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Short communication

Evaluation of a weather generator for four weather stations of Gujarat

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Weather generators are statistical models used to generate near real daily sequences of meteorological variables— precipitation, maximum and minimum temperature, humidity, etc. These are used for gap filling of missing data or for incorporation in long-term simulation models. Usually precipitation sequences are generated first, and other data sequences are derived using statistical relationships between these data and precipitation, with different relationships developed for wet and dry days .Precipitation is divided into an occurrence process (i.e., whether the day is wet or dry) modeled as a Markov chain, and an amount process (the amount of precipitation on a wet day) sampled randomly from an appropriate distribution, such as a Gamma distribution. A large number of sequences can be generated, all of which have similar statistical properties as the original data. This is a crucial factor in assessing uncertainties associated with the chaotic nature of daily weather variability.

Several computer programs have been developed that are capable of producing stochastically generated data from existing daily data like WGEN (Richardson and Wright,1984) ,WXGEN (Sharpley and Williams, 1990), CLIGEN (Arnold and Elliot, 1996). ClimGen is a modified version of WGEN and developed by Graylon S. Campbell (Stockle *et al.,* 1997). In the present study, an attempt was made to generate weather data from 2001 to 2005 through ClimGen using daily data from 1983 to 2000 for four weather stations in Gujarat state. The generated data was evaluated against the actual data.

The study was conducted for four weather stations of Gujarat, namely Ahmedabad ($23^0$04'N,$72^0$38'E), Bhavnagar ($21^0$45'N,$72^0$12'E), Deesa ($24^0$12'N, $72^0$12'E) and Rajkot ($22^0$18'N,$70^0$47'E). Deesa has a semiarid type of climate. It lies in North Gujarat region near the Rajasthan border. Bhavnagar is a coastal station and lies in Saurashtra region, towards Southwest of Gujarat. It has a moderate type of climate. Ahmedabad and Rajkot lie in Central Gujarat and have semiarid type of climatic conditions. Month wise climatic normals for the four stations are given in Table1.

In ClimGen, precipitation occurrence is modelled using a first-order two-state Markov procedure, which describes two precipitation classes, i.e., wet or dry, and takes into account precipitation occurrence on the previous day only. If precipitation occurs, then the amount of precipitation falling on wet days is determined usually by using a predefined frequency distribution i.e. Weibull distribution. The remaining climate variables, such as temperature, are then calculated based on their correlations with each other and on the wet or dry status of each day. The details of methodology of weather generation are available in Stockle *et al.* (1997).

Daily data for 18 years, 1983 to 2000 were used as input in the ClimGen model to generate daily data from 2001 to 2005. The data for the years 2003, 2004 and 2005 were used for evaluation. We wanted to evaluate whether the weather generator is able to capture the variability in the weather data and the extremes of the weather parameters. For this purpose, monthly mean and standard deviation were calculated from the daily series of actual and generated data and compared.

The standard deviations (SD) for the actual and generated maximum temperature values were compared for summer months (Table 2). The SD for the month of June was high for both actual and generated values. They varied from 2.66 to 5.11 for the actual data and from 1.52 to 5.6 in the generated data. The fluctuation can be attributed to the onset of Monsoon in the month of June. They were low in April and May. The SD for

Table 1: Monthly average (1983-2000) weather parameters of the weather stations of Gujarat

