Mausam, (1992), **43**, 3, 315-320

551.553.21

Monsoon onset and reservoir build up — A case study for Hirakud

O. N. DHAR and S. S. NANDARGI
Indian Institute of Tropical Meteorology, Pune
(Received 28 November 1990)

सार — हीराकड जलाशय के जल स्तरों में तीव्र वृद्धि का विचार करते हुए ऊपरी महानदी बेसिन में 1961 से 1986 तक की अवधि के प्रत्येक वर्ष के लिए मानसून के आरम्भ का अध्ययन किया गया। इस अध्ययन से पता चला है कि जलाशयों में मानसून वाह के आगमन में सकारात्मक और नकारात्मक काल पश्चातायें है। यह देखा गया है कि सकारात्मक काल पश्चतायें मानसून के आरम्भ से पूर्ण बेसिन के पूर्ववर्ती अवस्था के कारण होते हैं जबकि नकारात्मक काल-पश्चता पूर्ण मानसून की तड़ित झंझाओं की गतिविधियों के कारण प्रकट होते हैं जिसके कारण मानसून के आरम्भ से पूर्व जलाशय के स्तर वृद्धि का कारण बनते हैं। इन सब मामलों पर संक्षिप्त रूप से विचार-विमर्श करने का प्रयास किया गया है। यह देखा गया है कि बहुत से अवसरों पर मानसून के वाह 1 स 4 दिनों के काल पश्चता के साथ जलाशय में पहुँचते हैं।

ABSTRACT. Onset of monsoon for each year of the period from 1961 to 1986 over the Upper Mahanadi basin has been studied taking into consideration the sharp increase in water levels of the Hirakud reservoir. This study has shown that there are positive and negative time-lags in the arrival of monsoon run off into the reservoir. It has been seen that positive time lags are due to antecedent condition of the basin before the onset of monsoon while negative time-lag appears to be due to pre-monsoon thunderstorm activity which causes reservoir levels to increase before the onset of monsoon. Attempt has been made to discuss all these cases briefly. It has been seen that on a majority of occasions monsoon runoff has reached the reservoir with a time-lag of 1 to 4 days.

Key words — Monsoon onset, Effective monsoon inflow, Reservoir build-up, Antecedent basin conditions

1. Introduction

In declaring onset of monsoon over a given region or a part of the country, India Meteorological Department (IMD) meteorologists are guided by several considerations such as, (a) sharp increase in rainfall activity over and near the region, (b) increase in humidity and decrease in temperature, (c) change in prevailing wind direction, etc. In recent years, satellite cloud pictures are also a valuable aid in predicting the advance of monsoon over different parts of the country. As early as 1940, IMD (1943) had prepared maps of the country showing isolines of normal dates of onset and withdrawal of monsoon over different parts of the country. According to Rao (1976), these isolines of normal dates are based upon sharp increase or decrease of rainfall as shown by 5-day mean rainfall and changes in the circulation pattern. In this connection, it has been said that whatever may be the uncertainty in forecasting monsoon advance, actual onset can generally be fixed within acceptable limits.

Now-a-days, with advanced techniques and due to availability of satellite pictures, day to day progress of monsoon over different parts of the country can be determined accurately. This information is also shown by IMD on maps which are published in their different weather bulletins. A sample map showing the actual onset dates of 1989 monsoon (*Mausam* 1990) is shown in Fig. 1. From this map date of onset of monsoon over a particular region or any part of the country can easily be determined.

On the basis of meteorological considerations stated above, it has been found that in this country monsoon normally sets in first over south Kerala on 30 May and moves to north Kerala by 1 June (Ananthakrishnan and Soman 1988). It has also been seen that it takes nearly one and a half month for the monsoon to cover the entire country. There have been, however, occasions in the past when onset of monsoon over Kerala was as early as 7 May in the year 1918 and as late as 22 June in the year 1972. Incidently, both these years were severe drought years for the country as a whole.

In the present study an attempt has been made to find out the lag-time between the onset of monsoon over the upper Mahanadi basin and the reservoir build up due to inflow of monsoon run off. Such information, if it could be obtained for other major reservoirs located in various parts of the country can give us an idea of the basin characteristics, like soil-vegetal characteristics, time of concentration, antecedent condition of the basin, etc.

