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Validation of PRECIS baseline (1961-1990) simulation for middle Gujarat agroclimatic zone

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ABSTRACT

The simulated temperature and precipitation by PRECIS model for nearest grid points were compared with the observed data of Anand (22.58 °N, 72.92 °E) during baseline period (1960–1990) to judge the usability of the simulated climate data. It was found that the simulation of rainfall events by model were fairly accurate only for July with overall agreement index value of 0.79 with considerably high values of difference measures. PRECIS showed average performance in simulation of maximum temperature with overall agreement index value of 0.81. The error statistics and difference measures were average except January, February and July months for maximum temperature. The simulation performance of PRECIS for all months of the year and overall performance (with index of agreement 'd'=0.96, r^2=0.85, RMSE=2.36 and CV%=11.74%) was found excellent in case of minimum temperature prediction for the baseline period (1961-1990). Though, minimum temperature was slightly overestimated for February to May months.

Key words: Validation, PRECIS, simulation, baseline period

It is reported that India and other countries of SAARC region are the most vulnerable to climate change that is affecting agriculture seriously (SAEO,2009). There is urgent need to study the impact of climate change on production of different agricultural crops. The regional climate model PRECIS (Providing REgional Climates for Impacts Studies) developed at Hadley Centre, United Kingdom can generate climate change scenarios (Jones *et al.*,2003). The weather parameters generated by the model are now widely used for various climate change studies. The model has been calibrated and validated for different regions on spatial scale (Rupa Kumar *et al.*, 2006; Yinlong *et al.*, 2006; Islam, 2009) using baseline (1961-90; also referred to as '1970s') projection and observed data of the same period. The attempts to explore the mitigation options have been started using various crop simulation models by providing assumed environment parameter for future as input. As the crop simulation models are very sensitive to slightest change in temperature and precipitation. Therefore, it is required to assess the reliability of PRECIS generated data as input for crop simulation study.

MATERIALS AND METHODS

The PRECIS generated monthly data of four grid points (22.74 °N,73.14 °E; 22.30 °N,73.14 °E; 22.30 °N,72.70 °E; 22.74 °N,72.70 °E) with 0.44° (representing ~50 km x 50 km area around Anand) resolution for the baseline period (1961–1990) were used for validating model with observed monthly data. The model generates data on precipitation, maximum and minimum temperatures. Using four grid points data, the spatial interpolation was performed to get data for the location of Anand (22.58 N, 72.92 E). The 30 years (1961-1990) weather data of Anand was used for validation of model output.

The model validation was performed by statistical analysis; the model validation parameters provide the basis for a model's difference measures (Fox, 1981). The simulation skill of the model and the ût can be assessed by the Root Mean Square Error (RMSE), the Bias and the Standard Error of Prediction Corrected from the bias (SEPC). Comparison of the SEPC with the mean value of the simulated parameter for evaluating of the signiûcance of the error given by the coefficient of variability (CV, as ratio of SEPC and mean of predicted values). The success of the model in prediction can be judged by investigating the proportion of the root mean squared error (RMSE) that is systematic (MSE_s) and the proportion that is unsystematic (MSE_u) (Willmott, 1981). The index of agreement (d) is a descriptive statistic that reflects the degree to which the observed variate was accurately estimated by the simulated variate. It is measure of the degree to which a model's predictions are error free (Willmott, 1981, Willmott and Wicks,1980):

RESULTS AND DISCUSSIONS

Rainfall

The frequency distribution plots (Fig. 1a) and scatter plot (Fig. 1b) showed prominent difference in rainfall frequency prediction for the 30 years period (1961-1990). Most events were over estimated and few events underestimated. Calculated monthly normal values (Fig. 1c) showed fair agreement with under estimation during month of

Table 1: Error and agreement statistics for PRECIS simulated and observed rainfall for period of 1961-1990.

