DRY SPELL FREQUENCIES AT SOME STATIONS IN PARAIBA STATE

K. KARUNA KUMAR[1], P. R. C. DANTAS[2], FRANCISCO de ASSIS S. de SOUSA.[3]

ABSTRACT

In the present study frequency distribution of dry spells of varying lengths at C. Grande are compared with those derived from three statistical models. The model with the best fit to the observed dry spell frequencies is then tested against data at ten stations in the state of Paraíba.

KEY WORDS

Dry spells, Markov chain model, Eggenberger-Polya model

INTRODUCTION

Various studies have been carriedout in the past to estimate the frequency distribution of sequences of dry days. The model most often used is the simple Markov chain which assumes that the probability of any particular day being dry or wet depends only on the nature of the previous day (Gabriel and Newmann 1962, Caskey 1963, Weiss 1964). Higher order Markov chain models have been used by Feyerherm and Bark (1967). The logarithmic series has been suggested by Williams (1952) as a fit to dry and wet spell distribution. The Eggenberger-Polya (1923) model has been employed by Berger and Goossens (1983) to estimate dry and wet spell frequencies.

Results of a study of dry spells at some stations in Paraiba state are reported in this paper.

METHODOLOGY

In this paper a dry day is defined as a day with no rainfall. A dry spell is a sequence of dry days bracketed by wet days on both sides. Daily rainfall data at C Grande for the months April-June during the period 1939-74 is used to obtain the frequency distribution of dry spells of different durations. These frequencies are compared with those computed using a) logarithmic model, b) Markov chain model and c) Eggenberger-Polya model..

In a first order Markov chain model the probability of a dry spell of length k is given by

where $P_{d/d}$ is the probability of a day being dry given that the previous day is dry.

Similarly the probability of a dry spell of length k in Markov models of 2nd and 3rd orders are given by

[1] PH.D. Professor. Department of Atmospheric sciences.Federal university of Paraiba,Campina Grande-PB.CEP 58.109-970.E-mail : karuna@dca.ufpb.br.
[2] MS Student.Department of Atmospheric sciences.Federal university of Paraiba.Campina Grande-PB.CEP 58.109-970.
[3] PH.D. Professor.Department of Atmospheric sciences.Federal university of Paraiba.Campina Grande-PB.CEP 58.109-970.

where $P_{d/dd,}$ $P_{d/dw}$ etc are the conditional probabilities which are derived from the observed runs of dry and wet days.

The logarithmic series is mathematically written as

where each term, in the case of dry spell series represents the number of spells of dry days lasting over 1, 2, 3, etc days.

The two constants X (which is always less than unity) and α can be computed from the two simultaneous equations:

where *S* is the total number of dry spells and *N* is the total number of dry days involved in the study period.

TheEggenberger-Polya (EP) distribution is given by

Where is the estimated probability of a spell of k dry days, (m+1) is the mean length of a spell,

.

For each value of K the corresponding frequency can be computed where S is the total number of dry spells.

The frequency distribution from the three models are compared with observed frequencies at C. Grande. The best of the models is tested against data from ten stations selected from different parts of the state.

RESULTS

In Table 1 are shown the observed frequencies of dry spells at Campina Grande together with those derived from the three statistical models. The three month period selected represents the

rainiest part of the year at this station. Only dry spells of durations up to ten days are considered since observed frequencies of greater lengths are extremely low. parameters for log and EP models are included in the table. From Table 1 it is seen that Markov chain of 2nd order and the EP model yield results better than the log model. The Markov chain and EP models are used to compute frequencies of dry spells at ten stations in the state. Precipitation data during the three rainiest months of the year at the stations are used and the study periods ranged between 23 and 48 years. In all the cases it is found that the frequencies derived from the Markov chain model differed significantly from the observed frequencies. Results from the EP model are shown in Table 2 together with the observed frequencies of dry spells. When the observed frequencies are very low the differences between observed and computed frequencies are significantly large. Since dry spells which occur rarely are not of much practical importance we chose to include in Table 2 only dry spells of durations whose observed frequencies are more than 3% of the total number of dry spells. From Table 2 it is seen that the EP model provides reasonably good estimates of dry spell frequencies at the selected stations

CONCLUSIONS

Frequencies of dry spells of different durations at some stations in Paraiba state are compared with those derived from three statistical models. It is found that the Eggenberger-Polya model provides good estimates of dry spell frequencies at the selected stations.

