MAUSAM, **50**, 1, (January 1999), 25-30

551.576.5:551.553.21(545:547)

Effect of eastward moving cloud clusters over northwest India and neighbourhood on the Indian summer monsoon

ASOI LAL, R. S. SUNDER and S. P. JOSHI

Meteorological Office, Pune - 411005, India

(Received 19 June 1995, Modified 13 August 1998)

सार— भारत में दक्षिणी पश्चिमी मानसून के आरम्भ होने की तारीख की प्रागुक्ति करने और उसकी गतिविधि से संबंधित अनेक प्रकार के अध्ययन किए गए हैं। इस अध्ययन में उत्तरी और प्रायद्वीपीय भारत में होने वाली वर्षा के व्यवहार को अफगानिस्तान के क्षेत्र ईरान और उत्तरी पश्चिमी भारत के उपग्रह मेघ समूह के साथ जोड़ने का प्रयास किया गया है। भारत में मानसून वर्षा जून के महीने में आरम्भ होती है। अतः परिवर्तनों की पद्धति को स्पष्ट करने के लिए मानसून पूर्व और मानसून के महीनों में मेघ समूहों के उत्तर पश्चिम की ओर से चलने के साथ मानसून वर्षा पैटर्न के विचलन का अध्ययन किया गया है। मानसून के निष्पादन की विभिन्नता व्यापक रूप से मानसून पूर्व और मानसून के महीनों में उत्तरी पश्चिमी क्षेत्रों में मेघों के समूहों की संख्या और उनकी गति पर निर्भर करती है।

ABSTRACT. A number of studies have been made relating to the prediction of date of onset and also the activity of southwest monsoon over India. In this study an attempt has been made to link the behaviour of rainfall in northern and peninsular India to the satellite cloud clusters over the region of Afghanistan, Iran and northwest India. The monsoon rainfall over India commences in June. Hence variation of monsoon rainfall pattern with the movement of cloud clusters from northwest in pre-monsoon and monsoon months have been studied to elucidate the pattern of changes. The variability of monsoon performance largely depends on the number and movement of cloud clusters over northwestern region during pre-monsoon and monsoon months.

Key words — Cloud clusters, Rhythmically, Satellite imageries, Sea-saw pattern.

1. Introduction

The progress of monsoon across the meteorological sub-divisions of India, as well as its vigour in its different phases, are effected by varied synoptic factors. Even the human factor of denudation of foliage cover and its effect on the climate have been brought to light in vivid detail.

Summer monsoon rainfall over India commences in June and the performance of monsoon is likely to be affected due to the late or early arrival and subsequent delays in the advance over India. Ananthakrishnan & Ramakrishnan (1965) and Ramaswamy (1965) and Rao (1976) studied synoptic features in relation to the southwest monsoon. Desai (1967) suggested a possible relationship between the movement of troughs and ridges in lower troposphere and the strength of monsoon.

However, whereas the interactions or counter-actions of extra tropical troughs in the westerlies in mid-troposphere moving rhythmically over the NW- India and neighbourhood, with the synoptic features over lower tropospheric levels in these regions have been brought to light, the implications of weather systems moving eastward over the northwestern parts of the country and beyond have yet to be prevailed upon in detail. Therefore, an attempt has been made in this study to link the arrival and advance of monsoon, and the distribution of rainfall, to the cloud clusters over the region of Iran, Afghanistan, Pakistan and northwest India, as revealed by the satellite imageries. The conventional observations from these regions being scanty most of the time, it is rather difficult to identify or visualise the movement of weather systems from west over these areas well in advance on the conventional synoptic charts.

