Modelling of Meteorological Parameters in Golestan Province of Iran Using LARS-WG Model in the Period of 2011-2030

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***Abstract*— The impact of climate change on hydrologic design and management of hydro systems could be one of the important challenges faced by future practicing hydrologists and water resources managers. Many water resources managers currently rely on the historical hydrological data and adaptive real-time operations without consideration of the impact of climate change on major inputs influencing the behavior of hydrologic systems and the operating rules. Issues such as risk, reliability and robustness of water resources systems under different climate change scenarios were addressed in the past. Also Changes in temperature and precipitation patterns have serious impacts on the quantity and quality of water supply. Because of the increasing demand for water, studying the potential climate change and its impacts on water resources is necessary. To predict the climate change based on the General Circulation Models (GCM), the successful downscaling tool of LARS-WG is applied. This stochastic weather generator downscaled the climate change of Hashemabd synoptic station in the Golestan province of Iran by using the HADCM3 model and emission scenarios in the period of 2011-2040. A real-life case study example is presented to illustrate the applicability of a LARS-WG Model for generating these parameters and direction of climate change. The results show increase in solar radiation and decrease in precipitation almost in all of the months, also not changing in minimum and maximum temperatures. The results of this study could advise the decision makers to take suitable actions in securing the water supply.**

Keywords: Lars-WG, Downscaling, Meteorological Parameters, GCM.

I. INTRODUCTION:

In general, water resources management includes two crucial basics: estimating water demand and predicting the flow. Estimating water demand is possible to be calculated by taking resource consumption, but what makes the problem difficult is to predict river flow in the coming months. At the beginning, rainfall should be anticipated for the months ahead for predicting the flow. Climate models are a new issue that is not more than 30 years old. Every climate model tries to simulate the processes that affect the climate and according to it, climate will be forecasted for the coming years. Since predicting the future climate is not definitively possible based on climate change affects, there is an alternative solution for specifying different possibilities which is called climate change scenarios. Currently, the most reliable tool for generating scenarios is General Circulation Model (GCM). These models are based on physical laws which are solved in a three-dimensional grid on the Earth's surface by the mathematical equations.

Some of these models are USCLIAMTE WGEN, GEM, LARS-WG CLIMGEN, SDSM andetc. The models WG-LARS, AXE-JEN and WG-PCA are also Stochastic Models that are also benefiting from the results of General Circulation Models. LARS- WG is one of the most popular models of Stochastic weather generator data in the series approach that is used To produce large amounts of precipitation, solar radiation, maximum and minimum daily temperatures in a Station under baseline and future climate changes. A preliminary version of this model was to develop as part of the project a risk assessment of agriculture in Hungary

In Budapest during 1990. Markov chain model is used to model the rainfall event. LARS- WG model in the new version uses an empirical probability distribution function instead of the normal distribution to estimate the temperature. Also, in this version, the range of values has been increased close to zero probability and one for better estimation of extreme values. Applying the results of 15 general circulation models of the LARS-WG is a possibility that other small-scale models don’t have it. Samanoo and Barrow compared LARS-WG and WGEN models at several stations in different parts of the world and concluded LARS-WG model gives better results than

WGEN model (Samanoo & Barrow, 1998). Bazrafshan and et. al compared the performance of two models LARS- WG and ClimeGen at the country stations and concluded that Lars model performs better in simulating rainfall and sundial while ClimeGen will perform better in temperature simulation. Harmsen and et. al have studied to assess precipitation, evaporation - aspiration and crop yields under climate change by using LARS-WG model under different scenarios and concluded that rainy season is getting more humid and humid and dry season is getting drier and drier because of the effect of climate change. Their results also showed that evaporation - aspiration and transpiration rates will be increased due to the reduction in rainfall and increasing in temperature in the dry months.

II. MATERIALS AND METHODS:

In this study, data will be used from Hashem Abad meteorological stations located in the basin of Gorganroud in Golestan province in a 25-year period (1986 to 2010). The data used includes temperature, rainfall and sundial. And future meteorological data are simulated by using of LARS- WG model. For producing data, at first, the profile of each station with daily meteorological data during observation period should enter into the model as input as input to the model is the observation period, then these data is analyzed by the model and the model is evaluated. Then it is necessary to be done small scale exponential in order to generate data for future periods, due to the mismatch of probability distribution functions of the model output and observed data by using statistical methods. The process of the synthetic data generation is simulated by the model in three steps which are: calibration phase, evaluation phase and simulation phase of the meteorological data in coming decades. In the calibration phase, The basic need of model is the file that defines the behavior of climate during last period and the file was prepared by using daily rainfall, minimum and maximum temperatures and sundial of weather station under study by considering a 25-year period as the base period and the model was performed based on it. In next phase, the data produced by the model and the actual data (observed) in the base period was evaluated by using Coefficient of Determination (R2), Root Mean Square Error (RMSE), Mean Bias Error (MAE) and Mean Absolute Error (MAE) which are Equations 1 to 4. The results of this phase are shown in Table 2.

