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EXTENDED ABSTRACT

Investigating the Uncertainty Effect of GCMs Output on the Prediction of Meteorological Parameters in Golestan Province

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Introduction

One of the important issues in assessing climate change using the output of General Circulation Models (GCMs) is their uncertainty so that the outputs of a model in a region may vary with another model in the same region. Disregarding the uncertainty of these models reduces the accuracy of the final outputs (Ashofteh and Massah, 2012). Various methods have been developed to analyze and reduce the amount of uncertainty. Among the methods used to investigate the uncertainty of the output of GCMs, one can mentioned the weighted means of observation, Wilcoxon Signed Rank test, Bootstrap confidence-interval estimation technique, Box Plot method, and the cumulative frequency distribution function. Accordingly, the present study, while predicting the temperature, precipitation and drought variables in Golestan province for the future 30 years via two general circulation models including ECHO-G and HadCM3, examined the uncertainty of these models by weighted means of observation and Box Plot methods. Also, statistical analysis of data by analysis of variance and mean comparison tests are among other goals of this research.

Methodology

In order to evaluate the uncertainty effect of the output of HadCM3 and ECHO-G models on the prediction of minimum and maximum temperatures, precipitation and drought severity in Golestan province during a 30-year period (2016- 2045) as compared to the base period (1986- 2015), the output of models under A2 scenario was downscaled by the LARS-WG model in 15 meteorological stations. The uncertainty of models was evaluated by weighted means of observation (Abbasnia *et al.,* 2016) and Box Plot methods (Amoako-Attah and B-Jahromi, 2016). In each station, the data was obtained from the network center where the station was located. All the stations were located within three networks, with 3, 4 and 8 stations located in the western, the central and the eastern networks,respectively. The ability of the models for predicting temperature and precipitation was examined by different statistics including determination coefficient (R^2), mean error (ME), mean absolute error (MAE), and root mean square error (RMSE). In this study, DIP software (Morid et al., 2007) was used to calculate drought severity by Standardized Precipitation Index (SPI).

Significance of changes in climate variables in the future period to base period was considered by using variance analysis (ANOVA) and mean comparison (LSD test) with regard to various factors including the statistical period, the GCM model, the weather station, the time scale (annually and monthly), and the drought class. To this end, the SPSS software version 21 was used.

Results and Discussion

The investigation of the LARS-WG model outputs using different statistics showed that the parameters were simulated with reasonable accuracy. At the same time, values of these statistics for the minimum temperature were much lower than the maximum temperature, which shows that the model is more accurate in predicting the minimum than the maximum temperature. The results of weighted means of observation method showed that while the simulation of temperature and precipitation parameters had more weights in the Western and Central regions by the HadCM3 model, it had more weights in the Eastern region by the ECHO-G model. Based on Box Plot analysis, relative equality, the low values of variance, standard deviation, coefficient of variation, and the range of variations of the two models within different months in predicting the minimum and maximum temperatures all indicated that both models had a certain degree of low uncertainty. As to the rainfall, however, the uncertainty of the HadCM3 model, compared to the ECHO-G model, was less in most months. The difference in the uncertainty of the GCM models within different regions and months can be attributed to the influence of various morphological factors on climate variables, their governing laws on the earth surface and the atmosphere, and the different structures in the GCM models. With regard to the forecasts of the HadCM3 and ECHO-G models, the annual average of minimum temperature will be increased by 0.4 and 1.6 °C, respectively. For the maximum temperature, these figures will be 0.2 and 0.7 °C, respectively. While increasing temperature is expected for the future period in both models, their amounts vary in different stations and regions due to their elevation, latitude and atmospheric humidity. These models also predicted a significant increment (30.9 mm) and an insignificant reduction (11.8 mm) in the annual precipitation. In addition, the significant interaction between the GCM models and the meteorological stations showed that the responses of stations to climate change were different. The maximum area of the annual rainfall class in the province was observed in the range of 550-350 mm during the base period according to the ECHO-G model's predictions. However, it was found to be in the range 450-450 mm in accordance with the HadCM3 model's predictions. Analysis of variance showed that modeling had a significant effect on the occurrence percentage of normal and wet classes by monthly scale and on severe wet occurrence percentage by annual scale. Nontheless, it did not have any significant effect on other drought classes in neither time scales.

Conclusions

Climate change had a significant effect on the precipitation of 40 percent of stations. The uncertainty of the GCM models by weighted means of observation method varied in different regions and in different months. However, the weight of the HadCM3 model in the Western and Central regions and the ECHO-G model in the Eastern region was greater. Based on the Box Plot method, both models had a certain degree of low uncertainty in

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predicting minimum and maximum temperatures. In case of rainfall, however, the uncertainty of the HadCM3 model was less in most months compared to the ECHO-G model.

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