Many times these are missed while moving over Afghanistan and Pakistan. While contributing to similar views, Agnihotri and Singh (1982) indicate that a perusal of satellite cloud pictures of western disturbances reveals that clouds show better continuity and indicate the movement and strength of the systems better than the synoptic charts, particularly in those cases where the system is not very strong and organisation on synoptic chart is poor. They conclude that, moving from the Middle-east to NW India, generally at a rate of 10° long. per day eastward, these systems occasionally strengthen on reaching the Indian region. Hence use of satellite imageries gives a better view of

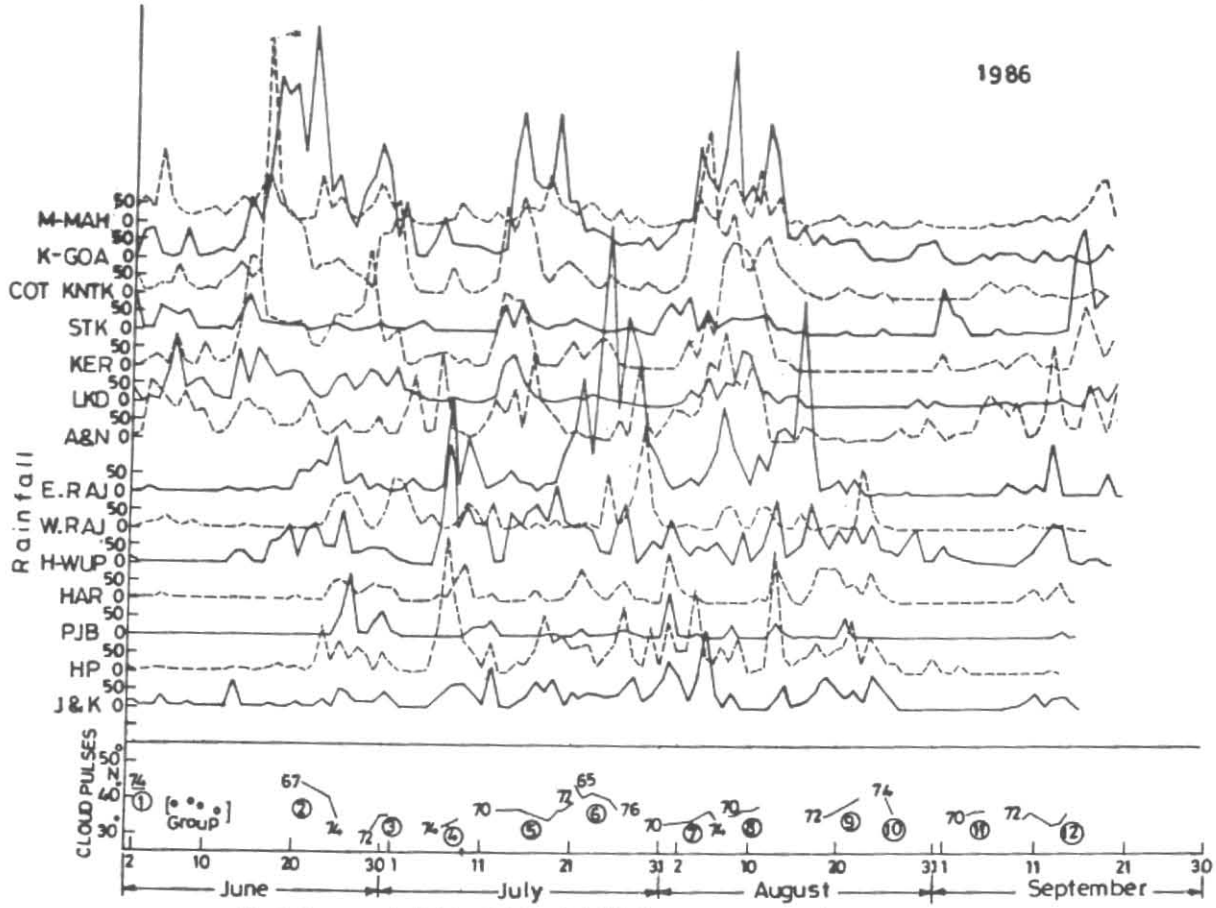

Fig. 1. Average sub-divisional daily rainfall during monsoon season for the year 1986.

the movement of cloud clusters. These cloud clusters are moving from the west throughout the year. However, the effect of such clusters on the monsoon variability is one important factor for the changes in climate.

