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A synoptic study of active and weak southwest monsoon over Andhra Pradesh

C.V.V.BHADRAM

Meteorological Centre, Airport, Hyderabad-500016, India

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सार – इस अध्ययन में वर्ष 1986 से 2000 तक के आंकड़ों का उपयोग करते हुए उन सिनॉप्टिक प्रणालियों का पता लगाने का प्रयास किया गया है जिनसे आंध्र प्रदेश के तीन मौसम वैज्ञानिक उपखड़ों में होने वाले सक्रिय अथवा प्रबल मानसून की अवस्थाएँ उत्पन्न होती हैं। हाल ही के वर्षों में मानसून अवदाबों के बनने की आवृत्ति में हुई उल्लेखनीय कमी के बावजूद मानसून का निष्पादन बहुत अच्छा रहा है। मानसून में कमी और उपरितन वायु चक्रवाती परिसंचरण (साइर्सस) प्रमुख सिनाप्टिक प्रणालियाँ पाई गई हैं जिससे राज्य में होने वाले मानसून में तेजी आई है। इन सिनाप्टिक स्थितियों के विशेष मामलों पर विचार विमर्श किया गया है।

ABSTRACT. An attempt has been made in this study to identify the synoptic systems that cause active or vigorous monsoon conditions over the three meteorological sub-divisions of Andhra Pradesh using the data for the years 1986 to 2000. Despite significant decrease in the frequency of formation of monsoon depressions in recent years, monsoon performance is noticed to be very good. Monsoon lows and upper air cyclonic-circulations (cycirs) found to be the chief synoptic systems which activate the monsoon over the state. Typical cases of these synoptic situations are discussed.

Key words – Active, Vigorous, Monsoon , Monsoon low/depression, Synoptic systems, Upper air trough/cycir.

