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Cloud patterns in the NE monsoon season

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सार — उत्तरपूर्वी मानसून के समय तमिलनाडू में वर्षा प्रायः निम्न दाब क्षेत्रों एवं अवदाबों से सम्बन्धित रहती है। उपग्रहों के आगमन से मौसम प्रणालियों को अधिक विस्तार में अध्ययन करना संभव हो गया है। इस अध्ययन में उत्तरपूर्वी मानसून (अक्तूबर एवं नवम्बर) के 1979 से 1985 तक प्रतिदिन नोवा उपग्रह के आंकड़ों को मौसम प्रणालियों को विभिन्न मेघीय ढांचों में वर्गीकृत करने के लिये उपयोग में लाया गया है। यह देखा गया है कि प्रायः पाये जाने वाले मेघीय ढाँचे अनाकार एवं पट्टीदार प्रकार के होते हैं। मेघीय ढांचों की घटनाओं का सिनॉप्टिक अवस्थाओं का ध्यान रखते हुए विश्लेषण किया गया है एवं उनसे उपयोगी परिणाम प्राप्त किये गये हैं।

ABSTRACT. The rainfall over Tamil Nadu during the NE monsoon occur mostly in association with low pressure areas and depressions. With the advent of satellites, it has been possible to study the weather systems in greater detail. In this study, the daily NOAA-data for the NE monsoon season (October and November) for the period 1979-1985 has been utilised to classify the synoptic systems into several cloud patterns. It has been found that the most frequently occurring cloud patterns are the amorphous and the banding type. The occurrence of the cloud patterns *vis-a-vis* synoptic situations has been analysed and meaningful results obtained.

1. Introduction

Tamil Nadu gets most of the annual rainfall during the NE monsoon (retreating monsoon season) from October to December. The rainfall occurs mostly from low pressure areas and depressions though less known systems also contribute to the total rainfall to some extent. With the advent of satellites, it has been possible to study synoptic systems in greater detail. In this paper an attempt has been made to study the cloud patterns associated with different synoptic situations as seen from NOAA satellite imagery.

2. Data utilised

The study is based on data for the seven year period of 1979 to 1985. The NOAA satellite data of the months October and November has been utilised to analyse the cloud patterns. The visible and IR data of the morning satellite pass has been used. The working charts of Area Cyclone Warning Centre (ACWC), Madras have been utilised to analyse the synoptic situations. The synoptic situation which existed over the area from equator to 20°N latitude covering Peninsular India and neighbourhood has been considered for the study.

3. Typical synoptic situations during NE monsoon season

Several synoptic weather systems which occur during the NE monsoon season affect the rainfall over Tamil Nadu and adjoining areas (Srinivasan *et al.* 1973). Most important among them are the low pressure area depression, cyclonic storm etc. For this study, the synoptic situations that have been analysed are as follows :

(*i*) Trough (T)
(*ii*) Trough in Westerlies (TW)
(*iii*) Low pressure area (L)
(*iv*) Depression (D)
(*v*) Cyclonic Storm (CS)
(*vi*) Cyclonic Circulation (CC)
(*vii*) Intertropical Convergence Zone (ITCZ)
(*viii*) Asymptotic Convergence (ASC)
(*ix*) Upper Anticyclone (UA)

The working charts of ACWC, Madras were utilised to analyse these systems in detail. These systems are found to have varying spatial and temporal rainfall distribution.

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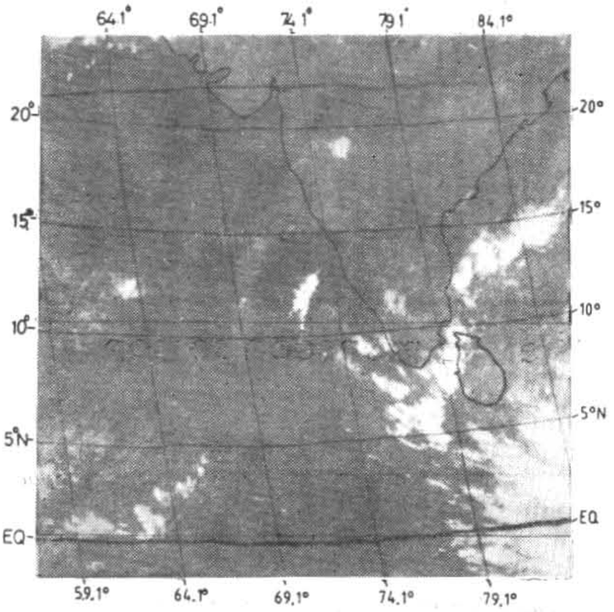