The summer monsoon rainfall over India commences in June. Hence the variation in the monsoon rainfall pattern with the movement of these cloud clusters from Northwest in pre-monsoon and monsoon months have been studied to elucidate the pattern of changes.

Since the onset phase over Bay and Arabian sea are linked with the rainfalls of Andaman and Nicobar islands and the sub-divisions along westcoast respectively, the stress was laid in comparing these with the rainfall pattern of Jammu & Kashmir, Haryana, Punjab, Hills of west UP and Himachal Pradesh where rainfall cloud be due to the passage of these cloud clusters in the month of June.

2. Data & method

The cloud clusters during the months April to September, as revealed by the satellite imageries of INSAT-1B over the area 55 to 80°E and 25 to 45°N have been studied for the years 1986 - 89. The cloud clusters persisting for 2 to 3 days in the minimum have been considered. The cloud clusters may be associated with trough, low or lower tropospheric cyclonic circulation. The year 1986 and 1987 have been identified as bad monsoon years and 1988 and 1989 have been estimated as good monsoon years.

The daily rainfall data of Andaman & Nicobar islands (A&N), and Kerala, Karnataka, Konkan & Goa, Tamil Nadu, Andhra Pradesh (AP), Maharashtra and Lakshadweep (referred to as southern states in the discussion), and those of Jammu & Kashmir (J&K), Punjab, Haryana (including Delhi & Chandigarh), Himachal Pradesh (HP), Uttar Pradesh (UP), Madhya Pradesh (MP), Rajasthan, Gujarat and Saurashtra & Kutch (S&K), (referred to as northern states) for 1986 to 1989 were collected for the months June to September. The onset dates of monsoon over Bay islands and Kerala were collected from India Daily weather reports and monsoon weather summaries.

The total daily rainfall in each of chosen sub-divisions were computed and plotted against the cloud clusters in north. The trend of increase or decrease of rainfall in the sub-divisions with the movement of cloud clusters were diagnosed qualitatively. The trend was analysed for the period when no cloud clusters were present also.

