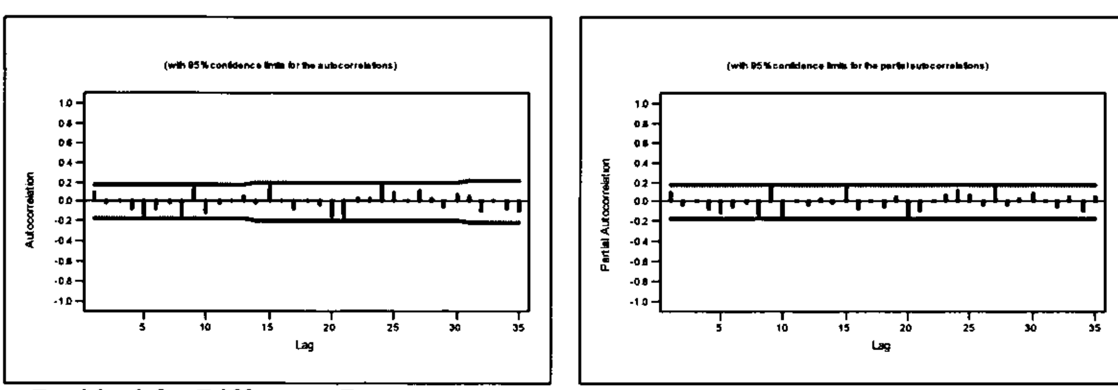
Figure (B.19): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Dec.) for Amman Airport Station



One. Extended Data



b. Difference for Extended Data



c. Residual for Difference Data

Figure (B.20): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Jan.) for Amman Airport Station

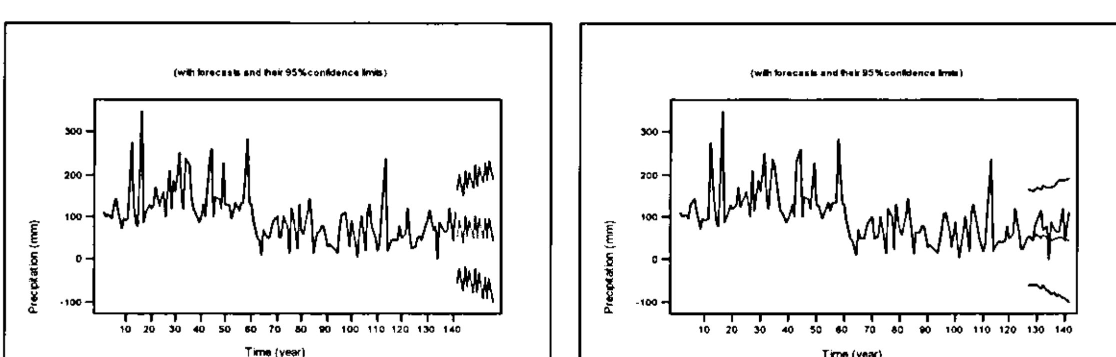
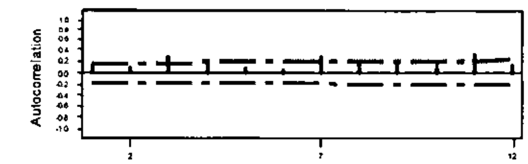
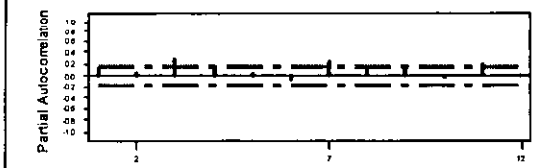


Figure (B.21): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Jan.) for Amman Airport Station

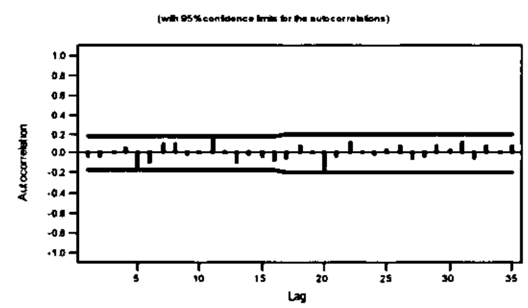


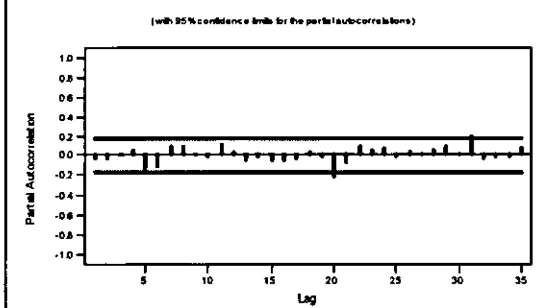
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.11	1.26	1.67	8	0.19	1.89	32.82
2	0.06	0.67	2.13	9	0.12	1.20	35.06
3	0.26	3.09	12.35	10	0.10	0.99	36.63
4	0.15	1.65	15.67	11	0.26	2.71	48.65
5	0.09	0.92	16.76	12	0.11	1.06	50.71
6	0.03	0.27	16.85				
7	0.27	2.86	27.56				



Lag	PAC	T	Lag	PAC	T
1	0.11	1.26	8	0.12	1.46
2	0.05	0.54	9	0.11	1.29
3	0.26	3.05	10	-0.03	-0.38
4	0.11	1.26	11	0.19	2.30
5	0.05	0.60	12	-0.01	-0.07
6	-0.06	-0.74			
7	0.22	2.64			

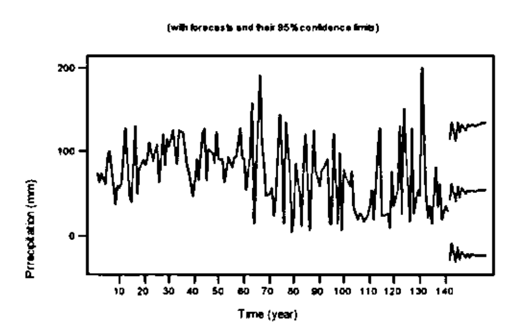
One. Extended Data





b. Residual for Extended Data

Figure (B.22): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Feb.) for Amman Airport Station



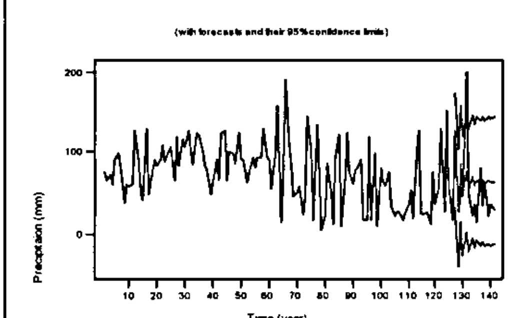


Figure (B.23): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Feb.) for Amman Airport Station

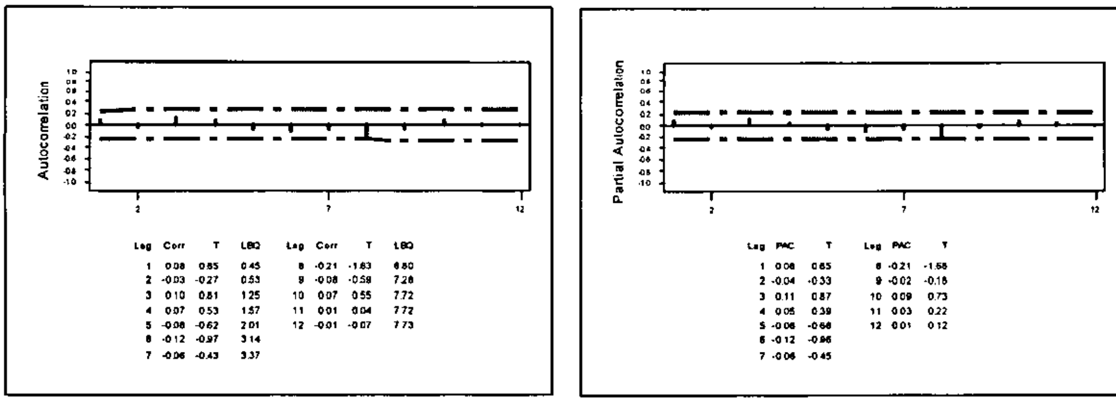


Figure (B.24): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Water Year for Irbid Station

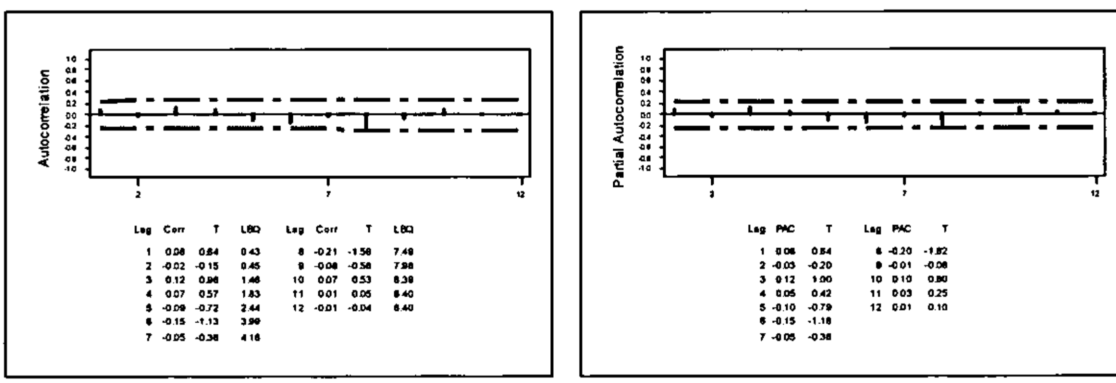


Figure (B.25): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Season from (Oct. to Mar.) for Irbid Station

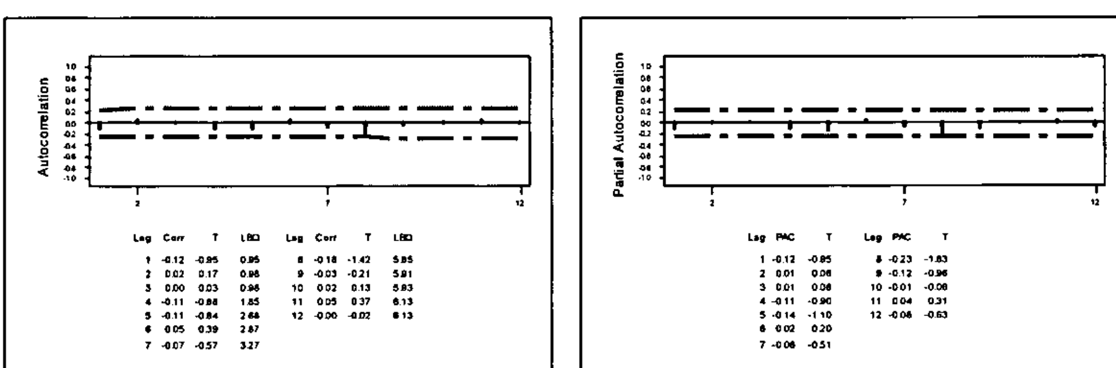


Figure (B.26): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Irbid Station

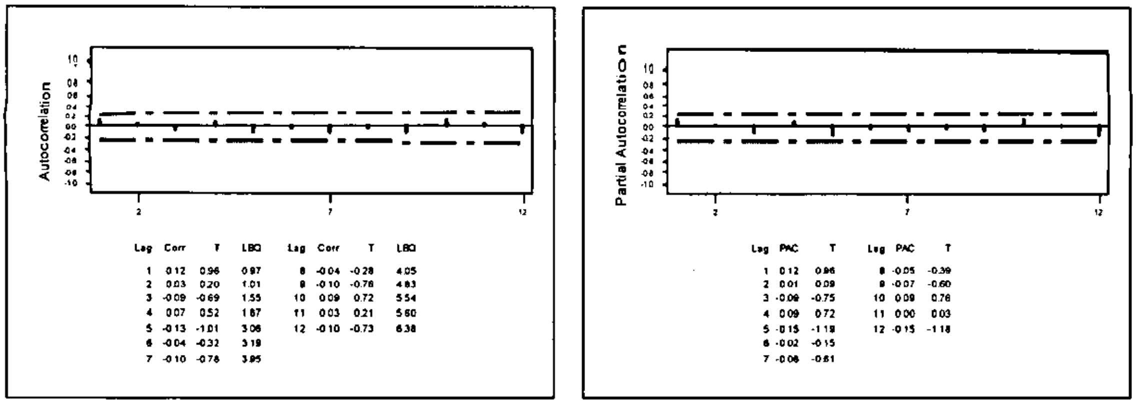


Figure (B.27): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Jan. to Mar.) for Irbid Station

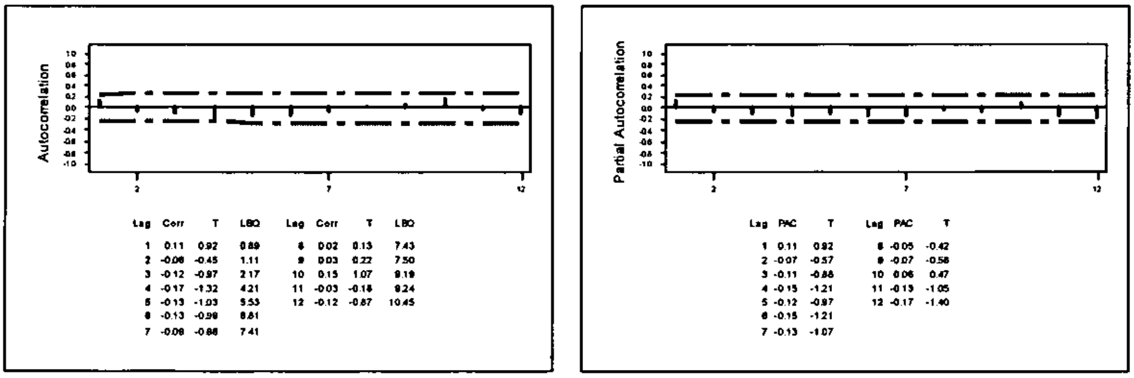


Figure (B.28): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Irbid Station

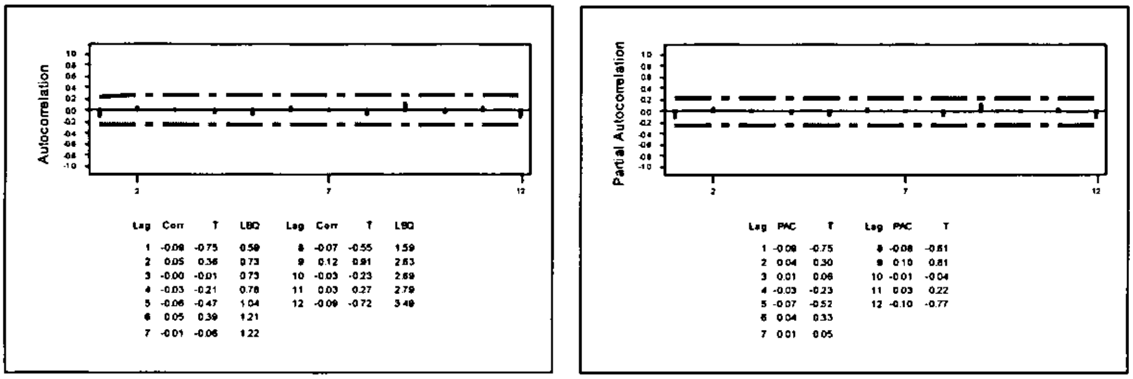
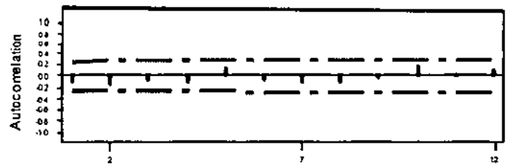
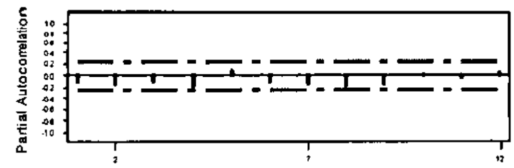


Figure (B.29): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Irbid Station

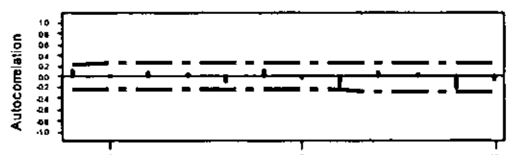


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.11	-0.90	0.85	8	-0.11	-0.79	8.78
2	-0.14	-1.14	2.27	9	-0.05	-0.33	6.92
3	-0.06	-0.48	2.54	10	0.16	1.18	8.95
4	-0.12	-0.95	3.61	11	0.01	0.09	8.97
5	0.13	0.96	4.75	12	0.08	0.56	9.43
6	-0.08	-0.59	5.20				
7	-0.10	-0.74	5.82				

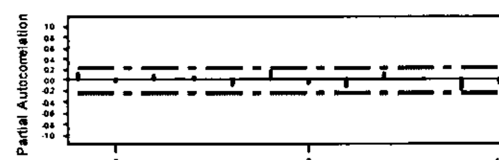


Lag	PAC	T	Lag	PAC	T
1	-0.11	-0.90	8	-0.20	-1.59
2	-0.16	-1.27	9	-0.15	-1.19
3	-0.10	-0.81	10	0.01	0.08
4	-0.18	-1.42	11	-0.05	-0.42
5	0.06	0.48	12	0.05	0.44
6	-0.12	-0.94			
7	-0.13	-1.04			

Figure (B.30): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Irbid Station

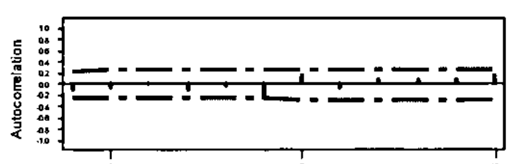


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.10	0.83	0.73	8	-0.17	-1.28	5.18
2	-0.01	-0.11	0.74	9	0.06	0.45	5.45
3	0.07	0.57	1.10	10	0.04	0.27	5.56
4	0.04	0.29	1.18	11	-0.20	-1.54	8.94
5	-0.11	-0.90	2.12	12	-0.08	-0.64	9.58
6	0.11	0.83	2.95				
7	-0.04	-0.33	3.08				

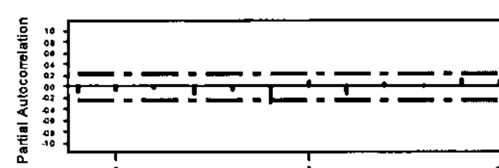


Lag	PAC	T	Lag	PAC	T
1	0.10	0.83	8	-0.14	-1.11
2	-0.02	-0.20	9	0.09	0.76
3	0.08	0.61	10	-0.01	-0.05
4	0.02	0.17	11	-0.17	-1.38
5	-0.12	-0.95	12	-0.06	-0.52
6	0.13	1.06			
7	-0.08	-0.66			

Figure (B.31): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Irbid Station

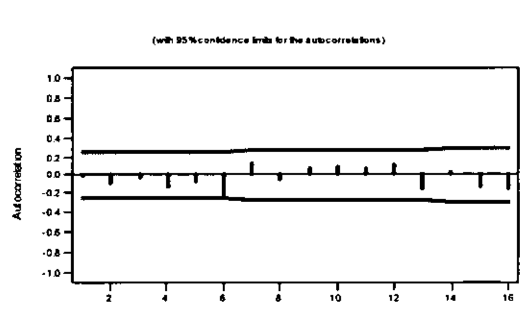


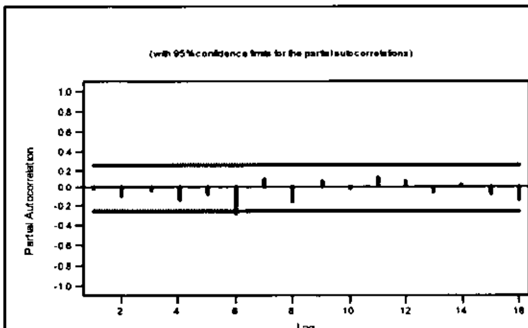
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.11	-0.87	0.78	8	-0.08	-0.61	9.20
2	-0.08	-0.60	1.18	9	0.07	0.53	9.63
3	-0.02	-0.12	1.20	10	0.08	0.57	10.13
4	-0.12	-0.96	2.23	11	0.06	0.41	10.40
5	-0.02	-0.17	2.27	12	0.13	0.93	11.81
6	-0.24	-1.90	6.64				
7	0.16	1.22	8.67				



Lag	PAC	T	Lag	PAC	T
1	-0.11	-0.87	8	-0.15	-1.22
2	-0.09	-0.71	9	0.05	0.43
3	-0.03	-0.28	10	-0.01	-0.08
4	-0.14	-1.10	11	0.11	0.85
5	-0.06	-0.48	12	0.09	0.72
6	-0.29	-2.33			
7	0.08	0.66			

a. Observed Data





Two. Residual for Observed Data

Figure (B.32): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Irbid Station

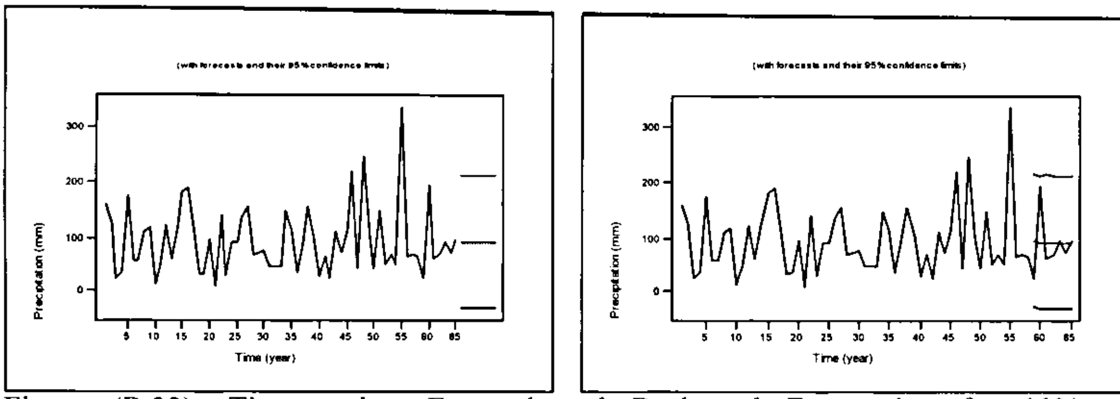
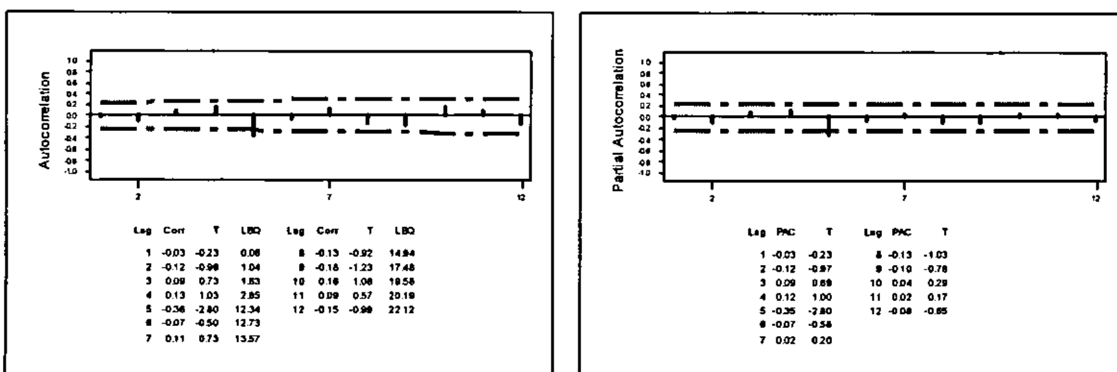
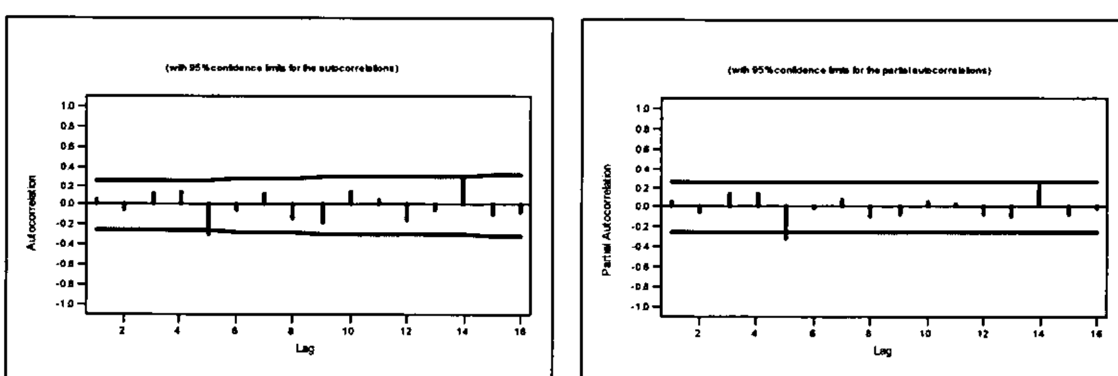


Figure (B.33): Time series, Forward and Backward Forecasting for 10% of Precipitation for (Feb.) for Irbid Station



One. Observed Data



b. Residual for Observed Data

Figure (B.34): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Irbid Station

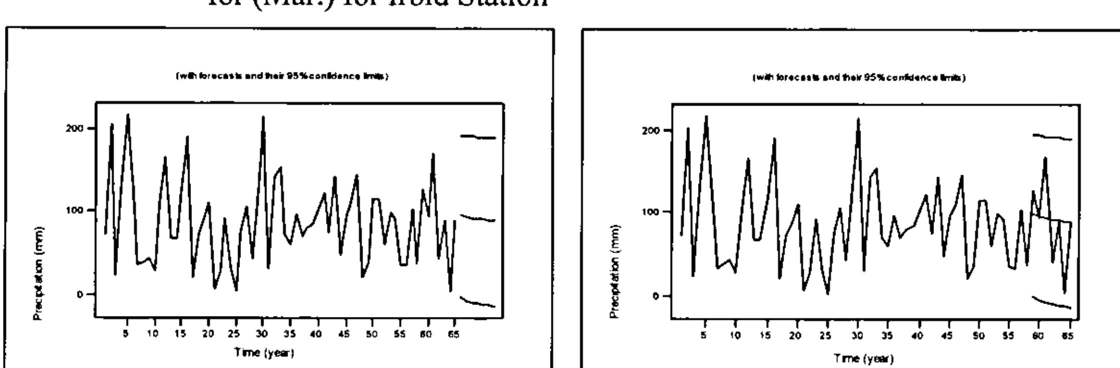
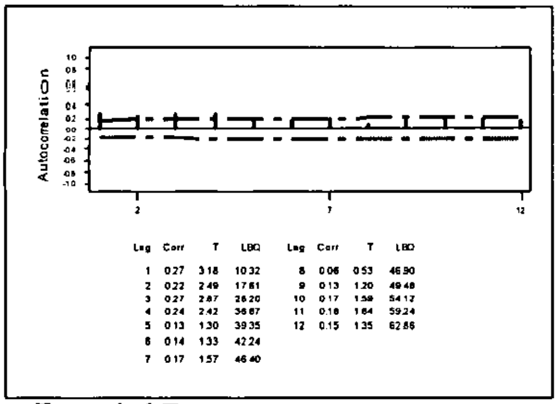
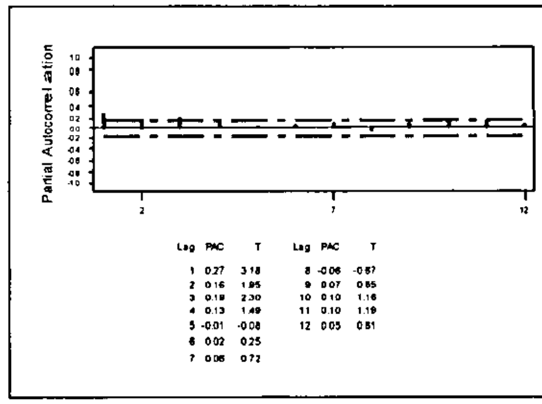


Figure (B.35): Time series, Forward and Backward Forecasting for 10% of Precipitation for (Mar.) for Irbid Station

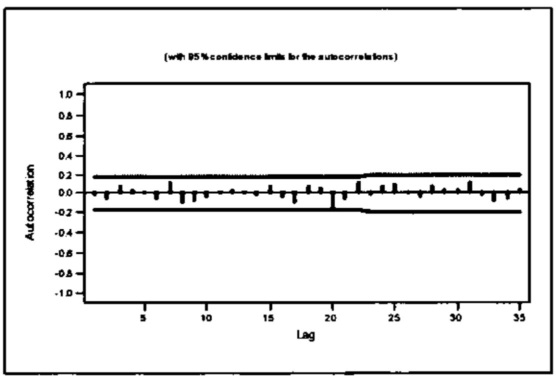


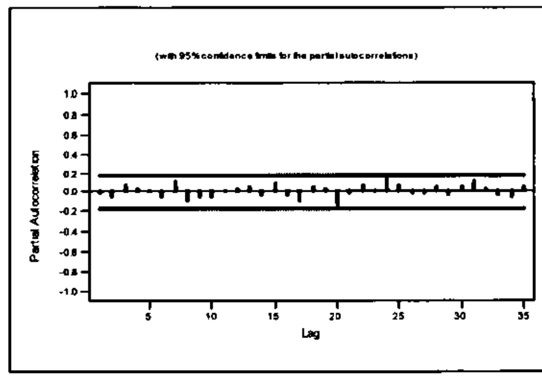
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.27	3.18	10.32	8	0.06	0.53	46.90
2	0.22	2.49	17.61	9	0.13	1.20	49.48
3	0.27	2.87	26.20	10	0.17	1.59	54.17
4	0.24	2.42	36.67	11	0.18	1.64	59.24
5	0.13	1.30	39.35	12	0.15	1.35	62.86
6	0.14	1.33	42.24				
7	0.17	1.57	46.40				



Lag	PAC	T	Lag	PAC	T
1	0.27	3.18	8	-0.06	-0.67
2	0.16	1.85	9	0.07	0.85
3	0.19	2.30	10	0.10	1.16
4	0.13	1.49	11	0.10	1.19
5	-0.01	-0.08	12	0.05	0.61
6	0.02	0.25			
7	0.06	0.72			

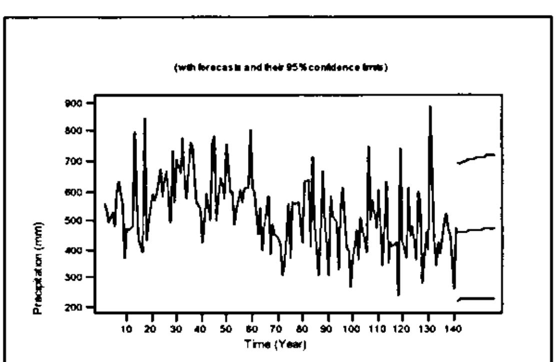
a. Extended Data





b. Residuals for Extended Data

Figure (B.38): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation in the Season form (Oct. to Mar.) for Irbid Station



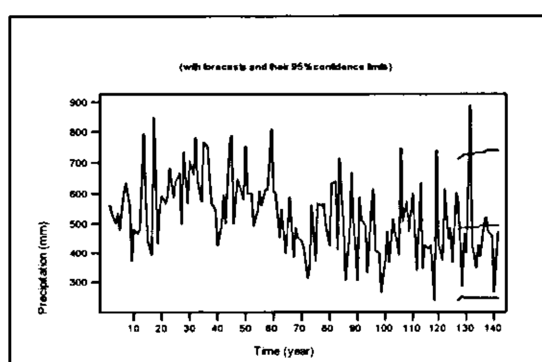
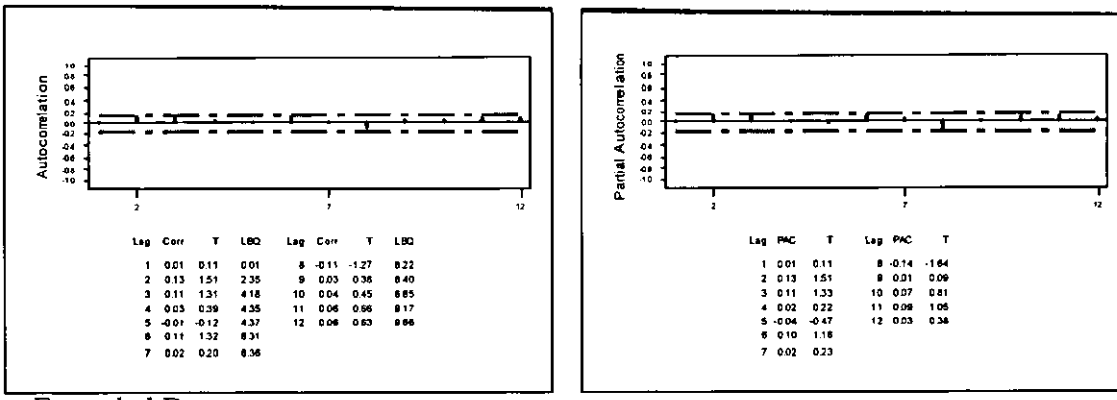
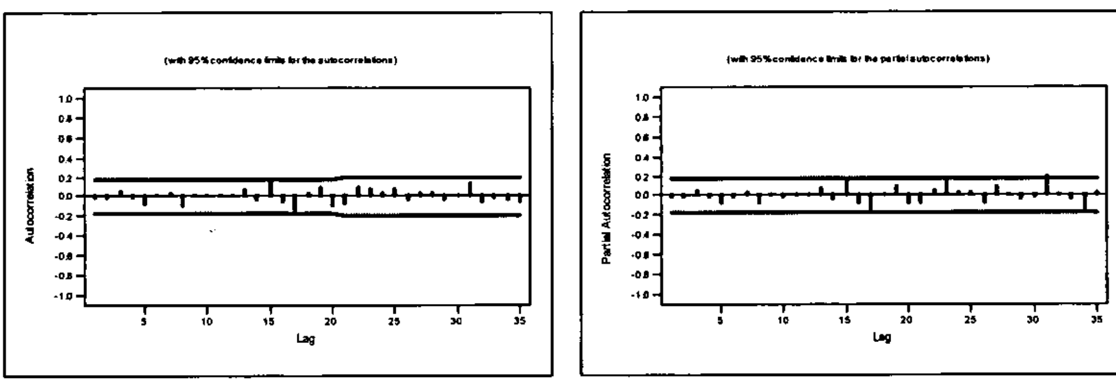


Figure (B.39): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation in the Season form (Oct. to Mar.) for Irbid Station



a. Extended Data



b. Residual for Extended Data

Figure (B.40): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Oct. to Dec.) for Irbid Station

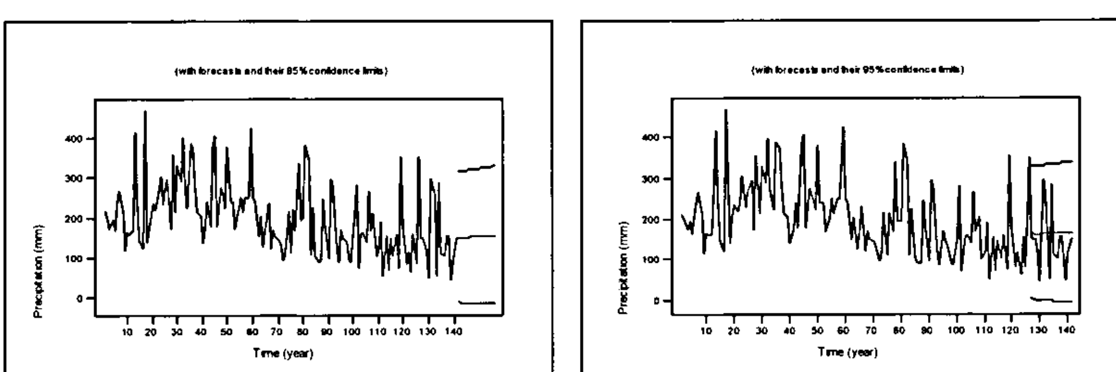
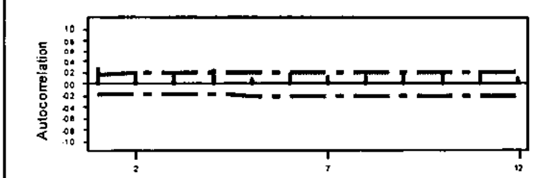
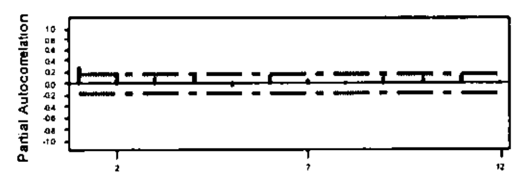


Figure (B.41): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Oct. to Dec.) for Irbid Station

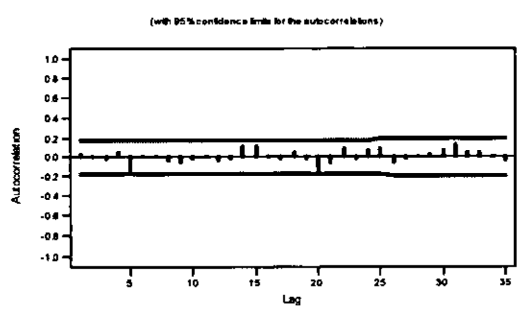


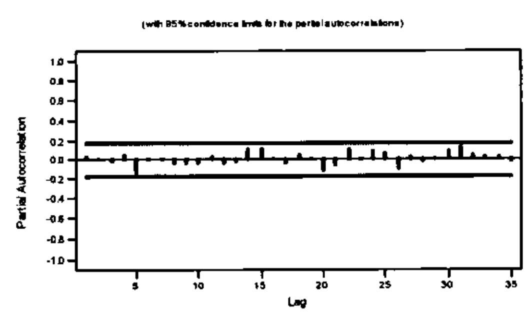
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.25	2.98	9.09	8	0.09	0.83	31.06
2	0.19	2.11	14.26	9	0.11	1.11	32.87
3	0.14	1.51	17.10	10	0.16	1.60	37.00
4	0.21	2.26	23.69	11	0.18	1.70	41.75
5	0.08	0.80	24.58	12	0.09	0.86	43.03
6	0.15	1.52	27.87				
7	0.11	1.13	29.78				



Lag	PAC	T	Lag	PAC	T
1	0.25	2.96	8	0.01	0.06
2	0.13	1.60	9	0.07	0.78
3	0.07	0.83	10	0.08	1.00
4	0.16	1.85	11	0.10	1.14
5	-0.03	-0.33	12	-0.02	-0.21
6	0.09	1.09			
7	0.04	0.43			

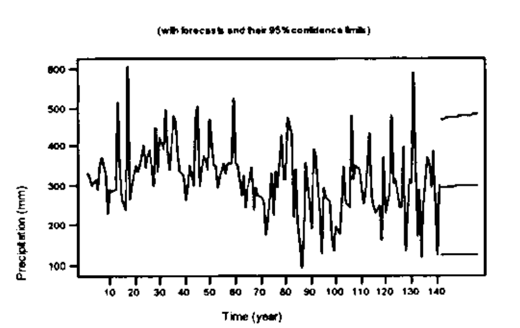
One. Extended Data





b. Residual for Extended Data

Figure (B.42): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Jan. to Mar.) for Irbid Station



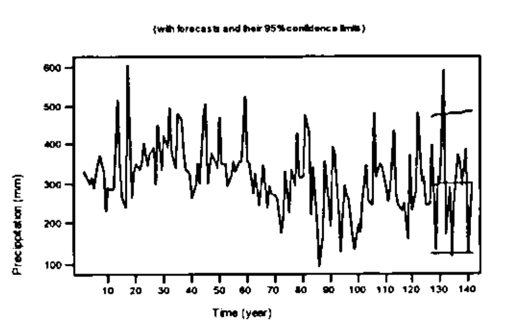


Figure (B.43): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Jan. to Mar.) for Irbid Station

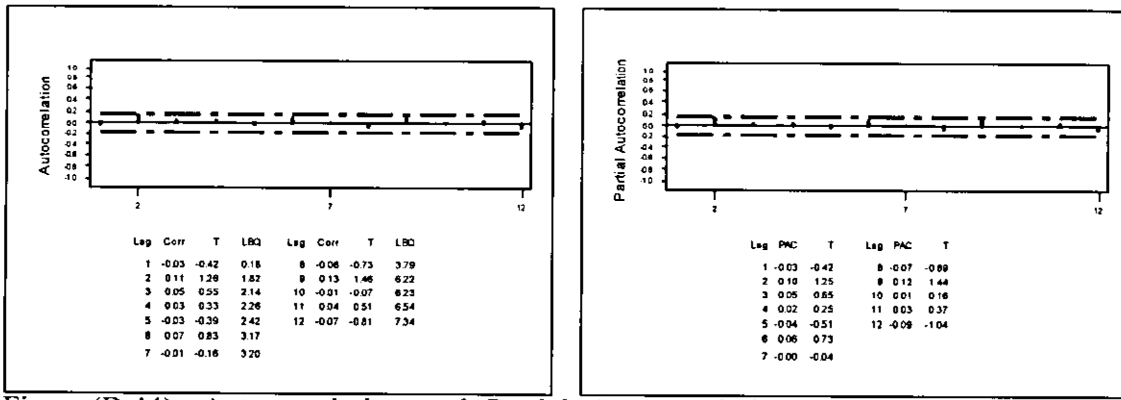


Figure (B.44): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Nov.) for Irbid Station

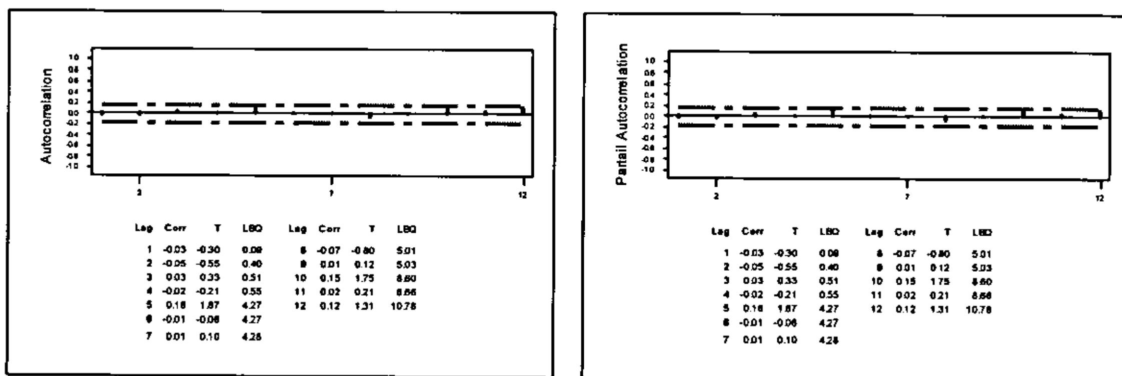
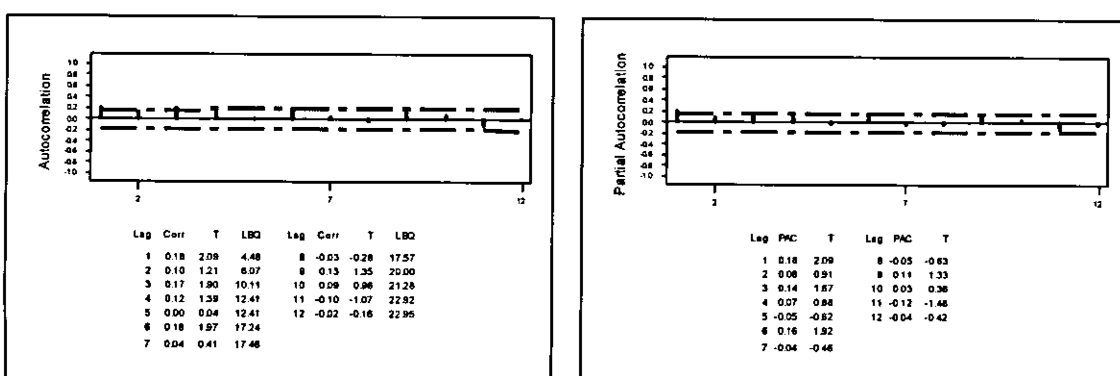
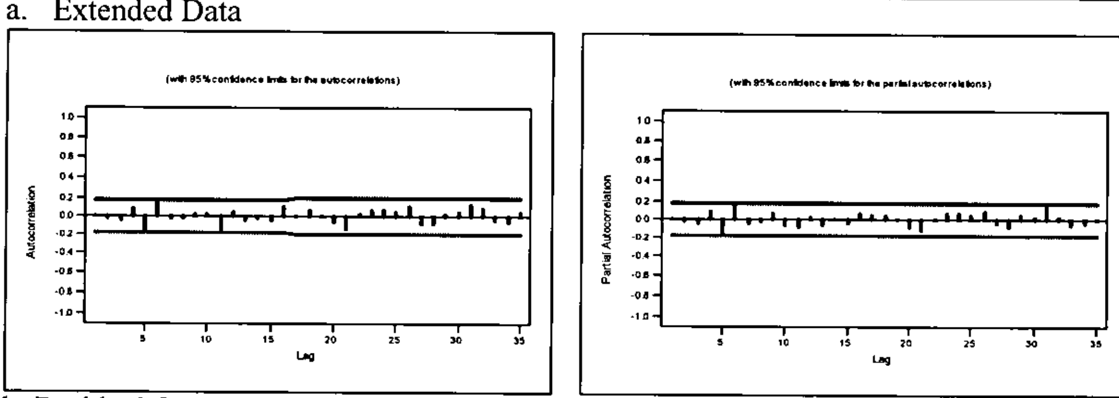


Figure (B.45): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Dec.) for Irbid Station



a. Extended Data



b. Residual for Extended Data

Figure (B.46): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Jan.) for Irbid Station

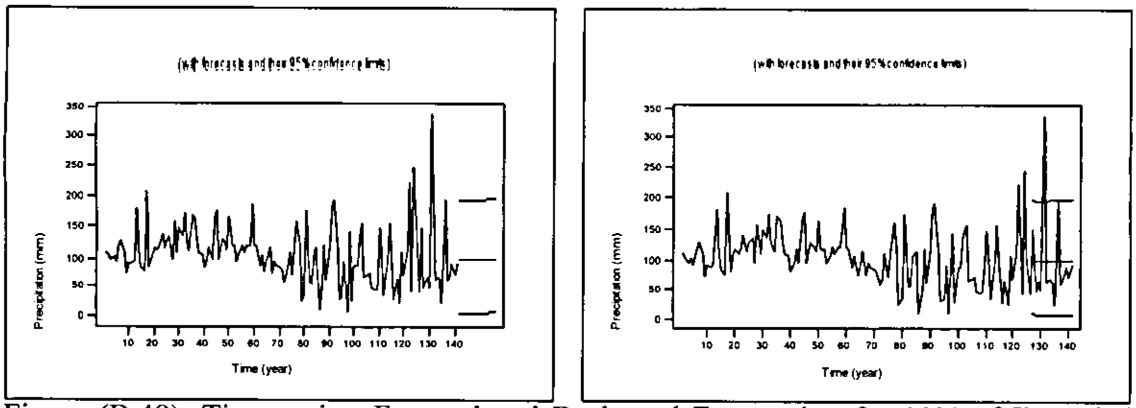
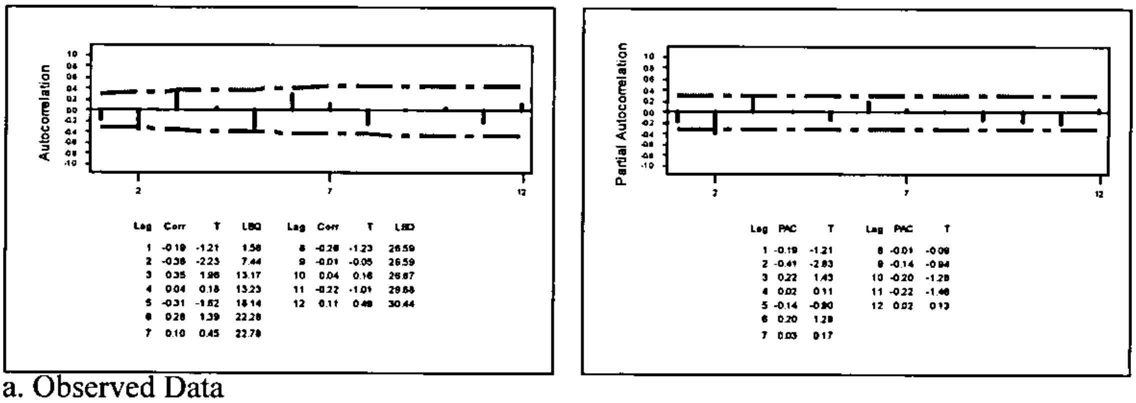
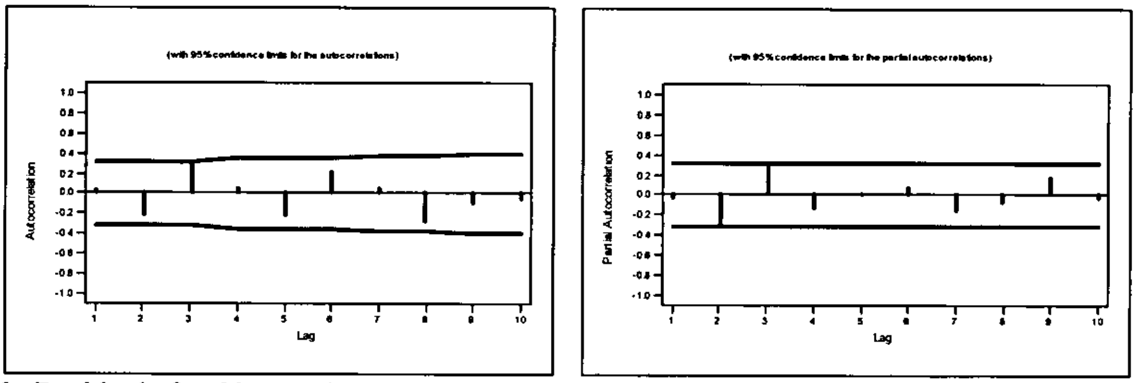


Figure (B.49): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Feb.) for Irbid Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.50): Autocorrelation and Partial Autocorrelation Functions for the Observed Precipitation in the Water Year for Aqaba Airport Station

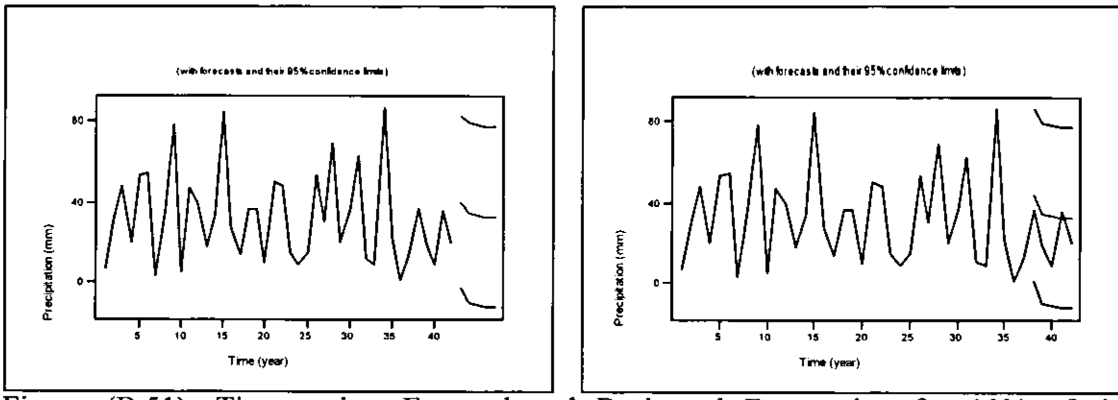
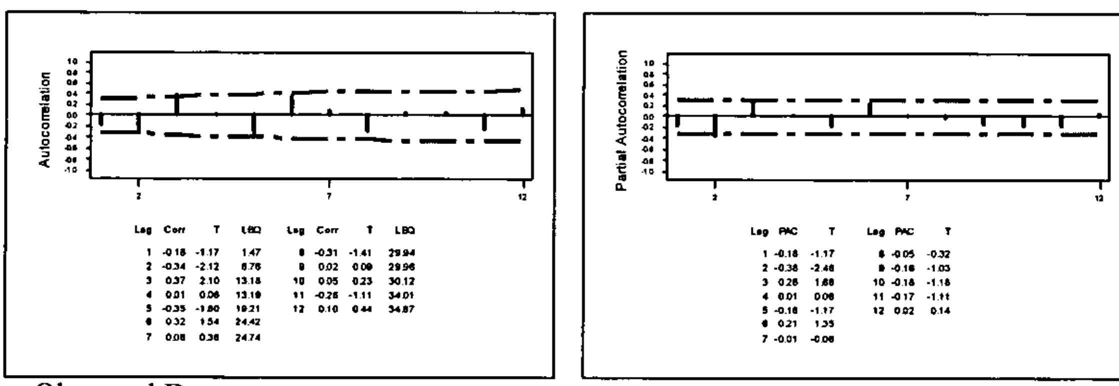


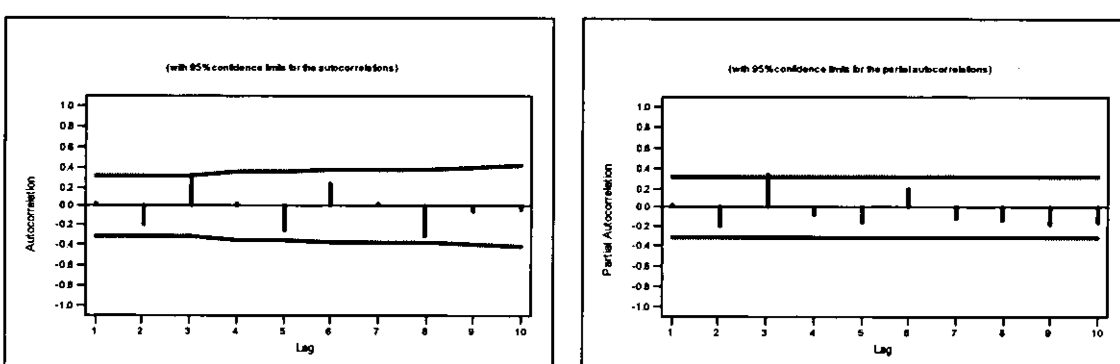
Figure (B.51): Time series, Forward and Backward Forecasting for 10% of the Observed Precipitation in the Water Year for Aqaba Airport Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.18	-1.17	1.47	8	-0.31	-1.41	29.94
2	-0.34	-2.12	8.76	9	0.02	0.09	29.96
3	0.37	2.10	13.18	10	0.05	0.23	30.12
4	0.01	0.06	13.19	11	-0.26	-1.11	34.01
5	-0.35	-1.80	19.21	12	0.10	0.44	34.87
6	0.32	1.54	24.42				
7	0.08	0.36	24.74				

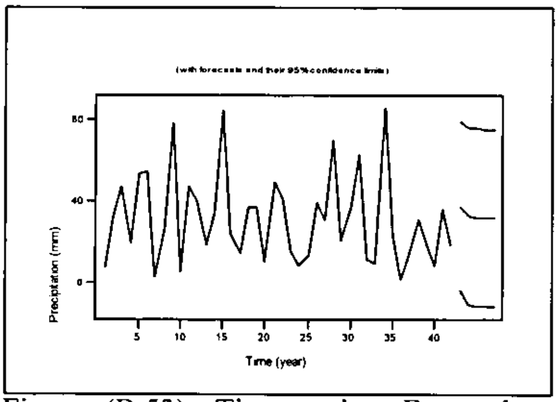
Lag	PAC	T	Lag	PAC	T
1	-0.18	-1.17	8	-0.05	-0.32
2	-0.38	-2.46	9	-0.16	-1.03
3	0.26	1.68	10	-0.18	-1.18
4	0.01	0.06	11	-0.17	-1.11
5	-0.18	-1.17	12	0.02	0.14
6	0.21	1.35			
7	-0.01	-0.06			

a. Observed Data



b. Residual for Observed Data

Figure (B.52): Autocorrelation and Partial Autocorrelation Functions for the Observed Precipitation in the Season from (Oct. to Mar.) for Aqaba Airport Station



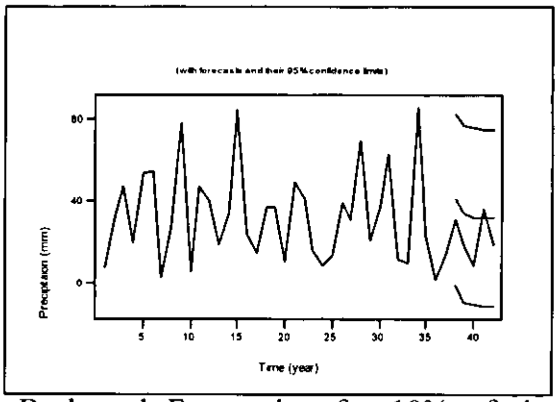
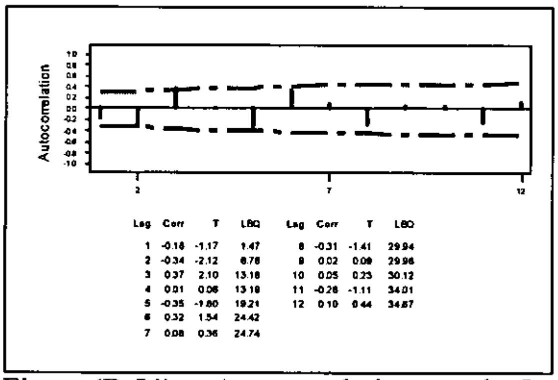


Figure (B.53): Time series, Forward and Backward Forecasting for 10% of the Observed Precipitation in the Season from (Oct. to Mar.) for Aqaba Airport Station



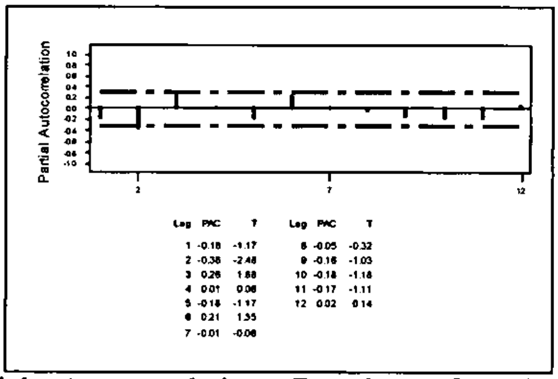
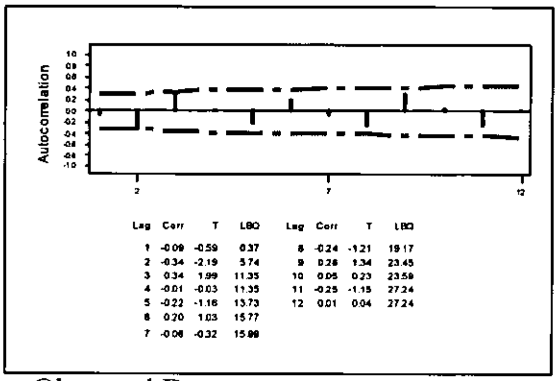
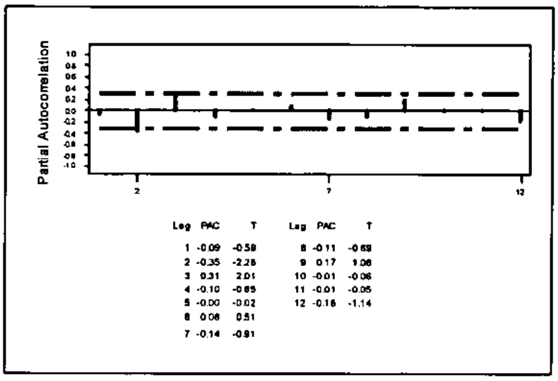


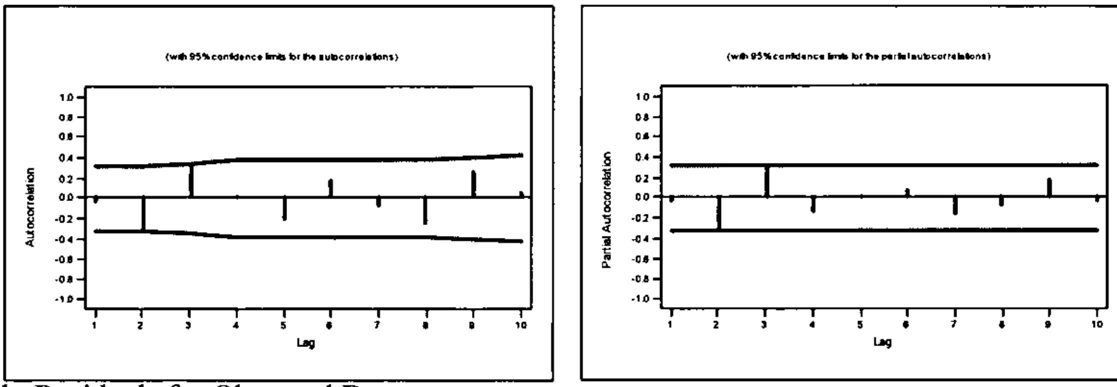
Figure (B.54): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Aqaba Airport Station





a. Observed Data

Figure (B.55): Continue



b. Residuals for Observed Data

Figure (B.55): Autocorrelation and Partial Autocorrelation Functions for the Observed Summation of (Jan. to Mar.) Precipitation for Aqaba Airport Station

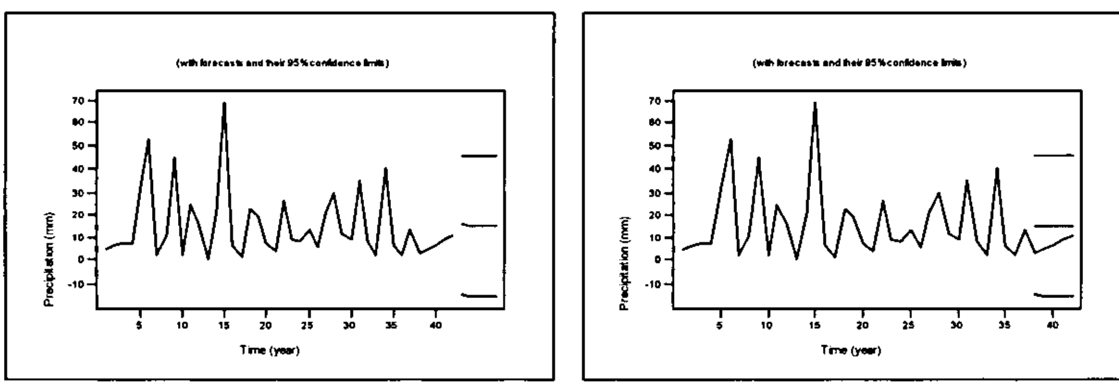
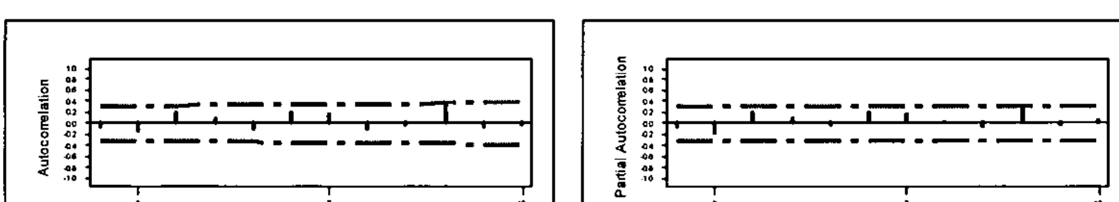


Figure (B.56): Time series, Forward and Backward Forecasting for 10% of the Observed Summation of (Jan. to Mar.) Precipitation for Aqaba Airport Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.08	-0.49	0.26	8	-0.11	-0.61	7.86
2	-0.16	-1.05	1.46	9	-0.04	-0.23	7.95
3	0.20	1.23	3.30	10	0.34	1.92	14.63
4	0.07	0.40	3.52	11	-0.08	-0.41	15.00
5	-0.12	-0.70	4.20	12	-0.05	-0.25	15.15
6	0.18	1.10	5.95				
7	0.16	0.90	7.23				

Lag	PAC	T	Lag	PAC	T
1	-0.08	-0.49	8	-0.02	-0.11
2	-0.17	-1.10	9	-0.08	-0.41
3	0.17	1.13	10	0.27	1.77
4	0.07	0.46	11	-0.03	-0.22
5	-0.05	-0.34	12	0.03	0.20
6	0.17	1.11			
7	0.14	0.92			

Figure (B.57): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Aqaba Airport Station

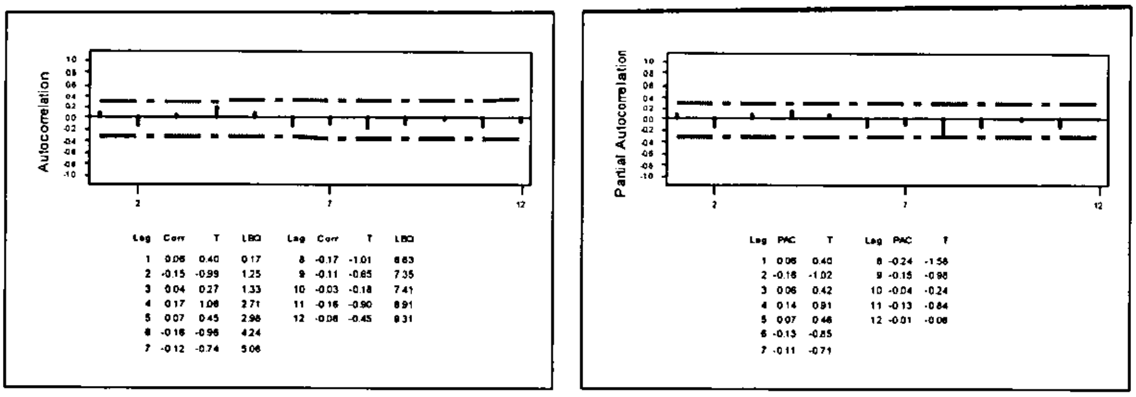


Figure (B.58): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Aqaba Airport Station

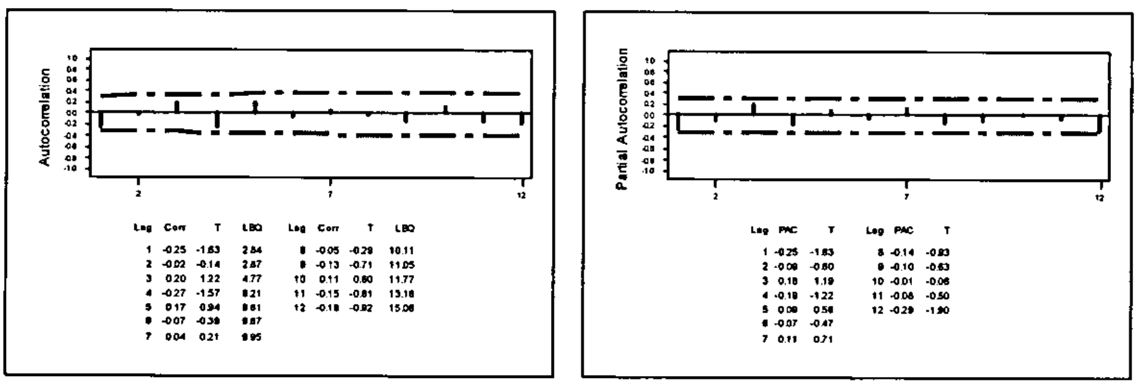


Figure (B.59): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Aqaba Airport Station

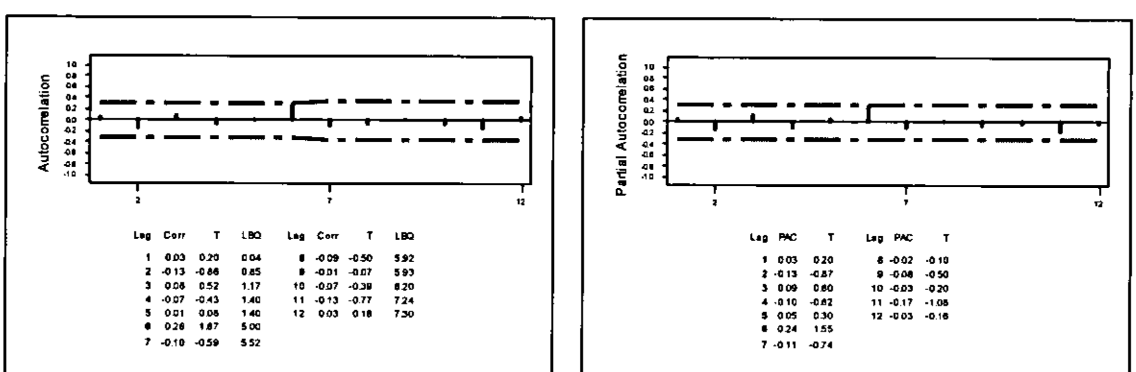
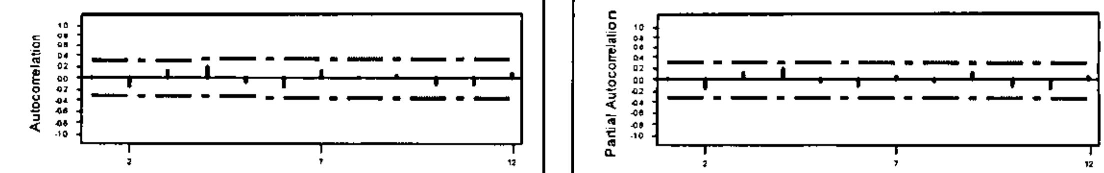


