Variability of southwest monsoon over Rajasthan and Kerala

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सार – इस शोध–पत्र में गत 63 वर्षों (1941–2003) के आँकड़ों के आधार पर पूर्वी और पश्चिमी राजस्थान के उपखंडों में दक्षिणी–पश्चिमी मानसून ऋतु के आरम्भ और उसकी वापसी की तारीखों की जाँच की गई है। इस जाँच का उद्देश्य इन प्राचलों द्वारा राजस्थान में दक्षिणी–पश्चिमी मानसून का पूर्वानुमान लगाने के लिए इनकी परिवर्तनशीलता और प्रवृत्ति के कुछ प्रमुख पहलुओं का पता लगाना है। इससे संबंधित विभिन्न अंतः सहसंबंध गुणांक तैयार किए गए हैं। इस अध्ययन से यह पता चला है कि मानसून की गतिविधि में परिवर्तन मानसून की अवधि में बढ़ोतरी, समय से पहले मानसून का आरम्भ होने और देर से इसकी वापसी के फलस्वरूप राजस्थान में मानसून की अवधि और मौसमी वर्षा में वृद्धि होती है। यदि पूर्वी राजस्थान में मानसून निर्धारित समय से पहले आता है तो निश्चित रूप से पश्चिमी राजस्थान में भी समय से पहले आ जाता है।

ABSTRACT. The onset, withdrawal dates and rainfall of southwest monsoon corresponding to east and west Rajasthan sub-divisions have been examined statistically for the past 63 years (1941-2003) to bring out some major aspects of their variability and trend to predict these parameters of southwest monsoon over Rajasthan. Various correlation coefficients have been worked out. Study reveals, shift in monsoon activity, enhancement of monsoon duration, early onset and late withdrawal enhances monsoon duration and seasonal rainfall over Rajasthan. Early onset over east Rajasthan certainly brings early onset over west Rajasthan.

Key words - Correlation coefficient (CC), Standard deviation (SD), Coefficient of variation (CV).

1. Introduction

Southwest monsoon rainfall is the principal rain bringing season for whole of India except Tamil Nadu which accounts for about 80% of annual rainfall. Monsoon rainfall influence the crop production and has a dramatic impact on the Indian economy as well as the living conditions of the inhabitants of the country as a whole.

India Meteorological Department has been issuing long range forecast of rainfall for southwest monsoon for "country as a whole" for over a century by now. However, demand for long range forecast for southwest monsoon with increased special and temporal resolution has been on the increase during past few years. Therefore it is of interest to examine the variability of various features of southwest monsoon on regional scale.

In the continent southwest monsoon normally sets in over Kerala coast around first June and reaches east Rajasthan around 29th June, covering the whole state of Rajasthan and thereby entire country by 15th July. The withdrawal of monsoon starts from 1^{st} September from west Rajasthan and within fifteen days the state becomes free from monsoon rain. Thus the duration of southwest monsoon rainfall over the state is practically from 29^{th} June to 15^{th} September *i.e.*, about 80 days annually.

Rajasthan is a state of least rainfall where the monsoon sets in the last but begins to withdraw early, and so observes relatively less monsoon duration and receives 75 to 80 % of its annual rainfall during the monsoon season. Therefore, the temporal and spatial distribution of rainfall has considerable importance for management of water resources and agricultural yields, particularly in dry farming. The feature of variability of onset, withdrawal and duration of monsoon will certainly help the agriculturist, farmers, planners of the country, various users and also facilitate weather forecasters.

Dates of monsoon onset and its associated features have been studied by Bhullar (1952), Ananthakrishnan *et al.* (1967) and Subramayya *et al.* (1984). Dhar *et al.* (1980) found that quantum of rainfall during monsoon season does not have any association with onset dates.

TABLE 1(a)

Dates of onset, withdrawal, monsoon duration & associate rainfall

krenlaE-RajW-RajD-Raj <t< th=""><th>S. N</th><th>o. Year</th><th></th><th>Dates of onset</th><th></th><th>Dates of v</th><th>vithdrawal</th><th>Dura</th><th>tion</th><th>Rainfa</th><th>ıll (mm)</th></t<>	S. N	o. Year		Dates of onset		Dates of v	vithdrawal	Dura	tion	Rainfa	ıll (mm)
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63 2003 08 Jun 05 Jul 05 Jul 30 Sep 10 Sep 87 76 590 352	62	2002	29 May	19 Jul	15 Aug	20 Sep	16 Sep	63	32	262	86
	63	2003	08 Jun	05 Jul	05 Jul	30 Sep	19 Sep	87	76	590	352