Month	RMSE	MSEs	MSEu	Bias	SEPC	CV %	d	r^2
Jan	63.4	2052.8	1971.9	3.3	63.4	86.1	0.91	0.83
Feb	62.1	3394.7	466.6	5.0	61.9	87.7	0.93	0.96
Mar	131.0	14157.0	3009.9	32.7	126.9	173.1	0.71	0.88
Apr	125.6	11792.0	3987.5	57.2	111.8	226.6	0.65	0.76
May	106.2	3950.5	7323.3	38.2	99.1	201.0	0.77	0.41
Jun	121.3	4908.6	9793.5	60.5	105.1	176.3	0.75	0.49
Jul	47.7	791.7	1483.8	-3.6	47.6	54.5	0.96	0.89
Aug	84.2	2870.3	4217.5	47.2	69.7	194.4	0.79	0.63
Sep	37.9	800.2	638.1	17.2	33.8	51.3	0.97	0.95
Oct	113.2	10865.0	1956.8	-27.8	109.8	86.8	0.87	0.86
Nov	97.0	6040.7	3373.0	27.6	93.0	130.7	0.79	0.74
Dec	103.0	4690.4	5914.5	58.2	84.9	252.3	0.70	0.59
30 years time series	105.8	1956.8	6040.7	13.3	104.9	145.2	0.79	0.55

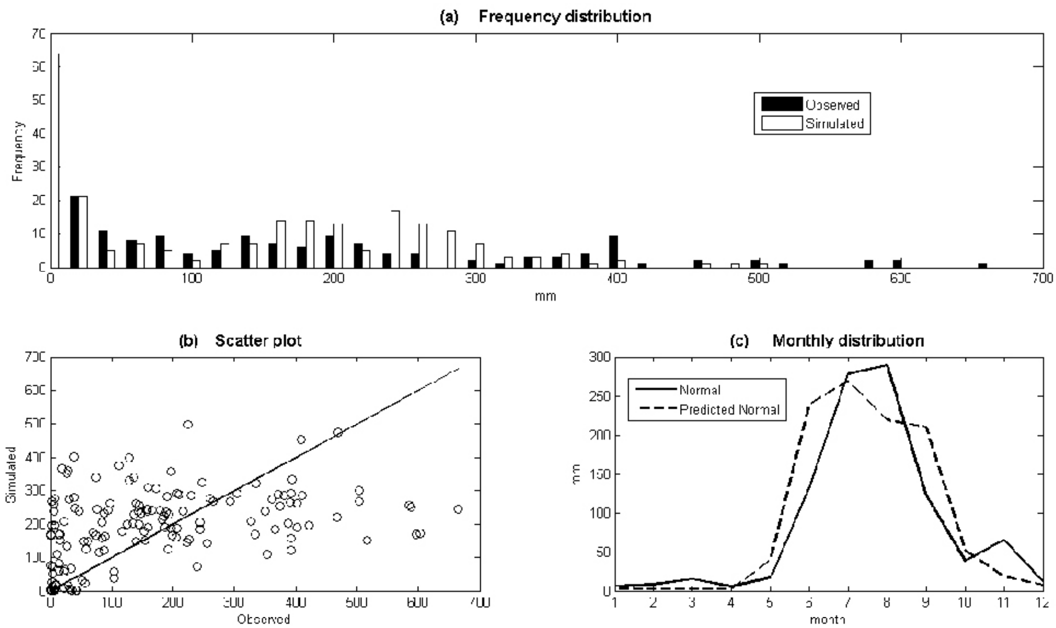

Fig. 1: Comparision of observed and PRECIS simulated rainfall for baseline(1961-1990) : (a)Frequency distribution (b) Scatter plot (c) Mean monthly distribution

July, August and November; while over estimation for rest of the months. Error indices and agreement parameters presented in Table .1, revealed that the PRECIS simulated rainfall events were most precise for the month of September (with index of agreement 'd'= 0.97, r^2 =0.95, RMSE= 37.9 and CV%= 51.3%) followed by for July, February and January months. For the months of June and August the PRECIS rainfall simulation was not good. The overall performance also found average looking to the values of statistical parameters (d = 0.79, r^2 =0.55, RMSE =105.8 CV=145%).

Maximum temperature

The frequency distribution plots (Fig. 2a) and scatter plot (Fig. 2b) of maximum temperature revealed that the simulated data were negatively skewed while observations had the normal distribution pattern. The maximum temperature was under estimated for temperatures < 38 °C and over estimated for temperatures >38°C. The monthly normal values (Fig. 2c) were not in agreement with simulation. The

Table 2: Error and agreement statistics for PRECIS simulated and observed maximum temperature for period of 1961-1990.

