

Time-series model & forecast of hydro-climatic data in basin area of river Bregalnica

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Abstract

The changes of hydro-climatic characteristics have effect on surrounding. The problems in the river Bregalnica basin (Eastern part of the Republic of Macedonia) are the result of abundant rainfalls and long drought periods. Observing and understanding the hydro-climatic effects may provide good estimate in several fields (agriculture, management of water resources and civil engineering).

Visualization of data on the hydro-climatic changes in the river basin provides a good forecast. Time Series of rainfalls and temperature can be analysing with statistical methods. ARIMA models analysis data on monthly and annual rainfalls and temperature. ARIMA models are good technique for predict of hydro-climatic variations.

Keywords: Rainfall, temperature, forecasting, ARIMA.

Introduction

The extreme climatic changes over the last several years have been of big economic and social important. Investigations tend to determinate possible direction of climatic changes.

This approach is becoming more and more popular as some of present day climatic conditions have resulted from the climatic changes with certain increase in some extreme cases. The Bregalnica river basin occupies area of 4307 km² or 17 percent of the territory in the Republic of Macedonia. The amount of precipitation cases enormous damage in several sectors of economy, first of all in agriculture witch is one of the most development.

Droughts and fluds are not the only ones that have impact on agriculture. However, the studies of conditions that arise from heavy rains are important for the development of agrarian climatology and water supply. So, unfavorable rainfalls in the Bregalnica river basin should be subject meter of observation.

Besides the extremely unfavourabe distribution of rainfalls, the are time periods in the year when the distribution makes it possible to create good strategy for periods of adverse weather conditions. In this manner, early determinations of possible weather changes make possible creations of good strategy for managment of the consequences heavy rainfalls in the river basin.

Observation and study helps evaluate the dynamics of situations in the river basin. This allows modeling of the consicence consist with the changes of the weather conditions.

The aim of the studies is monthly forecast of precipitations and temperature in the river basin for the next 5 years as well as investigations of directions and conditions of precipitations.

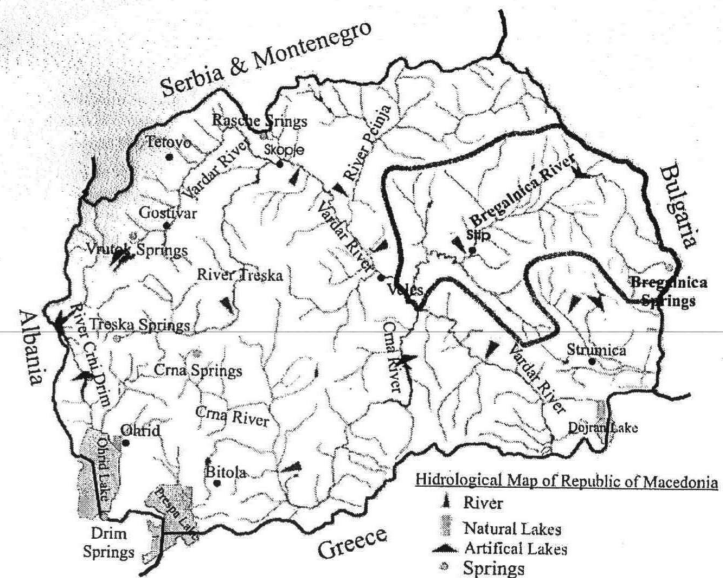


Fig. 01. Hydrological Map of The Republic of Macedonia, River Bregalnica Basin

Method of work

For modeling of time-series data is used about rainfall in the river Bregalnica basin (1926-2005). In this regard technique applied for processing of data in economy.

Upon the study of outcome data obtain from time-series analysis of rainfall, simulations created by use of stohastic ARIMA models.

The final goal is to predict models of rainfalls and temperatures obtained by combination of analytical practice and the results obtained from it that are used to determination of the conclusions.

ARIMA modeling

ARIMA modeling of data of time-series is carryout as follows.

- Determinations,
- Evaluations,
- Forecast.

For the formations of ARIMA model data are used about annual precipitation and temperature for time period of 80 years.

First data are plotted on a diagram and used as basis for estimation of the next 5 years. The estimation autocorrelation function (ACF) and partial autocorrelation function (PACF) is used to present time-series.

First data for annual precipitation and temperature in the basin for time period of 80 years are plotted on the diagram. Then data are used to create ARIMA model witch are used estimate the situation in the next 5 years. For the further presentation of time-series are used the estimated autocorrelations (ACF) and partial autocorrelation (PACF) functions (Figure 02 & Figure 03).

