Eco. Env. & Cons. 26 (November Suppl. Issue) : 2020; pp. (S140-S144)

ISSN 0971–765X

Prediction of temperature data for Ghataprabha Sub-basin using change factor method

[1]Bharath A., [2]Preethi S., [3*]Manjunatha M., [4]Ranjitha B. Tangadagi and [5]Shankara

[1,2,3*,4]Department of Civil Engineering, GITAM University, Bengaluru, Karnataka, India
[5]Amrita School of Engineering, Bengaluru, Amrita Vishwa Vidyapeetham, Bengaluru, India

(Received 23 April, 2020; Accepted 13 May, 2020)

ABSTRACT

In this work, two-dimensional interpolation technique has been used to re-grid the large-scale temperature outputs data (daily temperature data) to predict the behavior of temperature variations at different time scales. Beijing Climate Center Climate System Model-1.1 (BCC-CSM 1.1) concept and India Meteorological Department (IMD) data to regional scales have been considered in the Change Factor Method (CFM) to project the temperature data to regional scale of 0.5° x 0.5° over Ghataprabha basin, India, for the time period 2021-2100. An attempt is made to predict the impacts of climate change on temperature by projecting to future scenarios such as Representative Concentration Pathways (RCP) at different time scales of the region. The study revealed that the temperature increases with an increase in greenhouse gas emissions. Because of increased temperatures, the natural, ecological and socio-economic conditions. Change factor methodology is found to be more accurate method in projecting the temperature data. The maximum values of T_{max} are 39.91°, 40.92°, 41.38° and 42.70°C whereas minimum of T_{min} are 10.89°, 10.92°, 10.97° and 11.20°C for 2.6, 4.5, 6 and 8.5 RCP scenarios respectively. Conversely, drying has been observed to be more severe under RCP 8.5 scenario.

Key words : *Climate change, Global circulation model, Re-gridding, Change factor method, Climate projection.*

Introduction

Global climate models or General Circulation Models (GCMs) are the crucial suits which helps in forecasting the future global climate changes based on the available data. It is known that, for lower scales (below about 200 km), these models will not give accurate results (Aavudai, 2011, Wang and Chen, 2014). In the process of finding the impacts of climate change on hydrology in the range of regional scales, it is necessary to consider the downscaling techniques, these techniques in their processes reduces the coarse spatial resolution of an original model (GCM) data to a finer scale so that that data can be used directly in various models of climate impact models (Aavudai *et al*., 2010; William D. Collins (USA) *et al.*, 2007). There are two methods of downscaling models those can be used. The first method is dynamic downscaling, involves the nesting a higher resolution RCM within a GCM of coarser resolution. Another one is Statistical downscaling methods, which involves establishing a numerical association between large scale climatic conditions and native variables based on past data. Numerical rationalizing techniques are reliable and feasible than dynamic downscaling techniques

[1,2,3*,4]Assistant Professor, [5]Assistant Professor

(Saraf and Regulwar, 2016, Semadeni-Davies *et al.,* 2008). Some of the statistical downscaling methods used are the Statistical Down Scaling Model (SDSM), the stochastic weather generator (LARS-WG), the change factor method, and weather typing (Chong-Hai and Ying, 2012, Hashmi *et al.,* 2011). Any method that we adopt to know the future climate scenarios will have its own advantages and drawbacks. The advantage that is in built in change factor method (CFM) is, which aligns the local data in line with that of GCM setup. Therefore, CFM can be used advantageously to forecast the future climate change impacts and its assessments favorably (Kyung-On Boo *et al.,* 2006, Mori *et al.*, 2010).

In this study, two-dimensional interpolation and Change factor method has been used to re-grid and project daily Temperature data to regional scale of 0.5° x 0.5° over Ghataprabha basin, India, for the time period 2021-2100.