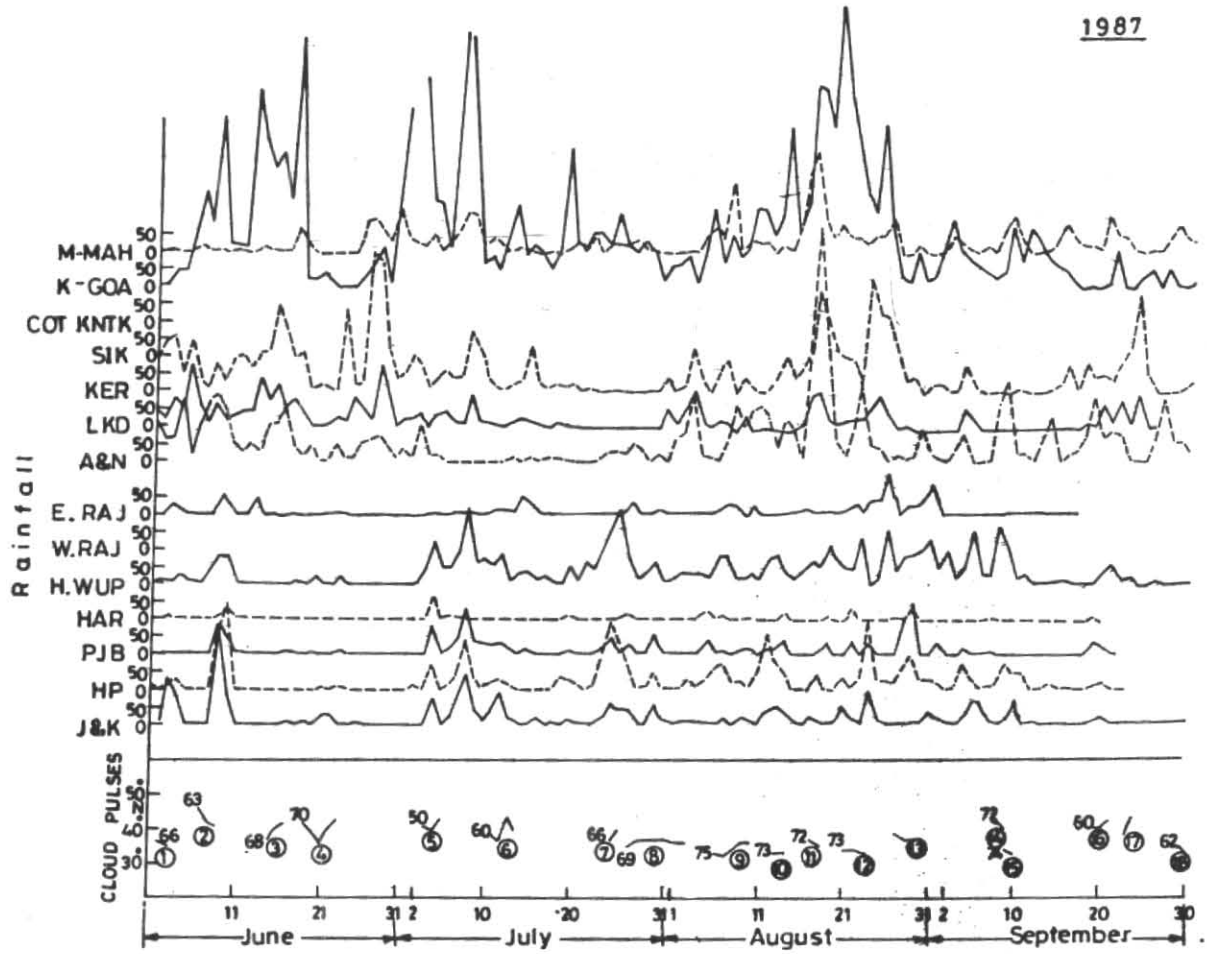

Fig. 2. Average sub-divisional daily rainfall during monsoon season for the year 1987

TABLE 1

Year	Number of cloud clusters			Onset dates		Covered the
	Apr-May	June	July-Sept	Bay	Kerala	country on
1986	13	3+1	9	20 May	4 June	24 July
1987	9	4	12	30 May	2 June	27 July
1988	6	2	8	19 May	26 May	1 July
1989	11	2	12	20 May	3 June	2 July

The onset phase over Bay and Arabian sea linked with rainfall of A&N and that of sub-divisions of west coast were compared with the rainfall pattern of J&K, Haryana, Punjab, hills of west UP and HP, whose rainfall during May - June could be due to the passage of cloud clusters from west.

3. Results & discussion

The northern Meteorological sub-divisions J&K (16), Himachal Pradesh (15), Punjab (14), Haryana (13), Hills of UP (12), Plains of west Uttar Pradesh (11) and west Rajasthan (17) and southern Meteorological sub-divisions Andman Nicobar (1), Lakshadweep (35), Kerala (34), South Interior Karnataka (33) Coastal Karnataka (31), North Interior Karnataka (32) and Konkan & Goa (23) were taken for comparison of rainfall. Figures in the bracket are number of the sub-division as per nomenclature of IMD. The year-wise cloud clusters were plotted against the rainfall of Bay islands and west coast sub-divisions and northern sub-divisions (Figs. 1 to 4). The number of cloud clusters, onset over Bay and Kerala and advance over the country is shown in Table1.

