Indian J. Met. Hydrol. Geophys. (1978), **29**, 1 & 2, 125-128

551.553.21 : 551·513 (540)

Relationship of the 850-500 mb thickness patterns over northern and southern hemispheres vis-a-vis the activity of the Indian summer monsoon

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ABSTRACT. The thickness between 850 and 500 mb over the Indian Ocean area have been determined from the SIRS data available on a real time basis. The five-day averages of thickness between the southern and northern hemisphere sub-tropical ridges, which give an idea of the main driving force for the Indian summer monsoon circulation were worked out for the monsoon period in 1975 and 1976 and their relationship with the monsoon activity examined.

The rainfall anomaly (percentage) of daily rainfall from 285 reporting stations in India having normals, the thickness difference between the locations (*i*) Lat. 17½°S, Long. 55°E and (*ii*) Lat. 32½°N, Long. 80°E and the actual thickness at the latter point were plotted. There is a close correspondence between the three curves. A time lag of one to two days has been noted between the variations in the thickness curves and the rainfall curve. Thus it can be said that the fluctuations in the rainfall activity of the southwest monsoon over India as a whole could be correlated with the thickness difference in the lower troposphere between the sub-tropical ridges in the two hemispheres.

1. Introduction

It is well-known that the large-scale circulation associated with the Indian summer monsoon is due to the differential heating of the vast Asian land mass and the oceanic regions, consequent on the movement of the sun relative to the equator. The monsoonal flow in the lower and middle troposphere upto 500 mb undergoes rather drastic changes in association with 'active' and 'weak/break' monsoon conditions. Since the monsoon circulation can be treated as an oscillation superimposed on the annual mean conditions, the fluctuations in the intensity of the sub-tropical high pressure belts in both the hemispheres would give an idea of the main driving force for the monsoon activity over the Indian subcontinent. These fluctuations are due to the thermal changes taking place in these belts and the thickness of the atmospheric layer where the monsoonal flow is affected (*i.e.*, upto 500 mb) has been considered as a measure of the intensity of the high pressure belts. This study has been undertaken with a view to examine the possibility of an objective criterion for medium range forecasting of monsoon rainfall over India as a whole and not over any specified sub-divisions.

2. Data used and method of analysis

The mean flow pattern over the Asian monsoon area during July at 500 mb level is shown in Fig. 1 (Raman and Ramage Atlas). The thickness values between 850 and 500 mb levels over the Indian Ocean area have been determined using the SIRS data available on a real-time basis. It would have been more appropriate if thickness between 1000 and 500 mb is considered instead of 850 and 500 mb. The height values are referenced to 1000 mb as the mean sea level in SIRS observations (*i.e.*, 1000 mb height is taken as zero). Since there was inadequate surface data from Indian Ocean region, the pressure-height corrections could not be worked out and so 850 mb has been chosen as the lower level for computing the thickness difference.