Study Area

The Ghataprabha river is an imperative tributary of the Krishna River. It flows eastward about a distance of 283 km and the confluence with the Krishna River at Almatti. The river has a basin area of 8,829 km^2 and stretches across Karnataka and Maharashtra states. Ghataprabha sub-basin region deceits between latitude 15° 45' and 16° 25' N and longitude 74° 00' and 75° 55' E. The basin receives an average maximum rainfall of 3011mm. The average maximum temperature and average minimum recorded are 34.4°C in the month of July and 14.0°C in the month of January respectively. The maximum comparative humidity is observed all through monsoon in the month of July andminimum during the march. Maximum wind velocity is experienced during July month and minimum during October.

Data Source

India Meteorological Department (IMD) data

The daily observed data of atmospheric variables were recorded at various types of surface and archived at the National Data Centre, Pune. IMD data having daily series temperature data from 1969 to 2005 has been used in this study. The data were having a horizontal resolution of 1^o x 1.

General Circulation Models (GCMs) data

The GCM selected in this study is BCC-CSM 1-1, has horizontal resolution of 2.8x2.8. BCC-CSM 1-1 developed by Beijing Climate Center (BCC), China Meteorological Administration (CMA), based on NCAR CCSM2.0.1. The future scenarios considered in this study are RCP 2.6, 4.5, 6.0 and 8.5 for both the models. The historical data from 1986-2005 is considered as the baseline period. The future data from 2021-2100 is used for projection of future local scale climate.

Methodology

In this study, the temperature data of IMD stations (1°x1°) and GCM (2.8°x2.8°) are re-gridded to 0.5°x0.5° stations using two-dimensional interpolation technique using MATLAB and single additive change factor method is adopted based on a temporal scale. In an additive CFM, the arithmetic difference is calculated between GCM variable developed using both the current and historical data simulation and forecasted climate variable taken at the same GCM network location. The difference is then added to the any other local observed values to accurately predict the future climate scenario. The GCM generates a favorable estimate of absolute changesin the value of a particular variable at a given station as it assumes current climate simulation. This method is typically used for temperature. (Aavudai, 2011; Aavudai *et al.,* 2010). The concept of calculating a change factor is explained in the following section. The changes in temperature pattern will be assessed by calculating the increase in mean temperature for different timescales and different scenarios (Mori *et al.,* 2010; Pourtouiserkani, 2014).

The first step is to calculate the average values of GCM simulated baseline and future climates.

$$\overline{GCMb} = \sum_{i=1}^{N_b} GCMb_i / N_b \quad .. (1)$$

$$\overline{GCMf} = \sum_{i=1}^{N_f} GCMf_i / N_f \quad .. (2)$$

In equations (1) and (2) GCMb and GCMf represent the values of GCM baseline and GCM future climate scenario respectively. GCMb and GCMf are the mean values of GCM baseline and future scenarios.N_b and N_f are the number of values in the temporal domain of the GCM baseline and GCM future scenario.

In the second step, additive change factor value

(CF_{add}) is calculated as shown in equation (3)

$$CF_{add} = \overline{GCMf} - \overline{GCMb} \quad .. (3)$$

The third step is to add change factor value to the local observed (IMD) values to obtain local scaled future values as shown in equation 4.

$$LSf_{add,i} = LOb_i + CF_{add} \quad .. (4)$$

where are observed values of the meteorological variable (at the i^{th} time step) at an individual IMD station. are values of future scenarios of the variable. A brief Methodology used in this study has been presented in Fig. 1.

Results

Total 9 GCM grid points and 9 IMD grid stations are selected which represents the study area. The GCM temperature data of 2.8°x2.8° and IMD temperature data of 1°x1° are re-gridded to 0.5°x0.5° grid stations (15 grid points of 0.5° which are located in and around the study area) as shown in Fig. 2. Then change factor methodology is applied to project the temperature data for four different time periods (2021-2040, 2041-2060, 2061-2080 and 2081-2100).