Month	RMSE	MSEs	MSEu	Bias	SEPC	CV %	d	r^2
Jan	4.0	8.8	7.1	-2.4	3.2	9.3	0.85	0.79
Feb	3.5	3.2	9.2	-1.4	3.2	9.5	0.86	0.71
Mar	3.6	6.8	6.1	-1.7	3.1	9.3	0.84	0.80
Apr	4.6	13.2	7.8	-2.9	3.6	10.5	0.81	0.77
May	5.0	11.4	14.0	-2.9	4.1	12.0	0.72	0.62
Jun	5.2	11.8	15.6	-3.1	4.2	12.5	0.67	0.53
Jul	3.2	3.5	7.0	-1.1	3.0	9.1	0.86	0.74
Aug	4.0	6.9	8.9	-1.2	3.8	11.5	0.79	0.67
Sep	3.7	5.4	8.4	-0.4	3.7	11.2	0.84	0.75
Oct	3.5	1.7	10.8	0.0	3.5	11.0	0.85	0.67
Nov	4.4	5.9	13.2	-0.3	4.4	14.0	0.65	0.32
Dec	4.6	8.2	13.1	-1.7	4.3	12.9	0.76	0.60
30 years time series	4.0	4.5	11.8	-1.3	3.8	11.4	0.81	0.62

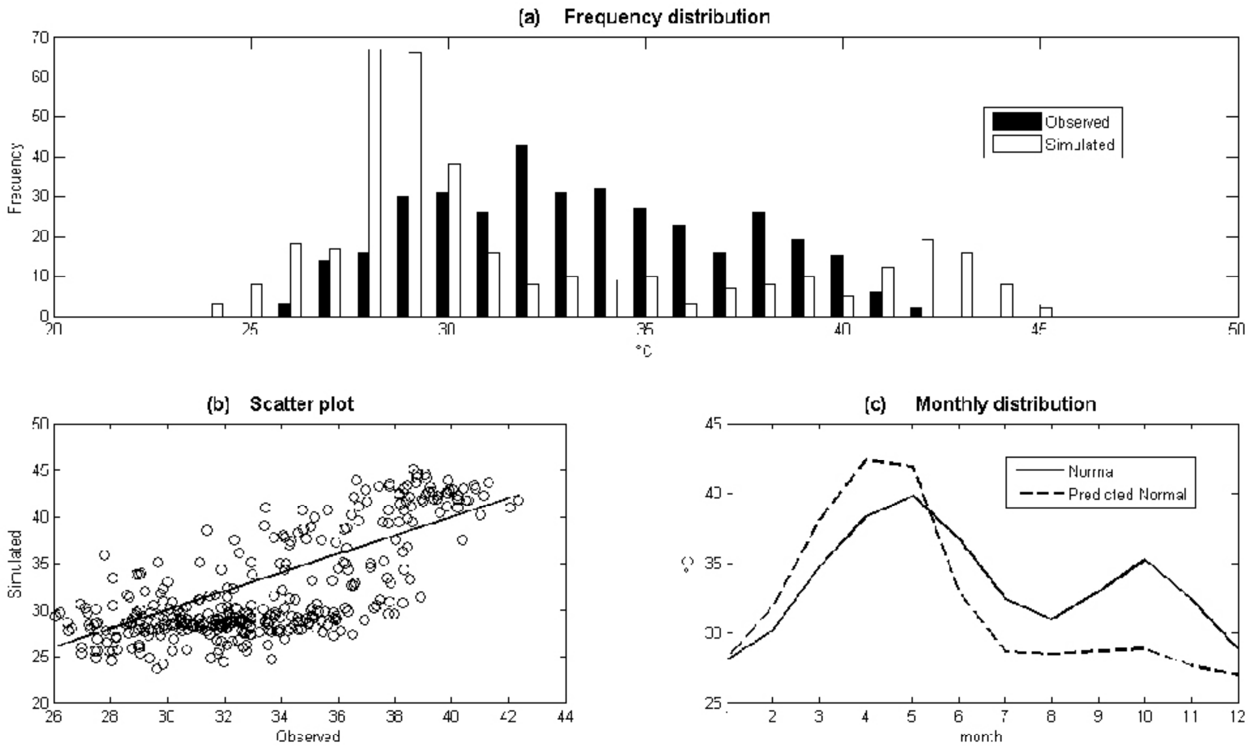

Fig. 2: Comparision of observed and PRECIS simulated maximum temperature for baseline(1961-1990) : (a)Frequency distribution (b) Scatter plot (c) Mean monthly distribution

