

VARIABILITY OF WINDS AND THE PROPORTION OF THE VARIANCES CAUSED BY SHORT PERIOD SYSTEMS IN ACTIVE AND POOR MONSOON YEARS

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ABSTRACT

Upper air data from Radio/rawin sonde stations in India for the period May to October for five stations, Trivandrum, Madras, Calcutta, New Delhi and Bombay for the active monsoon years 1975 and 1977 and weak monsoon years 1972 and 1979 have been used for the study of variance and proportion of variance caused by the short period weather systems. The result for the above four years for the five stations have been compared. The study indicates that in the poor monsoon years the proportion of variance is large in the lower troposphere in the southern sub-continent and large over the entire sub-continent in the middle and upper troposphere.

INTRODUCTION

It is well known that the constancy of the trade winds in the tropics is quite high and it is very low in the middle latitude westerlies. In the tropics, again the constancy of the winds is maximum in the middle of the trade wind belts and lowest in the equatorial trough. The low value is due to travelling disturbances in the equatorial trough. The low constancy of middle latitude westerlies is because of the extra-tropical cyclones in the lower levels and the trough sytems in the upper levels. Therefore, the variability which is opposite to the constancy at any place is mainly due to the synoptic disturbances.

The total variance of the winds in the present study is the sum of the variances of zonal and meridional components over the total length of the period. The total variance is not only due to the synoptic disturbances but also partly due to the seasonal trends and long period fluctuations within the season which may not have much synoptic significance. It is expected that the variance of winds may have some differences between the good and bad monsoon years.

The climatology of the easterly jet stream and its role in the monsoon development over the Indian sub-continent and the rainfall were examined by Koteswaram¹. The core of jet has been reported to have a ribbon like structure² and the maximum winds occur at a lower elevation in the lower latitudes. A large part of the variance of the zonal winds and in the tropics, is mainly due to the wave numbers^{1,2}.

They are quasi-stationary and are due to the easterly jet over Africa and South Asia in the 200mb global field of motion in the tropics during June, July and August 1967³.

The formation of easterly wind maxima at 200mb south of monsoon depression can be explained with the help of conservation of angular momentum when the northeasterly air stream emerging from the cold system acquires the additional easterly momentum during its motion towards southwest⁴. According to Kanamitsu and Krishnamurti⁵, the following features were noted at 200 mb level.

1. Strong easterly jet,
2. Weaker meridional pressure gradients at the surface and
3. Southeast ward shift of the major circulation patterns in the upper troposphere.

However, these observations regarding the easterly jet stream are contrary to the studies of Ananthkrishnan and Ramakrishnan⁶.

Power spectral study of the daily pressure departures and the meridional and zonal components of winds at three stations, Trivandrum, Nagpur and New Delhi are found to exhibit large variance in poor monsoon seasons⁷. Keshavamurthy⁸ studied the meridional winds at different levels in the troposphere over Calcutta, Lucknow and Nagpur during southwest monsoon of 1967. He attributed a 15-20 day period in the lower and middle troposphere to monsoon depressions, a 5-6 day period to weak monsoon lows and a 7-8 day period to the troughs in the upper troposphere westerlies.

MATERIALS AND METHODS

For the present study, upper air data from five radio/rawin sonde stations - New Delhi, Calcutta, Bombay, Madras and Trivandrum representing different regions of the country (Fig.1) for the years 1975 and 1977 (Active monsoon years) and 1972 and 1979 (Weak monsoon years) from May to October have been used. Wind data for 0000 GMT and 1200 GMT at these stations were analysed to study the variability of winds. The variability of winds at any place is defined in different

ways by different workers. The variance of the winds has been computed using the equation.

$$1/N [(U - \bar{U})^2 + (V - \bar{V})^2]$$

where V = meridional wind, U = zonal wind and N = Number of values.

The time series data were first passed through a low pass filter consisting of 61 normally distributed weights with a standard deviation of 7.5 days. The smoothed values thus obtained were subtracted from the original values. The residual values contain all the periods of less than 20 days. Therefore, it became possible to calculate the proportion of the variance caused by the short period systems.