Table 1 shows the maximum, minimum and mean T_{max} and T_{min} values of all four scenarios and

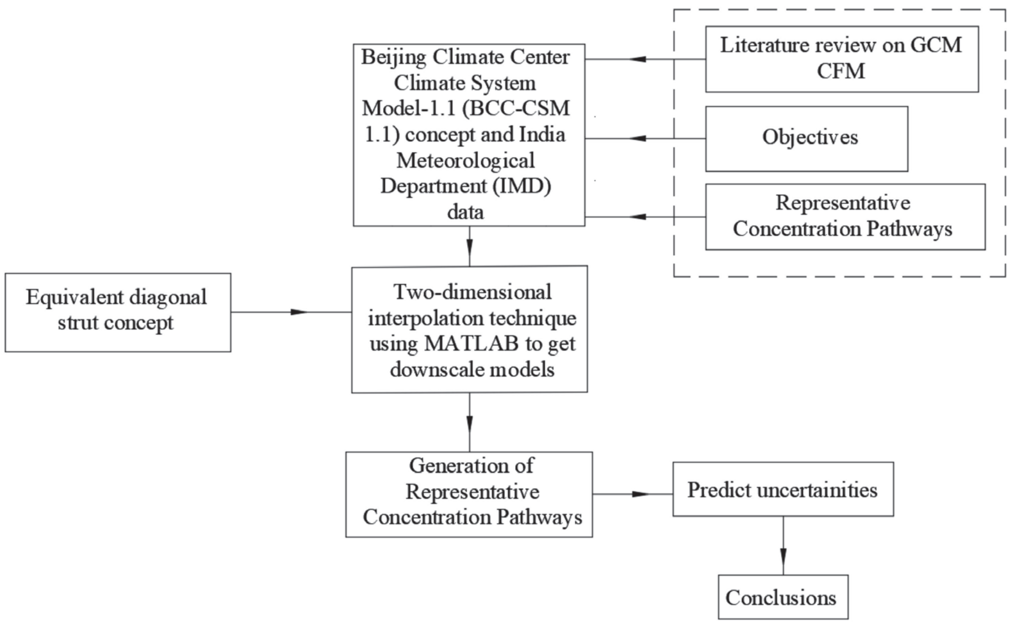

Fig. 1. Methodology used in this study

Table 1. Maximum, minimum and mean values of T_{max} and T_{min}

Temporalscale	Temperature	T_{max}				T_{min}			
	RCP scenario	2.6	4.5	6	8.5	2.6	4.5	6	8.5
2021-2040	Max	39.35	39.61	39.32	39.45	27.32	27.55	27.47	27.58
	Min	24.21	24.56	24.42	24.22	10.89	10.92	10.97	11.20
	Avg	32.14	32.20	32.23	32.33	21.43	21.48	21.48	21.66
2041-2060	Max	39.51	40.28	39.87	41.62	27.47	27.91	27.74	28.39
	Min	23.52	24.26	23.89	24.71	11.17	11.33	11.30	12.01
	Avg	32.12	32.58	32.34	33.88	21.60	21.96	21.74	22.37
2061-2080	Max	39.90	40.22	40.61	41.62	27.67	28.21	28.53	29.59
	Min	22.40	23.12	23.49	24.71	11.75	12.03	12.44	13.33
	Avg	32.30	32.74	32.96	33.88	21.89	22.28	22.47	23.41
2081-2100	Max	39.91	40.92	41.38	42.70	27.71	28.59	29.17	30.49
	Min	22.82	23.34	23.44	24.47	11.80	12.53	12.95	14.73
	Avg	32.42	33.02	33.41	34.66	21.74	22.49	22.84	24.46