3.1. *1986 (Fig. 1)* — The monsoon rainfall of 1986 was near normal (± 19%) or excess (above 20%) in 16 sub-divi-

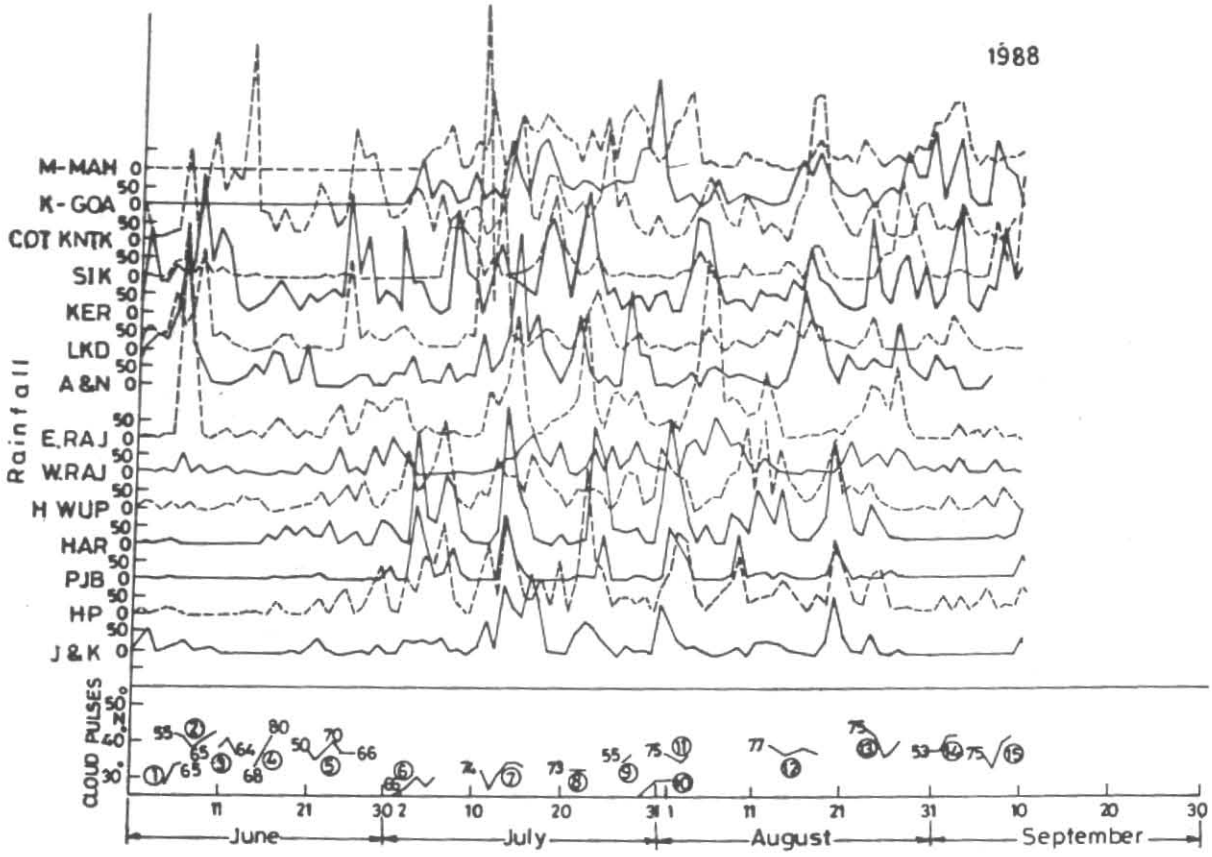

Fig. 3. Average sub-divisional daily rainfall during monsoon season for the year 1988

sions, but was deficient (below -20%) in 19 divisions. The onset over Bay was normal by 20th May, and nearly normal over Kerala by 4th June, and then stalled upto 12th. It advanced with a pace near normal thereafter upto 30th, but covered west Rajasthan quite late, by 24th July, after a long delay. There were a total of 17 cloud clusters during April to June and 9 during July to September. These large number of cloud clusters slowed down the pace of advance.