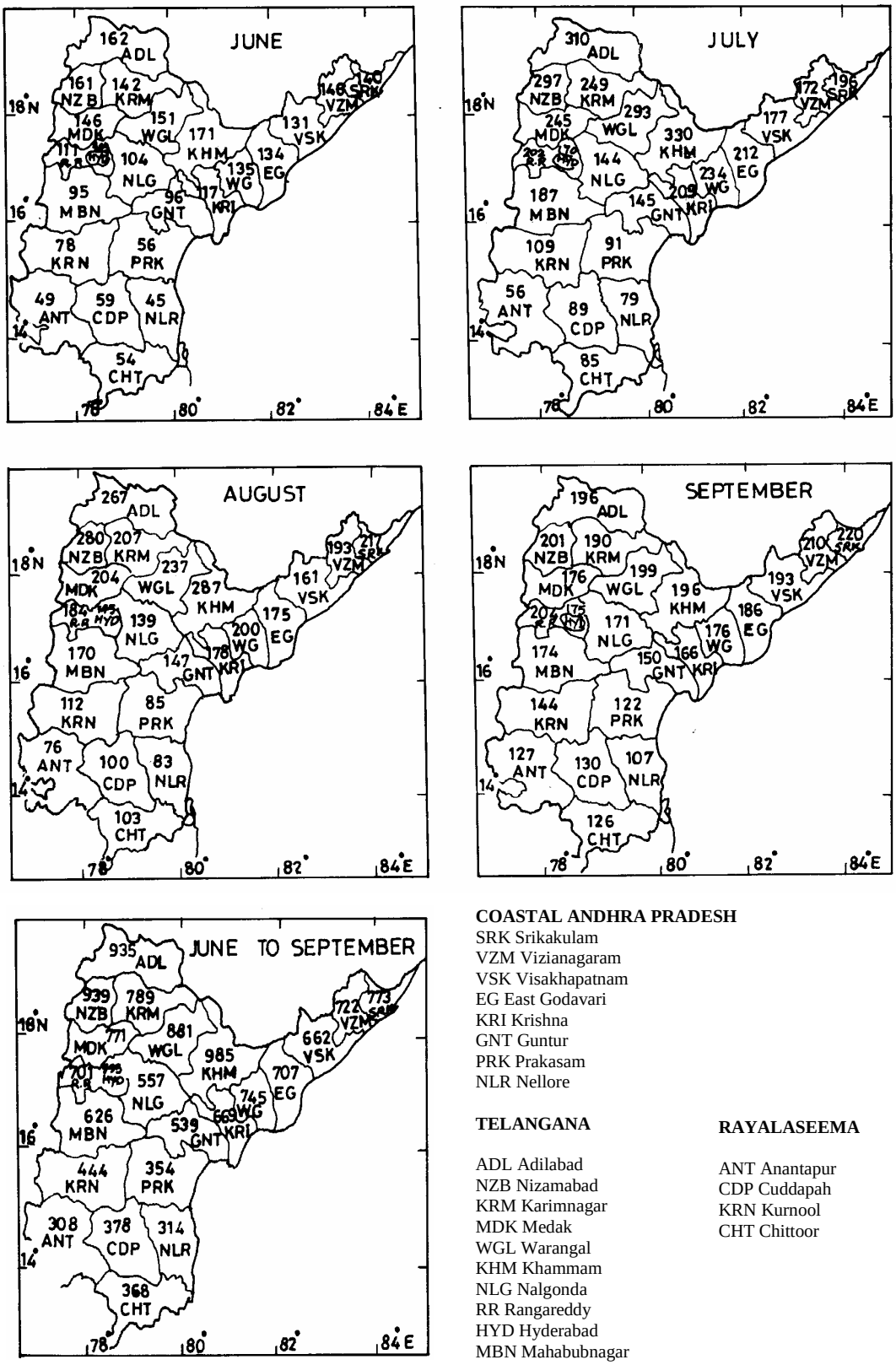
1. Introduction

India being an agricultural country where agriculture is mostly rainfed, the performance of Southwest monsoon is vital for the Indian economy. Abnormal monsoons whether it is flood or drought adversely affect the agricultural sector. The planetary scale monsoon circulation although is highly periodic in nature, there are large variations in the circulation and rainfall within the monsoon season. In other words, each monsoon is unique in many respects, starting from onset and progress of monsoon, frequency and area of formation of synoptic scale disturbances (lows, depressions), their intensity and most importantly the rainfall distribution both in space and time. Several authors have addressed different aspects of inter-annual and intra-seasonal variability of Indian monsoon rainfall and its relationship with regional and planetary scale circulations. However, prediction of temporal rainfall distribution and intra-seasonal variability on a smaller scale like that of a state or sub-division still remains a grey area in monsoon forecasting. Singh *et al.* (1997) have showed that the lowest m.s.l. pressure of heat low over central Pakistan for the month of May has a great potential to foresee monsoon seasonal rainfall for contiguous area comprising the sub-divisions along the monsoon trough region. By Canonical Correlation Analysis model, Rajeevan *et al.* (1999) have showed useful predictive skill for monsoon seasonal rainfall in respect of meteorological sub-divisions across the central parts of the country and NW India. Pandharinath (1991) studied the behaviour of wet and dry spells over Andhra Pradesh during the monsoon period by applying Markov chain model.

In this paper, an attempt has been made to identify the important synoptic systems that result in vigorous or active monsoon conditions over the three meteorological sub-divisions of Andhra Pradesh, the state which ranks high in agriculture production in the country. Further, typical case studies of such important synoptic situations are also discussed. The period of present study is from 1986 to 2000, which covers E1 Nino, La Nina, early onset, late onset, good and bad monsoon years.

2. General features of Andhra Pradesh

Andhra Pradesh lies between Latitudes $12^{o}45'$ N & $19^{o}54'$ N and Longitudes $76^{o}51'$ E & $84^{o}42'$ E. The state comprises three meteorological sub-divisions, namely Coastal Andhra Pradesh (CAP), Telangana (TLGN) and Rayalaseema (RYSM). There are 23 districts in all.