Fig. 1. NOAA imagery of 6 November 1984 showing surface trough

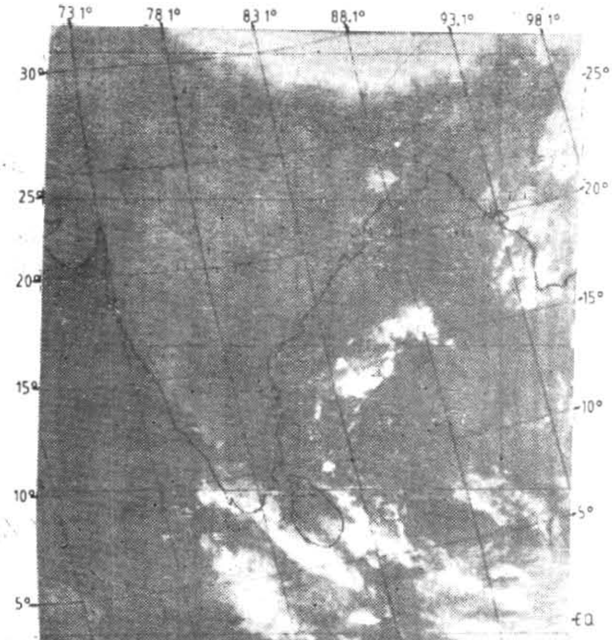

Fig. 2. NOAA imagery of 24 October 1985 showing cyclonic circulation

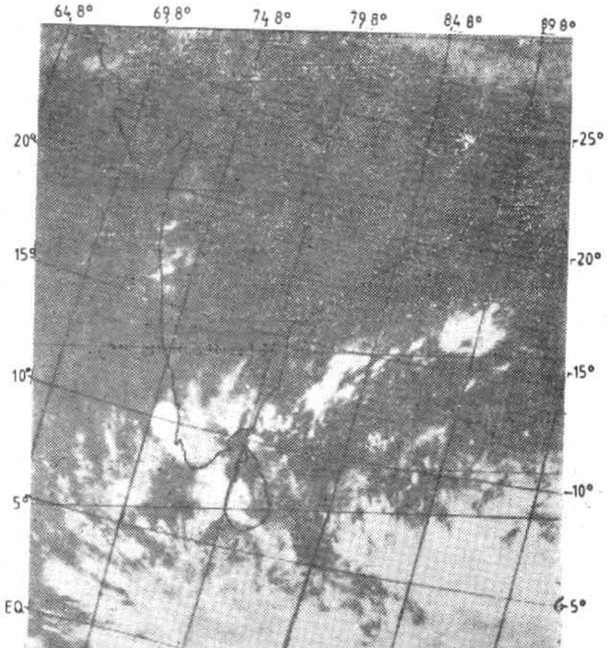

Fig. 3. NOAA imagery of 22 November 1984 showing ITCZ

TABLE 1

Occurrence of synoptic systems

System	No. of occasions in		Total (%)
	Oct	Nov	
Surface trough	37	29	12.4
Trough in westerlies	42	28	13.2
Low pressure area	63	92	29.2
Depression/Deep depression	14	20	6.4
Cyclonic storm	11	9	3.8
Cyclonic circulation (upper air)	45	69	21.4
Inter-tropical convergence zone	25	17	7.8
Asymptotic convergence	8	13	3.9
Upper air anticyclone	3	7	1.9

TABLE 2

Association of cloud patterns with different synoptic situations for the period (1979-85) for October and November

Synsituations	Cloud pattern				Coastal band	Cp/ Co	Curved band
	AM	BKN	LgB	LtB			
				(a) October			
T	14	5	10	12	2	0	1
TW	8	5	1	5	6	0	1
L	29	12	8	11	3	1	3
D	3	1	2	1	—	—	12
CS	—	1	—	—	—	—	14
CC	17	18	6	6	3	—	3
ITCZ	3	—	—	24	—	—	—
ASC	2	—	1	3	2	—	—
UA	—	—	—	—	—	4	—
Total	76	42	28	62	16	5	34
%	29	16	10	23	7	2	13
				(b) November			
T	12	1	8	14	—	—	—
TW	4	1	2	5	—	—	1
L	39	6	16	19	—	1	6
D	8	—	1	2	—	—	13
CS	1	1	—	—	—	—	10
CC	11	7	4	13	3	2	1
ITCZ	1	—	—	21	—	—	—
ASC	2	3	1	1	—	—	—
UA	—	—	—	—	—	7	—
Total	78	19	32	75	3	10	31
%	31	8	13	30	1	4	13