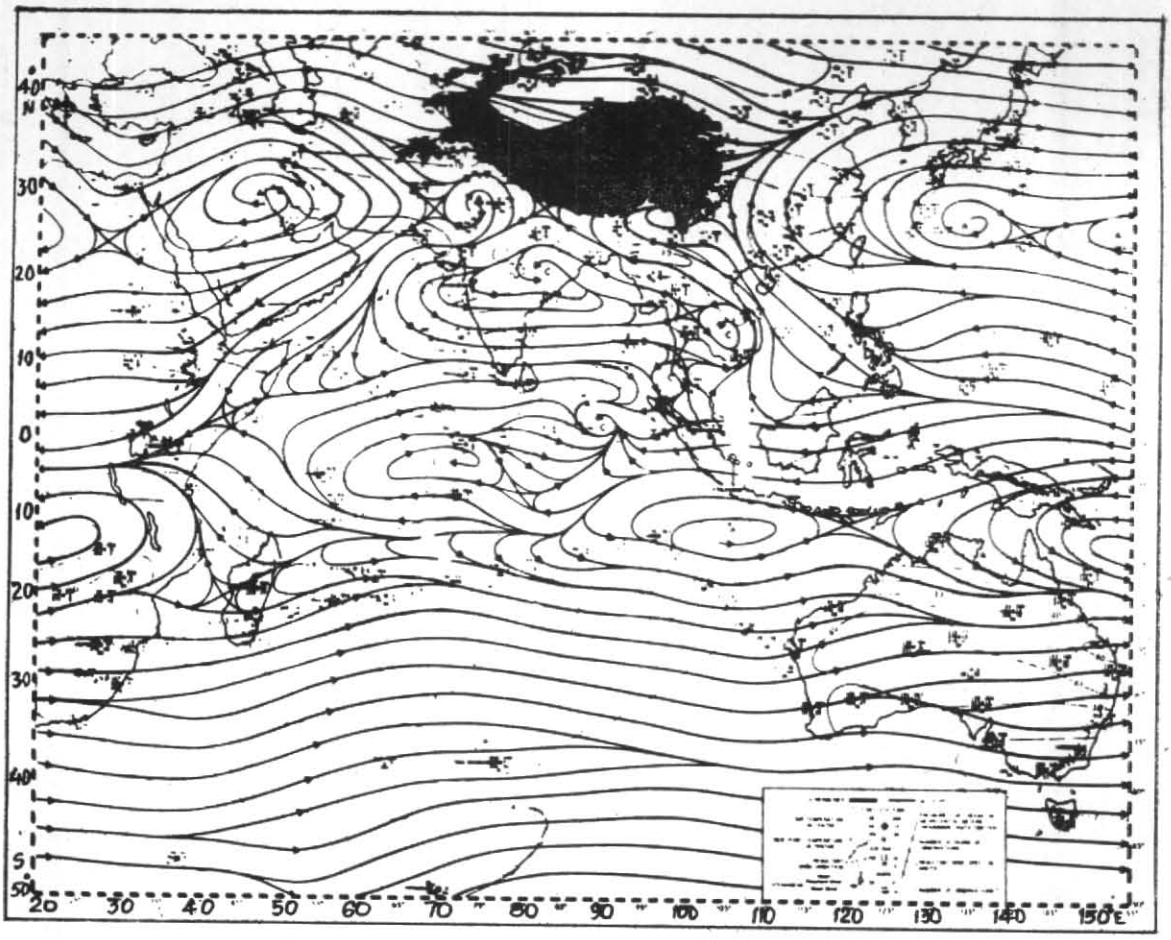

Fig. 1. Mean flow pattern over the Asian monsoon area during July at 500 mb level (Raman and Ramage Atlas)

The five-day averages of gradients of thickness between the southern and northern hemisphere sub-tropical ridges were worked out for the monsoon periods during 1975 and 1976 and their relationship with the monsoon activity examined. We have chosen the points, (*i*) Lat. 17½°S, Long. 55°E just northeast of Malagasy Republic and (*ii*) Lat. 32½°N, Long. 80°E over western Tibet, as broadly representative of the sub-tropical belts in both the hemispheres. The difference of thickenss at these two points, the actual thickness at the latter point and the rainfall anomaly (percentage) of 285 reporting stations in India having normals (taken as a measure of the monsoon activity over India as a whole) were plotted for the periods 1 June to 18 August 1975 (with some breaks) and 1 June to 26 August 1976 (Figs. 2 and 3).

3. Discussion of results

It is interesting to note from Figs. 2 and 3 that there is a close correspondence between the three curves. A time lag of one to two days can be observed between the variations in the thickness curves and the rainfall curve. Thus, it can be said that the fluctuations in the rainfall activity of the southwest monsoon over India could be correlated with thickness difference between Lat. 18°S and Lat. 32°N with a time lag of one to two days. A critical value of 70 gpm for the thickness difference and 4380 gpm for the actual thickness in the vicinity of western Tibet appear to be imperative for good monsoon activity. The anti-cyclone over Tibet during active spells of monsoon will be well-marked and elongated (east to west oriented) at 500 and 300 mb and the thickness is generally about 4400 gpm at 500 mb.

There is very little difference between the two hemispheres at Lat. 20°S/N, but in higher latitudes the range in northern hemisphere increases until it is more than double that in the northern hemisphere (Van Loon and Taljaard 1958). Thus