COASTAL ANDHRA PRADESH

SRK Srikakulam
VZM Vizianagaram
VSK Visakhapatnam
EG East Godavari
KRI Krishna
GNT Guntur
PRK Prakasam
NLR Nellore

TELANGANA

ADL Adilabad
NZB Nizamabad
KRM Karimnagar
MDK Medak
WGL Warangal
KHM Khammam
NLG Nalgonda
RR Rangareddy
HYD Hyderabad
MBN Mahabubnagar

RAYALASEEMA

ANT Anantapur
CDP Cuddapah
KRN Kurnool
CHT Chittoor

Fig. 1. Mean monthly district rainfall of Andhra Pradesh

TABLE 1

Main synoptic systems associated with monsoon performance over Andhra Pradesh during June to September (1986 – 2000)

Year	CS	Dep	LOPAR/ WML	Upper air Cycir	North-south upper air trough	East-west upper air trough	Percentage seasonal rainfall over		
							CAP	TLGN	RYSM
1986	-	1	3	9	1	-	-5	-21	3
1987	-	-	-	9	1	1	-41	-19	-10
1988	-	1	6	13	-	1	43	46	46
1989	-	2	4	11	2	-	42	39	45
1990	-	1	5	10	-	-	-10	13	-13
1991	-	1	2	10	2	1	17	-10	14
1992	-	1	4	7	3	-	-6	-17	-16
1993	-	-	2	12	1	-	-24	-20	+3
1994	-	-	2	13	1	1	-20	-19	-43
1995	-	-	4	11	-	1	5	-4	29
1996	1	-	5	10	1	1	30	4	123
1997	1	-	1	8	4	3	3	-26	14
1998	-	1	5	10	4	1	29	13	55
1999	-	1	2	8	3	2	-13	-6	-12
2000	-	1	5	9	3	1	20	19	43
Total	2	10	50	150	26	13			
Average	0.13	0.66	3.3	10.0	1.73	0.86			

WML : Well Marked Lopar CAP : Coastal Andhra Pradesh
TLGN : Telangana RYSM : Rayalaseema

TABLE 2

Monsoon activity over Andhra Pradesh (No. of days)

Year	Vig			Act			W/FW		
	CAP	TLGN	RYSM	CAP	TLGN	RYSM	CAP	TLGN	RYSM
1986	9	8	-	11	15	5	1	3	3
1987	2	2	6	10	19	6	1	3	2
1988	9	6	17	23	40	10	3	7	1
1989	9	6	5	8	14	10	3	10	2
1990	5	18	4	18	17	10	11	14	3
1991	12	8	5	19	20	9	5	8	5
1992	13	8	3	19	15	4	10	9	3
1993	3	2	5	23	27	5	8	16	11
1994	2	8	2	25	17	4	14	26	1
1995	8	7	11	32	34	9	2	8	1
1996	11	9	13	20	28	12	11	19	1
1997	5	3	5	25	20	6	9	19	2
1998	8	10	9	34	31	14	8	18	-
1999	2	2	3	12	25	7	5	12	2
2000	7	9	9	17	20	10	4	9	5

Vig : Vigorous (Rainfall in the sub-division is fairly widespread or widespread and the average rainfall received in a sub-division is more than 4 times the normal.

Act : Active (Rainfall in the sub-division is fairly widespread or widespread and the average rainfall received in a sub-division is 1.5 to 4 times the normal.

