MAUSAM, 52, 2 (April 2001), 365-370

551.582 : 551.577.3 : 551.553.21

Climatology of dry and wet spell over Vidarbha region during monsoon months

JAYANTA SARKAR, K. SEETHARAM* and S.K. SHAHA

India Meteorological Department, Pune – 411 005, India

(Received 25 February 1999, Modified 10 November 2000)

सार - इस शोध-पत्र में दक्षिणी पश्चिमी मानसून वर्षा ऋतु के महीनों में विदर्भ क्षेत्र में 10 दिन के काल खंडों की वर्षा की सामान्य संभाव्यता, 10 दिन के काल खंडों की लगातार सूखा और वर्षा की विभिन्न संभावित अवधियों की तथा मार्कोव चेन मॉडल के अनुसार विभिन्न प्राचलों और विशेषताओं की माहवारी जाँच की गई है।

इस कार्य के लिए विदर्भ के सभी जिलों के अंतर्गत आने वाले 11स्थानों के 1960-90 तक की अवधि के दैनिक वर्षा आँकडों (1 जून से 30 सितंबर) का उपयोग किया गया है।

इस अध्ययन में मानसून वर्षा ऋतु (जून-सितंबर) के दौरान विदर्भ में, मानसून ऋतु के चरमावस्था वाले जुलाई और अगस्त के महीनों में क्रमशः अंतिम और पहले 10 दिन की अवधि में कुल मिलाकर एक दिन की वर्षा की संभाव्यता और विभिन्न लगातार वर्षा वाली अवधियों की संभाव्यताओं के प्रबल होने का पता चलता है। जून के महीने में 10 दिन के पहले दो काल खंड़ों तथा सितंबर के महीने में 10 दिन के अंतिम दो काल खड़ों में वर्षा की कमी वाले एक सूखे दिन की संभाव्यता और विभिन्न अवधियों में लगातार सूखे की संभाव्यताएँ काफी प्रबल हैं। जूलाई और अगस्त के महीनों में वर्षा वाले दिन अधिक से अधिक 12 से 14 तक अपेक्षित होते हैं तथा औसतन वर्षा वाले दौर 2 दिनों तक रहते हैं। वर्षा वाले दिन (π_2) की स्थाई संभाव्यता जुलाई के महीने में अधिकतम पाई गई है जिससे यह महीना मानसून वर्षा ऋतु का सबसे नमी वाला महीना होता है।

ABSTRACT. In this investigation 10-day periodwise simple probability, 10-day periodwise probability of consecutive dry and wet spells of different lengths,and monthwise different parameters and properties of Markov Chain Model over Vidarbha region during south-west monsoon months have been studied.

For this purpose, daily rainfall data (1 June - 30 September) of 11 stations covering all the districts of Vidarbha for the period 1960-90 have been utilized.

The study reveals that over Vidarbha during monsoon season (June - September) probability of a day being wet and probability of consecutive wet spell of different lengths are by and large high during the last and first 10-day periods of July and August respectively when the monsoon is at its peak. During the first two 10-day periods in June and last two 10-day periods in September, the probabilities of a dry day and that of consecutive dry spell of different lengths are quite high. During July and August a maximum of 12-14 wet days are expected and wet spell,on an average,lasts for 2 days. Stationary probability of the occurrence of wet day (π_2) is found to be maximum during July making it the most humid month in the monsoon season.

Key words – Markov chain model, Dry spell, Wet spell, Stationary probability.

1. Introduction

Many scientists in India and abroad have studied the behaviour of wet and dry spell by applying Markov Chain Model. Pioneering work on this subject was done by Gabriel and Neumann (1962) who studied the sequences in daily rainfall occurrence at Tel Aviv and found them to be well described by a Markoy chain model. Some of the recent studies in India include those by Pandharinath (1991), Sarkar (1994).

Recently Sarkar (1997) has studied the behaviour of dry and wet spell for each consecutive 10-day period in October, November and December for Madras. Information on chances of a wet day and wet spell of a particular length highest in a particular 10 day period could be of some use to the agricultural planners and farmers for irrigation water, application of fertilizers, pesticides etc. to crops.

