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The southwest monsoon activity over India in relation to upper tropospheric thermal features

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सार — यह देखा गया है कि 1972 और 1979 में मानसून बहुत कम सक्रिय रहा। परिणामस्वरूप उत्तर पश्चिम भारत का उपरितन क्षोभमंडल मानसून की शुरुआत से पहले की अवधि में 1970-1979 के दशक के वर्षों की तुलना में, जिनमें मानसून सक्रिया सामान्य थी, अधिक शीतल रहा।

शोधपत्र में 1970-1979 के वर्षों के मानसून पूर्व की अवधि के उपरितन क्षोभमंडल के ताप अभिलक्षणों का 300 मि० बार के स्तर और 75° पू० देशांतर की परिच्छेदिका के तापमानों की सहायता से अध्ययन प्रस्तुत किया गया है। अध्ययन से पता चला है कि मानसून से पूर्व के उपरितन क्षोभमंडल के तापीय अभिलक्षण प्रभावी मानसून की सक्रियता से अच्छी तरह संबंधित हैं।

ABSTRACT. It has been observed that in 1972 and 1979 which were years of very poor monsoon activity, the upper troposphere over northwest India in the period preceding the onset of monsoon was considerably colder compared to other years of the decade 1970-1979 which experienced generally normal monsoon activity.

The paper presents a study of upper tropospheric thermal features in the pre-monsoon period for the years 1970-1979 with the help of temperature cross-sections at 300 mb level roughly along longitude 75 deg. E. The study has revealed a good association of upper tropospheric thermal features in the pre-monsoon period with the subsequent monsoon activity.

1. Introduction

It is quite well known that significant changes in the airflow pattern and thermal structure at various levels in the atmosphere take place over the Indian region in the months preceding the onset of the southwest monsoon.

While there were a number of studies to find correlation between the changing wind field and the date of onset of monsoon, sufficient attention does not appear to have been devoted to relate the monsoon activity directly with the thermal structure of the atmosphere, except for limited studies in this direction by Rai Sircar (1961) and Jagannathan (1962).

In this paper a preliminary study of the relation between the upper tropospheric thermal features in the premonsoon period and the subsequent monsoon activity has been made.

2. Normal upper tropospheric thermal features

The normals of upper air temperatures have been worked out from the data of all radiosonde stations for the years 1968 to 1979 thus making use of only the homogeneous temperature observations after the introduction of the audio modulated instruments.

An examination of the monthly normal temperatures of all radiosonde stations shows that there is a progressive warming of the atmosphere at all levels in the pre-monsoon months, the warming being more pronounced between April and May and in particular over northwest India at 300 mb level. The mean month to month warming at all levels over northwest India represented by Delhi, Jodhpur and Ahmedabad is brought out in Fig. 1. Hence 300 mb level is chosen for this study.

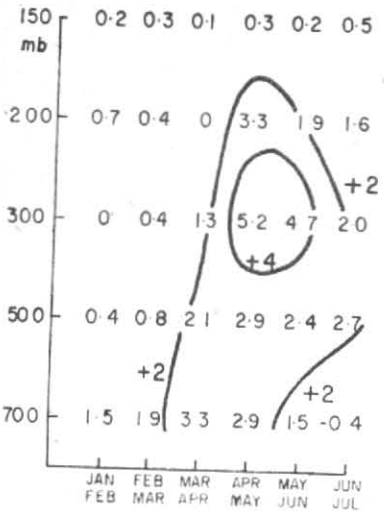


Fig. 1. Differences in normal temperatures between consequtive months from Jan to Jul for levels 700 mb to 150 mb (Averages of Delhi, Jodhpur and Ahmedabad)

Figs. 2(a-c) show the normal temperature field at the 300 mb level for the months April, May and June. It may be seen that the thermal ridge over the Bay in the month of April lies as a warm area over north Bay in May and shifts inland into central India by June. The thermal gradient which is very sharp in April, slightly slackens by May and reverses in June. The evolution of the thermal pattern in this way is a significant feature and it is to be expected that if any marked deviation from this normal patterns are observed in any year, a study of these is likely to be useful for forecasting the behaviour of the monsoon in that year.

3. Temperature anomaly charts

Figs. 3(a-b) show the anomalies of mean monthly temperatures at the 300 mb level for the month of May in respect of two selected years, 1970 (an year of good monsoon) and 1972 (a drought year).

It is seen that in the year 1970 the temperatures at 300 mb level are generally above normal over the whole country whereas in 1972 they were below normal. In 1979 which is another year of very poor monsoon activity, the anomaly features were similar to that of 1972. The temperature departures were —5.1°C at Delhi and —2.7°C at Ahmedabad and between 0 and —1°C over whole peninsular India. Temperature observations were unfortunately not available for other stations in north India and hence the chart (for the year 1979) is not presented. In the other years of the decade 1970-1979 the anomalies of temperatures are generally of smaller magnitude. In these years the monsoon was generally normal except for 1974 which was marginally below normal. From a study of these charts, a tentative conclusion is drawn that when the temperatures at 300 mb level in the month of May are below normal over the whole country and appreciably so over northwest India, the subsequent monsoon activity is poor.

