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Short communication

Forecast future rainfall & temperature for the study area using seasonal auto-regressive integrated moving averages (SARIMA) model

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Abstract
Meteorological data is required to evaluate the long term effect of proposed man made hydrological changes. Such evaluations are often hydrologic processes which use weather data as input. The meteorological variables required for most of hydrologic models includes precipitation it is essential to have a sufficient long historic data to achieve an operating mathematical rule. Records which consist of short term data are not suitable for proper planning and arrangement processes and also available of a location of interest. in such circumstances, it become necessary to deterministic as well as stochastic component, but stochastic time series models, such as autoregressive (AR), moving average(MA) autoregressive and moving average (ARMA) are widely used to developed and generate the rainfall and temperature. They apply Seasonal ARIMA models that counted for 92% of the total variability in the monthly means of air temperature. Their forecasted values showed good agreement with the actual observed values of temperature. They concluded that for highly variable time series, ARIMA models yield better forecasts than the simple models which are only based on means of previous observation.

Keywords: rainfall, temperature, seasonal, auto-regressive, SARIMA

Introduction

Rainfall is natural climatic phenomena whose prediction is challenging and demanding. Its forecasts of particular relevance to agriculture sector, which contributes significantly to the economy of the nation. On a worldwide scale, numerous attempts have been made to predict its behavioral pattern using various techniques. In the last few decades, time series forecasting has received tremendous attention of researchers. Planning, designing, management and other important activities in all branches of engineering and other fields need the time series forecasting methods. Conventionally, the researchers have employed traditional methods of time series analysis, modeling, and forecasting, e.g. Box-Jenkins methods of autoregressive (AR), auto-regressive moving average (ARMA), auto-regressive integrated moving average (ARIMA), auto-regressive moving average with exogenous inputs (ARMAX), etc.

The conventional time series modeling methods have served the scientific community for a long time; though, they provide only reasonable accuracy and suffer from the stationary and linear assumptions. Patil *et al.,* (2014) [16]. The most influential factors in the climate are temperature and moisture. Climate change seems to be one of the most important issues in the recent two decades and temperature has been identified as one of the key elements that can indicate climate change.

The gradual rise in the mean temperature of the Earth's atmosphere and its oceans is referred to as Global warming. It is widely believed that the changing temperature due to global warming is permanently changing the entire Earth's climate. For a long time the biggest debate in a number of local and international forums worldwide has been whether global warming is real. Some people think that global warming is not real. However several climate scientists have carried out researches and have come to a conclusion that the globe is gradually warming. People perceive the impacts of global warming differently with some taking the necessary precautions to help reduce the rates of the rising temperatures. In the past century alone, studies have shown that the globe‟s mean temperature has risen by between 0.4 °C and 0.8 °C. According to a study by IPCC (2007), the temperatures could rise by between 1.4 °C and 5.8 °C by the end of the 21st century. This increase in temperature may seem to be minute but the impacts are great. Increase in temperatures are likely to lead to a global increase in drought conditions, decreased water supplies due to evapotranspiration and an increase in urban and agricultural demand.

Methodology

The box-jenkins method

This study follows the Box-Jenkins methodology for modeling. The methodology involves four step processes which include:

a) Model identification- In this step, the appropriate model structure of AR, MA or ARIMA and order of model is identified. Models can be identified by studying the plots of the ACF and PACF.

b) Estimation of the model parameters - Non-linear least-squares estimation or Maximum likelihood estimation methods are employed to estimate the coefficients of the models. A more complicated iteration procedure is required when estimating the parameters of MA and ARMA models.

c) Diagnostic checking – is important in ensuring the adequacy of the model. The residuals of the model have to be a white noise and that estimated parameters must also be statistically significant. According to Anderson (1977) [5] misspecification can be identified by observing; the plots of the residual means and variance over time; plots of the autocorrelation function and partial autocorrelation function of the residuals or performing a Box-Ljung test.

d) Forecasting- Here the appropriate model is estimated to obtain the forecasted values. These four steps are used to form the conceptual framework of this study.

- **Conceptual Framework**

Conceptual framework is a scheme of concepts which the researcher operationalizes in order to achieve the set objectives. The following conceptual framework proposed by Box- Jenkins (1976) is considered in this study.