Keeping in view, the potential use of the 10-day behaviour of wet and dry spell for the medium range weather forecasting and its further usefulness to the farming community, the present study has been taken up. Monthwise different parameters and properties of Markov Chain Model were also studied.

**Present affiliation* : Meteorological Office, Hyderabad, India

TABLE 1

Ten day periodwise probabilities (%) of dry days, *P(D)*, wet day, *P(W)*, dry days preceded by a dry day, *P(DD)*, wet days preceded by a wet day, *P(WW)*

	I				II				III			
	P(W)	*P(D)*	*P(WW)*	*P(DD)*	*P(W)*	*P(D)*	*P(WW)*	*P(DD)*	*P(W)*	*P(D)*	*P(WW)*	*P(DD)*
						June						
Akola	14	86	24	80	26	74	37	83	38	62	54	73
Amraoti	16	84	38	79	25	75	30	83	37	63	48	71
Gondia	16	84	29	78	24	76	38	86	54	46	64	59
Buldhana	16	84	22	77	21	79	29	83	35	65	54	77
Chandrapur	17	83	33	78	30	70	36	77	44	56	60	70
Sironcha	19	81	35	77	27	73	36	82	47	53	56	65
Nagpur	17	83	33	78	30	70	46	80	46	54	57	65
Yeotmal	20	80	38	75	30	70	39	81	41	59	56	70
Wardha	19	81	38	77	30	70	34	79	46	54	57	64
Pusad	21	79	3@	74	30	70	40	79	39	61	52	72
Brahmapur.	15	85	24	78	30	70	40	81	50	50	66	64
Average	17	83	32	77	27	73	37	81	43	57	57	68
						July						
Akola	36	64	44	65	33	67	44	75	39	61	57	71
Amraoti	38	62	49	63	40	60	42	70	41	59	55	71
Gondia	58	42	60	50	53	47	63	68	56	44	63	57
Buldhana	34	66	38	64	35	65	47	66	42	58	55	68
Chandrapur	46	54	51	54	50	50	52	66	54	46	65	60
Sironcha	46	54	55	59	49	51	60	73	57	43	69	61
Nagpur	43	57	45	52	46	54	52	71	49	51	63	64
Yeotmal	47	53	48	52	47	53	57	68	43	57	52	64
Wardha	42	58	46	55	46	54	48	65	48	52	56	59
Pusad	37	63	44	62	39	61	41	71	43	57	56	65
Brahmapur	57	43	65	54	54	46	57	61	56	44	66	58
Average	44	56	50	57	46	54	51	68	48	52	60	63
						August						
Akola	41	59	53	62	36	64	43	74	30	70	63	84
Amraoti	40	60	53	65	36	64	47	74	32	68	51	76
Gondia	58	42	60	49	55	45	59	61	51	49	64	61
Buldhana	42	58	57	64	38	62	49	71	30	70	60	81
Chandrapur	51	49	56	52	49	51	56	68	44	56	70	72
Sironcha	56	44	61	52	51	49	62	72	48	52	60	61
Nagpur	50	50	51	51	43	57	49	72	38	62	58	71
Yeotmal	49	51	59	59	40	60	52	72	40	60	57	71
Wardha	46	54	54	59	39	61	47	72	35	65	53	74
Pusad	45	55	50	58	38	62	44	72	34	66	58	77
Brahmapur	53	47	59	53	55	45	64	71	45	55	65	69
Average	48	52	56	57	44	56	52	71	39	61	60	72
						September						
Akola	25	75	41	72	14	86	32	90	20	80	40	84
Amraoti	37	63	52	66	26	74	35	80	24	76	49	84
Gondia	40	60	56	67	32	68	53	81	23	77	42	80
Buldhana	28	72	56	77	19	81	38	88	24	76	47	83
Chandrapur	38	62	53	65	27	73	50	86	24	76	44	84
Sironcha	47	53	55	58	32	68	49	78	27	73	44	78
Nagpur	40	60	51	63	23	77	39	84	25	75	43	80
Yeotmal	41	59	57	67	22	78	46	86	23	77	38	81
Wardha	40	60	60	71	22	78	47	86	24	76	41	81
Pusad	30	70	53	76	16	84	30	89	22	78	46	84
Brahmapur	39	61	54	65	30	70	47	77	28	72	38	77
Average	37	63	53	68	24	76	42	84	24	76	43	81