During the cloud clusters between 7 & 9 July, 9 sub-divisions in the north had increasing trend of rainfall while 13 in south had decreasing trend. With clusters from 16 to 22 and 24 to 27 July, together, 13 divisions in north had increase of rainfall and 13 had decrease in south. During the cloud free periods negative trend was seen in northern sub-divisions, with positive trend over southern divisions. Between 10 & 15 July, 13 sub-divisions in south had positive trends, the negative trend of northern divisions was reduced to 4 only due to the formation of cycir over Bihar, moving NW-ward. Similarly, from 24 July to 3 August positive trend was registered in 12 sub-divisions.

During August there were two groups of cloud clusters between 4 & 12 and 19 & 27. Both gave an increasing rainfall trend in south. During cloud free period, the decrease in rainfall over northern sub-divisions was considerably high but increase in south was marginal probably due to the fact that cyclonic circulations or surface systems confined to eastern sector only. During the month of September, cloud cluster period had positive response in 12 divisions and negative in 9. The contrasting negative trend in cloud cluster free region and positive in southern regions were apparent. Monsoon started withdrawing from north during the week ending 17 September.

3.2. *1987* (*Fig. 2*) — During 1987, the rainfall was in excess or normal in only 10 divisions, out of which 6 were in NE, 3 in peninsula, and Lakshadweep was the remaining one. These contribute to 20% of the area of the country, and the rainfall was comparable with the performance in 1972.

During 1987, a large succession of cloud clusters over the NW region was observed from April to June. In that year, the onset was delayed over Bay; it was on 30th May. It set over Kerala on 2nd June. The advance was sluggish. The country was covered by 27 July. Most of the circulations developed over Bay dissipated *in situ*, or moved east.