W/FW : At most places (more than 75% stations of a sub-division reporting rainfall atleast 2.5mm)/at many places (51% to 75% stations of a sub-division reporting rainfall atleast 2.5mm)

CAP : Coastal Andhra Pradesh TLGN: Telangana RYSM: Rayalaseema

TABLE 3

Chief synoptic systems associated with all India monsoon performance during June to September (1986 – 2000)

Year	CS	Dep	LOPAR/WML	All India monsoon performance (%)	El Nino	La Nina
1986	0	5	7	87	-	-
1987	1	3	7	81	1986-87	-
198	0	4	14	119	-	1988
1989	1	4	11	101	-	-
1990	0	4	10	106	-	-
1991	1	3	8	91	-	-
1992	1	2	11	93	1991-92	-
1993	0	1	14	100	-	-
1994	1	1	14	110	-	-
1995	0	2	11	100	-	-
1996	2	1	16	103	-	-
1997	1	5	5	102	-	-
1998	1	3	9	105	1997-98	-
1999	0	4	11	96	-	-
2000	0	2	13	92	-	-
Total	9	44	161			
Average	0.6	2.9	10.7			

Southwest monsoon generally sets in over Andhra Pradesh during first week of June and withdraws during first week of October. The monsoon seasonal (June to September) rainfall over CAP, TLGN and RYSM are 61 cm, 78 cm and 37 cm respectively. On examining the mean monthly and seasonal rainfall distribution over different districts of the state from June to September (Fig. 1), it is noticed that the mean rainfall increases progressively from the coastal districts towards northwestwards inland in Telangana. During the season, Khammam district in Telangana records highest rainfall of 98 cm, while Anantapur district in Rayalaseema gets the lowest rainfall of 31 cm. It may be mentioned that Nellore, Prakasam districts of South coastal Andhra and Chittoor district of Rayalaseema receive significant rainfall in the post-monsoon months of October and November due to northeast monsoon.

The onset of monsoon over Andhra Pradesh during the period 1986 to 2000 was mostly around its normal dates except in the years 1986, 1992 and 1997 when it was delayed by 7 to 11 days. It is noticed that normal onset or late onset of monsoon has no significant effect on the overall monsoon performance for the season.

3. Results and discussion

Rainfall distribution on any given day is related to the presence of synoptic scale disturbances and quasi-symmetric zones of convergence. In particular, rainfall depends upon the frequency, intensity, life cycle and propagation characteristics of the synoptic disturbances that influence a specific region. On examining the daily weather charts prepared at the centre, satellite inputs from INSAT, Daily & Weekly weather reports for the period 1986 to 2000, it is found that the main synoptic situations which activate the monsoon over Andhra Pradesh may be broadly divided into the following types:

(*i*) Cyclonic Storms & Monsoon Depressions

(*ii*) Low Pressure Areas (LOPARS)/Well Marked LOPARS

(*iii*) Upper Air Cyclonic-circulations (Cycirs)