I = 1 – 10th, II = 11 – 20th, III = 21 – 30th / 31st

TABLE 2

10-day periodwise probabilities (%) of consecutive dry spells of different lengths

	I				II				III			
	Days				Days				Days			
	3	4	5	6	3	4	5	6	3	4	5	6
						June						
Akola	55	44	35	28	52	43	36	30	33	24	18	13
Amraoti	53	42	33	27	51	43	35	29	32	22	16	11
Gondia	51	40	31	24	57	49	42	36	16	9	6	3
Buldhana	50	39	30	23	54	45	37	31	38	29	23	17
Chandrapur	50	39	30	23	42	32	25	19	27	19	13	9
Sironcha	48	36	28	21	49	40	32	26	23	15	10	6
Nagpur	50	39	31	24	45	36	29	23	22	14	9	6
Yeotmal	45	34	25	19	46	37	30	25	29	20	14	10
Wardha	49	38	29	22	43	34	27	21	22	14	9	6
Pusad	43	32	24	17	43	34	27	21	31	23	16	12
Brahmapur	52	41	32	25	46	38	31	25	21	13	9	5
Average	50	38	30	23	48	39	32	26	27	18	13	9
						July						
Akola	27	17	11	7	38	28	21	16	31	22	15	11
Amraoti	25	16	10	6	29	20	14	10	30	21	15	11
Gondia	11	5	3	1	22	15	10	7	14	8	4	3
Buldhana	27	17	11	7	38	29	22	17	27	18	12	8
Chandrapur	16	9	5	3	22	15	10	6	16	10	6	3
Sironcha	18	11	6	4	27	20	14	10	16	10	6	4
Nagpur	15	8	4	2	27	19	14	10	21	14	9	6
Yeotmal	14	8	4	2	25	17	11	8	23	15	10	6
Wardha	17	9	5	3	23	15	10	6	18	11	6	4
Pusad	24	15	9	5	31	22	16	11	24	16	10	6
Brahmapur	13	7	4	2	17	10	6	4	15	9	5	3
Average	19	11	6	4	27	19	13	9	21	14	9	6
						August						
Akola	23	14	9	5	35	26	20	15	49	41	34	29
Amraoti	25	16	11	7	35	26	19	14	39	29	22	17
Gondia	10	5	2	1	17	10	6	4	18	11	7	4
Buldhana	24	15	10	6	31	22	16	11	47	38	31	25
Chandrapur	13	7	4	2	24	16	11	8	29	21	15	11
Sironcha	12	6	3	2	25	18	13	9	20	12	7	5
Nagpur	13	7	3	2	30	21	16	11	31	22	16	11
Yeotmal	18	11	6	4	31	23	16	12	30	22	15	11
Wardha	19	11	7	4	31	22	16	12	35	26	19	14
Pusad	18	11	6	4	32	23	17	12	39	30	23	18
Brahmapur	13	7	4	2	23	16	11	8	26	18	12	9
Average	17	10	6	3	28	20	15	10	33	24	18	14
						September						
Akola	39	28	20	15	69	62	55	50	56	46	39	32
Amraoti	28	18	12	8	48	38	31	25	54	46	38	32
Gondia	27	18	12	8	44	35	29	23	50	40	32	36
Buldhana	43	33	25	19	63	55	49	43	52	43	36	30
Chandrapur	26	17	11	7	55	47	41	35	54	45	38	32
Sironcha	18	11	6	4	41	32	25	19	44	34	26	21
Nagpur	24	15	9	6	54	45	38	32	48	38	31	24
Yeotmal	26	18	12	8	57	49	42	36	51	41	33	27
Wardha	30	21	15	11	58	50	43	37	49	40	32	26
Pusad	40	31	23	18	66	59	53	47	55	46	39	32
Brahmapur	25	16	11	7	42	33	25	20	42	32	25	19
Average	30	21	14	10	54	46	39	33	50	41	33	28

TABLE 3

10-day periodwise probabilities (%) of consecutive wet spells of different lengths