maximum temperature was over estimated during February to May and under estimated during June to December. Prediction of maximum temperature in January was very close to observed data.

The error indices of simulation (Table, 2) was more or less consistent for all the months of the year with CV % ranging from 9.1 to 12.9. The index of agreement 'd' was lowest in June (0.67) and highest in July (0.86), while general value was 0.81. Other statistical parameters also revealed similar average performance of the model for prediction of maximum temperature.

Minimum temperature

The frequency distribution of the simulation and observation of the minimum temperature was fairly similar (Fig. 3a), with more frequency between 24 °C to 26 °C as

Table 3: Error and agreement statistics for PRECIS simulated and observed minimum temperature for period of 1961-1990.

Month	RMSE	MSEs	MSEu	Bias	SEPC	CV %	d	r^1
Jan	2.1	0.2	4.3	0.1	2.1	10.9	0.97	0.87
Feb	2.4	1.1	4.9	0.7	2.3	11.9	0.96	0.86
Mar	2.3	0.3	5.1	0.1	2.3	11.5	0.96	0.86
Apr	2.3	1.5	4.0	0.6	2.3	11.9	0.97	0.90
May	2.4	1.1	4.9	-0.3	2.4	12.2	0.95	0.87
Jun	2.4	1.2	4.7	0.8	2.3	12.0	0.95	0.84
Jul	2.6	1.0	5.6	0.4	2.5	13.0	0.95	0.83
Aug	2.5	2.6	3.8	1.1	2.3	11.7	0.95	0.87
Sep	2.7	1.8	5.6	0.9	2.6	12.7	0.93	0.81
Oct	2.1	3.2	1.0	1.1	1.8	9.1	0.97	0.97
Nov	1.7	0.9	1.9	-0.9	1.4	7.0	0.98	0.94
Dec	2.5	0.7	5.8	-0.5	2.5	12.4	0.95	0.86
30 years time series	2.4	0.5	5.1	0.5	2.3	11.7	0.96	0.85