4. Time section charts of upper air temperatures

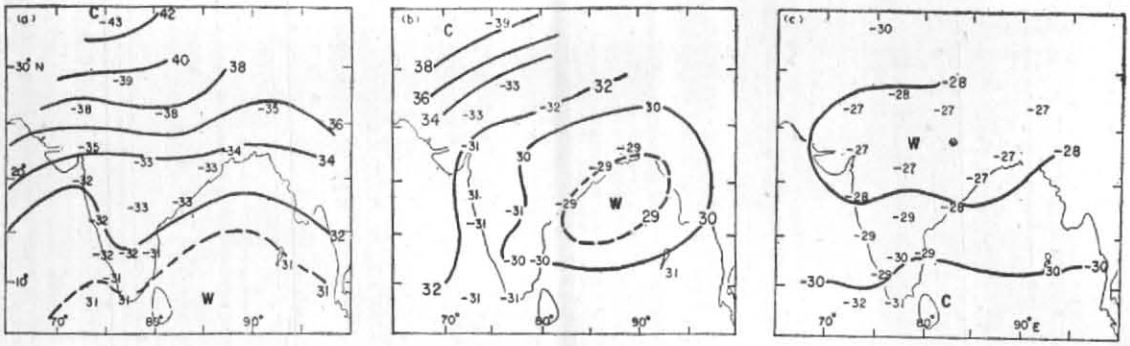
To examine the problem in greater detail, time section charts of temperatures at the 300 mb level roughly along 75°E have been prepared for all the years 1970-1979 and studied with the idea of finding the relationship between the progressive warming of the upper air troposphere in the pre-monsoon period and subsequent monsoon activity.

Fig. 4 shows the trend of 5-day mean temperatures for the period April 21 to May 31 for all the years 1970 to 1979. The following features are noticed in the cross sections :

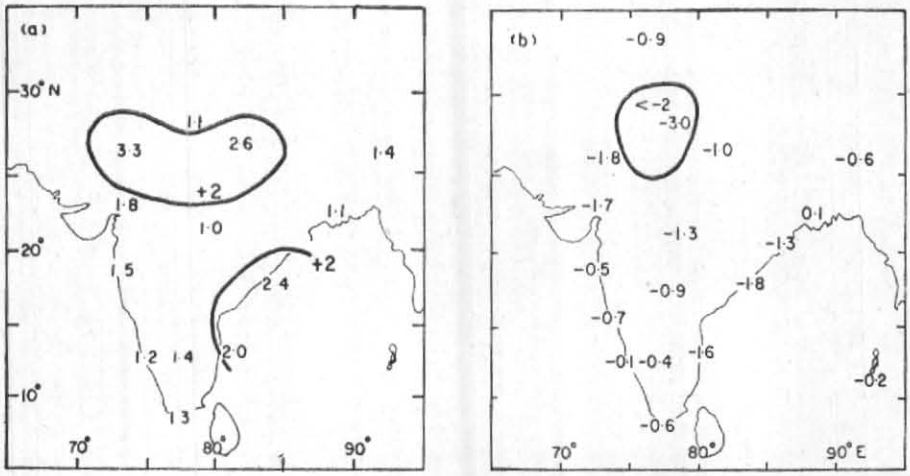
(*i*) In all the years excepting 1972 and 1979 (data of Ahmedabad not available for second half of May in 1971) the 300 mb level warms up to a temperature of —30°C or higher by the end of May in the latitudinal belt between 20°N and 25° N of longitudinal section along 75° E. There are some variations in the individual years in the time of commencement and the latitudinal extent of warming as represented by the —30°C isotherm. For example in 1970, the —30°C isotherm appears at the latitude of Ahmedabad (23°N) by the end of April itself and is seen extending upto the latitude of Delhi by the second half of May.

(*ii*) In contrast, in the years 1972 and 1979 the —30°C isotherm does not make its appearance in the cross sections and its place is taken by the — 35°C isotherm. There is also a distinction between the thermal patterns of 1972 and 1979. In 1979 the isotherms dip southwards during the second half of May indicating a cooling trend instead of normal warming trend. The southwest monsoon activity was very poor in the years 1972 and 1979 with drought conditions over many parts of the country. In the other years of the decade under study the monsoon rainfall over the country on the whole was nearly normal.

Thus, it is seen that in the years when there was sufficient warming of the upper troposphere in the latitudinal belt 20° N to 25° N (or to higher latitudes), *i.e.*, roughly over northwest India, the monsoon activity over the country on the whole was nearly normal whereas, the monsoon was a failure when the upper troposphere was considerably cold as in the years 1972 and 1979. The degree of warming and cooling is represented by the location of the —30°C and —35°C isotherms in the time sections.