	I				II				III			
	Days				Days				Days			
	3	4	5	6	3	4	5	6	3	4	5	6
						June						
Akola	1	0	0	0	4	1	0	0	11	6	3	2
Amraoti	2	1	0	0	2	1	0	0	8	4	2	1
Gondia	1	0	0	0	3	1	1	0	23	15	9	6
Buldhana	1	0	0	0	2	0	0	0	10	5	3	2
Chandrapur	2	1	0	0	4	1	0	0	16	10	6	3
Sironcha	2	1	0	0	3	1	0	0	15	8	5	3
Nagpur	2	1	0	0	6	3	1	1	15	9	5	3
Yeotmal	3	1	0	0	5	2	1	0	13	7	4	2
Wardha	3	1	0	0	3	1	0	0	15	9	5	3
Pusad	3	1	0	0	5	2	0	0	10	5	3	1
Brahmapur	1	0	0	0	5	2	1	0	22	14	9	6
Average	2	1	0	0	4	1	0	0	14	8	5	3
						July						
Akola	7	3	1	1	6	3	1	1	12	7	4	2
Amraoti	9	4	2	1	7	3	1	1	12	7	4	2
Gondia	21	12	7	4	21	13	8	5	23	14	9	6
Buldhana	5	2	1	0	8	4	2	1	13	7	4	2
Chandrapur	12	6	3	2	13	7	4	2	23	15	10	6
Sironcha	14	8	4	2	18	10	6	4	27	19	13	9
Nagpur	9	4	2	1	12	6	3	2	19	12	7	5
Yeotmal	11	5	3	1	15	9	5	3	22	6	3	2
Wardha	9	4	2	1	11	5	2	1	15	9	5	3
Pusad	7	3	1	0	7	3	1	0	13	8	4	2
Brahmapur	24	15	10	6	17	10	6	3	24	16	11	7
Average	12	6	4	2	11	7	4	2	18	11	7	5
						August						
Akola	12	6	3	2	7	3	1	1	12	7	5	3
Amraoti	11	6	3	2	8	4	2	1	8	4	2	1
Gondia	21	13	8	5	19	12	7	4	21	13	9	6
Buldhana	14	8	5	3	9	4	2	1	11	6	4	2
Chandrapur	16	9	5	3	25	9	5	3	22	16	11	8
Sironcha	21	13	8	5	20	12	8	5	17	10	6	4
Nagpur	13	7	3	2	11	5	3	1	13	7	4	2
Yeotmal	17	10	6	4	11	6	3	1	13	7	4	2
Wardha	13	7	4	2	9	4	2	1	10	5	3	1
Pusad	11	6	3	1	7	3	1	0	11	6	4	2
Brahmapur	19	11	6	4	22	14	9	6	19	12	8	5
Average	15	9	5	3	13	7	4	2	14	8	5	3
						September						
Akola	4	2	1	0	1	0	0	0	3	1	1	0
Amraoti	10	5	3	1	3	1	0	0	6	3	1	1
Gondia	12	7	4	2	9	5	3	1	4	2	1	0
Buldhana	9	5	3	1	3	1	0	0	5	2	1	1
Chandrapur	10	5	3	2	7	3	2	1	5	2	1	0
Sironcha	14	8	4	2	8	4	2	1	5	2	1	0
Nagpur	10	5	3	1	3	1	1	0	5	2	1	0
Yeotmal	13	8	4	2	5	2	1	0	3	1	0	0
Wardha	14	8	5	3	5	2	1	0	4	2	1	0
Pusad	8	4	2	1	1	0	0	0	4	2	0	0
Brahmapur	12	6	3	2	6	3	1	1	4	2	1	0
Average	9	6	3	1	5	2	1	0	4	2	1	0

2. Data and methodology

In this investigation the study area chosen was Vidarbha and the study was conducted for the south-west monsoon season (June-September). Daily rainfall data (1 June – 30 September) of 11 stations,covering all the districts of Vidarbha region, for the period 1961-90 have been utilised in this study. A day was considered wet when it received rainfall of atleast 2.5 mm/day; otherwise it was termed as a dry day.