(*iv*) East-West oriented upper air troughs and

(*v*) North-South upper air troughs

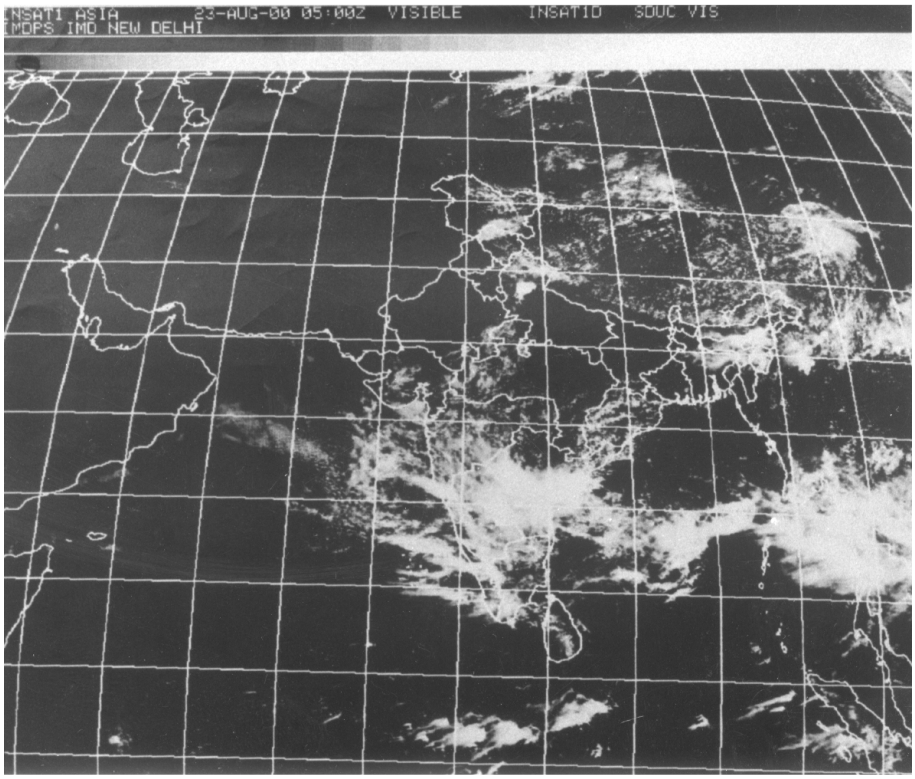


Fig. 2. INSAT ID cloud picture (visible) of 23 August 2000 (0500 UTC)

Main synoptic systems associated with monsoon performance over Andhra Pradesh during the period from 1986 to 2000, alongwith percentage seasonal rainfall in the three sub-divisions of the state are depicted in Table 1. The degree of rainfall activity caused by above systems depend upon their intensity as well as their location with reference to Andhra Pradesh. Number of occasions of vigorous, active and widespread/fairly widespread monsoon conditions over CAP, TLGN and RYSM yearwise are presented in Table 2. It would be rather difficult to clearly isolate the individual contribution of above stated synoptic situations for the occurrence of active or vigorous monsoon conditions over the state.

It can be seen from Table 1 that 1988 ranks as the best monsoon year followed by 1989 wherein the seasonal rainfall was not only excess but also well distributed in all the three sub-divisions of the state. The years 1996, 1998 and 2000 are the other good monsoon years. The good monsoon activity in these years was basically due to formation of higher number of monsoon lows which affected the state. On the other hand, 1994, 1987 and 1993 are notably the bad monsoon years.

From Table 1, it is clear that the total number of cyclonic storms and depressions which affected Andhra Pradesh during the period were 2 and 10 with annual frequency of 0.13 and 0.66 respectively. While there were 50 low pressure areas and 150 upper air cycirs with an average of 3.3 and 10 respectively. As regards the chief synoptic systems associated with All India monsoon rainfall during the same period (1986-2000) , it is seen (Table 3) that the total number of cyclonic storms and depressions was 9 and 44 respectively with an annual average of 0.6 and 2.9 as against the long period (1891-1970) average of 2 and 7.5 as reported by Rao (1976). It is interesting to note that although the number of monsoon depressions which cause most of the monsoon rains has strikingly decreased over the years, all India as well as sub-divisionwise monsoon rainfall have been very good. This clearly suggests that frequency of low pressure areas and upper air cycirs are the main deciding factors, as these synoptic systems contribute significantly to the monsoon rainfall.

As regards the frequency of cyclonic storms and depressions which cross Andhra coast during the period