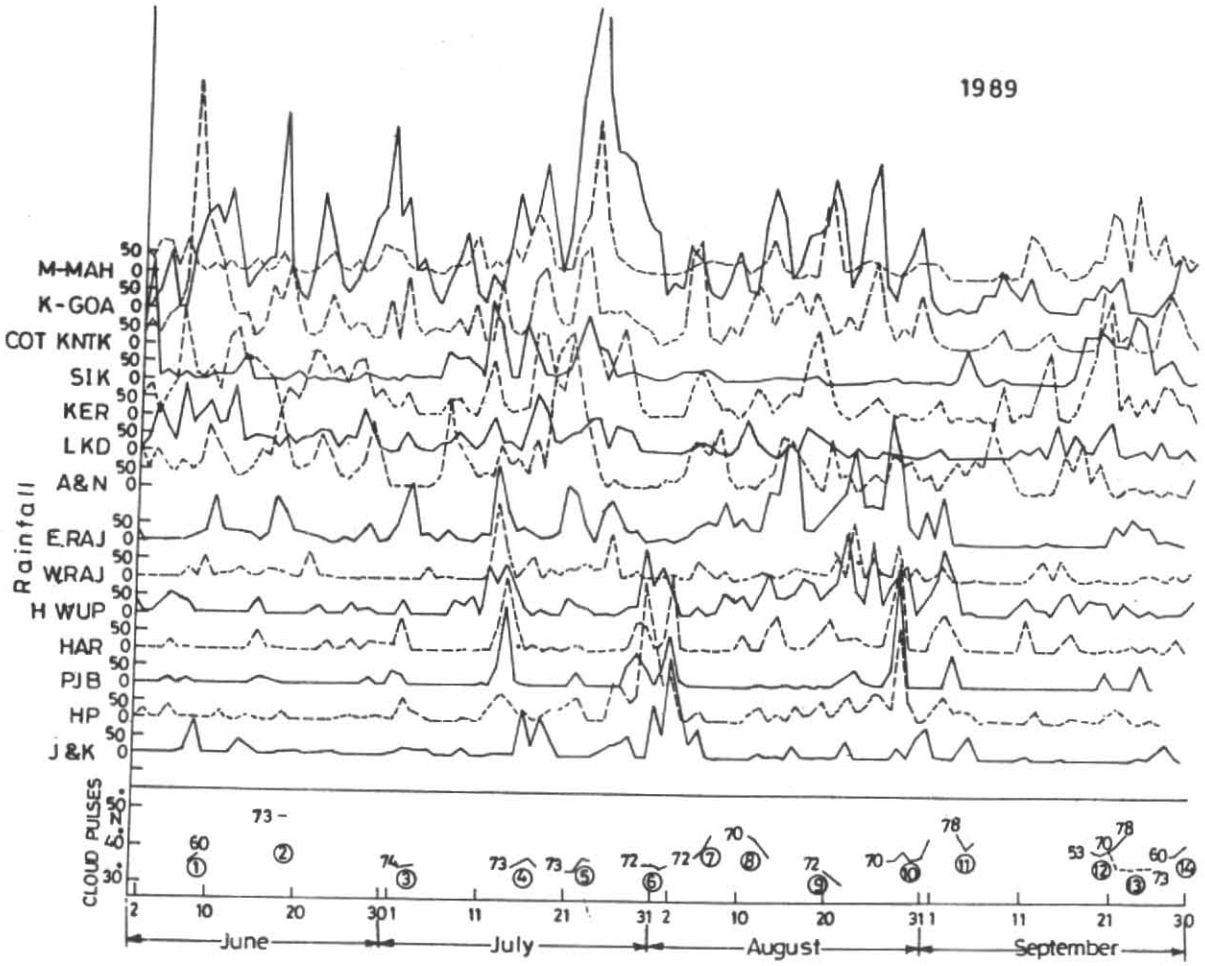

Fig. 4 . Average sub-divisional daily rainfall during monsoon season for the year 1989

All the sub-divisions in south recorded negative trend of rainfall during the cloud cluster period of 11 to 14 July. Due to the continuing slackness in systems causing rainfall and the sluggish monsoon current, the positive effects on southern sub-divisions were minimal during cloud-cluster-free period over NW between 6 & 10 and 15 & 26 July.

During August out of 5 spells of cloud clusters 3 showed the positive trend over northern divisions. Two did not register their negative effect over southern divisions. During these spells of cloud clusters, a cycir over Marathwada and off-shore trough caused rainfall. The positive trends were observed over southern divisions, when cloud clusters were absent. With the movement of cloud clusters over NW the apparent sea-saw pattern of rainfall is evident in September also.

3.3. *1988 (Fig. 3)* — All but three divisions, totalling an area of 88%, received excess or normal rainfall in 1988. The depressions over Arabian sea and Bay have been referred to as causative factors for early onset of monsoon, which set over Kerala on 26 May and the country was covered by 1st July. In this year only 6 cloud clusters moved from April to June. Thus the negative effects over west coast sub-divisions were absent favouring a positive trend upto June end. This coupled with an early onset by 16th May over Bay, yielded good start for the monsoon.

During July 1988, the trend was almost a reversal of July 1987. Between 7 & 10 July, 11 divisions recorded negative trend, whereas 9 divisions in south recorded positive trend. Upto 4th August, the movement of depression upto SW Rajasthan, had a countering negative effect of cloud clusters over northwest. During the absence of the cloud clusters between 16 and 23 August, there was practically no system, except for one cycir near MP, to cause rainfall increase in the southern divisions.

During September 1988 the SW monsoon withdrew from J & K, Punjab and Rajasthan by the week ending 14th;

it was active over the rest of the country upto the end of the month. There were only 2 pulses; the first one continued from 31 August but the effect was less : the pulse from 6th at 75°E caused an increase of rainfall in 7 divisions over north and decrease in 5 divisions in south.