2. Monsoon onset over upper Mahanadi basin

In the present study, the basin under consideration is the upper Mahanadi basin whose area is about 82,880 sq km (Thomas 1990) and which is located in the meteorological sub-division of east Madhya Pradesh and in the adjoining districts of west Orissa. A multi-purpose dam has been built about 15 km northwest of Sambalpur in Orissa on the *Mahanadi* river (Fig. 2). The dam was completed in 1956 (Thomas 1990) and is known as the

TABLE 1

Dates of onset of monsoon over the upper Mahanadi basin and EMI into Hirakud reservoir (1961-86)

Year	Monsoon onset date as per IMD's maps	Date of EMI into reservoir	Time-lag (days)
1961	6 June	10 June	+4
1962	11 July	11 July	0
1963	12 June	15 June	+3
1964	25 June	27 June	+2
1965	20 June	27 June	+7
1966	18 June	19 June	+1
1967	18 June	20 June	+2
1968	20 June	28 June	+8
1969	1 July	1 July	0
1970	11 June	10 June	−1
1971	5 June	6 June	+1
1972	24 June	30 June	+6
1973	14 June	28 June	+14
1974	18 June	2 July	+14
1975	20 June	24 June	+4
1976	27 June	10 June	−17
1977	22 June	22 June	0
1978	21 June	25 June	+4
1979	26 June	30 June	+4
1980	21 June	20 June	−1
1981	23 June	3 July	+10
1982	13 July	15 July	+2
1983	28 June	1 July	+3
1984	12 June	14 June	+2
1985	26 June	1 July	+5
1986	21 June	20 June	−1

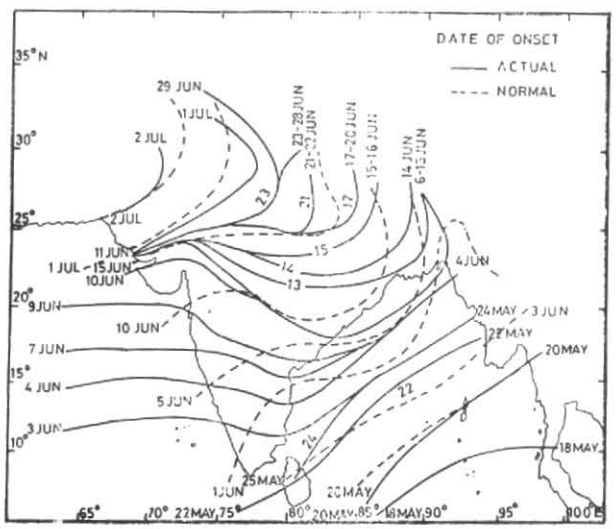

Fig. 1. Actual and normal dates of onset of southwest monsoon 1989 over India

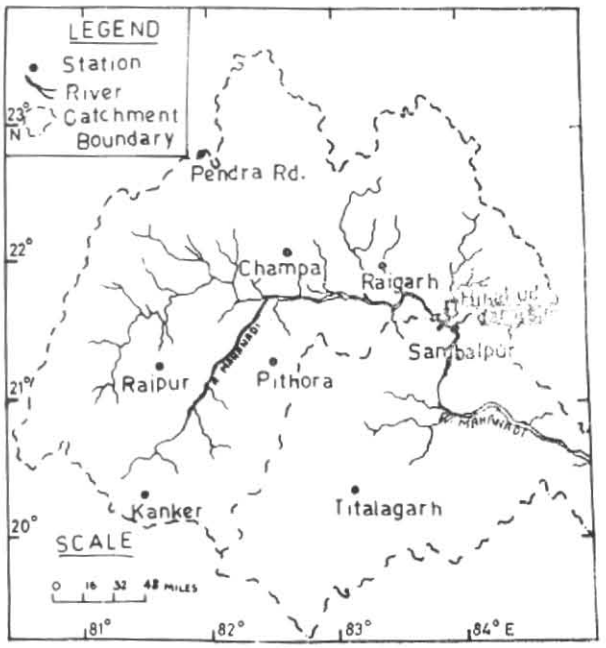

Fig. 2. Index map of upper Mahanadi catchment showing important stations and Hirakud dam site