REFERENCES

BERGER, A and C.H.R. GOOSSENS.. Persistence of wet and dry spells at **Uccle**(Belgium). J.Climatol,3.21. 1983

CASKEY, J. E. A Markov Chain model for probability of precipitation occurrences in intervals of various length, **Mon. Wea.Rev., 91,** p.298. 1963.

EGGENBERGER, F. and POLYA, G.. Uber die Statistik verketteter Vorgange, **Z. angew. Math. Mech** (Berlin)**, 3,** p.279. 1923.

FEYERHERM, A. M. and BARK, L. D. Goodness of fit of a Markov Chain model for sequences of wet and dry days, **J. Appl. Meteor., 6,** p.770. 1967.

GABRIEL, K. R. and NEUMANN, J. A Markov Chain model for daily rainfall ocurrence at Tel Aviv. **Quart. J. R. Met. Soc.,** London, **88**, p.90. 1962.

WEISS, L. L. Sequences of wet and dry days described by a Markov Chain Probability model, **Mont. Wea. Rev., 92,** p.160. 1964.

WILLIAMS, C. B. Sequences of wet and dry days considered in relation to logarithmic series, **Quart. J. R. Met. Soc., 78,** p.91. 1952.

Table.I - Observed frequencies of dry spells at C. Grande compared with those derived from Markov chain,logarithmic and Eggenberger - Polya (EP) models.

Duration of dry spells in days	Observed frequencies	THEORETICAL FREQUENCIES					
		MARKOV CHAIN				LOGARITHMIC	EGGENBERGER-POLYA
		I	II	III	IV		
1	226	-	-	-	-	253	225
2	119	126	-	-	-	109	115
3	63	85	73	-	-	62	77
4	47	57	51	46	-	40	53
5	37	38	36	33	34	27	37
6	23	26	25	24	24	19	26
7	20	17	18	17	18	14	18
8	13	12	13	13	13	11	13
9	7	8	9	9	9	8	9
10	6	5	6	7	7	6	7

Parameters N = 1762 d = 2.9153 Period - 1939-74
S = 574 m =1.9983 Months - April-June
χ = 0.85616 σ =7.8237
α = 296.0207

Table II - Observed and theoretical (EP model) frequencies of dry spells

Duration of Dry Spell	Água Branca		Bom Jesus		Catolé do Rocha		Condado		Imaculada		Itaporanga		João Pessoa		Monteiro		Pombal		São Gonçalo	
	Obs	Cal	Obs	Cal	Obs	Cal	Obs	Cal	Obs	Cal	Obs	Cal	Obs	Cal	Obs	Cal	Obs	Cal	Obs	Cal
1	85	79	57	54	299	328	183	200	114	115	189	195	256	259	106	92	219	231	279	287
2	47	49	45	46	146	133	107	96	80	71	103	100	89	84	55	63	105	101	118	118
3	37	38	32	37	96	90	71	68	55	56	74	71	40	43	52	50	76	71	72	79
4	28	30	27	30	62	64	48	50	41	45	42	52	17	22	37	41	49	52	58	55
5	20	24	29	24	51	47	26	38	33	36	43	39	12	12	34	34	35	39	42	39
6	19	20	24	19	-		28	29	21	30	27	29	-		20	29	20	30	23	29
7	16	17	17	15	24	26	24	23	21	24	-		-		17	24	18	23	-	
8	10	14	-		-		-		16	20	-		-		23	20	-		-	
9	-		-		-		-		-		-		-		16	17	-		-	
N	1951		1539		2531		2144		2813		2114		766		3194		2165		1966	
Parameters S	325		290		759		552		474		554		425		449		590		651	
D	6.0027		3.8359		4.3776		4.6983		6.096		4.1645		1.4674		6.5339		4.9665		3.8282	
σ	30.4886		19.744		11.726		15.6188		31.1421		13.647		1.9797		38.525		15.5433		9.6045	
Period	1934–1975		1939-1961		1931-1978		1943-1979		1934-1975		1940-1967		1933-1969		1940-1967		1939-1973		1941-1980	
Months	Feb - Apr		Feb - Apr		Feb - Apr		Feb - Apr		Feb - Apr		Feb - Apr		May - jul		Feb - Apr		Feb - Apr		Feb - Apr	