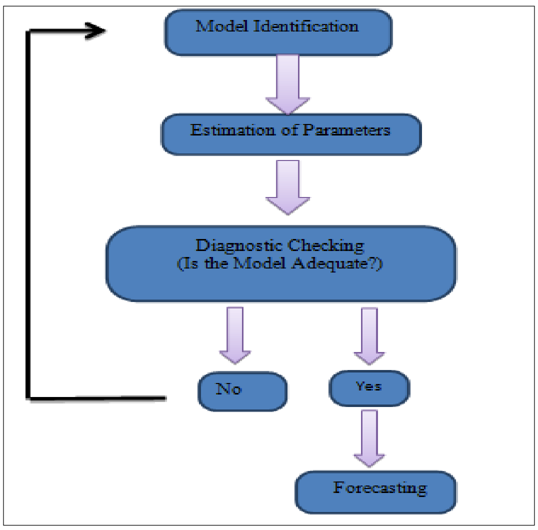

Fig 1: Box Jenkins arima model

Univariate time series contain measurements of a single variable while multivariate time series contain more than one variable. Time series can also be continuous or discrete depending on the instance when the measurements are taken. In discrete the measurements are taken at discrete (distinct) points of time, for example weekly, monthly, yearly etc while for continuous they are taken at every instant of time.

An autoregressive integrated moving-average (ARIMA) model is basically an ARMA model. The difference is that ARIMA is used when the raw data is no stationary and it requires differencing to become stationary. Once the data is differenced, the procedure becomes an ARMA procedure. The outcomes from the ARMA procedure are then integrated to reverse the effect of the initial differencing.

The seasonal autoregressive integrated moving-average (SARIMA) model on the other hand, takes into account the seasonal effect in the data series. If there is any seasonal or cyclic pattern in the series, the SARIMA model would be more appropriate to be used. There are actually other models which have similar concept with the ARMA model. One example would be the autoregressive conditional heteroscedastic (ARCH) model. However, the more commonly used models from the ARMA family are the ARMA model itself, the ARIMA model and the SARIMA model.

Bruen *et al*, (2005) they applied two types of functional network models, separable and associativity functional networks, to forecast river flows for different lead-times. We compared them with a conventional artificial neural network model, an ARMA model and a simple baseline model in three catchments. Results show that functional networks are flexible and comparable in performance to artificial neural networks. In addition, they are easier and quicker to train and so are useful tools as an alternative to artificial neural networks. These results were obtained with only the simplest structures of functional networks and it is possible that a more detailed study with more complex forms of the model will improve even further on these results.

Somvanshi *et al.*, (2006) [19] presented tools for modeling and predicting the behavioral pattern in rainfall phenomena based on past observations. The paper introduces two fundamentally different approaches for designing a model, the statistical method based on autoregressive integrated moving average (ARIMA) and the emerging computationally powerful techniques based on ANN. In order to evaluate the prediction efficiency, they made used data of 104 years of mean annual rainfall from year 1901 to 2003 of Hyderabad region (India). The models were trained with 93 years of mean annual rainfall data. The ANN and the ARIMA approaches are applied to the data to derive the weights and the regression coefficients respectively. The performance of the model was evaluated by using remaining 10 years of data.

Studied that the correlation between the seasonal autocorrelation coefficient of the rainfall time series and the rainfall coefficient of variation and elevation of the stations is significant while lag-one autocorrelation coefficient does not correlate to rainfall coefficient of variation and the elevation of the stations. Different models also imply the high variation in the spatial rainfall producing mechanism and different stationary and periodicity characteristics of the rainfall temporal pattern over Iran.

Stated that prediction of Temperature and rainfall parameters on monthly and seasonal time scales is not only scientifically challenging but is also important for planning and devising agricultural strategies. They describe the Box-Jenkins time series seasonal ARIMA (Auto Regression Integrated Moving Average) approach for prediction of temperature and rainfall on monthly scales. The Box Jenkins technique is applied to predict temperature and rainfall of next five years by analyzing last twelve years data (1994-2006). Previous year's data was used to formulate the seasonal ARIMA mode land in determination of model parameters. The performance evaluations of the adopted models are carried out on the basis of correlation coefficient (R2) and root mean square error (RMSE). The study was conducted at Mirzapur, Uttar Pradesh (India).The results indicate that the seasonal ARIMA model provide reliable and satisfactory predictions for rainfall and temperature parameters on monthly scale.

