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EXTENDED ABSTRACT

Application of ARMA Model in Downscaling and Climate Change Impact Assessment in Annual Time-Scale

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1. Introduction

In result of recent human activities, concentration of greenhouse gases has been increased and consequently temperature of the Earth's surface has been raised. Also, it is expected that temperature of the Earth's surface will be increased in the future (IPCC, 2001; IPCC, 2013). This increase will also influence other climate variables such as precipitation. For active adaptation strategy, it is necessary to assess the potential future climate change impacts. To obtain future climate scenarios, the most common tools are GCMs. since resolution of the GCM outputs is course, it is necessary to downscale its outputs. Among downscaling techniques, Weather Generator (WG) method have several unique advantages, such as: 1- Changes in various statistics, predicted by the GCMs experiments, may be preserved in downscaled series (Khazaei et al., 2013; Semenov et al., 1998). 2- WGs produce long term series that decrease uncertainty of climate variability (Chapman, 1998; Semenov et al., 1998). ARMA model and daily LARS-WG model are two stochastic WGs. LARS-WG frequently used for climate change impact assessment. But despite the specific capabilities of the ARMA model to assess the impacts of climate change on an annual scale, this model has been rarely considered in previous climate change studies. The reason is that it is not clear how skewed series can be downscaled using this model (Khazaei et al., 2013). Precipitation series on the daily and monthly time-scales is often skewed, but annual rainfall in many areas has a normal distribution. In this paper, the performance of the annual ARMA model and the LARS-WG daily model for generating annual rainfall and temperature series is compared. Then, the ARMA model is utilized to downscale GCM outputs and climate change impact assessment.

2. Methodology

LARS-WG model was fitted to the daily temperature and precipitation series of the Zanjan station. Daily temperature and precipitation series were generated and annual series were produced by aggregating the daily series. Also annual ARMA models of various degrees were fitted to the observed annual temperature and precipitation series. Model tests, including reliability of parameters, parsimony of parameters, independence of residuals, and normality of residuals, were performed to the models to obtain the best model for each variable. Among the ARMA models, the ARMA (1, 0) for annual temperature and the ARMA (0, 0) for annual precipitation were found as the best for Zanjan station. For validation and comparison of performance of the ARMA and the LARS-WG models, 100 series of each variable of length 30 years were generated. Statistical characteristics of the generated series were compared with the corresponding observed series characteristics. Observed statistics falling within the 90% interval of the corresponding generated statistics were considered as suitable model performance. ARMA models were selected for climate change impact assessment on annual precipitation and temperature. Downscaling using the ARMA model is described as follows: Using the annual GCM outputs for the control period and for the future scenario, annual averages and standard deviations of precipitation and temperature were calculated. Then relative changes of the GCM output statistics were applied

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to the corresponding observed statistics. The obtained statistics were used instead of observed statistics in the ARMA model to generate future downscaled scenarios. Climate change impact on annual precipitation and temperature of the Zanjan station was assessed using HADGEM2 outputs under RCP 4.5 scenario.

3. Results and discussion

The results show that the ARMA model well reproduces the various statistics of annual observed rainfall and temperature, as well as the frequency distribution of these variables. But the LARS-WG model, which has a good performance in reproduction of daily statistics, does not have an acceptable performance in reproducing the annual distribution frequencies. It is because of the inability of the LARS-WG model in reproducing of inter-annual variabilities (especially annual standard deviation) (Fig. 1). The results of climate change impact assessment on annual precipitation and temperature of the Zanjan station indicate that for various return periods, the temperature will be increased and precipitation will be decreased. Based on the results, by considering climate variability and change, 2-year return period precipitation will be decreased between 7% to 23% and 2-year return period temperature will be increased between 2.2 to 3.8ºC respect to the corresponding observed values.

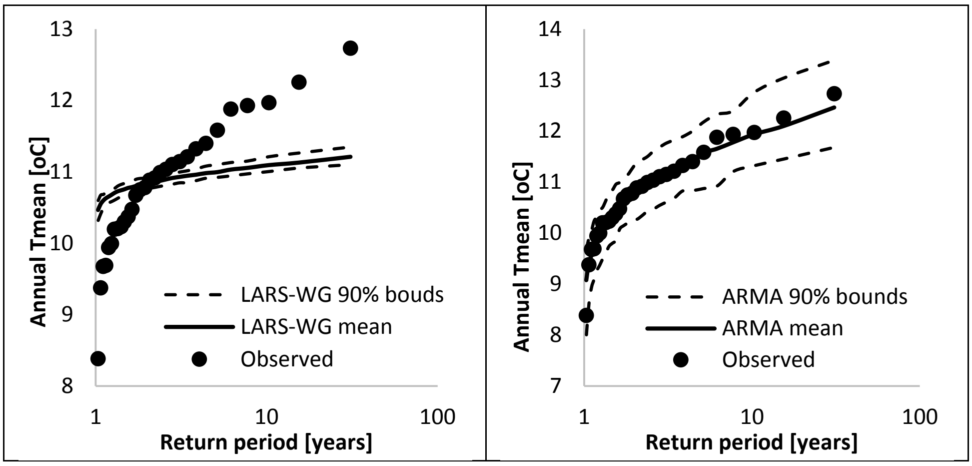

Fig. 1. Performance of ARMA and LARS-WG for reproduction of annual temperature distribution

4. Conclusions

Since the memory of the LARS-WG daily weather generator is shot, it cannot reproduce low-frequency variability. Furthermore, it underestimated variance of the annual temperature. The performance of the ARMA model for reproduction of annual precipitation and temperature characteristics is satisfactory. It is concluded that for assessment of climate change impacts in annual time-scale it is better to use the annual ARMA model. Moreover, the climate change may impose considerable increase on temperature and decrease on precipitation. As a result, it is necessary to consider the future climate change impacts to active adaptation strategy.

5. References

Chapman T, "Stochastic modelling of daily rainfall: the impact of adjoining wet days on the distribution of rainfall amounts", Environmental Modelling and Software, 1998, 13, 317-324.

IPCC, "Climate change 2001. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change", UK: Cambridge University Press, 2001.

IPCC, "Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis", Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2013.

Khazaei MR, Ahmadi S, Saghafian B, Zahabiyoun B, "A new daily weather generator to preserve extremes and low-frequency variability", Climatic Change, 2013, 119, 631-645.

Semenov MA, Brooks RJ, Barrow EM, Richardson CW, "Comparison of the WGEN and LARS-WG stochastic weather generators for diverse climates", Climate Research, 1998, 10, 95-107.