Associate characteristic of Southwest monsoon											
Period		Onset			Withdrawal		Duration		Rainfall (cm)		
		Kerala	E-Raj	W-Raj	E-Raj	W-Raj	E-Raj	W-Raj	E-Raj	W-Raj	
1941-2003	Mean	31 May	03 Jul	10 Jul	26 Sep	20 Sep	85	71	62.2	28.6	
	S.D.	7	10	12	11	9	15	15	16.4	12.5	
	Earliest	14 May 1960	07 Jun 1941	10 Jun 1956	30 Aug 1968	30 Aug 1968	52	32	26.2	8.6	
							lowest	lowest	lowest	lowest in 2002	
							in 1968	in 2002	in 2002		
	Most Delayed	18 Jun 1972	26 Jul 1944	15 Aug 2002	25 Oct 1945	14 Oct 1959	130	103	97.8	78.7	
							highest	highest	highest	highest in	
							in 1961	in 1961	in 1946	1944	
1941-1970	Mean	30 May	03 Jul	10 Jul	30 Sep	23 Sep	88	74	65.3	27.6	
(1 st slot)											
	S.D.	8	12	13	13	10	17	15	16	13	
1971-2000 (2 nd slot)	Mean	02 Jun	03 Jul	09 Jul	24 Sep	16 Sep	83	69	60.7	30.2	
(2 5101)	S.D.	5	8	9	8	7	13	13	16	13	

TABLE 1(b)

Pant and Hingane (1998) found slight increase in monsoon rainfall, inspite of the large variability in the arid zone. In this paper results of analysis of onset, withdrawal, duration and rainfall over Rajasthan (extreme northwest frontier) from 1941 to 2003 are presented and statistically examined including the onset dates over Kerala (extreme southern tip). In addition, it is proposed to examine whether onset dates and monsoon duration have any relationship with monsoon rainfall.

2. Data

The actual dates of onset (withdrawal) of monsoon over east Rajasthan, west Rajasthan and Kerala and rainfall data were extracted from the Weekly and Daily Weather Reports published by the India Meteorological Department for the recent 63 years period (1941-2003). For east and west Rajasthan the onset dates thus collected are the dates when monsoon has set in over the entire region. The duration of monsoon has been calculated by getting the difference between onset and withdrawal dates.

3. Results & discussion

Tables 1(a&b) presents the dates of onset (withdrawal), monsoon duration, seasonal rainfall and their associate characteristics. Analysis and computation based on the data for the period 1941-2003 including decadal and two 30 years blocks of data from 1941-70 & 1971-2000 reveals the following.

3.1. Onset of southwest monsoon

(*i*) For east Rajasthan

Mean date : 3rd July, S. D : 10 days, range : 7 June to 27 July

(ii) For west Rajasthan

Mean date : 10th July, S. D : 12 days, range : 11 June to 15 August

(iii) For Kerala

3.1.1. Difference of onset dates between Kerala and east (west) Rajasthan

After onset over Kerala, normally after 33 (40) days onset occurs over east (west) Rajasthan with S. D 10 (12) days and Range : east (west) Rajasthan are 13 - 58 (17 - 78) days.



Figs. 1(a-c). Decadal mean fluctuations of monsoon onset (a) Kerala, (b) east Rajasthan and (c) west Rajasthan

3.1.2. Variability

(*i*) Table 1 reveals that over Kerala during first 30 years slot mean onset is 1 day earlier and 2 days later during second 30 years slot while for west Rajasthan it is one day earlier in second slot as compared to 63 years mean dates.

(*ii*) The variability during first slot is higher than the second slot.

(*iii*) Figs. 1(a-c) reveal that the lowest decadal mean is found in 70s in Kerala and in 60s (80s) in east (west) Rajasthan. The highest variability is found in the 50s in Rajasthan and in Kerala it was in 60s & 70s, the decadal





Figs. 2(a&b). Decadal mean fluctuations of withdrawal of monsoon over (a) east Rajasthan and (b) west Rajasthan

variability from 60s and onwards is lower than the long period variability and the amplitude of variability over west Rajasthan is highest.

3.2. Withdrawal of southwest monsoon

(i) For east Rajasthan

Mean date : 26^{th} September, S. D : 11 days, range : 30^{th} August to 25^{th} October

(ii) For west Rajasthan

Mean date : 19^{th} September, S. D : 9 days, range : 30^{th} August to 14^{th} October

3.2.1. Variability

(*i*) The mean dates of withdrawal are observed later than the existing normal dates for Rajasthan.

(*ii*) The mean values are lower in second 30 years slot in Rajasthan than first 30 years slot.

(*iii*) Figs. 2(a&b) reveal that the decadal mean was found highest in 50s and lowest in 80s in Rajasthan, the



Figs. 3(a&b). Decadal mean duration of monsoon over (a) east Rajasthan and (b) west Rajasthan

highest variability was observed in 60s while lowest in 1991-2000 and the variability in the mean date has been lower in second 30 years slot

3.3. Duration of southwest monsoon

(*i*) For east Rajasthan

Mean : 85 days, S. D : 15 days, Range : 52 to 130 days

(ii) For west Rajasthan

Mean : 71 days, S. D : 15 days, Range : 32 to 103 days

3.3.1. Variability

(*i*) The mean duration and variability are found higher in first slot.

(*ii*) Figs. 3(a&b) reveal that the lowest decadal mean duration has been found in 80s in east Rajasthan and in 50s in west Rajasthan while highest in the 60s and the lowest variability occurred in the decade 1991-2000 and the highest was in 50s.