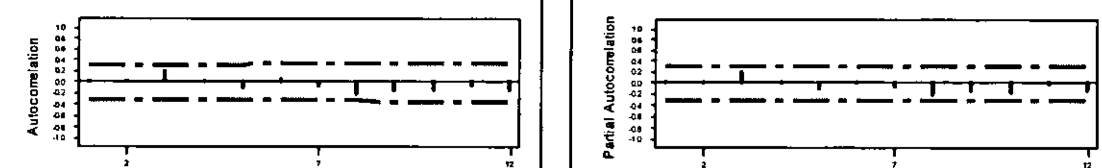
Figure (B.60): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Aqaba Airport Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.01	0.06	0.00	8	0.01	0.06	5.33
2	-0.15	-0.95	0.99	9	0.05	0.28	5.48
3	0.12	0.76	1.67	10	-0.12	-0.73	6.34
4	0.19	1.20	3.47	11	-0.11	-0.62	7.04
5	-0.08	-0.46	3.75	12	0.09	0.50	7.50
6	-0.14	-0.85	4.77				
7	0.10	0.60	5.32				

Lag	PAC	T	Lag	PAC	T
1	0.01	0.06	8	-0.04	-0.24
2	-0.15	-0.95	9	0.13	0.82
3	0.13	0.81	10	-0.12	-0.77
4	0.17	1.12	11	-0.14	-0.89
5	-0.05	-0.32	12	0.05	0.33
6	-0.11	-0.73			
7	0.05	0.32			

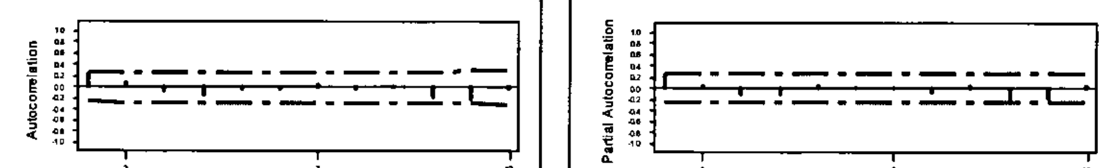
Figure (B.61): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Aqaba Airport Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.00	0.03	0.00	8	-0.23	-1.43	5.30
2	-0.00	-0.01	0.00	9	-0.13	-0.78	6.27
3	0.18	1.14	1.46	10	-0.18	-0.95	7.80
4	-0.00	-0.01	1.46	11	-0.08	-0.48	8.24
5	-0.10	-0.65	1.89	12	-0.15	-0.83	8.57
6	0.03	0.19	2.04				
7	-0.08	-0.52	2.41				

Lag	PAC	T	Lag	PAC	T
1	0.00	0.03	8	-0.20	-1.32
2	-0.00	-0.01	9	-0.15	-0.97
3	0.18	1.14	10	-0.17	-1.08
4	-0.00	-0.03	11	-0.03	-0.20
5	-0.11	-0.68	12	-0.15	-0.95
6	0.00	0.01			
7	-0.08	-0.55			

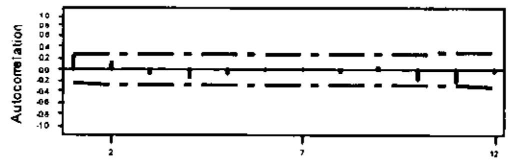
Figure (B.62): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Aqaba Airport Station



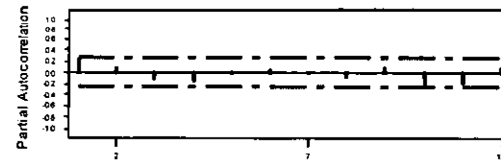
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.22	1.72	3.10	8	-0.05	-0.37	5.77
2	0.08	0.59	3.51	9	0.02	0.13	5.79
3	-0.08	-0.62	3.98	10	-0.18	-1.27	8.14
4	-0.15	-1.10	5.47	11	-0.23	-1.56	12.08
5	-0.03	-0.18	5.52	12	-0.05	-0.35	12.29
6	-0.02	-0.14	5.54				
7	0.02	0.16	5.58				

Lag	PAC	T	Lag	PAC	T
1	0.22	1.72	8	-0.08	-0.61
2	0.03	0.25	9	0.05	0.37
3	-0.11	-0.89	10	-0.20	-1.53
4	-0.12	-0.92	11	-0.18	-1.41
5	0.05	0.37	12	0.05	0.38
6	-0.01	-0.10			
7	0.00	0.02			

Figure (B.63): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Water Year for Azraq Station

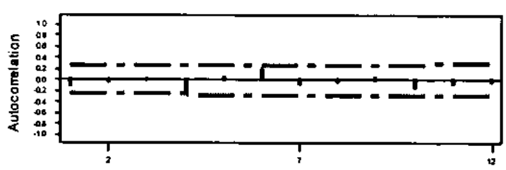


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.22	1.68	2.98	8	-0.05	-0.38	5.95
2	0.11	0.79	3.71	9	0.04	0.27	6.05
3	-0.06	-0.42	3.92	10	-0.18	-1.26	8.39
4	-0.15	-1.13	5.49	11	-0.23	-1.60	12.44
5	-0.06	-0.42	5.73	12	-0.05	-0.37	12.67
6	-0.01	-0.07	5.73				
7	0.01	0.06	5.74				

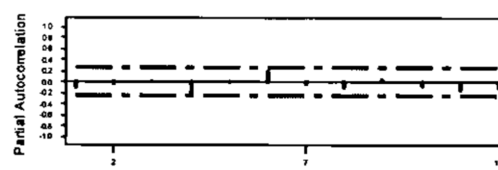


Lag	PAC	T	Lag	PAC	T
1	0.22	1.68	8	-0.09	-0.69
2	0.06	0.48	9	0.06	0.49
3	-0.10	-0.75	10	-0.19	-1.50
4	-0.14	-1.07	11	-0.20	-1.52
5	0.01	0.12	12	0.06	0.44
6	0.03	0.20			
7	-0.01	-0.06			

Figure (B.64): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Season from (Oct. to Mar.) for Azraq Station

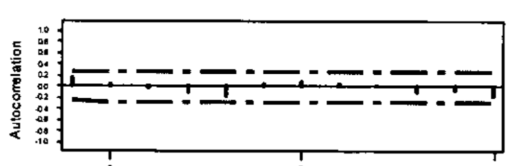


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.09	-0.71	0.53	8	-0.05	-0.36	6.55
2	-0.04	-0.33	0.85	9	0.03	0.23	6.62
3	0.01	0.09	0.86	10	-0.15	-1.05	8.27
4	-0.21	-1.64	3.69	11	-0.09	-0.60	8.83
5	0.04	0.29	3.79	12	-0.03	-0.18	8.89
6	0.18	1.32	6.01				
7	-0.07	-0.51	6.37				

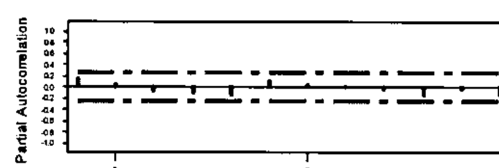


Lag	PAC	T	Lag	PAC	T
1	-0.09	-0.71	8	-0.10	-0.78
2	-0.05	-0.41	9	0.03	0.25
3	0.00	0.02	10	-0.08	-0.63
4	-0.22	-1.68	11	-0.16	-1.22
5	-0.00	-0.01	12	-0.12	-0.95
6	0.17	1.32			
7	-0.04	-0.32			

Figure (B.65): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Azraq Station

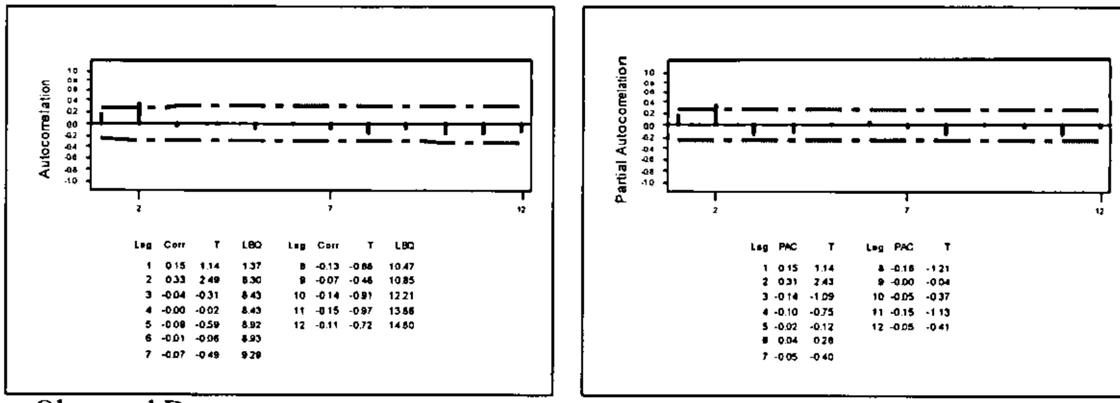


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.15	1.19	1.48	8	0.05	0.37	5.07
2	0.04	0.34	1.60	9	0.02	0.13	5.09
3	-0.05	-0.35	1.75	10	-0.12	-0.84	6.11
4	-0.11	-0.85	2.60	11	-0.09	-0.65	6.74
5	-0.17	-1.25	4.50	12	-0.19	-1.34	8.53
6	0.04	0.29	4.61				
7	0.06	0.45	4.88				

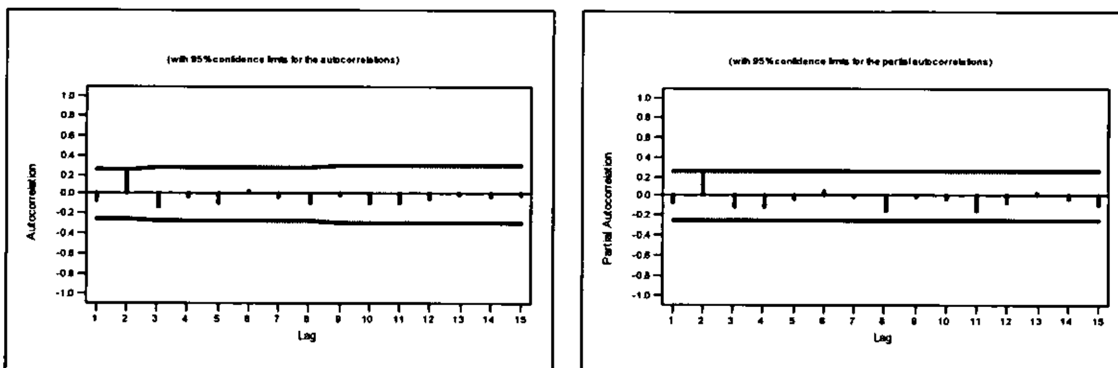


Lag	PAC	T	Lag	PAC	T
1	0.15	1.19	8	0.01	0.08
2	0.02	0.17	9	-0.02	-0.17
3	-0.06	-0.45	10	-0.14	-1.06
4	-0.10	-0.78	11	-0.03	-0.21
5	-0.14	-1.06	12	-0.15	-1.19
6	0.09	0.72			
7	0.05	0.39			

Figure (B.65): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Jan. to Mar.) for Azraq Station



a. Observed Data



b. Residual for Observed Data

Figure (B.66): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Azraq Station

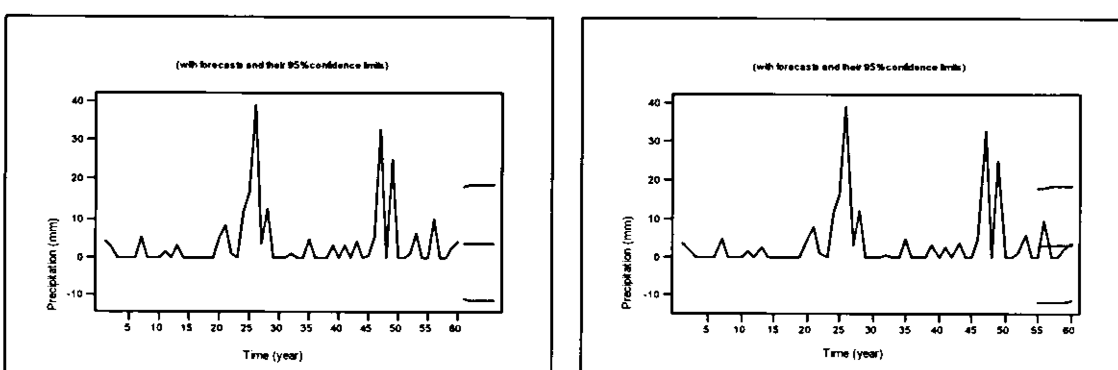
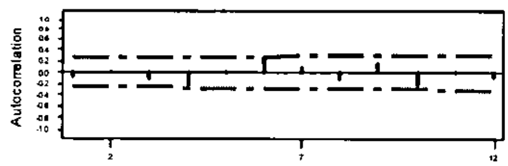
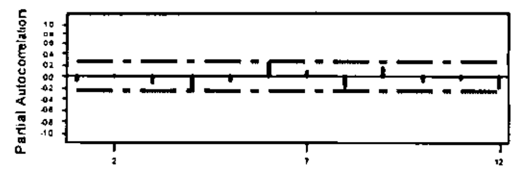


Figure (B.67): Time series, Forward and Backward Forecasting for 10% of Precipitation for (Oct.) for Azraq Station

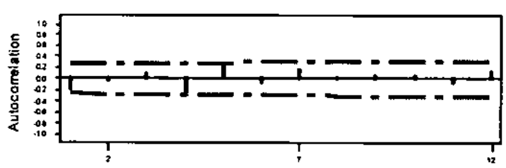


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.07	-0.53	0.30	8	-0.10	-0.72	8.89
2	-0.00	-0.01	0.30	9	0.13	0.91	10.15
3	-0.10	-0.81	1.01	10	-0.21	-1.41	13.35
4	-0.20	-1.55	3.77	11	-0.01	-0.08	13.36
5	-0.02	-0.13	3.79	12	-0.07	-0.46	13.73
6	0.24	1.77	7.78				
7	0.07	0.49	8.13				

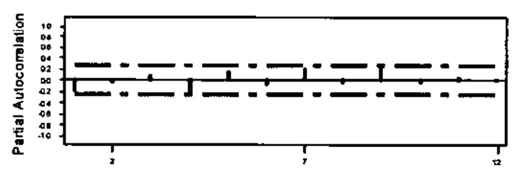


Lag	PAC	T	Lag	PAC	T
1	-0.07	-0.53	8	-0.17	-1.29
2	-0.01	-0.05	9	0.16	1.24
3	-0.11	-0.82	10	-0.07	-0.52
4	-0.22	-1.72	11	-0.04	-0.31
5	-0.06	-0.44	12	-0.17	-1.31
6	0.23	1.80			
7	0.08	0.59			

Figure (B.68): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Azraq Station

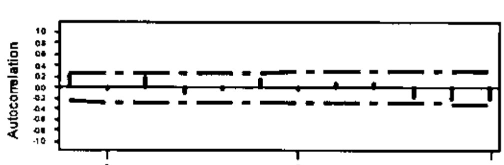


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.17	-1.28	1.75	8	0.00	0.01	11.02
2	-0.02	-0.18	1.78	9	0.05	0.32	11.18
3	0.08	0.57	2.17	10	0.04	0.24	11.27
4	-0.24	-1.83	6.12	11	-0.09	-0.60	11.87
5	0.21	1.52	9.18	12	0.11	0.76	12.89
6	-0.08	-0.58	9.68				
7	0.14	0.94	11.02				

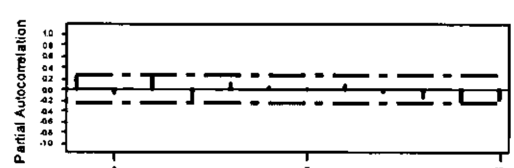


Lag	PAC	T	Lag	PAC	T
1	-0.17	-1.28	8	-0.05	-0.39
2	-0.05	-0.41	9	0.18	1.39
3	0.06	0.50	10	-0.04	-0.35
4	-0.23	-1.77	11	0.04	0.33
5	0.15	1.20	12	0.01	0.08
6	-0.06	-0.46			
7	0.18	1.40			

Figure (B.69): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Azraq Station

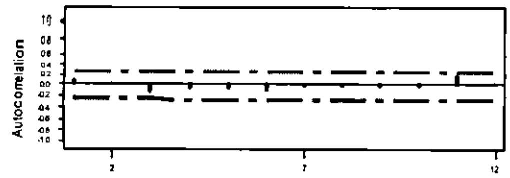


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.22	1.87	2.92	8	0.06	0.40	8.13
2	-0.03	-0.25	2.99	9	0.08	0.53	8.55
3	0.18	1.43	5.41	10	-0.19	-1.29	11.14
4	-0.12	-0.85	6.35	11	-0.24	-1.60	15.45
5	-0.04	-0.31	6.48	12	-0.21	-1.33	18.78
6	0.14	1.00	7.85				
7	-0.02	-0.17	7.89				

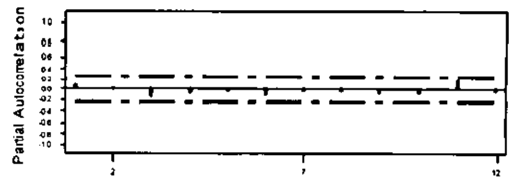


Lag	PAC	T	Lag	PAC	T
1	0.22	1.87	8	0.07	0.53
2	-0.08	-0.65	9	-0.02	-0.17
3	0.23	1.79	10	-0.18	-1.27
4	-0.25	-1.91	11	-0.20	-1.59
5	0.11	0.82	12	-0.17	-1.30
6	0.05	0.37			
7	0.00	0.01			

Figure (B.70): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Azraq Station

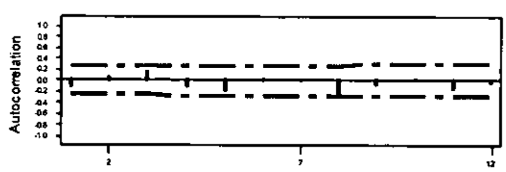


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.06	0.49	0.25	8	-0.03	-0.20	2.81
2	0.00	0.02	0.25	9	-0.05	-0.37	2.99
3	-0.13	-0.99	1.33	10	-0.03	-0.25	3.07
4	-0.07	-0.56	1.69	11	0.19	1.44	5.92
5	-0.06	-0.42	1.90	12	0.01	0.04	5.92
6	-0.10	-0.78	2.65				
7	-0.04	-0.30	2.76				

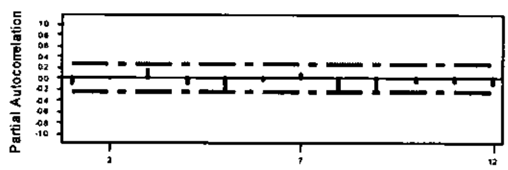


Lag	PAC	T	Lag	PAC	T
1	0.06	0.49	8	-0.04	-0.33
2	-0.00	-0.01	9	-0.09	-0.67
3	-0.13	-1.00	10	-0.06	-0.47
4	-0.06	-0.45	11	0.16	1.37
5	-0.05	-0.37	12	-0.05	-0.42
6	-0.12	-0.91			
7	-0.05	-0.36			

Figure (B.71): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Azraq Station

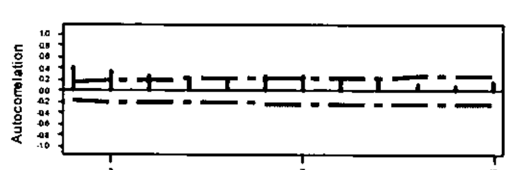


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.09	-0.71	0.53	8	-0.24	-1.74	9.55
2	0.02	0.18	0.57	9	-0.07	-0.48	9.91
3	0.15	1.18	2.12	10	-0.00	-0.01	9.91
4	-0.12	-0.92	3.12	11	-0.13	-0.91	11.25
5	-0.16	-1.34	5.34	12	-0.05	-0.36	11.47
6	0.01	0.05	5.34				
7	0.01	0.05	5.36				

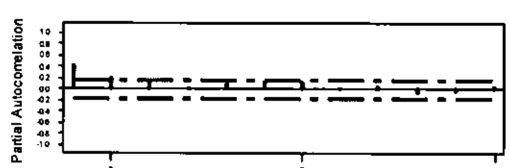


Lag	PAC	T	Lag	PAC	T
1	-0.09	-0.71	8	-0.20	-1.58
2	0.01	0.11	9	-0.18	-1.43
3	0.16	1.23	10	-0.06	-0.48
4	-0.10	-0.76	11	-0.07	-0.55
5	-0.22	-1.86	12	-0.12	-0.93
6	-0.05	-0.36			
7	0.06	0.48			

Figure (B.72): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Azraq Station



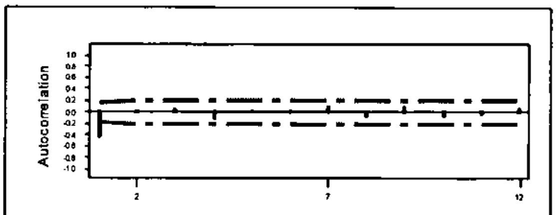
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.40	4.69	22.49	8	0.20	1.64	87.90
2	0.32	3.34	37.58	9	0.21	1.70	94.77
3	0.27	2.58	48.06	10	0.11	0.90	96.77
4	0.18	1.69	53.03	11	0.09	0.71	98.05
5	0.23	2.07	60.66	12	0.14	1.05	100.90
6	0.26	2.24	70.58				
7	0.27	2.31	81.81				



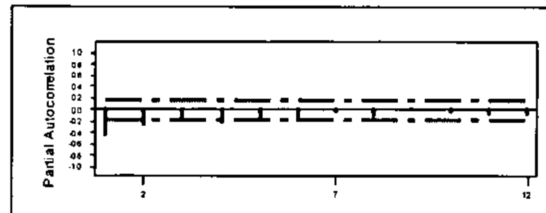
Lag	PAC	T	Lag	PAC	T
1	0.40	4.69	8	-0.01	-0.15
2	0.20	2.34	9	0.05	0.63
3	0.11	1.29	10	-0.07	-0.78
4	0.01	0.13	11	-0.03	-0.37
5	0.12	1.40	12	0.04	0.48
6	0.12	1.48			
7	0.11	1.36			

a. Extended Data

Figure (B.73): Continue

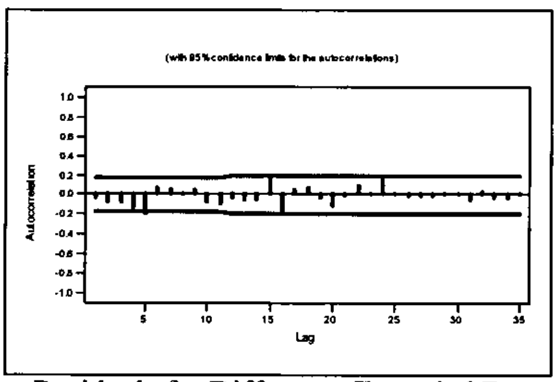


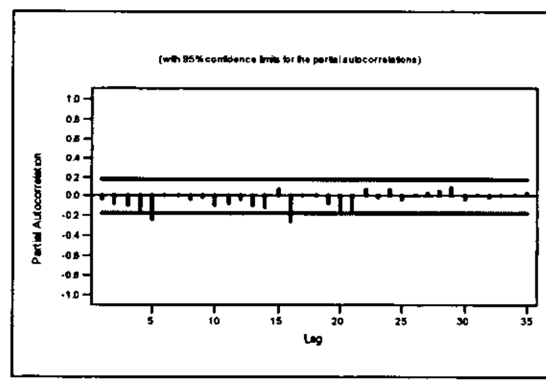
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.44	-5.25	28.14	8	-0.06	-0.78	31.86
2	-0.02	-0.15	28.17	9	0.09	0.85	32.98
3	0.02	0.22	28.24	10	-0.06	-0.55	33.46
4	-0.10	-0.98	29.85	11	-0.04	-0.42	33.74
5	0.01	0.09	29.86	12	0.03	0.26	33.86
6	0.00	0.01	29.66				
7	0.09	0.80	30.90				



Lag	PAC	T	Lag	PAC	T
1	-0.44	-5.25	8	-0.10	-1.16
2	-0.26	-3.12	9	0.01	0.14
3	-0.14	-1.64	10	-0.02	-0.25
4	-0.21	-2.45	11	-0.07	-0.79
5	-0.20	-2.34	12	-0.06	-0.72
6	-0.18	-2.16			
7	-0.03	-0.36			

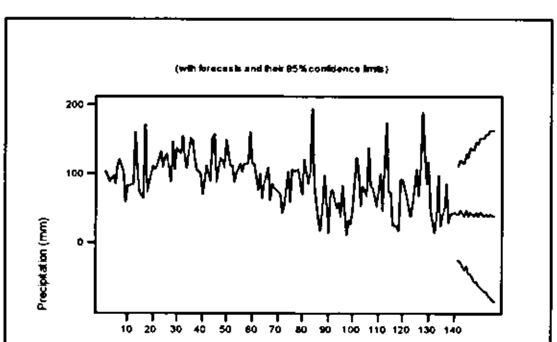
One. Difference Extended Data





c. Residuals for Difference Extended Data

Figure (B.73): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation in the Water Year for Azraq Station



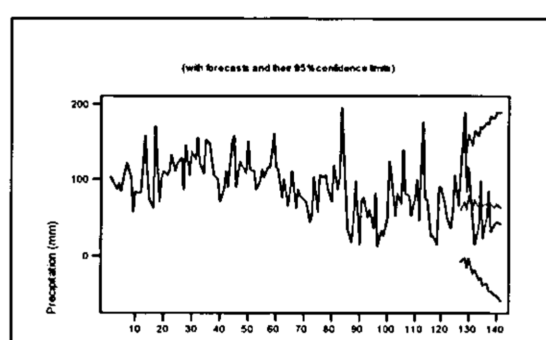
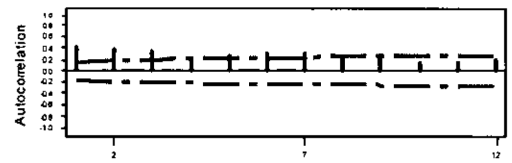
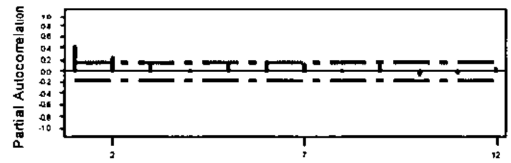


Figure (B.74): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation in the Water Year for Azraq Station



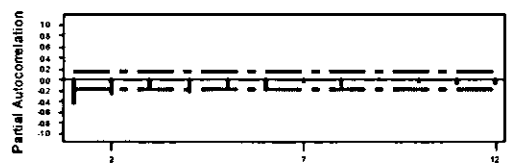
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.42	5.00	25.49	8	0.23	1.78	108.24
2	0.38	3.69	44.50	9	0.25	1.89	117.77
3	0.32	2.94	59.01	10	0.15	1.12	121.33
4	0.22	1.94	66.17	11	0.13	0.97	124.09
5	0.25	2.11	75.13	12	0.17	1.24	128.65
6	0.29	2.39	87.45				
7	0.29	2.34	100.32				



Lag	PAC	T	Lag	PAC	T
1	0.42	5.00	8	-0.01	-0.12
2	0.22	2.67	9	0.06	0.71
3	0.13	1.56	10	-0.06	-0.71
4	0.01	0.09	11	-0.02	-0.22
5	0.10	1.14	12	0.05	0.54
6	0.14	1.71			
7	0.11	1.32			

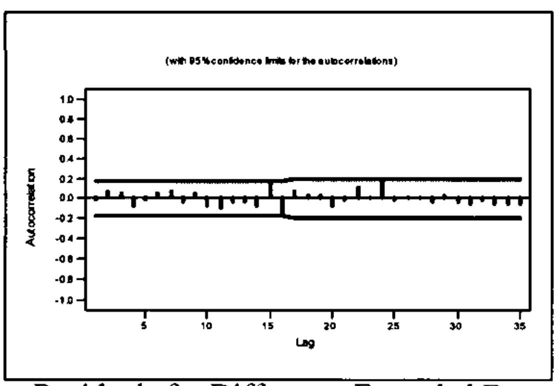
One. Extended Data

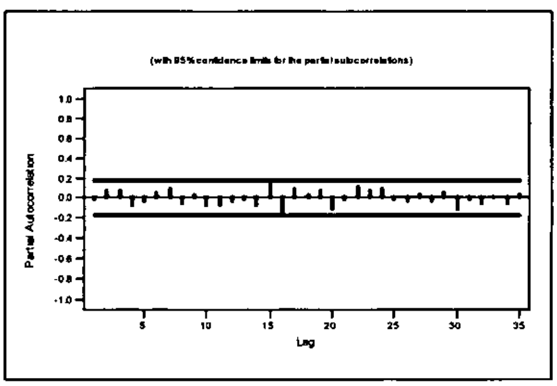
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.44	-5.25	28.14	8	-0.08	-0.79	31.86
2	-0.02	-0.15	28.17	9	0.09	0.85	32.98
3	0.02	0.22	28.24	10	-0.06	-0.55	33.46
4	-0.10	-0.98	29.65	11	-0.04	-0.42	33.74
5	0.01	0.09	29.66	12	0.03	0.26	33.86
6	0.00	0.01	29.66				
7	0.09	0.90	30.90				



Lag	PAC	T	Lag	PAC	T
1	-0.44	-5.25	8	-0.10	-1.16
2	-0.26	-3.12	9	0.01	0.14
3	-0.14	-1.64	10	-0.02	-0.25
4	-0.21	-2.45	11	-0.07	-0.79
5	-0.20	-2.34	12	-0.06	-0.72
6	-0.18	-2.18			
7	-0.03	-0.36			

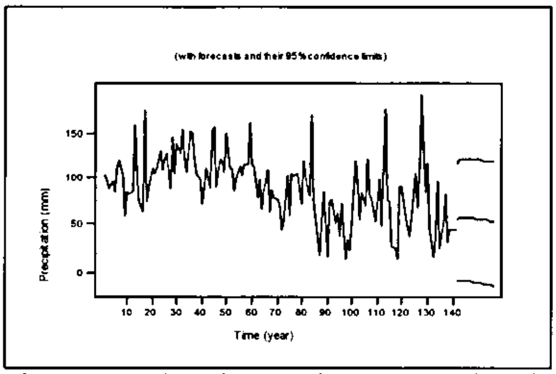
b. Difference Data





c. Residuals for Difference Extended Data

Figure (B.75): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation in the Season form (Oct. to Mar.) for Azraq Station



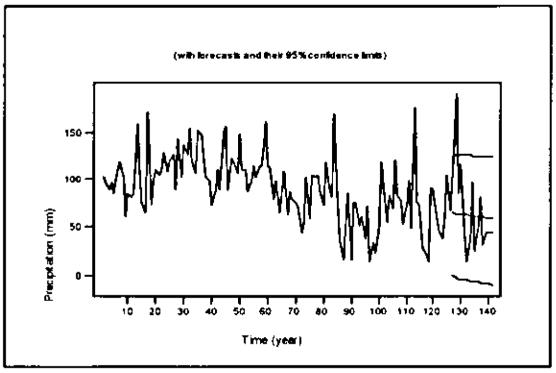
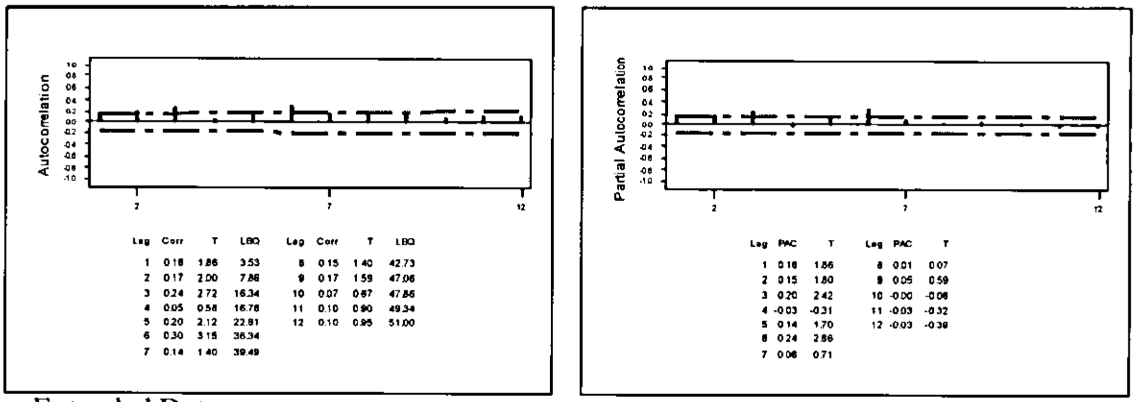
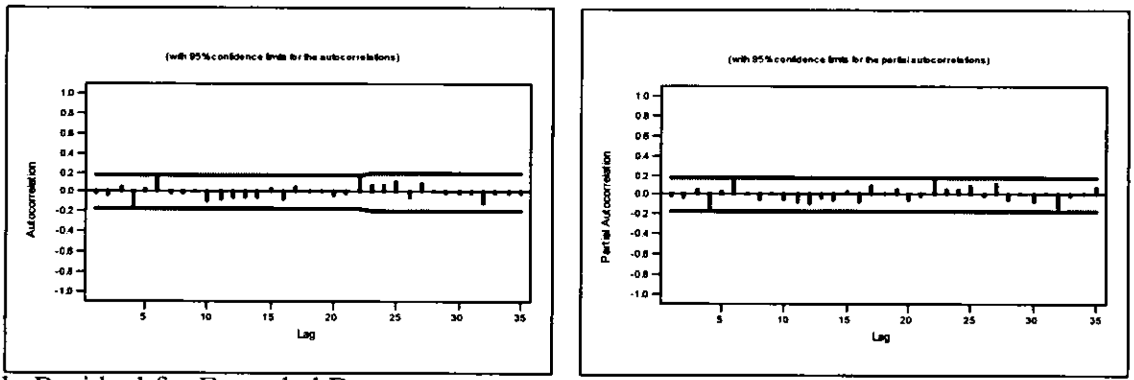


Figure (B.76): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation in the Season form (Oct. to Mar.) for Azraq Station



a. Extended Data



b. Residual for Extended Data

Figure (B.77): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Oct. to Dec.) for Azraq Station

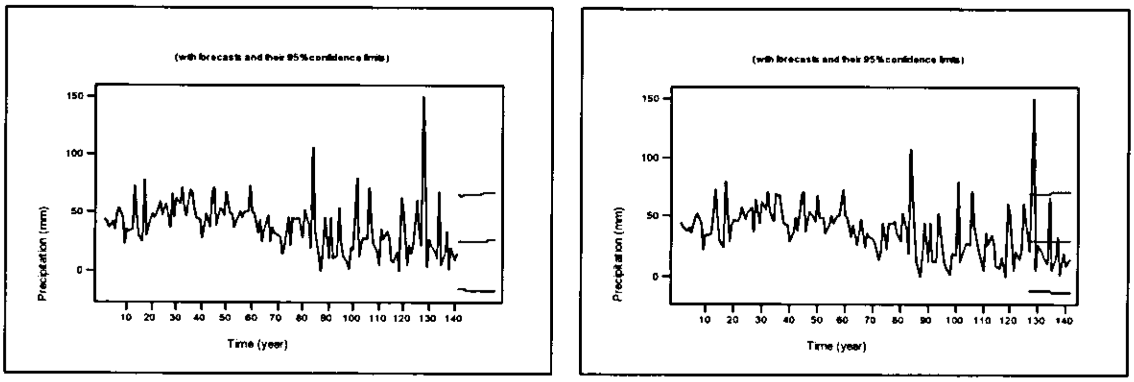
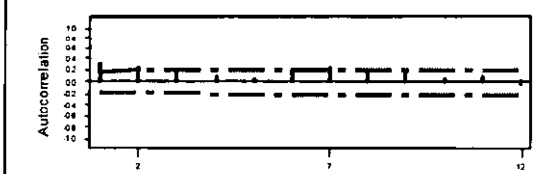
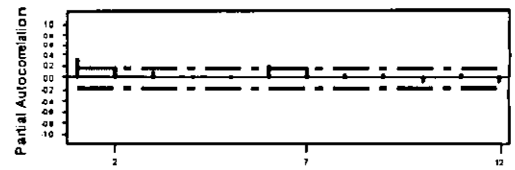


Figure (B.78): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Oct. to Dec.) for Azraq Station

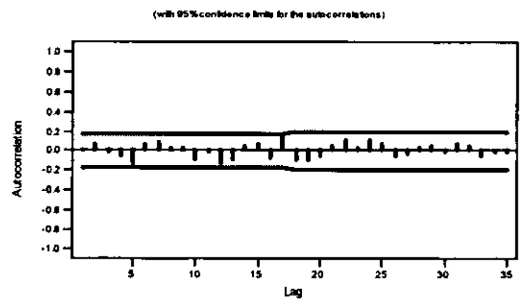


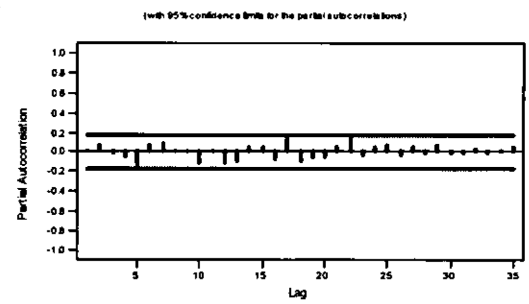
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.29	3.39	11.72	8	0.18	1.56	38.67
2	0.21	2.33	18.23	9	0.14	1.35	41.67
3	0.15	1.60	21.55	10	0.03	0.28	41.82
4	0.08	0.88	22.61	11	0.08	0.59	42.43
5	0.04	0.42	22.88	12	-0.02	-0.20	42.50
6	0.19	1.95	26.13				
7	0.21	2.11	34.73				



Lag	PAC	T	Lag	PAC	T
1	0.29	3.39	8	0.04	0.45
2	0.14	1.68	9	0.02	0.24
3	0.06	0.77	10	-0.08	-0.94
4	0.00	0.05	11	0.04	0.51
5	-0.01	-0.18	12	-0.07	-0.88
6	0.18	2.12			
7	0.14	1.62			

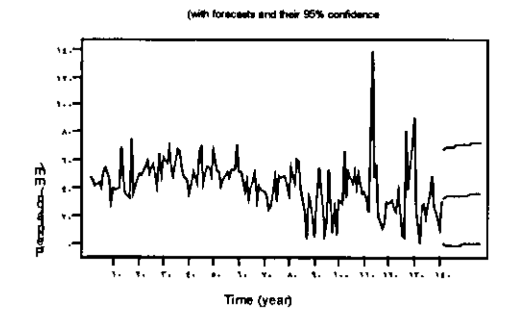
a. Extended Data





b. Residual for Extended Data

Figure (B.79): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Jan. to Mar.) for Azraq Station



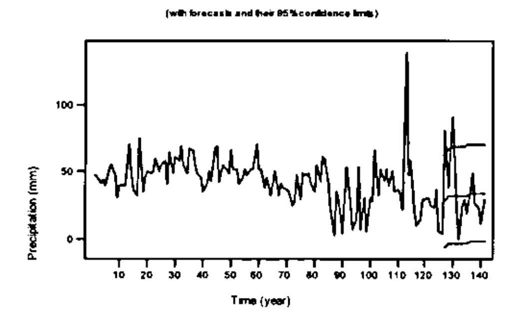
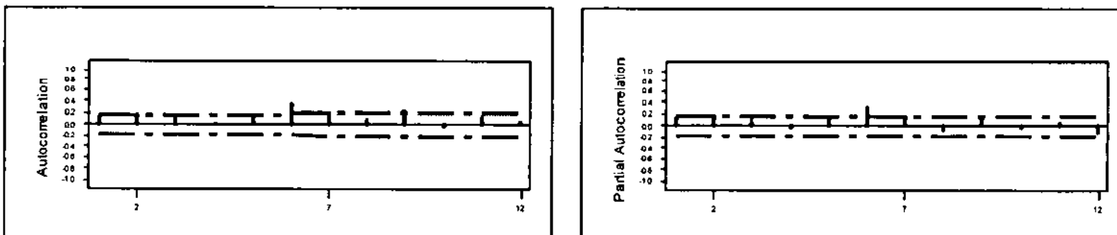


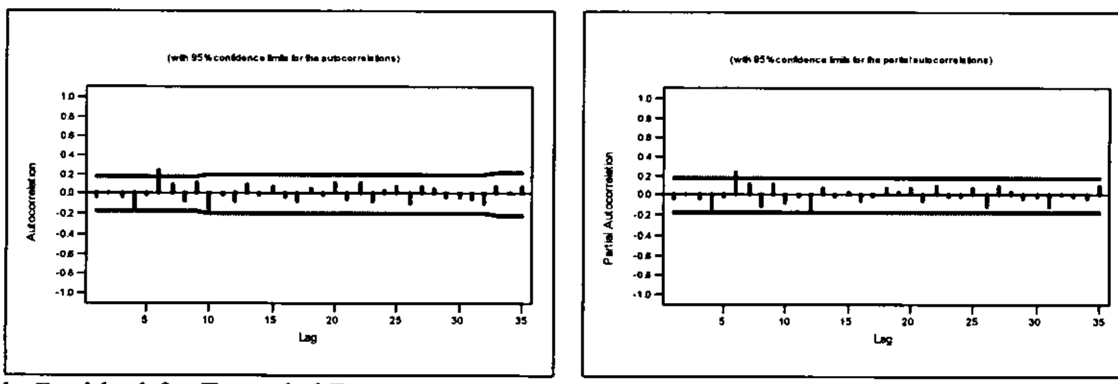
Figure (B.80): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Jan. to Mar.) for Azraq Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.11	1.33	1.81	8	0.06	0.58	29.52
2	0.15	1.72	4.84	9	0.21	2.13	34.39
3	0.10	1.19	6.51	10	-0.03	-0.27	38.50
4	-0.00	-0.03	6.51	11	0.10	0.99	38.11
5	0.12	1.37	8.67	12	0.04	0.34	38.31
6	0.31	3.53	23.46				
7	0.19	1.89	29.00				

Lag	PAC	T	Lag	PAC	T
1	0.11	1.33	8	-0.07	-0.83
2	0.14	1.62	9	0.15	1.83
3	0.08	0.91	10	-0.05	-0.56
4	-0.04	-0.48	11	0.03	0.34
5	0.10	1.23	12	-0.12	-1.40
6	0.31	3.65			
7	0.14	1.64			

a. Extended Data



b. Residual for Extended Data

Figure (B.81): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Nov.) for Azraq Station

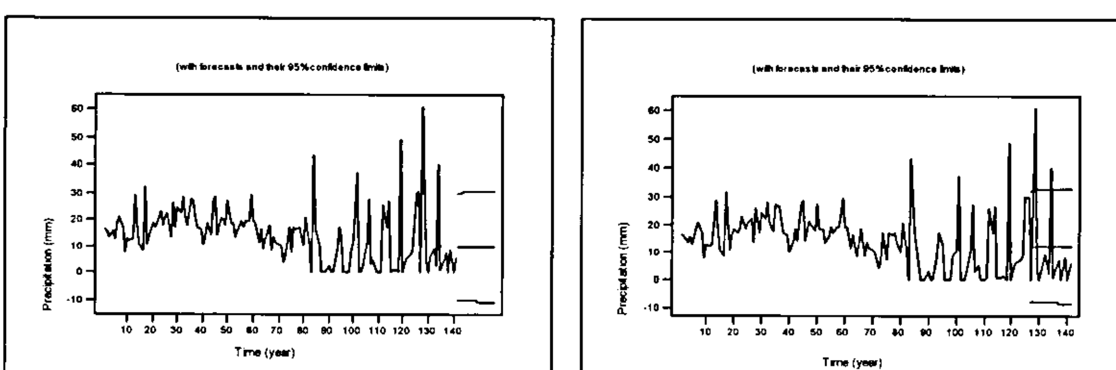
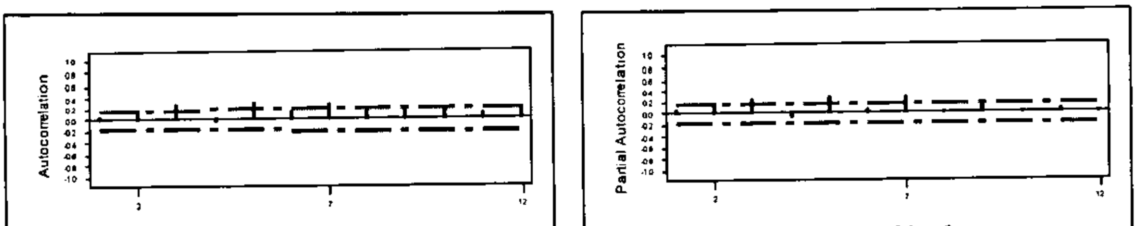


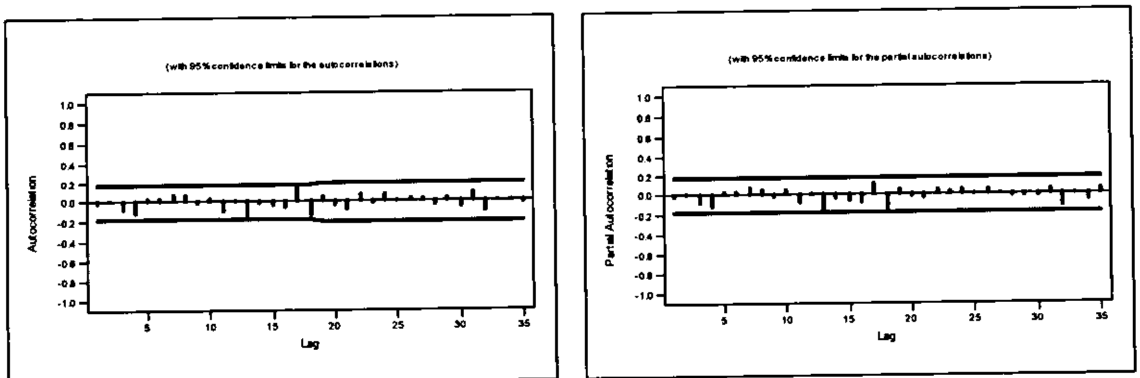
Figure (B.82): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Nov.) for Azraq Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.04	0.52	0.27	8	0.15	1.47	37.48
2	0.14	1.61	2.94	9	0.14	1.36	40.51
3	0.24	2.78	11.27	10	0.16	1.57	44.65
4	-0.03	-0.34	11.41	11	0.08	0.52	45.12
5	0.29	3.16	23.58	12	0.17	1.62	49.79
6	0.09	0.96	24.86				
7	0.25	2.54	34.08				

Lag	PAC	T	Lag	PAC	T
1	0.04	0.52	8	0.01	0.16
2	0.13	1.59	9	0.14	1.65
3	0.23	2.76	10	-0.01	-0.07
4	-0.06	-0.76	11	0.03	0.35
5	0.25	2.91	12	0.01	0.10
6	0.04	0.49			
7	0.24	2.89			

a. Extended Data



b. Residual for Extended Data

Figure (B.83): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Dec.) for Azraq Station

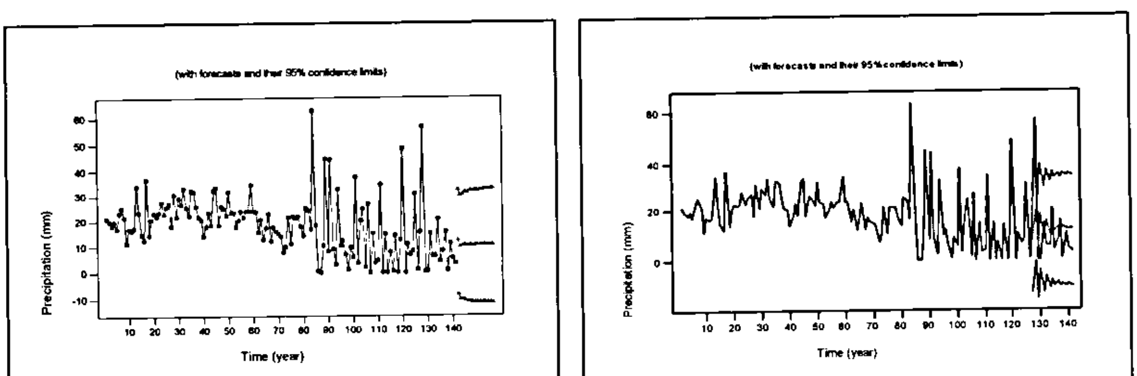
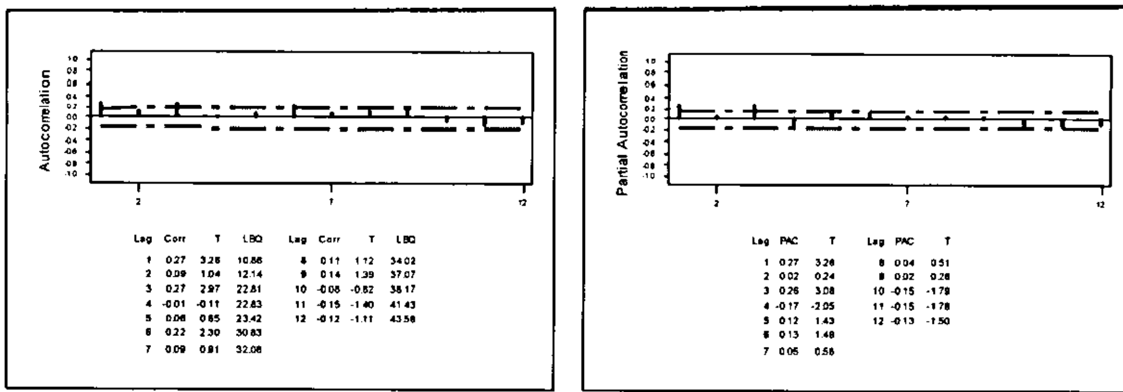


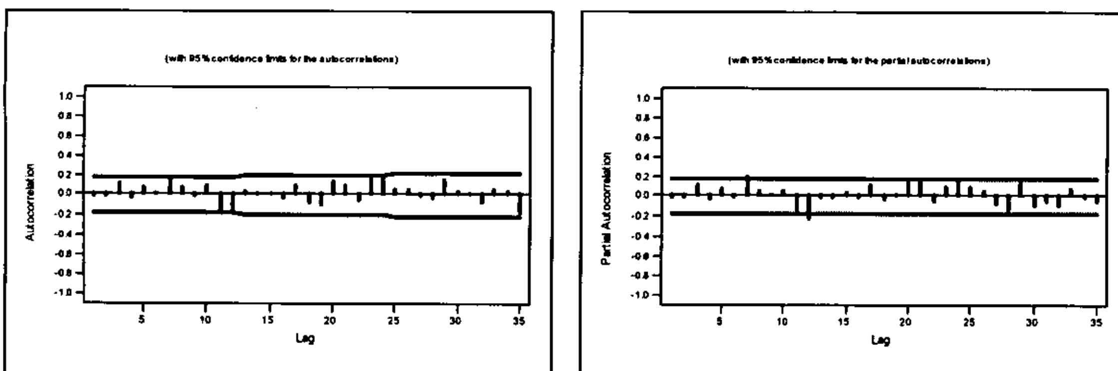
Figure (B.84): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Dec.) for Azraq Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.27	3.26	10.86	8	0.11	1.12	34.02
2	0.09	1.04	12.14	9	0.14	1.39	37.07
3	0.27	2.97	22.81	10	-0.08	-0.82	38.17
4	-0.01	-0.11	22.83	11	-0.15	-1.40	41.43
5	0.06	0.65	23.42	12	-0.12	-1.11	43.58
6	0.22	2.30	30.83				
7	0.09	0.81	32.08				

Lag	PAC	T	Lag	PAC	T
1	0.27	3.26	8	0.04	0.51
2	0.02	0.24	9	0.02	0.26
3	0.26	3.08	10	-0.15	-1.79
4	-0.17	-2.05	11	-0.15	-1.78
5	0.12	1.43	12	-0.13	-1.50
6	0.13	1.48			
7	0.05	0.56			

a. Extended Data



b. Residual for Extended Data

Figure (B.85): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Jan.) for Azraq Station

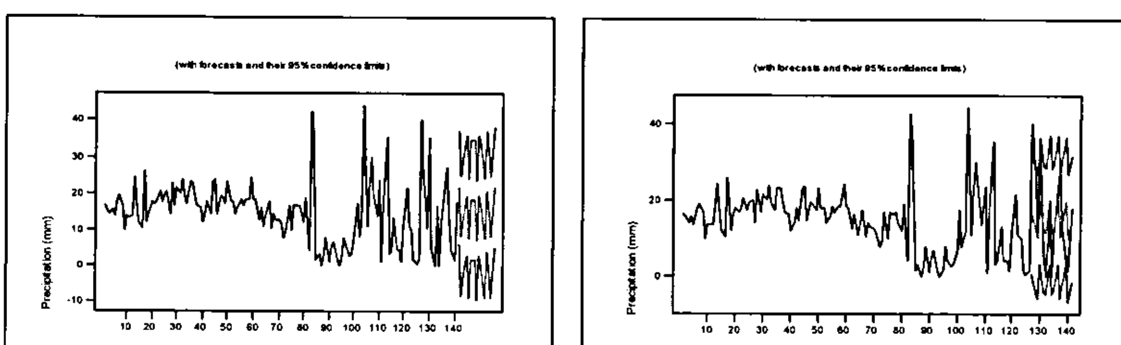
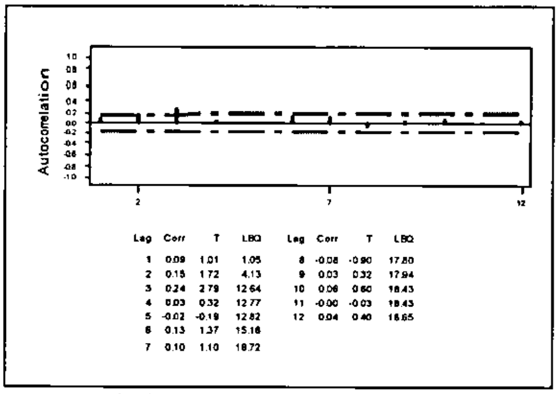
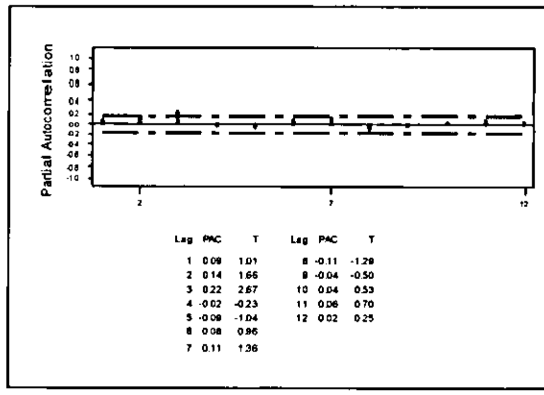
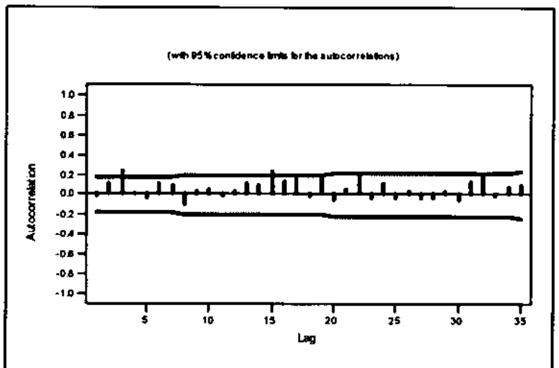


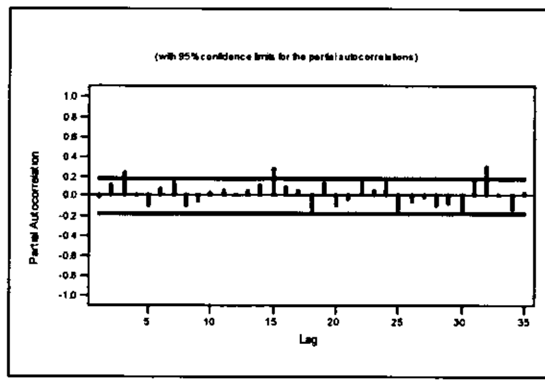
Figure (B.86): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Jan.) for Azraq Station





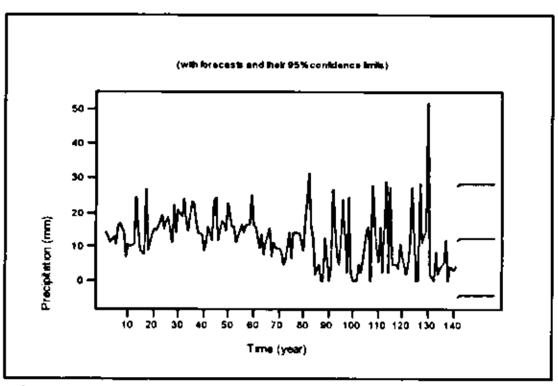
a. Extended Data





b. Residual for Extended Data

Figure (B.89): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Mar.) for Azraq Station



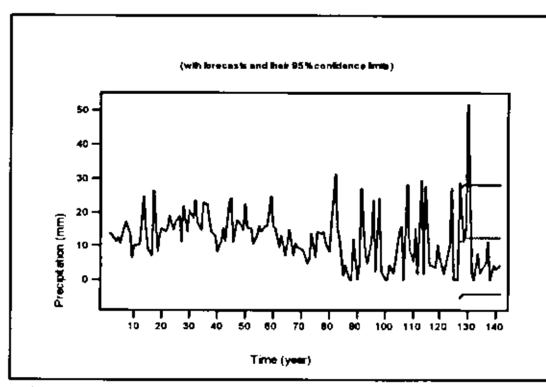


Figure (B.90): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Mar.) for Azraq Station

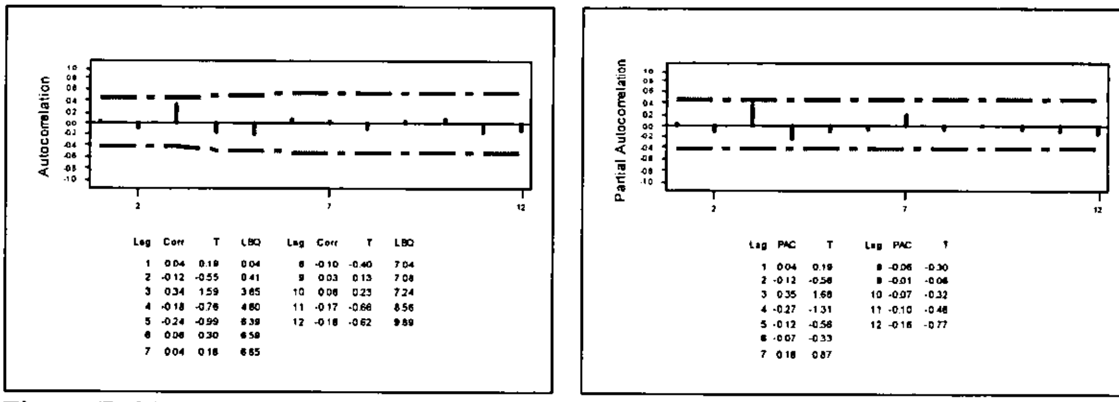


Figure (B.91): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Water Year for Jafar Station

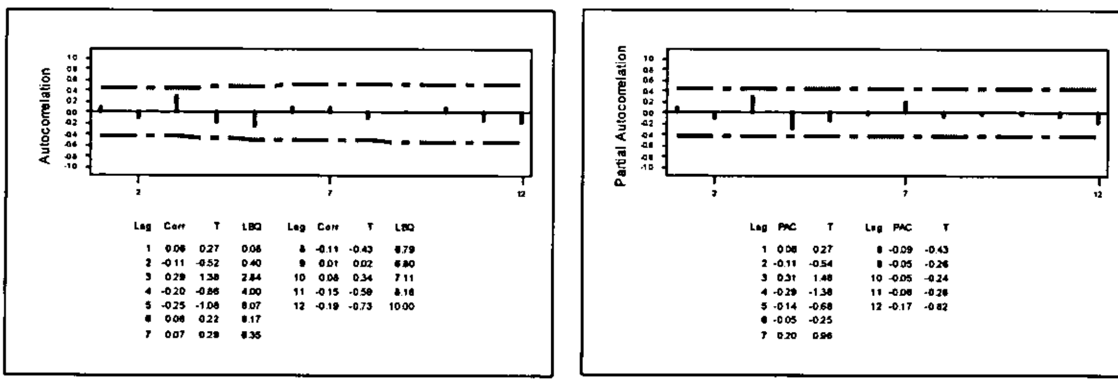


Figure (B.92): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Season from (Oct. to Mar.) for Jafar Station

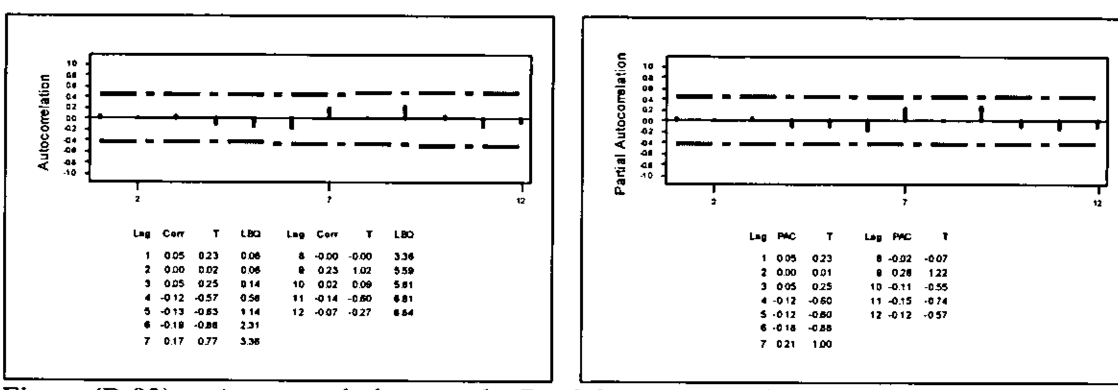
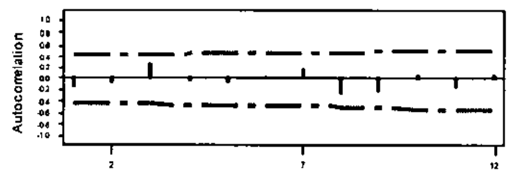
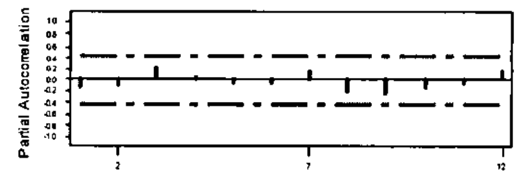


Figure (B.93): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Jafar Station

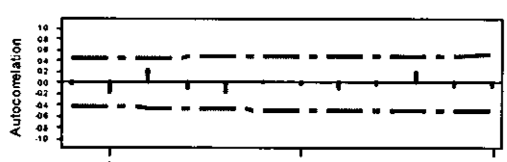


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.14	-0.66	0.49	8	-0.27	-1.17	6.45
2	-0.08	-0.36	0.65	9	-0.21	-0.85	8.24
3	0.24	1.15	2.38	10	0.05	0.18	8.33
4	-0.03	-0.15	2.41	11	-0.14	-0.56	9.29
5	-0.08	-0.37	2.64	12	0.03	0.13	9.35
6	-0.01	-0.03	2.64				
7	0.16	0.73	3.62				

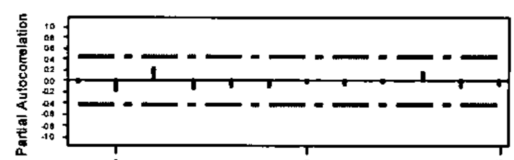


Lag	PAC	T	Lag	PAC	T
1	-0.14	-0.66	8	-0.23	-1.06
2	-0.10	-0.47	9	-0.27	-1.30
3	0.23	1.09	10	-0.14	-0.69
4	0.03	0.12	11	-0.07	-0.33
5	-0.06	-0.27	12	0.14	0.66
6	-0.09	-0.43			
7	0.16	0.76			

Figure (B.94): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Jan. to Mar.) for Jafar Station

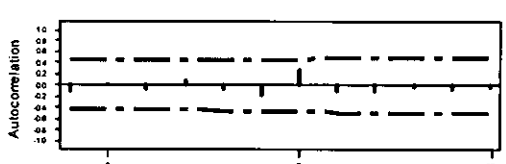


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.05	-0.22	0.05	8	-0.10	-0.42	4.21
2	-0.17	-0.84	0.89	9	-0.02	-0.09	4.23
3	0.23	1.06	2.45	10	0.19	0.81	5.86
4	-0.12	-0.52	2.87	11	-0.08	-0.34	8.19
5	-0.17	-0.73	3.76	12	-0.09	-0.36	8.58
6	-0.01	-0.04	3.77				
7	-0.05	-0.20	3.84				



Lag	PAC	T	Lag	PAC	T
1	-0.05	-0.22	8	-0.09	-0.44
2	-0.18	-0.85	9	-0.05	-0.26
3	0.22	1.07	10	0.16	0.79
4	-0.15	-0.70	11	-0.10	-0.48
5	-0.10	-0.48	12	-0.06	-0.28
6	-0.12	-0.57			
7	-0.04	-0.18			

Figure (B.95): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Jafar Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.13	-0.61	0.42	8	-0.10	-0.42	4.61
2	-0.01	-0.05	0.43	9	-0.09	-0.40	4.97
3	-0.06	-0.26	0.52	10	-0.04	-0.18	5.05
4	0.09	0.40	0.74	11	-0.07	-0.30	5.30
5	-0.07	-0.31	0.88	12	-0.05	-0.22	5.45
6	-0.17	-0.80	1.88				
7	0.28	1.16	4.25				

Lag	PAC	T	Lag	PAC	T
1	-0.13	-0.61	8	-0.07	-0.34
2	-0.03	-0.13	9	-0.13	-0.63
3	-0.06	-0.29	10	-0.01	-0.03
4	0.07	0.35	11	-0.17	-0.83
5	-0.05	-0.24	12	-0.09	-0.42
6	-0.19	-0.92			
7	0.23	1.10			

