Geophysical Research Abstracts
Vol. 19, EGU2017-780-3, 2017
EGU General Assembly 2017

Applicability of ranked Regional Climate Models (RCM) to assess the impact of climate change on Ganges: A case study.

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The negative impact of climate change is felt over wide range of spatial scales, ranging from small basins to large watershed area, which can possibly outweighs the benefits of natural water system. General Circulation Models (GCMs) has been widely used as an input to a hydrological models (HMs), to simulate different hydrological components of a river basin. However, the coarser scale of GCMs and spatio-temporal biases, restricted its use at finer resolution. If downscaled, adds one more level of uncertainty i.e. downscaling uncertainty together with model and scenario uncertainty. The outputs computed from Regional Climate Models (RCM) may aid the uncertainties arising from GCMs, as the RCMs are the miniatures of GCMs. However, the RCMs do have some inherent systematic biases, hence bias correction is a prerequisite process before it is fed to HMs. RCMs, together with the input from GCMs at later boundaries also takes topography of the area into account. Hence, RCMs need to be ranked a priori. In this study, impact of climate change on the Ganga basin, India, is assessed using the ranked RCMs. Firstly, bias correction of 14 RCM models are done using Quantile-Quantile mapping and Equidistant cumulative distribution method, for historic (1990–2004) and future scenario (2021-2100), respectively. The runoff simulations from Soil Water Assessment Tool (SWAT), for historic scenario is used for ranking of RCMs. Entropy and PROMETHEE-2 method is employed to rank the RCMs based on five performance indicators namely, Nash-Sutcliffe efficiency (NSE), coefficient of determination (R2), normalised root mean square error (NRMSE), absolute normalised mean bias error (ANMBE) and average absolute relative error (AARE).

The results illustrated that each of the performance indicators behaves differently for different RCMs. RCA 4 (CNRM-CERFACS) is found as the best model with the highest value of [U+F066] (0.85), followed by RCA4 (MIROC) and RCA4 (ICHEC) with [U+F066] values of 0.80 and 0.53, respectively, for Ganga basin. Flow–duration curve and long-term average of streamflow for ranked RCMs, confirm that SWAT model is efficient in capturing the hydrology of the basin. For monsoon months (June, July, August and September), future annual mean surface runoff decreases substantially (∼ -50 % to -10%), while the base flow for October, November and December is projected to increase (∼10- 20 %). Analysis of snow-melt hydrology, indicated that the snow-melt is projected to increase during the months of November to March, with a maximum increase (400%) shown by RCA 4 (CNRM-CERFACS) and least by RCA4 (ICHEC) (15%). Further, all the RCMs projected higher and lower frequency of dry and wet monsoon, respectively. The analysis of simulated base flow and recharge illustrates that the change varies from +100% to - 500% and +97% to -600%, respectively, with central part of the basin undergoing major loss in the recharge. Hence, this research provides important insights of surface runoff to climate change projections and therefore, better administration and management of available resources is necessary.

Keyword: Climate change, uncertainty, Soil Water Assessment Tool (SWAT), General Circulation Model (GCM), Regional Climate Models (RCM), Bias correction.