The probabilities of dry day $P(D)$, wet day $P(W)$, dry days preceded by a dry day, $P(DD)$, and wet days preceded by a wet day $P(WW)$ have been calculated for each consecutive 10-day period in June, July, August and September using the following equations:

$$P(D) = F(D) \quad (1)$$
$$P(DD) = F(DD)/F(D) \quad (2)$$
$$P(W) = F(W)/n \quad (3)$$
$$P(WW) = F(WW)/F(W) \quad (4)$$

where $F(D)$ and $F(W)$ are the frequencies of dry and wet days respectively during a 10-day period; $F(DD)$ is the frequency of dry days preceded by another dry day. $F(WW)$ has similar meaning; n is the period in days, *i.e.* 10 in the present case.

In each 10-day period probability of the continuation of dry/wet spell of different lengths has been calculated by the following formulae :

$$P(W_y) = P(W) \times P(WW)^{y-1} \quad (5)$$
$$P(D_y) = P(D) \times P(DD)^{y-1} \quad (6)$$

Where, $P(W_y)$ and $P(D_y)$ are the probabilities of 'y' consecutive wet days and dry days respectively in a particular 10-day period.

For the monthwise computations of different parameters and properties of Markov Chain Model, Victor and Sastri (1979) was followed. Stationary probabilities for the occurrence of dry and wet days ($\pi_1$and π_2 respectively) were worked out using the following two equations :

$$\pi_1 = \frac{1 - P(W/W)}{1 + P(W/D) - P(W/W)} \quad (7)$$

$$\pi_2 = \frac{P(W/D)}{1 + P(W/D) - P(W/W)} \quad (8)$$

where $P(W/W)$ and $P(W/D)$ are the probabilities of occurrence of wet day preceded by another wet day and that preceded by a dry day respectively.

3. Results and discussion

3.1. *Basic probabilities*

The probabilities of a dry day, $P(D)$, wet day $P(W)$, dry days preceded by a dry day $P(DD)$ and wet days preceded by a wet day $P(WW)$ in each 10 - day period for the four months of south-west monsoon season have been presented in Table 1.

Examination of the data reveals that the probability of dry day far exceeds that of wet day during the first two 10-day periods of June, and again during the month of September over the region. $P(D)$ values are comparable during 21 June to 20 August so also the $P(W)$ values. $P(D)$ registers comparatively lower values (average 52%) during the two 10-day periods of 21 July to 10 August; similarly $P(W)$ values are by and large high(average 48%) during this period indicating that in Vidarbha this is the peak monsoon activity period.

Data in Table1 further reveals that the $P(DD)$ values are generally more than that of $P(D)$ in all the 10 – periods except 1-10 June like $P(D)$ and $P(W)$, here also $P(DD)$ and $P(WW)$ values are comparatively low and high respectively during 21 July - 10 August.

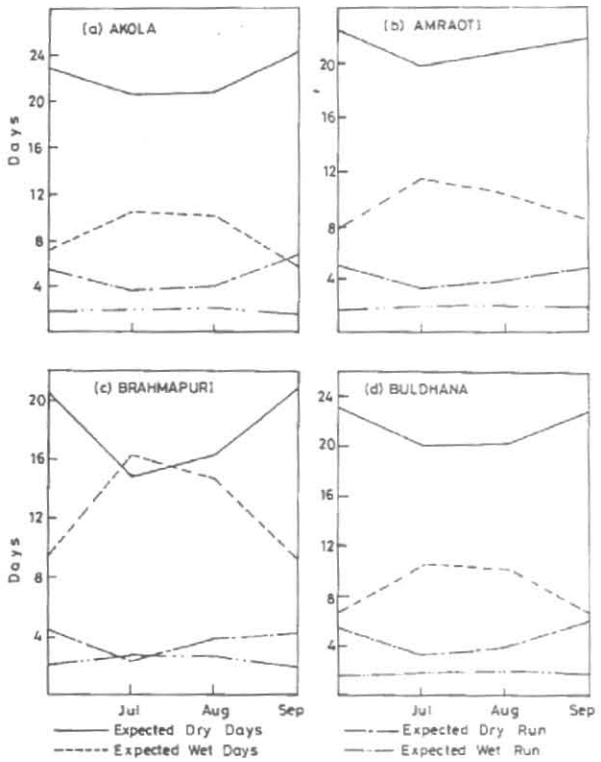
3.2. *Consecutive dry/wet spells of different length*

Ten-day durationwise probabilities of continued dry/wet spells of different length have been presented in Table 2 and 3. During the first two 10-day periods in June and last two 10 days in September the probability of wet spell of 5 or more continuous days is almost zero. During 21-31 July and 1-10 August the probability of consecutive wet days is about 15-18 % for 3 consecutive days and is comparable with the last 10 day period of June (21-30 June) and last two 10 day periods of August (11- 20 and 21-31 August). Wet spell of 4 consecutive wet days also has got comparatively fairly high probability values during 21 July – 10 August.