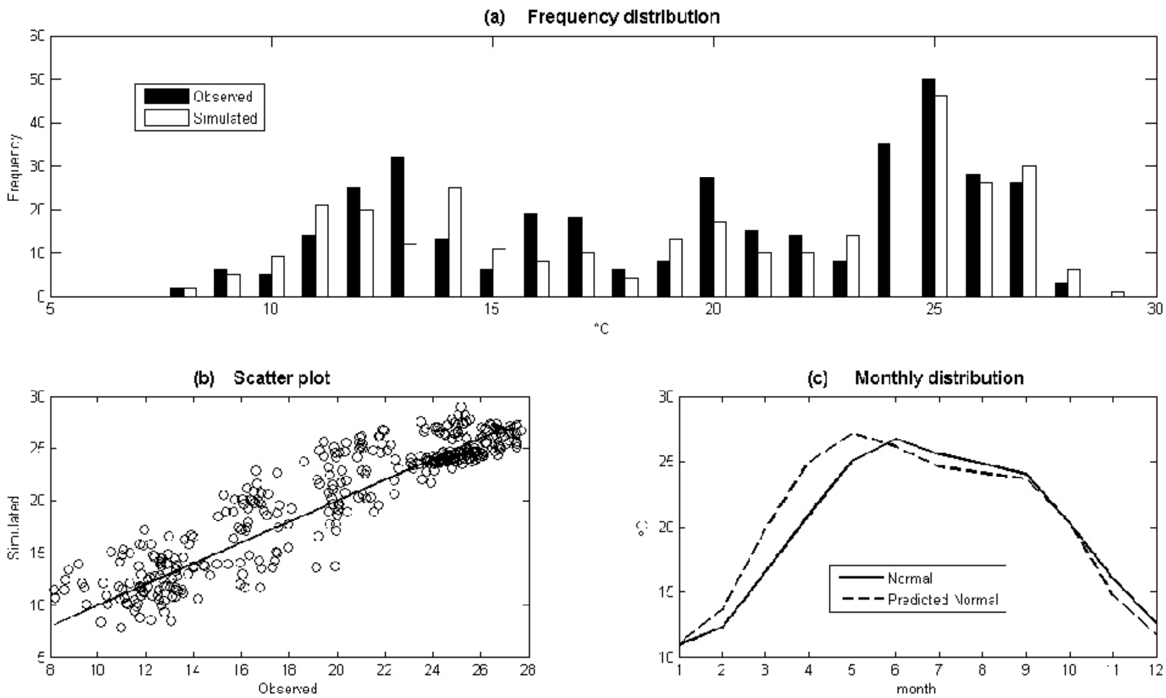

Fig. 3: Comparision of observed and PRECIS simulated minimum temperature for baseline(1961-1990) : (a)Frequency distribution (b) Scatter plot (c) Mean monthly distribution

compared to observed value distribution. The simulated data points were normally scattered near best line (b=1) of prediction (Fig. 3b). The mean monthly minimum temperature simulated were slightly higher than the observed data during February to May, while it was very close to observed during rest of the months.

The validation statistics showed very good simulation skill of PRECIS for minimum temperature. Minimum temperature for November (with index of agreement 'd' 0.98, r^2 0.94, RMSE 1.67 and CV% 7.04%) and October(with index of agreement 'd'= 0.97, r^2 =0.97, RMSE =2.1 and CV% =9.1%) months were simulated more precisely as compared to other months of the year. Though, simulation performance for all months of the year and overall performance (with index of agreement 'd' =0.96, r^2=0.85, RMSE=2.4 and CV%=11.7%)

was found excellent.

CONCLUSION

The rainfall events were fairly accurate for July month only among the monsoon period. PRECIS showed average performance in simulation of maximum temperature. The simulation performance of PRECIS for all months of the year was found excellent in case of minimum temperature prediction for the baseline period (1961-1990). Though, PRECIS has slightly overestimated values of minimum temperature for February to May period of the year. Simulated minimum temperature may be used as such as inputs in crop weather models. As most crop simulation models are sensitive to minute variation in the weather parameters, simulated rainfall and maximum temperature values can only used after site specific calibration.

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REFERENCES

Fox, D.G.(1981). Judging air quality model performance: A summary of the AMS Workshop on Dispersion Model Performance. *Bull. Am. Meteorol. Soc.*, 62, 599-609.

Islam, N.(2009). Rainfall and Temperature Scenario for Bangladesh. *The Open Atmos. Sci. J.*, 3: 93-103.

Jones, R., Hassell, D., Hudson, D., Wilson, S., Jenkins G. and Mitchell, J. (2003). Workbook on generating high resolution climate change scenarios using PRECIS. Hadley Centre for Climate Prediction and Research, Met Office, Bracknell, UK.

Rupa Kumar, K. , Sahai, A. K. , Krishna Kumar, K. , Patwardhan, S. K. , Mishra, P. K., Revadekar, J. V. , Kamala, K. and Pant, G. B.(2006). High-resolution climate change scenarios for India for the 21st century. *Current Sci.*, 90(3):334-345.

South Asian Economic Outlook-2009. SAARC Secretariat, Kathmandu,2009, p.15.

Willmott, C. J. and Wicks, D. E.(1980). An emerical method for the spatial interpolation of monthly precipitation within California. *Phys. Geog.,* 1, 59-73.

Willmott, C. J. (1981). On the validation of models. *Phys. Geog.,* 2, 184-194.

Willmott, C. J.(1982). Some comments on the evaluation of model performance. *Bull. Amer.Meteorol. Soc.*, 63, 1309-1313.

Yinlong , X., Xiaoying, H., Yong,Z., Wantao, L. and Erda, L.(2006). Statistical analyses of climate change scenarios over china in the 21st century. *Adv. Clim.*

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