Moller *et al.,* (2009) used SARIMA model for the whole series to forecast the monthly temperature of the 2008 and compare it with the true monthly temperature of 2008. They also compare the prediction results of the whole series and the sub series from 1986-2007, results are very close and Compared the prediction temperature with the true temperature, they find the prediction value is very close to the true value except January and February, and all of the true values fall into the confidence interval except February. So, the SARIMA model can be used to analyze the Stockholm temperature series.

Nigam *et al.* (2009) [12] presented research to simulate flood episode in order to develop flood management strategies to reduce disaster. The complex city of natural hydrological phenomenon and dependent random variables can be better expressed considering it as stochastic process. Flood (maximum river flow) forecasting on the Kulfo River with monthly runoff data using stochastic ARIMA, Time Series model was developed for warning purposes. The analysis of seasonally varying time series of discharge data has revealed that a higher order ARIMA model may produce excellent results for three to six months forecast.

Oluwafemi *et al.,* (2010) climate change can influence all natural systems and thus threaten the human development and their social, political and economical survival. Temperature is among the key elements that affect the climatic system and it has been studied by a number of researchers in the recent decades. Forecasting of temperature assists stakeholders who directly depend on it to prepare in advance for any eventualities.

Sarraf *et al.,* (2011) used Box-Jenkins model and finally they assessed by providing final model. For assessing the given value model there was obtained the (EF) model for average temperature, relative moisture and this indicating the higher efficiency of model. The correlation coefficient for average temperature and relative moisture was obtained. Therefore, considering the higher accuracy of model, one can use it for anticipating the average monthly temperature and moisture.

Tanusree and Kishore (2012) studied temporal variation in temperature over Dibrugarh city in India, and fit the traditional seasonal ARIMA model using Box-Jenkins approach. Using their most adequate SARIMA model, the forecasted temperature data showed reliable values compared to the actual recorded data. Their results support the effectiveness of the SARIMA model in predicting the average monthly temperature.

Syeda (2012) carries out an investigation in Bangladesh to study the variability and trend for seasonal and annual mean maximum temperature for six meteorological stations: Khulna, Dhaka, Sylhet, Rajshahi, Chittagong and Barisal. He applies univariate Box-Jenkin‟s ARIMA modelling technique to predict the average monthly maximum temperature from 2009-2012 for these stations. In his study he encounters the problem of missing data and uses the median of the corresponding years to fill them. He tested the Stationary of the residuals for average maximum temperature using ACF and PACF and checked for normality by normal probability plot. He 9 found out that the average maximum temperature is varying indicating that the climate of Bangladesh is gradually changing. He points out at the fact that these changes will impact the agricultural sector of the county and recommends that proper planning is required to sustain the development of the sector.

Zakaria *et al.,* (2012) [21] studied that Box-Jenkins (ARIMA) model methodology could be used as an appropriate tool to forecast the weekly rainfall in semi-arid region like North West of Iraq for the up-coming 5 years (2012-2016). The results achieved for rainfall forecasting will help to estimate hydraulic events such as runoff, then water harvesting techniques can be used in planning the agricultural activities in that region. Predicted excess rain can be stored in reservoirs and used in a later stage. The modelling techniques demonstrated in this contribution can help farmers in the area to enlarge the areas of land to be cultivated using supplemental irrigation.

Arbain (2012) found that prediction using original and cleansing rainfall data from ANN models were compared with those obtained from SARIMA traditional time series approaches. The ability of ANN to recognize time series patterns and nonlinear characteristic gives better accuracy over SARIMA method for water level prediction. From the analysis of both methods, we can conclude that the suitable model to predict the water level at Dungun River is ANN with cleansing rainfall data since it has best performance compared to SARIMA and ANN without cleansing data.

Tung *et al.,* (2012) studied that medium range rainfall and flood forecasting for operation of the reservoir system in the Ca River basin of Vietnam can be one of efforts to meet this need. A combination of rainfall and flood forecasting with flood propagation and reservoir control models has been implemented and applied for the Ca River basin. A combination of a Numerical Weather Prediction with conceptual hydrological schemes integrated with ARIMA and BPNN-Back Propagation Neural Network models was applied and finally, rainfall and flood forecast models have been integrated into the operation model of reservoir system.

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