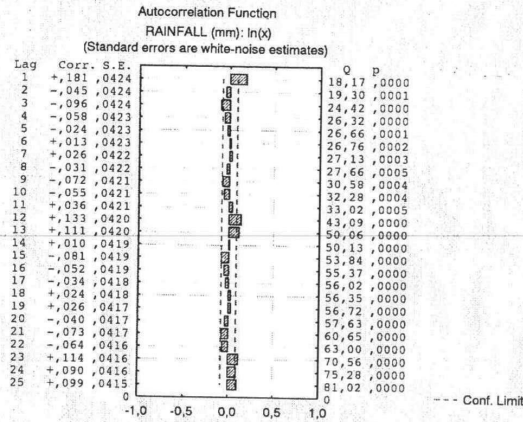


Fig 02. ACF of data for monthly precipitation

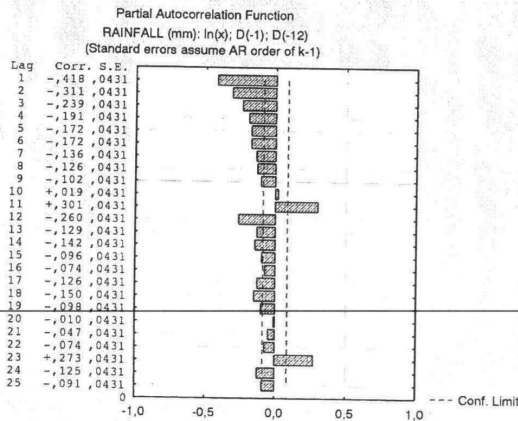


Fig 03. PACF for data for monthly precipitation

Estimations & forecast

The Statistica software package is used for calculation of ARIMA model parameters. The software is widely used, and is recommended as an irreplaceable tool. To see original software is presenting the outcomes in graphs, the graphs of Statistica will be given. After this calculations the outcomes are summarize.

The use of ARIMA model for forecast is the first step for forecast in the next 5 years. For this five forecast values are used to forecast the next 5 years. Each model is used for each parameter as monthly rainfalls, annual rainfalls, monthly and annual temperatures. Forecast are based on existing obtained for the meteorological stations in Stip, Delcevo, Kocani and Berovo. The forecast time-series are with 95 % confidence.

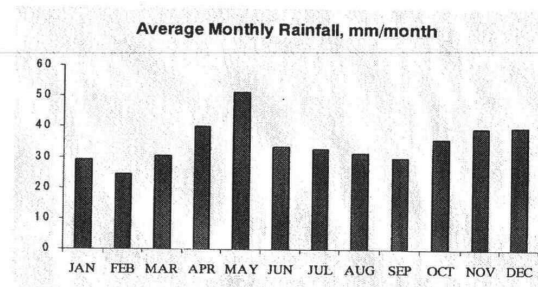


Fig. 04. Graph of average monthly rainfalls (1925-2005)

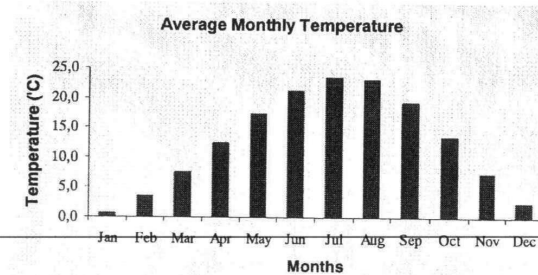


Fig. 05. Graph of average monthly temperature (1961-2005)

Forecast for annual rainfalls

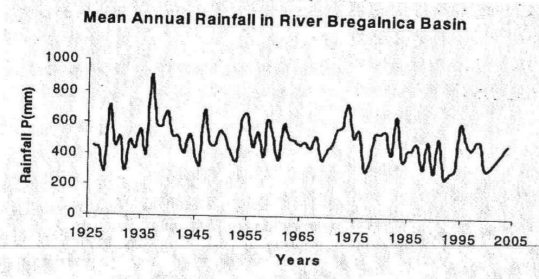


Figure 06. Mean annual rainfalls in river Bregalnica basin (1925-2005)

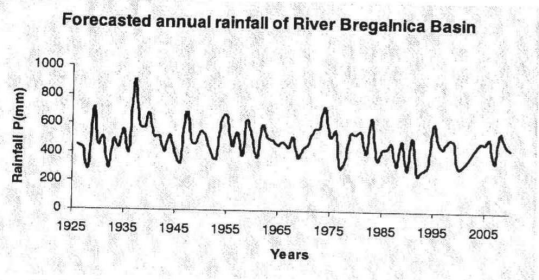


Figure 07. Forecast of annual rainfalls in river Bregalnica basin (1925-2010)

ARIMA modeling of annual rainfalls was performed for a period from 2005 to 2010. Figure 07 is combination of data about rainfalls from 1925 to 2005 and forecast for rainfalls form 2005 to 2010. Are clearly shows that the levels of intensity of annual rainfalls decrease slightly. Frequent changes have been notes in 1973 and are added to the global climatic changes as effect by industrialization, urbanization and pollutions.