In contrast, even 5 consecutive dry days has got comparatively large probability values (at least 30%) during the first two 10 day periods in June and last two 10 days in September. For obvious reasons, probability increases as the dry spell length decreases. Thus in each 10 day period during 1 June-20 June and again during 11 September-30 September whereas for 4 consecutive dry days the probability is at least 30%, for 3 continuous dry days it is at least 40%.

3.3. *Parameters and properties of Markov Chain Model*

Monthwise different parameters and properties of Markov Chain probability Model [*viz.* $P(W/W)$, $P(W/D)$,



Figs. 1(a-d). Expected dry/wet days & dry/wet runs

expected length of wet and dry run, expected number of wet and dry days and π_1 and π_2] for each of the 4 months of monsoon season have been computed and monthwise variations of expected dry/wet run and expected dry/wet days for each of the 11 stations of the region have been analyzed; for the sake of brevity graphical analysis for the four stations have been presented in Figs.1(a-d). The figures reveal that the probability of occurrence of wet day preceded by another wet day *P(W/W)* has higher values than that preceded by a dry day *P(W/D)*. *P(W/W)* values are fairly high during July and August. On an average wet spell lasts for 2 days during July and August whereas dry spell lasts for 2-3 days in July and August and 4-6 days in June and September. On an average a maximum of 12-14 wet days are expected in July and August; these values are in fair agreement with the values in the 'Climatological Tables, 1951-80', of India Met. Deptt. (1999), whereas 21- 22 dry days are possible in June and September. Stationary probability of the occurrence of wet day (π_2) is found to be maximum in July or in other words that of dry day(π_1) in July is found to be the least which indicates that this is the most humid month over the region.

4. Conclusions

Following conclusions emerge out from the study:

(*i*) In Vidarbha region during 21 July to 10 August probability of a day being wet as well as that of three consecutive wet days have the highest chances of occurrence.

(*ii*) On an average wet spell lasts for 2 days during July and August whereas dry spell lasts for 2-3 days during July and August and 4-6 days in June and September.

(*iii*) During July and August a maximum of 12-14 wet days and during June and September 21-22 dry days could be expected.

(*iv*) Stationary probability of the occurrence of wet day is found to be maximum in July making it the most humid month of the region.

Acknowledgements

The authors are thankful to Dr. U.S. De, Additional Director General of Meteorology (Research), and Dr. K.C. Sinha Ray, Director, India Meteorological Department, Pune for ' their guidance and encouragement in taking up the study. The authors are also thankful to the anonymous referee for his constructive comments. Thanks are also due to Shri A. G. Tamboli for neatly typing the manuscript and Shri Abhraham Philipose for rendering DTP services.

References

Gabriel, K.R. and Neumann, J., 1962, "A Markov chain model for daily rainfall occurrence at Tel Aviv", *Quart. J.R. Met. Soc.*, **88**, 90-95.

India Met. Dep., 1999, "Climatological Tables of Observatories in India,1951- 80".

Pandharinath, N., 1991, "Markov Chain Model probability of dry, wet weeks during monsoon period over Andhra Pradesh", *Mausam*, **42**, 4, 393-400.

Sarkar Jayanta, 1994, "The length distribution of weather cycles and dry and wet spells at Madras during the northeast monsoon months", *Vayu Mandal*, **24**, 3-4, 77-80.

Sarkar Jayanta, 1997, "Further studies on dry and wet spell at Madras during north-east monsoon", *Mausam*, **48**, 3, 453- 456.

Victor, U.S. and Sastri, P.S.N., 1979, "Dry spell probability by Markov chain model and its application to crop developmental stages", *Mausam*, **30**, 4, 479-484.