Figs. 4(a&b). Decadal mean seasonal rainfall over (a) east Rajasthan and (b) west Rajasthan

3.4. Rainfall

(i) For east Rajasthan

Mean : 62.2 cm, S. D : 16.4 cm, C.V. : 26%, Range : 26.2 cm to 97.8 cm.

(ii) For west Rajasthan

Mean : 28.6 cm, S. D : 12.5 cm, C.V. : 44%, Range : 8.6 cm to 78.7 cm.

3.4.1. Variability

(*i*) The mean values is found higher in first 30 years slot in east Rajasthan while it is in second slot in west Rajasthan. However, there is consistent pattern of variability in both these slots over both these sub-divisions of Rajasthan.

(*ii*) Figs. 4(a&b) reveal that the lowest decadal mean over east (west) Rajasthan was in 90s (70s) while highest values in 50s (1991-2000) and the variability was highest in 50s and lowest in 90s over Rajasthan.

Trend analysis





Figs. 5(a&b). Onset trend analysis over (a) east Rajasthan and (b) west Rajasthan





Duration

 $\label{eq:Figs.5} Figs. \ 5(c\&d). \ Withdrawal \ trend \ analysis \ over \ (a) \ east \ Rajasthan \ and \ (b) \ west \ Rajasthan$





Figs. 5(e&f). Trend in duration of monsoon over (a) east Rajasthan and (b) west Rajasthan

Rainfall (mm)







Fig. 5(i). Trend in onset over Kerala

TABLE 2

Serial number of functions 2 7 Functions 1 3 4 5 6 8 9 1.00 1. Kerala onset 2. East Rajasthan 0.37** 1.0 onset 3. West Rajasthan 0.26** 0.71*1.0 onset 4. East Rajasthan -0.02 -0.02 0.24 1.0withdrawal 5. West Rajasthan -0.002 -0.03 0.11 0.79* 1.0 withdrawal 0.60* 1.0 6. East Rajasthan -0.26 -0.68* -0.30 0.74*duration 7. West Rajasthan -0.22 0.31 -0.62*-0.76* 0.56* 0.64*1.0 duration 8. East Rajasthan -0.01 -0.19 0.33* 0.39* 0.30* 1.0 -0.100.36* rainfall 9. West Rajasthan 0.08 -0.07 -0.09 0.38* 0.36* 0.33* 0.30*+0.59*1.0 rainfall

Correlation Coefficients(CC) for the period 1941-2003

* Significant at 5% level and ** Significant at 1% level

Decadal mean values of onset (Fig. 1), withdrawal (Fig. 2) and duration (Fig. 3) and rainfall (Fig. 4) of Southwest Monsoon.

3.5. Trend analysis

Fluctuations in onset, withdrawal, duration and seasonal rainfall along with the linear trend and 10-years moving average are depicted in Figs. 5(a-i). It reveals slight decreasing trend in these parameters over Rajasthan and slight increasing trend in onset over Kerala. However, no significant trend could be established.

4. Relation based on correlation analysis

Correlation coefficients (CC) between various dates of series have been computed and found significant mostly at 1% level and presented in matrix form in Table 2. The following points emerge :

(*i*) Early onset over Kerala have chance to cause early onset over east (west) Rajasthan [+0.37 (+0.26)].

(*ii*) Early onset over east Rajasthan certainly brings early onset over west Rajasthan (+0.71).

(*iii*) Early onset over east (west) Rajasthan enhances monsoon duration $[-0.70 \ (-0.77)]$.

(*iv*) Early (late) onset favours good (poor) monsoon rainfall for the period 1971-2003 was observed [-0.47 (-0.43)] for east (west) Rajasthan.

(v) Early withdrawal over west Rajasthan followed by early withdrawal over east Rajasthan (+0.79).

(*vi*) Early withdrawal gives rise to less monsoon duration over east (west) Rajasthan $[+0.74 \ (+0.56)]$ and less monsoon rainfall $[+0.36 \ (+0.36)]$.

(vii) Higher monsoon duration over east Rajasthan favours higher monsoon duration over west Rajasthan (0.64).

(*viii*) Higher monsoon duration attributes to higher monsoon rainfall both over east (+0.39) & west (+0.33) Rajasthan.

(ix) Good rainfall over east Rajasthan results in good rainfall over west Rajasthan (+0.59).

(x) Early onset does not govern early withdrawal.

5. Conclusion

The following points emerge by the analysis of the data for the period 1941-2003.

(*i*) The mean onset date is found one day earlier over Kerala, four days later (five days earlier) over east (west) Rajasthan while withdrawal mean date was 11 (19) days later over east (west) Rajasthan as compared to the existing normal date. It indicates shift in monsoon activity and enhancement of monsoon duration over Rajasthan.

(*ii*) The variability during 1941-70 over Rajasthan was higher in onset, withdrawal and duration as well as over Kerala onset.

(*iii*) There is consistent pattern of variability in seasonal rainfall over Rajasthan.

(*iv*) Analysis shows slight decreasing trends in onset, withdrawal, rainfall and duration over Rajasthan and slight increasing trend in onset over Kerala (Fig. 5)

(v) Early onset and late withdrawal enhances monsoon duration and rainfall over Rajasthan.

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