TABLE 1: PROFILE OF STATION UNDER STUDY

Height	Latitude	Longitude	Type of Station	Station Name
١٣/٣	٣٦/٥١	٥٤/١٦	Synoptic	Hashem Abad Gorgan

$$R^2 = \frac{[\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})]^2}{\sum_{i=1}^{n}(X_i - \bar{X})^2 \sum_{i=1}^{n}(Y_i - \bar{Y})^2} \quad (1)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_i - Y_i)^2}{n}} \quad (2)$$

$$MBE = \frac{\sum_{i=1}^{n}(X_i - Y)}{n} \quad (3)$$

$$MAE = \frac{\sum_{i=1}^{n}|X_i - Y_i|}{n} \quad (4)$$

In the above equations, X_i and Y_i are ith of observed data and simulated data by the model, respectively, $\bar{X}$ and $\bar{Y}$ are mean of observed data and simulated data and n is the total number of data. After verifying the evaluation results and the feasibility and reliability of WG5-LARS model to simulate rainfall climate data, minimum temperature , maximum temperature and sundial, implementation of the third phase or climate simulation data in the period 2011-2030 has been started. WG5-LARS was implemented by using AIB pessimistic climate change scenario which was confirmed by the IPCC. This scenario depicts a world of rapid economic growth and population so that maximum growth of population has been occurred in the half-century and then the increase in population would be reduced. Also, the rapid development of new technologies and effective on the scenario basis will occur in future periods. At the end, the monthly mean of weather data was calculated and the results were plotted as graphs which are shown in Figures 1 to 4.

III. DISCUSSION AND CONCLUSIONS:

After analyzing the data generated by the model Lars, the results were analyzed by using statistical test which was student-T.

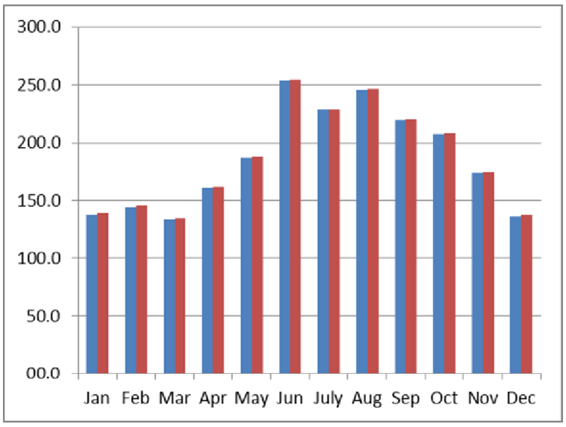

Figure (1) monthly average changes of observed data and simulated data of sundial

According to Figure 1, simulated sundial is more than the observed amount in almost every month. The maximum difference in the sundial is in February, January and April and it is 6/1 and 5/1 and 2/1 hour more than the observed average, respectively.

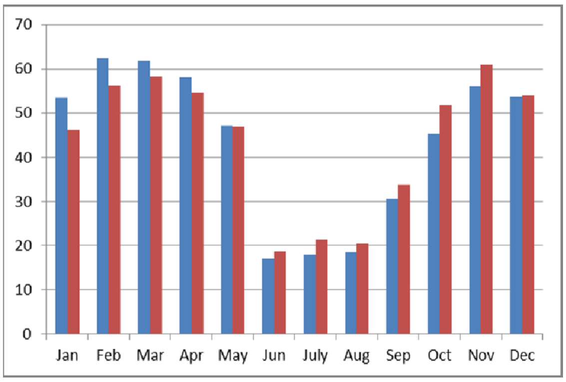

Figure (2) monthly average changes of observed data and the simulated data of rainfall

According to Figure 2, simulated data of rainfall is less than the observed amount in almost every month. The Greatest difference in the amount of rain falling is occurred during January which is Equal to 3/7 mm more than the average observations.

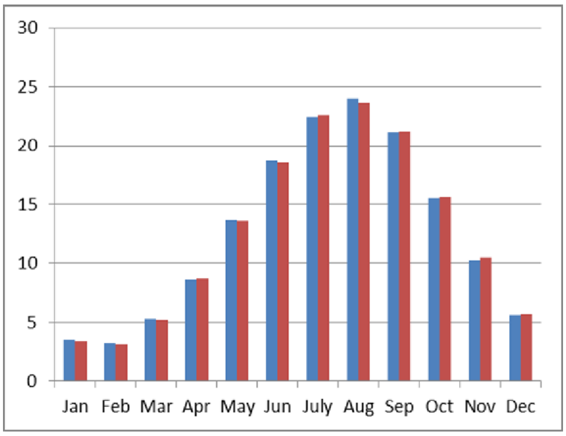

Figure (3) monthly average changes of observed data and the simulated data of minimum temperature

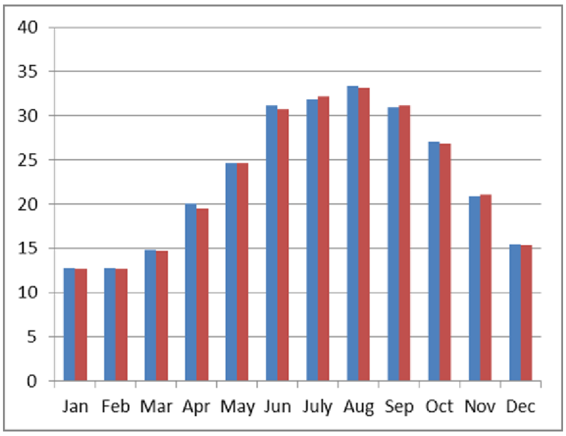

Figure (4) monthly average changes of observed data and the simulated data of maximum temperature

According to Figure 3 and 4, the simulated values of maximum and minimum temperatures are not much different than the values observed, but the greatest change in minimum temperature has been observed in August and the highest difference in maximum temperature was observed in April.

IV. CONCLUSION AND DISCUSSION

In this paper, four meteorological parameters - minimum temperature and maximum temperature, rainfall and sundial have been simulated by using WG5-LARS model. The results showed that these variables are modelled with good accuracy. As a general conclusion it can be said LARS model can be used with high confidence to reproduce the daily meteorological data and to study the climate change in future periods.

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