3.4. *1989* (*Fig. 4*) — The country as a whole received 1% above normal rainfall, with excess or normal in an area of 77% of the country. During this year, 13 cloud clusters moved over NW from April to June. In July also only four clusters moved. The onset over the Bay was on 20 May and over Kerala it was 3 June.

A hurricane during the week ending 31 May and two depressions in Arabian sea and Bay of Bengal during the weak ending 14 June, have provided necessary support for positive spells of rainfall activity in the region upto Central India and contributed to the advancement of the monsoon over entire country by 4 July.

When a cloud cluster was seen between 18 & 19 June over NW, 3 sub-divisions reported positive rainfall, but 12 in south recorded negative trend. In cloud free spells of 12 & 17 June, seven divisions in north were negative and 3 in south were positive.

With the movement of cloud clusters between 30 July and 5 August, 8 divisions registered positive trend in north while all 14 sub-divisions in south were negative. The advance of monsoon current has overshadowed the effect of cloud clusters between 2 and 5 July. During August, cloud free spells of 24 & 26, there were no rain producing systems to register increase of rainfall in southern divisions. Whenever cloud clusters moved over NW, northern divisions reported positive trend.

Cloud clusters during the first week of September were rather weak and ineffective. The withdrawal phase was also similar to 1986. During cloud movement between 28 & 30, the southern divisions did not register negative trend because of offshore trough off Maharashtra coast and the withdrawal of monsoon.

Thus from the study of movement of cloud clusters over northwest, the sea-saw pattern of variations could be observed over the above mentioned regions in the north and west coast sub-divisions, *i.e.*, a trend of increase in rainfall over north with movement of cloud clusters and decrease otherwise. Correspondingly a decrease in rainfall in coastal divisions and increase aftermath were observed simultaneously.

4. Conclusions

From the study of cloud clusters movement over northwest India and adjoining region during 1986 to 1989, the following conclusions are drawn:

(*i*) The early or late arrival of monsoon depends on the number of cloud clusters movement during pre-monsoon season.

(*ii*) The advance of monsoon depends on the movement of number of clusters during the month of June.

(*iii*) In general, there is a sea-saw pattern of rainfall during the movement of cloud clusters, *i.e.*, increase in northern sub-divisions and decrease in south and reverse trend prevails during cloud free period.

(*iv*) When monsoon currents are either advancing or active, the effect of cloud clusters over southern sub-divisions are countered effectively and rainfall is realised there.

(*v*) Even when active systems are present, the passages of cloud clusters causes a negative trend in rainfall in south; however the presence of such systems may reduce the negative effect to certain extent.

(*vi*) The variability of monsoon performance largely depends on the number of cloud clusters movement during July to September.

Thus the movement of cloud clusters from the northwest also contributes to the variability of monsoon which in turn, contributes to the climatic change.

References

Agnihotri, C.L. and Singh, M.S., 1982, "Satellite study of western disturbances", *Mausam*, **33**, 2, 249-254.

Ananthkrishnan, R. and Ramkrishnan, A.R., 1965, Proc. Symp. on Met. Results, IIOE, Bombay, India, 415-419.

Desai, B. N., 1967, "On the formation, direction of movement and structure of the Arabian Sea cyclone of 20-29 May 1963", *Indian J. Met. Geophys*, **18**, 61-68.

Ramaswamy, C., 1965, Proc. Symp. on Met. Results, IIOE, Bombay, India, 317-336.

Rao, Y.P., 1976, South West Monsoon, IMD, Met, Monogr. No. **1,** 35-40.

Sharma, R. V. and Subramaniam, D.V., 1983, "The western disturbance of 22 December 1980 - A case study", *Mausam*, **34**, 1, 117-120.

Weather Summaries, 1987-90, *Mausam*, **38**, 2, 265-72; **38**, 3, 371-84; **39**, 2, 231-38; **39**, 3, 325-40; **40**, 2, 233-42; **40**, 3, 351-64; **41**, 2, 347-55 & **41,** 3, 505-20.