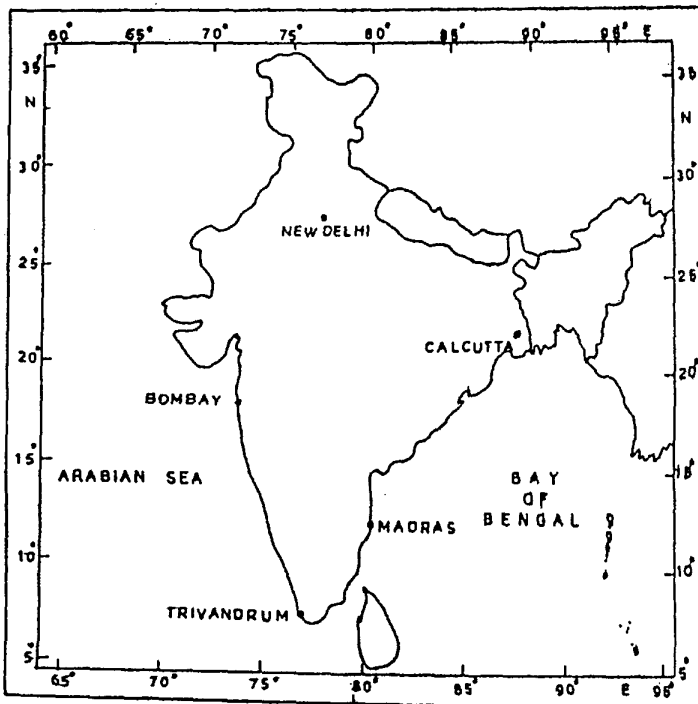


Fig.1. Map showing station locations

The distributions of the variance and the corresponding fractions due to short periods as percentage are presented in

Figs. 2, 3 and 4. The figures to the left of the station point is the total variance and that to the right is the percentage of the component of the short period variance.

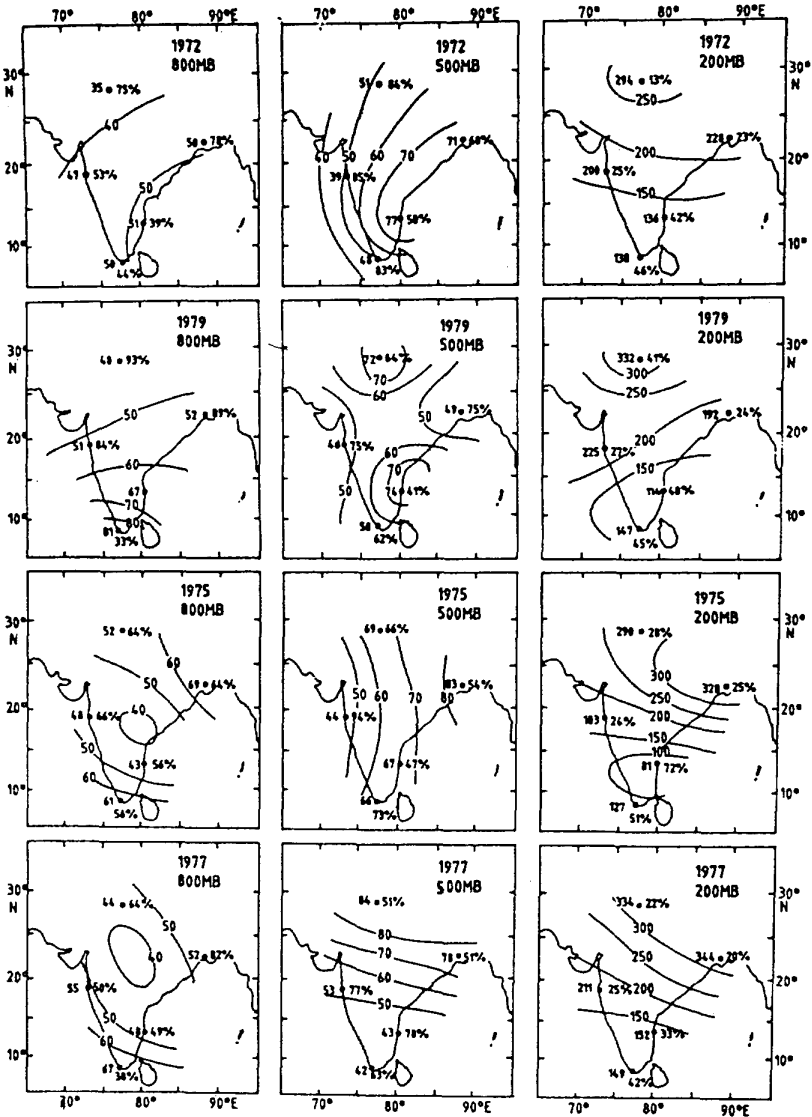


Fig.2. Total variance of the winds (May to July)