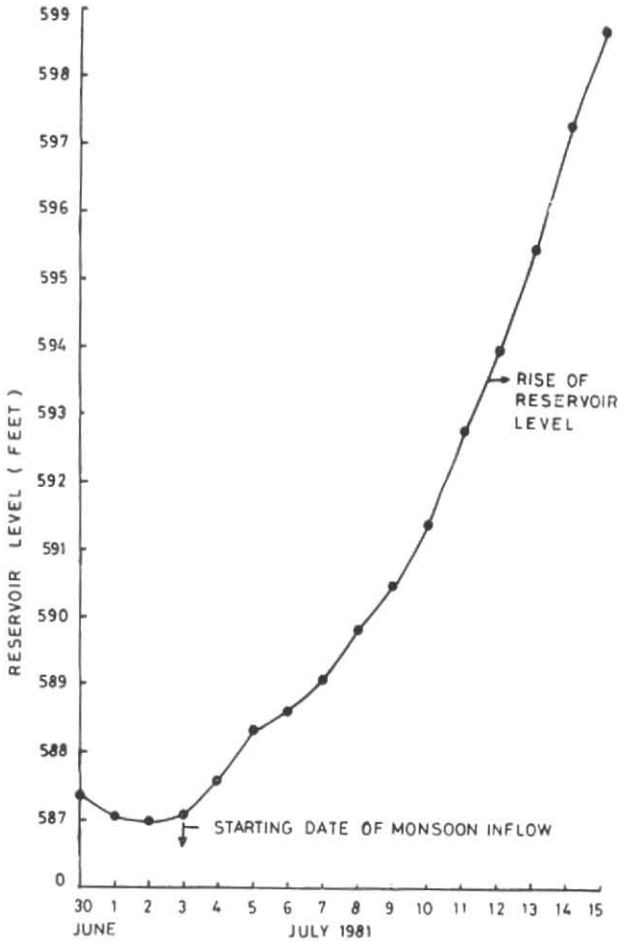

Fig. 3. Graphical representation of sharp rise in reservoir levels after the onset of 1981 monsoon

