RAINFALL PERSISTENCY AT SÃO GONÇALO, PB.

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ABSTRACT: Results of a study of rainfall persistency at São Gonçalo are reported in this paper. Daily rainfall data for the months February-April during the period 1941-80 is used. According to the Eriksson's (1965) model the persistency effect lasts for three to four days. Jorgensen's (1949) model suggests that persistency reaches a maximum value on the third day of a wet spell.

KEYWORDS: Wet spells, rainfall persistency, Erikson's model

PERSISTÊNCIA DA PRECIPITAÇÃO EM SÃO GONÇALO, PB.

RESUMO: Resultados de um estudo de persistência da precipitação em São Gonçalo são apresentados neste trabalho. Dados de precipitação diária para os meses de fevereiro a abril durante o período de 1941 a 1980 são usados. De acordo com o modelo de Eriksson (1965) o efeito da persistência dura três a quatro dias. O modelo de Jorgensen (1949) sugere que a persistência atinge o valor máximo no terceiro dia de uma seqüência de dias úmido.

PALAVRAS-CHAVE: Seqüência de dias úmidos, persistência de precipitação, modelo de Eriksson.

INTRODUCTION: Information on the occurrence of dry and wet spells during the crop-growing season is a matter of much importance in regions with limited water resources. This is particularly so in the estimation of crop growing periods and in irrigation planning (Robertson 1985,1970).

Various studies have been carried out in the past to estimate the frequency distribution of sequences of dry and wet 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 rainfall persistency at São Goncalo ($38^{o}\,13^{'}$ W, $6^{o}\,45^{'}$ S) are reported in this paper.

METHODOLOGY: Daily rainfall data for the months February-April during the period 1941-1980 is used in this study. These months represent the wettest part of the year at this station. A wet spell is defined as a sequence of rainy days bracketed by dry days on both sides. From the daily rainfall data frequencies of wet spells of different durations are obtained. Frequencies of occurrence of rain on the first, second and third etc days following rainy periods of various durations are also derived. This information is used to study the persistency of rainfall at the station.

RESULTS: The total number of days considered in the study is 3570 and the number of rainy days(Nw) is 1604.The probability on chance of rain on any day(P) is 0.45 and that of a dry day (Q) is 0.55. The probability of one, two and three etc wet days in sequence is 0.45, 0.20, 0.09 and so on. The number of wet spells (Sw) is 652 and the number of dry spells (Sd) is 651. The conditional probabilities P(d/d) and P(w/w) are

P(d/d) = 1 – Sd/Nd = 0.67

P(w/w) = 1- Sw / Nw =0.59

If P is the general probability of an event and P_1 is the probability that the event will occur after an occurrence on the preceding occurrence then the persistence as defined by Bessen (1924) is

$$R_b = \left(\frac{1-P}{1-P_1}\right) - 1$$

This expression is zero when there is no persistence i.e. if P_1 =P and will become infinite if occurrence of an event were always followed by another occurrence i.e. if P_1 = 1.

The 95 % confidence limits of the persistence ratio are (Brooks and Carruthers 1953)

$$\frac{Q}{Q \pm 1.96\sqrt{\frac{PQ}{N}}}$$

Where N is the total number of possible occurrences and Q=1-P.

In the present case for wet days at Sao Gonçalo Rb is 0.34 and the value of the persistence ratio (1+ R_b) is well above the upper limit (1.03) and the hypothesis of no persistence can be discarded.

To appreciate the effect of persistence we can compute the number of wet spells of different lengths if there is no persistence and compare them with the observed frequencies of wet spells.

Frequencies of occurrence of wet spells of different durations expected on chance (no persistence) are computed using the expression: NP^rQ^2 (Berger and Goossens, 1983) where N is the total number of days considered in the study.

The frequencies obtained are given in Table 1 together with the observed frequencies of wet spells. Also included in the table are cumulative totals of observed wet spells from the longest to the shortest. The occurrence of wet spells lasting one, two and three days is less than that expected on chance and wet spells lasting longer than three days are more frequent than expected on chance basis. Rainfall persistency can also be studied by means of Erickson's (1965) model.