Months	Ahmedabad			Bhavnagar			Deesa			Rajkot		
	T_{max} (^oC)	T_{min} (^oC)	RF mm	T_{max} (^oC)	T_{min} (^oC)	RF mm	T_{max} (^oC)	T_{min} (^oC)	RF mm	T_{max} (^oC)	T_{min} (^oC)	RF mm
January	28.4	11.7	2.6	28.0	12.6	1.2	27.3	9.8	2.7	28.1	11.1	0.9
February	31.3	13.8	1.1	30.7	14.9	1.5	30.2	12.0	0.9	30.9	13.1	0.6
March	36.0	18.8	1.0	35.0	19.5	2.4	35.1	17.1	4.3	35.3	17.4	1.7
April	39.9	23.4	0.9	38.1	23.8	0.4	39.0	21.9	0.1	38.7	21.3	0.6
May	41.8	26.2	6.0	39.8	26.2	4.6	41.0	25.3	1.4	40.3	24.6	2.6
June	38.4	27.0	108.7	37.1	26.9	114.9	38.5	26.7	59.2	37.4	25.8	110.1
July	33.3	25.7	265.3	33.4	25.9	180.5	33.6	25.4	215.7	32.8	24.8	238.5
August	31.9	24.8	219.8	32.3	25.0	152.9	32.2	24.5	163.2	31.4	23.8	209.8
September	33.4	24.1	171.9	33.0	24.1	117.4	33.7	23.5	102.2	32.9	22.7	96.3
October	35.8	20.9	10.8	34.9	22.3	26.1	36.1	19.7	12.6	35.4	21.0	39.8
November	33.2	16.5	8.9	32.3	18.2	10.8	33.0	15.2	10.2	32.9	17.2	7.8
December	29.8	13.0	2.6	29.0	14.3	2.0	29.3	11.2	6.3	29.5	13.1	1.1

Table 2: Comparative evaluation of standard deviation of maximum temperature in actual and generated data

Month	2003		2004		2005	
	Actual	Generated	Actual	Generated	Actual	Generated
			Ahmedabad			
April	1.8	2.18	1.56	1.86	2.08	2.0
May	1.84	1.44	2.65	1.57	1.63	1.76
June	4.27	5.6	2.76	5.11	4.4	1.52
			Bhavnagar			
April	1.61	2.17	1.96	2.41	2.14	2.07
May	2.45	2.35	2.69	1.6	1.85	1.66
June	3.17	2.84	2.62	4.15	4.2	3.4
			Deesa			
April	1.71	3.16	1.98	2.17	2.33	2.1
May	1.68	2.04	2.64	1.72	1.58	2.2
June	3.58	3.28	2.66	4.78	2.64	3.0
			Rajkot			
April	1.94	2.31	1.20	2.5	1.98	2.23
May	1.36	1.91	3.38	1.2	1.49	1.45
June	3.33	2.61	3.29	3.8	4.8	5.09

both the actual and generated values were comparable, indicating the fluctuations being depicted correctly by the generated data.

The standard deviations for the actual and generated minimum temperature values were compared for winter, i.e. December, January and February (table 3). In most cases, the SD for minimum temperature were similar for both actual and generated values. They varied from 1.53 to 3.98 for the actual data and from 1.48 to 3.47 for the generated data. The rainfall variability in Gujarat is very high therefore the generated and actual values differed a lot. Thus the Climgen weather generator was not good enough to generate rainfall amounts.

The results indicated that the Climgen weather generator showed a fairly good performance in generating both minimum and maximum temperatures with similar amount of variability as in the actual data. Thus the generated data could depict the basic climatology and seasonal variations of that station.

Table 3: Comparative evaluation of standard deviation of maximum temperature in actual and generated data

Month	2003		2004		2005	
	Actual	Generated	Actual	Generated	Actual	Generated
			Ahmedabad			
December	2.39	3.03	2.12	2.02	2.57	1.9
January	2.67	3.1	3.38	3.13	1.65	2.5
February	2.76	2.77	2.72	3.17	3.65	2.3
			Bhavnagar			
December	2.07	3.06	1.82	2.53	1.95	2.6
January	2.32	2.36	1.74	1.48	1.53	2.46
February	2.62	2.44	2.87	1.86	3.43	2.19
			Deesa			
December	2.52	2.52	2.42	3.26	1.72	1.78
January	2.97	2.01	1.83	2.49	1.54	2.66
February	3.05	2.91	2.94	2.83	3.45	3.58
			Rajkot			
December	2.88	3.47	2.08	2.87	2.44	2.84
January	2.39	2.43	2.08	1.94	1.73	2.51
February	2.64	2.57	2.79	1.93	3.98	2.31

However, the weather generator was not successful in generating rainfall data, which was highly different from the actual data. As mentioned earlier, this might be due to the high variability in rainfall in the study area. Hence, although it is not possible to use this model for weather forecasting but it can be used as an aid for substituting missing data and also for study of climate change.

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