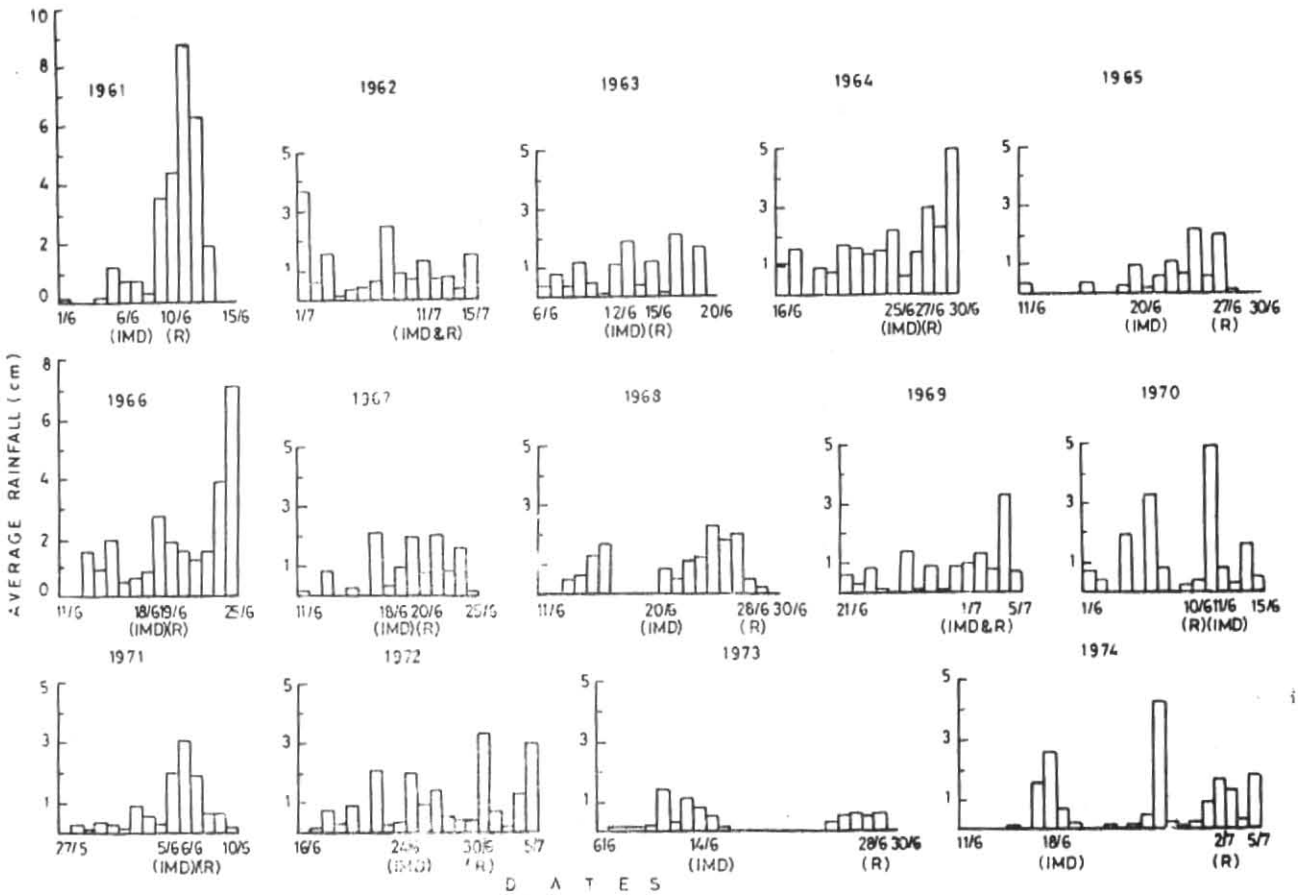

Fig. 4(a). Average rainfall (cm) for the upper Mahanadi catchment a few days before and after the IMD and reservoir onset dates of monsoon for the period 1961-1974

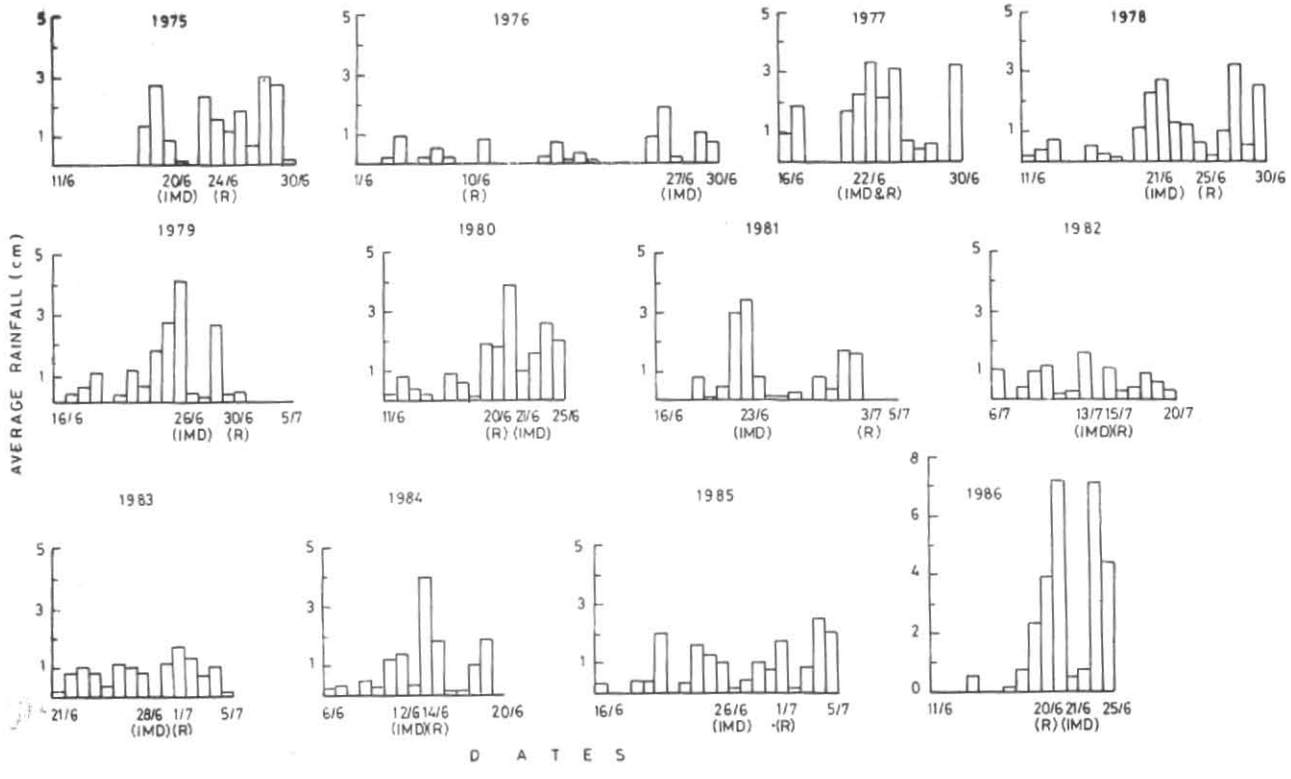

Fig. 4(b). Average rainfall (cm) for the upper Mahanadi catchment a few days before and after the IMD and reservoir onset dates of monsoon for the period 1975-1986