If the probability of rain on day n is Pn if day 0 is rainy and pn if day 0 is dry,

$$P_n = P_{n-1}P(w/w) + (1-P_{n-1})P(w/d)$$

where $P_1 = P(w/w)$ and

$$p_n = p_{n-1}P(w/w) + (1 - p_{n-1})P(w/d)$$

where $p_1 = P(w/d)$

$$\lim_{n\to\infty} P_n = \lim_{n\to\infty} p_n = P$$

Similarly if the probability of dry weather on day n is Qn if no rain occurs on day 0 and qn if day 0 is wet

$$Q_n = Q_{n-1}P(d/d) + (1 - Q_{n-1})P(d/w)$$

where $Q_1 = P(d/d)$ and

$$q_n = q_{n-1}P(d/d) + (1 - q_{n-1})P(d/w)$$

where $q_1 = P(d/w)$

$$\lim_{n\to\infty} Q_n = \lim_{n\to\infty} q_n = Q$$

In practice the value of n for which

$P_n \approx p_n = P$ and $Q_n \approx q_n = Q$

gives a measure of the length of the period over which the system is still remembering the state of day 0.

Values of Qn, qn, Pn and pn for Sao Goncalo (Table 2) show that after three to four days the persistency effect has ebbed out and suggest that a third order Markov chain model may be appropriate for the study of frequencies of wet spells at this station.

Rainfall persistency is defined by Jorgensen (1949) as the observed percentage frequency in excess of chance that a period of M rainy days is followed by N or more consecutive days with rain beginning L days later.

From Table 1 it is seen that out of 652 cases of wet spells of at least one day duration 356 or about 55% are of at least two days duration, 209 cases or 32% are of minimum three days duration etc. Of the 356 cases of wet spells of at least two days length 209 or 59% are of at least three days duration, 38% are of minimum four days duration etc. Such information is presented in Table 3 together with percentage frequencies of a wet spell continuing for 1,2,3 etc days on a chance basis.

The highest value of probability of a wet spell continuing for at least one more day occurs after a wet spell of three days with a value of 65% as compared with 45% expected on chance. Maximum value of probability of a wet spell continuing for at least two more days occurs after a wet spell of five days. According to the definition given above, rainfall persistency is given by the difference between the observed probabilities of rain continuing for one, two, three, etc days and the corresponding probabilities based on chance. Persistency values for L=1 and N=1 are computed using data presented in Table 3. It is seen that persistency reaches a maximum value of 20% on the third day of a wet spell. It has a low value of 10% on the first day of a wet spell.

CONCLUSIONS: Rainfall persistency at São Gonçalo is investigated using daily rainfall data for the period 1941 – 80. The occurrence of wet spells lasting upto three days is less than that expected on chance and wet spells lasting longer are more frequent than expected on a chance basis. It is found that persistency reaches a maximum value on the third day of a wet spell.

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Table 1. Wet spells at São Gonçalo – PB.

	Duration of wet spells (days)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Observed Frequencies	296	147	73	58	34	13	7	5	5	2	3	3	0	3	0	1	2
Frequencies expected on chance	486	219	98	44	20	9	4	2	1	0	0	0	0	0	0	0	0
Cumulative totals of observed frequencies	652	356	209	136	78	44	31	24	19	14	12	9	6	6	3	3	2

Table 2. Probabilities of Erikson's model together with P and Q.

	n					P or Q
	1	2	3	4	5	
P_n	0.59	0.48	0.45	0.45		0.45
p_n	0.33	0.42	0.44	0.44		
Q_n	0.67	0.58	0.56	0.55		0.55
q_n	0.41	0.52	0.54	0.55		

Table 3. Percentage frequencies of occurrence of rain on N or more days following a wet spell of M-days. Probabilities of N consecutive rainy days expected on chance are given at the top.

M - Length in days of preceding wet spell	45%	20%	9%	4%	2%	<1%
5	56	40	31	24	18	15
4	57	32	23	18	14	10
3	65	37	21	15	11	9
2	59	38	22	12	9	7
1	55	32	21	17	7	5
	1	2	3	4	5	6

N – Number of rainy days following a wet spell of M days