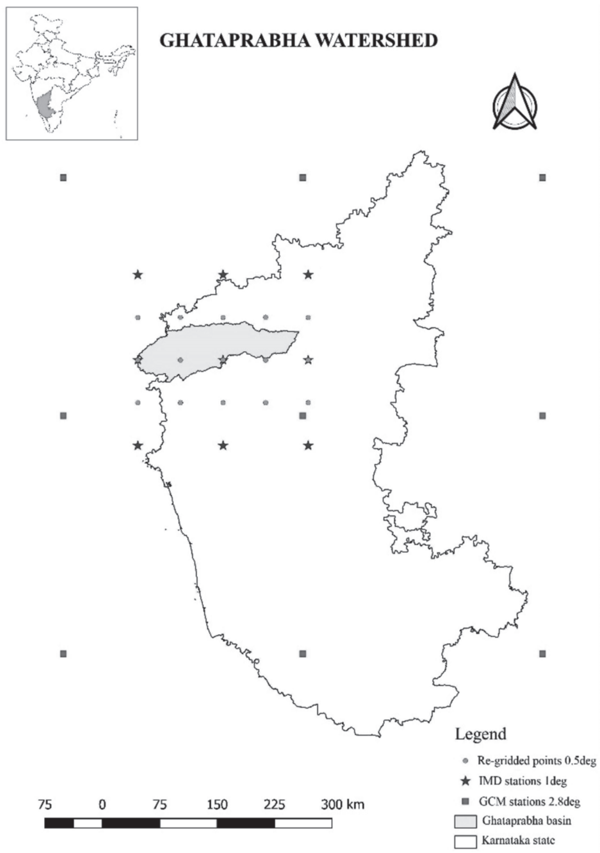

Fig. 2. Map of study area showing GCM, IMD and Re-gridded stations

all time periods (2021-2040, 2041-2060, 2061-2080 and 2081-2100).

The variation in magnitude of T_{max} of all four scenarios from 2021-2100 in Fig. 3. It can clearly be noticed that the temperature (T_{max}) increases randomly from 2041 onwards in each scenario. By comparing the variation scenario-wise, the temperature increases with an increase in Greenhouse Gas emissions. The mean maximum temperature (T_{max}) of 2.6, 4.5, 6 and 8.5 scenarios are 32.24°, 32.64°, 32.74°, 33.68°C respectively for the time period 2021-2100.

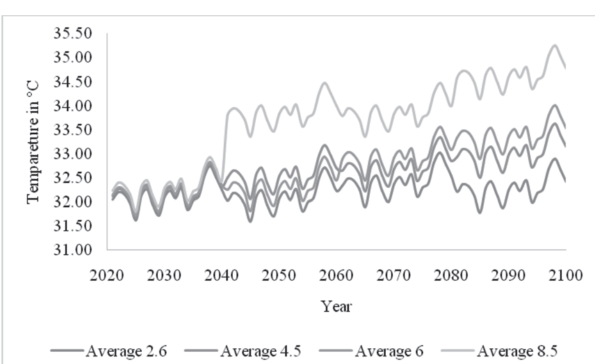

Fig. 3. T_{max} variation form 2020 – 2100 for all RCP scenarios

The variation in magnitude of T_{min} of all four scenarios from 2021-2100 Fig. 4. It can clearly have noticed that the temperature (T_{min}) increases randomly from 2041 onwards in each scenario. By comparing the variation scenario-wise, the temperature increases with an increase in Greenhouse Gas emissions. The mean temperature of 2.6, 4.5, 6 and 7.5 scenarios are 21.67°, 22.05°, 22.14°, 22.97°C respectively for the time period 2021-2100.

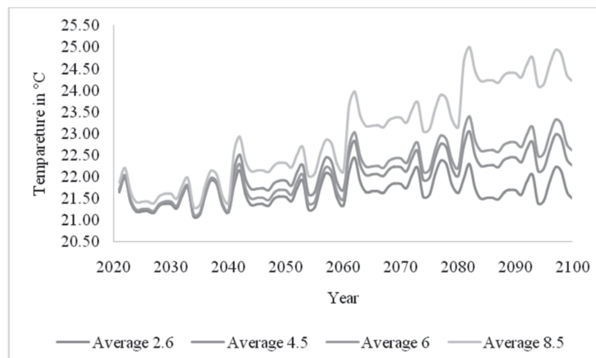

Fig. 4. T_{min} variation form 2020 – 2100 for all RCP scenarios

The maximum of T_{max} and minimum of T_{min} of all four scenarios for the time period 2021 to 2100 are shown in Fig. 5, the maximum values of T_{max} are 39.91°, 40.92°, 41.38° and 42.70 °C whereas minimum of T_{min} are 10.89°, 10.92°, 10.97° and 11.20 °C for 2.6, 4.5, 6 and 8.5 RCP scenarios respectively.

