The use of Climatic Data Generator to cope with Daily Climatic Data Scarcity in Simulation Studies

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Abstract

The use of simulation modelling approaches to evaluate how systems respond to historical climates and how systems will respond to change in management practices has been widely applied. This approach normally requires long records of historical daily climatic data. However, in most developing countries, historical records of daily climate data are not well maintained, but the historical monthly data is frequently available. This study evaluated the use of generated daily climatic data from the monthly means in simulation studies to overcome the problem of data scarcity. Two simulation models, APSIM and VIC-BASIN, were run using the generated and observed daily climatic data. It was found that the outputs from the models resulted from the generated and observed daily climatic data were not significantly different. This result promotes the use historical monthly climatic data to assess historical response of biological systems to variable climate.

Media Summary

The use of climatic data generator models in simulation of crop growth and streamflow to overcome the problem of daily data scarcity is promising.

Key word : Climatic data generator, simulation modelling, crop yield, APSIM, VIC-BASIN.

Introduction

The response of biological systems to a variable climate can be assessed from long historical data of the systems. However, the long-term historical data of biological systems normally shows a trend as a result of human intervention. Therefore, evaluation of climate variability impact on the systems is done firstly by removing the trend. The long-term historical data were fitted using curve fitting and the deviations of the data points from the fitting line are then be used to assess the effect of climate variability (Jones et al. 2004). However, such data is frequently not available. Therefore, the use of simulation modelling is becoming more and more adopted (e.g. Messina et al. 1999; Meinke and Hochman, 2000; Mkankam Kamga, 2001). However, such approach requires long daily climatic data record, as inputs for the simulation models and such data are often not available in many developing countries. In some circumstances, the long climatic data record is well maintained but only for monthly data.

This paper evaluates the use of a climatic data generator model for use in simulation studies where available historical climatic data record is only monthly rainfall.

Method

A model for generating daily climatic data from observed monthly data was developed based on the works of Stern and Coe (1984), McCaskill (1990) and Epstein (1991). The model used in this study firstly generates daily rainfall data, and then estimates other climatic data (temperature, evaporation and radiation). The rainfall model is estimates probability of rainfall occurrence from monthly rainfall means using Epstein equations and distribution of daily rainfall depth from seasonal rainfall. The probability of rainfall occurrence was developed using Markov Chain Ordo 1 where the probability of having rain on day *i* depend on whether rain occurred or not on day *i-1*. The rainfall depth was generated using gamma distribution (Hann, 1976). Other climatic variables (P) other than rainfall were generated using McCaskill equations (1990). The error of the McCaskill equation was modeled using autoregression (AR) Ordo 1, in order to remove the error autocorrelation problem.

The observed daily data and the generated daily climatic data were used to run two simulation models; the APSIM Crop model (McCown et al. 1996) and the VIC-SEA BASIN hydrology model (Liang et al. 1994; Liang et al. 1996). Twenty sets of generated climate data were used with APSIM to simulate the yield of soybeans over the period 1973 to 2000 at Pusakanegara, Indonesia. Five sets of generated climate data were used with the VIC-Basin model to simulate streamflow from the Upper Citarum Basin. Outputs from the two models resulted from the use of the observed and the generated daily climatic data were then compared using statistical *t* test.

Results

The median of simulated soybean yield using the 20 sets of generated daily climatic data was found to have a similar historical pattern to the simulated yield generated using the observed daily climatic data (Figure 1). Similarly, the simulated and the observed stream flow data of Upper Citarum Basin also showed similar pattern (Figure 2). Further analysis using *t*-test, both simulated and observed data were not significantly different at 10% level for the soybean yield and at 5% level for the stream flow. This suggests that the use of climatic data generator model to cope with limited daily climatic data record is promoted. However, prior to the analysis, the climatic data generator needs to be validated and be evaluated whether daily statistical characteristics of the data, in particular rainfall data, could mimic the observed ones. Impact of changing number of realization on the result also needs to be evaluated.

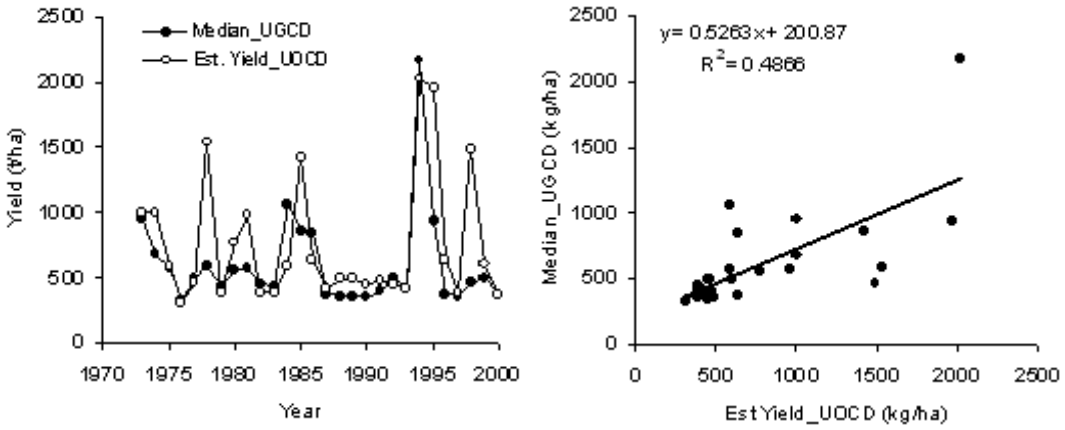

Figure 1. Comparison between estimated soybean yield (estimated using observed climatic data) (Est.Yield_UOCD) and median of simulated yields (simulated using generated daily climatic data)(Median_UGCD) at Pusakanegara.

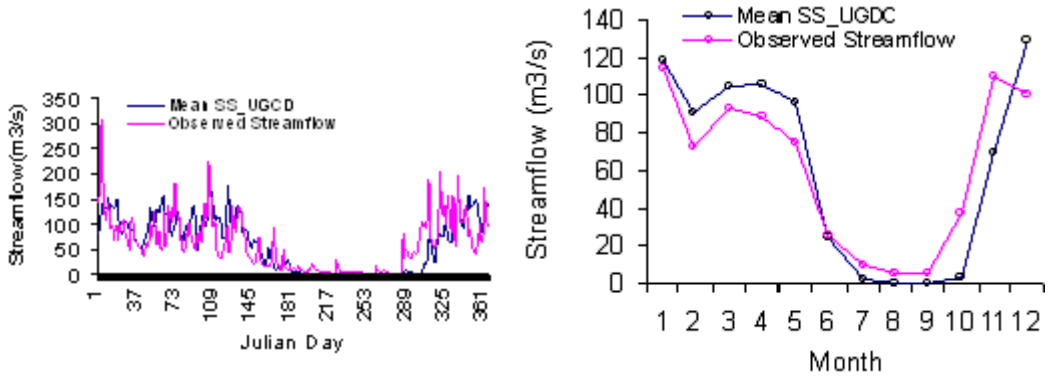

Figure 2. Comparison between mean stream flow from Upper Citarum Basin generated using daily climatic data (Mean SS_UGCD) from monthly means and observed stream flow

Conclusion

The climatic data generator model developed in this study is relatively simple. It is able to generate daily climatic data from monthly data. In the simulation studies, models run using the generated daily climatic data produced outputs that have similar pattern to outputs of model run using observed climatic data and to outputs from observation. Therefore, historical monthly climatic data is possible to be used to assess historical response of biological systems to variable climate.

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