Hirakud dam and the reservoir formed by the dam is also known by the same name. The normal dates of onset and withdrawal of monsoon as picked up from IMD (Rao 1976) maps of this region are about 12 June and 7 October respectively. From these dates it can be said that the normal duration of monsoon over this basin is of the order of 117 days.

3. Effective monsoon inflow (EMI) into Hirakud reservoir

The Hirakud dam authorities have been taking daily observations of water levels of the reservoir. After the monsoon onset over the basin, there is a sharp increase in the reservoir level due to inflow of large volume of water caused by monsoon rainfall over the basin. Subsequently, when monsoon withdraws from this region, there is a sharp decrease in the flow of monsoon run off into the reservoir. The dam authorities have recorded for each year both these dates of sharp increase and decrease of reservoir levels from 1961 onwards. The increase in reservoir levels due to monsoon run off has been called as 'Effective Monsoon Inflow' (EMI) by the dam authorities. Fig. 3 shows the 'EMI' date for the 1981 monsoon as 3 July whereas the actual monsoon onset over this region/basin was on 23 June as per IMD records. The sharp rise in the reservoir levels due to inflow of monsoon run off is quite evident from Fig. 3. Knowing the EMI dates of onset and withdrawal of monsoon for the reservoir over a period of 26 years from 1961 to 1986, the dam authorities have worked out average onset and withdrawal dates of monsoon inflow (*i.e.,* EMI) into the reservoir as 24 June and 14 October respectively and the average duration of EMI into the reservoir as 111 day. (Pattanaik 1987). Considering IMD's normal dates of monsoon onset (*i.e.,* 12 June) and withdrawal (*i.e,* 7 October) over this region,the total duration of monsoon period in a normal year works out to be 117 days. In other words, on an average, there is a difference of about 6 days between durations of actual monsoon and EMI so far Hirakud reservoir is concerned.

4. Year to year time-lag variations between the dates of monsoon onset and EMI

Data of actual dates of 'EMI' of 26 years from 1961 to 1986 used in this study were obtained from the Hirakud dam authorities (Pattanaik 1987). For each of these years actual monsoon onset dates over this region were picked out from IMD's *Indian Daily Weather Reports* (IDWRs) of the period. These dates are given in Table 1.

It is seen from Table 1 that for the period considered in this study, the actual monsoon onset dates declared by IMD varied from 5 June in 1971 to 13 July in 1982 whereas 'EMI' dates varied from 6 June in 1971 to 15 July in 1982. For each of the 26 years, the time-lags (in days) between the actual monsoon onset and 'EMI' dates were worked out and this data have also been given in Table 1. It has been found that there have been two types of time-lags. The first type of time-lag is when the actual monsoon onset date is well before the date of 'EMI'. Such time-lags are considered in this study as positive, because EMI can normally occur after the monsoon has set in over the basin. The second type of time-lag is when there is a sharp increase in the reservoir levels before the actual onset of monsoon and this type of time-lag has been called as negative, because increased inflow into the reservoir was caused by rainfall which apparently was not of monsoon origin. This can happen due to widespread pre-monsoon thunderstorm activity over the basin. Sometimes the declaration of monsoon onset can be delayed on technical grounds but such delays can hardly be of 1 or 2-day duration only.

5. Discussion of time-lags between dates of monsoon onset and EMI

In order to examine positive and negative time-lags, daily average basin rainfall was taken into consideration for about a week or so before and after the monsoon onset date over the basin/region and arrival of 'EMI' into the reservoir. In working out the average daily rainfall for the upper Mahanadi basin (*see* Fig. 2), the daily rainfall data of the following nine representative stations within the basin was considered :

Raipur, Kanker, Pithora, Pendra Road, Champa, Raigarh, Hirakud, Sambalpur and Titlagarh.