Figure (B.96): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Jafar Station

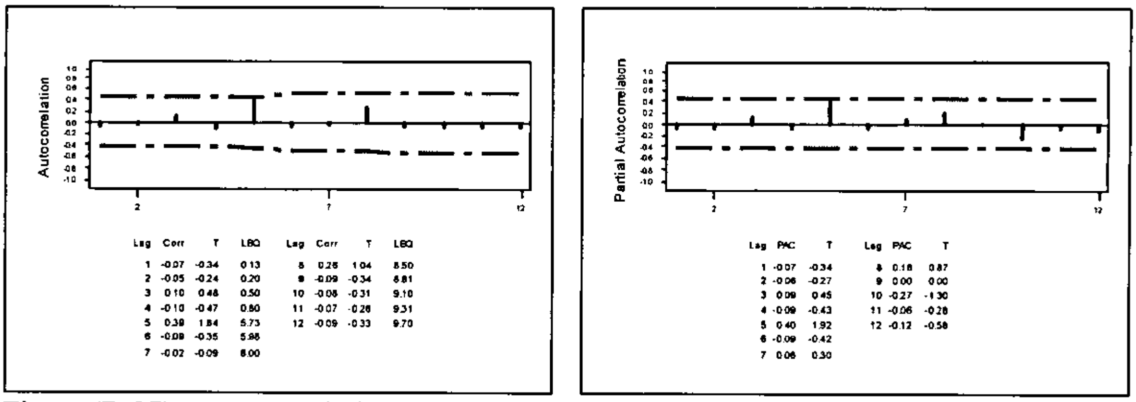


Figure (B.97): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Jafar Station

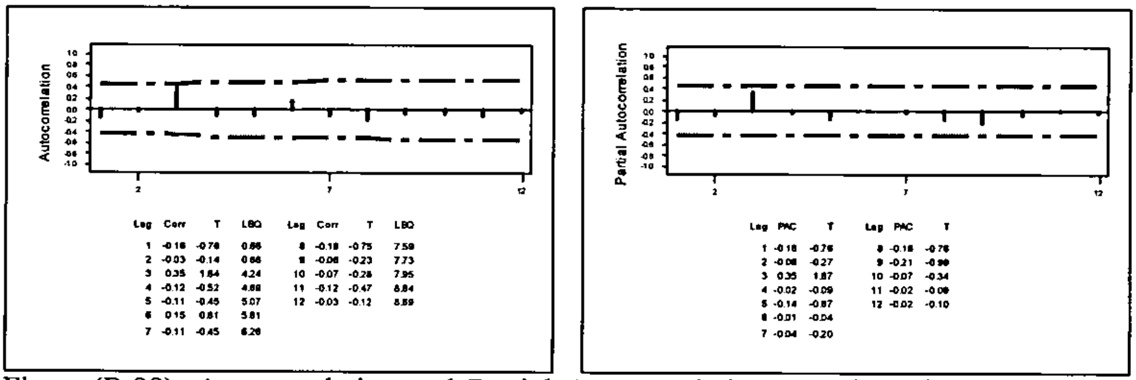


Figure (B.98): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Jafar Station

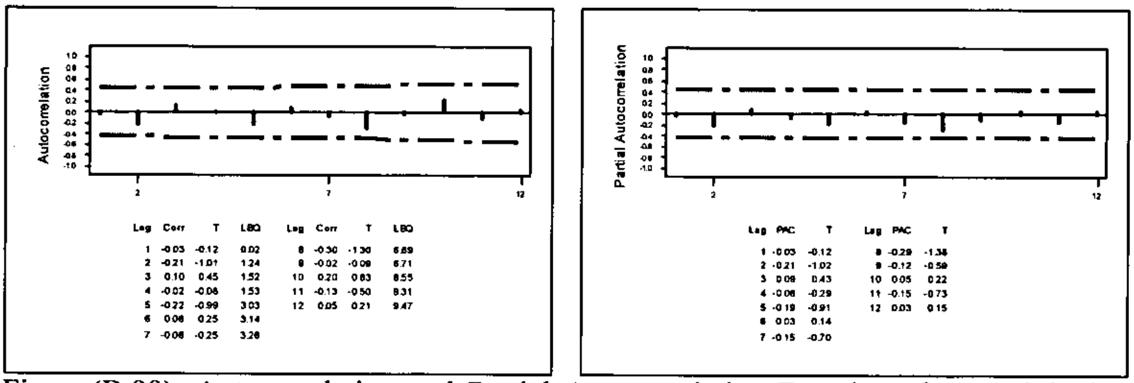


Figure (B.99): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Jafar Station

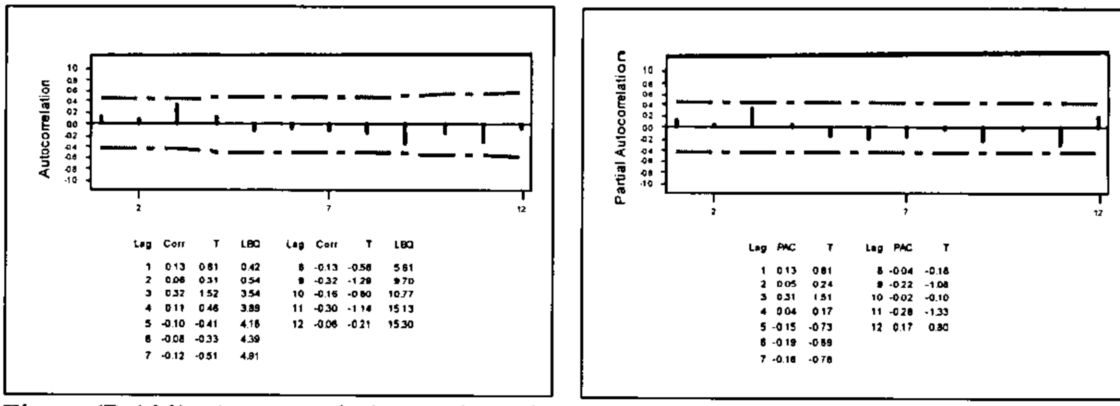
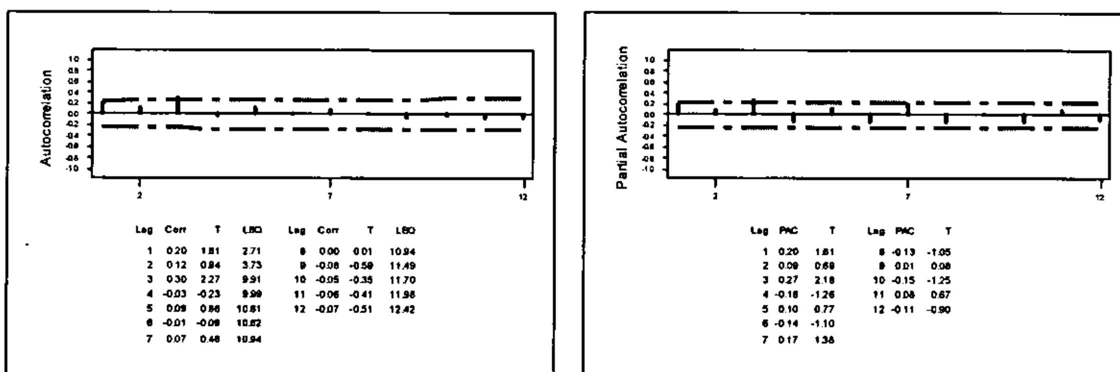
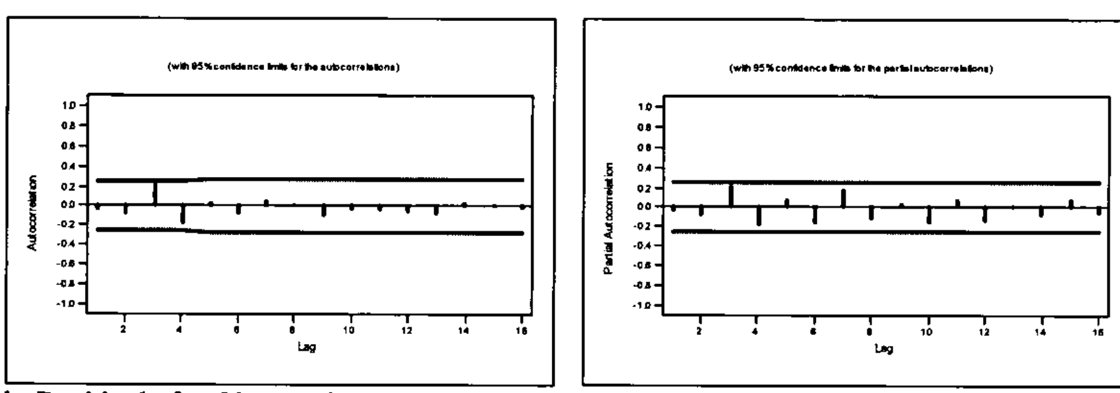


Figure (B.100): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Jafar Station

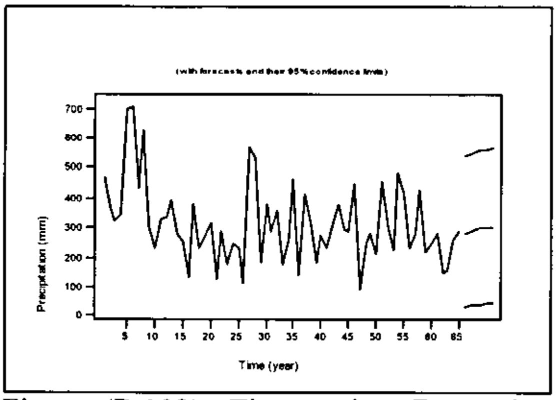


a. Observed Data



b. Residuals for Observed Data

Figure (B.101): Autocorrelation and Partial Autocorrelation Functions for the Observed Precipitation in the Water Year for Shoubak Station



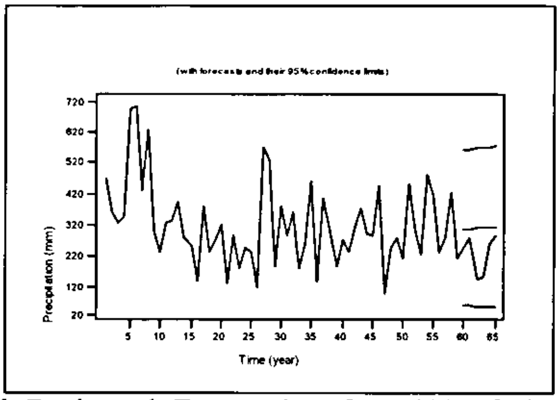
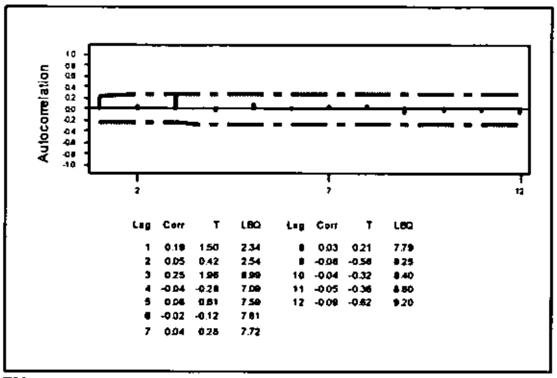


Figure (B.102): Time series, Forward and Backward Forecasting for 10% of the Observed Precipitation in the Water Year for Shoubak Station



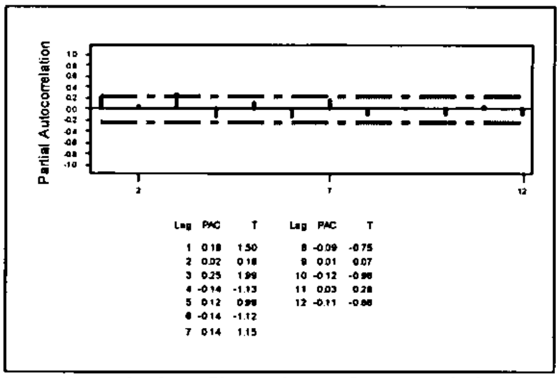
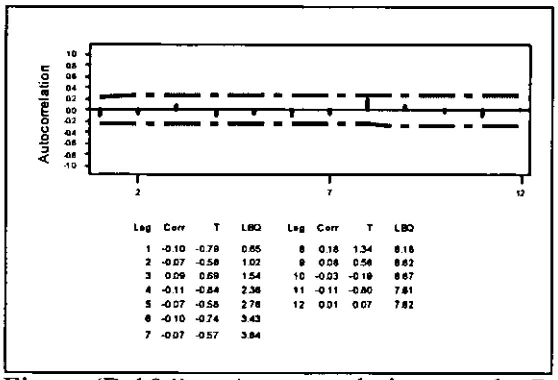


Figure (B.103): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Season from (Oct. to Mar.) for Shoubak Station



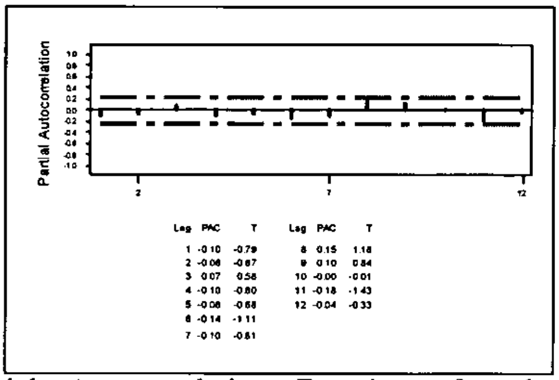
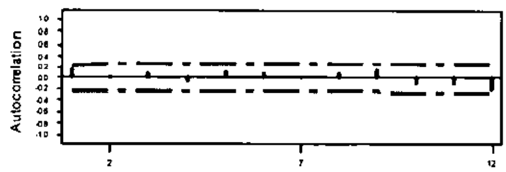
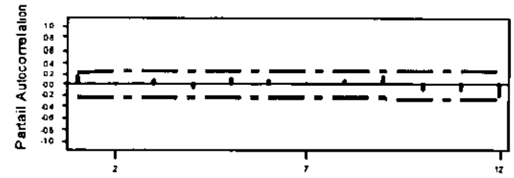


Figure (B.104): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Shoubak Station

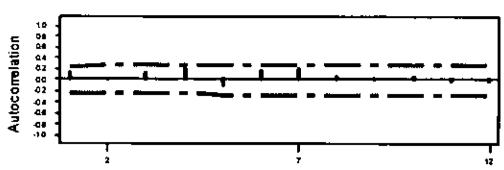


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.18	1.33	1.84	8	0.08	0.65	3.97
2	0.01	0.07	1.85	9	0.16	1.24	6.00
3	0.08	0.62	2.29	10	-0.11	-0.81	6.92
4	-0.06	-0.47	2.54	11	-0.13	-0.93	8.20
5	0.09	0.73	3.18	12	-0.21	-1.55	11.82
6	0.06	0.44	3.42				
7	-0.01	-0.09	3.43				

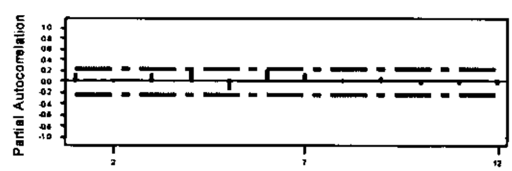


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.18	1.33	1.84	8	0.08	0.65	3.97
2	0.01	0.07	1.85	9	0.16	1.24	6.00
3	0.08	0.62	2.29	10	-0.11	-0.81	6.92
4	-0.06	-0.47	2.54	11	-0.13	-0.93	8.20
5	0.09	0.73	3.18	12	-0.21	-1.55	11.92
6	0.06	0.44	3.42				
7	-0.01	-0.09	3.43				

Figure (B.105): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Jan. to Mar.) for Shoubak Station

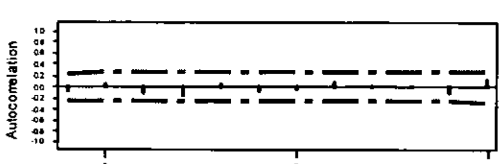


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.12	0.93	0.90	8	0.05	0.38	9.44
2	-0.00	-0.03	0.90	9	-0.00	-0.01	9.44
3	0.12	0.95	1.81	10	0.05	0.34	9.83
4	0.19	1.51	4.56	11	-0.02	-0.17	9.87
5	-0.11	-0.81	5.34	12	-0.04	-0.28	9.80
6	0.13	1.00	6.69				
7	0.18	1.36	9.22				

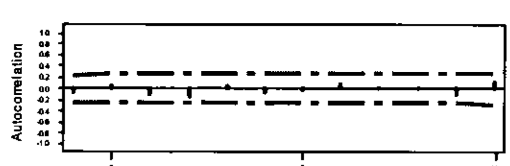


Lag	PAC	T	Lag	PAC	T
1	0.12	0.93	8	0.01	0.12
2	-0.02	-0.13	9	0.02	0.17
3	0.12	1.00	10	-0.05	-0.44
4	0.17	1.38	11	-0.05	-0.39
5	-0.15	-1.21	12	-0.02	-0.20
6	0.17	1.35			
7	0.11	0.81			

Figure (B.106): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Shoubak Station

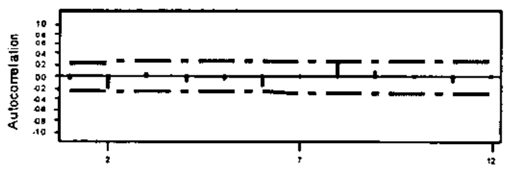


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.07	-0.59	0.38	8	0.06	0.47	3.57
2	0.04	0.35	0.48	9	-0.02	-0.13	3.59
3	-0.09	-0.74	1.09	10	-0.00	-0.03	3.59
4	-0.14	-1.12	2.53	11	-0.12	-0.93	4.76
5	0.05	0.39	2.71	12	0.11	0.86	5.83
6	-0.08	-0.58	3.13				
7	-0.05	-0.35	3.28				

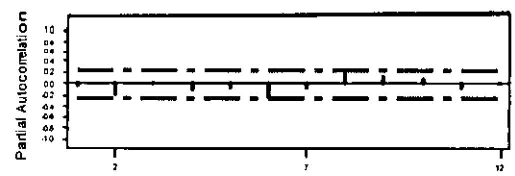


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.07	-0.59	0.38	8	0.06	0.47	3.57
2	0.04	0.35	0.49	9	-0.02	-0.13	3.59
3	-0.09	-0.74	1.09	10	-0.00	-0.03	3.59
4	-0.14	-1.12	2.53	11	-0.12	-0.93	4.76
5	0.05	0.39	2.71	12	0.11	0.86	5.83
6	-0.08	-0.58	3.13				
7	-0.05	-0.35	3.28				

Figure (B.107): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Shoubak Station

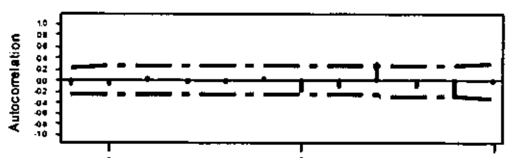


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.04	-0.35	0.13	8	0.26	1.93	10.16
2	-0.19	-1.51	2.56	9	0.09	0.63	10.76
3	0.02	0.15	2.59	10	0.01	0.04	10.78
4	-0.08	-0.63	3.06	11	-0.08	-0.60	11.34
5	-0.05	-0.41	3.26	12	-0.02	-0.12	11.37
6	-0.16	-1.23	5.13				
7	-0.01	-0.10	5.14				

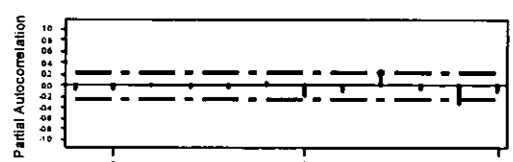


Lag	PAC	T	Lag	PAC	T
1	-0.04	-0.35	8	0.18	1.42
2	-0.19	-1.53	9	0.10	0.63
3	0.00	0.01	10	0.08	0.61
4	-0.12	-0.97	11	-0.08	-0.65
5	-0.06	-0.51	12	-0.00	-0.02
6	-0.22	-1.75			
7	-0.07	-0.54			

Figure (B.108): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Shoubak Station

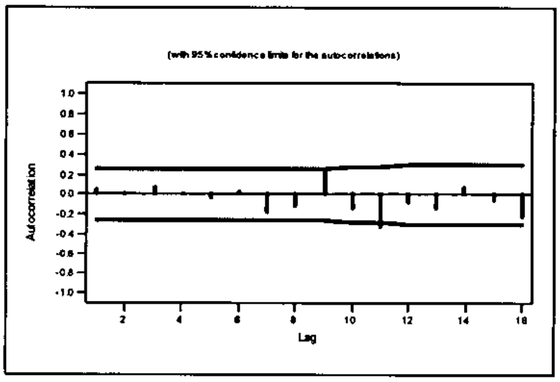


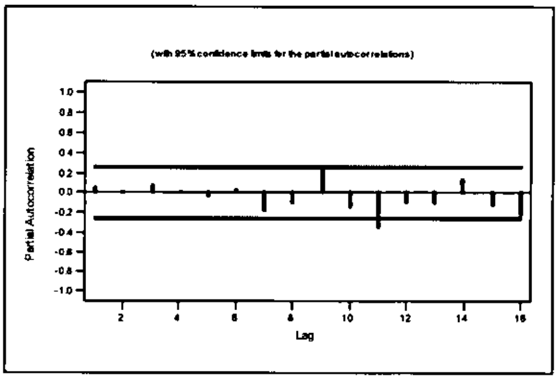
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.06	-0.52	0.28	8	-0.09	-0.71	3.92
2	-0.07	-0.57	0.63	9	0.29	2.23	10.49
3	0.02	0.19	0.67	10	-0.10	-0.69	11.23
4	-0.02	-0.20	0.71	11	-0.30	-2.09	18.27
5	-0.04	-0.31	0.82	12	-0.03	-0.23	18.37
6	0.03	0.25	0.89				
7	-0.18	-1.42	3.28				



Lag	PAC	T	Lag	PAC	T
1	-0.06	-0.52	8	-0.12	-0.94
2	-0.06	-0.60	9	0.26	2.10
3	0.01	0.12	10	-0.08	-0.66
4	-0.03	-0.22	11	-0.32	-2.58
5	-0.04	-0.33	12	-0.12	-0.94
6	0.02	0.17			
7	-0.18	-1.47			

a. Observed Data





b. Residual for Observed Data

Figure (B.109): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Shoubak Station

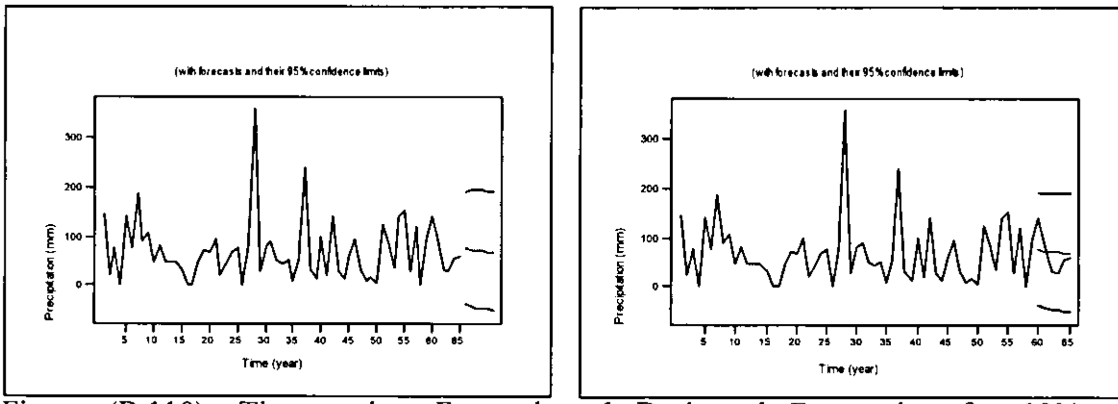


Figure (B.110): Time series, Forward and Backward Forecasting for 10% of Precipitation for (Jan.) for Shoubak Station

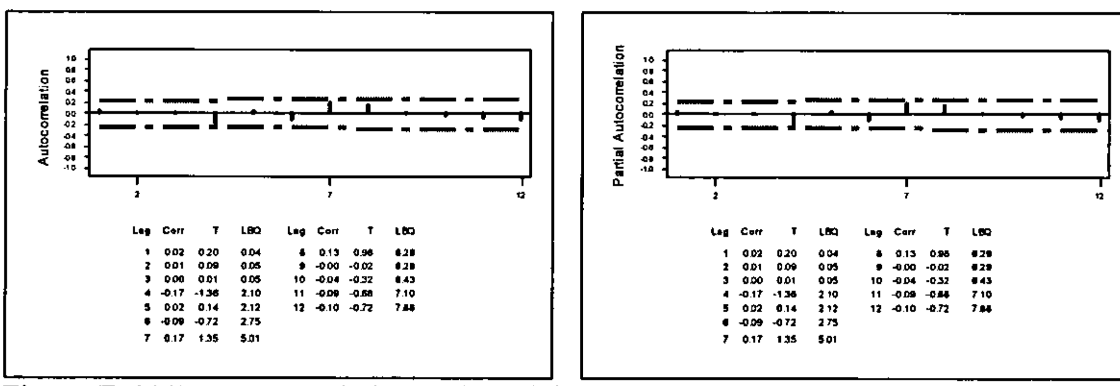


Figure (B.111): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Shoubak Station

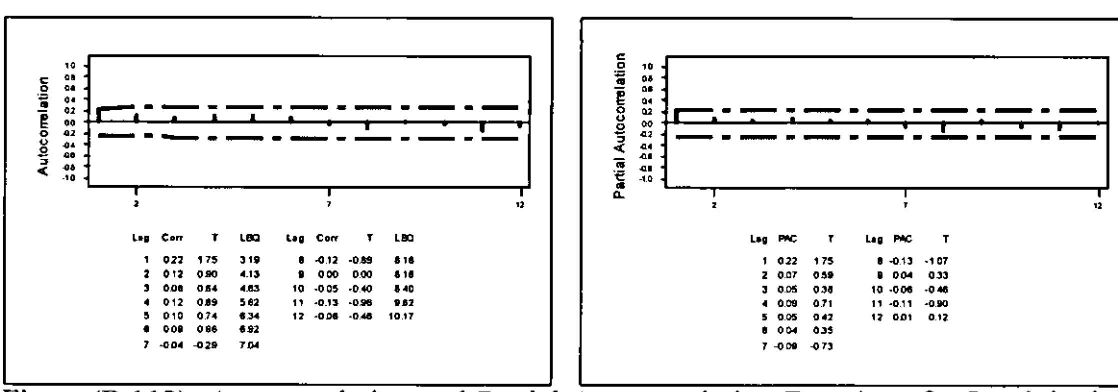
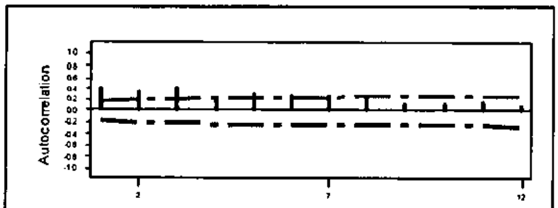
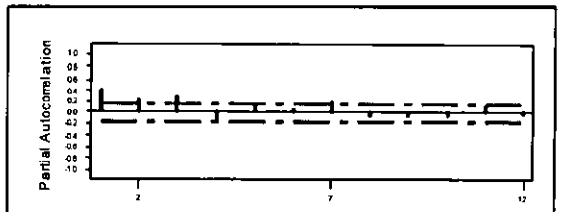


Figure (B.112): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Shoubak Station

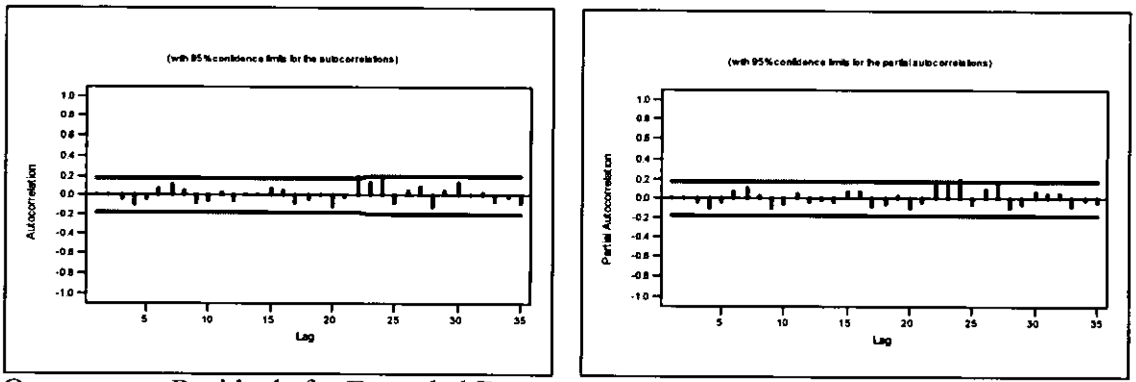


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.39	4.65	22.07	8	0.21	1.61	103.79
2	0.33	3.46	38.20	9	0.10	0.78	105.31
3	0.42	4.01	63.72	10	0.11	0.82	107.08
4	0.17	1.44	67.76	11	0.14	1.05	110.04
5	0.28	2.36	79.09	12	0.09	0.66	111.24
6	0.24	1.98	87.78				
7	0.25	2.02	97.33				



Lag	PAC	T	Lag	PAC	T
1	0.39	4.65	8	-0.07	-0.82
2	0.21	2.53	9	-0.07	-0.79
3	0.29	3.41	10	-0.06	-0.75
4	-0.12	-1.46	11	0.11	1.34
5	0.16	1.85	12	-0.02	-0.29
6	0.02	0.24			
7	0.17	1.98			

a. Extended Data



One. Residuals for Extended Data

Figure (B.113): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation in the Water Year for Shoubak Station

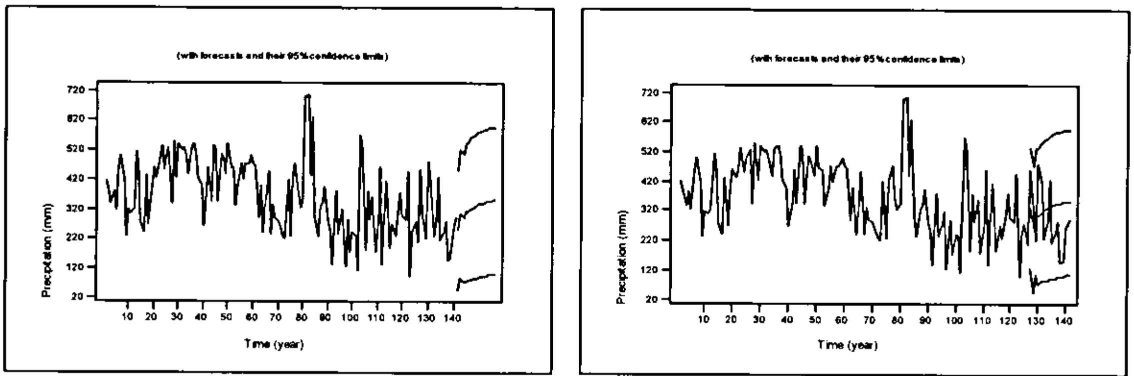
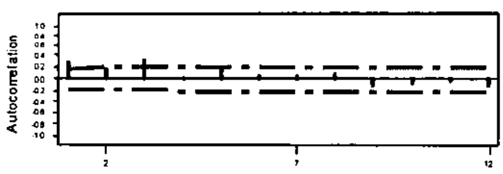
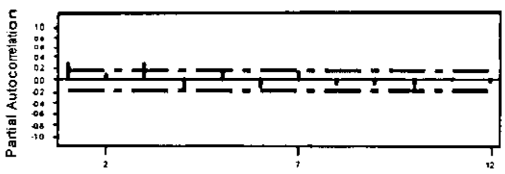


Figure (B.114): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation in the Water Year for Shoubak Station

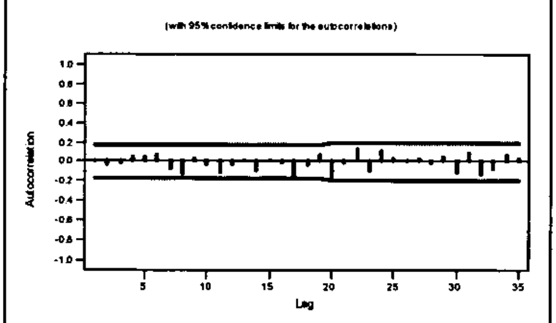


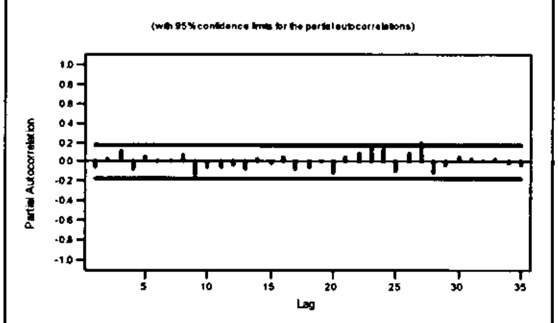
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.26	3.13	10.02	8	0.07	0.74	29.20
2	0.13	1.50	12.65	9	-0.10	-0.96	30.65
3	0.26	3.09	24.31	10	-0.07	-0.73	31.47
4	0.02	0.16	24.34	11	-0.04	-0.41	31.73
5	0.15	1.53	27.63	12	-0.09	-0.92	33.07
6	0.05	0.50	28.00				
7	0.05	0.51	28.38				



Lag	PAC	T	Lag	PAC	T
1	0.26	3.13	8	-0.06	-0.74
2	0.07	0.83	9	-0.08	-0.93
3	0.25	2.98	10	-0.10	-1.19
4	-0.13	-1.56	11	0.02	0.19
5	0.16	1.94	12	-0.05	-0.60
6	-0.11	-1.28			
7	0.11	1.32			

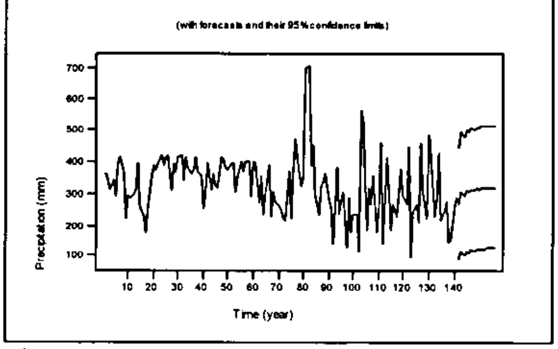
a. Extended Data





b. Residuals for Extended Data

Figure (B.115): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation in the Season form (Oct. to Mar.) for Shoubak Station



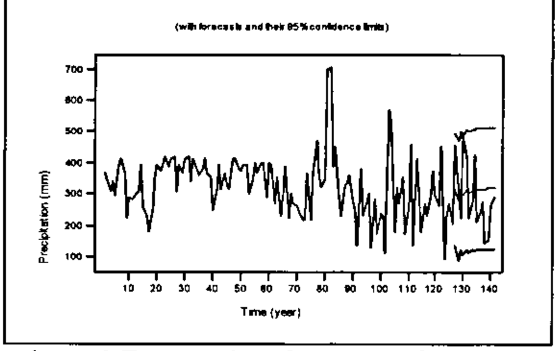
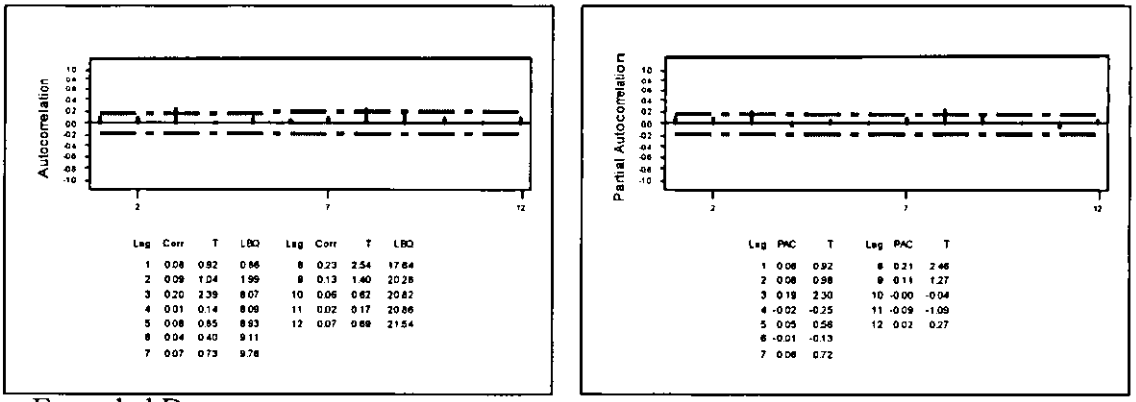
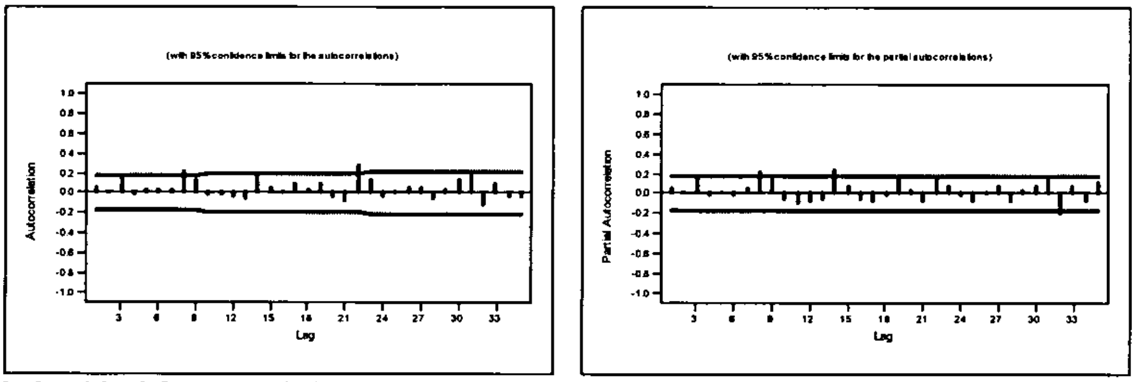


Figure (B.116): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation in the Season form (Oct. to Mar.) for Shoubak Station



a. Extended Data



b. Residual for Extended Data

Figure (B.117): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Oct. to Dec.) for Shoubak Station

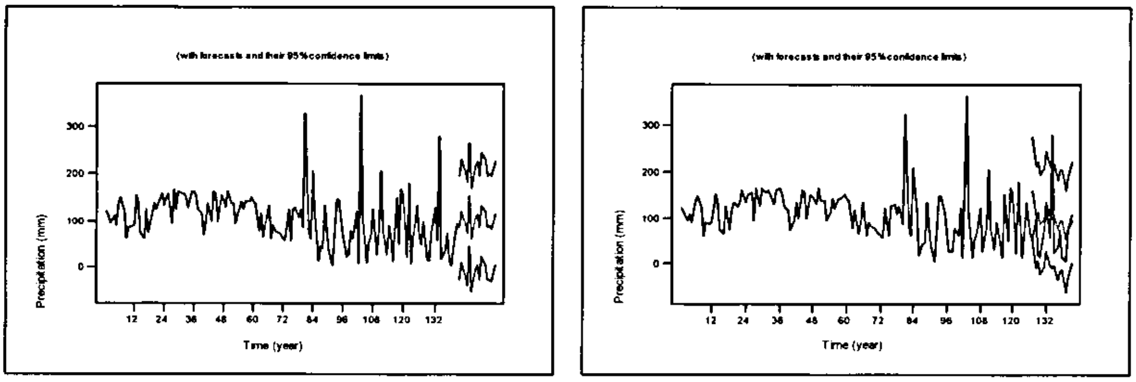
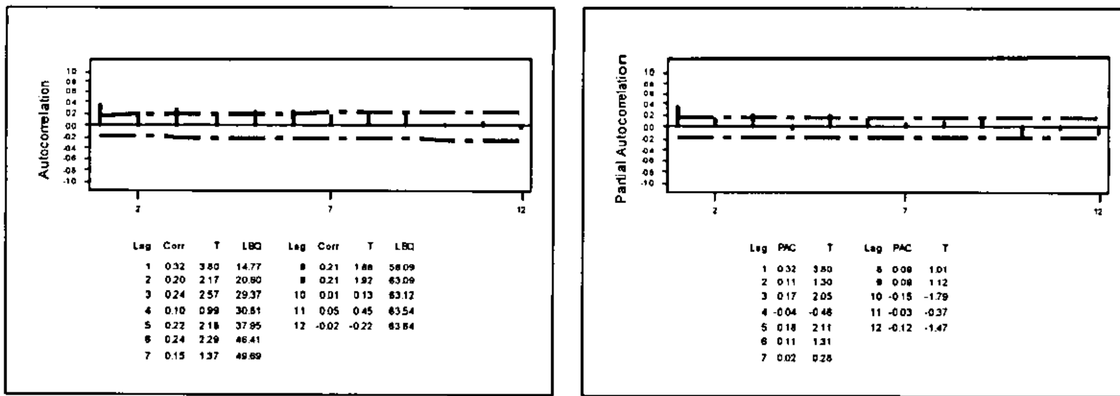
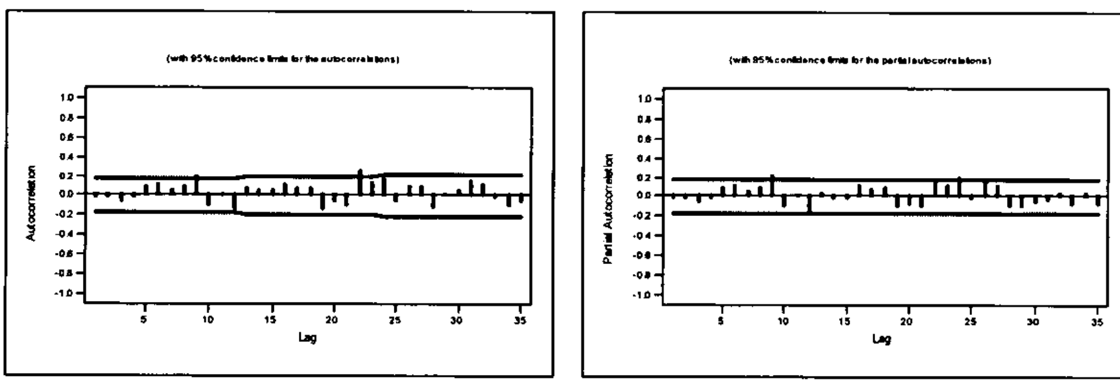


Figure (B.118): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Oct. to Dec.) for Shoubak Station



One. Extended Data



b. Residual for Extended Data

Figure (B.119): Autocorrelation and Partial Autocorrelation Functions for the Summation of Extended Precipitation for (Jan. to Mar.) for Shoubak Station

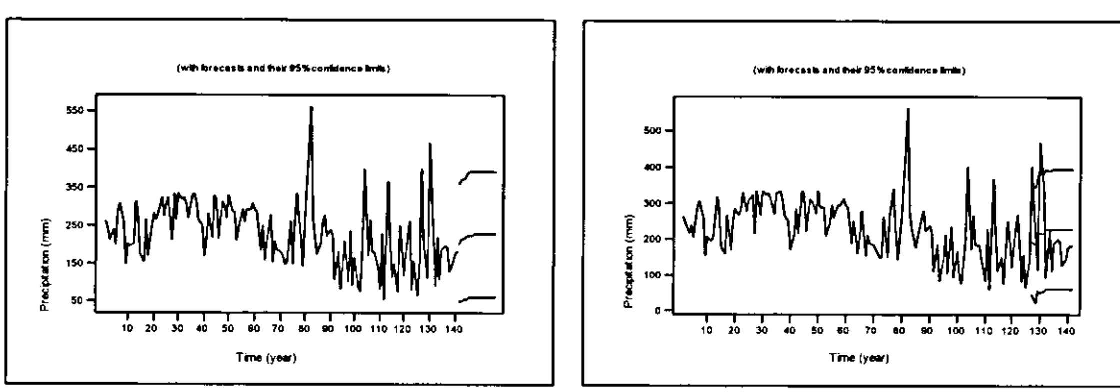
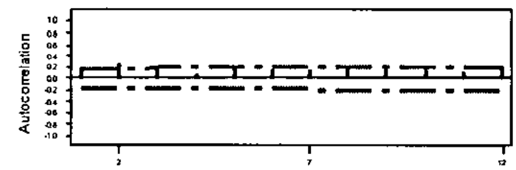
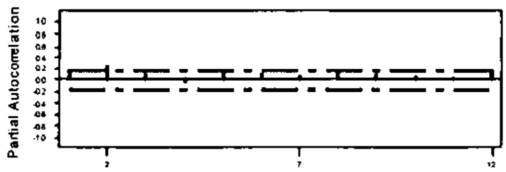


Figure (B.120): Time series, Forward and Backward Forecasting for 10% of the Summation of Extended Precipitation for (Jan. to Mar.) for Shoubak Station

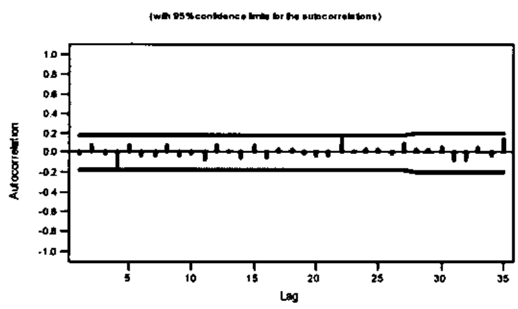


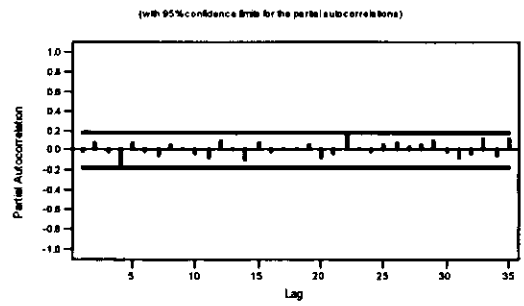
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.15	1.83	3.43	8	0.20	2.06	27.82
2	0.22	2.57	10.54	9	0.12	1.20	29.95
3	0.14	1.52	13.29	10	0.13	1.26	32.40
4	0.02	0.24	13.37	11	0.07	0.71	33.20
5	0.19	2.09	18.79	12	0.18	1.78	38.28
6	0.10	1.09	20.36				
7	0.10	1.04	21.87				



Lag	PAC	T	Lag	PAC	T
1	0.15	1.83	8	0.14	1.61
2	0.20	2.40	9	0.07	0.80
3	0.08	1.00	10	0.02	0.24
4	-0.05	-0.61	11	-0.02	-0.21
5	0.16	1.91	12	0.15	1.79
6	0.07	0.76			
7	0.02	0.23			

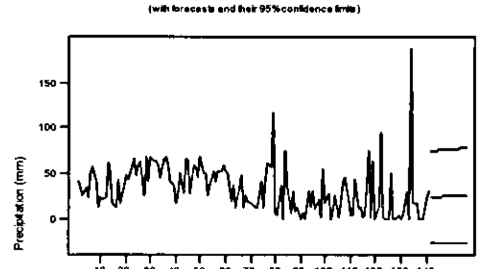
a. Extended Data





b. Residual for Extended Data

Figure (B.121): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Nov.) for Shoubak Station



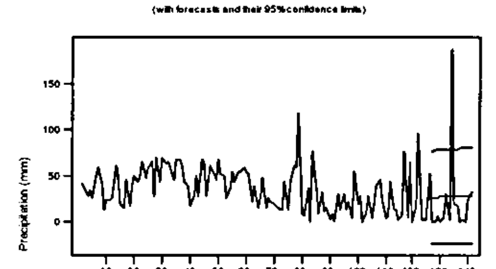
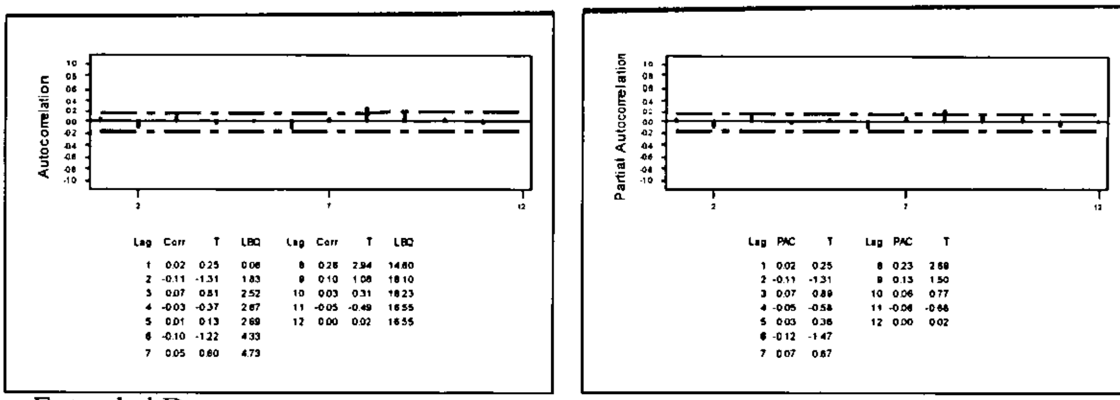
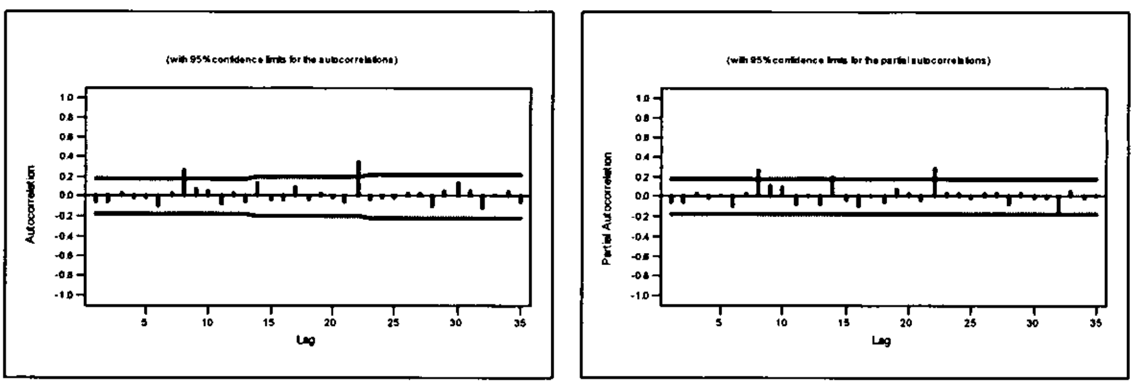


Figure (B.122): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Nov.) for Shoubak Station



a. Extended Data



b. Residual for Extended Data

Figure (B.123): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Dec.) for Shoubak Station

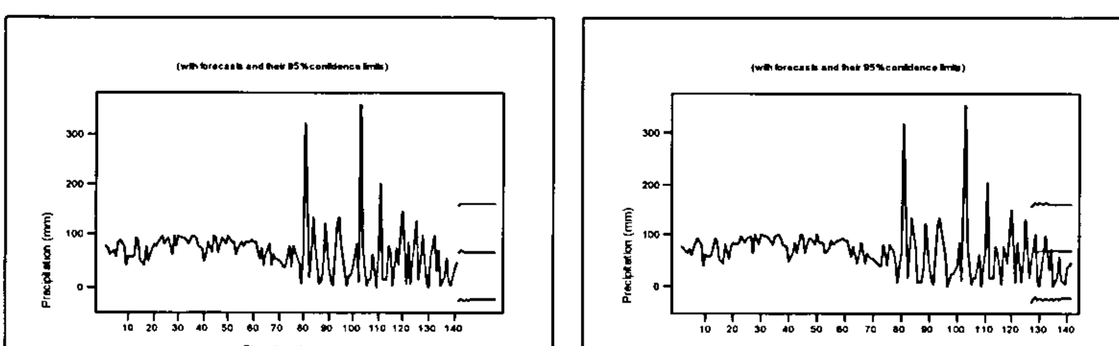
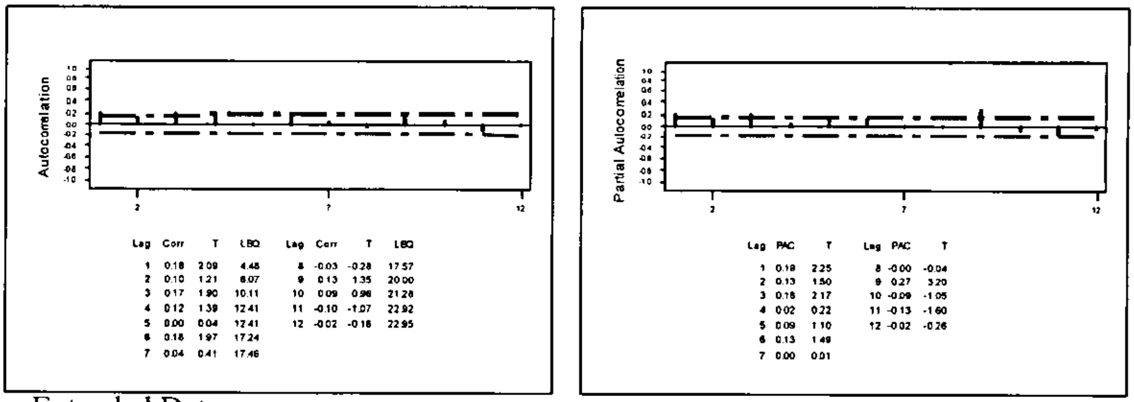
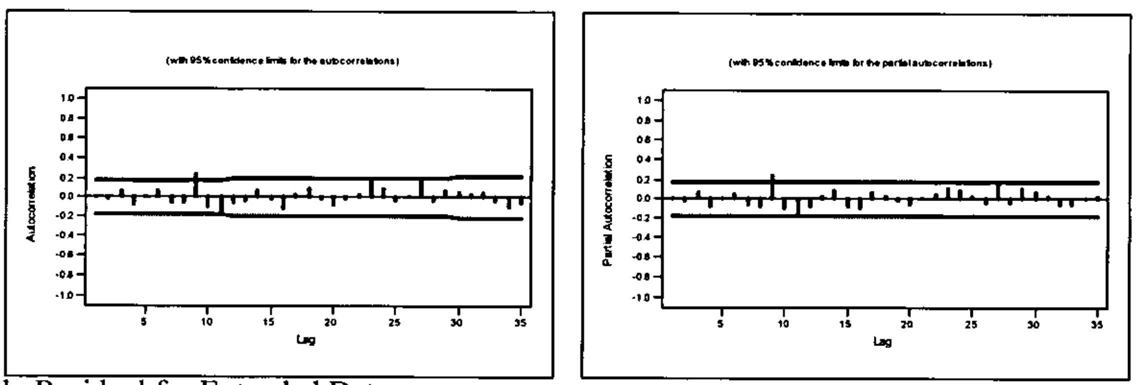


Figure (B.124): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Dec.) for Shoubak Station



a. Extended Data



b. Residual for Extended Data

Figure (B.125): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Jan.) for Shoubak Station

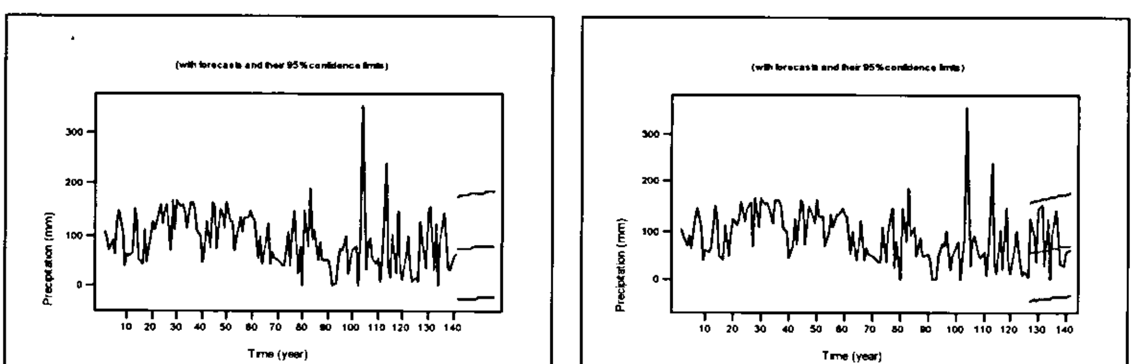
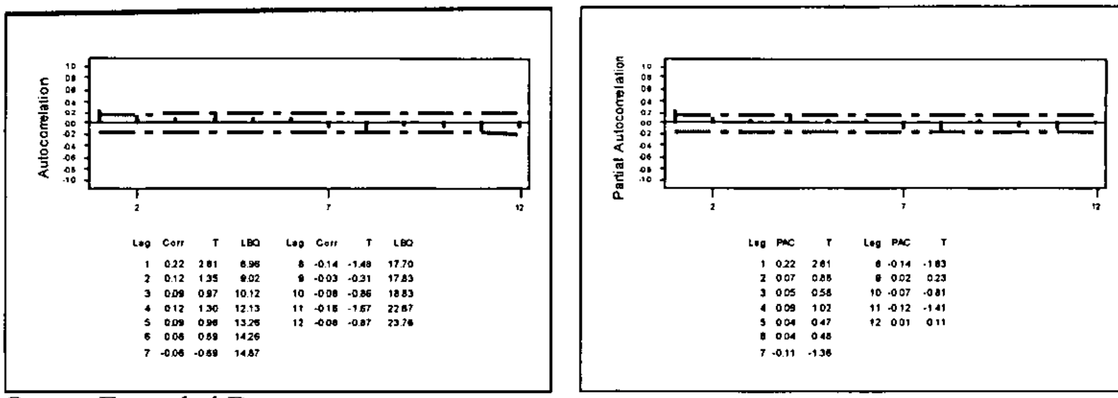
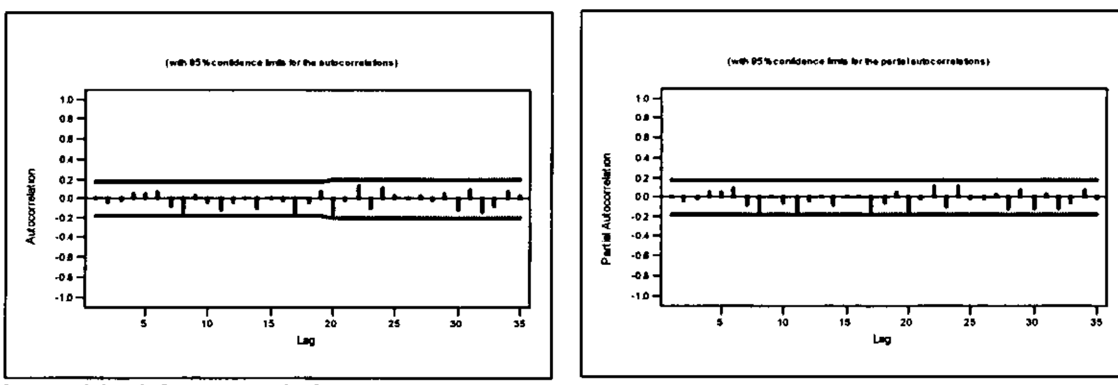


Figure (B.126): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Jan.) for Shoubak Station



One. Extended Data



b. Residual for Extended Data

Figure (B.127): Autocorrelation and Partial Autocorrelation Functions for Extended Precipitation for (Mar.) for Shoubak Station

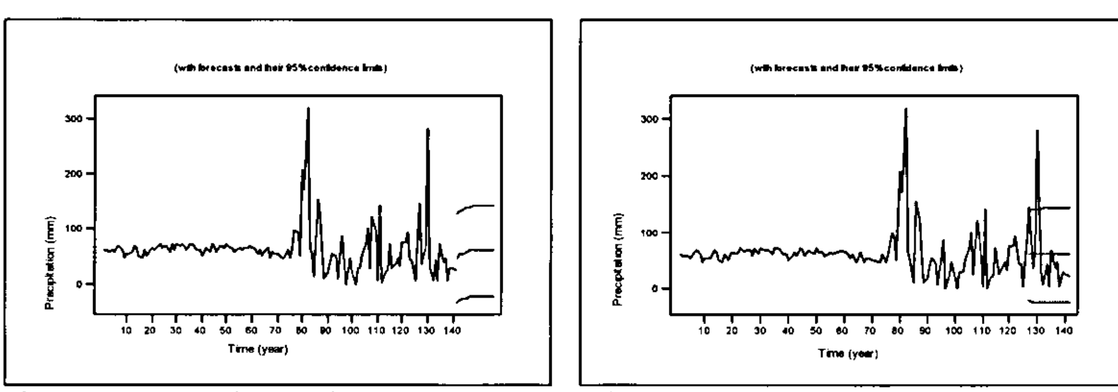
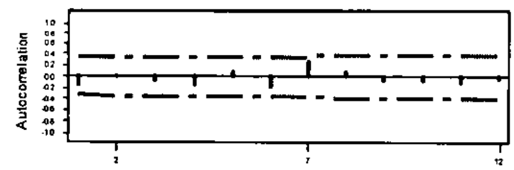
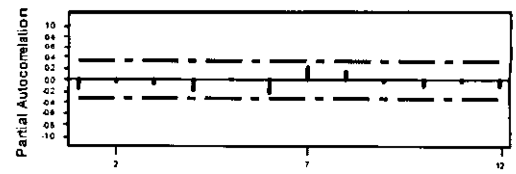


Figure (B.128): Time series, Forward and Backward Forecasting for 10% of Extended Precipitation for (Mar.) for Shoubak Station

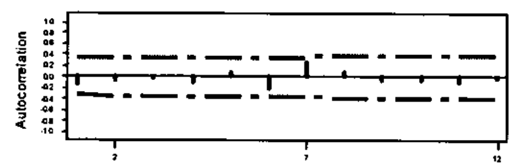


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.16	-0.99	1.06	8	0.09	0.47	8.24
2	-0.02	-0.11	1.07	9	-0.07	-0.37	8.50
3	-0.06	-0.37	1.24	10	-0.06	-0.34	8.73
4	-0.14	-0.86	2.17	11	-0.11	-0.60	8.45
5	0.07	0.43	2.43	12	-0.03	-0.14	8.49
6	-0.19	-1.13	4.18				
7	0.27	1.54	7.84				

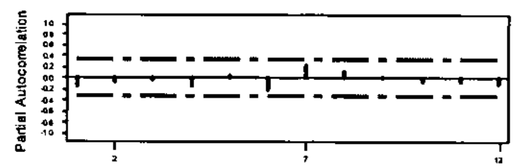


Lag	PAC	T	Lag	PAC	T
1	-0.16	-0.99	8	0.14	0.86
2	-0.05	-0.28	9	-0.03	-0.16
3	-0.07	-0.46	10	-0.10	-0.61
4	-0.17	-1.07	11	-0.05	-0.33
5	0.01	0.09	12	-0.10	-0.63
6	-0.21	-1.29			
7	0.20	1.25			

Figure (B.129): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Water Year for Mafraq Station

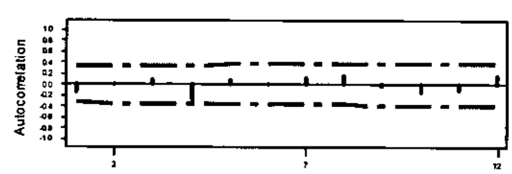


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.16	-0.99	1.07	8	0.08	0.44	8.12
2	-0.06	-0.34	1.20	9	-0.06	-0.31	8.30
3	-0.03	-0.16	1.23	10	-0.06	-0.31	8.48
4	-0.12	-0.74	1.81	11	-0.12	-0.62	9.26
5	0.08	0.45	2.18	12	-0.02	-0.13	9.29
6	-0.20	-1.19	4.11				
7	0.27	1.55	7.78				

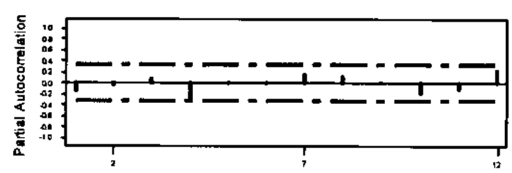


Lag	PAC	T	Lag	PAC	T
1	-0.16	-0.99	8	0.12	0.74
2	-0.06	-0.52	9	0.02	0.10
3	-0.05	-0.32	10	-0.08	-0.55
4	-0.15	-0.90	11	-0.07	-0.41
5	0.02	0.15	12	-0.12	-0.73
6	-0.22	-1.35			
7	0.22	1.35			

Figure (B.130): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Season from (Oct. to Mar.) for Mafraq Station

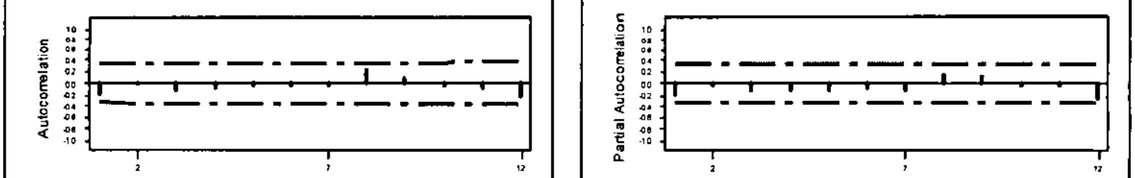


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.15	-0.93	0.93	8	0.16	0.87	7.29
2	0.00	0.01	0.93	9	-0.05	-0.26	7.41
3	0.07	0.41	1.13	10	-0.15	-0.78	8.56
4	-0.30	-1.77	5.03	11	-0.10	-0.52	9.10
5	0.07	0.39	5.25	12	0.15	0.79	10.41
6	-0.01	-0.08	5.26				
7	0.12	0.68	6.01				



Lag	PAC	T	Lag	PAC	T
1	-0.15	-0.93	8	0.13	0.78
2	-0.02	-0.14	9	0.01	0.07
3	0.07	0.41	10	-0.20	-1.22
4	-0.28	-1.74	11	-0.10	-0.63
5	-0.01	-0.07	12	0.24	1.46
6	-0.01	-0.09			
7	0.16	1.01			

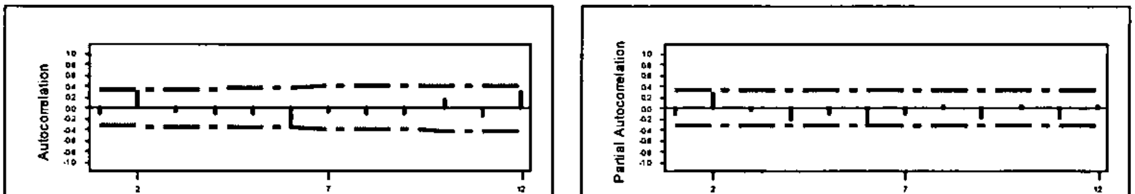
Figure (B.131): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Mafraq Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.17	-1.06	1.21	8	0.20	1.19	4.13
2	-0.01	-0.03	1.21	9	0.06	0.34	4.31
3	-0.09	-0.55	1.58	10	-0.05	-0.26	4.43
4	-0.06	-0.36	1.74	11	-0.06	-0.33	4.82
5	-0.05	-0.32	1.88	12	-0.24	-1.34	7.92
6	-0.03	-0.19	1.93				
7	-0.05	-0.29	2.04				

Lag	PAC	T	Lag	PAC	T
1	-0.17	-1.06	8	0.16	0.96
2	-0.04	-0.22	9	0.11	0.67
3	-0.10	-0.63	10	-0.03	-0.16
4	-0.10	-0.61	11	-0.05	-0.30
5	-0.09	-0.56	12	-0.25	-1.55
6	-0.08	-0.50			
7	-0.10	-0.62			

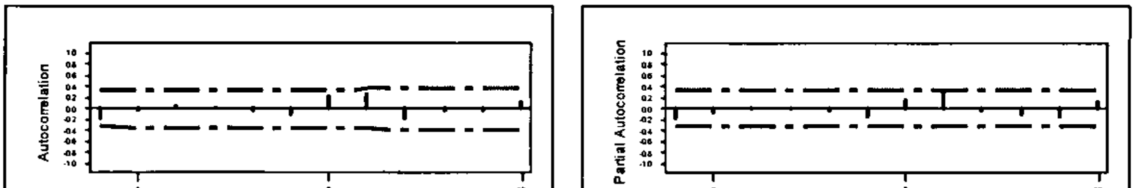
Figure (B.132): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Jan. to Mar.) for Mafraq Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.09	-0.57	0.35	8	-0.11	-0.53	11.97
2	0.28	1.69	3.56	9	-0.10	-0.52	12.53
3	-0.07	-0.38	3.75	10	0.16	0.81	13.86
4	-0.12	-0.71	4.45	11	-0.14	-0.68	15.01
5	-0.10	-0.57	4.93	12	0.29	1.40	19.94
6	-0.36	-2.03	11.24				
7	-0.06	-0.29	11.41				

Lag	PAC	T	Lag	PAC	T
1	-0.09	-0.57	8	0.04	0.24
2	0.27	1.68	9	-0.17	-1.05
3	-0.03	-0.18	10	0.05	0.30
4	-0.22	-1.38	11	-0.19	-1.18
5	-0.11	-0.69	12	0.05	0.29
6	-0.33	-2.00			
7	-0.10	-0.63			

Figure (B.133): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Mafraq Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.20	-1.24	1.66	8	0.24	1.37	7.70
2	-0.04	-0.27	1.75	9	-0.18	-0.96	8.40
3	0.03	0.16	1.78	10	-0.04	-0.21	8.49
4	-0.01	-0.06	1.78	11	-0.05	-0.25	8.62
5	-0.05	-0.29	1.89	12	0.11	0.55	10.28
6	-0.12	-0.70	2.56				
7	0.21	1.21	4.88				

Lag	PAC	T	Lag	PAC	T
1	-0.20	-1.24	8	0.34	2.07
2	-0.09	-0.55	9	-0.03	-0.21
3	-0.00	-0.01	10	-0.11	-0.66
4	-0.01	-0.06	11	-0.13	-0.81
5	-0.05	-0.33	12	0.13	0.78
6	-0.15	-0.92			
7	0.15	0.95			

Figure (B.134): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Mafraq Station

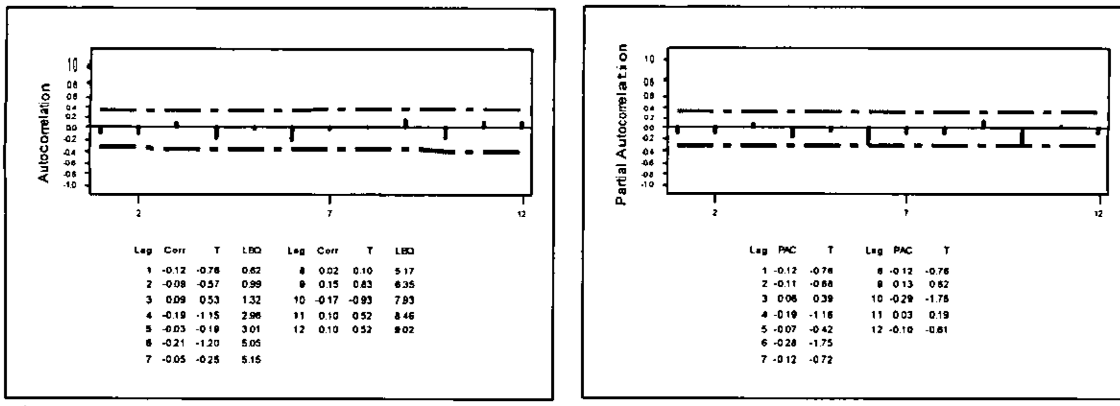


Figure (B.135): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Mafraq Station

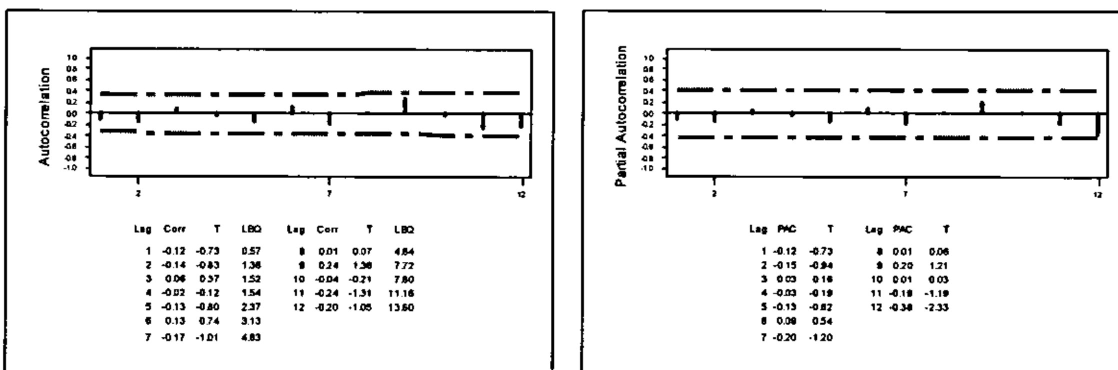


Figure (B.136): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Mafraq Station

