International Journal of Agricultural Engineering, Vol. 2 No. 1 : 140-145 (April to September 2009)

Stochastic modelling of crop evapotranspiration for Rahuri region

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Accepted : ***February, 2009***

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ABSTRACT

Evapotranspiration (ET) is the foremost important parameter in irrigation scheduling and water resources planning and management. This necessitated the forecasting of ET and time variant characteristics of ET necessitated the stochastic modelling of crop evapotranspiration. In this paper, stochastic models of autoregressive integrated moving average (ARIMA) class were developed for generation and forecasting of weekly ETr values estimated by Penman-Monteith method. Twenty four years (1975-1998) climatological data were used for the stochastic modelling. ARIMA models of different orders were selected based on observing autocorrelation function (ACF) and partial autocorrelation function (PACF) of the ETr series. The parameters of the selected model were obtained with the help of maximum likelihood method. The diagnostic checking of the selected models was then performed with the help of three tests (standard error of parameters, ACF and PACF of residuals and akaike information criteria) to know the adequacy of the selected models. The ARIMA models that passed the adequacy test were selected for forecasting. The weekly ETr values for two years (1999-2000) were forecasted with the help of these selected models and compared with the values of ETr obtained from the climatological data of these two years by root mean square error (RMSE). The ARIMA (1, 1, 1) $(0, 1, 1)_{52}$ gave the lower values of RMSE and hence is the best stochastic model for generation and forecasting of weekly ETr values.

Key words : Evapotranspiration, Stochastic modeling, ARIMA.

ET is the main component of irrigation requirement of any crop. The stochastic models are based on the time dependent variation and consider random effects involved in the ET process. Stochastic linear models are fitted to hydrological data or time series such as evapotranspiration series for two main reasons: to enable forecasts of the data one or more time periods ahead and to enable the generation of sequences of synthetic data. The synthetic and forecast data are of considerable importance to the design and operation of water resource systems. Hence, this study which aimed at stochastic modelling of crop evapotranspiration was undertaken for Rahuri region.

The multiplicative seasonal autoregressive integrated moving average (ARIMA) models that have been described by Box and Jenkins (1976) have been used for generation and forecast of weekly, fortnightly and monthly values. In past ARIMA models have been used successfully to model hydrologic time series (Gorantiwar, 1984; Mohan and Arumugam, 1995 and Bhakar, 2000). In this study, therefore, it was proposed to use ARIMA class of models for stochastic modelling of evapotranspiration. The stochastic modeling of weekly reference evapotranspiration was performed for the generation and forecasting of weekly ETr values.

METHODOLOGY

The climatological data for twenty six years (1975-2000) of Rahuri region were obtained from E-Block Observatory, M.P.K.V., Rahuri and the lysimetric data of crop evapotranspiration (ETc) of different crops were obtained from AICRP on water management, Mahatma Phule Krishi Vidyapeeth, Rahuri for this study.

Seasonal ARIMA model:

A time series involving seasonal data has relations at a specific lag s which depends on the nature of the data, e.g. for monthly data s = 12 and weekly data s = 52. Such series can be successfully modelled only if the model includes the connections with the seasonal lag as well. Such models are known as multiplicative or seasonal ARIMA (SARIMA) models. The general multiplicative seasonal ARIMA (p,d,q) $(P,D,Q)_s$ model has the following form.

$$\varphi_p(B)\Phi_p(B^s)(1-B)^d(1-B^s)^P x_t = c + \theta_q(B)\Theta_Q(B^s)e_t \quad (1)$$

where,

c - constant;
B - a backshift operator;
d - order of nonseasonal difference operator;
D - order of the seasonal difference operator;
p - order of nonseasonal AR operator;