In Figs. 4(a & b) daily average basin rainfall has been plotted for each day of all the years as bar diagrams, a week or so before and after the monsoon onset date over the basin. In the bar diagrams of Figs. 4 (a & b) "IMD" stands for the monsoon onset date given by the India Met. Dept. and "R" stands for the arrival date of "EMI" into the Hirakud reservoir.

It may be worthwhile to mention here that time-lag between the rainfall caused by monsoon onset and its subsequent conversion into run off and its travel from the farthest end of the basin to the reservoir will depend upon basin characteristics, such as :

(a) soil-vegetation characteristics of the basin,

(b) size and slope of the basin,

(c) antecedent conditions of the basin and

(d) intensity, duration and magnitude of rainfall associated with monsoon onset.

From Figs. 4 (a & b) and Table 1, it is seen that during the 26-year period, on 12 occasions, monsoon run off has taken 1 to 4 days to reach the reservoir after the onset of monsoon was declared by IMD. For three years, *i.e.,* 1962, 1969 and 1977, monsoon onset dates and EMI dates were found to be same. In these three cases it was seen that heavy rain occurred before and on the onset date at stations close to the dam site and hence the duration of time-lag was reduced to almost zero. The years 1970, 1980 and 1986 have shown 1-day negative time-lags, meaning thereby that reservoir levels started increasing a day before the onset of monsoon. This was perhaps due to pre-monsoon thunderstorm activity or the onset date declaration was delayed by a day or so. Figs. 4 (a & b) show that there was considerable rainfall activity over the basin prior to arrival of monsoon.

Time-lags of longer duration of 5 days or more have also been indicated in Table 1. It has been seen in all such cases that long time-lags were either due to dry antecedent condition of the basin, as there were long dry spells before the onset of monsoon or in some cases monsoon current over the region was weak which had caused little rainfall over the basin. This happened specially

in the years 1973 and 1974 when there was a time-lag of +14 days for each of these years. There was quite a different picture in 1976 in which year the time-lag was of the order of —17 days. In this case it was observed that water level in the reservoir started increasing from 10 June while the actual monsoon set in over the basin on 27 June. As can be seen from Fig. 4(b), the basin experienced light to moderate rainfall activity from 3 June to 8 June and this rainspell was, perhaps, responsible for causing increase in reservoir levels by 10 June. There was again another spell of light rain over the basin from 16 to 20 June, which kept the reservoir level increasing while the actual monsoon arrived over the region/basin by 27 June.

6. Summary and conclusions

This study has shown that in the case of Hirakud reservoir, in majority of cases, monsoon run off reaches the reservoir within a time-lag ranging from 1 to 4 days after the actual onset of monsoon over the upper Mahanadi basin, provided monsoon continues to be active over the region after it has set in. In years when the basin experiences widespread pre-monsoon thunderstorm activity, the reservoir starts building up even before the actual onset of monsoon.

Acknowledgements

Authors are grateful to Dr. A.B. Pattanaik, Supdt. Engineer, Hirakud Dam Circle, Orissa for supplying the relevant data and other details without which this study was not possible. Thanks are also due to Prof. D. R. Sikka, Director, Indian Institute of Tropical Meteorology, Pune for giving all the facilities to the authors for undertaking this study. Authors are also thankful to the Director General of Meteorology for utilizing the daily rainfall data of stations in the upper Mahanadi basin from IMD records. Sincere thanks are also due to Dr. O.N. Wakhloo, Hydrologic Engineer and Ex-Principal, Regional Engineering College, Srinagar (Kashmir) for his constructive comments.

References

Ananthakrishnan, R. and Soman, M.K., 1988, 'The onset of the southwest monsoon over Kerala 1901-1980, '*J. Clim.*, **8**, pp 283-296,

India Meteorological Department, 1943, '*Climatological Atlas for Airmen,* IMD Publication.

Mausam, 1990, 'Weather-Monsoon Season 1989 (June to September) *Mausam,* **41**, 3, 506-520.

Pattanaik, A.B., 1987, Communication dated 11 Sept and 14 Sept. 1987 to the senior author.

Rao, Y.P., 1976, '*Southwest monsoon,*' Met. Monograph: Synoptic Meteorology, No. 1, 1976, IMD Publication.

Thomas, K.C., 1990, 'Estimation of design floods for large dams—A critical review, Paper presented at workshop at Nagarjunsagar on unusual storm events and their Relevance to Dam Safety, C B I & P, New Delhi.