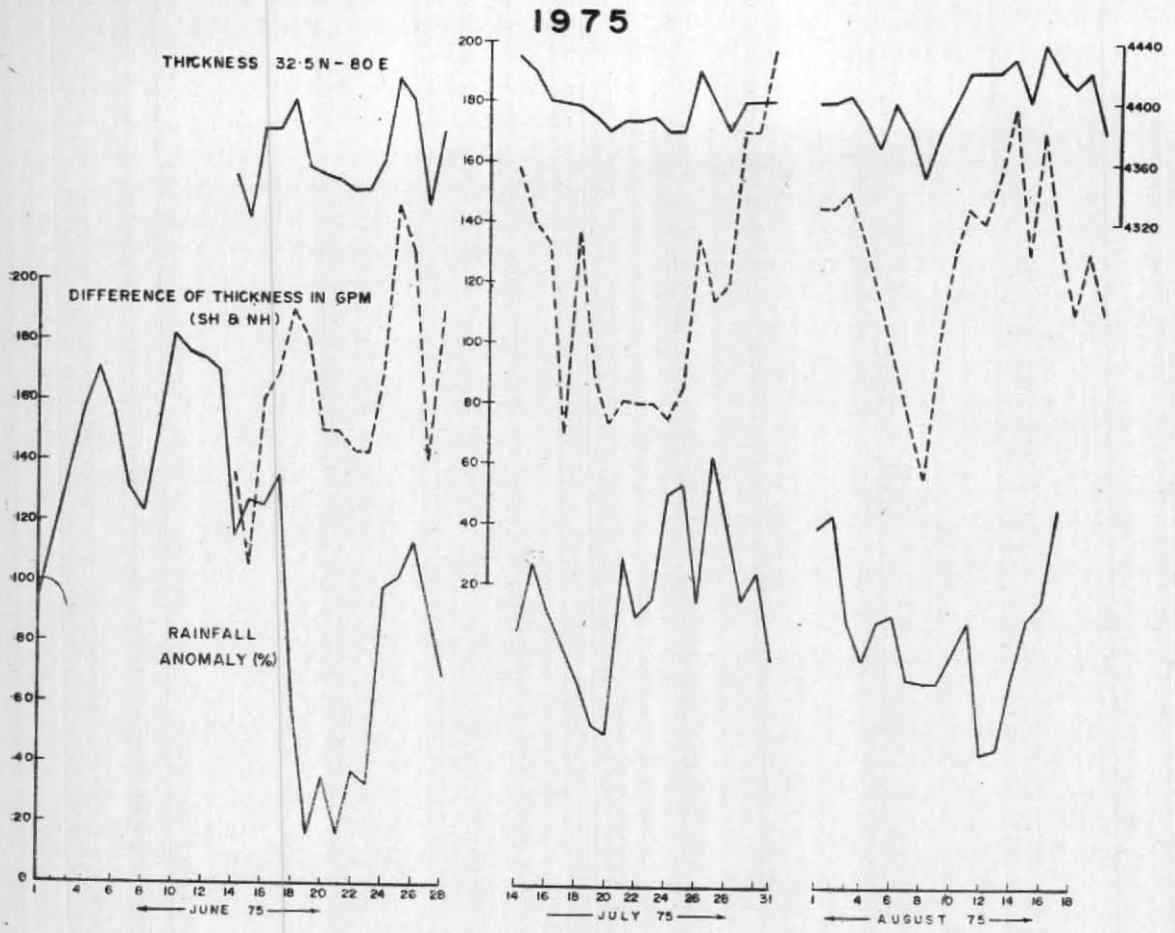
1975
THICKNESS 32·5N-80E
DIFFERENCE OF THICKNESS IN GPM
(SH & NH)
RAINFALL
ANOMALY (%)
JUNE 75
JULY 75
AUGUST 75