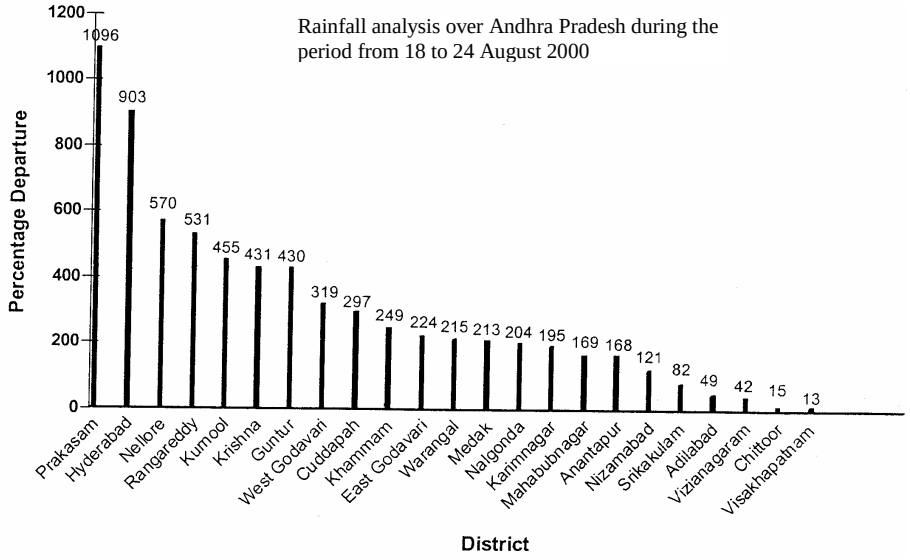


Fig. 3. Districtwise percentage departure of rainfall (18-24 August 2000)

from June to September, it is observed that these systems mostly cross north Andhra coast between Latitude 16° N and Latitude 19° N.

El Nino and La Nina events during the period 1986 to 2000 are shown in Table 3. There is evidence of El Nino years (like 1987) tending to become years of deficit rainfall and La Nina years (like 1988) being years of excess rainfall for all India. However, on a sub-divisional scale, although excess rainfall occurred in all the three sub-divisions of Andhra Pradesh during La Nina year of 1988, no clear association is noticed between El Nino / La Nina events and monsoon rainfall over Andhra Pradesh.

4. Case studies

In this section, typical cases of synoptic situations which caused active and vigorous monsoon conditions over Andhra Pradesh are briefly discussed.

4.1. *Depression from Bay of Bengal moving across Andhra Pradesh: 23-24 August 2000*

A low pressure area formed over northwest Bay off Orissa coast on August 18 August 2000. It persisted over the same area till August 21 and became well marked and was seen over west central Bay off north Andhra coast on August 22. It then concentrated into a depression and lay centred at 0830 IST of August 23 near Lat/Long. 16.5° N / 83.5° E, about, 150 km south of Visakhapatnam. The associated cloudiness as seen in an INSAT picture is shown in Fig. 2. It crossed north Andhra coast near Kakinada by midnight of August 23 and weakened into a well marked low pressure area and lay over north Telangana on August 24. Associated upper air cycir extended up to 7.6 km. a.s.l. sloping southwestwards with height. Moving in a westnorthwesterly direction, the system gradually dissipated over south Gujarat coast.

Under the influence of above system, scattered heavy to isolated very heavy falls occurred over coastal Andhra Pradesh, Telangana and Rayalaseema leading to vigorous and active monsoon conditions over the state. Percentage departures of rainfall for all the 23 districts of Andhra Pradesh for the period 18 to 24 August 2000 are pictorially presented in Fig. 3. Due to widespread rains, Nellore, Prakasam, Guntur, Hyderabad, Rangareddy and Kurnool districts were most affected. Hyderabad city too experienced severe floods with the city registering an all time record rainfall of 241.5mm on 24 August, 2000. Floods were reported in Kundu, Pennar, Romperu, Paleru, Musi and Manjira rivers; breaches in a number of irrigation tanks caused damage to crops, roads and electrical installations. Loss of human life was also reported.