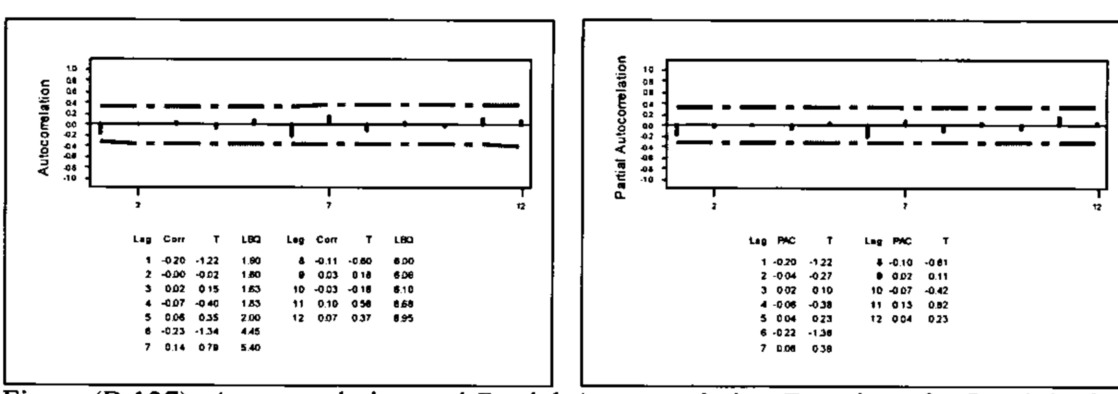


Figure (B.137): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Mafraq Station

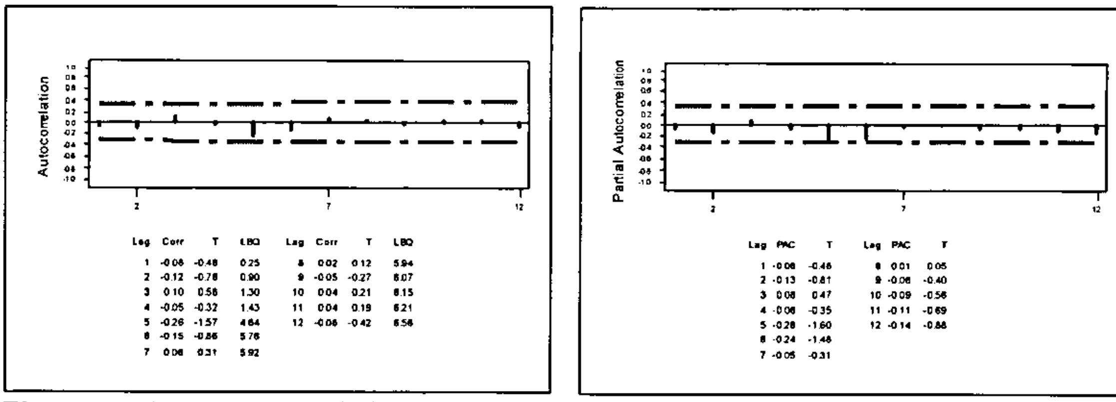


Figure (B.138): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Mafraq Station

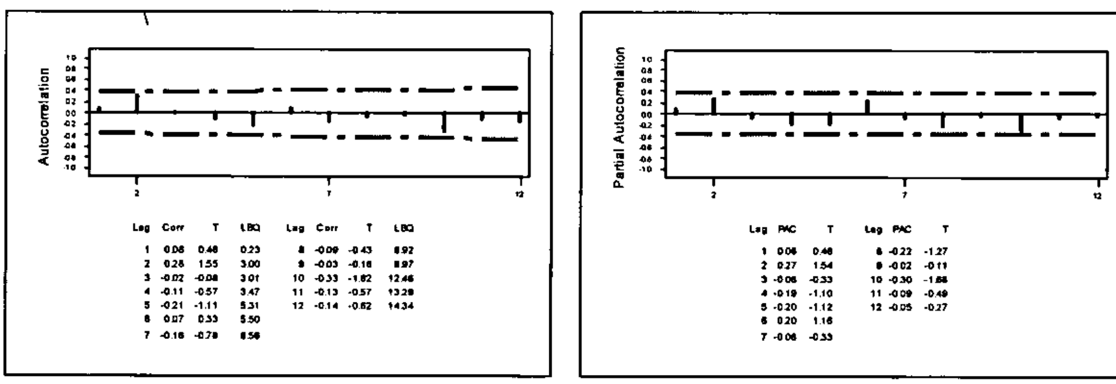


Figure (B.139): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Water Year for Safawi Station

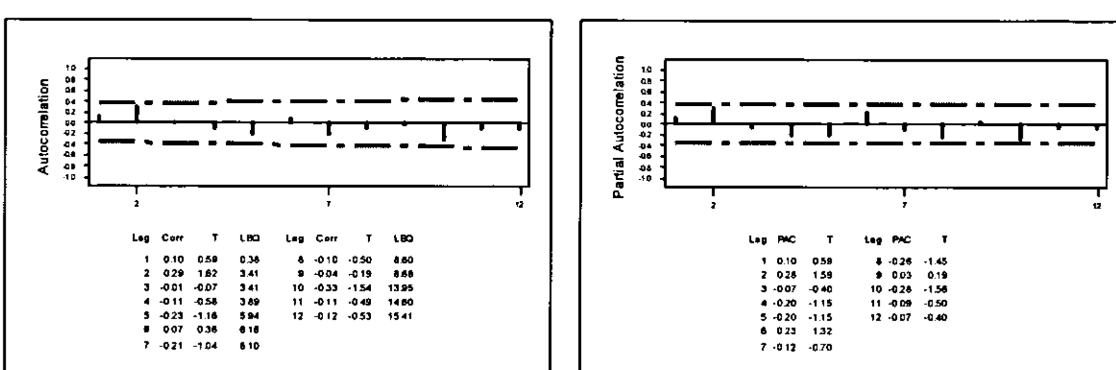
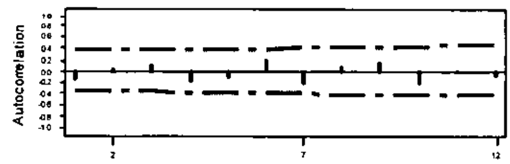
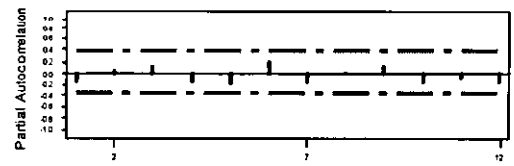


Figure (B.140): Autocorrelation and Partial Autocorrelation Functions for Precipitation in the Season from (Oct. to Mar.) for Safawi Station

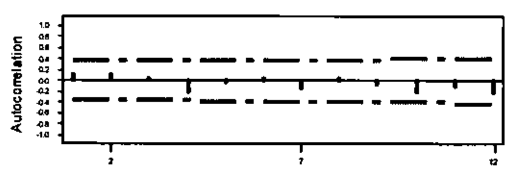


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.16	-0.92	0.92	8	0.08	0.37	7.28
2	0.05	0.25	1.00	9	0.13	0.63	8.08
3	0.11	0.60	1.44	10	-0.22	-1.08	10.58
4	-0.18	-0.97	2.58	11	0.02	0.07	10.59
5	-0.11	-0.60	3.20	12	-0.07	-0.32	10.66
6	0.19	1.01	4.78				
7	-0.23	-1.15	7.02				

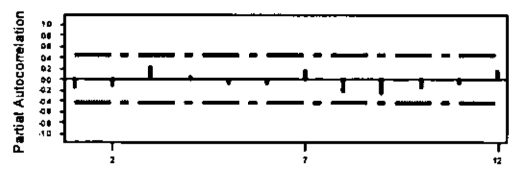


Lag	PAC	T	Lag	PAC	T
1	-0.18	-0.92	8	-0.00	-0.01
2	0.02	0.11	9	0.10	0.57
3	0.12	0.69	10	-0.15	-0.87
4	-0.15	-0.84	11	-0.08	-0.45
5	-0.18	-1.04	12	-0.14	-0.80
6	0.17	0.95			
7	-0.13	-0.76			

Figure (B.141): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Oct. to Dec.) for Safawi Station

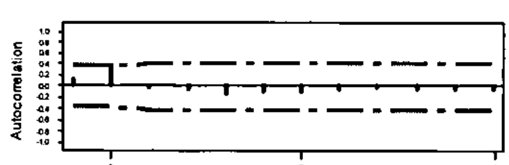


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.10	0.56	0.34	8	0.02	0.11	3.84
2	0.11	0.63	0.80	9	-0.09	-0.44	4.18
3	0.04	0.22	0.88	10	-0.21	-1.07	6.33
4	-0.22	-1.22	2.74	11	-0.11	-0.57	7.01
5	-0.04	-0.24	2.82	12	-0.23	-1.13	8.90
6	0.05	0.28	2.84				
7	-0.14	-0.75	3.82				

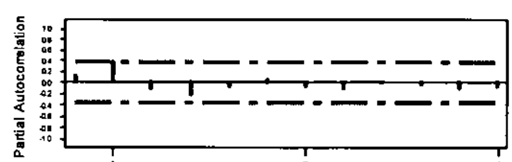


Lag	PAC	T	Lag	PAC	T
1	-0.14	-0.88	8	-0.23	-1.06
2	-0.10	-0.47	9	-0.27	-1.30
3	0.23	1.09	10	-0.14	-0.69
4	0.03	0.12	11	-0.07	-0.33
5	-0.06	-0.27	12	0.14	0.66
6	-0.09	-0.43			
7	0.16	0.78			

Figure (B.142): Autocorrelation and Partial Autocorrelation Functions for the Summation of Precipitation for (Jan. to Mar.) for Safawi Station

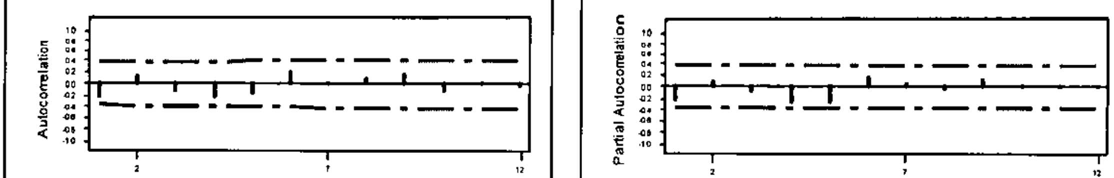


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.11	0.60	0.39	8	-0.09	-0.42	7.52
2	0.36	2.02	5.10	9	-0.05	-0.23	7.83
3	-0.04	-0.20	5.16	10	-0.06	-0.30	7.82
4	-0.08	-0.39	5.40	11	-0.08	-0.38	8.14
5	-0.14	-0.68	6.16	12	-0.07	-0.32	8.39
6	-0.09	-0.45	6.52				
7	-0.12	-0.59	7.17				



Lag	PAC	T	Lag	PAC	T
1	0.11	0.60	8	-0.10	-0.56
2	0.35	2.00	9	-0.00	-0.01
3	-0.12	-0.67	10	-0.03	-0.14
4	-0.22	-1.27	11	-0.11	-0.65
5	-0.07	-0.39	12	-0.08	-0.43
6	0.04	0.24			
7	-0.06	-0.33			

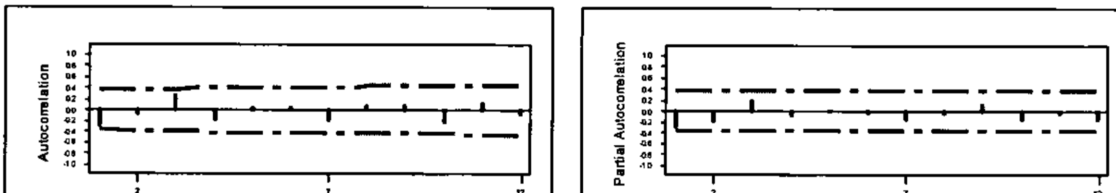
Figure (B.143): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Oct.) for Safawi Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.22	-1.23	1.65	8	0.09	0.43	6.87
2	0.10	0.55	2.03	9	0.14	0.68	7.84
3	-0.10	-0.51	2.37	10	-0.11	-0.52	8.42
4	-0.22	-1.17	4.26	11	-0.01	-0.05	8.43
5	-0.15	-0.75	5.12	12	-0.04	-0.20	8.52
6	0.18	0.91	6.51				
7	-0.01	-0.07	6.52				

Lag	PAC	T	Lag	PAC	T
1	-0.22	-1.23	8	-0.05	-0.28
2	0.06	0.32	9	0.10	0.57
3	-0.07	-0.37	10	0.01	0.08
4	-0.27	-1.55	11	0.01	0.08
5	-0.27	-1.53	12	-0.02	-0.10
6	0.14	0.78			
7	0.05	0.30			

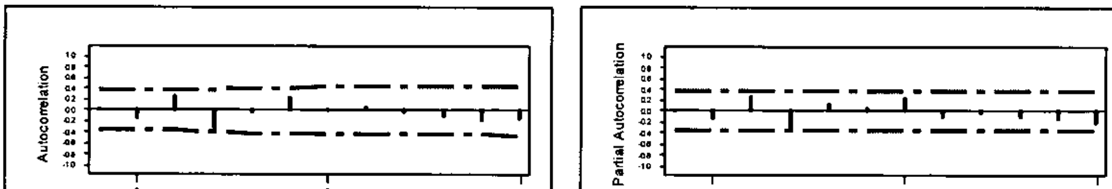
Figure (B.144): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Nov.) for Safawi Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.28	-1.68	3.03	8	0.06	0.30	8.56
2	-0.06	-0.43	3.27	9	0.09	0.41	8.92
3	0.26	1.34	5.74	10	-0.23	-1.08	11.55
4	-0.19	-0.92	7.11	11	0.11	0.49	12.17
5	0.03	0.15	7.15	12	-0.08	-0.40	12.62
6	0.03	0.13	7.18				
7	-0.17	-0.79	8.38				

Lag	PAC	T	Lag	PAC	T
1	-0.29	-1.66	8	-0.05	-0.28
2	-0.18	-1.04	9	0.09	0.52
3	0.20	1.12	10	-0.15	-0.85
4	-0.07	-0.39	11	-0.02	-0.11
5	0.00	0.01	12	-0.16	-0.90
6	-0.04	-0.25			
7	-0.13	-0.78			

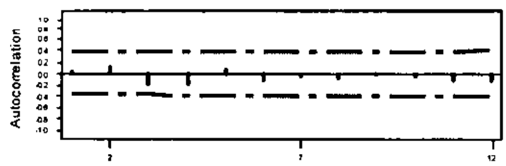
Figure (B.145): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Dec.) for Safawi Station



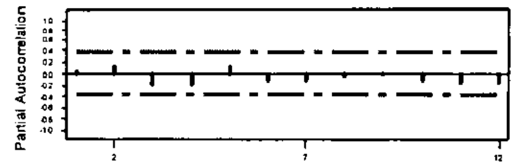
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.01	-0.07	0.01	8	0.02	0.12	8.92
2	-0.13	-0.75	0.64	9	-0.03	-0.13	8.96
3	0.26	1.42	3.10	10	-0.11	-0.52	9.57
4	-0.32	-1.67	7.04	11	-0.17	-0.81	11.14
5	-0.03	-0.18	7.08	12	-0.16	-0.74	12.80
6	0.21	1.00	8.69				
7	0.00	0.01	8.69				

Lag	PAC	T	Lag	PAC	T
1	-0.01	-0.07	8	-0.12	-0.67
2	-0.13	-0.75	9	-0.05	-0.28
3	0.26	1.45	10	-0.10	-0.54
4	-0.37	-2.08	11	-0.14	-0.79
5	0.10	0.57	12	-0.21	-1.19
6	0.03	0.19			
7	0.20	1.16			

Figure (B.146): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Jan.) for Safawi Station

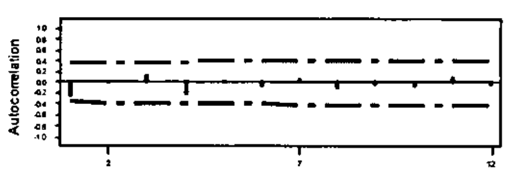


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.05	0.30	0.10	8	-0.06	-0.31	3.56
2	0.10	0.56	0.46	9	-0.02	-0.08	3.57
3	-0.17	-0.95	1.53	10	-0.04	-0.20	3.65
4	-0.17	-0.93	2.66	11	-0.11	-0.60	4.33
5	0.06	0.29	2.80	12	-0.12	-0.60	5.07
6	-0.12	-0.61	3.37				
7	-0.03	-0.15	3.40				

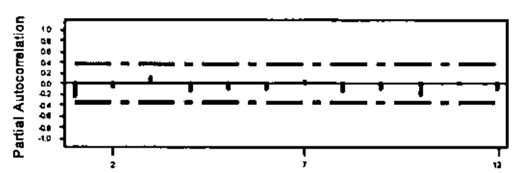


Lag	PAC	T	Lag	PAC	T
1	0.05	0.30	8	-0.02	-0.13
2	0.10	0.55	9	-0.01	-0.07
3	-0.18	-1.03	10	-0.11	-0.63
4	-0.17	-0.96	11	-0.14	-0.79
5	0.12	0.66	12	-0.13	-0.74
6	-0.13	-0.71			
7	-0.11	-0.60			

Figure (B.147): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Feb.) for Safawi Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	-0.27	-1.55	2.63	8	-0.12	-0.61	5.88
2	-0.01	-0.04	2.63	9	-0.03	-0.13	5.89
3	0.12	0.64	3.19	10	-0.08	-0.39	6.20
4	-0.21	-1.11	4.84	11	0.06	0.29	6.38
5	0.01	0.03	4.85	12	-0.04	-0.20	6.47
6	-0.06	-0.29	5.09				
7	0.05	0.24	5.19				



Lag	PAC	T	Lag	PAC	T
1	-0.27	-1.55	8	-0.15	-0.85
2	-0.09	-0.50	9	-0.12	-0.70
3	0.10	0.59	10	-0.21	-1.18
4	-0.18	-0.83	11	0.00	0.00
5	-0.10	-0.56	12	-0.11	-0.62
6	-0.12	-0.67			
7	0.04	0.22			

Figure (B.148): Autocorrelation and Partial Autocorrelation Functions for Precipitation for (Mar.) for Safawi Station

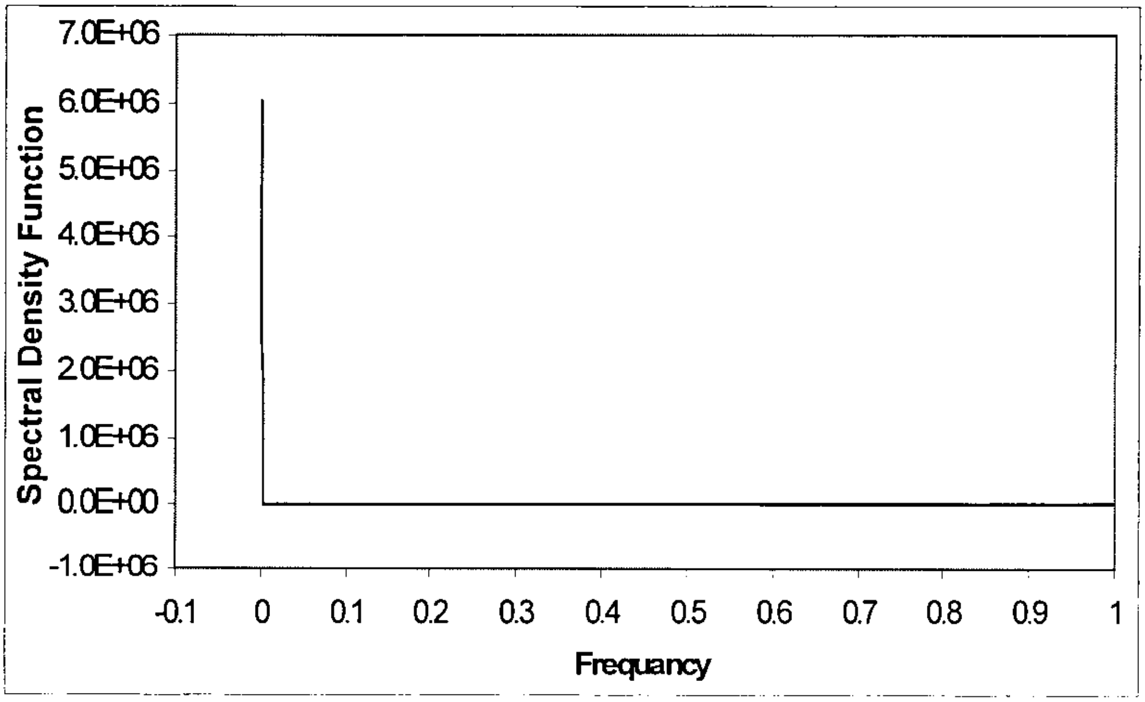
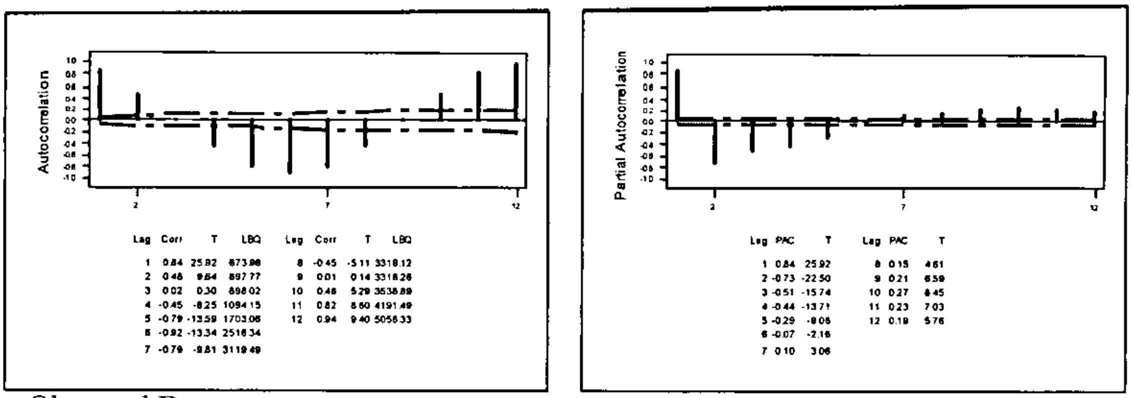
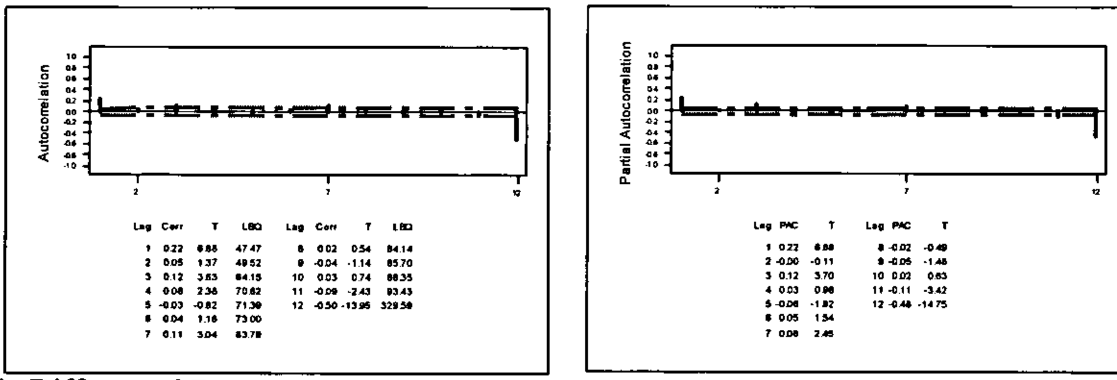


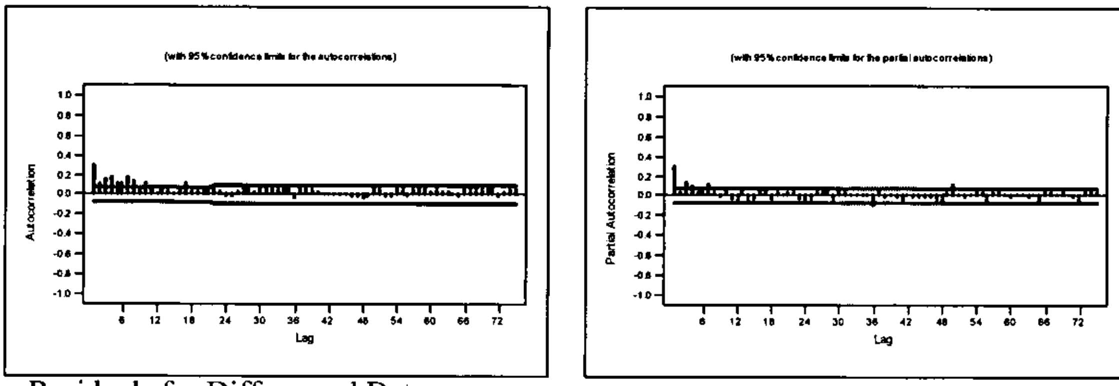
Figure (B.139): The Spectral Density Function for The Summation of Extended Precipitation for (Oct. to Dec.) for Amman Airport Station



a. Observed Data



b. Differenced Data



c. Residuals for Differenced Data

Figure (B.150): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Minimum Temperature for Amman Airport Station

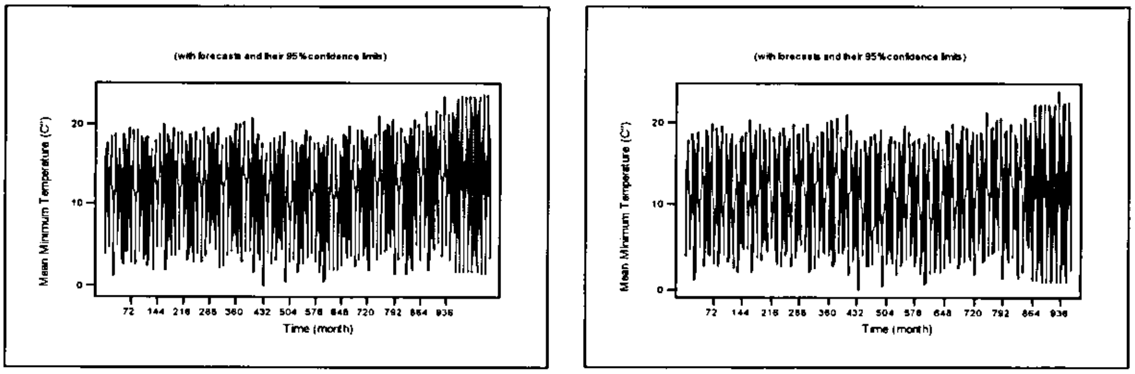


Figure (B.151): Time series, Forward and Backward Forecasting for 10% of Observed Mean Monthly Minimum Temperature for Amman Airport Station

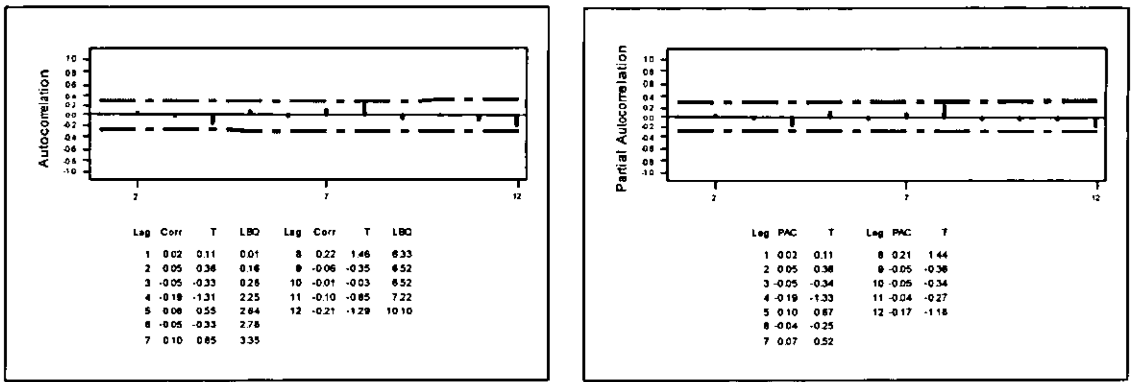
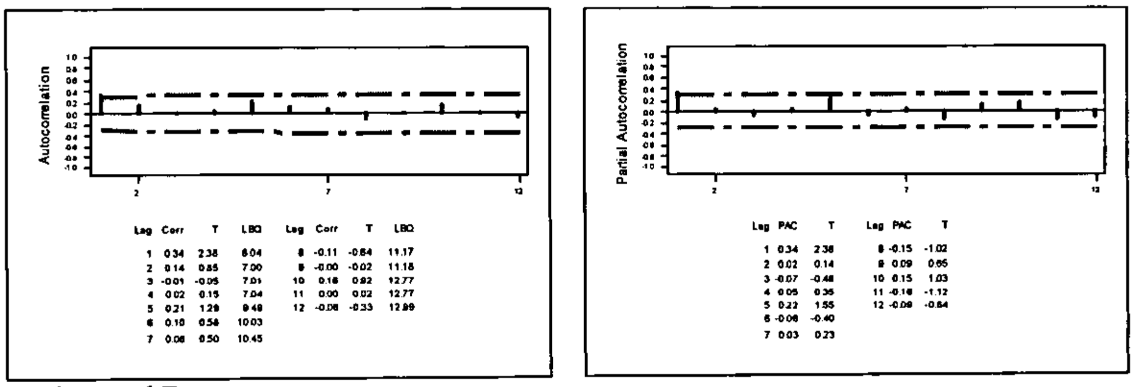
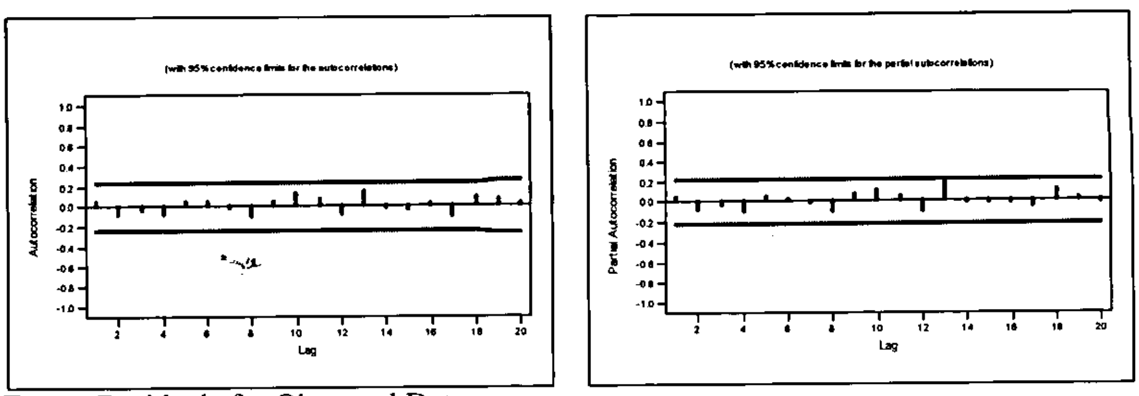


Figure (B.152): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Amman Airport Station



a. Observed Data



Two. Residuals for Observed Data

Figure (B.153): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Apr., May and Jun. for Amman Airport Station

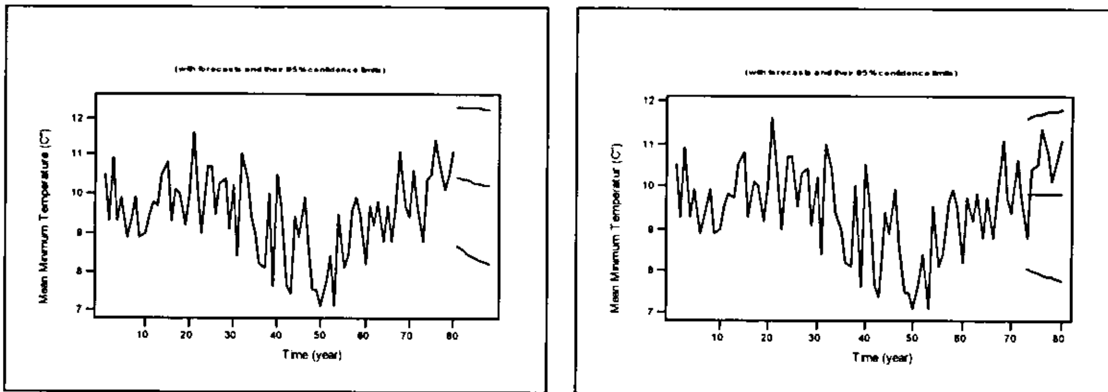


Figure (B.158): Time series, Forward and Backward Forecasting for 10% of Observed Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Amman Airport Station

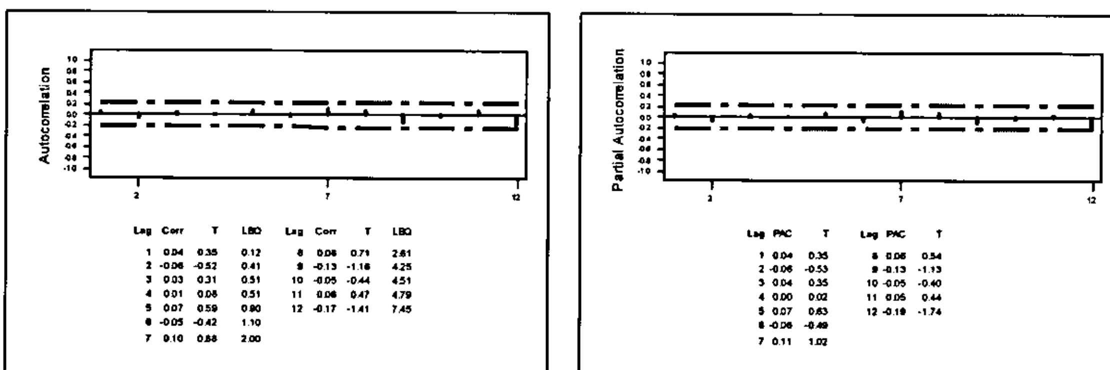


Figure (B.159): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Amman Airport Station

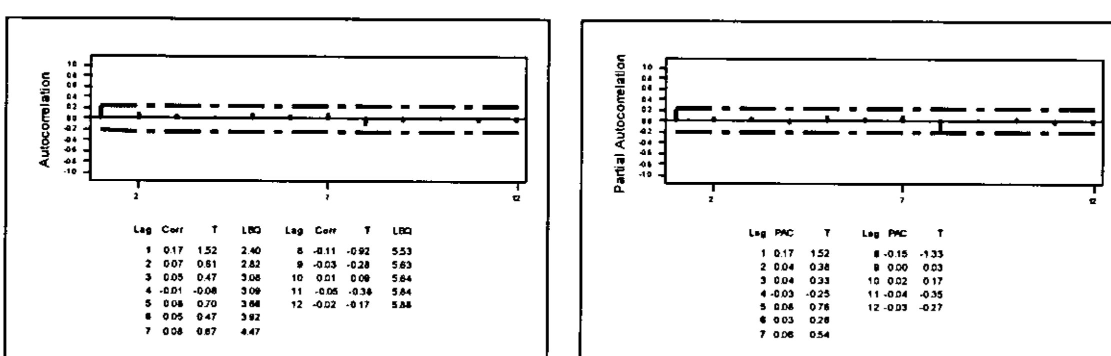
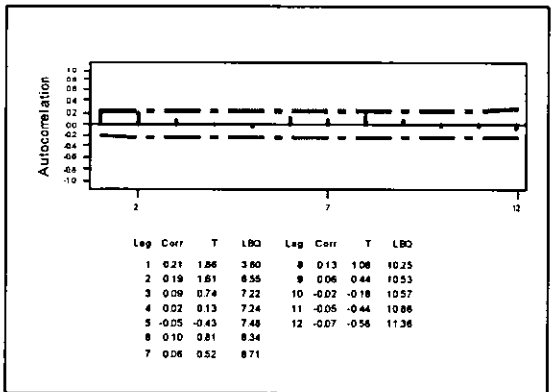


Figure (B.160): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Apr., May and Jun. for Amman Airport Station



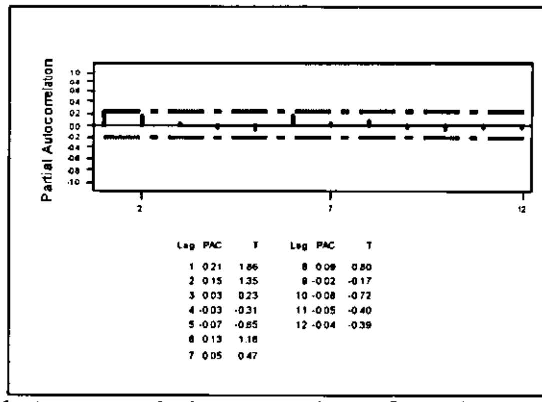
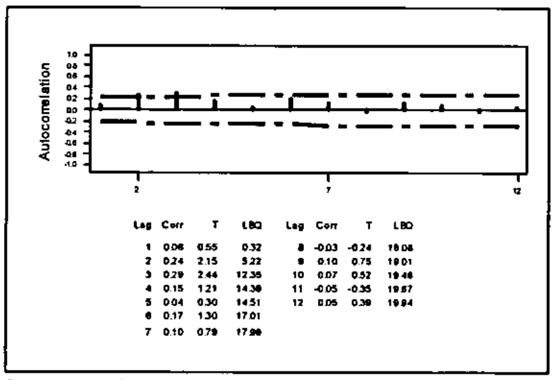
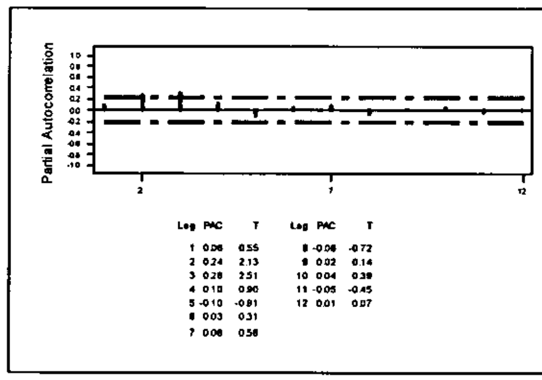
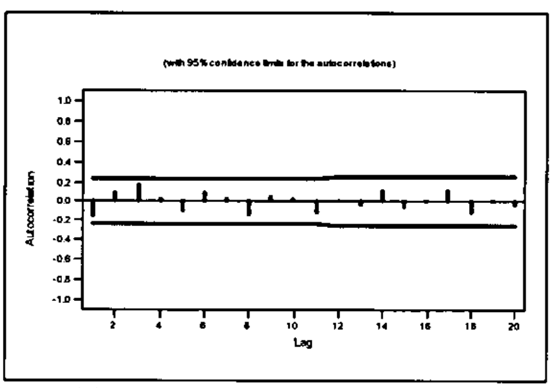


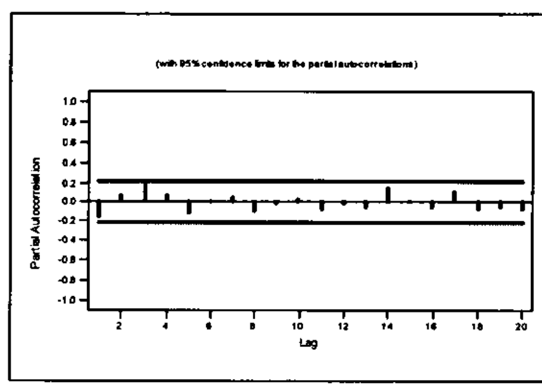
Figure (B.161): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Amman Airport Station





One. Observed Data





b. Residuals for Observed Data

Figure (B.162): Autocorrelation and Partial Autocorrelation Functions for Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Amman Airport Station

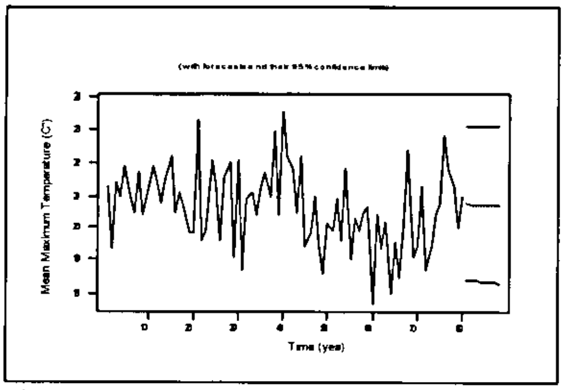
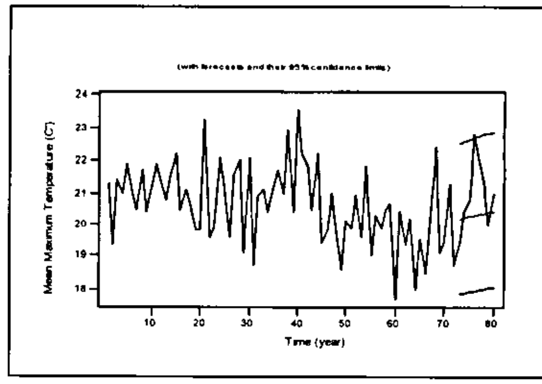
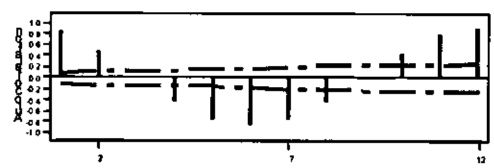
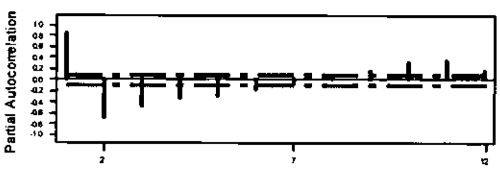



Figure (B.163): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Amman Airport Station

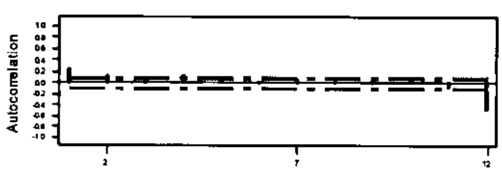


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.83	19.86	396.56	8	-0.45	-4.06	1919.55
2	0.47	7.29	523.40	9	-0.01	-0.08	1919.60
3	0.01	0.07	523.41	10	0.45	3.92	2038.76
4	-0.44	-6.35	637.92	11	0.80	6.80	2416.33
5	-0.77	-10.34	984.58	12	0.93	7.33	2926.75
6	-0.89	-10.21	1448.21				
7	-0.77	-7.60	1798.95				

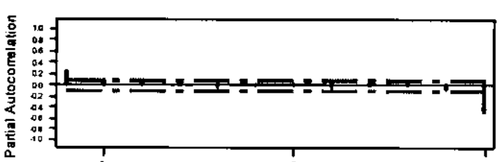


Lag	PAC	T	Lag	PAC	T
1	0.83	19.86	8	0.03	0.72
2	-0.68	-16.55	9	0.15	3.67
3	-0.47	-11.33	10	0.30	7.22
4	-0.35	-8.36	11	0.34	8.17
5	-0.30	-7.17	12	0.16	3.90
6	-0.17	-4.12			
7	-0.07	-1.57			

One. Observed Data

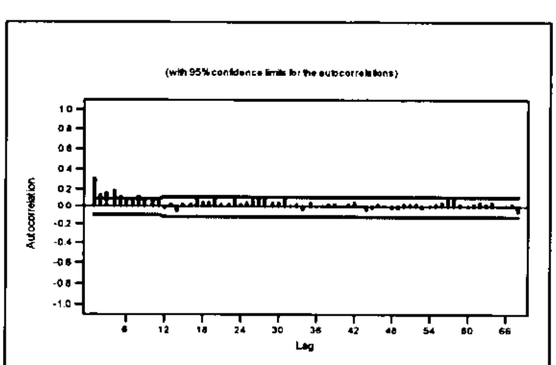
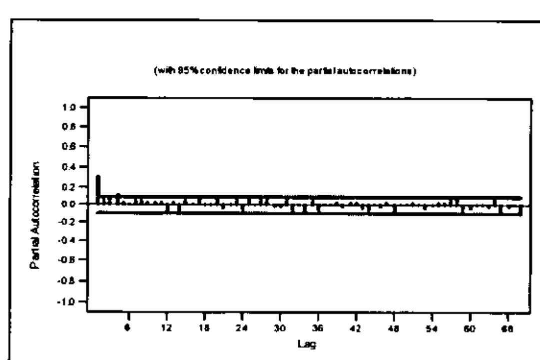


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.23	5.49	30.28	8	-0.01	-0.24	48.40
2	0.12	2.64	38.03	9	0.01	0.26	48.48
3	0.09	1.92	42.25	10	0.02	0.42	48.68
4	0.10	2.13	47.53	11	-0.06	-1.42	51.12
5	0.02	0.48	47.80	12	-0.46	-10.07	173.87
6	0.02	0.39	47.98				
7	0.02	0.54	48.33				



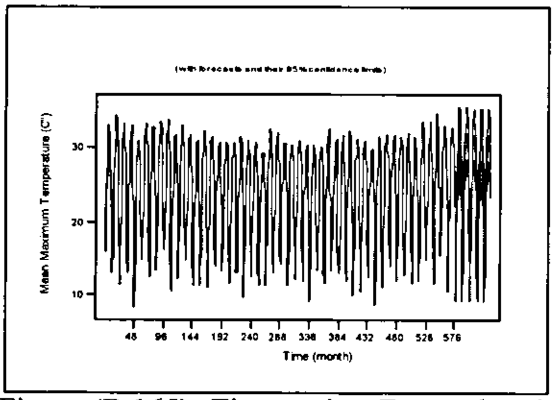
Lag	PAC	T	Lag	PAC	T
1	0.23	5.49	8	-0.03	-0.64
2	0.07	1.59	9	0.02	0.42
3	0.05	1.15	10	0.01	0.34
4	0.06	1.52	11	-0.08	-1.90
5	-0.02	-0.55	12	-0.46	-11.04
6	0.00	0.05			
7	0.01	0.32			

Two. Differenced Data

Three. Residuals for Differenced Data

Figure (B.164): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Maximum Temperature for Irbid Station



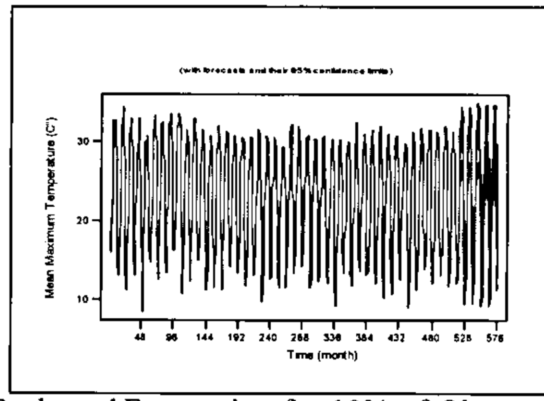
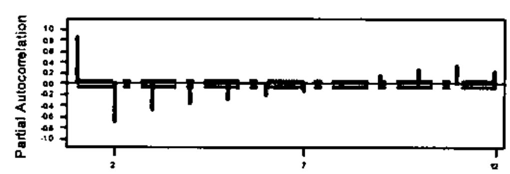


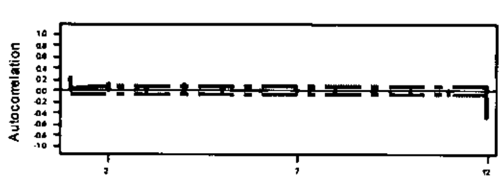
Figure (B.165): Time series, Forward and Backward Forecasting for 10% of Observed Mean Monthly Maximum Temperature for Irbid Station

Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.83	25.80	857.21	8	-0.46	-5.30	3223.06
2	0.46	8.31	882.86	9	-0.01	-0.12	3223.18
3	-0.00	-0.06	882.97	10	0.45	5.06	3421.87
4	-0.45	-8.39	1060.74	11	0.80	8.78	4052.45
5	-0.78	-13.48	1646.56	12	0.84	8.47	4805.12
6	-0.90	-13.24	2426.53				
7	-0.78	-8.66	3017.47				

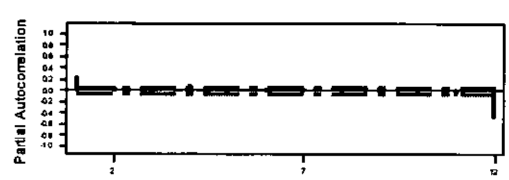


Lag	PAC	T	Lag	PAC	T
1	0.83	25.80	8	-0.04	-1.24
2	-0.69	-21.51	9	0.15	4.51
3	-0.46	-14.34	10	0.27	8.45
4	-0.35	-10.88	11	0.35	10.71
5	-0.31	-9.62	12	0.20	6.30
6	-0.22	-6.92			
7	-0.13	-4.06			

One. Extended Data

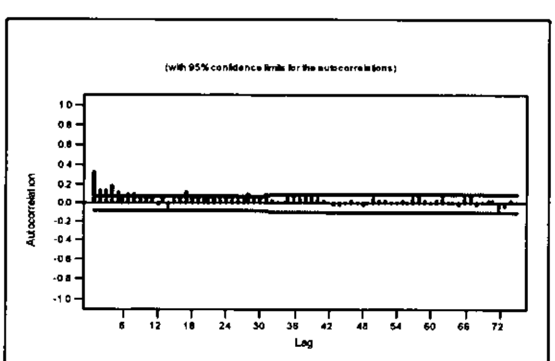


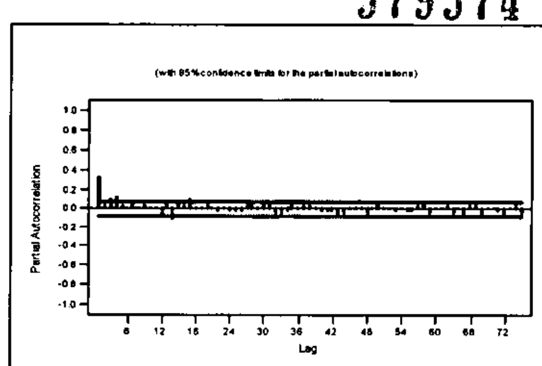
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.23	6.98	48.81	8	-0.04	-1.17	77.69
2	0.10	2.95	58.42	9	-0.02	-0.64	78.17
3	0.07	2.17	63.74	10	-0.01	-0.37	78.33
4	0.11	3.22	75.56	11	-0.08	-2.39	85.05
5	0.02	0.53	75.69	12	-0.48	-13.82	313.88
6	-0.00	-0.05	75.69				
7	0.01	0.40	76.07				



Lag	PAC	T	Lag	PAC	T
1	0.23	6.98	8	-0.06	-1.75
2	0.05	1.59	9	-0.00	-0.04
3	0.04	1.35	10	-0.00	-0.01
4	0.09	2.65	11	-0.08	-2.58
5	-0.03	-0.97	12	-0.48	-14.68
6	-0.02	-0.47			
7	0.01	0.32			

Two. Differenced Extended Data





Three. Residuals for Differenced Extended Data

Figure (B.166): Autocorrelation and Partial Autocorrelation Functions for Extended Amman Mean Monthly Maximum Temperature for Irbid Station

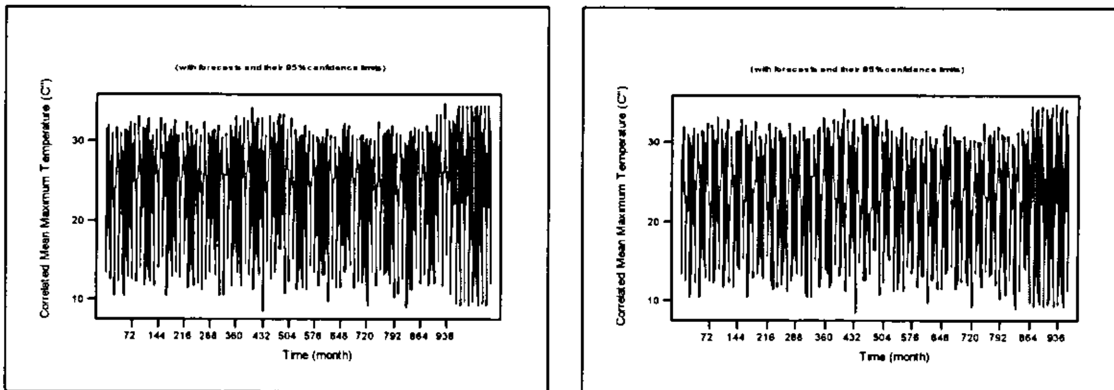


Figure (B.167): Time series, Forward and Backward Forecasting for 10% of Extended Mean Monthly Maximum Temperature for Irbid Station

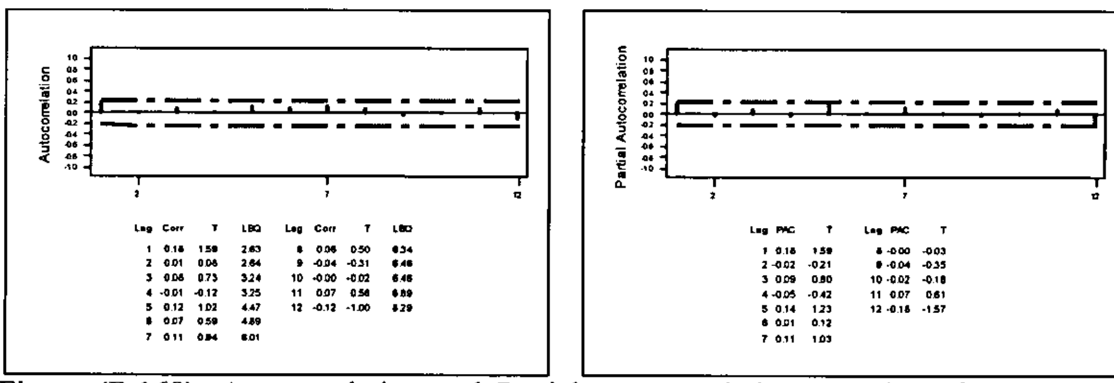


Figure (B.168): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Irbid Station

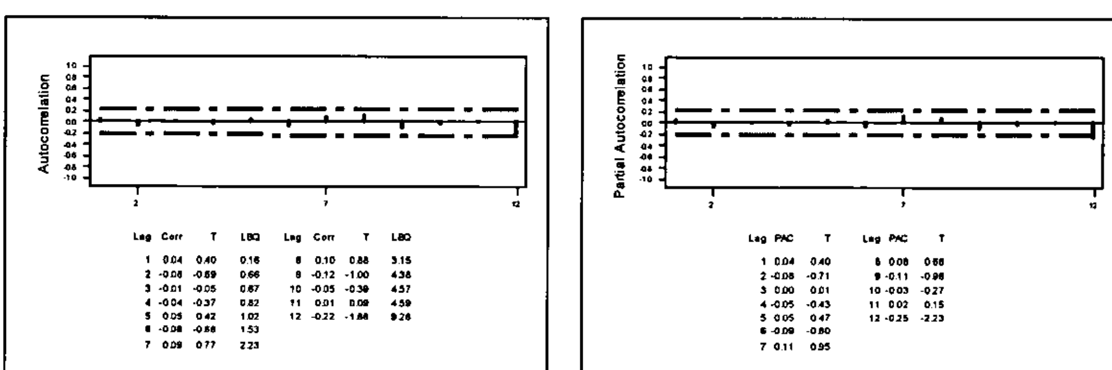
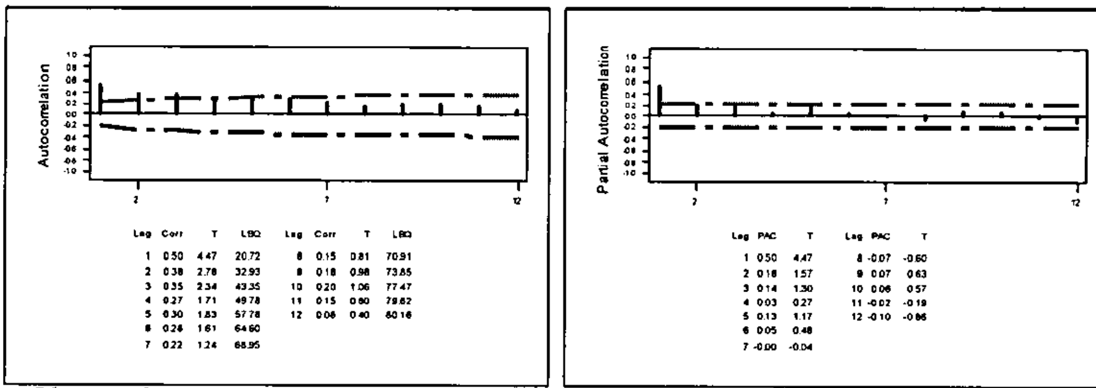
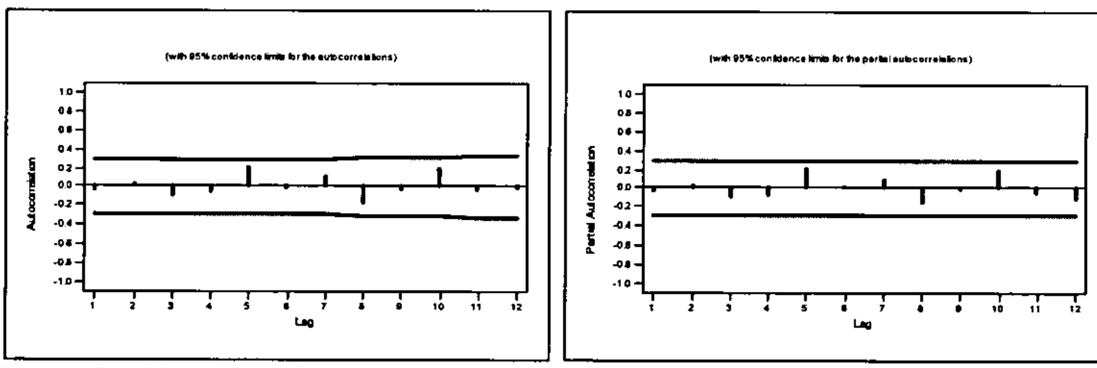


Figure (B.169): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Irbid Station



a. Observed Data



Two. Residuals for Observed Data

Figure (B.170): Autocorrelation and Partial Autocorrelation Functions for Mean Maximum Temperature for the Average of Apr., May and Jun. for Irbid Station

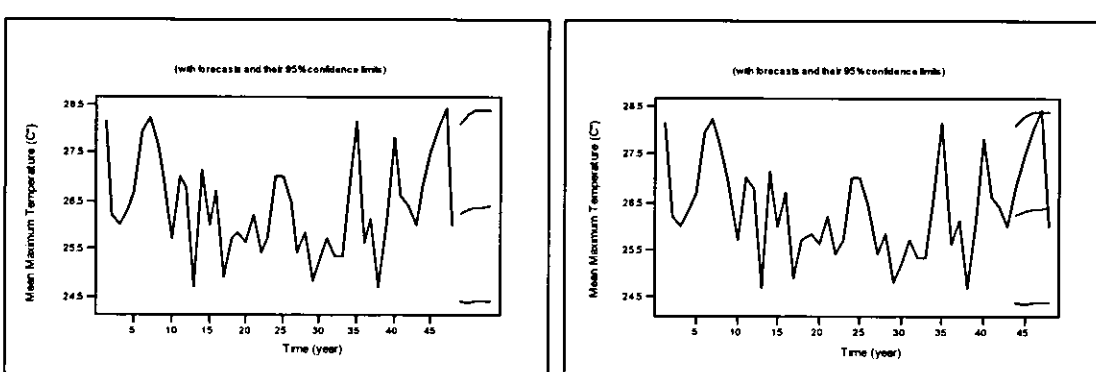
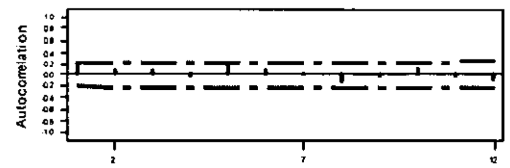
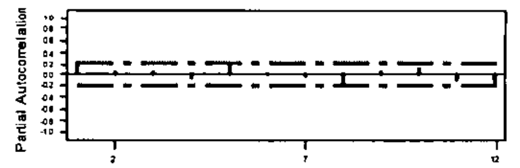


Figure (B.171): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Apr., May and Jun. for Irbid Station

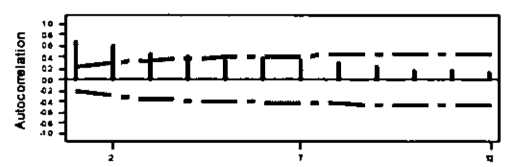


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.22	1.96	3.97	8	-0.13	-1.10	9.54
2	0.07	0.60	4.39	9	-0.05	-0.42	9.79
3	0.07	0.58	4.80	10	0.11	0.88	10.84
4	-0.04	-0.38	4.95	11	-0.05	-0.38	11.05
5	0.17	1.42	7.40	12	-0.11	-0.89	12.24
6	0.07	0.62	7.90				
7	0.00	0.02	7.90				

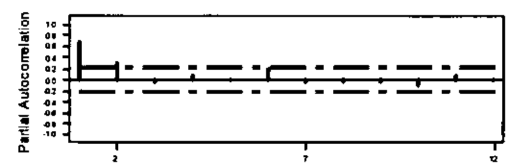


Lag	PAC	T	Lag	PAC	T
1	0.22	1.96	8	-0.16	-1.58
2	0.02	0.21	9	0.05	0.40
3	0.05	0.46	10	0.11	0.97
4	-0.07	-0.65	11	-0.10	-0.88
5	0.20	1.77	12	-0.14	-1.21
6	-0.00	-0.03			
7	-0.02	-0.17			

Figure (B.172): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Apr., May and Jun. for Irbid Station

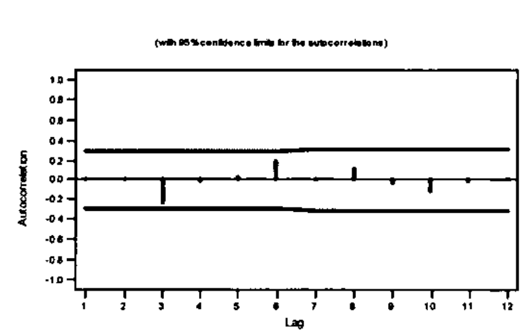


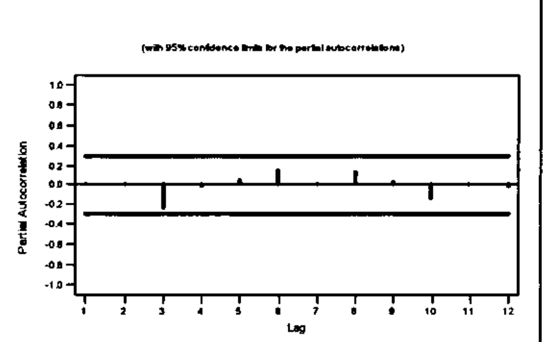
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.64	5.77	34.51	8	0.28	1.31	129.87
2	0.58	3.81	62.50	9	0.22	1.00	134.63
3	0.43	2.44	78.30	10	0.15	0.87	136.82
4	0.40	2.11	92.10	11	0.14	0.83	138.81
5	0.32	1.60	100.99	12	0.13	0.56	140.39
6	0.38	1.84	113.71				
7	0.31	1.45	122.44				



Lag	PAC	T	Lag	PAC	T
1	0.64	5.77	8	-0.03	-0.29
2	0.28	2.47	9	-0.02	-0.20
3	-0.03	-0.27	10	-0.10	-0.90
4	0.08	0.78	11	0.07	0.59
5	-0.00	-0.02	12	-0.00	-0.03
6	0.19	1.70			
7	-0.02	-0.18			

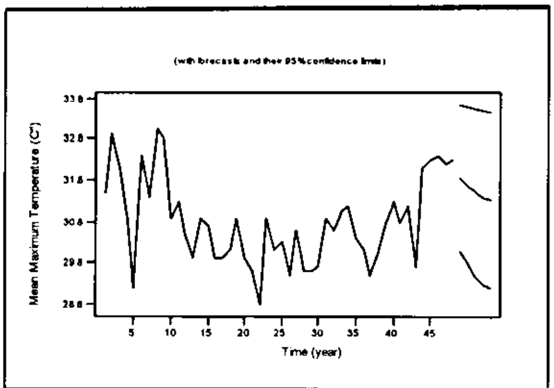
a. Observed Data





Three. Residuals for Observed Data

Figure (B.173): Autocorrelation and Partial Autocorrelation Functions for Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station



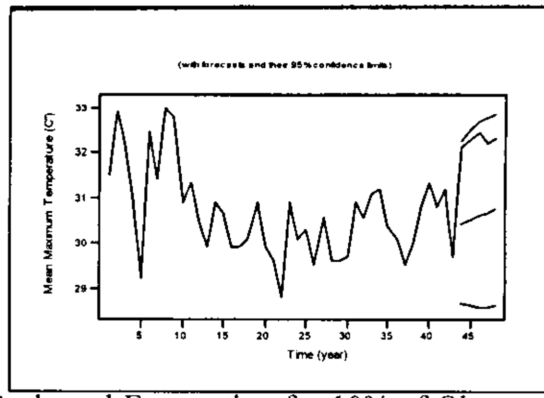
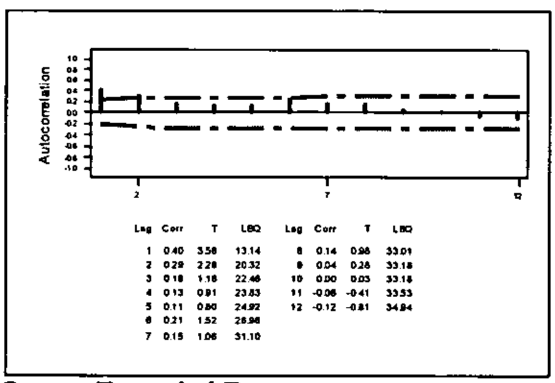
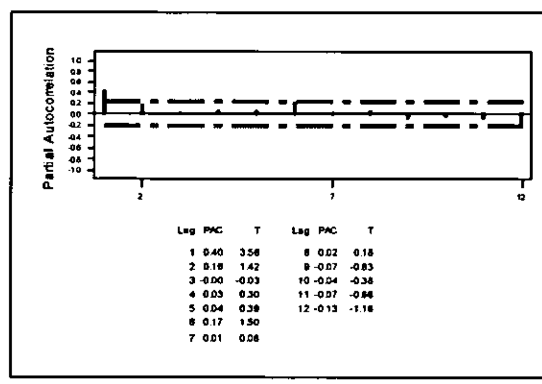
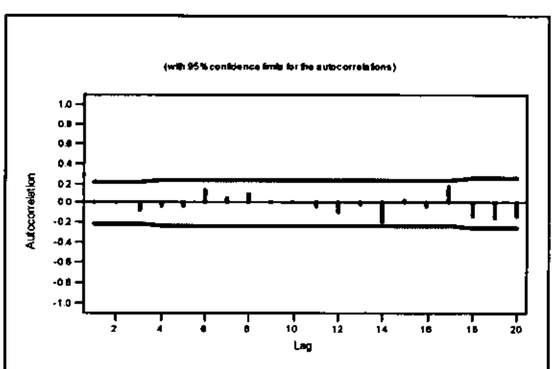


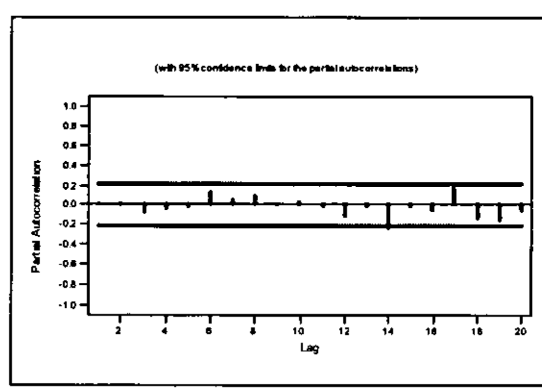
Figure (B.174): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station