Figs. 2(a-c). Normal temperature (°C) at 300 mb levels for (a) April, (b) May & (c) June



Figs. 3. (a-b). Monthly mean temperature (°C) anomalies at 300 mb level for (a) May 1970 and (b) May 1972

The averages of Delhi, Jodhpur and Ahmedabad temperature data are computed to serve as an index of the warming of the atmosphere over northwest India and are given below :

Upper air temperatures at 300 mb level in May over northwest India (Average of Delhi, Jodhpur & Ahmedabad)

Year	temp (°C)
1970	—30.0
1971	—33.1
1972	—34.5
1973	—31.4
1974	—32.0
1975	—31.4
1976	—32.6
1977	—33.1
1978	—32.6
1979	—35.7

The abnormally deficient years of 1972 and 1979 are clearly seen to be associated with very cold temperatures at 300 mb level over northwest India.

5. Conclusions

There appears to be an association between pre-monsoon thermal features over the northwest India and subsequent monsoon activity and that it is possible to have a general indication about the behaviour of the monsoon as normal or below normal by following the trend of temperatures at the 300 mb level in the type of cross sections presented in the paper.

The following explanation is offered regarding the warming of the upper troposphere in the pre-monsoon periods and its importance in the subsequent monsoon activity over the country :

(*i*) The variation in the degree of warming in different years may be probably due to varying pre-monsoon thunderstorm activity. This is being examined in a separate study.

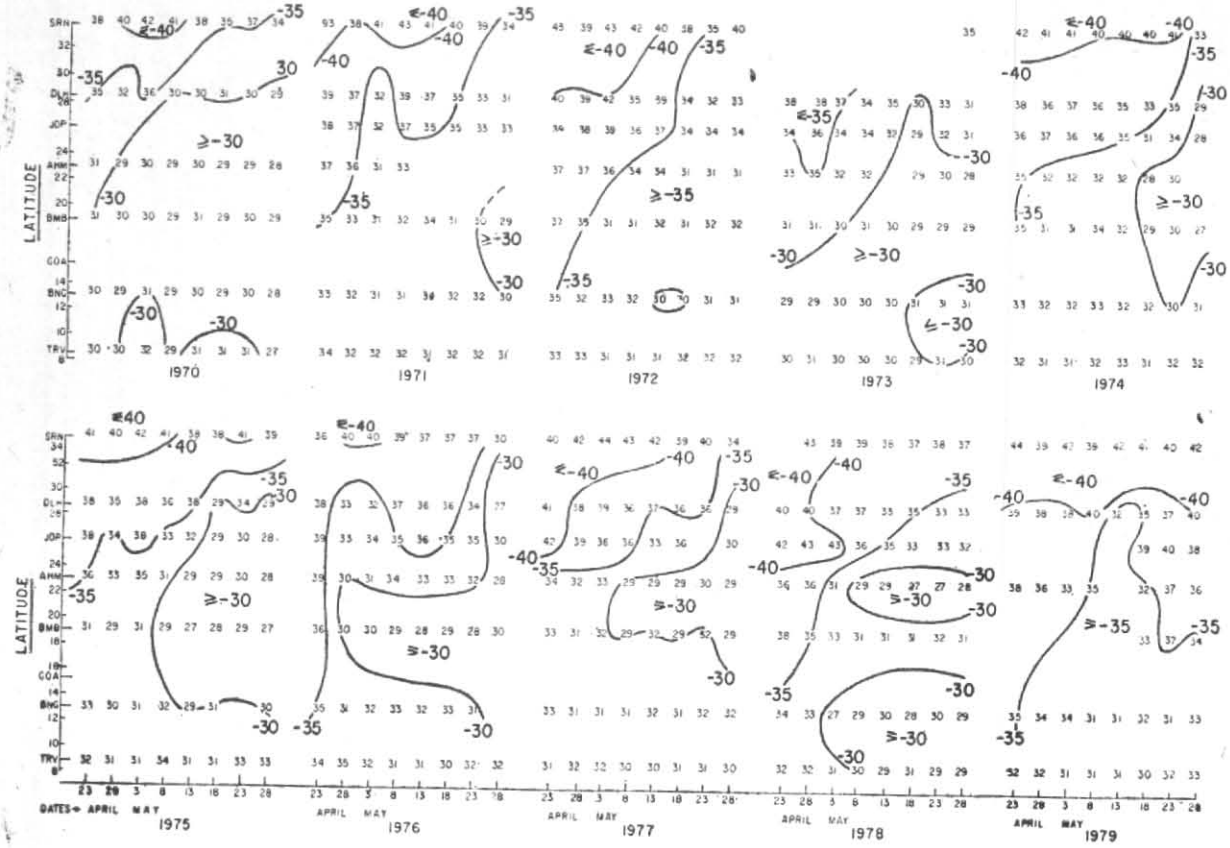


Fig. 4. Five day mean temperature cross-section at 300 mb level roughly along Long. 75° E for the years 1970-1979, April 21 to May 31 (All temperature values negative)

(*ii*) Above normal warming of upper troposphere over northwest India may result in the early breaking up of the normal Hadley cell and establishment in its place of the monsoon cell. It may be mentioned that Joseph (1978) finds a significant correlation between good monsoon activity and northerly meridional component of the upper tropospheric winds over Indian area.

These aspects of the problem require a further detailed study.

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