Fig. 2

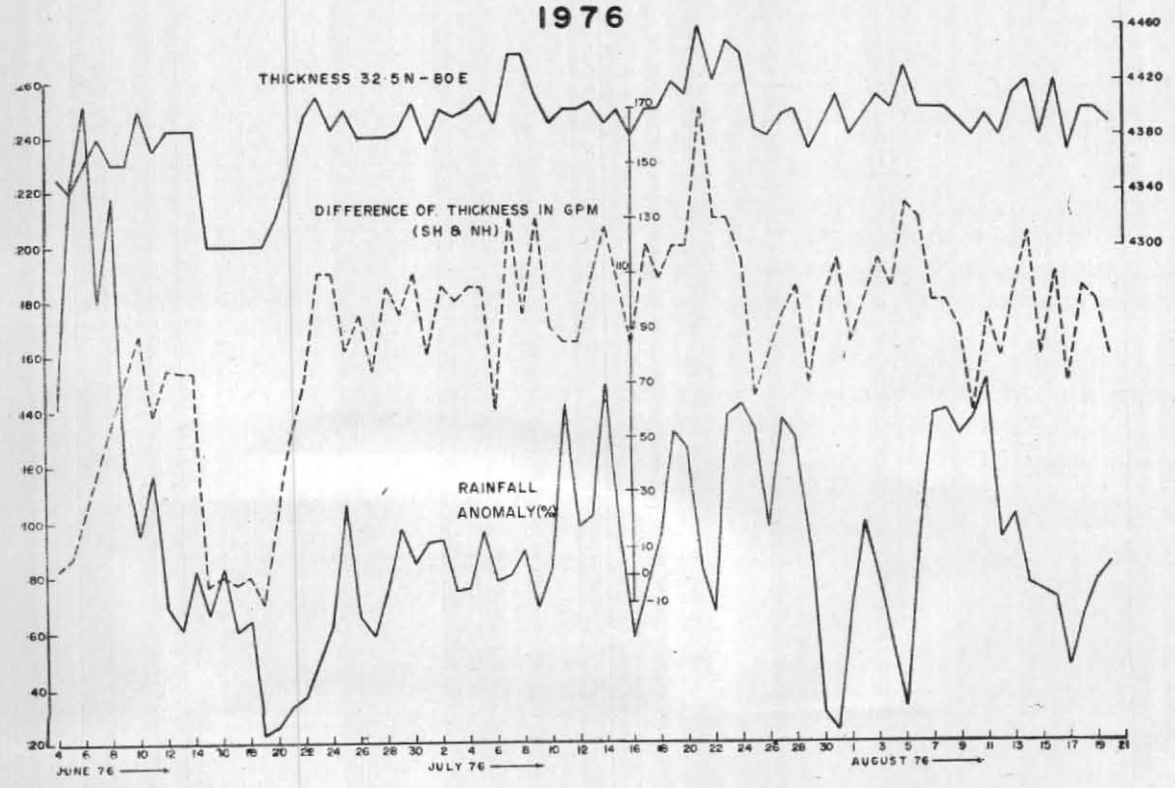
1976
THICKNESS 32·5N-80E
DIFFERENCE OF THICKNESS IN GPM
(SH & NH)
RAINFALL
ANOMALY(%)
JUNE 76
JULY 76
AUGUST 76

Fig. 3

the variations in the contour heights during the summer monsoon can be attributed to the effects of the strength of monsoon circulation.

"It appears as though the monsoon effect of the Himalayas also extends into the upper flow pattern of the southern hemisphere. That the southeast trades of the southern hemisphere over the Indian Ocean merge into the southwest monsoon of summer and of the northern hemisphere is already a well-known fact. A coupling of the circulation of both hemispheres, thus seems to be indicated" (Reiter 1963).

4. Conclusion

The fluctuations in the rainfall activity of the southwest monsoon over India as a whole can be correlated in a broad measure with the thickness difference between the sub-tropical ridges in both the hemispheres.

During the two monsoon seasons in 1975 and 1976 to which this study refers, there were no pronounced break monsoon conditions. Hence the pre-conditions as also the time lag could not be studied during the change-over from normal activity to a weak/break monsoon condition and *vice-versa*, which is of crucial importance for agricultural operations. This aspect requires further study in the coming years when SIRS and other aerological data over the ocean areas are expected to become available and marked fluctuations in the rainfall activity also occur.

The approach may appear to be an over simplification of the complicated processes leading to the rainfall activity during southwest monsoon. Nevertheless, further refinement and critical examination of the methodology may yield some encouraging results.

Acknowledgement

Thanks are due to Mr. M.H. Chowdhry for the processing of data and the preparation of the diagrams.

REFERENCES

Reiter, E. R. 1963 *Jet Stream Meteorology.*

Van Loon, H. and Taljaard, J. J. 1958 A study of the 1000-500 mb thickness distribution in the Southern Hemisphere, NOTOS 7, pp. 123-158.

DISCUSSION

(Paper presented by A. H. Subramaniam)

D.B. SHAW : Could you comment on the accuracy of the SIRS data over the Indian Ocean? I understand that little reliance is placed on SIRS data in the Analysis Centres of I.M.D.

AUTHOR : My experience at the Indian Ocean and Southern Hemisphere Analysis Centre, Pune, is that, while the contour heights given by SIRS observations do require correction due to the assumption that 1000 mb is taken as the mean sea level, the temperature data are reasonably accurate. These are, however, likely to be erroneous over the areas of extensive cloudiness due to low pressure systems.

K.R. SAHA : In what way, the difference in the thickness is related to the monsoon rainfall?

AUTHOR : This study is of a very preliminary nature. Nevertheless thickness difference of about 70-80 gpm appears to be critical, below which the overall rainfall over India is likely to be below normal.