One. Extended Data





b. Residuals for Extended Data

Figure (B.175): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station

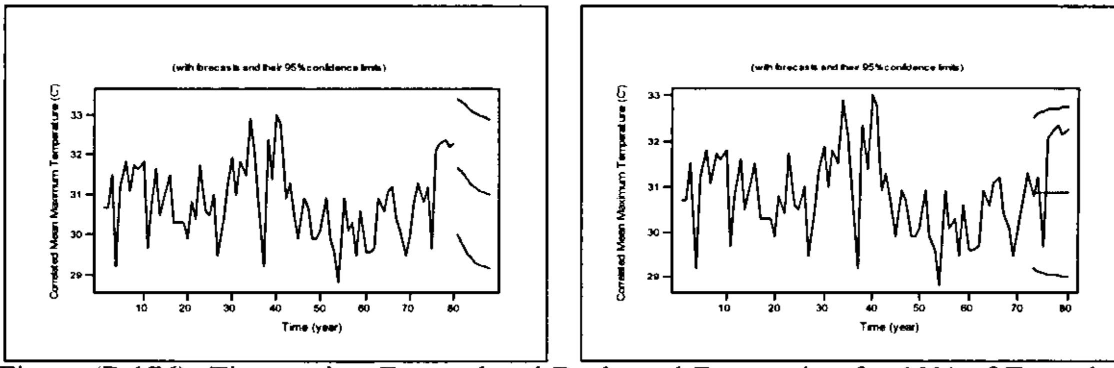
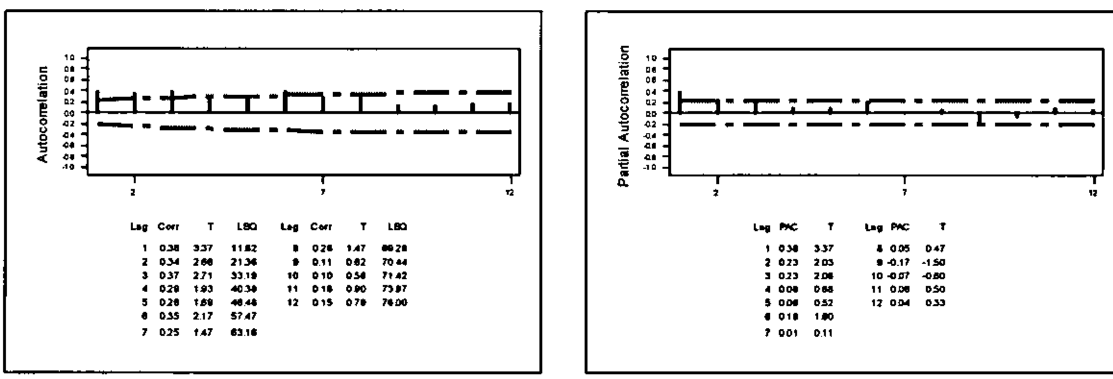
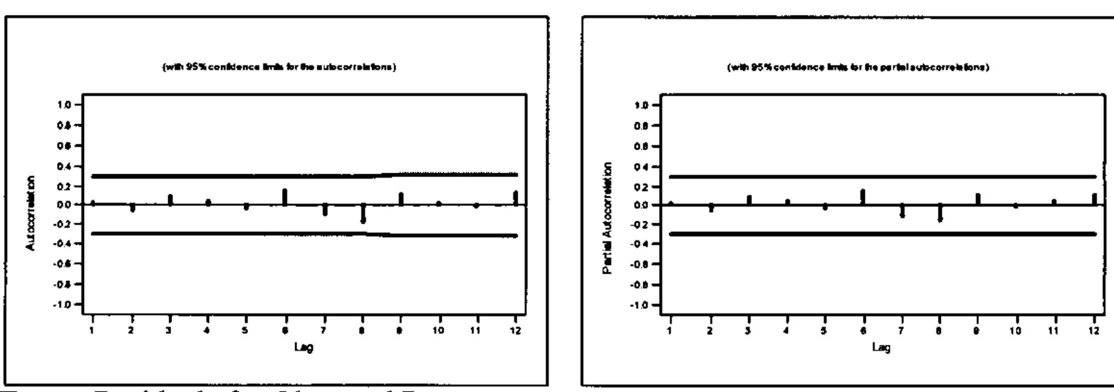


Figure (B.176): Time series, Forward and Backward Forecasting for 10% of Extended Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station



One. Observed Data



Two. Residuals for Observed Data

Figure (B.177): Autocorrelation and Partial Autocorrelation Functions for Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Irbid Station

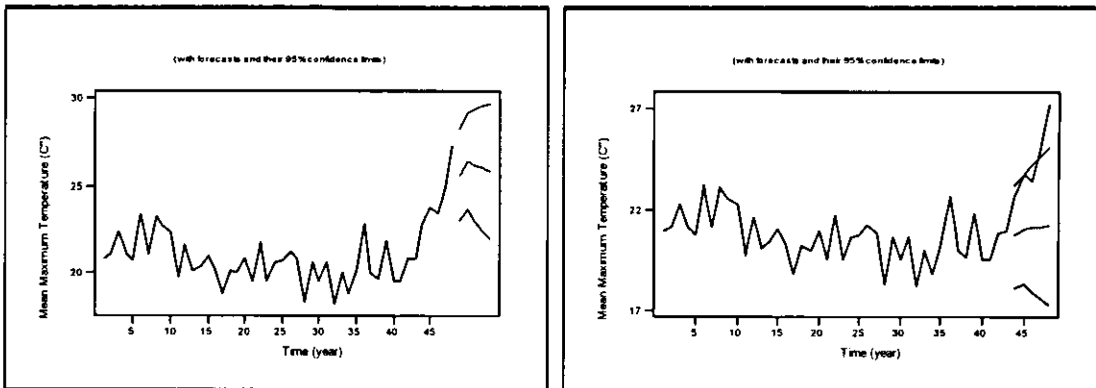
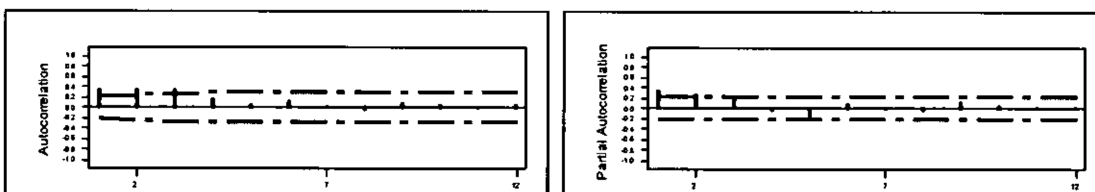


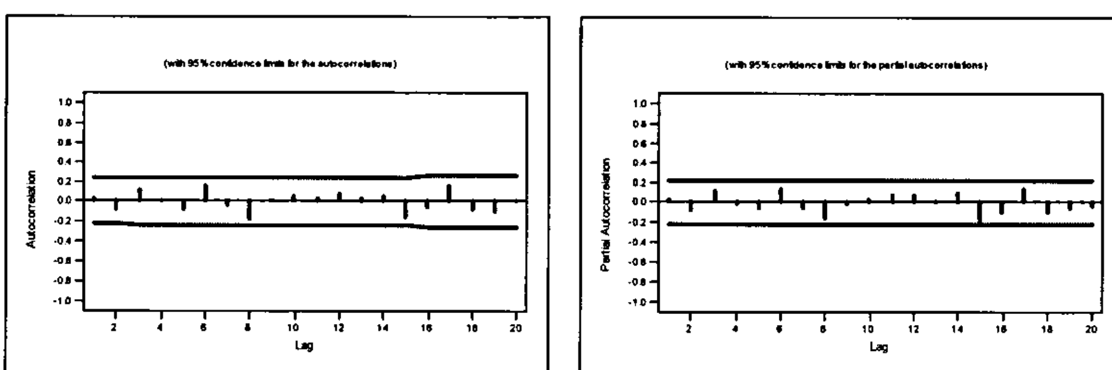
Figure (B.178): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Irbid Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.33	2.97	9.18	8	-0.04	-0.24	32.40
2	0.35	2.61	19.28	9	0.06	0.54	33.00
3	0.33	2.47	28.80	10	0.03	0.22	33.10
4	0.18	1.12	31.10	11	0.01	0.08	33.11
5	0.02	0.15	31.15	12	0.05	0.35	33.37
6	0.11	0.78	32.27				
7	0.01	0.08	32.29				

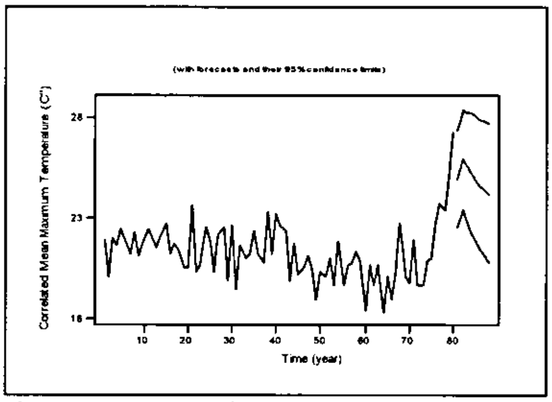
Lag	PAC	T	Lag	PAC	T
1	0.33	2.97	8	-0.03	-0.31
2	0.27	2.38	9	0.10	0.87
3	0.19	1.74	10	0.02	0.18
4	-0.05	-0.47	11	-0.01	-0.08
5	-0.18	-1.58	12	-0.01	-0.08
6	0.08	0.55			
7	0.00	0.02			

One. Extended Data



b. Residuals for Extended Data

Figure (B.179): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Irbid Station



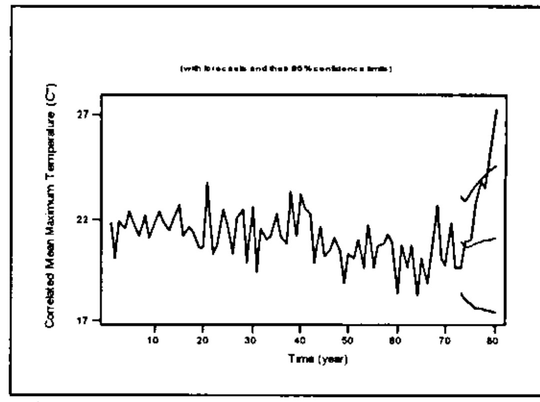
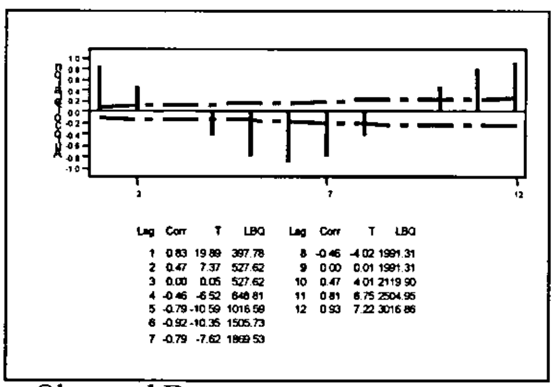
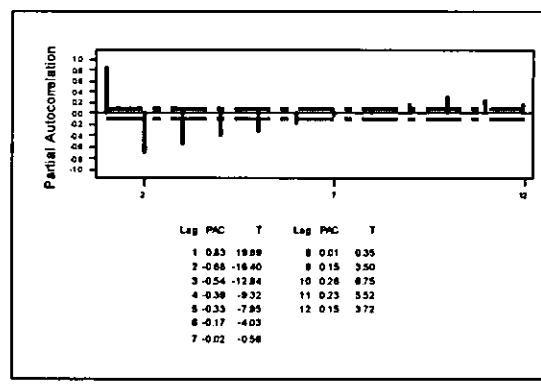
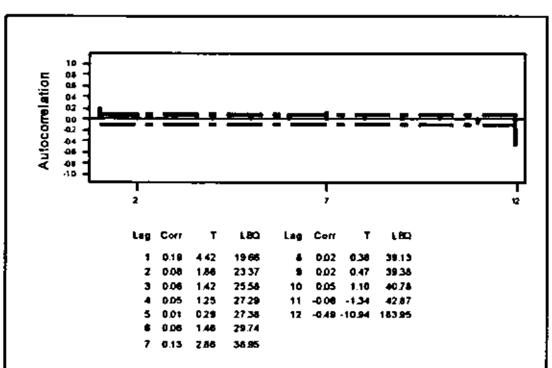


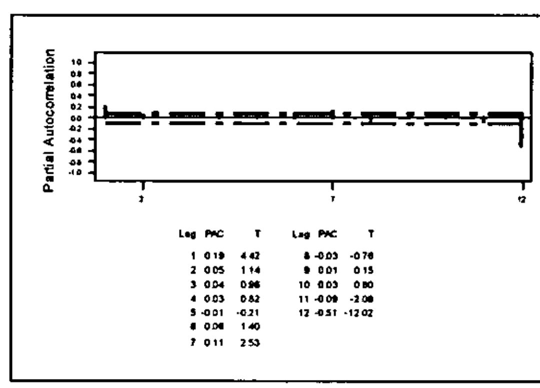
Figure (B.180): Time series, Forward and Backward Forecasting for 10% of Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Irbid Station



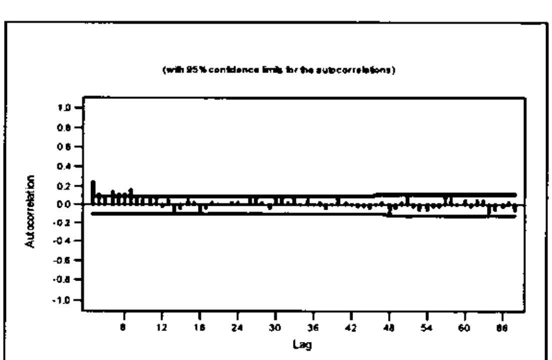


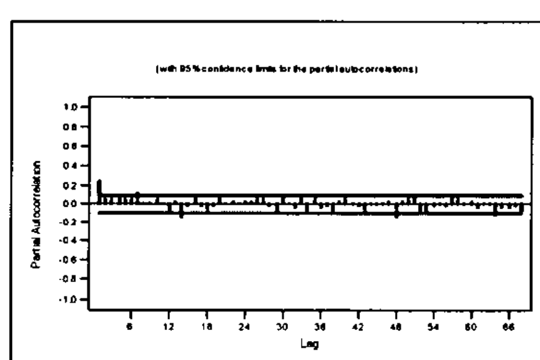
a. Observed Data





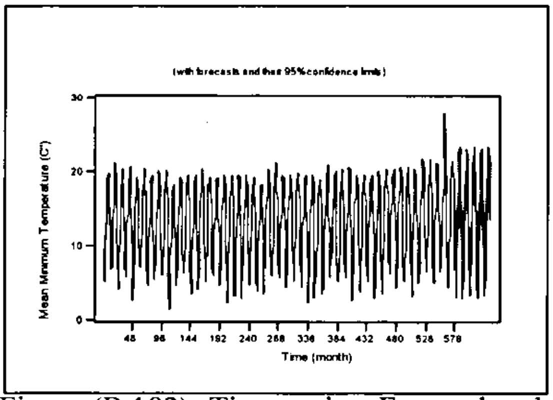
b. Differenced Data





Two. Residuals for Differenced Data

Figure (B.181): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Minimum Temperature for Irbid Station



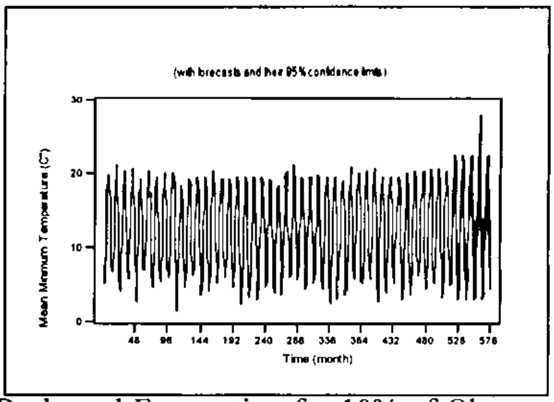
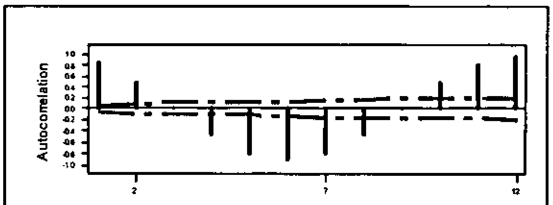
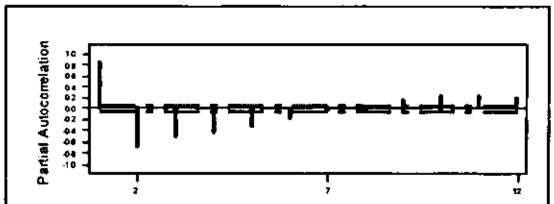


Figure (B.182): Time series, Forward and Backward Forecasting for 10% of Observed Mean Monthly Minimum Temperature for Irbid Station

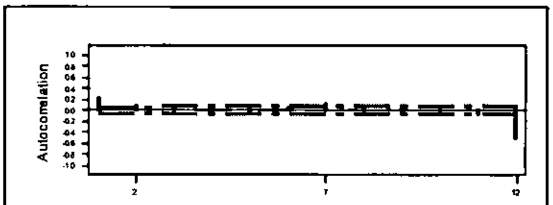


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.83	25.77	666.03	8	-0.46	-5.23	3378.32
2	0.47	8.51	882.50	9	0.00	0.01	3378.32
3	0.00	0.08	882.51	10	0.47	5.15	3592.86
4	-0.46	-8.52	1088.55	11	0.81	8.89	4237.54
5	-0.80	-13.81	1715.94	12	0.94	9.33	5096.97
6	-0.93	-13.46	2548.14				
7	-0.80	-8.90	3169.14				

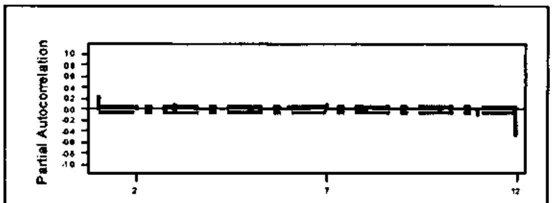


Lag	PAC	T	Lag	PAC	T
1	0.83	25.77	8	-0.00	-0.08
2	-0.71	-21.88	9	0.16	4.87
3	-0.52	-16.23	10	0.24	7.35
4	-0.44	-13.60	11	0.24	7.34
5	-0.34	-10.53	12	0.18	5.64
6	-0.18	-5.56			
7	-0.05	-1.69			

One. Extended Data

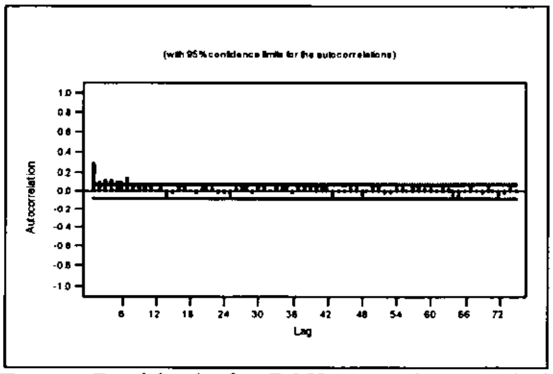


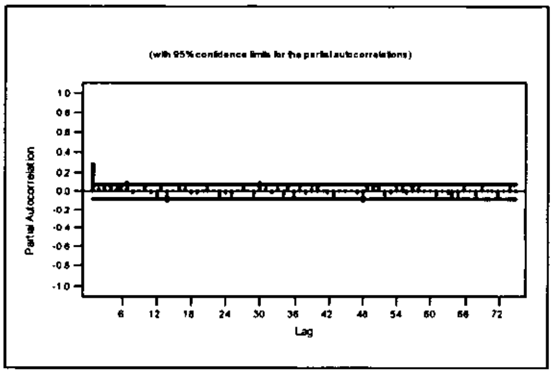
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.20	6.24	39.10	8	-0.01	-0.26	64.45
2	0.07	2.20	44.38	9	-0.02	-0.67	64.87
3	0.08	2.45	51.00	10	0.01	0.33	65.10
4	0.05	1.58	53.78	11	-0.08	-2.42	71.87
5	-0.02	-0.59	54.17	12	-0.50	-14.35	312.37
6	0.04	1.02	55.34				
7	0.10	2.83	64.37				



Lag	PAC	T	Lag	PAC	T
1	0.20	6.24	8	-0.05	-1.41
2	0.03	1.07	9	-0.02	-0.74
3	0.06	1.98	10	0.01	0.26
4	0.02	0.75	11	-0.09	-2.84
5	-0.04	-1.35	12	-0.49	-15.06
6	0.04	1.26			
7	0.08	2.61			

b. Differenced Extended Data





Two. Residuals for Differenced Extended Data

Figure (B.183): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Monthly Minimum Temperature for Irbid Station

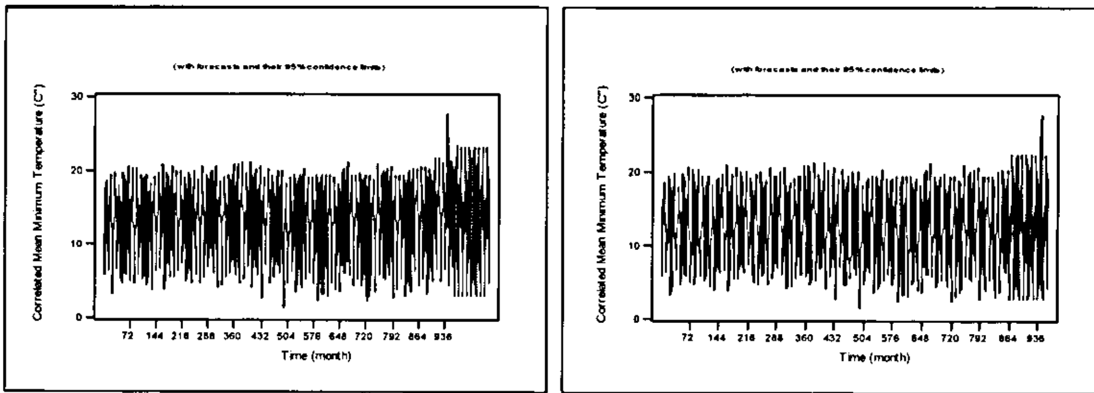


Figure (B.184): Time series, Forward and Backward Forecasting for 10% of Extended Monthly Mean Minimum Temperature for Irbid Station

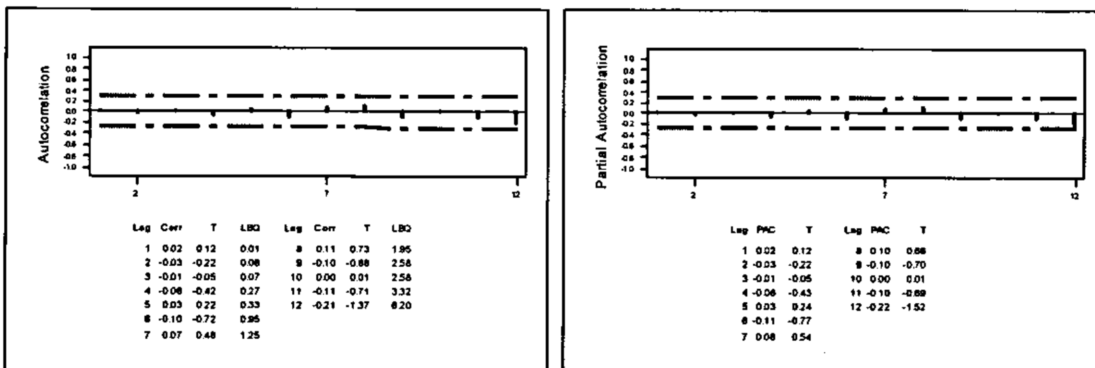


Figure (B.185): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Irbid Station

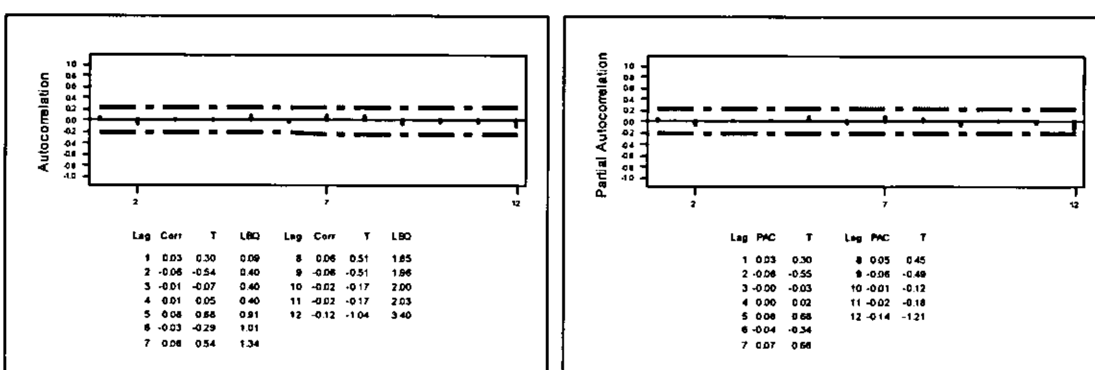
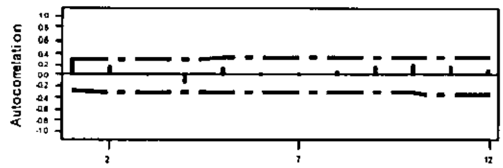
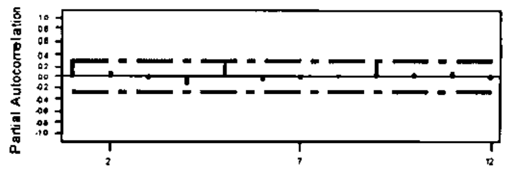


Figure (B.186): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Irbid Station

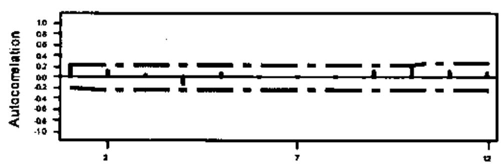


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.28	1.83	3.96	8	0.03	0.16	8.97
2	0.15	0.95	5.08	9	0.14	0.85	8.14
3	0.01	0.08	5.09	10	0.18	1.08	10.12
4	-0.15	-0.93	8.27	11	0.15	0.90	11.62
5	0.11	0.67	8.91	12	0.06	0.33	11.83
6	-0.02	-0.11	8.93				
7	0.00	0.01	8.93				

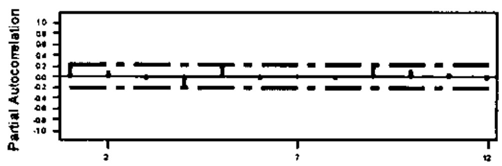


Lag	PAC	T	Lag	PAC	T
1	0.28	1.93	8	0.01	0.10
2	0.08	0.52	9	0.22	1.53
3	-0.05	-0.34	10	0.05	0.32
4	-0.16	-1.14	11	0.06	0.41
5	0.21	1.47	12	-0.03	-0.21
6	-0.07	-0.49			
7	-0.02	-0.15			

Figure (B.187): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Apr., May and Jun. for Irbid Station

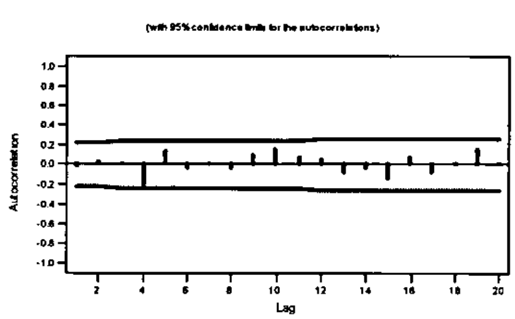


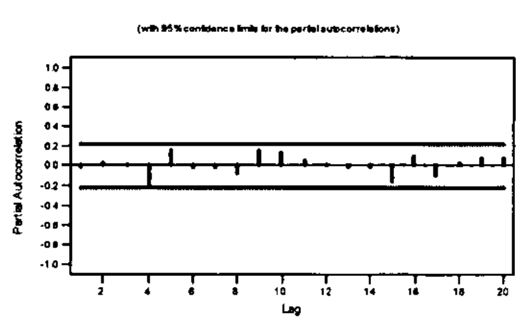
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.24	2.12	4.87	8	0.00	0.03	8.86
2	0.12	1.05	5.95	9	0.12	0.97	9.88
3	0.02	0.17	5.99	10	0.19	1.49	13.20
4	-0.15	-1.25	7.91	11	0.12	0.92	14.52
5	0.09	0.75	8.84	12	0.06	0.43	14.82
6	-0.01	-0.12	8.85				
7	0.01	0.06	8.86				



Lag	PAC	T	Lag	PAC	T
1	0.24	2.12	8	-0.03	-0.26
2	0.07	0.64	9	0.19	1.74
3	-0.02	-0.22	10	0.10	0.82
4	-0.17	-1.50	11	0.03	0.27
5	0.18	1.57	12	-0.03	-0.27
6	-0.04	-0.40			
7	-0.00	-0.02			

a. Extended Data





b. Residuals for Extended Data

Figure (B.188): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Apr., May and Jun. for Irbid Station

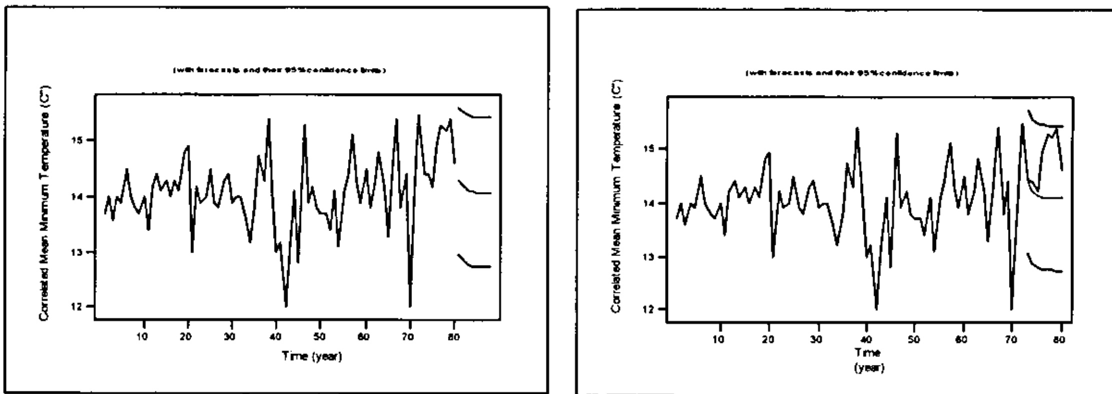
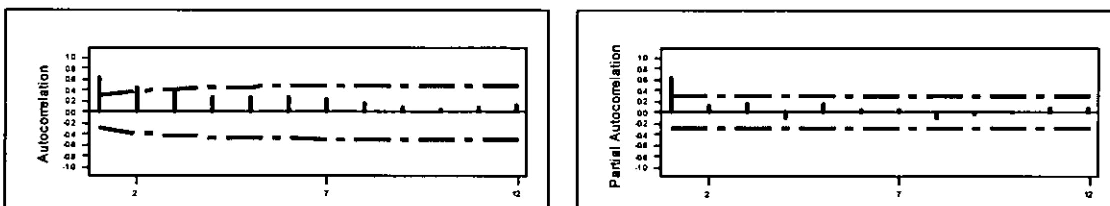


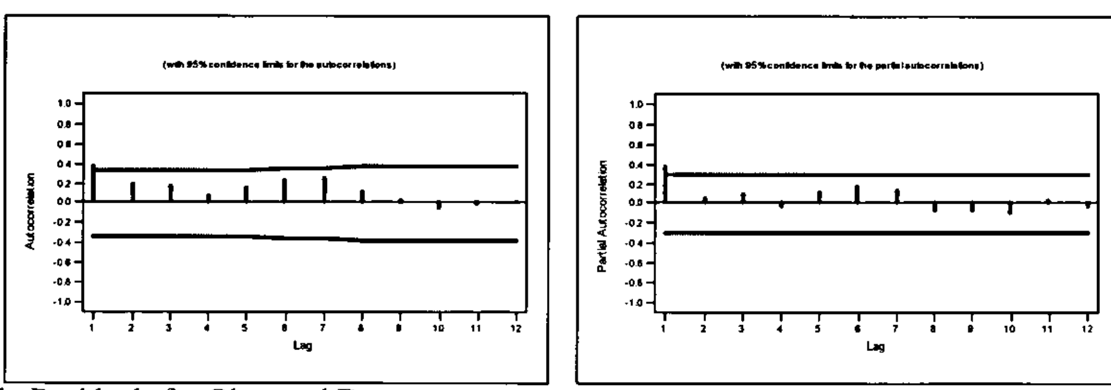
Figure (B.189): Time series, Forward and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Apr., May and Jun. for Irbid Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.61	4.20	18.77	8	0.14	0.57	51.90
2	0.45	2.34	28.13	9	0.07	0.28	52.19
3	0.39	1.87	37.44	10	0.05	0.18	52.33
4	0.24	1.08	40.70	11	0.07	0.27	52.62
5	0.25	1.10	44.30	12	0.12	0.47	53.55
6	0.25	1.06	47.90				
7	0.22	0.91	50.73				

Lag	PAC	T	Lag	PAC	T
1	0.61	4.20	8	-0.11	-0.78
2	0.12	0.86	9	-0.05	-0.38
3	0.13	0.92	10	0.00	0.03
4	-0.10	-0.71	11	0.06	0.54
5	0.13	0.93	12	0.09	0.58
6	0.05	0.36			
7	0.04	0.28			

a. Observed Data



b. Residuals for Observed Data

Figure (B.190): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station

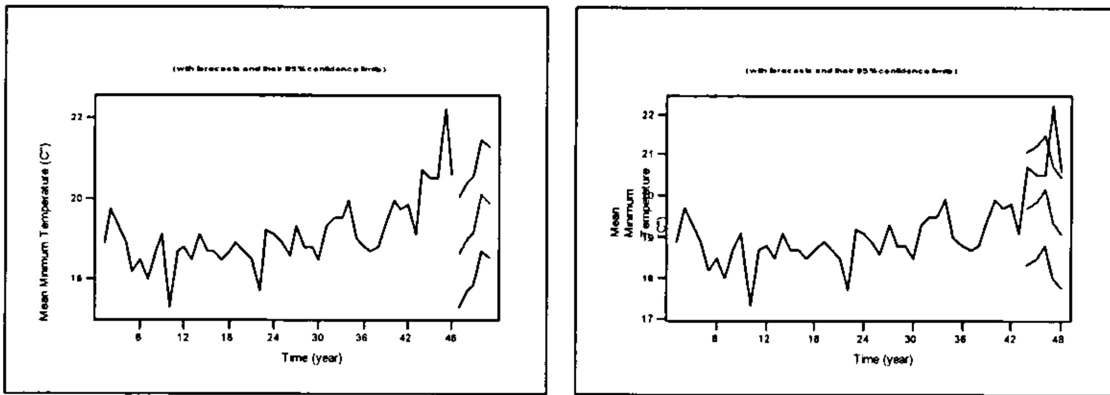
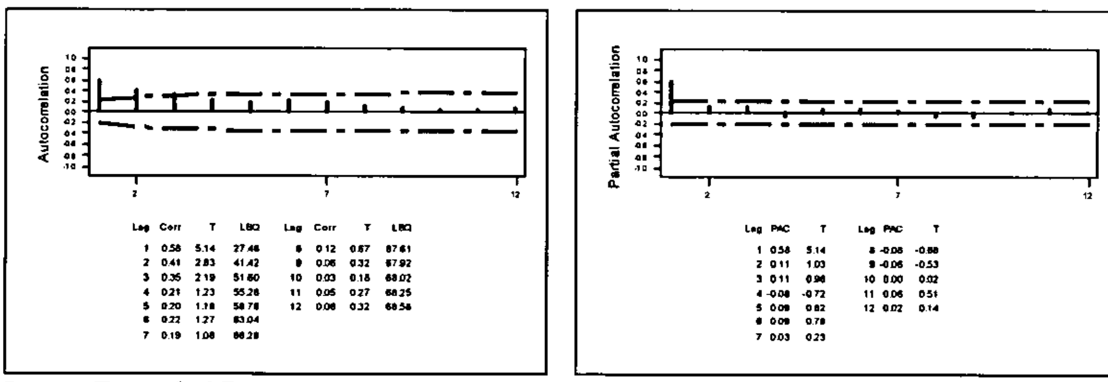
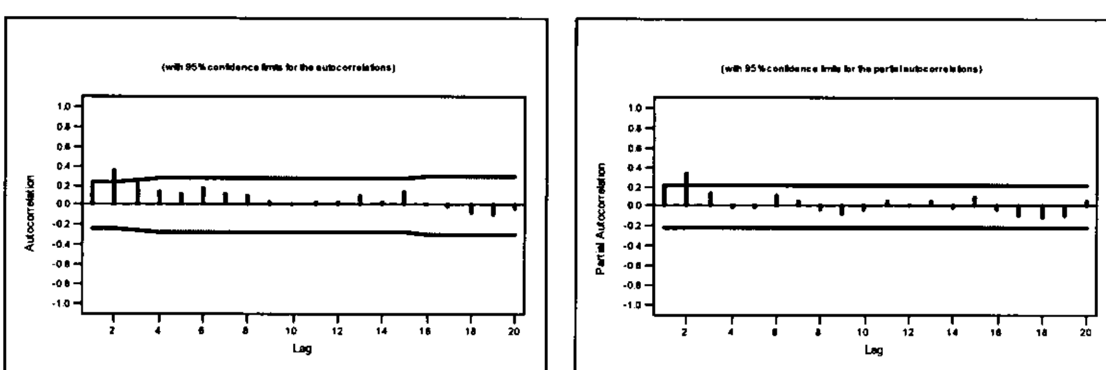


Figure (B.191): Time series, Forward and Backward Forecasting for 10% of Observed Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station



One. Extended Data



b. Residuals Extended Data

Figure (B.192): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station

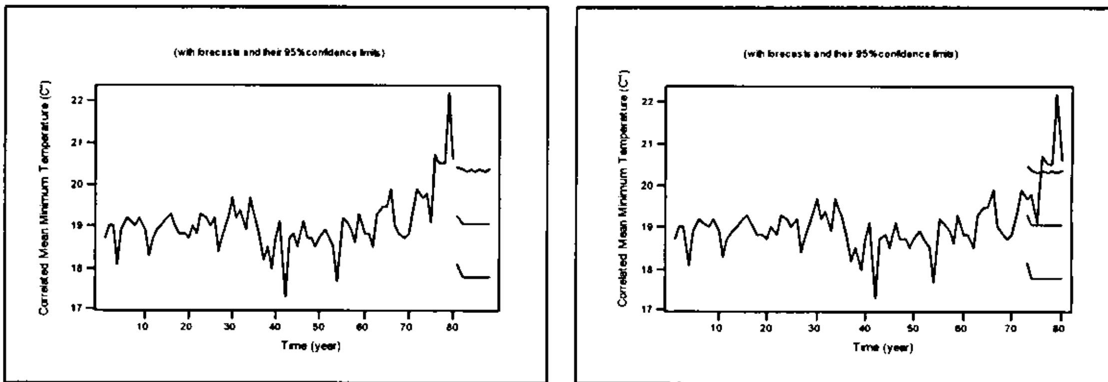


Figure (B.193): Time series, Forward and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Irbid Station

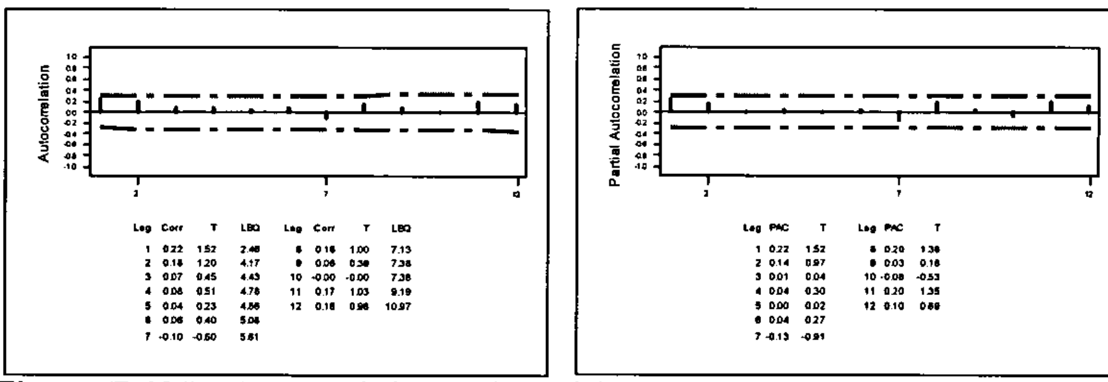


Figure (B.194): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Irbid Station

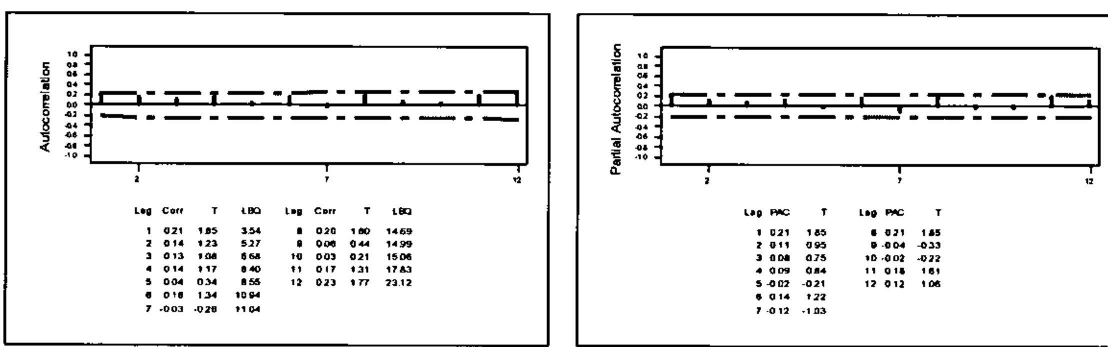
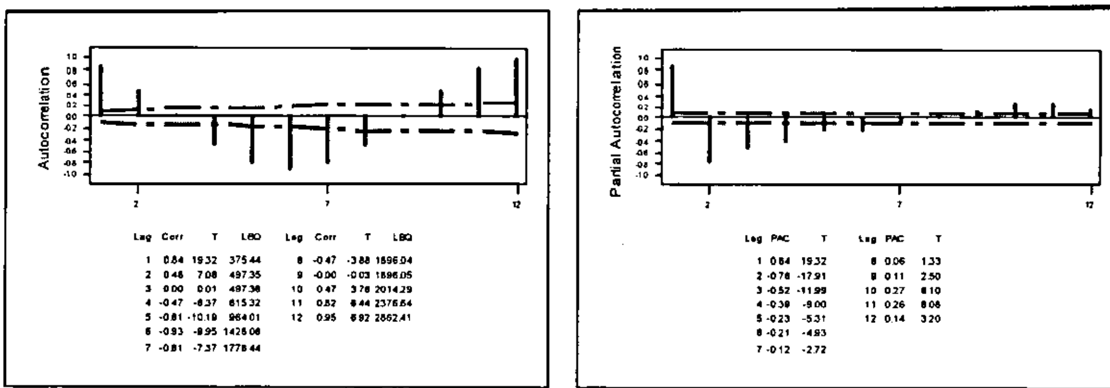
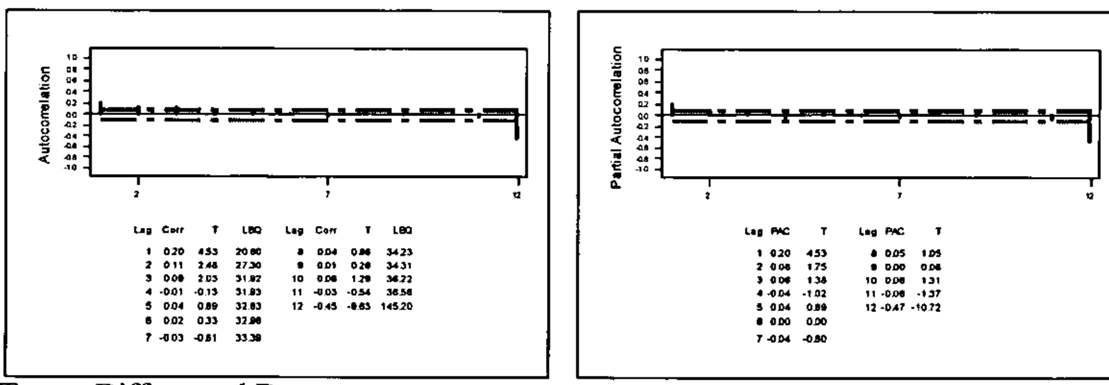


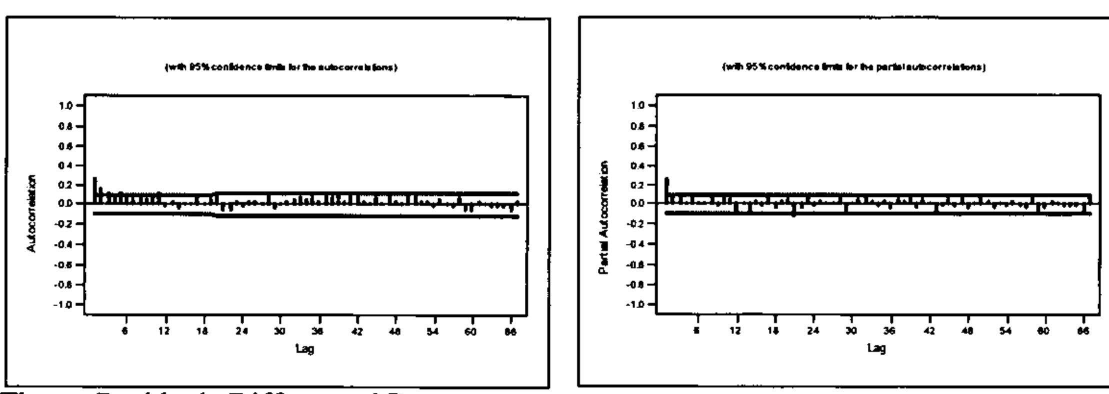
Figure (B.195): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Irbid Station



a. Observed Data



Two. Differenced Data



Three. Residuals Differenced Data

Figure (B.196): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Maximum Temperature for Aqaba Airport Station

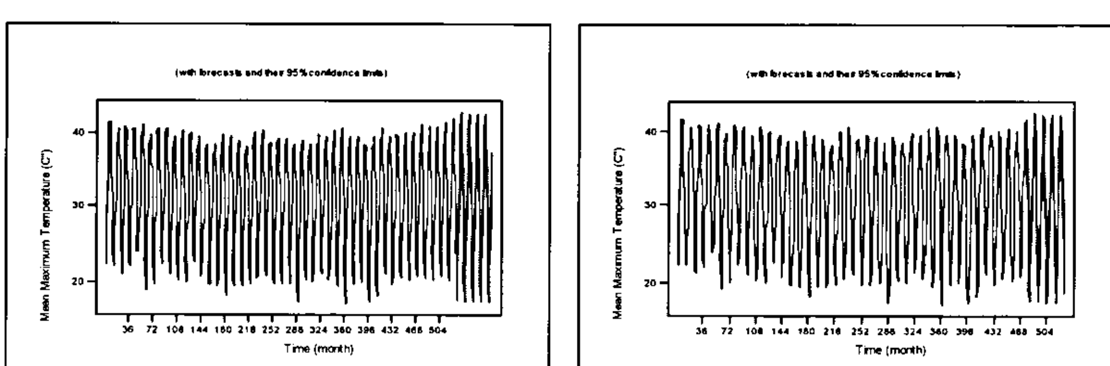
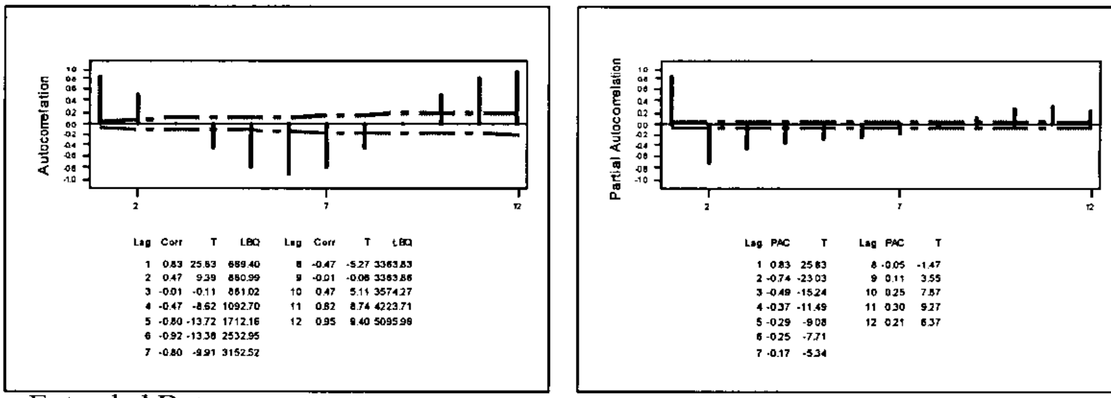
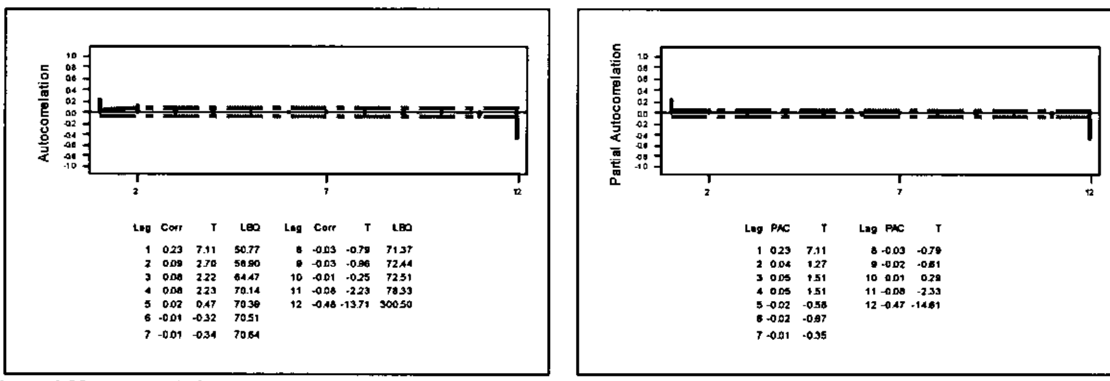


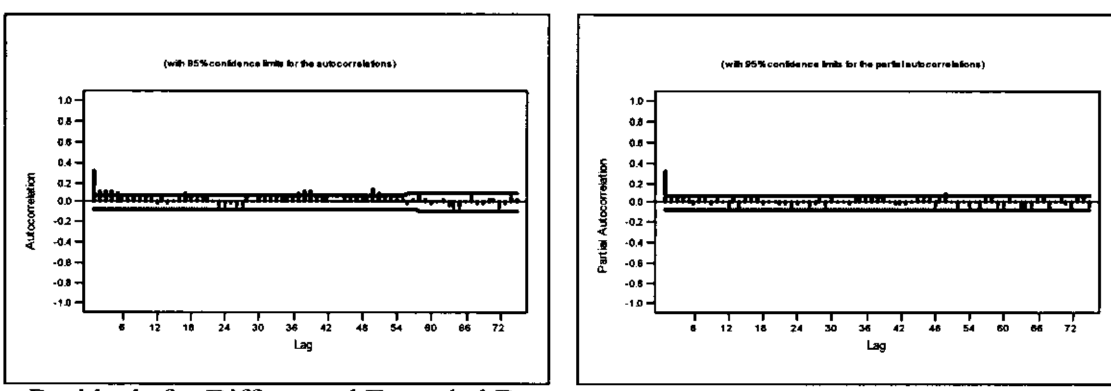
Figure (B.197): Time series, Forward and Backward Forecasting for 10% of Observed Mean Monthly Maximum Temperature for Aqaba Airport Station



a. Extended Data



b. Differenced for Extended Data



c. Residuals for Differenced Extended Data

Figure (B.198): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Monthly Maximum Temperature for Aqaba Airport Station

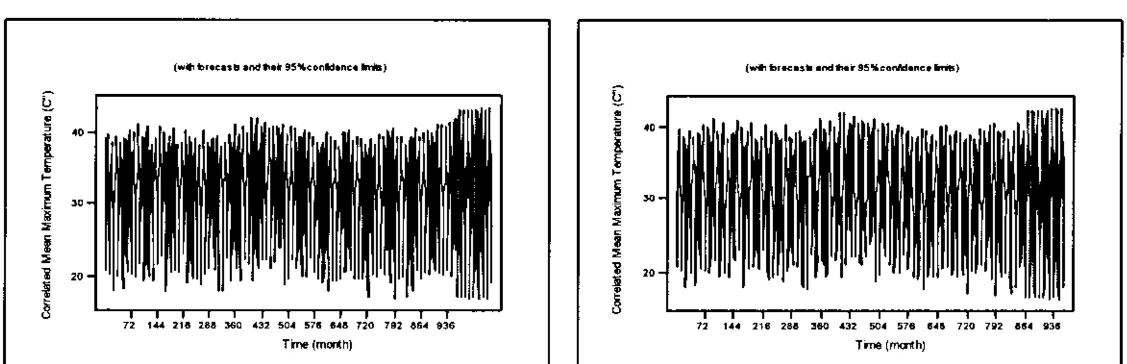
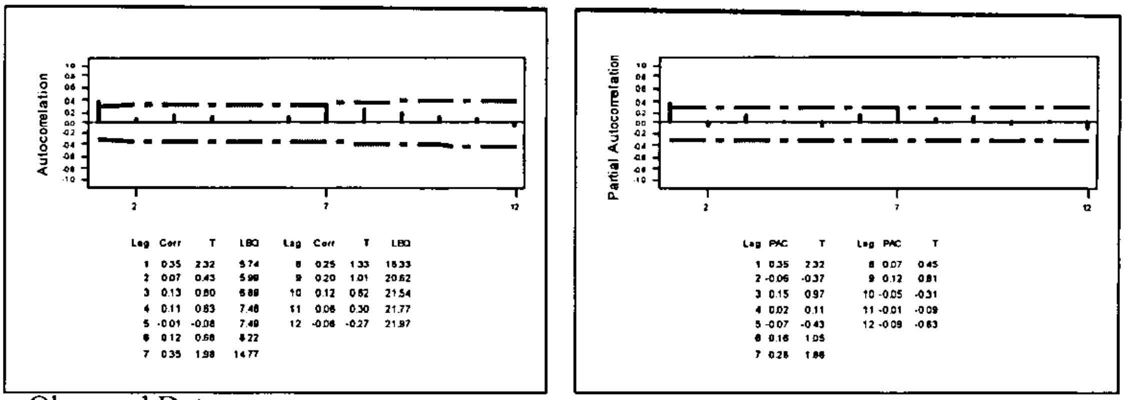
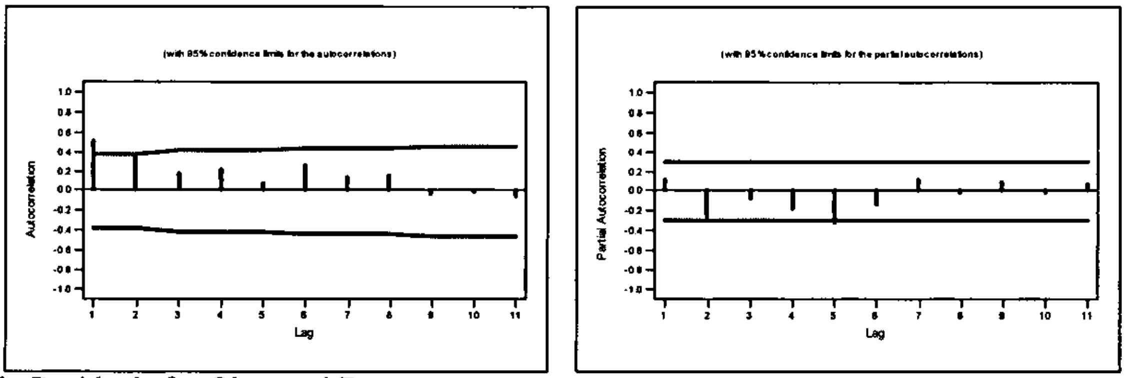


Figure (B.199): Time series, Forward and Backward Forecasting for 10% of Extended Mean Monthly Maximum Temperature for Aqaba Airport Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.200): Autocorrelation and Partial Autocorrelation Functions for Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Aqaba Airport Station

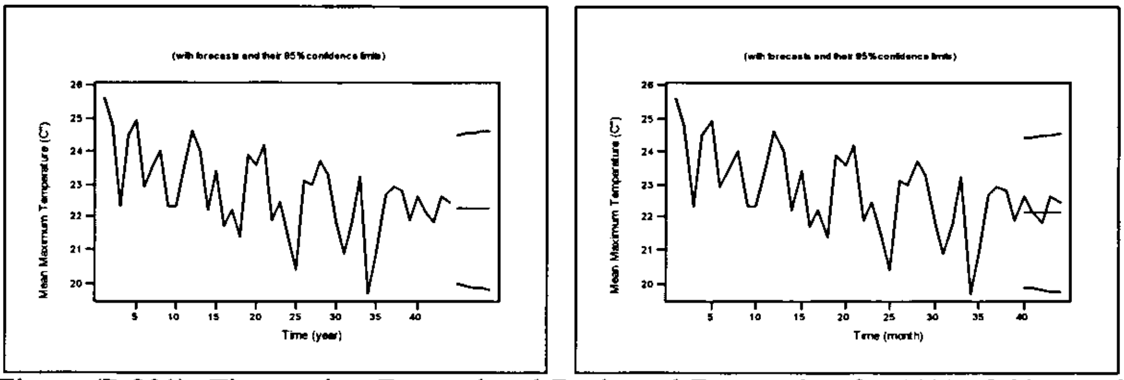
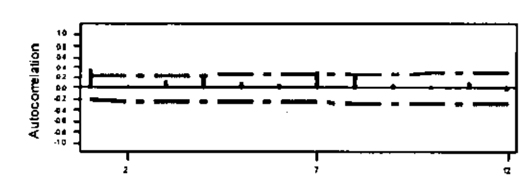
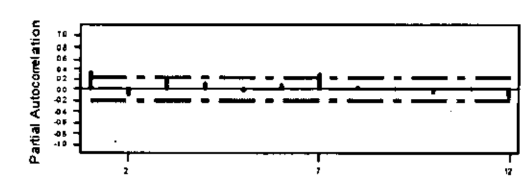


Figure (B.201): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Aqaba Airport Station

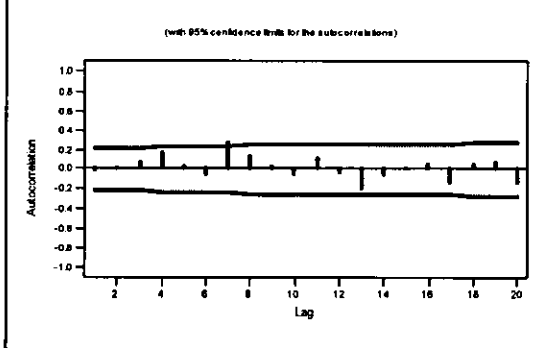


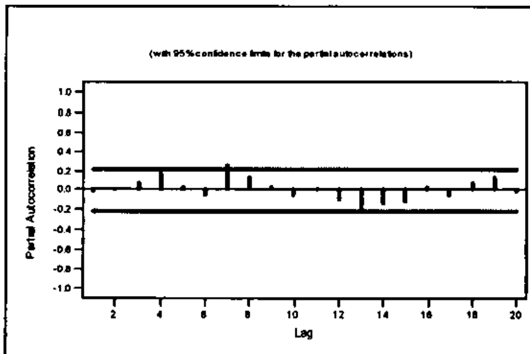
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.32	2.83	8.32	8	0.24	1.76	27.84
2	-0.01	-0.08	8.32	9	0.05	0.35	28.08
3	0.12	1.02	9.64	10	-0.01	-0.05	28.08
4	0.21	1.72	13.57	11	0.09	0.63	28.85
5	0.08	0.48	13.88	12	-0.04	-0.30	29.04
6	0.04	0.30	14.01				
7	0.31	2.37	22.45				



Lag	PAC	T	Lag	PAC	T
1	0.32	2.83	8	0.03	0.30
2	-0.12	-1.09	9	0.01	0.05
3	0.19	1.68	10	-0.06	-0.52
4	0.12	1.10	11	0.00	0.03
5	-0.04	-0.35	12	-0.16	-1.48
6	0.06	0.51			
7	0.28	2.54			

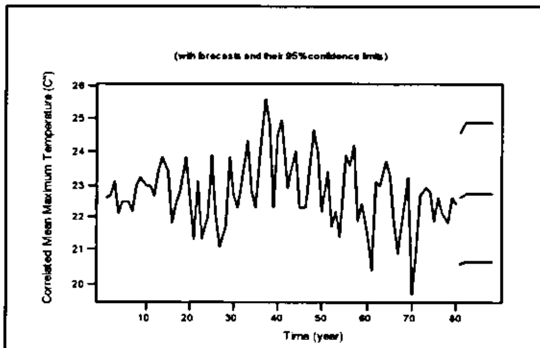
One. Extended Data





Two. Residuals for Extended Data

Figure (B.202): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Aqaba Airport Station



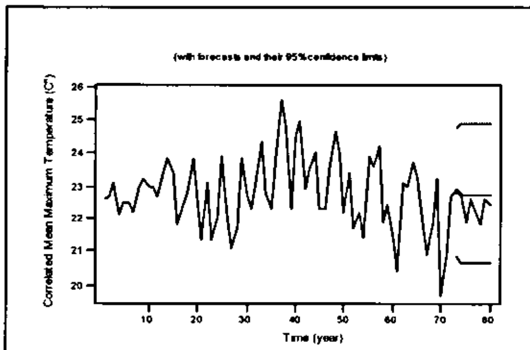
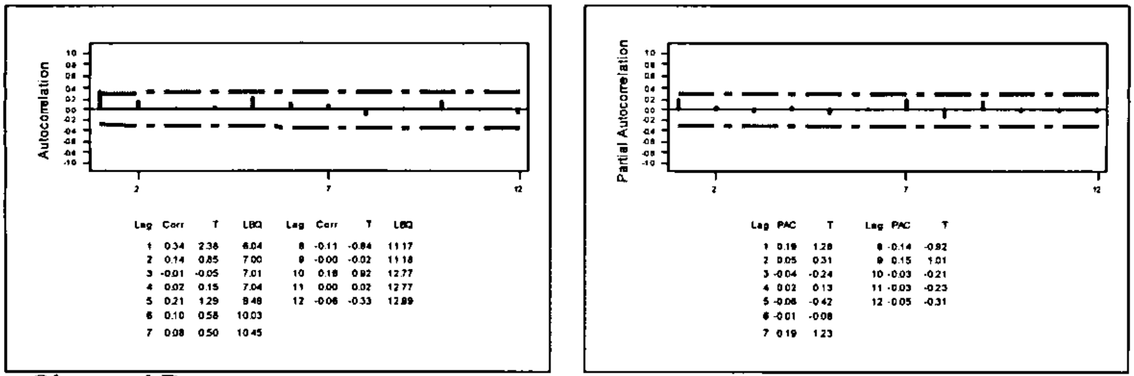
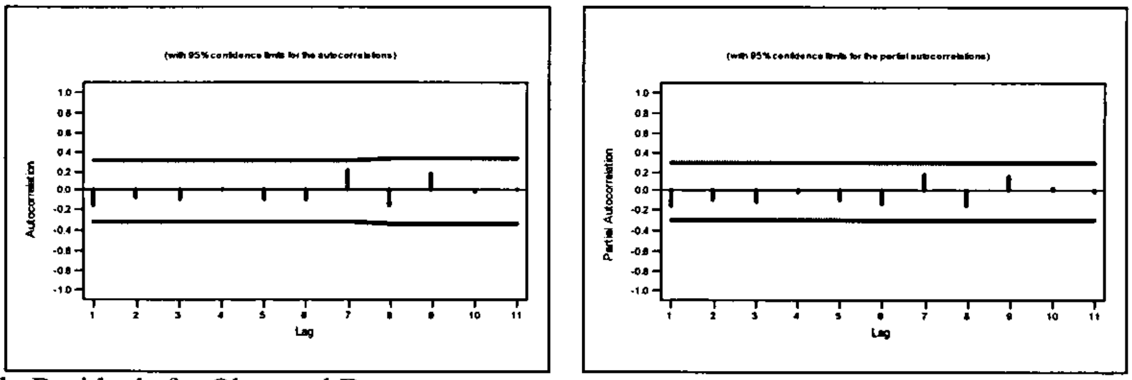


Figure (B.203): Time series, Forward and Backward Forecasting for 10% of Extended Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Aqaba Airport Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.204): Autocorrelation and Partial Autocorrelation Functions for Mean Maximum Temperature for the Average of Apr., May and Jun. for Aqaba Airport Station

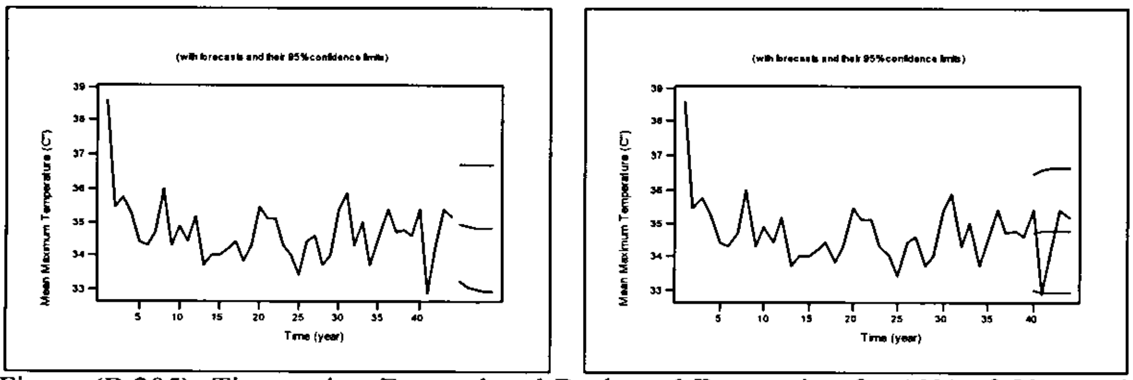
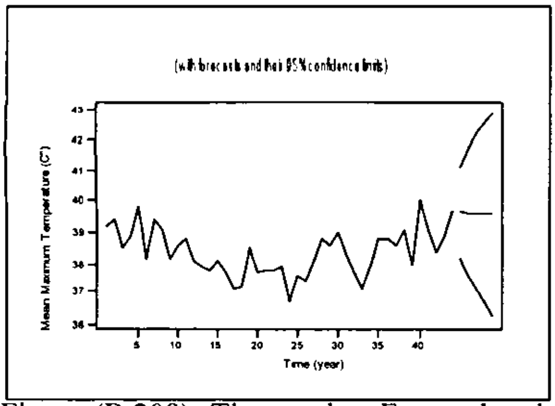


Figure (B.205): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Apr.,May and Jun. for Aqaba Airport Station



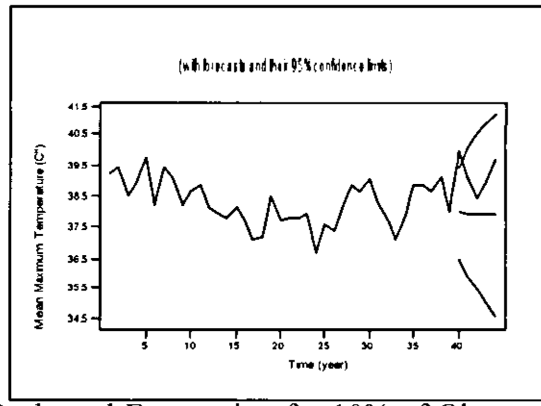
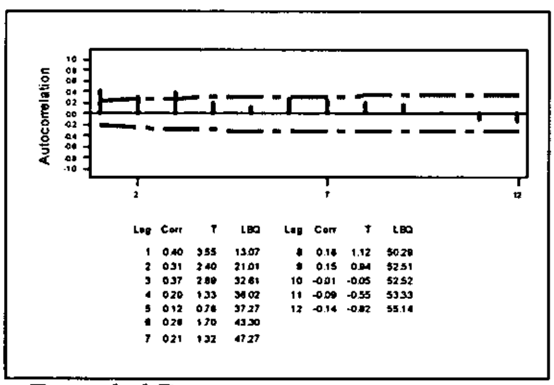
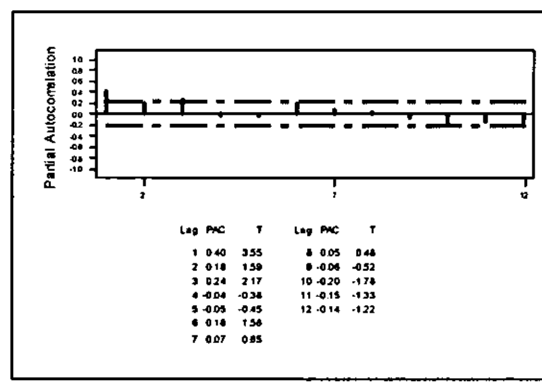
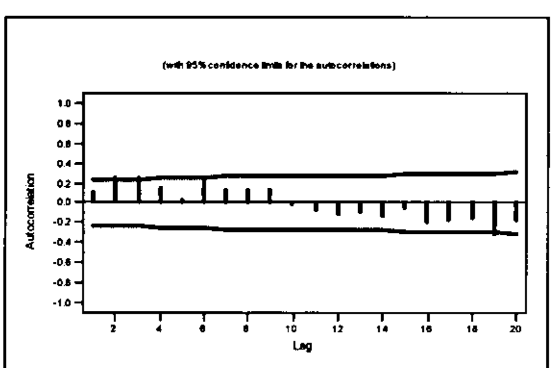


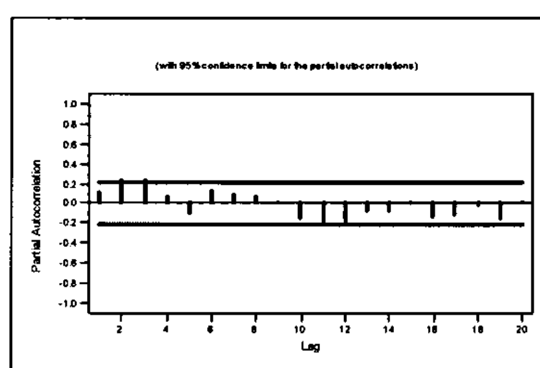
Figure (B.208): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Aqaba Airport Station





a. Extended Data





b. Residuals for Extended Data

Figure (B.209): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Aqaba Airport Station