Conclusion

The study aimed to re-grid and project the daily

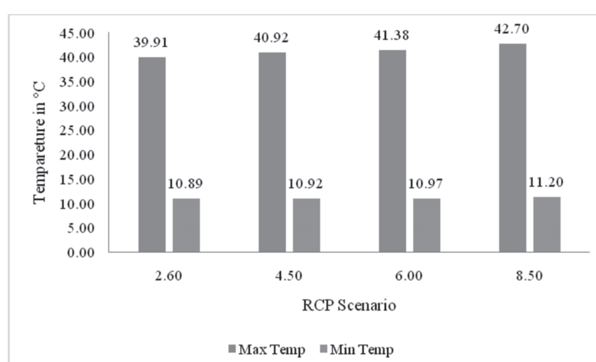

Fig. 5. Maximum of T_{max} and minimum of T_{min} of different RCP scenarios

temperature data for the Ghataprabha basin for the future time period of 2021-2100. Change factor methodology is found to be quite easier method in projecting the temperature data. It is found the maximum values of T_{max} are 39.91°, 40.92°, 41.38° and 42.70 °C whereas minimum of T_{min} are 10.89°, 10.92°, 10.97° and 11.20 °C for 2.6, 4.5, 6 and 8.5 RCP scenarios respectively. Conversely, drying is seen more severe under RCP 8.5 scenario compared to all other. The study revealed that the temperature increases with an increase in greenhouse gas emissions. Because of increased temperature, the natural, ecological and socio-economic conditions will be essentially influenced by the dry season, and more efficient mitigation and adaptation strategies should be done to address the effect of future dry spells.

References

Aavudai, A. 2011. Uncertainties in downscaled relative humidity for a semi-arid region in India. *Journal of Earth System Science.* 120 : 375-386.

Aavudai, A., Allan, F., Donald C. Pierson, Elliot M Schneiderman, Mark S. Zion, David Lounsbury and Adao H. Matonse, 2010. Examination of change factor methodologies for climate change impact assessment. *Water Resources Research.* 47 : 1-10.

Chong-Hai, X. U. and Ying, X. 2012. The projection of temperature and precipitation over China under RCP scenarios using a CMIP5 multi-model ensemble. *Atmospheric and Oceanic Science Letters.* 5 : 527-533.

Hashmi, M. Z., Shamseldin, A. Y. and Melville, B. W. 2011. Comparison of SDSM and LARS-WG for simulation and downscaling of extreme precipitation events in a watershed. *Stochastic Environmental Research and Risk Assessment* 25 **:** 475-484.

Kyung-On Boo, Won-Tae Kwon and Hee-Jeong Baek 2006. Change of extreme events of temperature and precipitation over Korea using regional projection of future climate change. *Geophysical Research Letters.* 33: 1-4.

Mori, N., Yasuda, T., Mase, H., Tom, T. and Oku, Y. 2010. Projection of extreme wave climate change under global warming. *Hydrological Research Letters.* 4 : 15-19.

Pourtouiserkani, A. 2014. Investigating Climate Change Impact on Extreme Rainfall Events (Case Study: Chenar-Rahdar Basin, Fars, Iran). *Scientia Iranica.* 21: 525-533.

Saraf, V. R. and Regulwar, D. G. 2016. Assessment of climate change for precipitation and temperature using statistical downscaling methods in Upper Godavari River basin. *India Journal of Water Resource and Protection.* 8 : 31-45.

Semadeni-Davies, A., Hernebring, C., Svensson, G. and Gustafsson, L. G. 2008. The impacts of climate change and urbanisation on drainage in Helsingborg, Sweden: Suburban stormwater. *Journal of Hydrology.* 350 : 114-125.

Wang, L. and Chen, W. 2014. A CMIP5 multimodel projection of future temperature, precipitation, and climatological drought in China. *International Journal of Climatology.* 34 : 2059-2078.

William, D. Collins, (USA), Pierre Friedlingstein (France, B., Amadou T. Gaye (Senegal), Jonathan M. Gregory (Uk), Andrew J. Weaver (Canada) and Zong-Ci Zhao (China) 2007. Global Climate Projections.