4.2. *Vigorous / active monsoon conditions over Andhra Pradesh caused by low pressure area : 28 to 31 July 1998*

A number of low pressure areas that form over west central Bay move inland without developing into depressions and cause good monsoon activity. Although the amounts of rainfall may not be as high as those

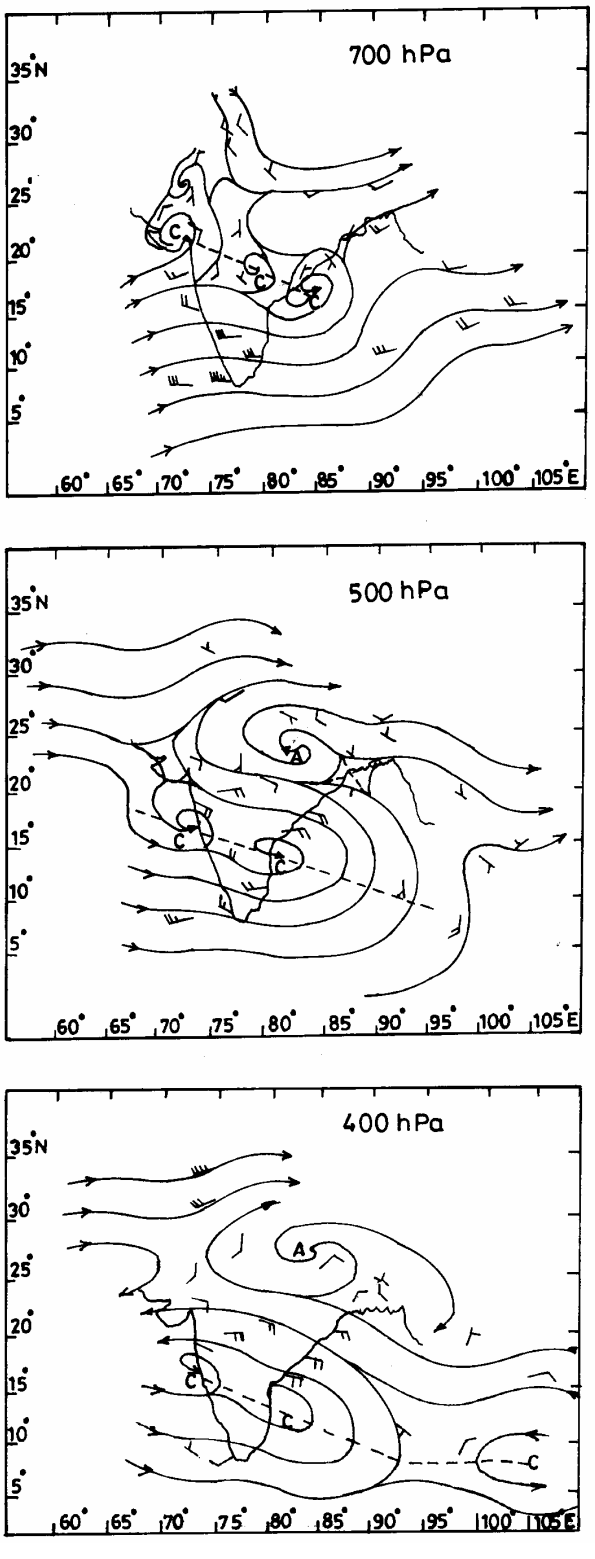


Fig. 4. Upper air flow of 0000 UTC on 18 July 1996

associated with depressions, significant falls are observed in association with low pressure areas affecting the state. The rainfall due to a low pressure area is mainly dependant upon the relative location of the system with reference to the state.

Under the influence of an upper air cycir, a low pressure area formed over west central and adjoining northwest Bay off north Andhra – south Orissa coasts on July 28, 1998. It moved inland on July 29 and lay over east Madhya Pradesh and adjoining Vidarbha on July 30. The associated upper air cycir extended up to mid-tropospheric levels sloping southwestwards with height. The system has resulted in vigorous monsoon over TLGN on July 29. Monsoon was active over CAP and RYSM on July 28 & 29 and over TLGN on July 28 & 30. Chief amounts of rainfall in cm are:

28 July 1998 : Bhongir, Pargi & Sirpur 9 each, Eturunagaram 8, Parkal, Perur & Suryapet 7 each, Eluru, Holagunda, Jangaon, Sircilla & Sultanabad 6 each, Boath, Hyderabad, Hanamakonda, Palakonda, Pathikonda & Prathipadu 5 each.