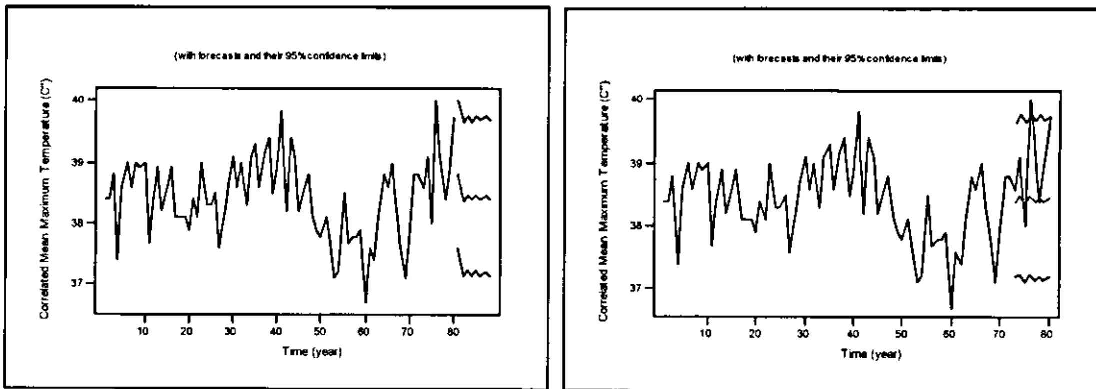
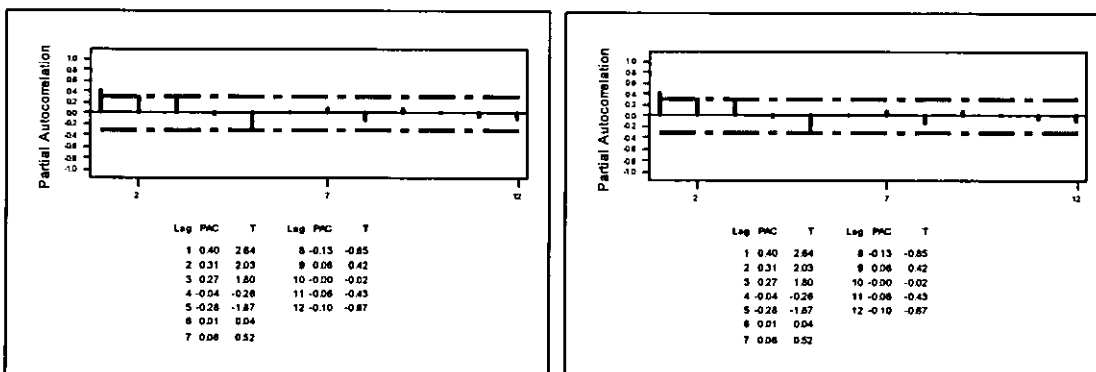
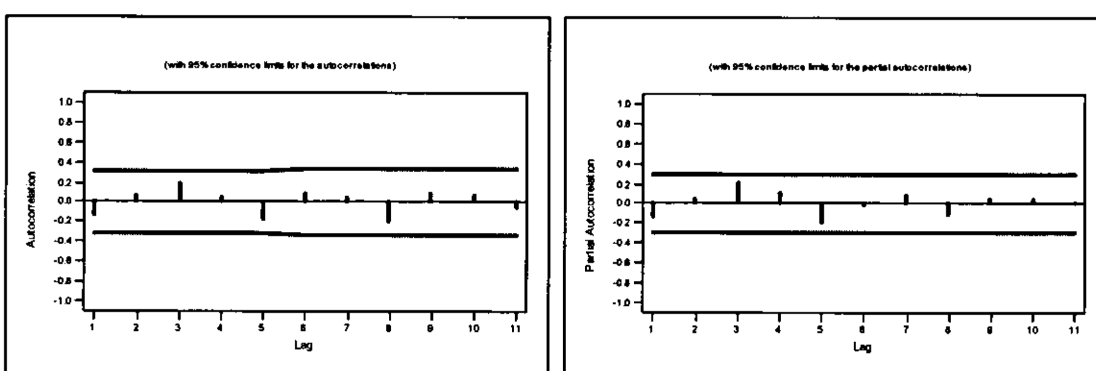


Figure (B.210): Time series, Forward and Backward Forecasting for 10% of Extended Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Aqaba Airport Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.211): Autocorrelation and Partial Autocorrelation Functions for Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Aqaba Airport Station

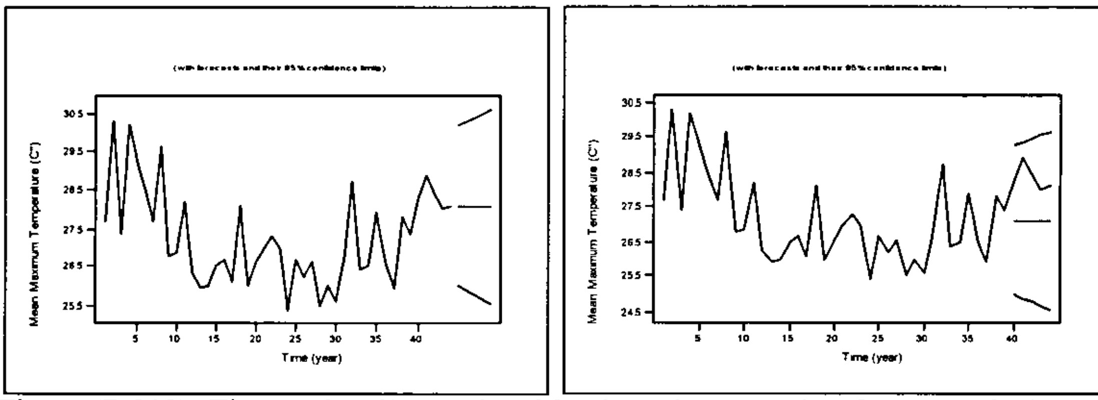
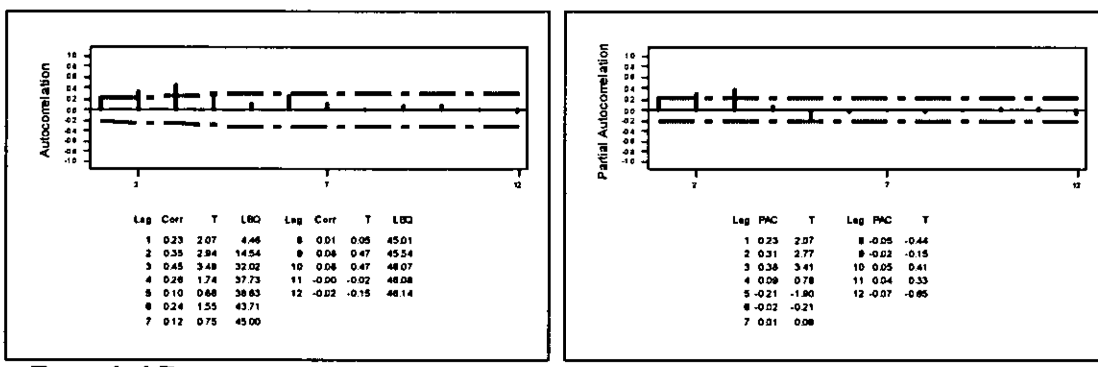
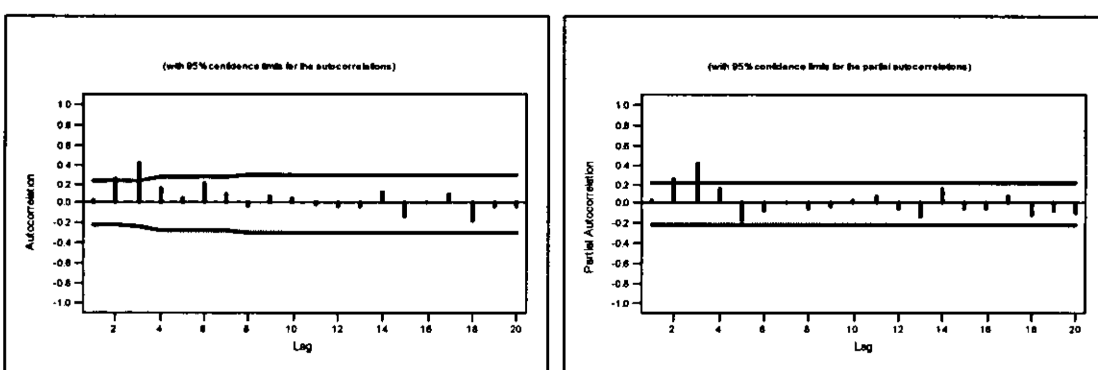


Figure (B.212): Time series, Forward and Backward Forecasting for 10% of Observed Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Aqaba Airport Station



a. Extended Data



b. Residuals for Extended Data

Figure (B.213): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Aqaba Airport Station

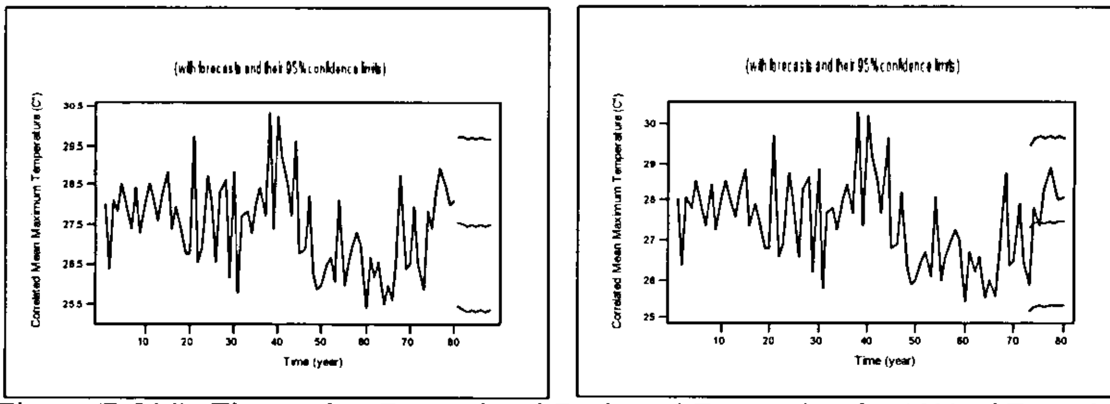
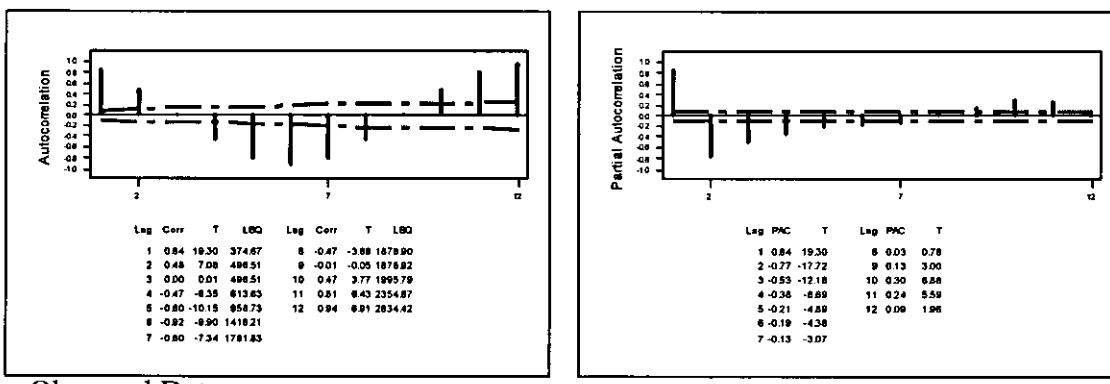
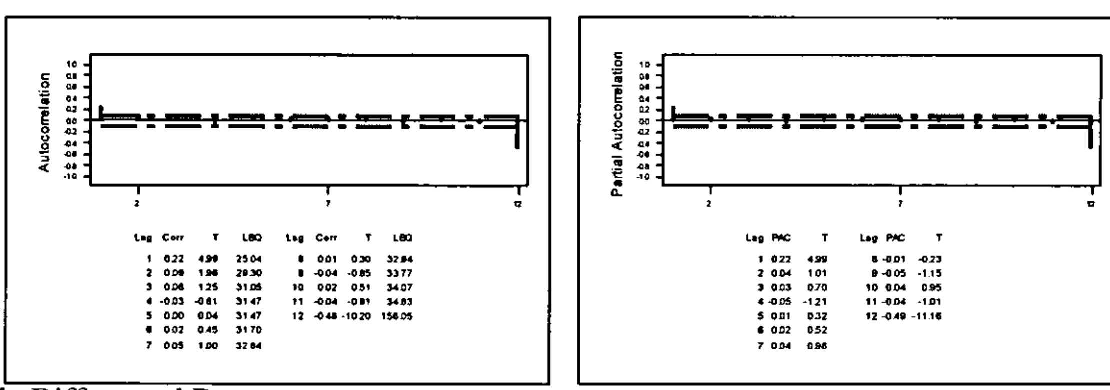


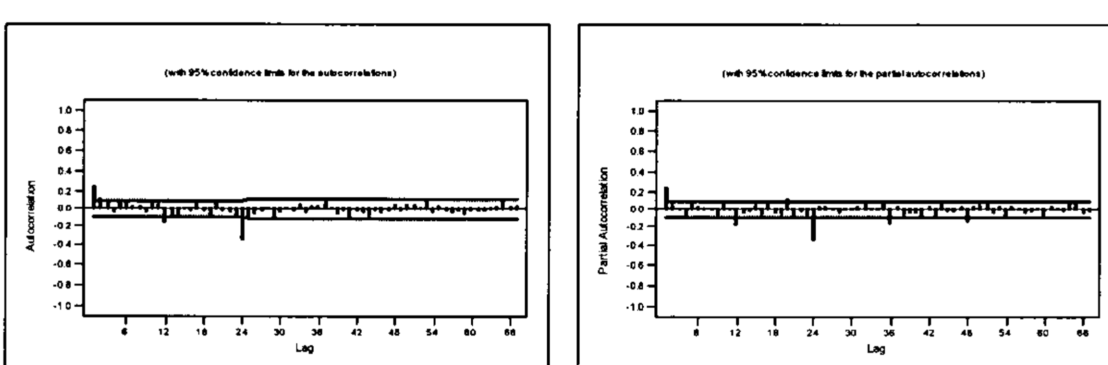
Figure (B.214): Time series, Forward and Backward Forecasting for 10% of Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Aqaba Airport Station



a. Observed Data



b. Differenced Data



Three. Residuals for Differenced Data

Figure (B.215): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Minimum Temperature for Aqaba Airport Station

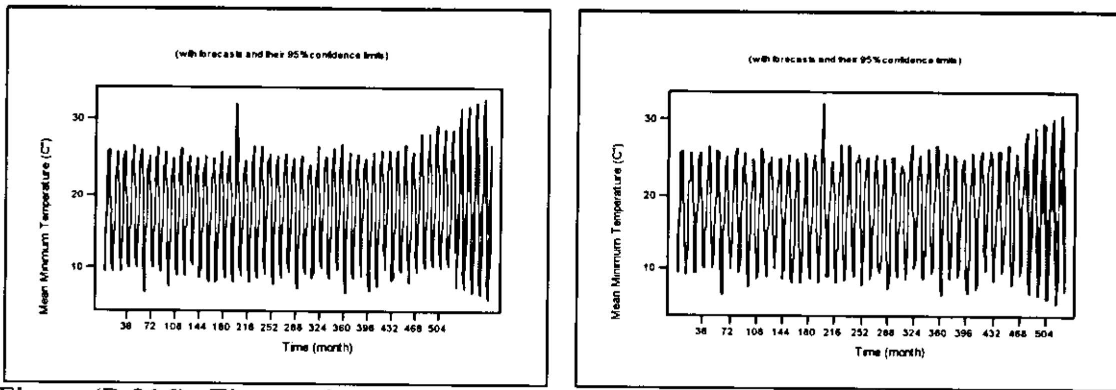
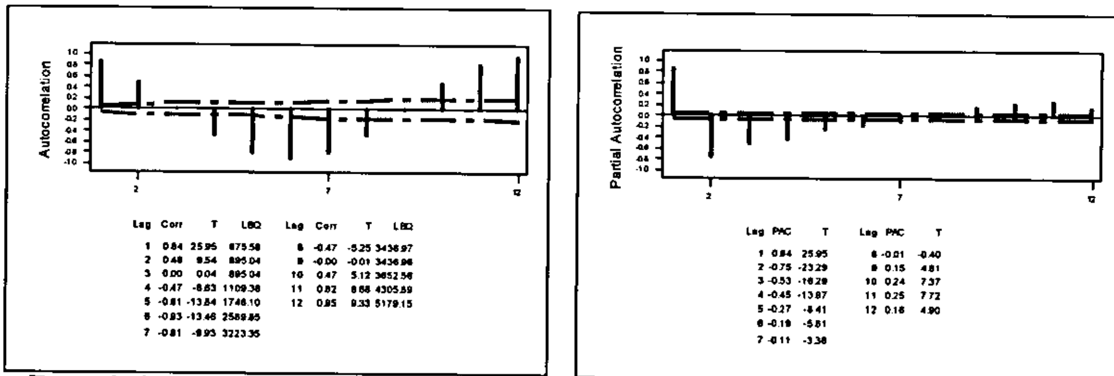
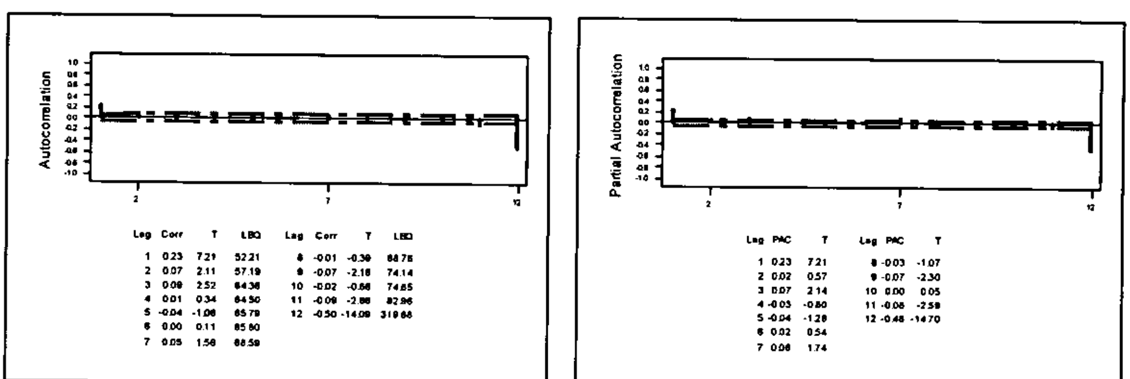


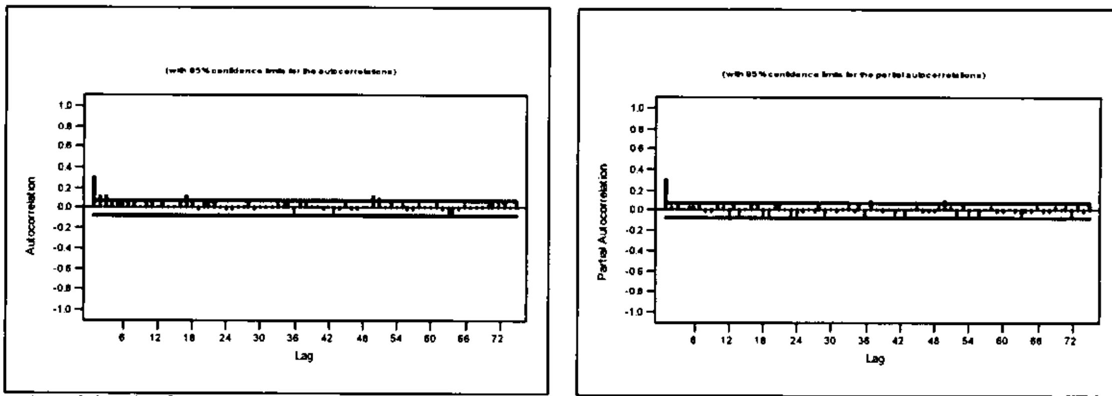
Figure (B.216): Time series, Forward and Backward Forecasting for 10% of Observed Mean Monthly Minimum Temperature for Aqaba Airport Station



a. Extended Data



b. Differenced for Extended Data



c. Residuals for Differenced Extended Data

Figure (B.217): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Monthly Minimum Temperature for Aqaba Airport Station

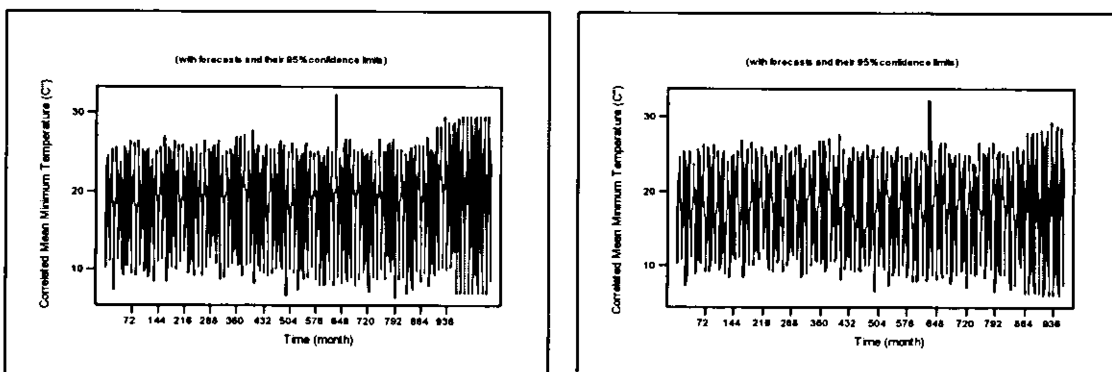
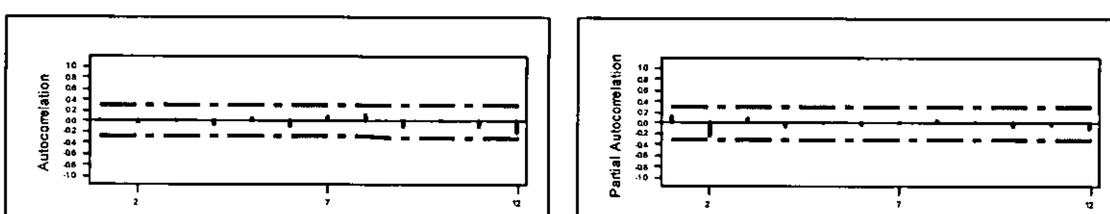


Figure (B.218): Time series, Forward and Backward Forecasting for 10% of Extended Mean Monthly Minimum Temperature for Aqaba Airport Station



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.02	0.12	0.01	8	0.11	0.73	1.95
2	-0.03	-0.22	0.06	9	-0.10	-0.68	2.58
3	-0.01	-0.05	0.07	10	0.00	0.01	2.58
4	-0.06	-0.42	0.27	11	-0.11	-0.71	3.32
5	0.03	0.22	0.33	12	-0.21	-1.37	6.20
6	-0.10	-0.72	0.95				
7	0.07	0.48	1.25				

Lag	PAC	T	Lag	PAC	T
1	0.10	0.68	8	0.04	0.27
2	-0.25	-1.65	9	-0.02	-0.11
3	0.09	0.60	10	-0.06	-0.41
4	-0.07	-0.48	11	-0.05	-0.34
5	-0.01	-0.10	12	-0.12	-0.79
6	-0.04	-0.30			
7	-0.00	-0.00			

Figure (B.219): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Aqaba Airport Station

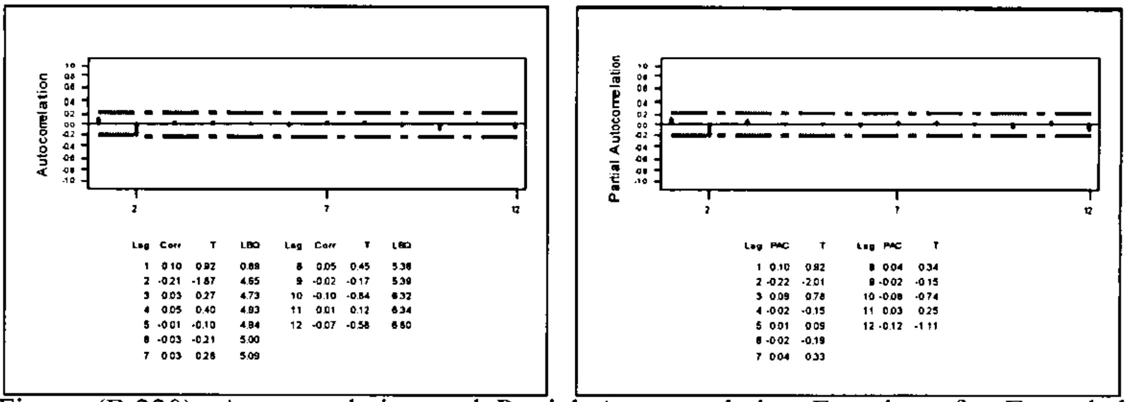


Figure (B.220): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Aqaba Airport Station

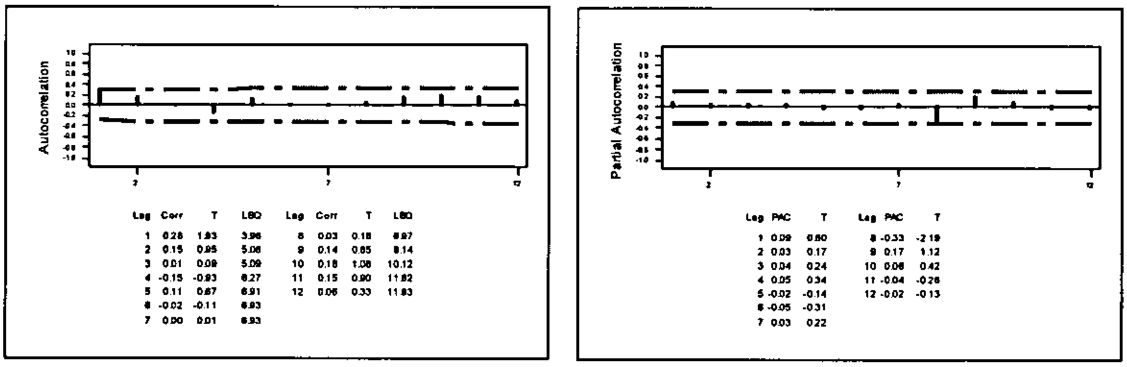
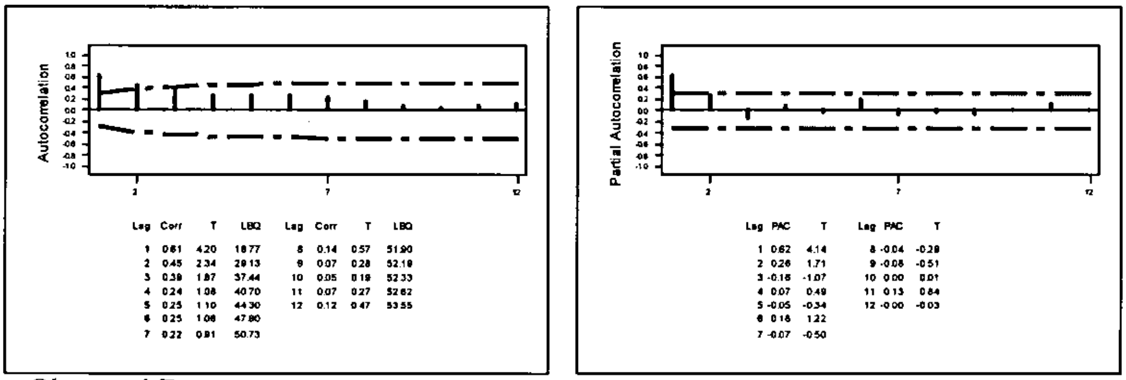
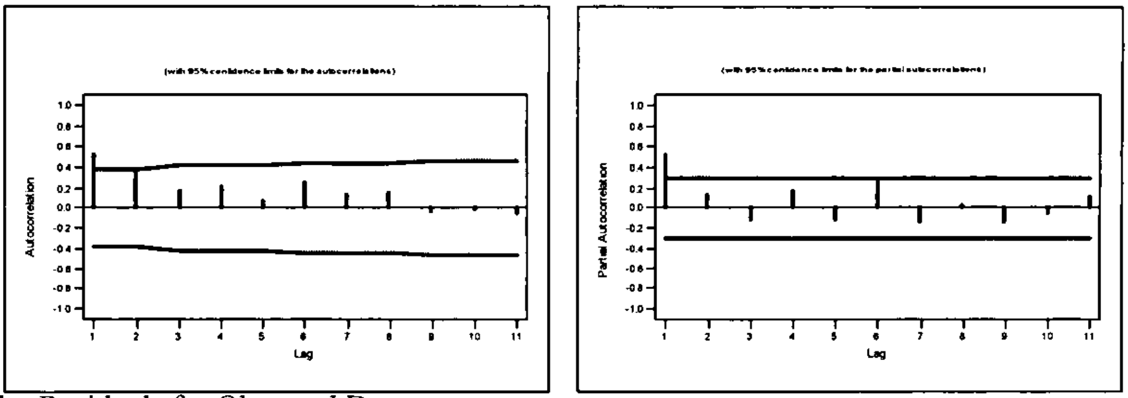


Figure (B.221): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Apr., May and Jun. for Aqaba Airport Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.222): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Aqaba Airport Station

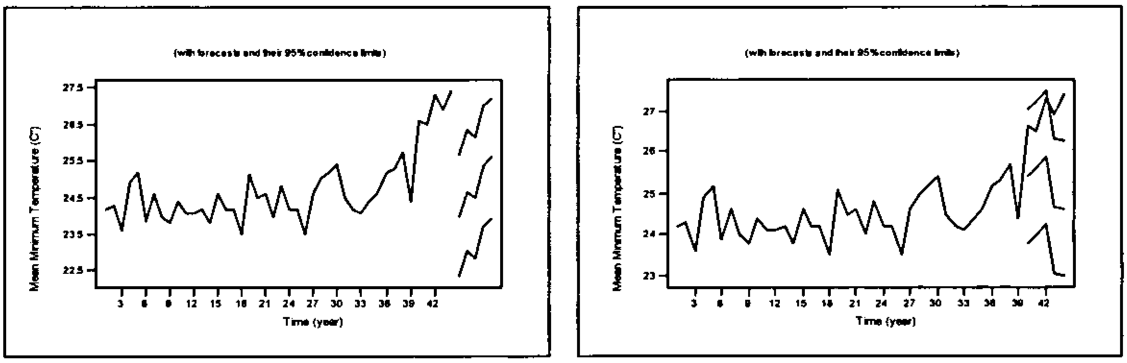
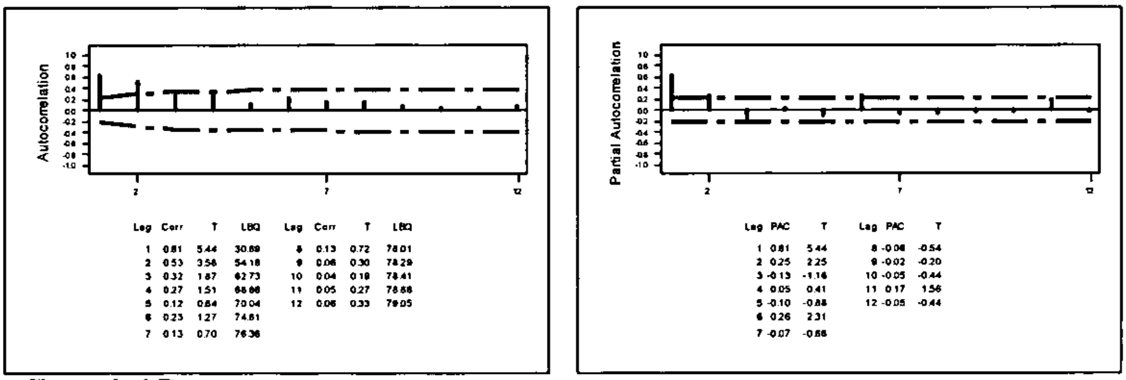
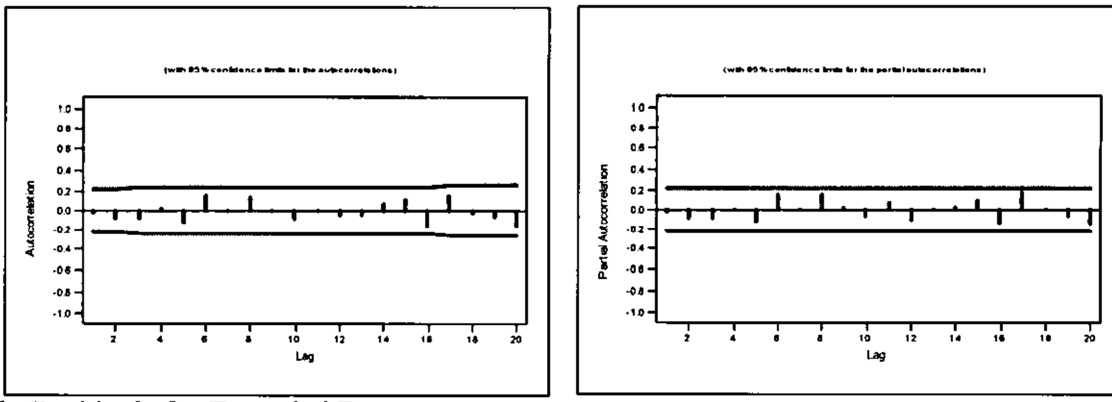


Figure (B.223): Time series, Forward and Backward Forecasting for 10% of Observed Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Aqaba Airport Station



a. Extended Data



b. Residuals for Extended Data

Figure (B.224): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Aqaba Airport Station

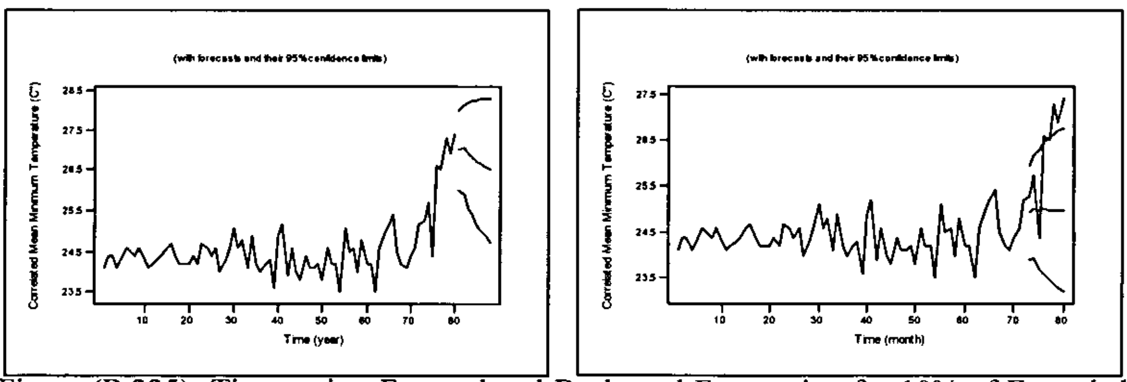
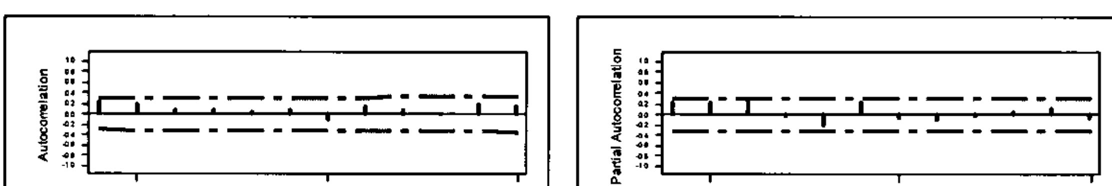


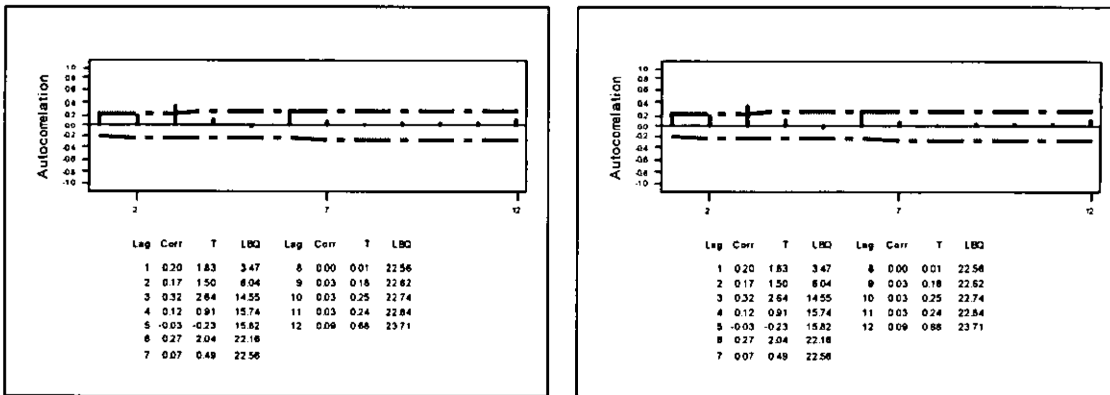
Figure (B.225): Time series, Forward and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Aqaba Airport Station



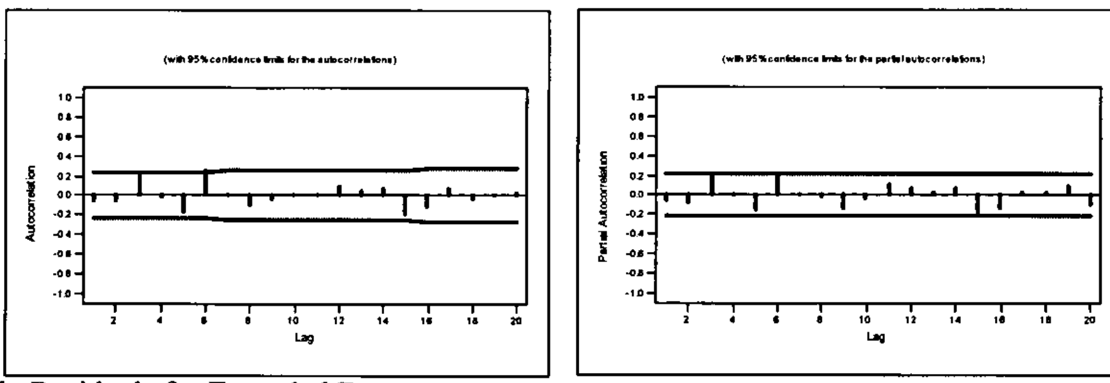
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.22	1.52	2.46	8	0.18	1.00	7.13
2	0.18	1.20	4.17	9	0.06	0.39	7.38
3	0.07	0.45	4.43	10	-0.00	-0.00	7.38
4	0.08	0.51	4.78	11	0.17	1.03	9.18
5	0.04	0.23	4.88	12	0.16	0.98	10.97
6	0.06	0.40	5.08				
7	-0.10	-0.60	5.61				

Lag	PAC	T	Lag	PAC	T
1	0.24	1.57	8	-0.11	-0.74
2	0.20	1.35	9	-0.03	-0.17
3	0.29	1.90	10	0.05	0.32
4	-0.03	-0.23	11	0.11	0.72
5	-0.21	-1.38	12	-0.07	-0.46
6	0.21	1.39			
7	-0.06	-0.40			

Figure (B.226): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Aqaba Airport Station



a. Extended Data



b. Residuals for Extended Data

Figure (B.227): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Aqaba Airport Station

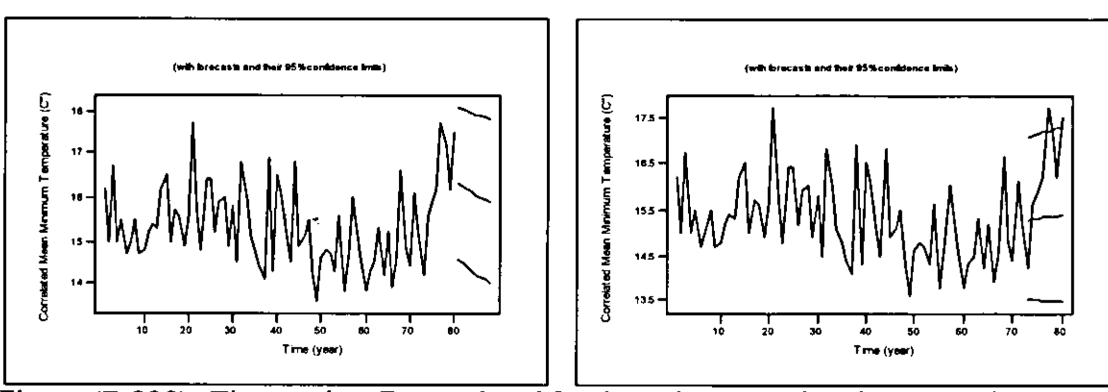
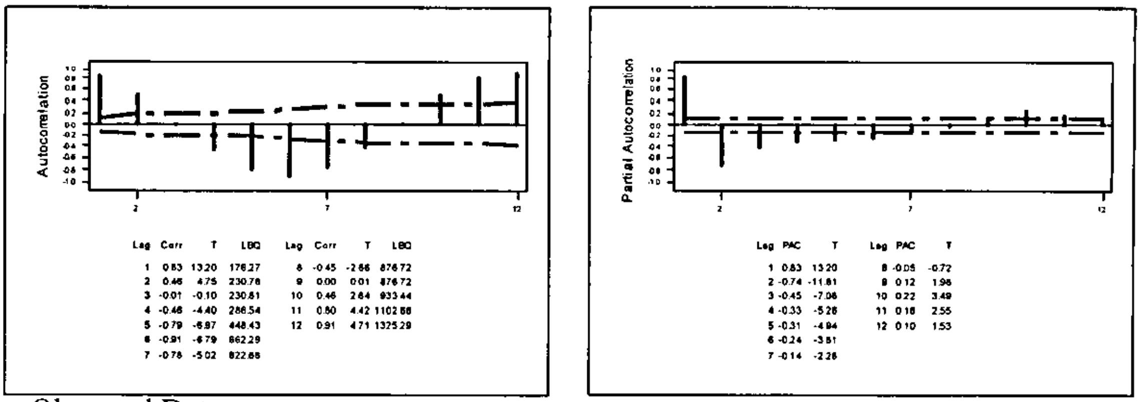
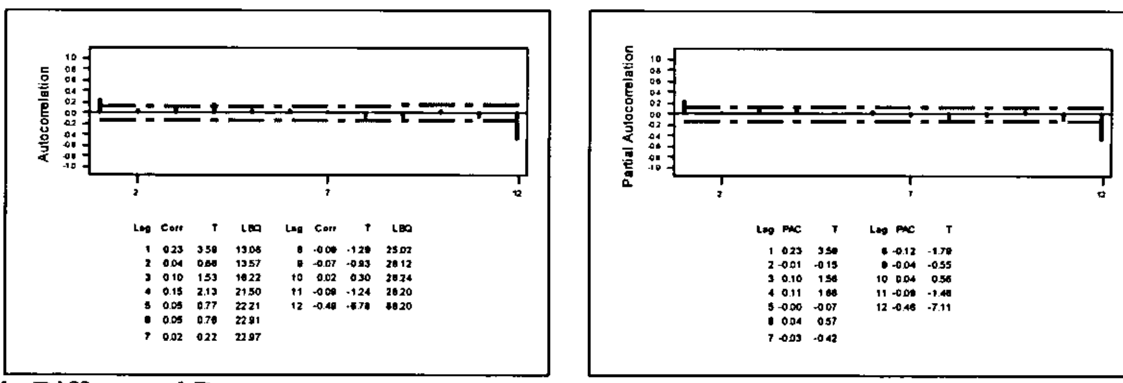


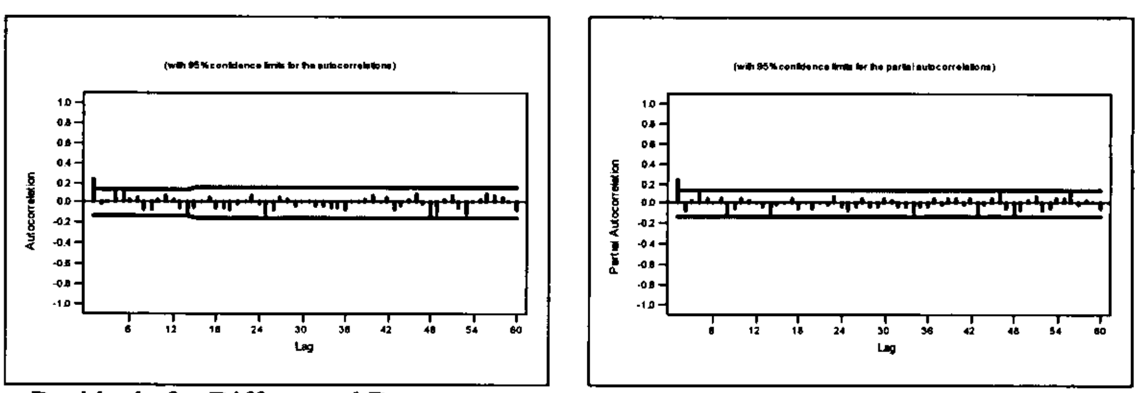
Figure (B.228): Time series, Forward and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Aqaba Airport Station



a. Observed Data



b. Differenced Data



c. Residuals for Differenced Data

Figure (B.229): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Maximum Temperature for Azraq Station

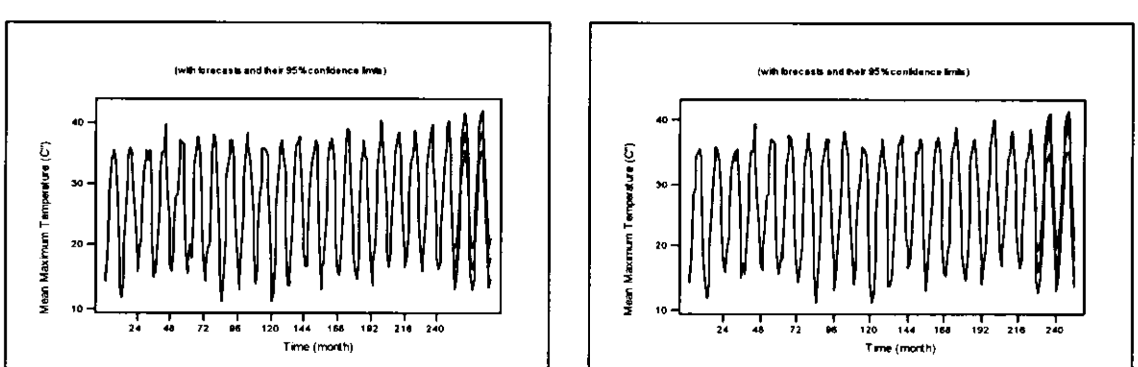
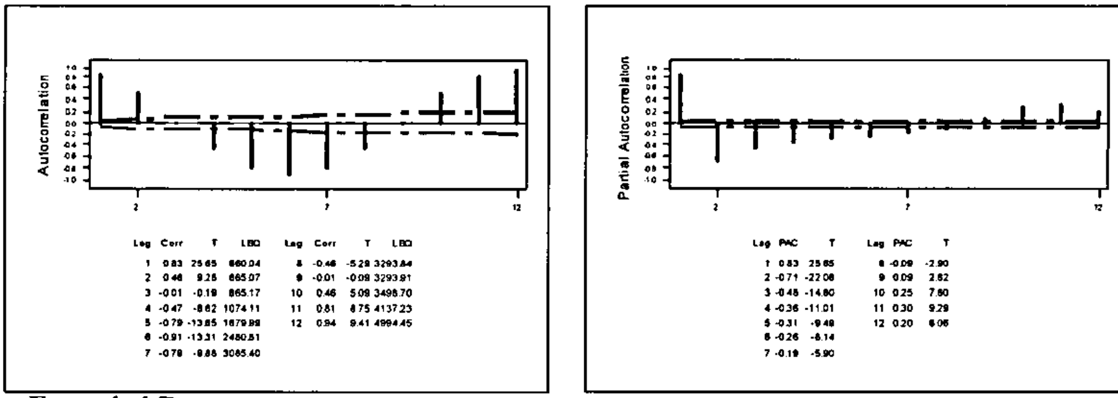
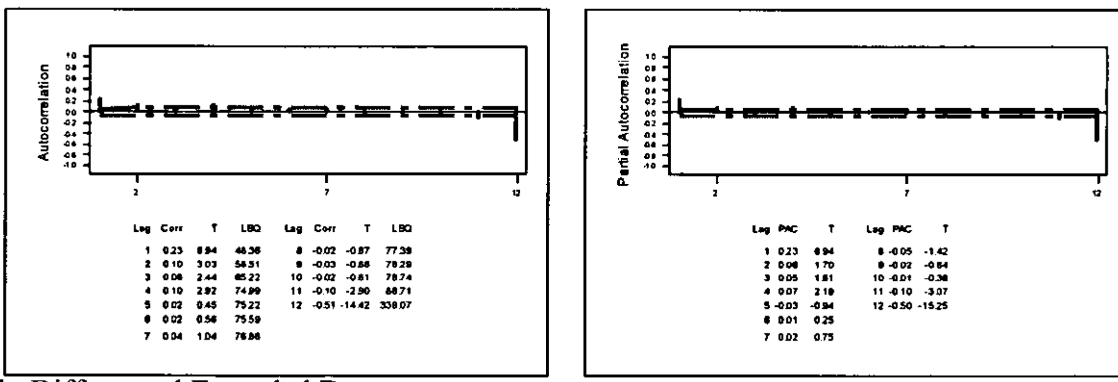


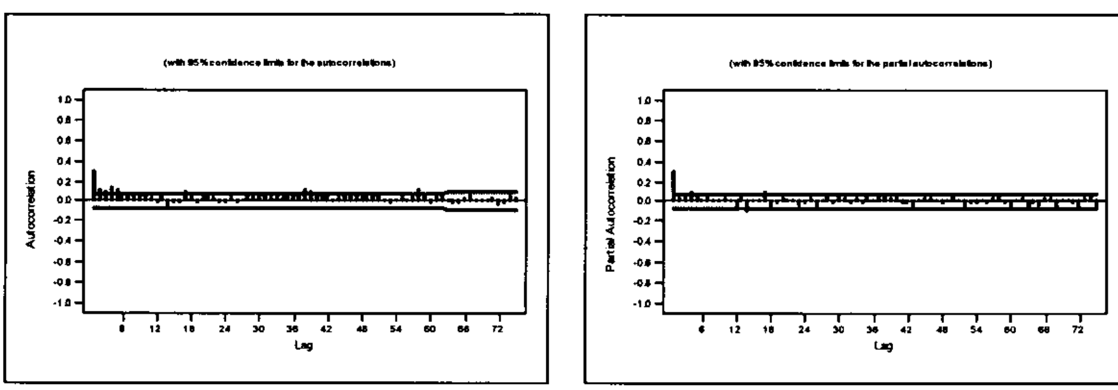
Figure (B.230): Time Series, Forward, and Backward Forecasting for 10% of Observed Mean Monthly Maximum Temperature for Azraq Station



a. Extended Data



b. Differenced Extended Data



c. Residuals for Differenced Extended Data

Figure (B.231): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Monthly Maximum Temperature for Azraq Station

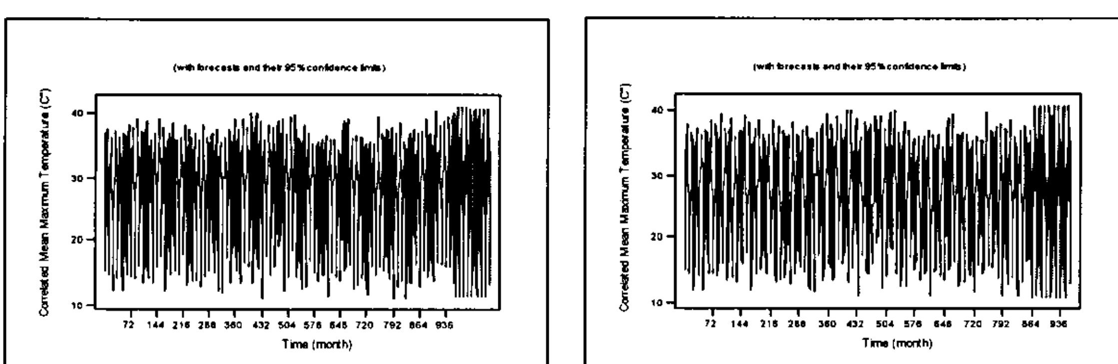


Figure (B.232): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Monthly Maximum Temperature for Azraq Station

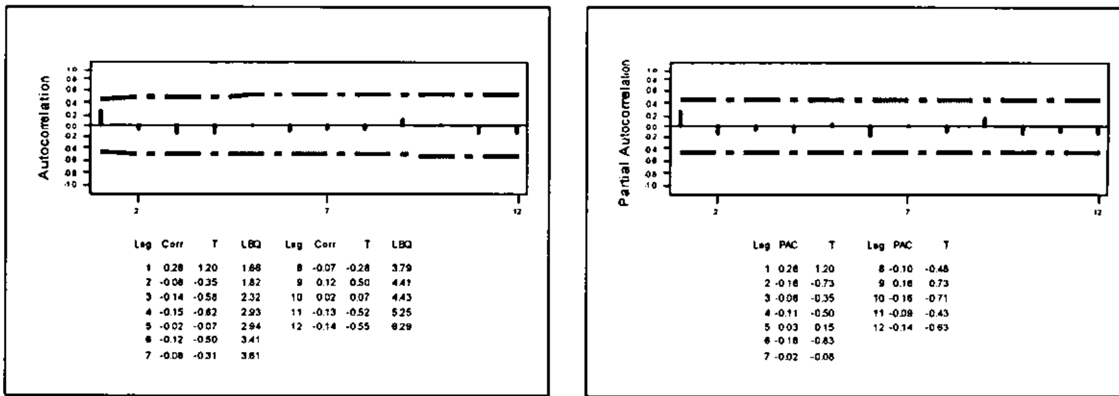


Figure (B.233): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Azraq Station

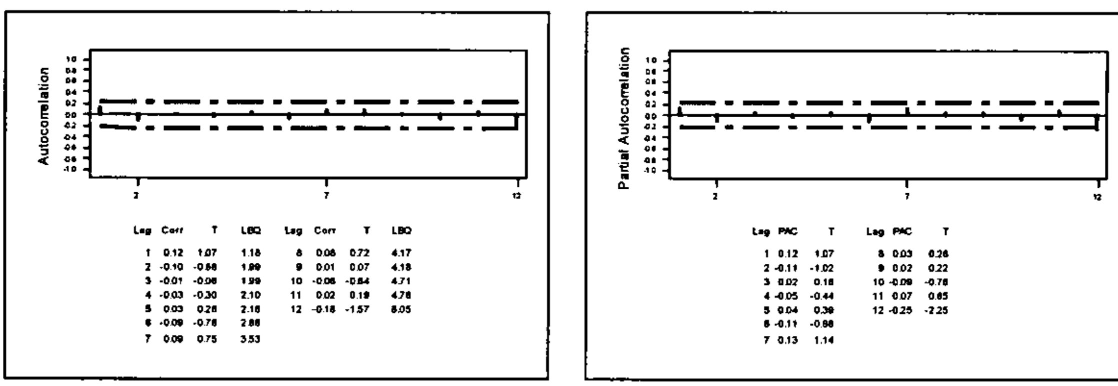


Figure (B.234): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Azraq Station

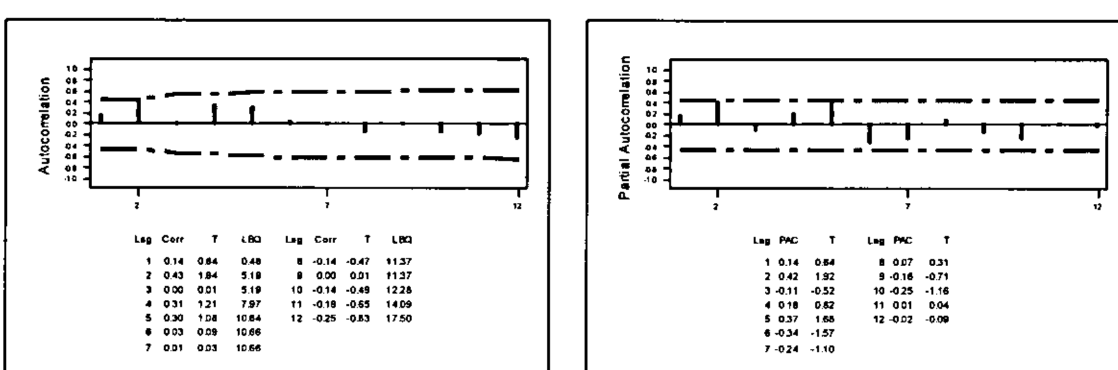
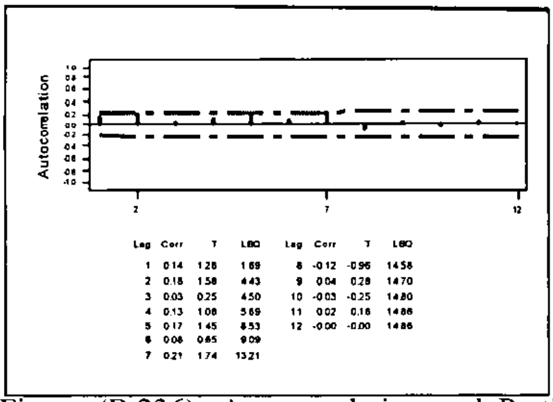


Figure (B.235): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Apr., May and Jun. for Azraq Station



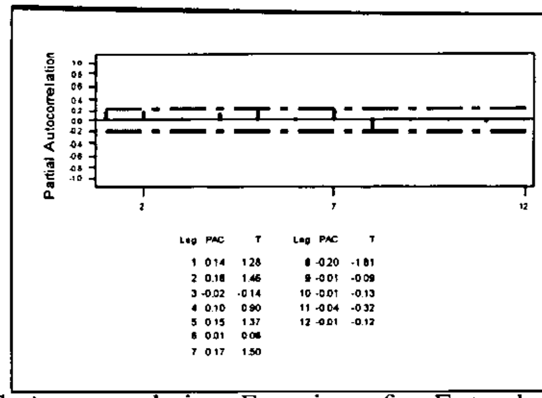
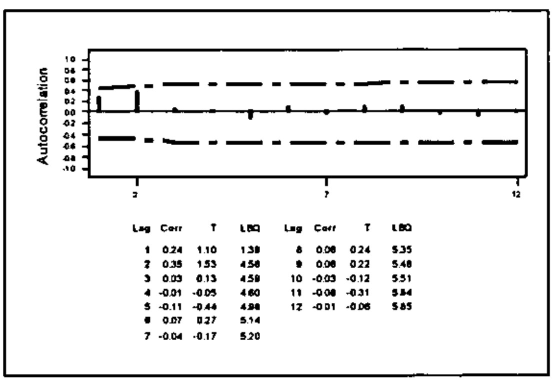


Figure (B.236): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Apr., May and Jun. for Azraq Station



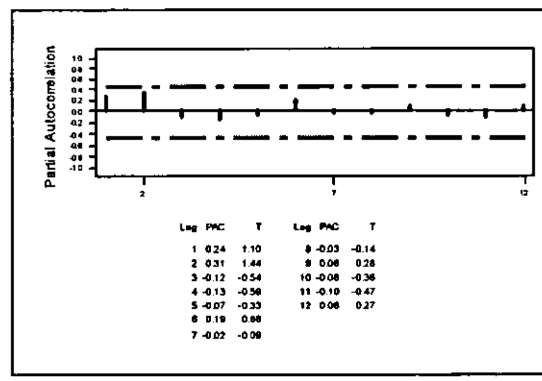
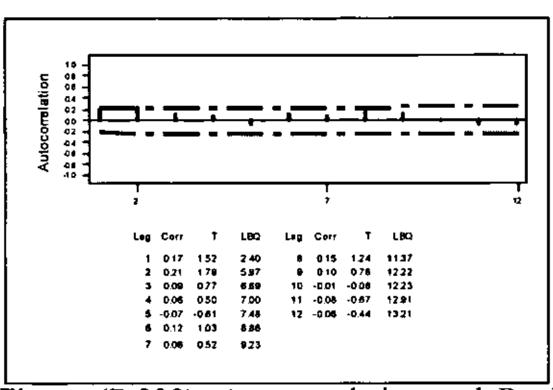


Figure (B.237): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Azraq Station



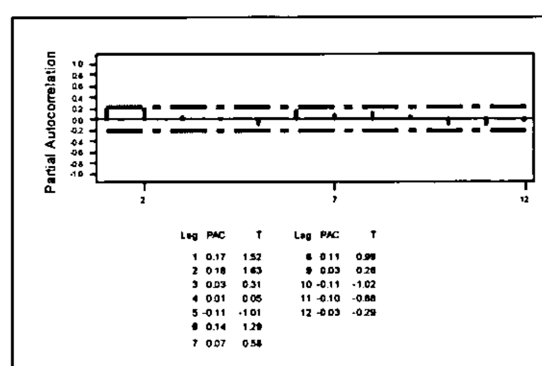
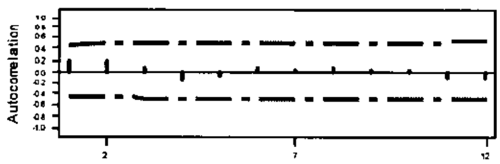
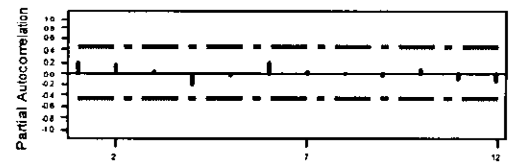


Figure (B.238): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Azraq Station

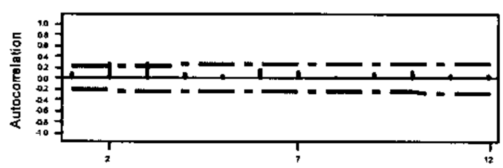


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.18	0.81	0.76	8	0.07	0.27	2.91
2	0.17	0.74	1.46	9	0.05	0.19	3.00
3	0.09	0.37	1.86	10	0.04	0.18	3.08
4	-0.15	-0.67	2.34	11	-0.11	-0.48	3.69
5	-0.07	-0.31	2.50	12	-0.13	-0.52	4.55
6	0.09	0.36	2.74				
7	0.02	0.09	2.75				

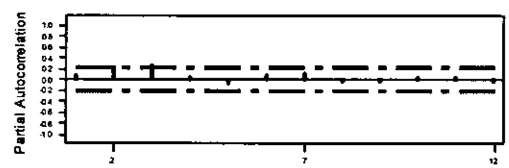


Lag	PAC	T	Lag	PAC	T
1	0.18	0.81	8	-0.02	-0.07
2	0.14	0.63	9	-0.02	-0.11
3	0.04	0.17	10	0.08	0.34
4	-0.21	-0.95	11	-0.12	-0.56
5	-0.04	-0.18	12	-0.13	-0.61
6	0.17	0.79			
7	0.04	0.17			

Figure (B.239): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Azraq Station

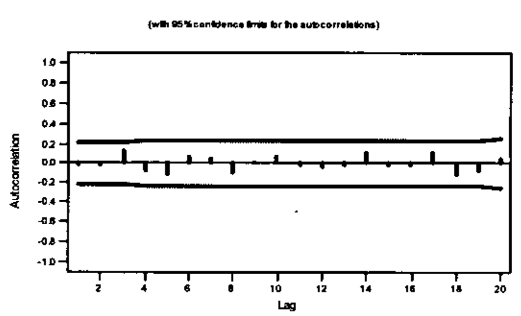


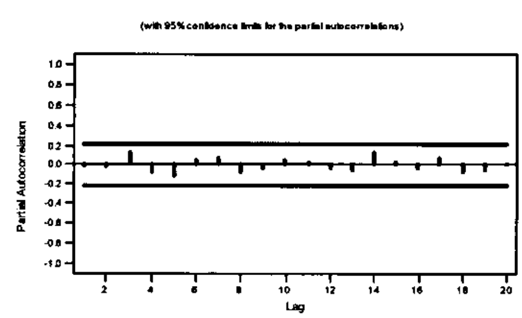
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.08	0.89	0.49	8	0.00	0.04	15.56
2	0.24	2.15	5.42	9	0.08	0.59	16.10
3	0.27	2.24	11.43	10	0.10	0.73	16.97
4	0.09	0.73	12.15	11	0.03	0.20	17.03
5	0.04	0.33	12.30	12	0.03	0.24	17.13
6	0.15	1.18	14.28				
7	0.12	0.92	15.56				



Lag	PAC	T	Lag	PAC	T
1	0.08	0.69	8	-0.04	-0.36
2	0.24	2.13	9	-0.03	-0.25
3	0.25	2.22	10	0.05	0.48
4	0.02	0.19	11	0.03	0.29
5	-0.09	-0.79	12	-0.02	-0.18
6	0.07	0.60			
7	0.12	1.04			

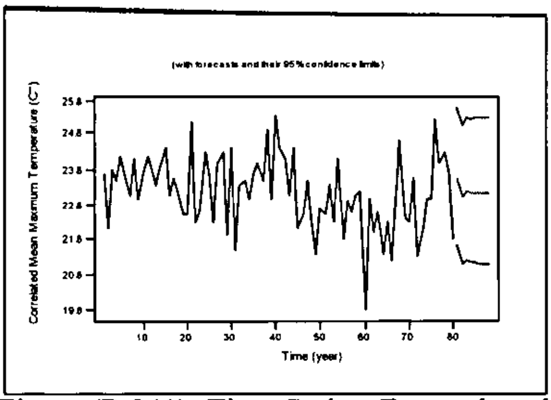
a. Extended Data





b. Residuals for Extended Data

Figure (B.240): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Azraq Station



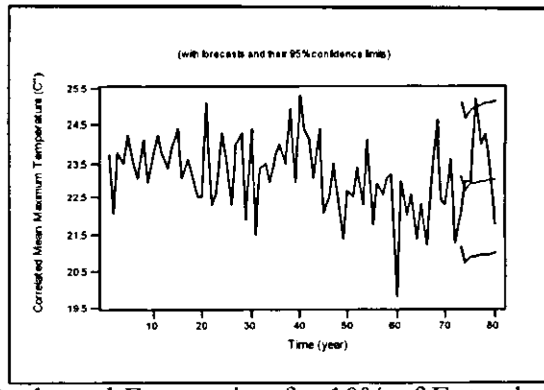
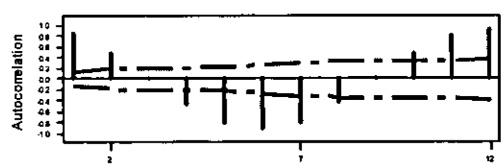
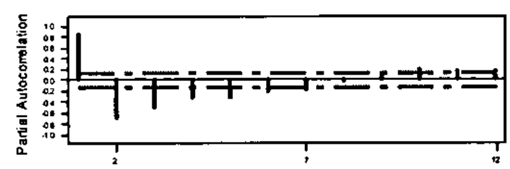


Figure (B.241): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Azraq Station

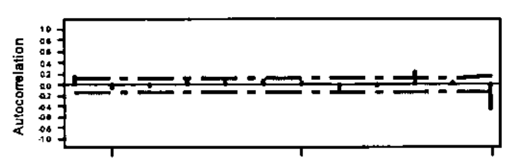


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.83	13.14	174.88	8	-0.48	-2.67	883.77
2	0.48	4.76	229.30	9	0.00	0.00	883.77
3	-0.01	-0.10	229.33	10	0.46	2.63	940.81
4	-0.47	-4.42	285.22	11	0.80	4.42	1110.33
5	-0.80	-7.02	449.04	12	0.92	4.72	1335.47
6	-0.91	-6.83	565.27				
7	-0.79	-5.08	628.75				

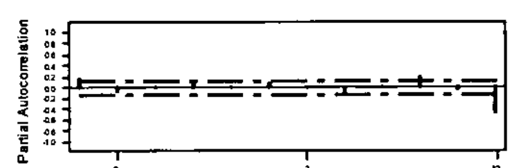


Lag	PAC	T	Lag	PAC	T
1	0.83	13.14	8	-0.04	-0.62
2	-0.71	-11.23	9	0.10	1.54
3	-0.50	-7.86	10	0.18	3.04
4	-0.34	-5.44	11	0.16	2.57
5	-0.34	-5.38	12	0.13	2.12
6	-0.24	-3.74			
7	-0.20	-3.18			

a. Observed Data

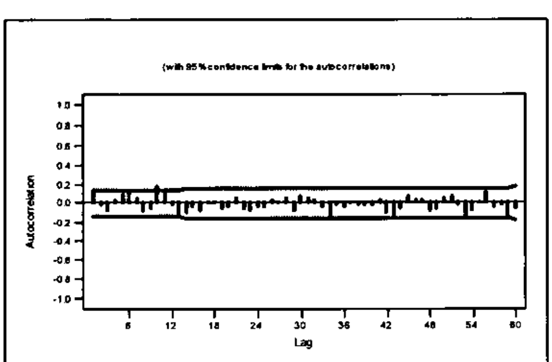


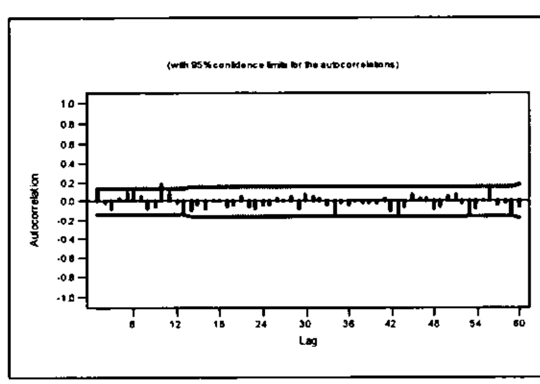
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.15	2.31	5.38	8	-0.09	-1.32	13.95
2	-0.07	-1.01	6.45	9	-0.04	-0.55	14.31
3	-0.03	-0.49	6.71	10	0.20	2.97	24.67
4	0.11	1.71	9.88	11	0.05	0.74	25.37
5	0.06	0.86	10.56	12	-0.47	-6.57	80.51
6	0.07	1.03	11.86				
7	0.02	0.28	11.95				