Forecast of annual temperature

Mean annual temperature in basin amount to 12.6 °C temperature will increase from 2006 to 2008 and will amount to 13 °C. This means that in several years it will increase for about 1 °C. This is most probably due to green house effect and increase number of vehicles and machinery.

Mean annual temperature of river Bregalnica basin

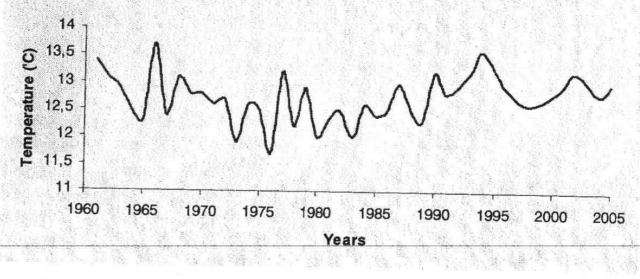


Figure 08. Mean annual temperature in river Bregalnica basin (1961-2005)

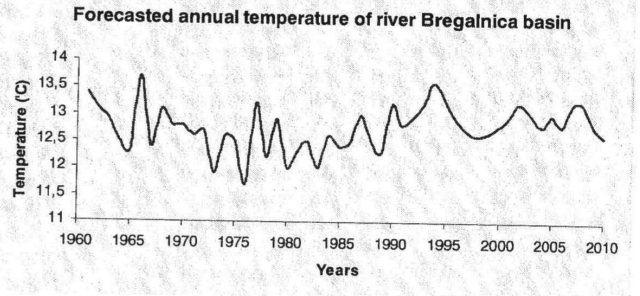


Figure 09. Forecasted mean annual temerature in river Bregalnica basin (1961-2010)

There is slight relationship between mean annual rainfalls and temperature at $s = 95\%$. The slight relationship due to small influences of annual rainfalls and temperature are consequence of local conditions. Air temperatures in the river basin do not depend on annual rainfalls.

Dry period in the river basin

ARIMA modeling of annual rainfalls is used to forecast climatic scenarios in river basin. This is so because there are years with heavy rainfalls and the years to represent a dry period. Intensity in certain time periods chronological is presented by data obtained from meteorological stations witch follow hydrological changes.

Dry periods are presented by their index:

$$D_i = \frac{P - P_i}{2P_i}$$

where P is annual rainfalls, and R_s is mean annual rainfalls.

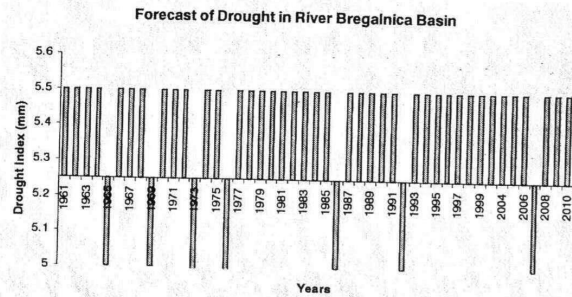


Figure 10. Дијаграм со податоци за сушни периоди и периоди со обилни врнежи во сливното подрачје на река Брегалница одредени со D_i индексот.

Dry period index in good periods has a value 5.5 and bad periods are period when D_i is 5. According to this index of forecasted data in 2005 and 2010 heavy rainfalls are expected, whereas drought is expected in 2007.

Conclusions

ARIMA model is used for analysis of basic investigations of hydro-climatic characteristics of the Bregalnica river basin.

The results of mean annual rainfalls offers forecast for years with good hydro-climatic state and dry years that have been determinate by the index of droughts. Forecasts have been done based on mean annual rainfalls and air temperature that make it possible to carryout detailed analysis.

It is concluded that:

- Mean annual forecast rainfalls (to 2010) will have a slight increase;
- Mean annual temperature will increase for $0.4\text{ }^{\circ}\text{C}$;
- The relation between mean annual temperature and rainfalls in the river basin is insignificant.

Besides basic hydro analysis this paper offers a model for the area. According to this, the use is econometric technique for data processing for rainfalls is more than necessary.

The conclusions in are used in making good decisions in agriculture and utilization of water resources. The basic goal is the models to be used as major direction for understanding of probable states that may occur in future.

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