29 July 1998 : Madnoor 22, Vikarabad 15, Pargi & Sriramsagar 12 each, Jagityal, Madhira & Tandur 11 each, Chevella 10, Paleru Bridge 9, Paderu & Suryapet 8 each, Bodhan, Nizamsagar, Hanamakonda, Khammam, Medchal & Nizamabad 7 each.

30 July 1998 : Bodhan, Nirmal & Nizamabad 5 each.

4.3. *East- west upper air trough : 18 - 19 July 1996*

Apart from monsoon depressions and lows which constitute most effective synoptic systems that cause active to vigorous monsoon conditions over the state, an east-west oriented upper air trough in midtropospheric levels lying across peninsula is another important synoptic situation which results in widespread rains with isolated heavy falls. It is a shear line separating easterlies in the North from westerlies to the south. Such an east-west trough line was seen running across the southern peninsula between 3.1 and 7.6 km a.s.l. on 18 & 19 July

1996. The upper air flow pattern at 700, 500 and 400 hPa of 0000 UTC of 18 July 1996 is presented in Fig. 4. The axis of the trough can be seen passing through parts of CAP and RYSM. With good moisture incursion over many parts of the state in the mid-tropospheric levels, this synoptic system caused fairly widespread to widespread rains over the state on 19 and 20 July 1996. Monsoon was vigorous/active over CAP and TLGN on these days. The chief amounts of rainfall in cm are:

19 July 1996 : Bobbili, Salur, Srisailam & Wanaparthy 9 each, Kollapur, Nidadavole & Tadepalligudem 7 each, Avanigadda, Machilipatnam, Guntur, Rentachintala & Tenali 6 each, Bhimavaram, Polavaram & Dowaleswaram 5 each.

20 July 1996 : Huzurabad 15, Narsampet 11, Manthani 10, Hanamakonda & Parkal 7 each, Luxettipet, Mancherial & Ranasthalam 6 each, Bobbili, Parvathipuram, Koida, Ramagundam, Sultanabad & Utnoor 5 each.

In the absence of any of the synoptic systems mentioned in section 3, it is noticed that weak monsoon conditions generally prevail with subdued rainfall activity over the state.

During break monsoon conditions, when the axis of monsoon trough shifts to its extreme northern position, generally westerly flow prevails over the country in the lower tropospheric levels. At times, wave-like disturbances travel eastwards in these westerlies. These north-south oriented troughs whenever extend upto Telangana and Rayalaseema result in isolated to scattered rainfall.

5. Conclusions

The present study based on the data for a 15 – year period (1986-2000) suggests that

(*i*) Frequency of formation of monsoon depressions, over the years, has significantly decreased; which, however, had little effect on the monsoon performance.

(*ii*) Monsoon lows and upper air cycirs are the chief synoptic systems which cause active and vigorous monsoon conditions over Andhra Pradesh. Frequency of these systems is the deciding factor for a good or bad monsoon for the state.

(*iii*) Cyclonic storms and depressions during the monsoon season mostly cross the north Andhra coast.

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References

Pandharinath, N., 1991 “Markov chain model probability of dry, wet weeks during monsoon period over Andhra Pradesh” *Mausam*, **42**, 4, 393-400.

Rajeevan, M., Thapliyal, V., Patil, S. R. and De, U. S., 1999, “Canonical Correlation Analysis (CAA) model for long – range forecasts of sub-divisional monsoon rainfall over India”, *Mausam*, **50**, 2, 145-152.

Rao, Y. P., 1976, “Southwest Monsoon, Met. Monograph. Synoptic Meteorology”, No.1/1976, India Meteorological Department.

Singh, Dhanna, Bhadram, C.V.V. and Mandal, G. S., 1997 “Intensity of heat low during May and interannual variability of Indian Summer Monsoon rainfall”, *Vayu Mandal*, **27**, 3 & 4, 26-30.