Lag	PAC	T	Lag	PAC	T
1	0.15	2.31	8	-0.10	-1.54
2	-0.09	-1.40	9	-0.01	-0.16
3	-0.01	-0.13	10	0.19	2.96
4	0.12	1.82	11	-0.03	-0.46
5	0.02	0.28	12	-0.48	-7.37
6	0.08	1.18			
7	0.01	0.14			

b. Differenced Data





c. Residuals for Differenced Data

Figure (B.242): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Monthly Minimum Temperature for Azraq Station

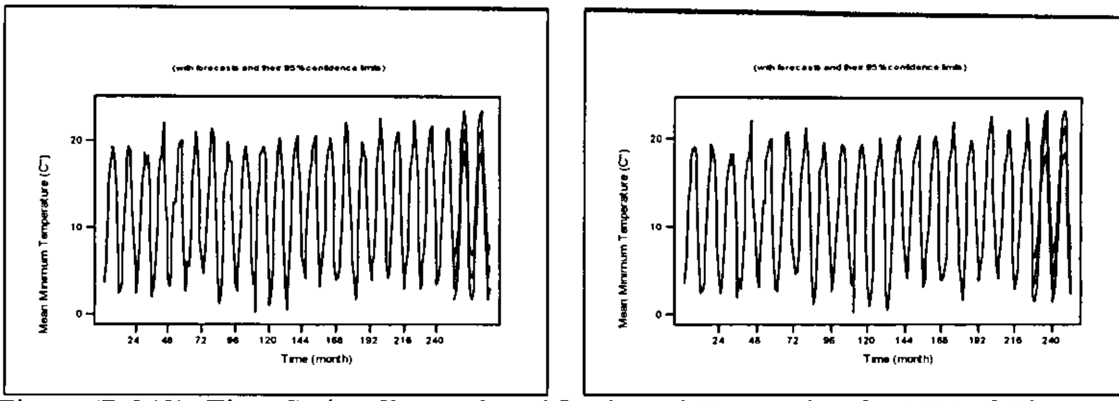
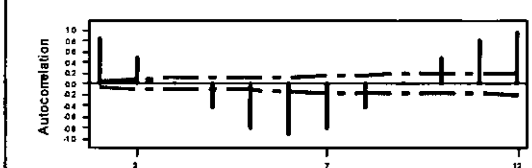
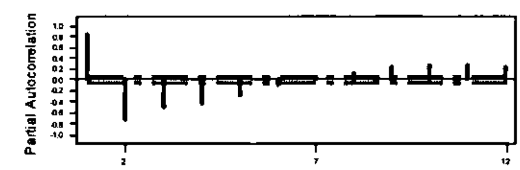


Figure (B.243): Time Series, Forward, and Backward Forecasting for 10% of Observed Mean Monthly Minimum Temperature for Azraq Station

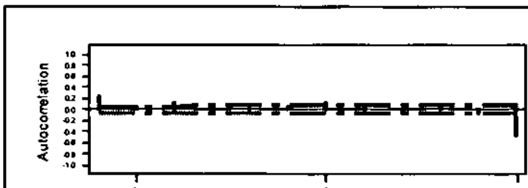


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.84	25.89	672.54	8	-0.45	-5.13	3321.08
2	0.48	8.56	893.38	9	0.01	0.13	3321.22
3	0.01	0.21	893.51	10	0.48	5.28	3543.74
4	-0.45	-8.34	1093.33	11	0.82	8.80	4198.09
5	-0.79	-13.82	1703.96	12	0.95	9.42	5069.19
6	-0.92	-13.34	2518.78				
7	-0.79	-9.83	3122.28				

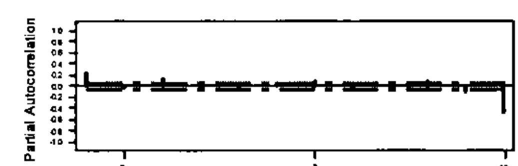


Lag	PAC	T	Lag	PAC	T
1	0.84	25.89	8	0.11	3.47
2	-0.73	-22.57	9	0.23	7.17
3	-0.50	-15.61	10	0.27	8.37
4	-0.43	-13.36	11	0.28	7.81
5	-0.28	-8.74	12	0.22	6.77
6	-0.11	-3.33			
7	0.02	0.74			

a. Extended Data

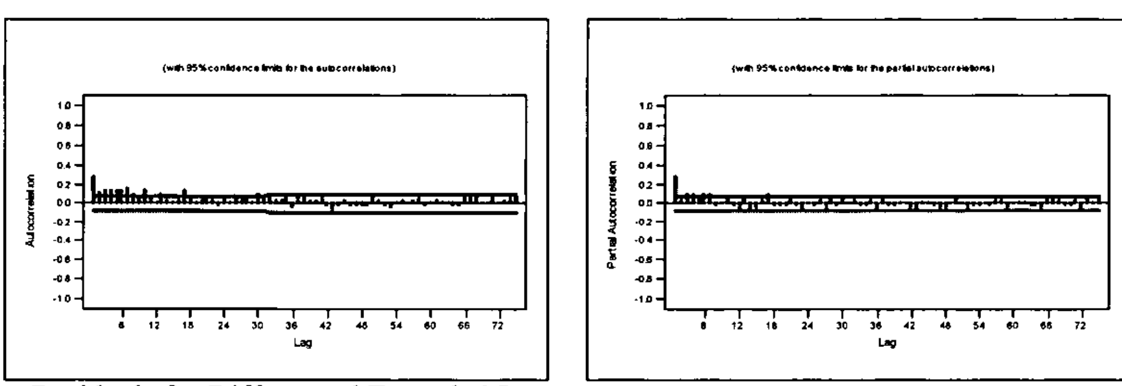


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.21	6.41	41.17	8	-0.00	-0.13	66.42
2	0.02	0.72	41.75	9	-0.03	-0.98	67.58
3	0.09	2.72	49.82	10	0.06	1.69	70.86
4	0.08	2.42	56.32	11	-0.06	-1.83	74.78
5	-0.01	-0.44	56.54	12	-0.49	-13.96	303.73
6	0.04	1.28	58.32				
7	0.09	2.67	66.40				



Lag	PAC	T	Lag	PAC	T
1	0.21	6.41	8	-0.04	-1.15
2	-0.02	-0.60	9	-0.03	-0.87
3	0.10	2.93	10	0.06	1.74
4	0.05	1.43	11	-0.10	-3.06
5	-0.04	-1.32	12	-0.48	-14.72
6	0.05	1.60			
7	0.06	1.99			

b. Differenced Extended Data



c. Residuals for Differenced Extended Data

Figure (B.244): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Monthly Minimum Temperature for Azraq Station

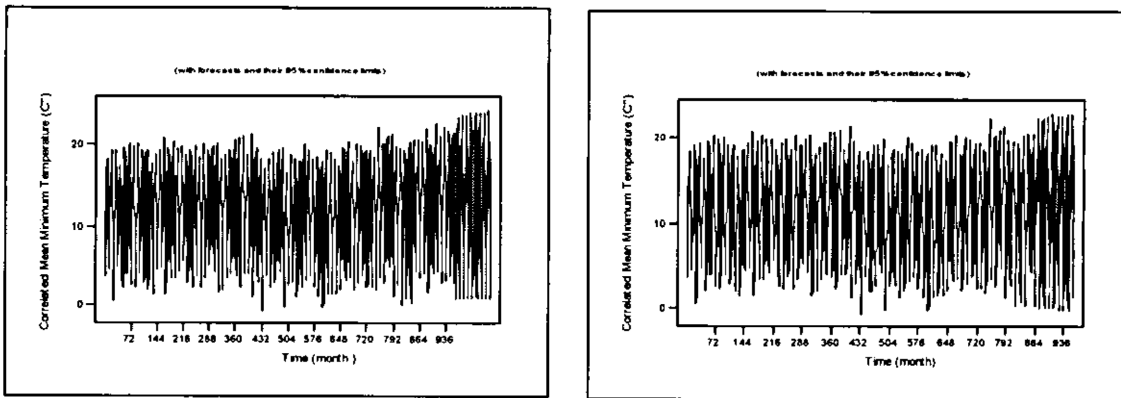


Figure (B.245): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Monthly Minimum Temperature for Azraq Station

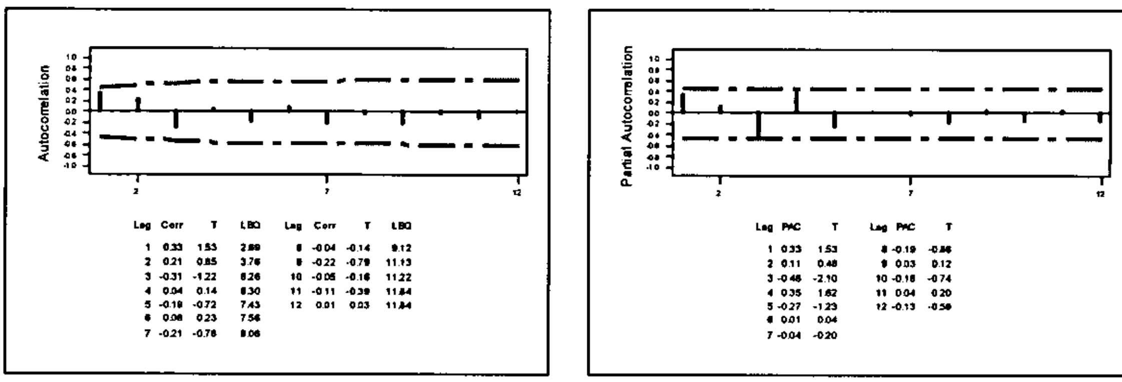
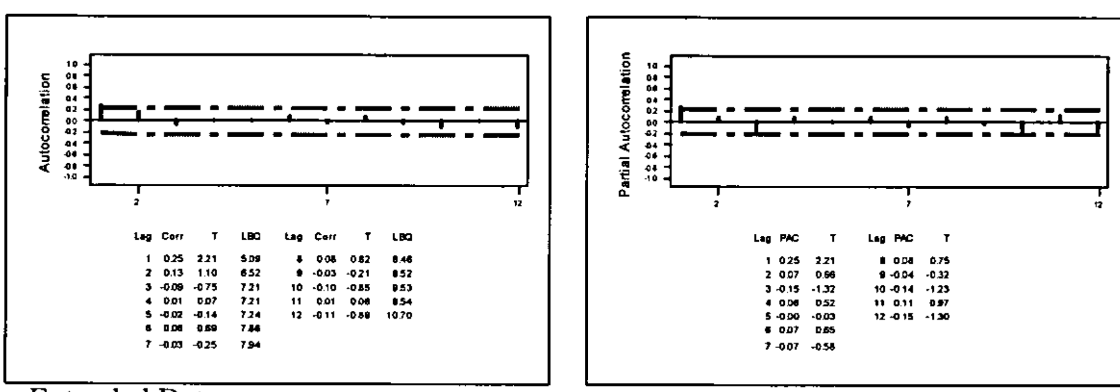
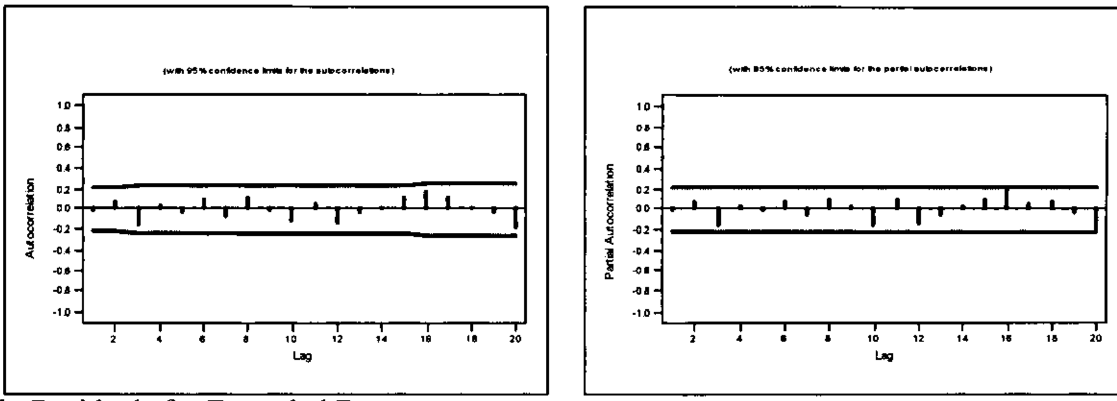


Figure (B.246): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Azraq Station



a. Extended Data



b. Residuals for Extended Data

Figure (B.247): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Azraq Station

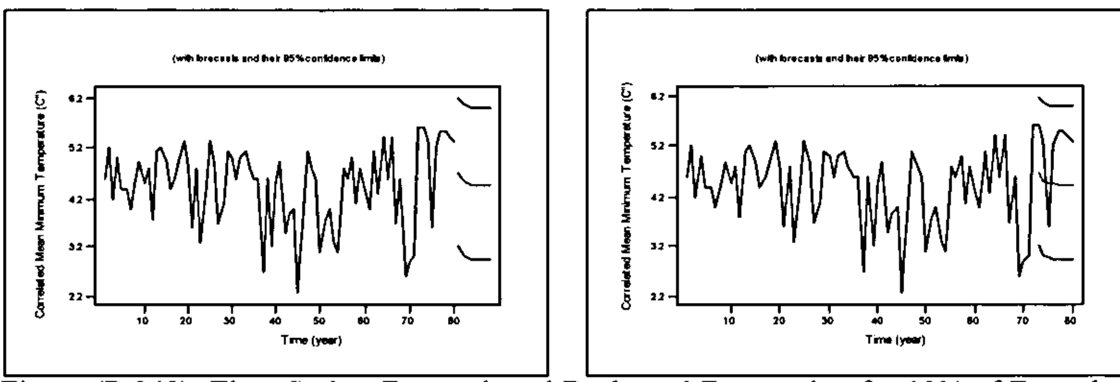


Figure (B.248): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Azraq Station

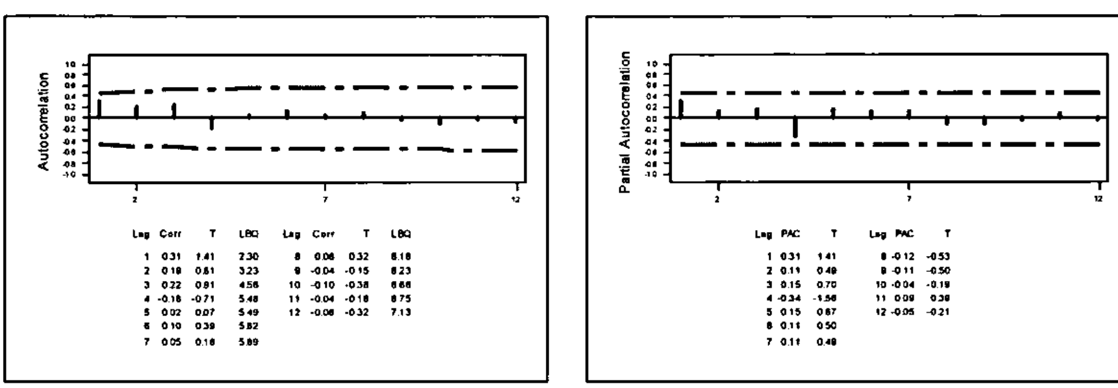
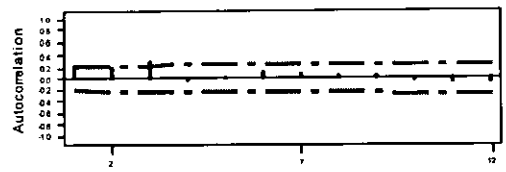
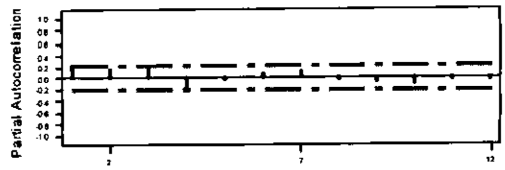


Figure (B.249): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Apr., May and Jun. for Azraq Station

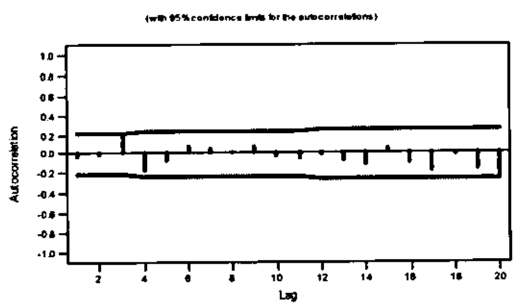


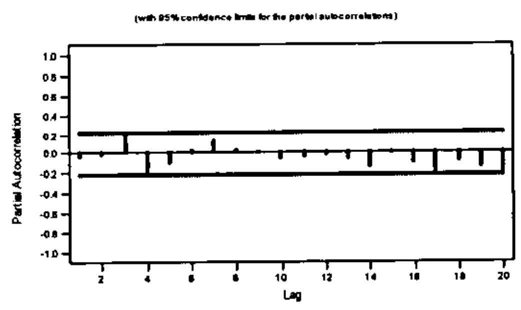
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.24	2.13	4.71	8	0.03	0.22	16.03
2	0.19	1.63	7.81	9	0.03	0.21	16.10
3	0.28	2.34	14.71	10	-0.05	-0.39	16.34
4	-0.03	-0.27	14.81	11	-0.09	-0.67	17.07
5	-0.00	-0.03	14.81	12	-0.09	-0.69	17.87
6	0.09	0.71	15.57				
7	0.07	0.50	15.95				



Lag	PAC	T	Lag	PAC	T
1	0.24	2.13	8	-0.02	-0.22
2	0.14	1.28	9	-0.06	-0.52
3	0.23	2.05	10	-0.09	-0.83
4	-0.18	-1.60	11	-0.04	-0.36
5	-0.04	-0.38	12	-0.04	-0.34
6	0.08	0.69			
7	0.12	1.05			

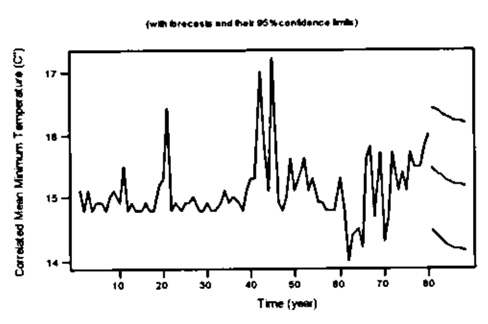
One. Extended Data





b. Residuals for Extended Data

Figure (B.250): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Apr., May and Jun. for Azraq Station



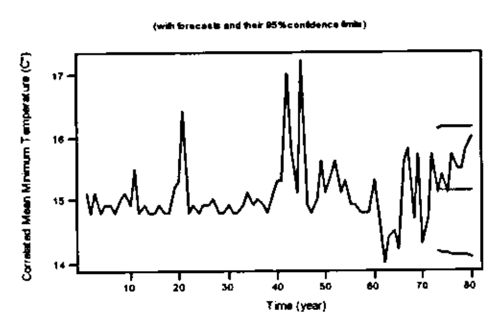
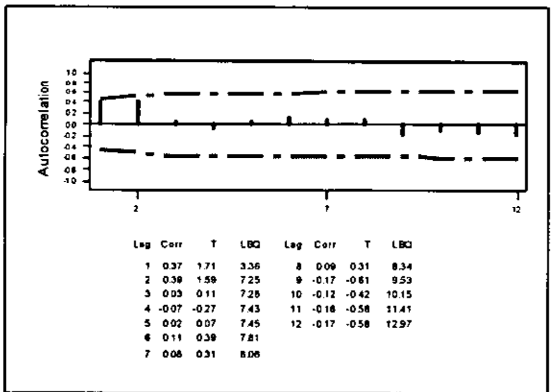


Figure (B.251): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Apr., May and Jun. for Azraq Station



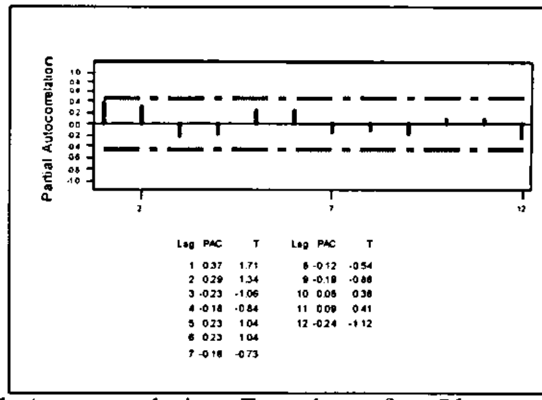
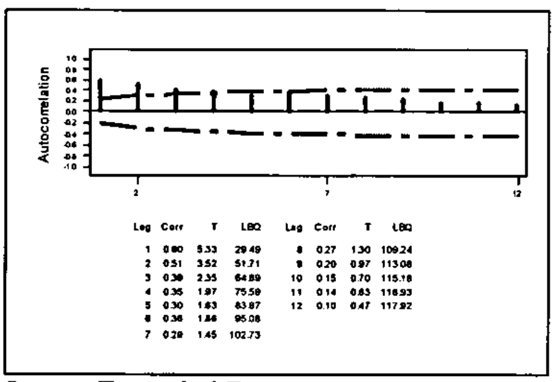
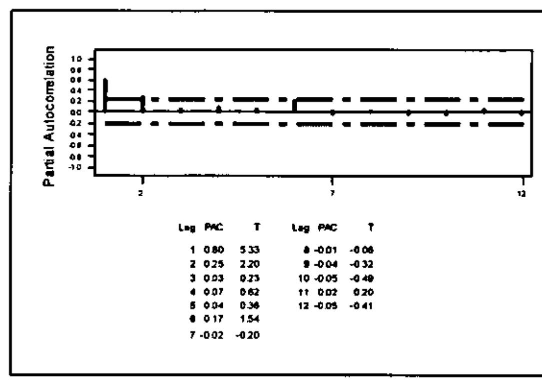
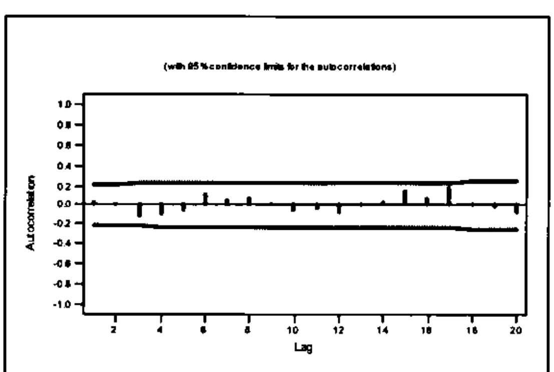


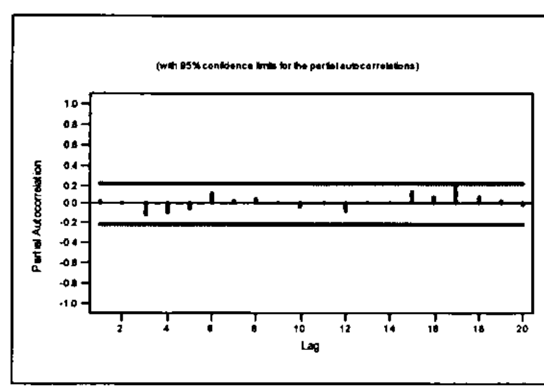
Figure (B.252): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Azraq Station





One. Extended Data





b. Residuals for Extended Data

Figure (B.253): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Azraq Station

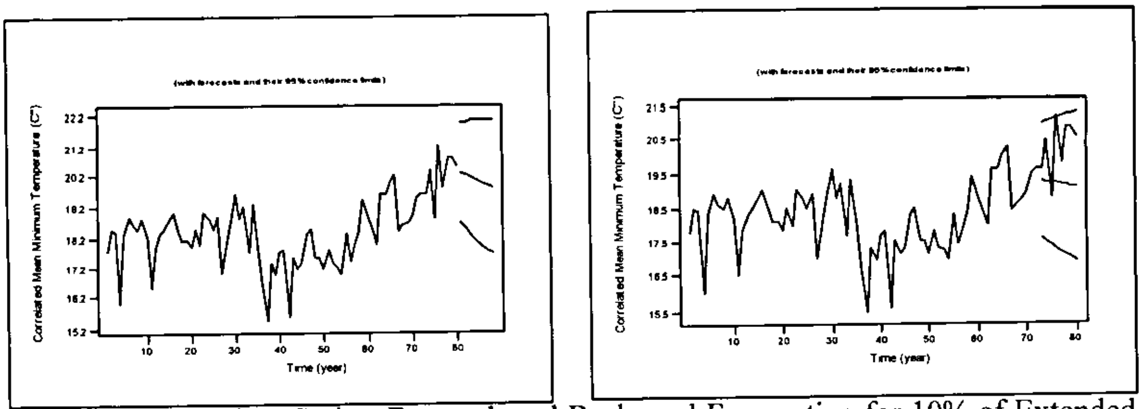


Figure (B.254): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Azraq Station

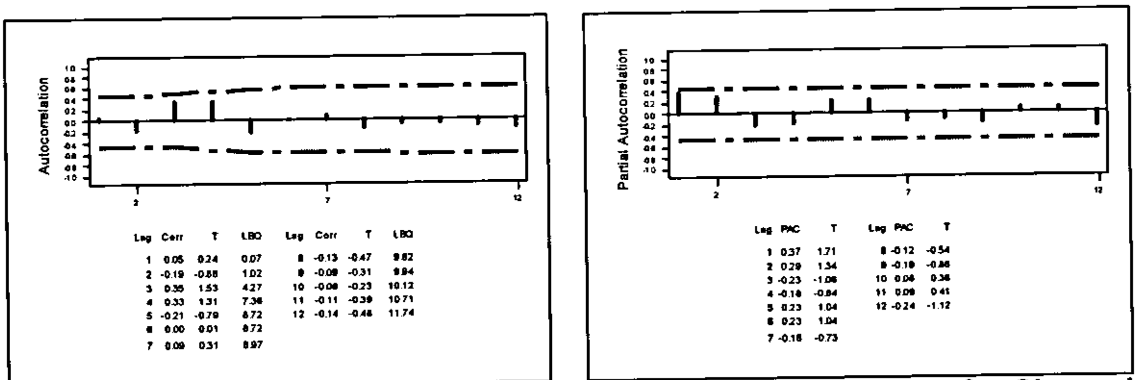
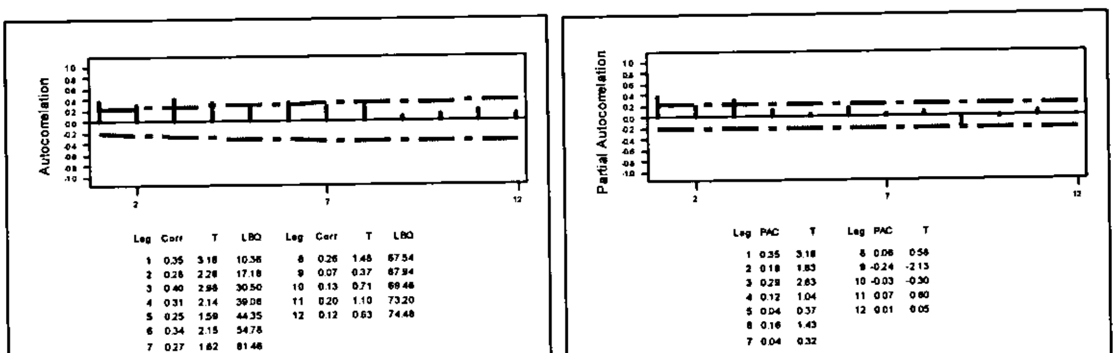
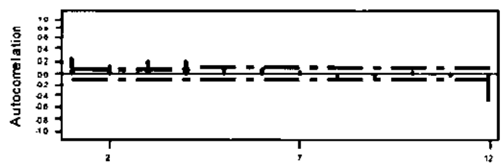


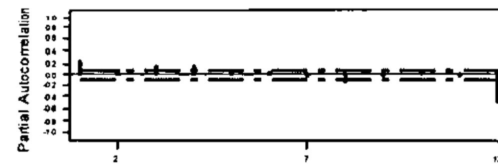
Figure (B.255): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Azraq Station



a. Extended Data

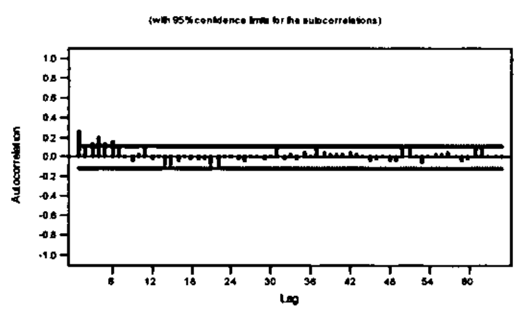


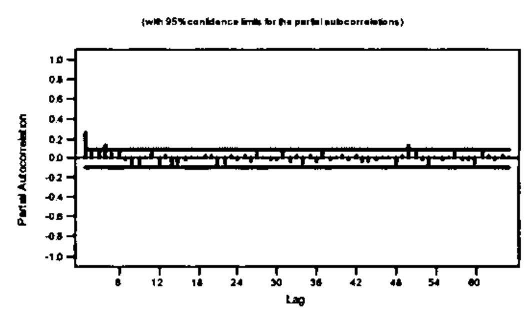
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.22	4.49	20.32	8	-0.08	-1.51	62.76
2	0.11	2.24	25.83	9	-0.05	-0.91	63.86
3	0.17	3.25	37.79	10	0.03	0.53	64.23
4	0.19	3.57	52.92	11	-0.05	-0.90	65.32
5	0.09	1.61	56.21	12	-0.47	-8.51	162.52
6	0.08	1.61	58.55				
7	0.02	0.41	58.77				



Lag	PAC	T	Lag	PAC	T
1	0.22	4.49	8	-0.13	-2.69
2	0.07	1.43	9	-0.04	-0.92
3	0.13	2.80	10	0.04	0.92
4	0.13	2.68	11	-0.03	-0.70
5	0.01	0.18	12	-0.48	-9.60
6	0.03	0.71			
7	-0.05	-0.99			

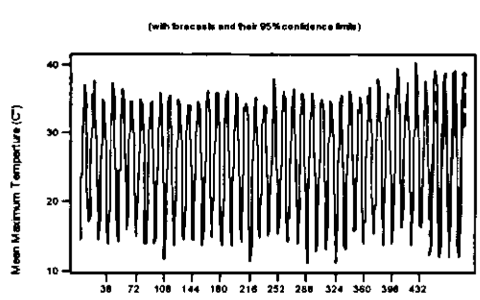
b. Differenced Data





c. Residuals for Differenced Data

Figure (B.258): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Maximum for Jafar Station



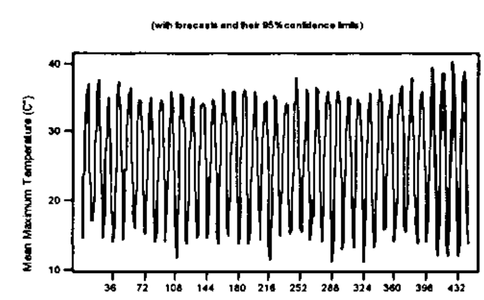
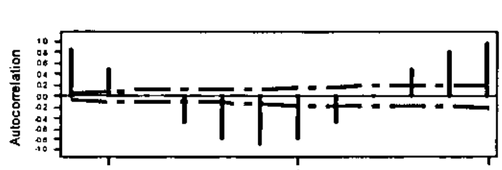
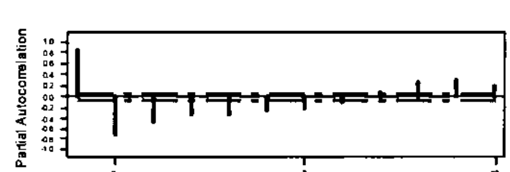


Figure (B.259): Time Series, Forward, and Backward Forecasting for 10% of Observed Mean Monthly Maximum Temperature for Jafar Station

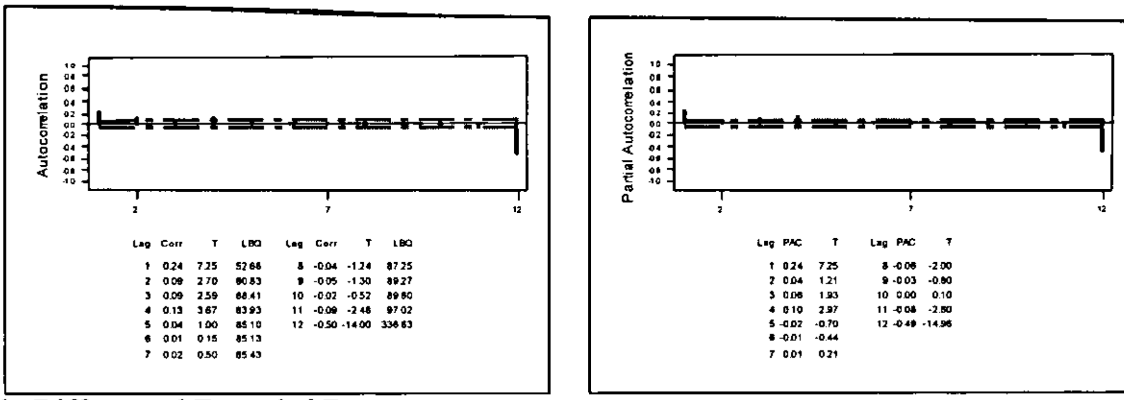


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.83	25.73	663.88	8	-0.47	-5.32	3326.62
2	0.46	9.29	870.21	9	-0.01	-0.14	3326.77
3	-0.01	-0.19	870.30	10	0.46	5.07	3531.77
4	-0.47	-8.62	1080.18	11	0.81	8.75	4176.12
5	-0.80	-13.88	1691.66	12	0.94	9.42	5042.26
6	-0.91	-13.34	2500.78				
7	-0.80	-9.91	3113.81				

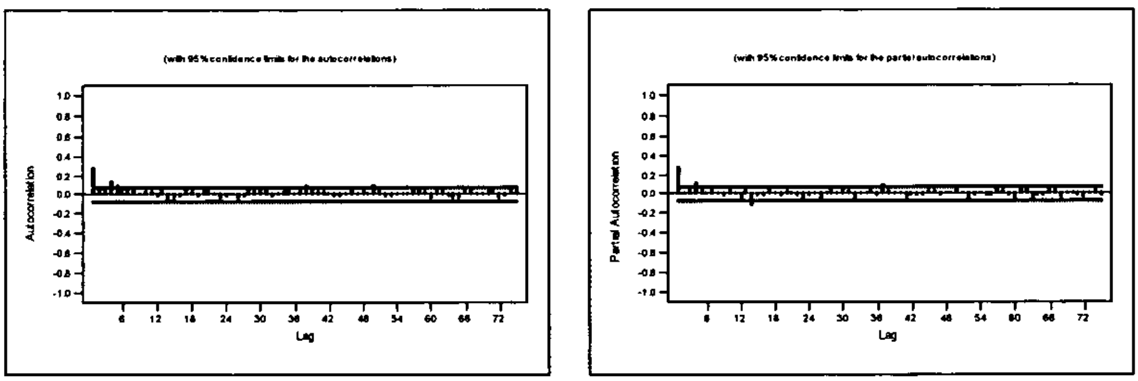


Lag	PAC	T	Lag	PAC	T
1	0.83	25.73	8	-0.11	-3.43
2	-0.73	-22.62	9	0.08	2.42
3	-0.47	-14.64	10	0.27	8.22
4	-0.35	-10.72	11	0.31	9.48
5	-0.32	-10.05	12	0.19	5.82
6	-0.26	-8.07			
7	-0.20	-6.34			

a. Extended Data



b. Differenced Extended Data



c. Residuals for Differenced Extended Data

Figure (B.260): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Monthly Maximum for Jafar Station

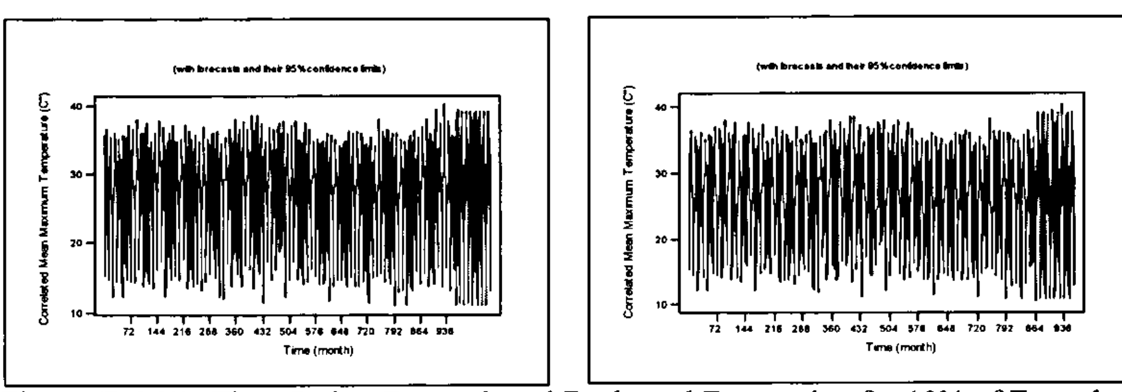


Figure (B.261): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Monthly Maximum Temperature for Jafar Station

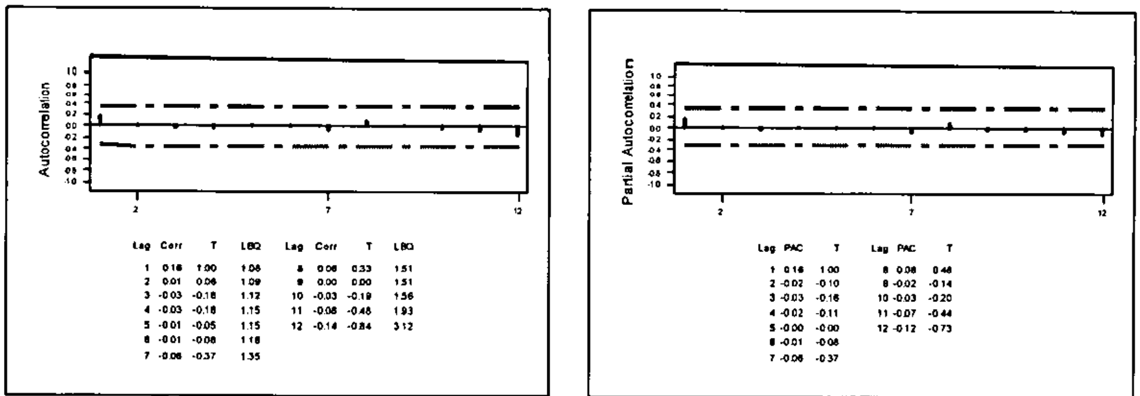


Figure (B.262): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Jafar Station

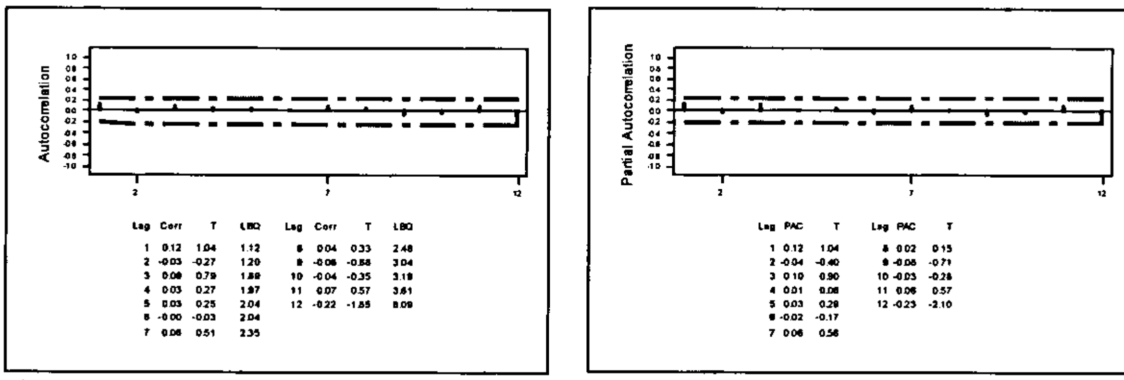


Figure (B.263): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jan., Feb. and Mar. for Jafar Station

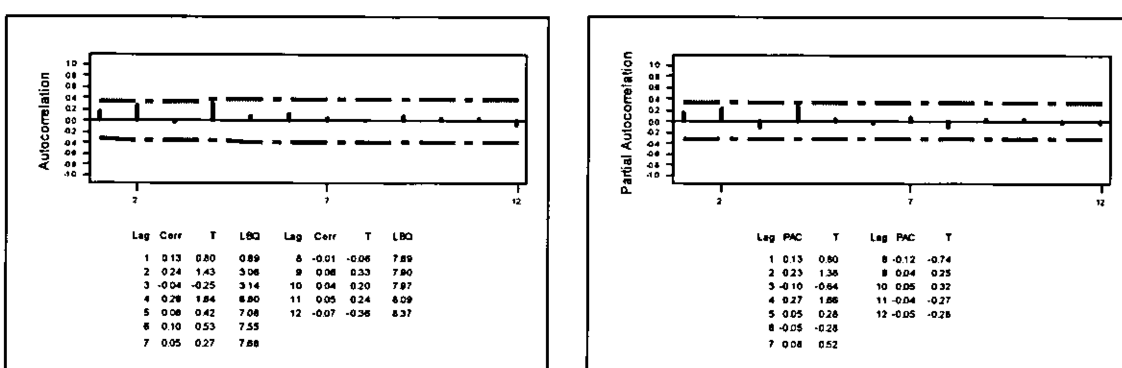


Figure (B.264): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Apr., May and Jun. for Jafar Station

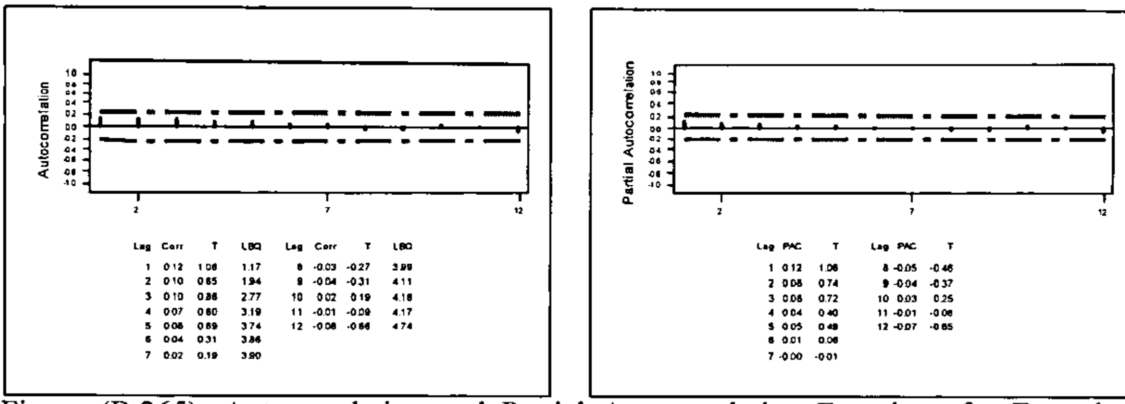


Figure (B.265): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Apr., May and Jun. for Jafar Station

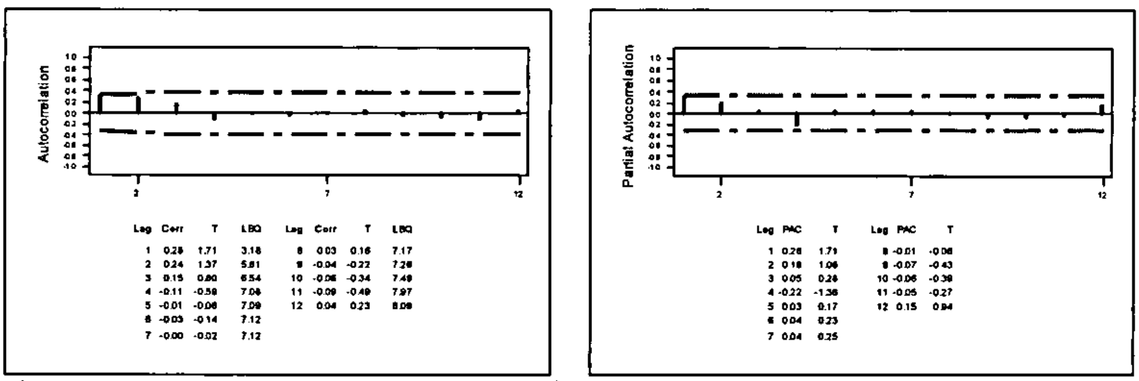


Figure (B.266): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Jafar Station

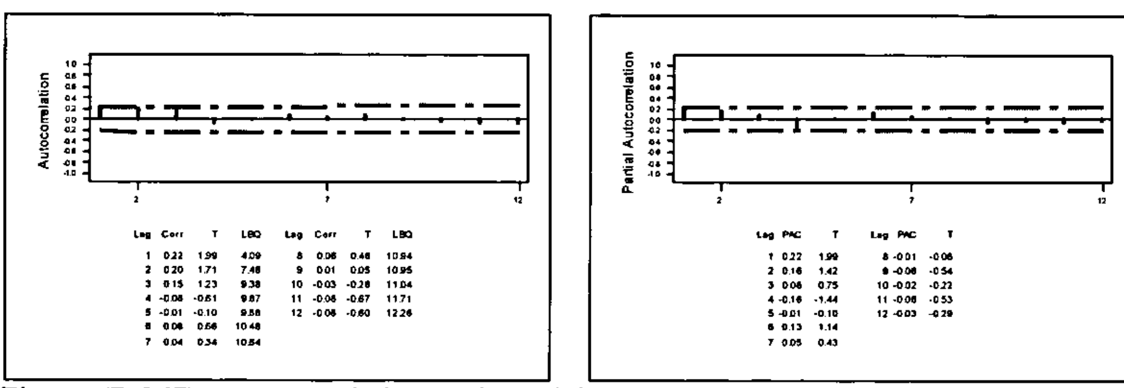
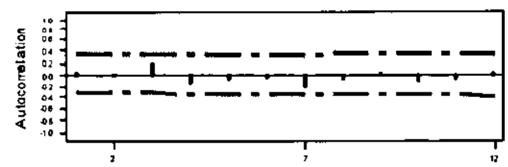
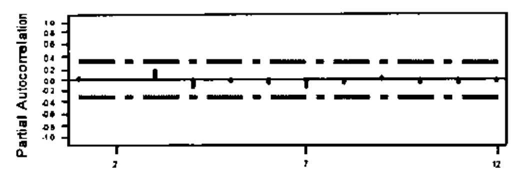


Figure (B.267): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Jul., Aug. and Sep. for Jafar Station

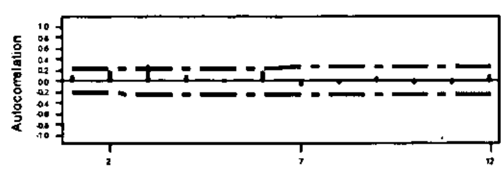


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.04	0.22	0.05	8	-0.08	-0.43	4.71
2	0.00	0.01	0.06	9	0.02	0.13	4.74
3	0.18	1.08	1.40	10	-0.12	-0.64	5.46
4	-0.14	-0.81	2.21	11	-0.08	-0.31	5.63
5	-0.06	-0.36	2.39	12	0.02	0.12	5.66
6	-0.03	-0.15	2.42				
7	-0.20	-1.18	4.42				

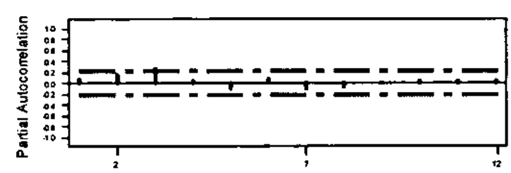


Lag	PAC	T	Lag	PAC	T
1	0.04	0.22	8	-0.07	-0.40
2	0.00	0.01	9	0.03	0.18
3	0.18	1.06	10	-0.08	-0.47
4	-0.15	-0.84	11	-0.08	-0.51
5	-0.05	-0.30	12	-0.02	-0.15
6	-0.06	-0.34			
7	-0.18	-0.85			

Figure (B.268): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Jafar Station

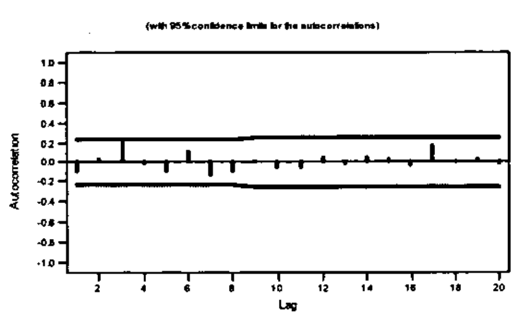


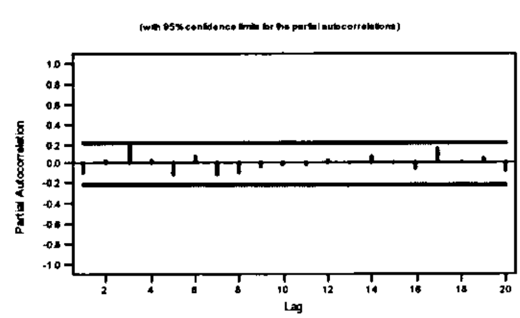
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.06	0.50	0.26	8	-0.05	-0.41	12.01
2	0.15	1.36	2.21	9	0.03	0.27	12.11
3	0.27	2.37	8.50	10	-0.03	-0.21	12.18
4	0.08	0.70	9.13	11	-0.03	-0.23	12.26
5	-0.02	-0.12	9.15	12	0.07	0.53	12.70
6	0.18	1.29	11.28				
7	-0.07	-0.58	11.77				



Lag	PAC	T	Lag	PAC	T
1	0.06	0.50	8	-0.08	-0.57
2	0.15	1.34	9	0.01	0.10
3	0.26	2.35	10	0.02	0.18
4	0.05	0.47	11	0.02	0.21
5	-0.10	-0.92	12	0.05	0.48
6	0.07	0.85			
7	-0.10	-0.84			

One. Extended Data





b. Residuals for Extended Data

Figure (B.269): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Jafar Station

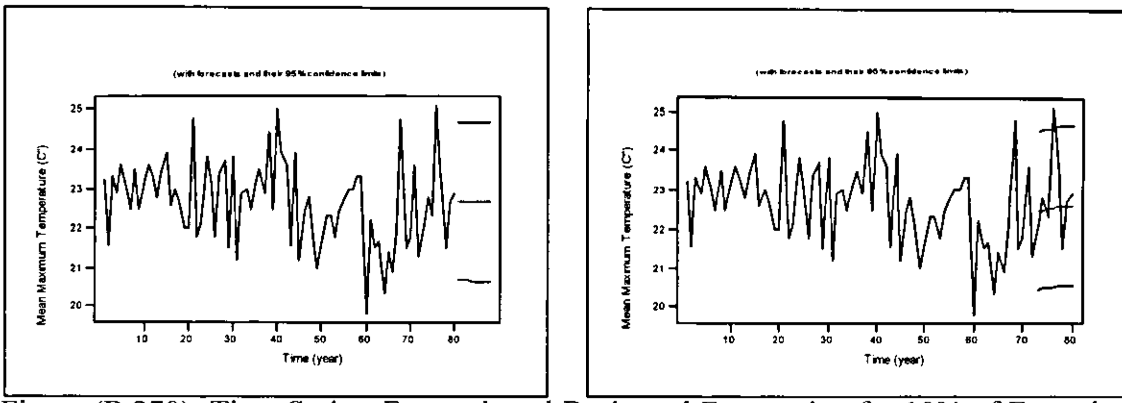
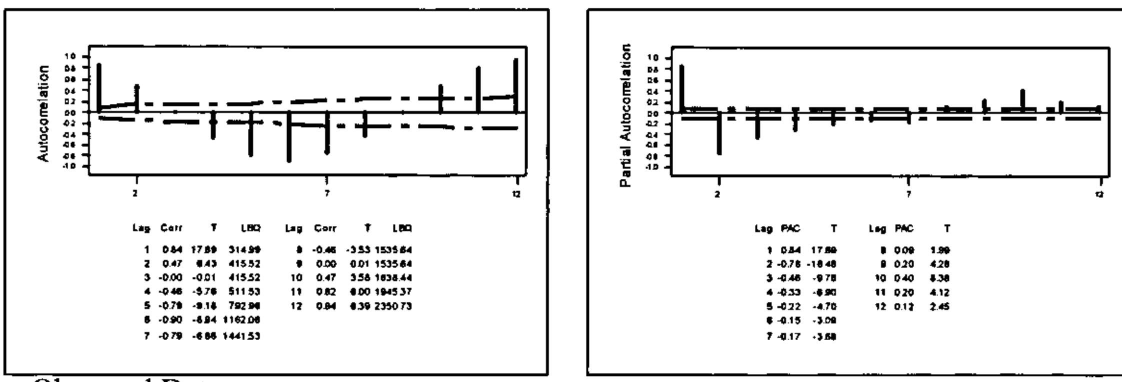
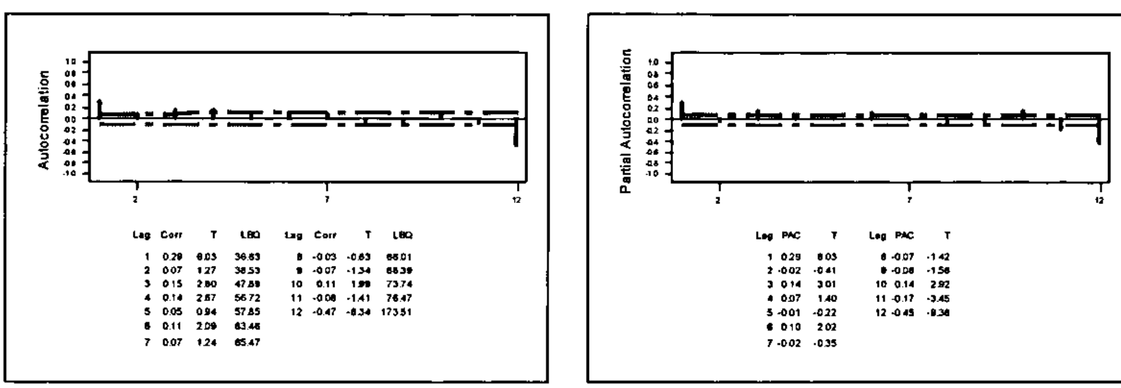


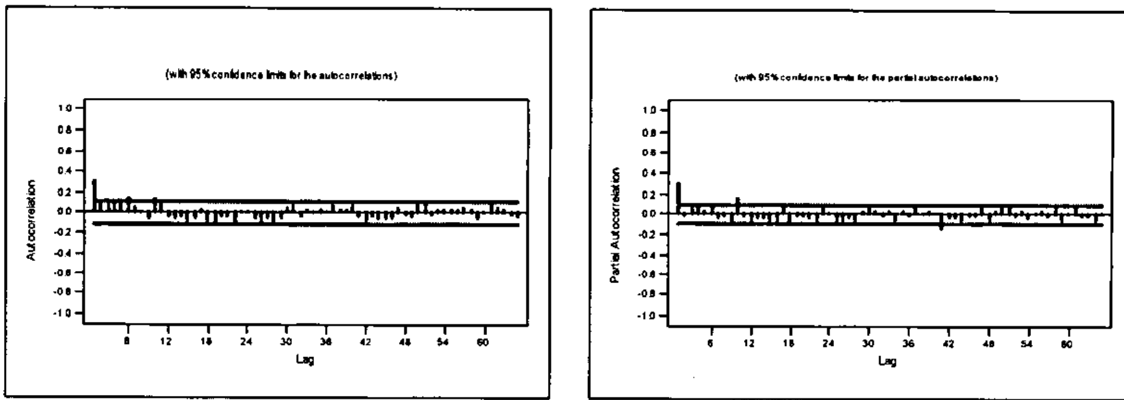
Figure (B.270): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Maximum Temperature for the Average of Oct., Nov. and Dec. for Jafar Station



a. Observed Data



b. Differenced Data



c. Residuals for Differenced Data

Figure (B.271): Autocorrelation and Partial Autocorrelation Functions for Mean Monthly Minimum for Jafar Station

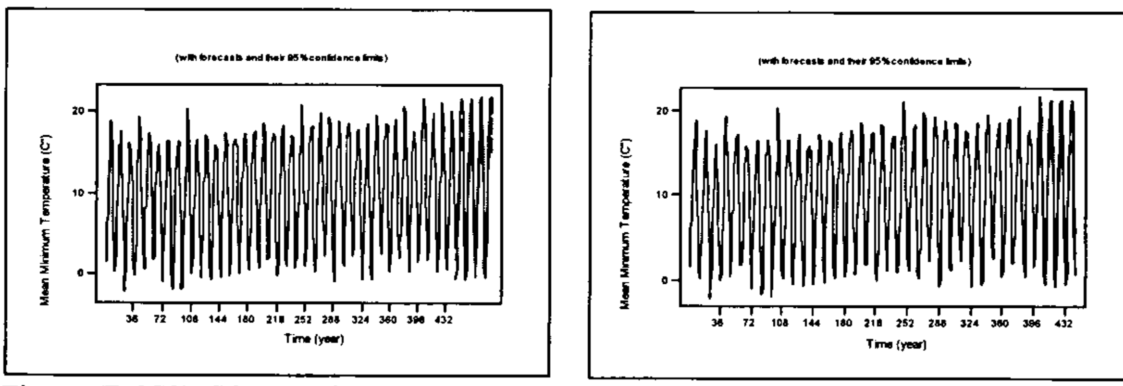
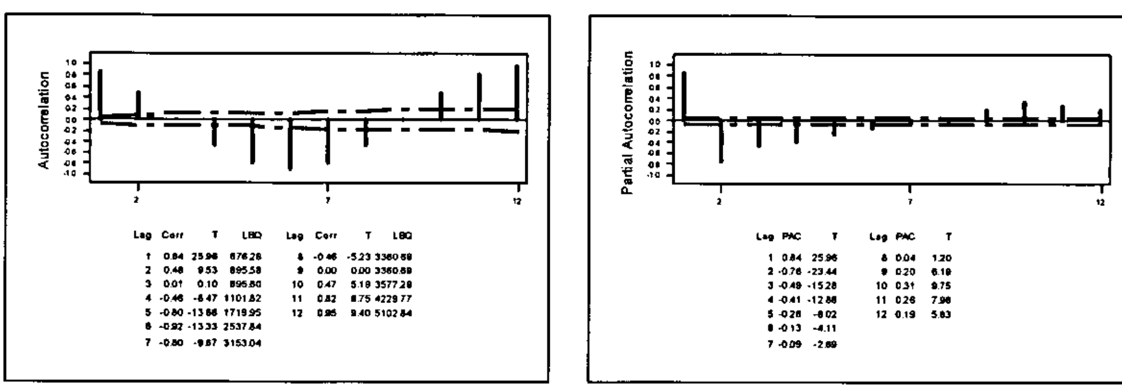
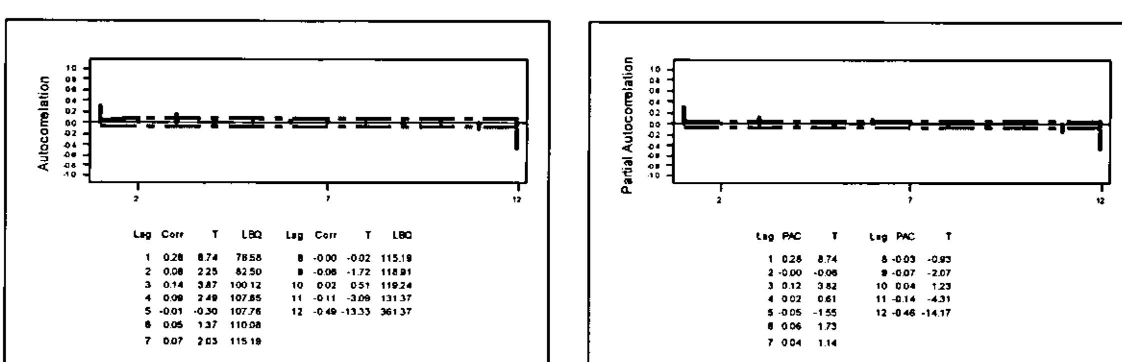


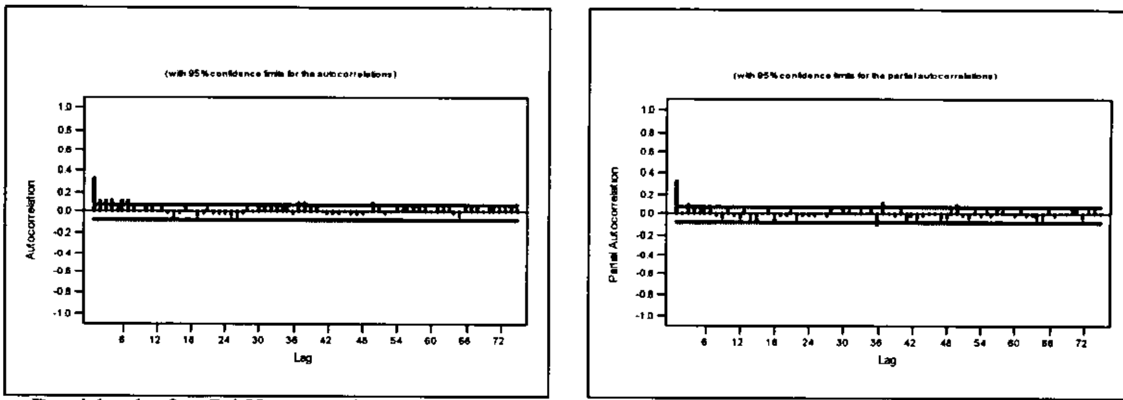
Figure (B.272): Time Series, Forward, and Backward Forecasting for 10% of Observed Mean Monthly Minimum Temperature for Jafar Station



a. Extended Data



b. Differenced Extended Data



c. Residuals for Differenced Extended Data

Figure (B.273): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Monthly Minimum for Jafar Station

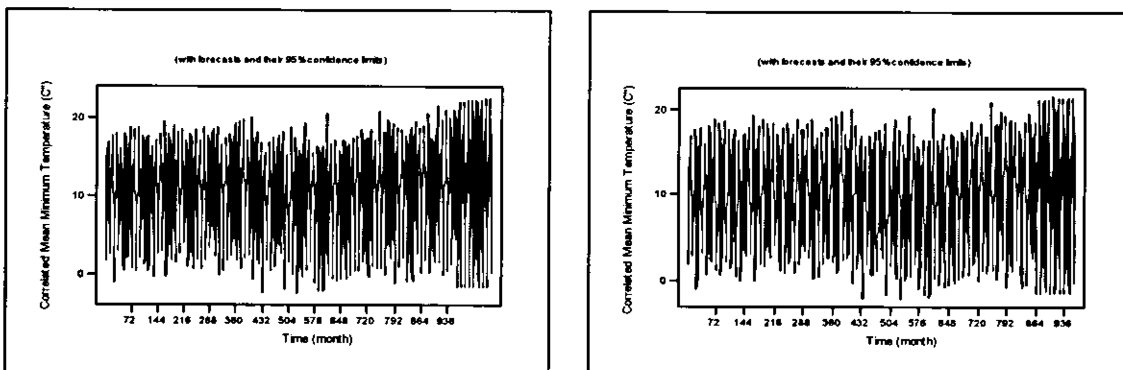


Figure (B.274): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Monthly Minimum Temperature for Jafar Station

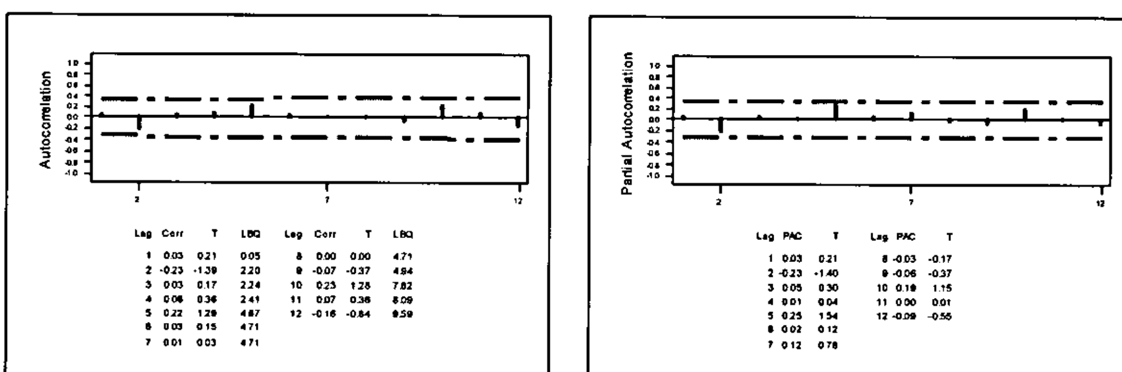


Figure (B.275): Autocorrelation and Partial Autocorrelation Functions for Observed Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Jafar Station

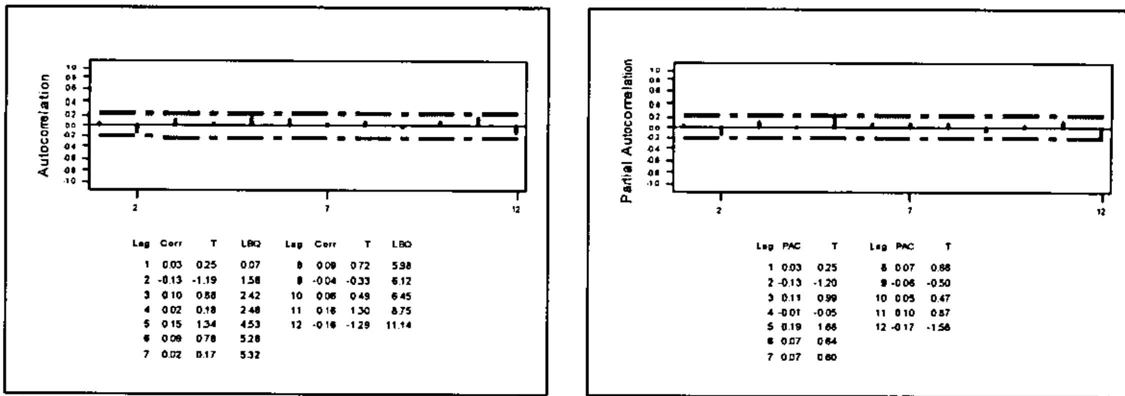
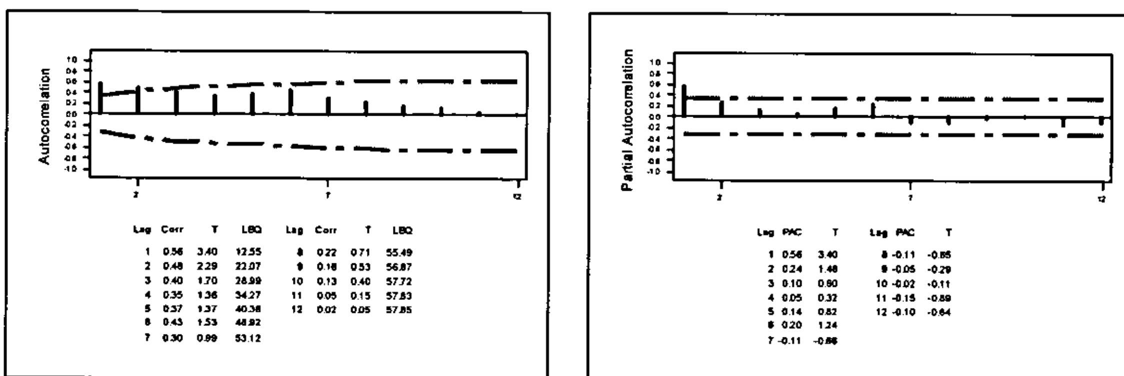
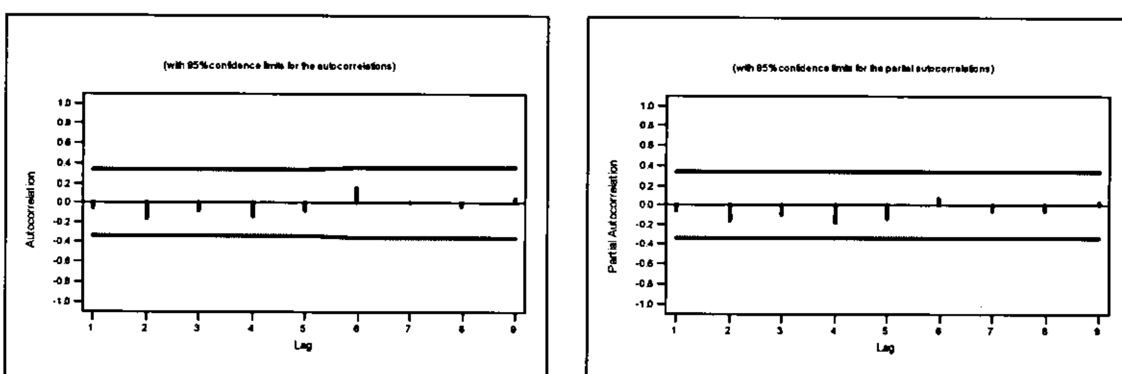