4. Analysis of satellite cloud imagery

The analysis of the cloud imagery as obtained from NOAA satellite revealed that several cloud patterns as occurring during this season. More closer analysis shows that certain categorisation could be done in general and with respect to the synoptic situations, in particular. On scrutinising the large number of cloud pictures, certain typical cloud patterns emerged. Earlier studies (Bhaskara Rao and Moray 1971; Onkari Prasad *et al.* 1983) have shown that certain systematic classification of cloud imagery is possible. Accordingly the classification adopted for this study is as below:

Amorphous (AM)
Broken (BKN)
Logitudinal Bands (LgB)
Latitudinal Bands (LtB)
Coastal Bands (CB)
Cirrus plumes/Cirrus outflow (Cp/Co)
Curved Bands (CB)

It was found that these cloud patterns occur in association with different synoptic situations. In order to understand the association of the cloud systems with each synoptic situation, the daily data has been analysed and categorised. Some typical examples are presented below:

Fig.1 shows the satellite cloud imagery of 6 November 1984. The synoptic situation that prevailed over the region was a trough of low pressure extending from southwest Bay to west central Bay. The associated circulation extended upto 1.5 km asl. From the cloud picture it can be seen that it is a banding type extending along the coast.

Fig. 2 shows the cloud imagery dated 24 October 1985. The synoptic situation as can be seen from the working charts shows the cyclonic circulation over southwest Bay off Srilanka extending up to 2. 1 km asl. The cloud pattern reveals broken, amorphous nature.

The cloud imagery of 22 November 1984 indicates ITCZ type clouding (Fig. 3). The clouding extending from equator up to almost 10°N shows banding nature and is of amorphous type.

5. Statistical analysis of data

The frequency of occurrence of the various synoptic situations during October and November is presented in Table 1. It can be seen that the low pressure areas are most frequent followed by cyclonic circulation, The occurrence of these systems is more frequent in November than in October. ITCZ type of situation occurs about 8% of the occasions. The depression and cyclonic storms contribute to 10% of the occasions

Table 2 presents the occurrence of different cloud patterns in association with various synoptic situations. During October the most frequently occurring cloud pattern is the amorphous type followed by latitudinal banding. The same is true for November. Associationwise the trough, low pressure and cyclonic circulation exhibit generally amorphous or banding type of cloud pattern while depression and cyclonic storm are mostly associated with curved bands. The ITCZ situation reveals itself as latitudinal bands. The upper anticyclone shows cirrus outflow. The coastal bands are rather a rare feature. To summarise the following are the salient features emerging from the analysis :

(*i*) The cloud pattern associated with trough, low pressure area and cyclonic circulation is mostly amorphous and latitudinal banding type, though the former type is more frequent in the case of low pressure and cyclonic circulation.

(*ii*) Cyclonic storm is invariably seen to have curved bands while to much less extent curved banding occurs in association with low, depression and cyclonic circulation.

(*iii*) The ITCZ clouding is almost always in the form of latitudinal banding and occurs over a large area around the equator.

(*iv*) A few cases of asymptotic convergence (ASC) occur and the associated cloud patterns can be of a variety of types.

(*v*) The cirrus clouding (Cp/Co) is associated with upper anticyclones, which occurs very rarely (only 3% of the occasions). This occurs generally after a cyclonic storm has dissipated.

(*vi*) In general, amorphous type of clouding accounts for 30% and banding type (longitudinal, latitudinal, coastal) for 42% of occasions.

6. Conclusions

The study has been carried out using NOAA satellite imagery for the NE monsoon season (October and November) for the period 1979-1985. The synoptic situations have been analysed on a day to day basis from surface/upper air charts and the cloud patterns as observed in the satellite imagery. The study indicates that the most frequent synoptic situations that occur are low pressure areas, surface trough, cyclonic circulations and trough in westerlies. The associated cloud patterns are amorphous and banding (latitude/longitude/coastal) type. The cyclonic storm is always associated with curved bands while the low pressure, depression and cyclonic circulation are associated with curved bands on a fewer occasions, depending probably on their stage of development.

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