Figure (B.276): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jan., Feb. and Mar. for Jafar Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.277): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Apr., May and Jun. for Jafar Station

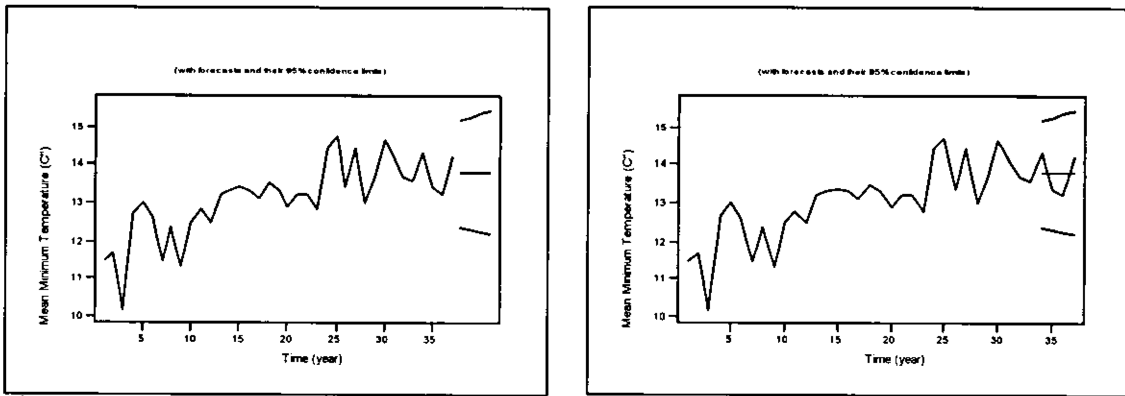
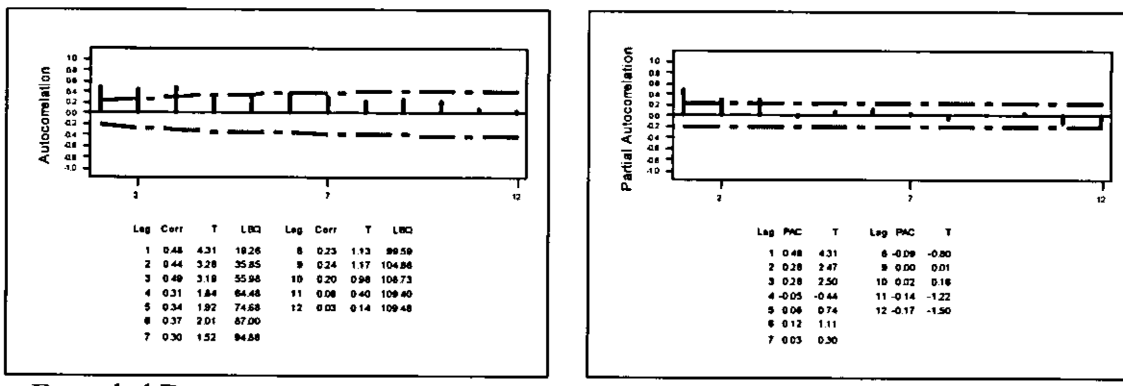
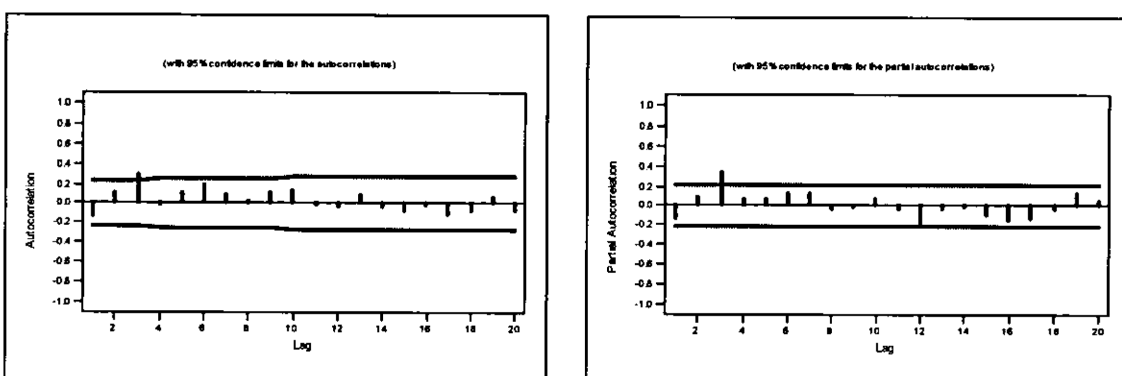


Figure (B.278): Time Series, Forward, and Backward Forecasting for 10% of Observed Mean Minimum Temperature for the Average of Apr. May and Jun. for Jafar Station



a. Extended Data



b. Residuals for Extended Data

Figure (B.279): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Apr., May and Jun. for Jafar Station

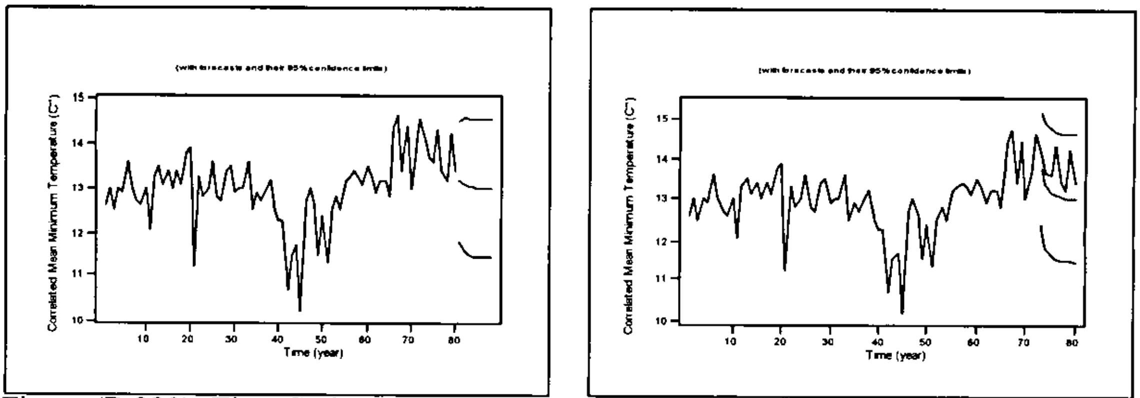
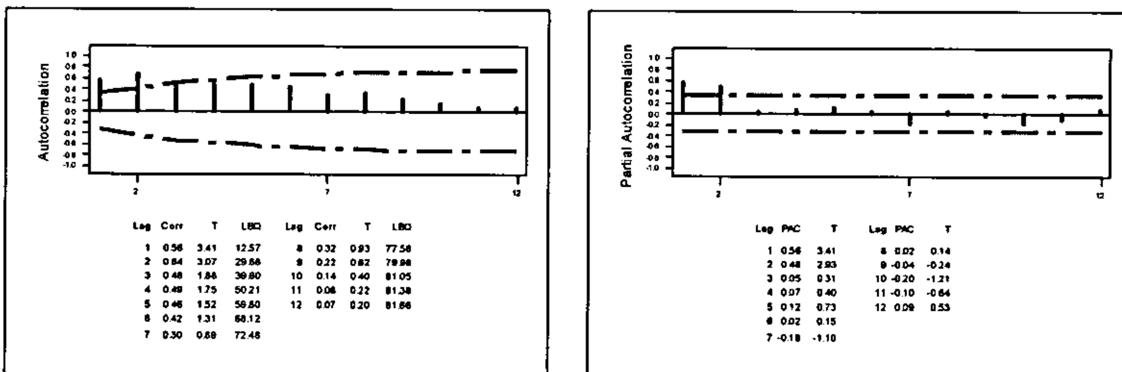
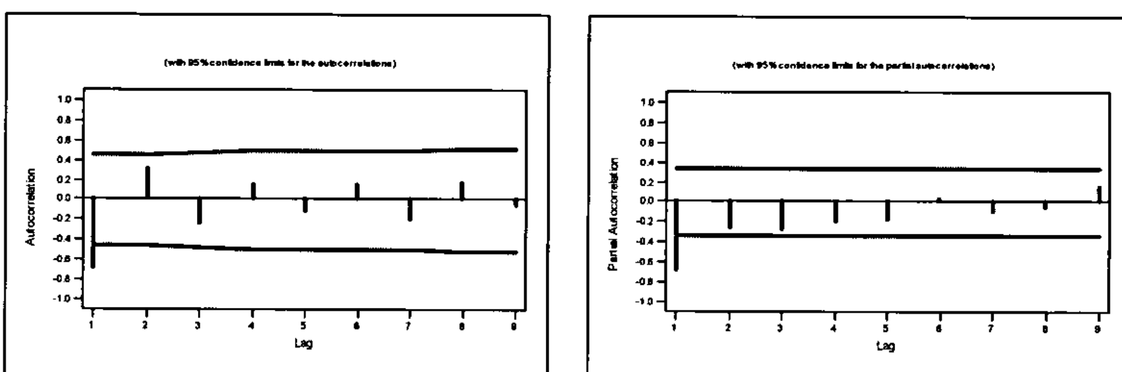


Figure (B.280): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Apr. May and Jun. for Jafar Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.281): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Jafar Station

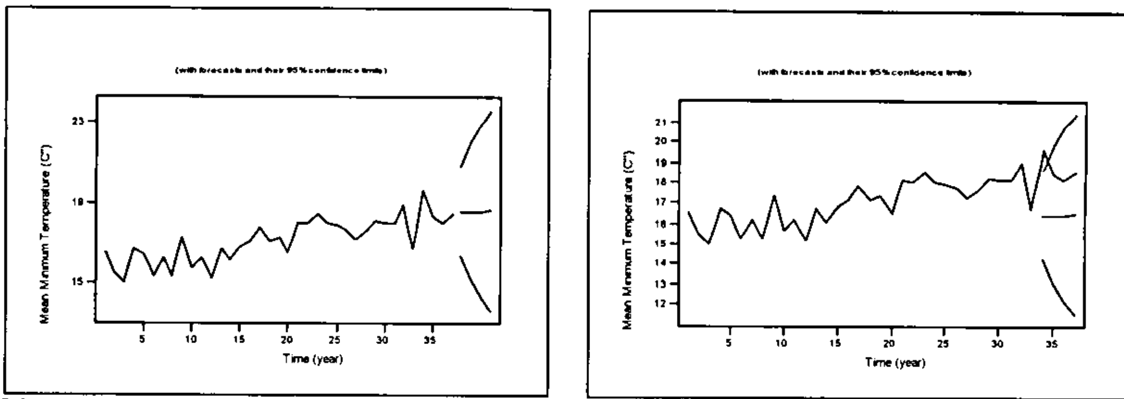
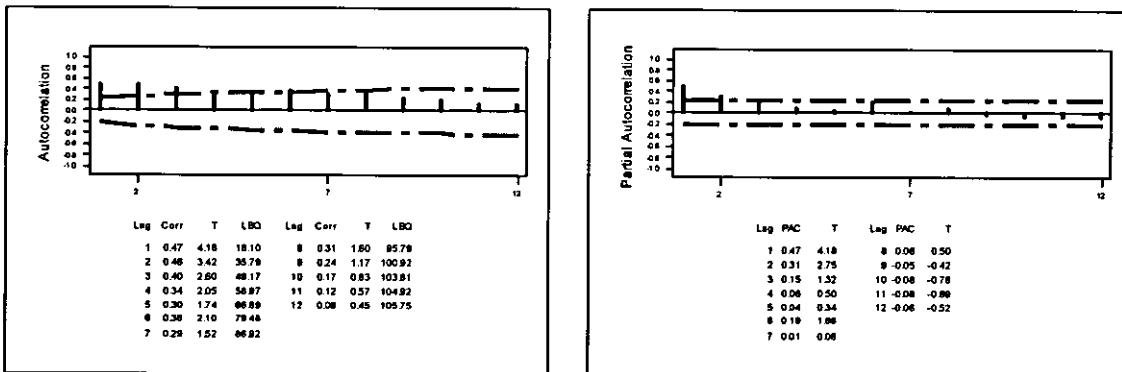
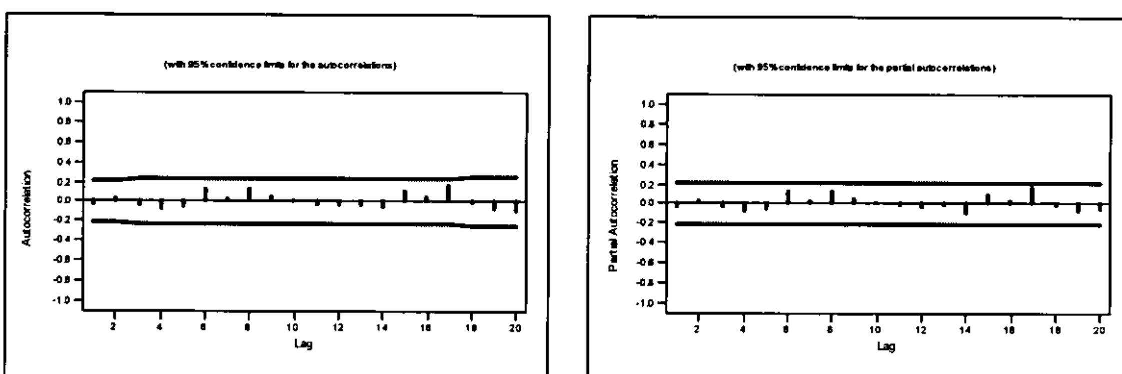


Figure (B.282): Time Series, Forward, and Backward Forecasting for 10% of Observed Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Jafar Station



a. Extended Data



b. Residuals for Extended Data

Figure (B.283): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Jafar Station

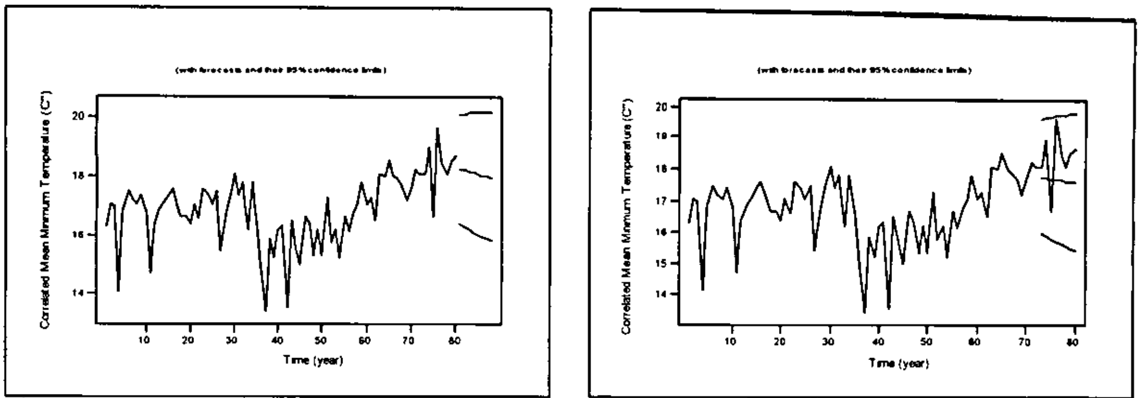
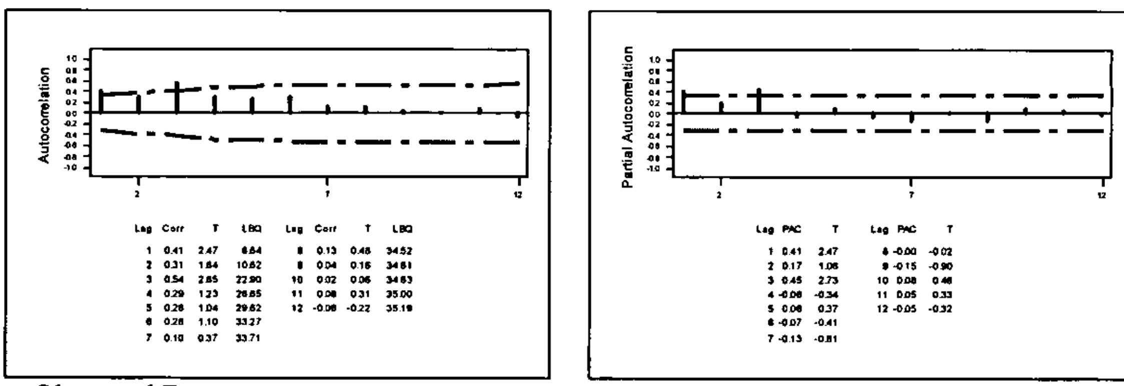
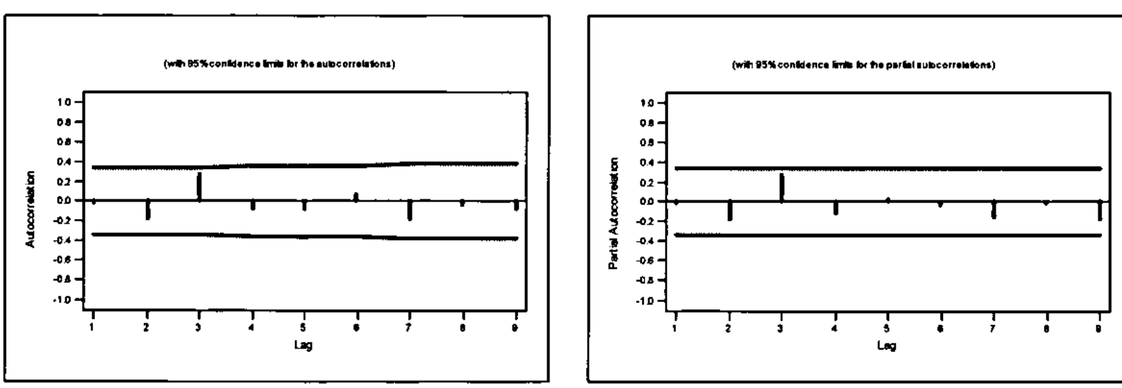


Figure (B.284): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Jul., Aug. and Sep. for Jafar Station



a. Observed Data



b. Residuals for Observed Data

Figure (B.285): Autocorrelation and Partial Autocorrelation Functions for Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Jafar Station

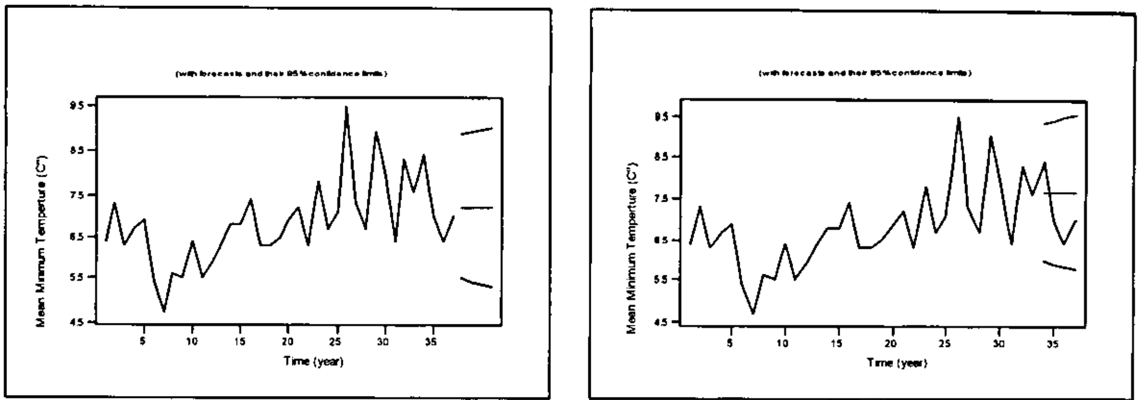
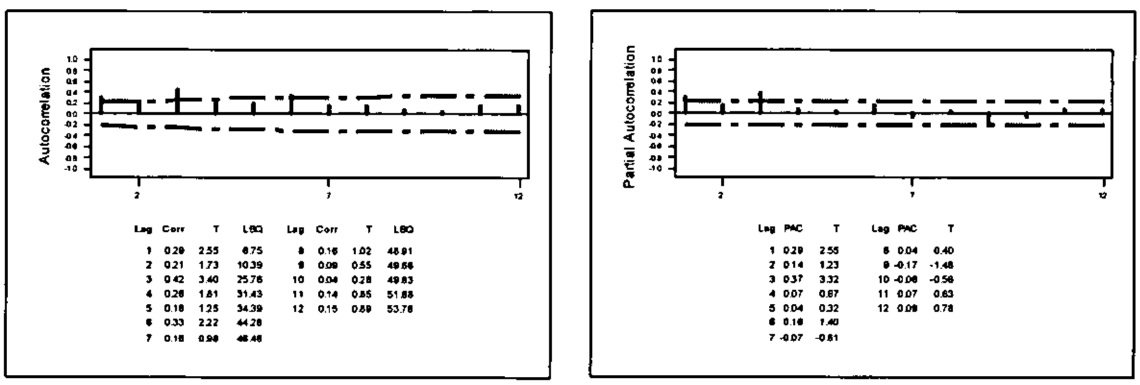
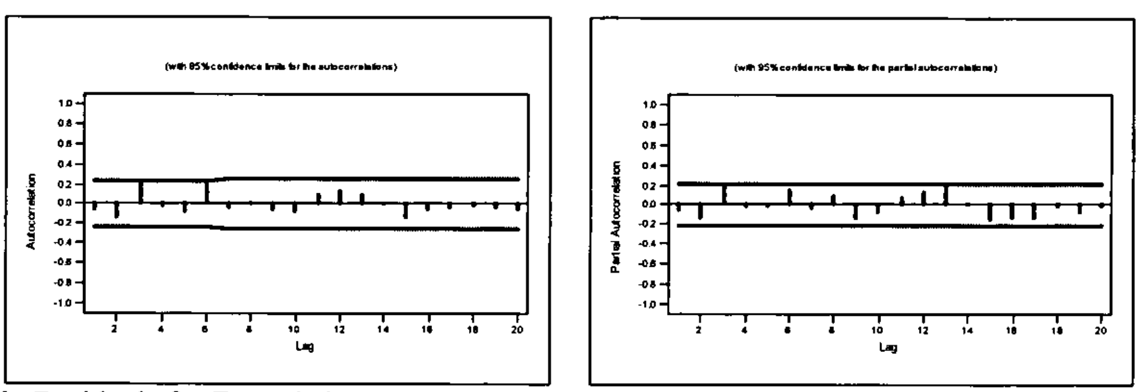


Figure (B.286): Time Series, Forward, and Backward Forecasting for 10% of Observed Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Jafar Station



a. Extended Data



b. Residuals for Extended Data

Figure (B.287): Autocorrelation and Partial Autocorrelation Functions for Extended Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Jafar Station

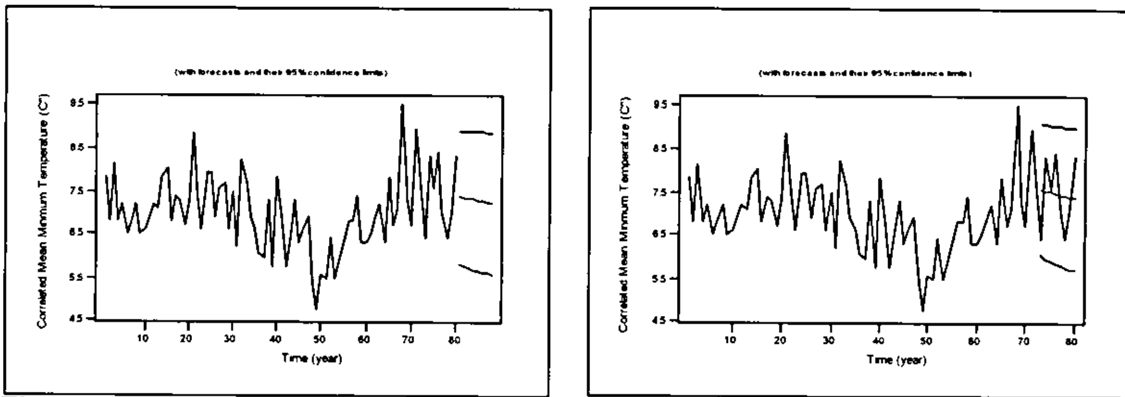


Figure (B.288): Time Series, Forward, and Backward Forecasting for 10% of Extended Mean Minimum Temperature for the Average of Oct., Nov. and Dec. for Jafar Station

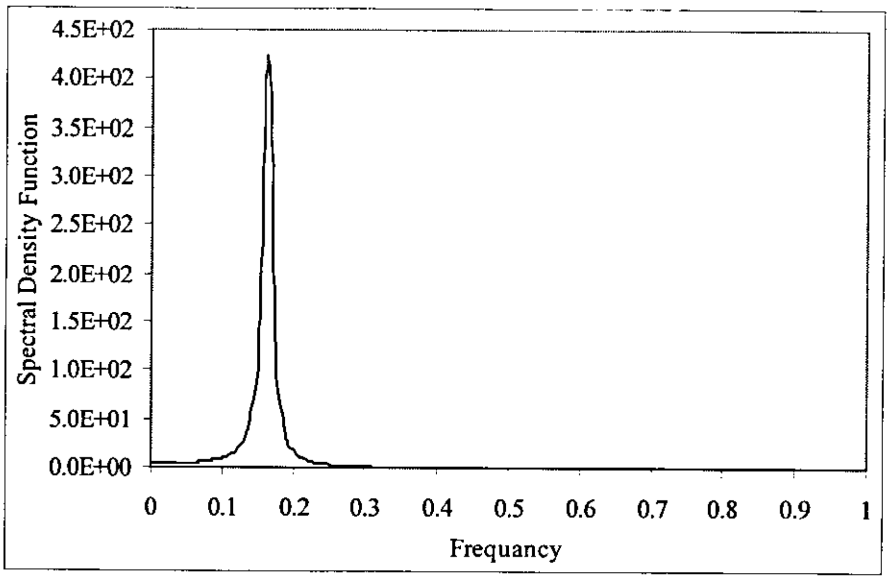


Figure (B.289): The Spectral Density Function for Mean Monthly Minimum Temperature for Amman Airport Station

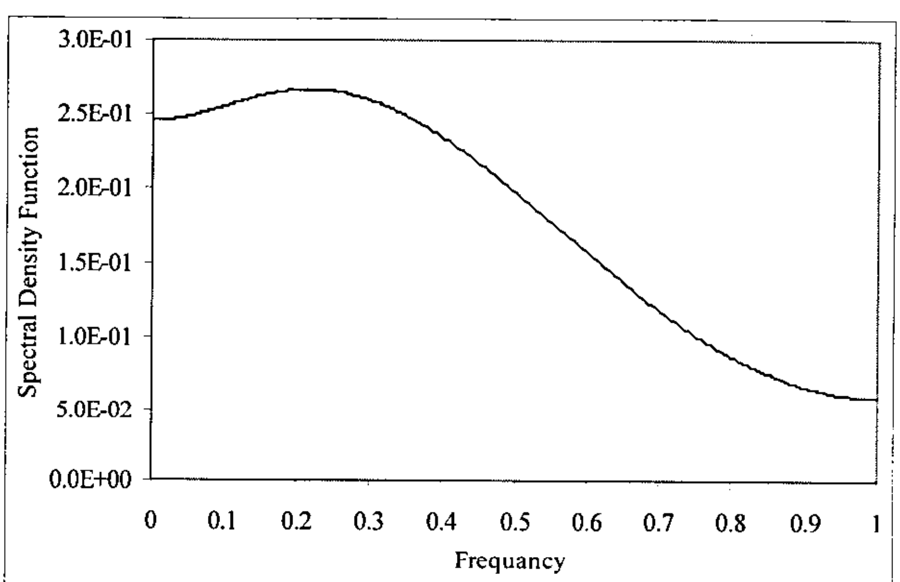


Figure (B.290): The Spectral Density Function for Mean Monthly Maximum Temperature for Irbid Station

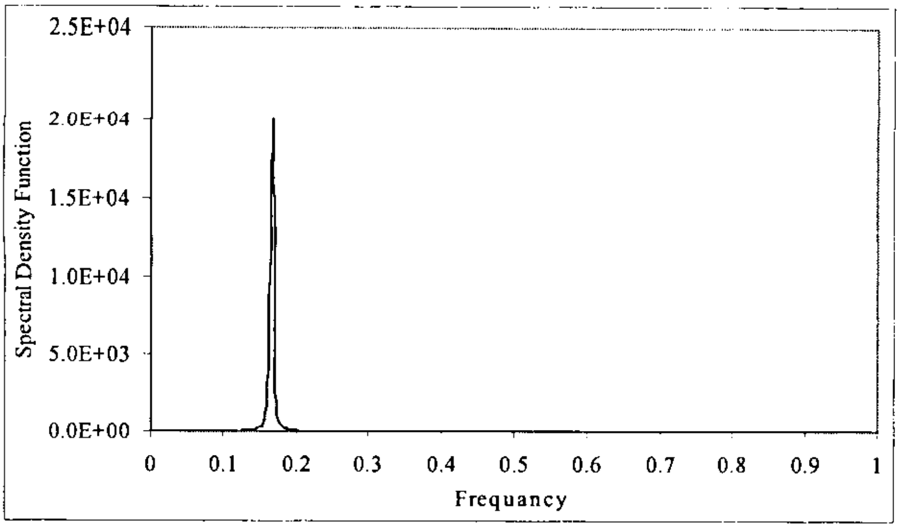


Figure (B.291): The Spectral Density Function for Mean Monthly Minimum Temperature for Irbid Station

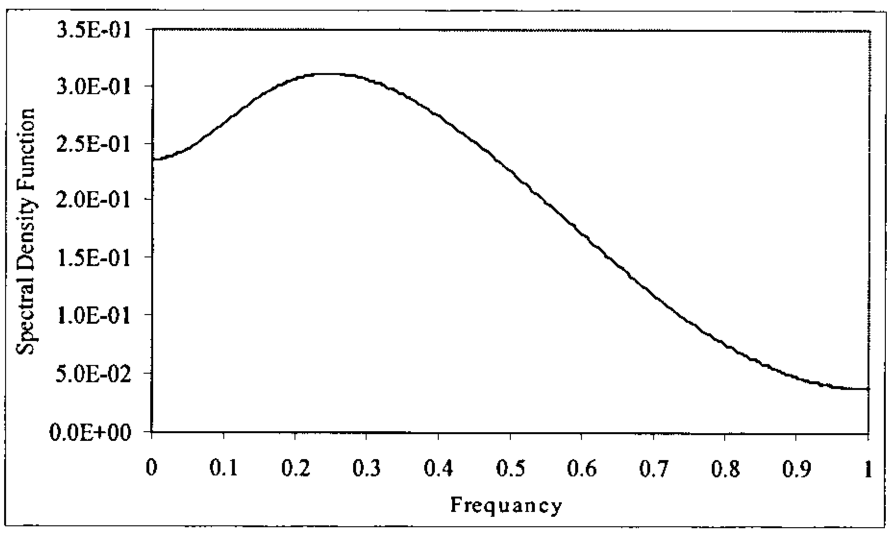


Figure (B.292): The Spectral Density Function for Mean Monthly Maximum Temperature for Aqaba Airport Station

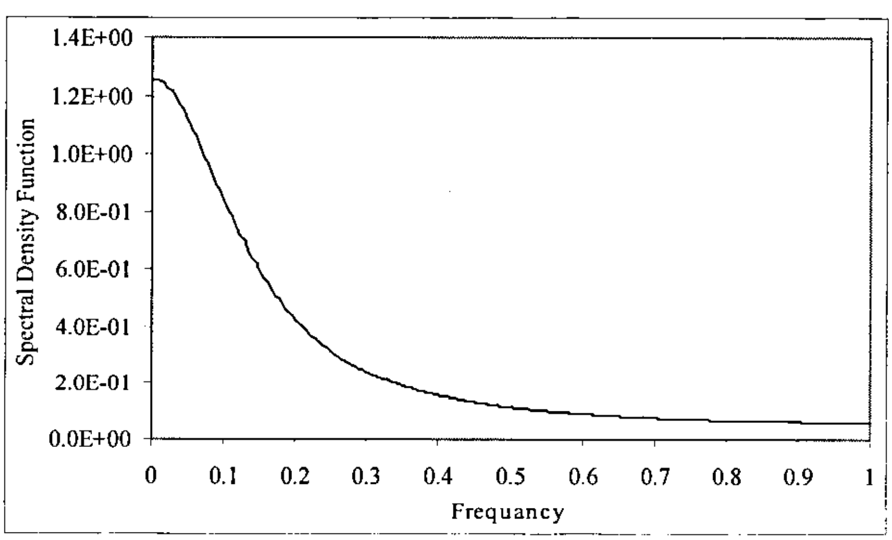


Figure (B.293): The Spectral Density Function for Mean Monthly Minimum Temperature for Aqaba Airport Station

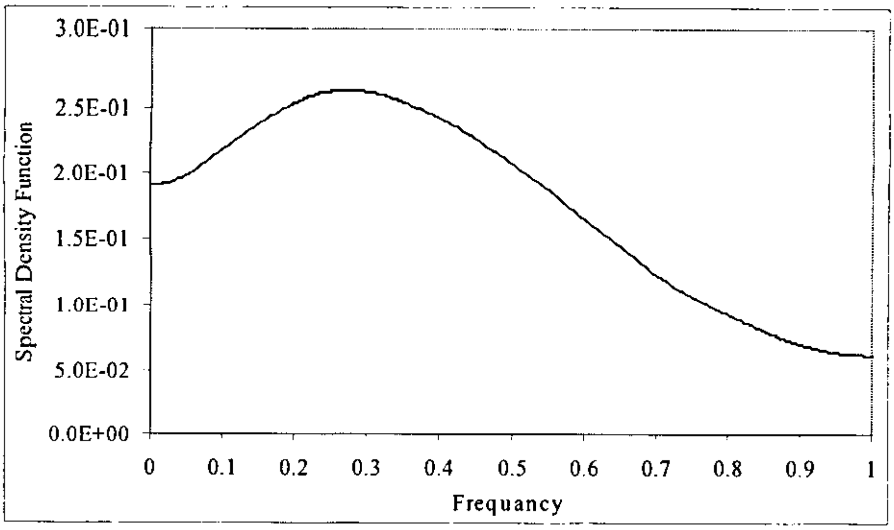


Figure (B.294): The Spectral Density Function for Mean Monthly Maximum Temperature for Azraq Station

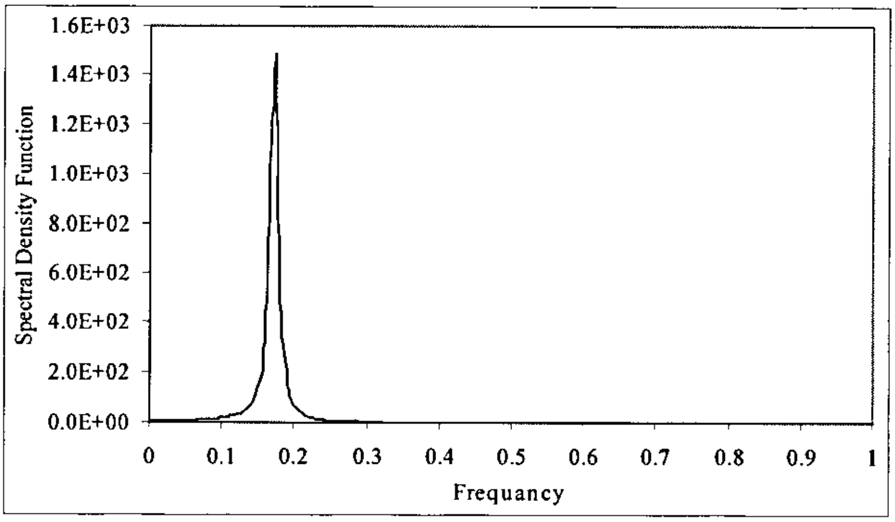


Figure (B.295): The Spectral Density Function for Mean Monthly Minimum Temperature for Azraq Station

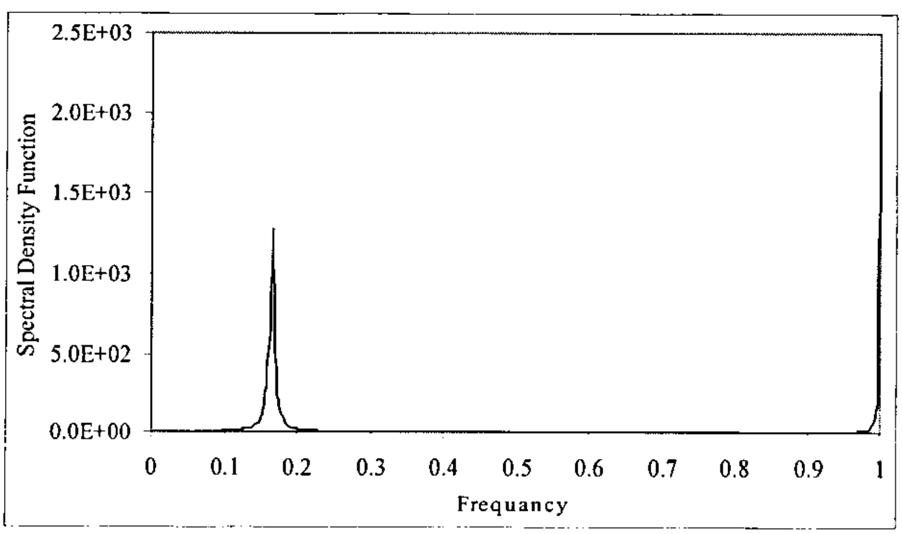


Figure (B.296): The Spectral Density Function for Mean Monthly Maximum Temperature for Jafar Station

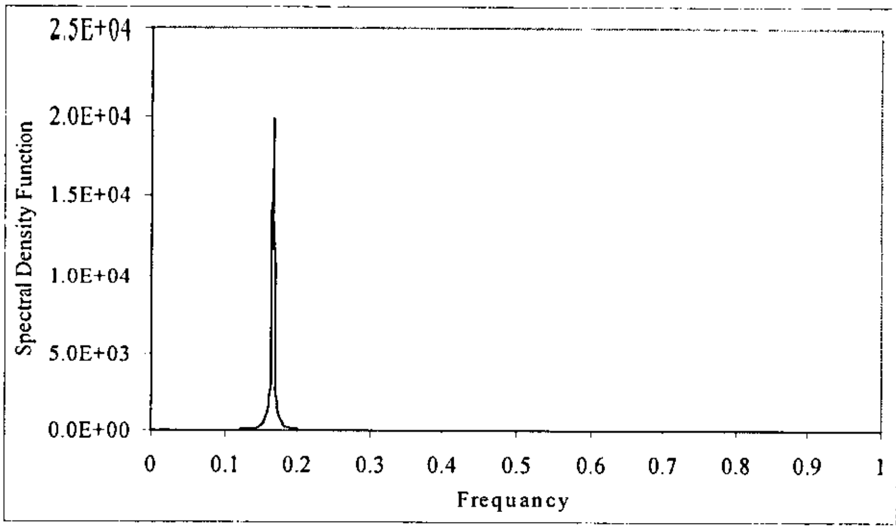


Figure (B.297): The Spectral Density Function for Mean Monthly Minimum Temperature for Jafar Station

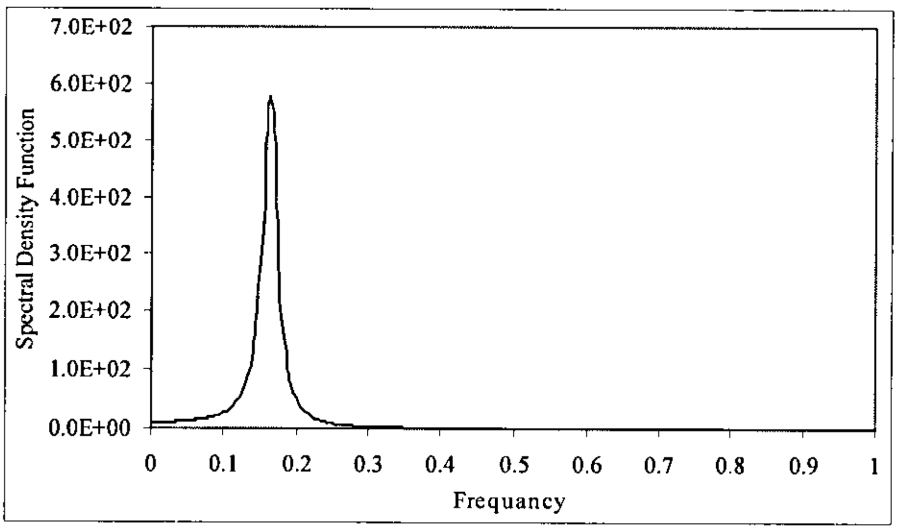


Figure (B.298): The Spectral Density Function for Extended Mean Monthly Maximum Temperature for Irbid Station

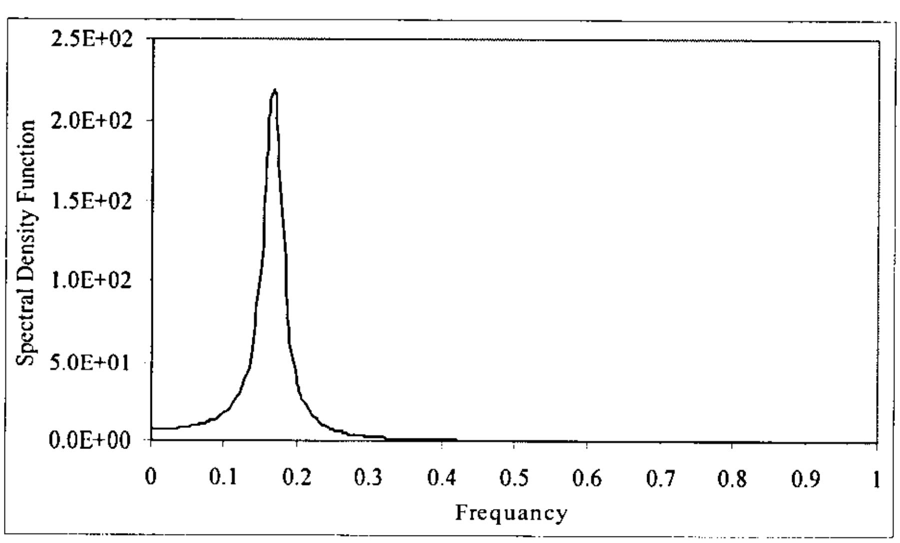


Figure (B.299): The Spectral Density Function for Extended Mean Monthly Minimum Temperature for Irbid Station

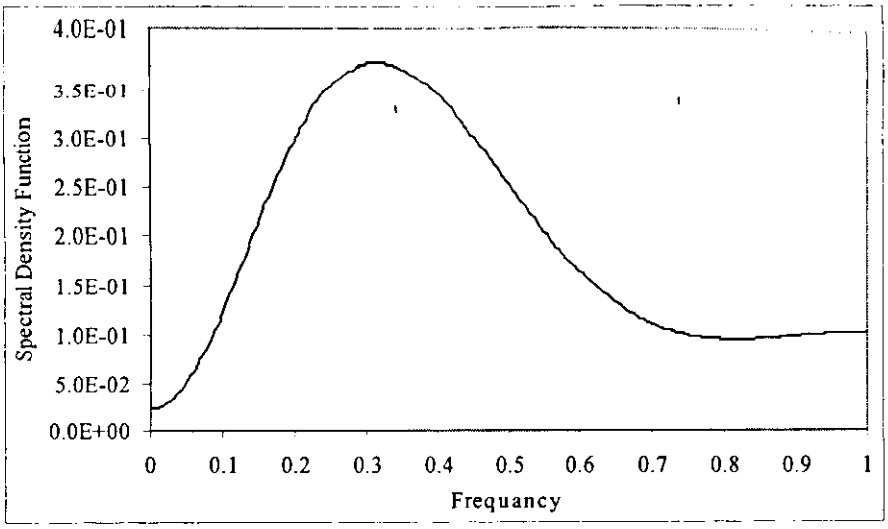


Figure (B.300): The Spectral Density Function for Extended Mean Monthly Maximum Temperature for Aqaba Airport Station

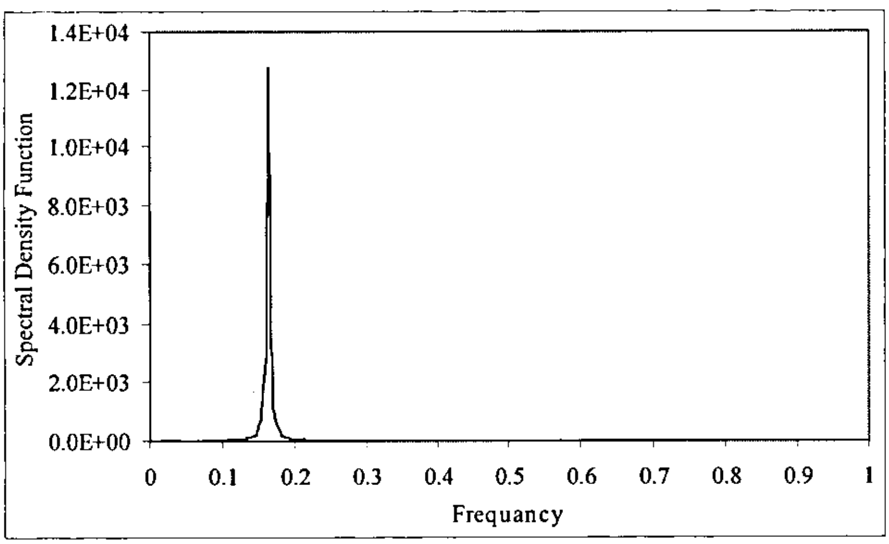


Figure (B.301): The Spectral Density Function for Extended Mean Monthly Minimum Temperature for Aqaba Airport Station

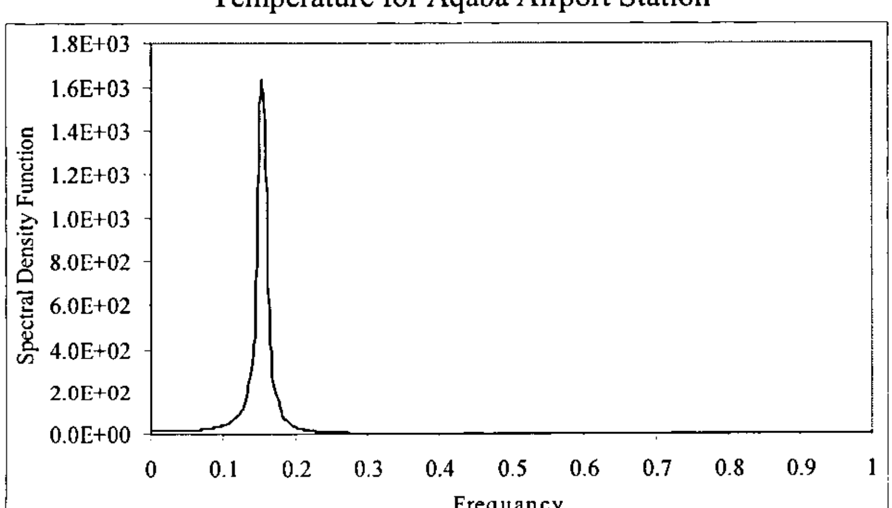


Figure (B.302): The Spectral Density Function for Extended Mean Monthly Maximum Temperature for Azraq Station

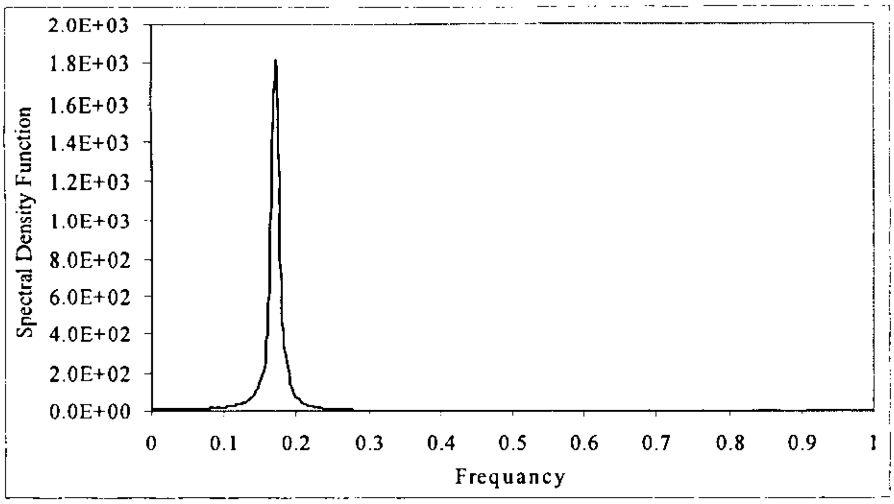


Figure (B.303): The Spectral Density Function for Extended Mean Monthly Minimum Temperature for Azraq Station

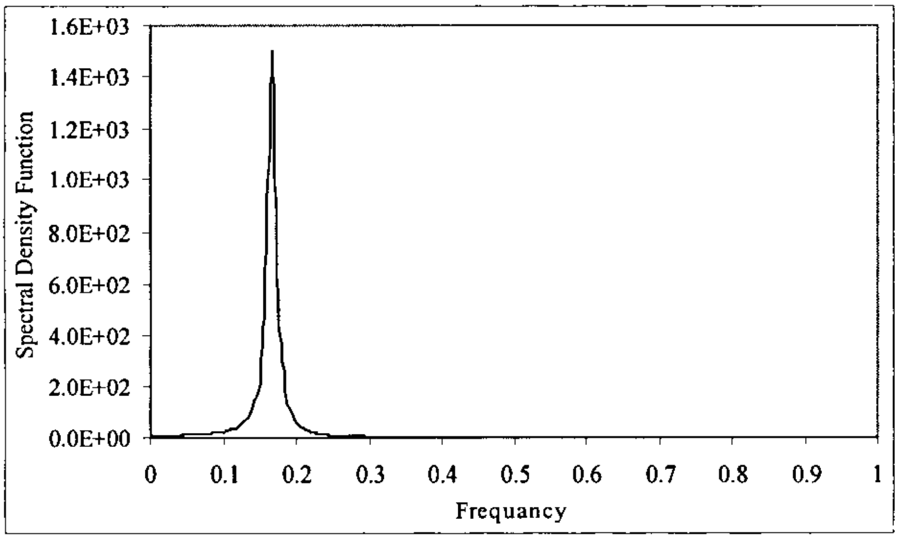


Figure (B.304): The Spectral Density Function for Extended Mean Monthly Maximum Temperature for Jafar Station

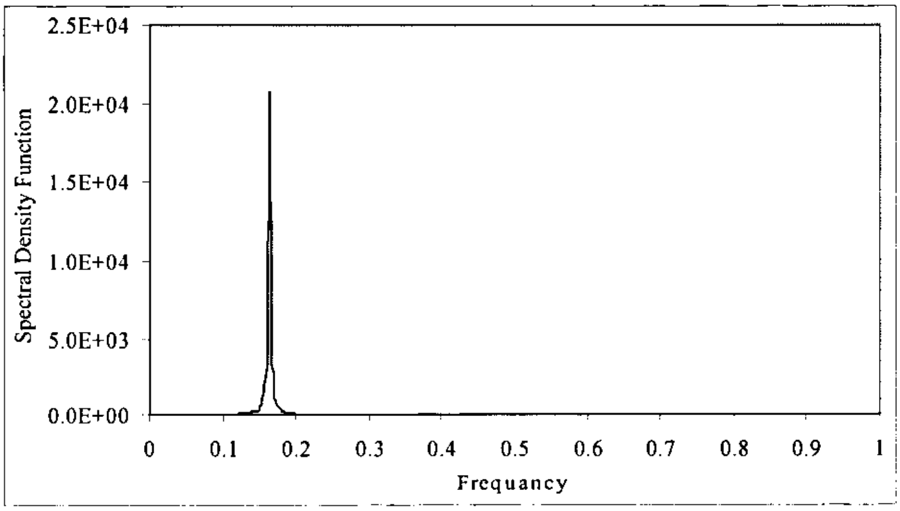
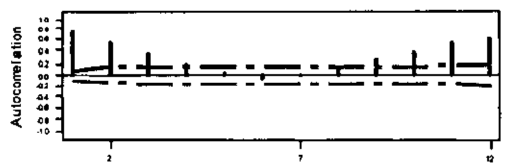
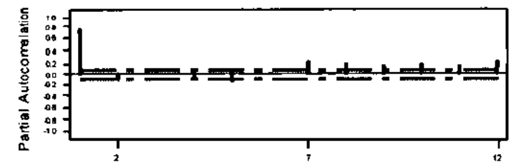


Figure (B.305): The Spectral Density Function for Extended Mean Monthly Minimum Temperature for Jafar Station

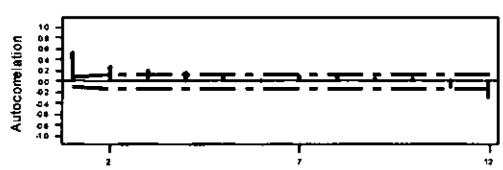


Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.74	14.69	217.37	8	0.13	1.52	386.89
2	0.50	6.92	318.43	9	0.25	2.90	412.35
3	0.34	4.16	363.82	10	0.38	4.37	472.51
4	0.19	2.24	378.21	11	0.50	5.41	573.90
5	0.03	0.39	378.65	12	0.59	5.99	716.93
6	-0.06	-0.70	380.10				
7	0.00	0.02	380.10				

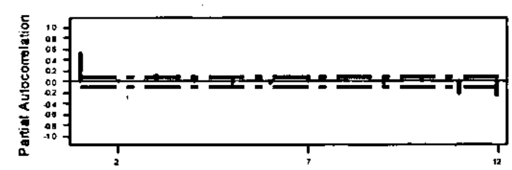


Lag	PAC	T	Lag	PAC	T
1	0.74	14.69	8	0.20	3.89
2	-0.09	-1.84	9	0.14	2.71
3	-0.00	-0.02	10	0.19	3.78
4	-0.08	-1.55	11	0.13	2.57
5	-0.13	-2.65	12	0.20	4.04
6	-0.00	-0.08			
7	0.23	4.58			

One. Observed Data

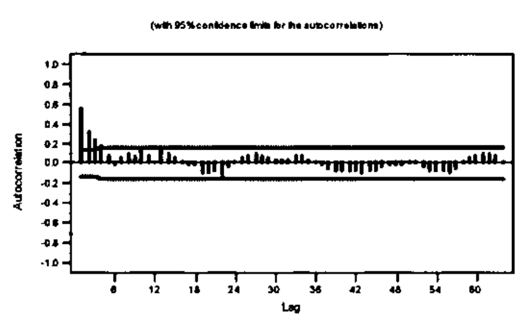


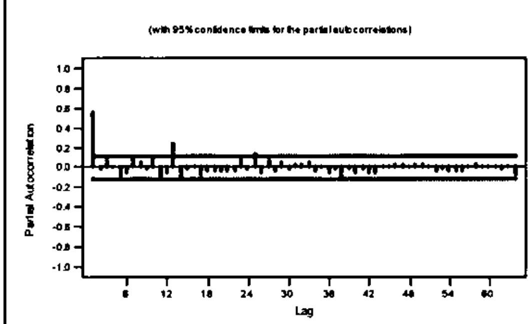
Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.50	9.85	97.77	8	0.07	1.05	152.98
2	0.25	4.05	122.78	9	0.02	0.30	153.16
3	0.20	3.05	138.14	10	0.04	0.66	153.95
4	0.15	2.29	147.25	11	-0.12	-1.73	158.49
5	0.07	1.08	149.34	12	-0.31	-4.50	197.69
6	0.01	0.20	149.41				
7	0.06	0.93	150.98				



Lag	PAC	T	Lag	PAC	T
1	0.50	9.85	8	0.01	0.27
2	0.00	0.03	9	-0.03	-0.67
3	0.08	1.65	10	0.05	1.03
4	0.02	0.46	11	-0.23	-4.58
5	-0.04	-0.72	12	-0.25	-4.95
6	-0.03	-0.67			
7	0.08	1.61			

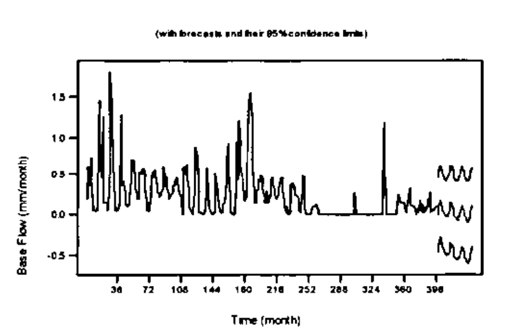
b. Different Data





Two. Residual for Different Data

Figure (B.306): Autocorrelation and Partial Autocorrelation Functions for Monthly Base Flow for Wadi Mujib Station



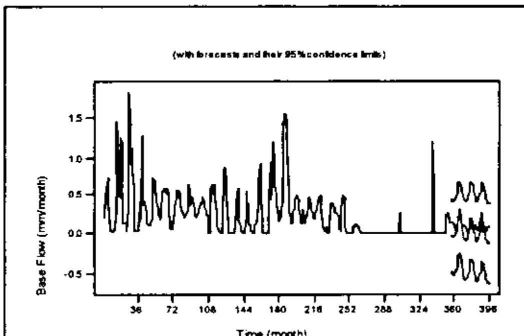
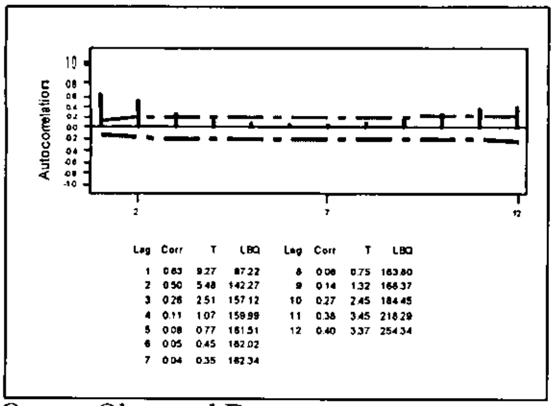
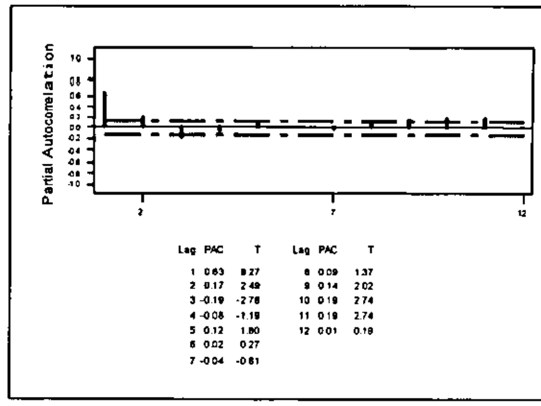
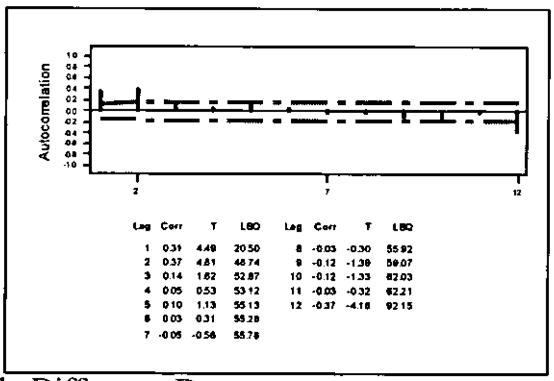


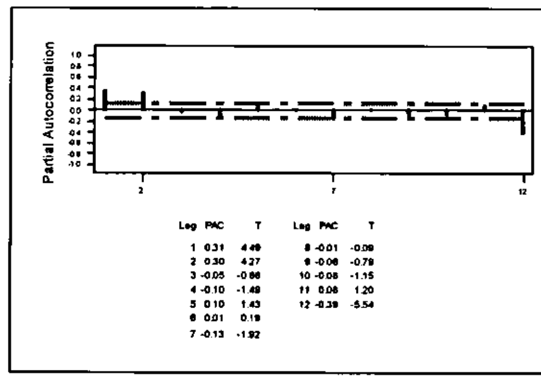
Figure (B.307): Time series, Forward and Backward Forecasting for 10% of Observed Monthly Base Flow for Wadi Mujib Station



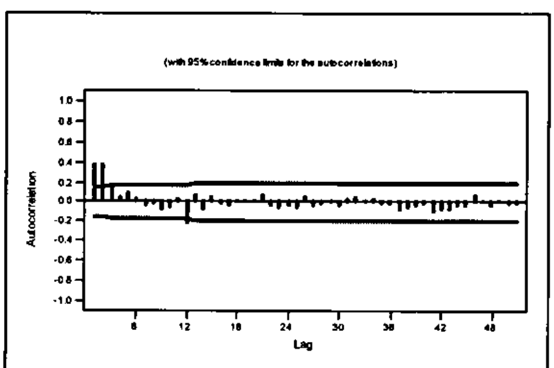


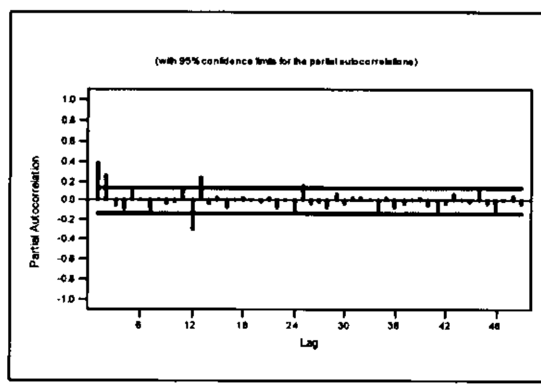
One. Observed Data





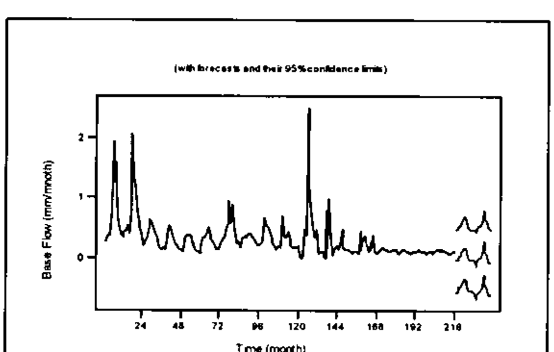
b. Difference Data





c. Residual for Difference Data

Figure (B.308): Autocorrelation and Partial Autocorrelation Functions for Monthly Base Flow for Wadi Hisban Station



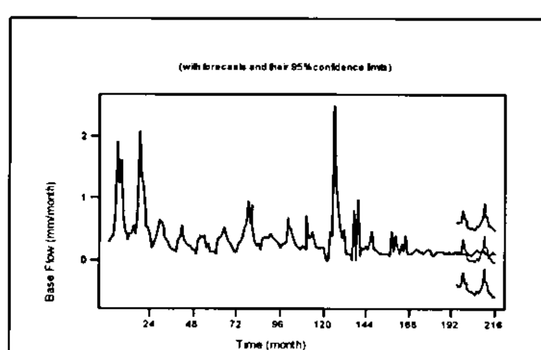


Figure (B.309): Time series, Forward and Backward Forecasting for 10% of Observed Monthly Base Flow for Wadi Hisban Station

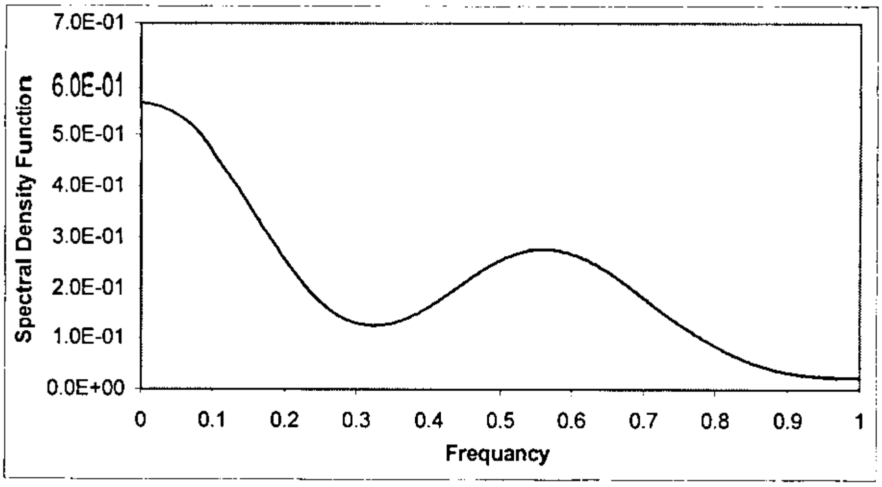


Figure (B.310): The Spectral Density Function for Observed Monthly Base Flow for Wadi Mujib Station

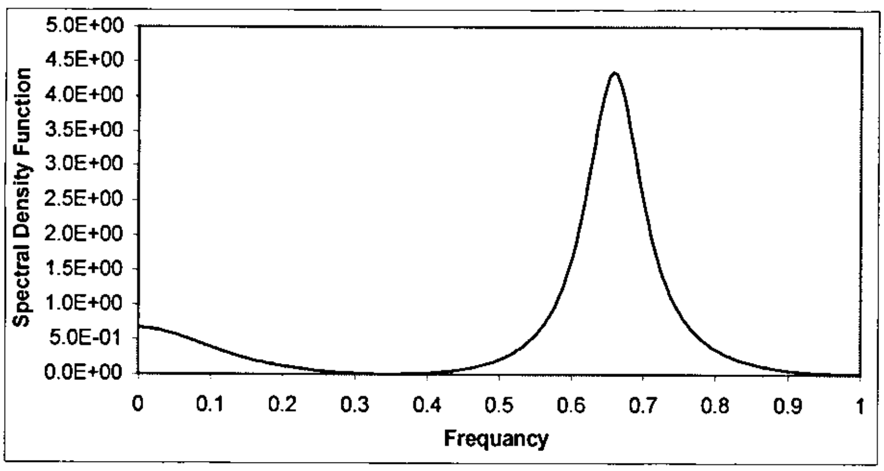


Figure (B.311): The Spectral Density Function for Observed Monthly Base Flow for Wadi Hisban Station

تحليل المتتاليات الزمنية في تطبيقات المصادر المائية والتغيرات المناخية

إعداد

ضياء عبد السيد

المشرف

د. عدنان الصالحي

الملخص

تصنف الأردن كمنطقة شبه صحراوية تمثل نموذجا جيدا لندرة المياه، حيث يتوجب التصرف بالمياه بحكمة لحل هذه المشكلة. والمعلومات الهيدرولوجية من الأدوات المهمة في إدارة المياه وهي تتكون من سلسلة من البيانات. وهنا يمكن أن يكون التحديث المستمر لقواعد البيانات الهيدرولوجية أداة فعالة في إدارة مصادر المياه. فمن خلال التحليل المناسب للمعلومات الهيدرولوجية، يمكن أن يتنبأ المحللون بدقة مقبولة، بمتغيرات محددة تتعلق بالمياه مثل كمية الأمطار المتساقطة ، الجريان، ...الخ. وتحليل المتتاليات الزمنية هي إحدى الطرق المستعملة في تحليل المعلومات الهيدرولوجية.

ان الهدف الرئيسي لهذه الدراسة هو تطوير طريقة مختارة للوصول إلى نموذج التنبؤ الأكثر فعالية لتقدير العوامل المناخية الـــتي تمثل المعدل الأقصى والمعدل الأدنى لدرجات الحرارة وكمية الأمطار في محطات مختلفة في مناطق مناخية مختلفة إضافة إلى الجريان الأساس لثلاثة سيول مختلفة في الأردن.

ولتحقـــيق هـــدف الدراســـة، تم تحليل البيانات باستعمال (Simple forecasting methods, Smoothing methods, Correlation analysis methods, and ARIMA modeling methods) وأجـــري تحلـــيل البـــيانات باســـتخدام أربعـــة بـــرامج حاســـوب هي: Excel, Minitab, S-Plus 2000, and ITSM for Windows.

أظهـــرت التحلـــيلات أن طريقة ARIMA هي أحسن طريقة للتنبؤ بجميع المتغيرات المدروسة. وقد اتضح هذا من خلال مقارنة معايير الدقة الثلاثة MAPE, MAD, and MSD التي تم الحصول عليها باستخدام الطرق المختلفة للنمذجة، و لم تكن طريقة ARIMA فعالة في حالة صغر حجم العينات لذا توجب إجراء ارتباط البيانات المحدودة مع سجلات بيانات أطول من مناطق مشابهة. يمكن تحسين دقة نموذج الأمطار باستخدام طريقةARIMA من خلال

تـــرابط بـــيانات الأمطار مع بيانات الحرارة. كما يمكن استخدام نماذج ARIMA للتحقق من التصنيفات المناخية للمناطق الجغرافية المختلفة.

لم يلاحـــظ (cyclic trend) للأمطار والجريان بسبب صغر العينة بينما تم الحصول عليه للحرارة وتبين أن مقداره 12 شـــهرا. ووجد أن هناك علاقة طردية بين الجريان والأمطار وعكسية بين الجريان والحرارة. ولكن علاقة الجريان لنهر الزرقاء مع الأمطار عكسية ويمكن تبرير ذلك بزيادة المياه العادمة المعالجة الخارجة من محطة خربة السمرة بسبب النمو السكاني في منطقة عمان-الزرقاء.