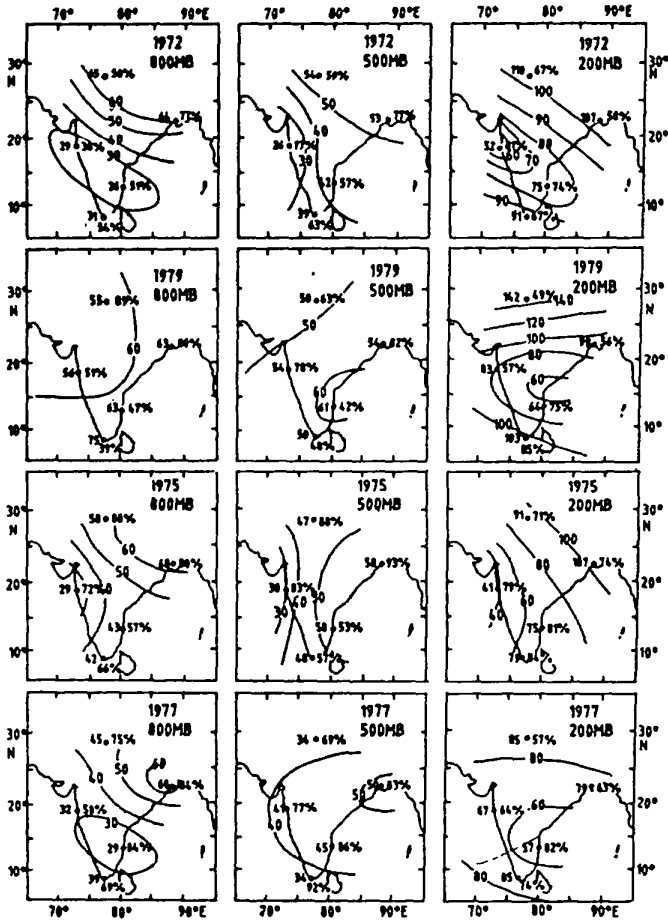


Fig.3. Total variance of the winds (15th June to 15th September)

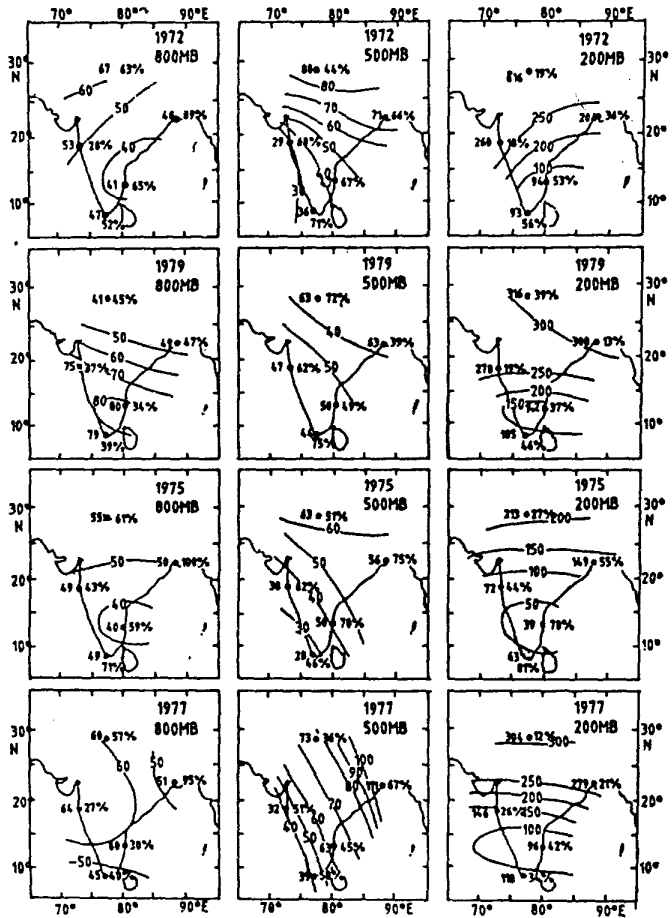


Fig.4. Total variance of the winds (August to October)

RESULTS AND DISCUSSION

Variance (May to July)

The variances are minimum in the central parts of the country in two good monsoon years (Fig.2) at 800 mb while in the bad monsoon years lowest variance occurred in the northwest and highest occurred in south/southeast. The large variance in the south in the four years appears to be due to the easterly disturbances at the time of the onset of the monsoon and earlier⁹. The low variance over central India and large variance in the monsoon trough results from the quick advance of the monsoon across the country and early establishment of the monsoon trough during the good monsoon years while in poor monsoon years, the northern limit of the monsoon (NLM) stagnates for a long time in the south and will not establish over the whole country quickly. The onset of the monsoon over Kerala in poor monsoon years (1972 and 1979) was delayed by two weeks from the normal data of onset, whereas in Active years (1975 and 1977) it is normal (dates of onset : 1972 - 18th, June; 1979 - 11th, June; 1976 - 31st May and 1977 - 30th May^{10,11}).

At the 500 mb level, the variance at the eastern stations is slightly greater than that at the western stations. The short period variance is also found to be more at the north Indian stations in the two poor monsoon years.

The variances are very much greater in the upper troposphere than in the lower troposphere. With the advance of the southwest monsoon the westerly jet stream gradually weakens while the easterly jet establishes at 200 mb to 100 mb levels. Due to this feature the winds show higher variance in the north in the upper troposphere. Similarly, the lowest variance in the south could be mostly due to the increasing seasonal trend in the strength of the easterlies. However, at Calcutta the variance shows a greater variability in the two good monsoon years where as at other stations there is no consistent difference in the variance. The proportion of the short period variance is strikingly very small during all the four years over the entire sub-continent. This may be due to the dominance of the winds due to seasonal variations.

Variance (15th June to 15th September)

The variance at 800, 500 and 200 mb levels in the monsoon period are presented in Fig.3. At 800 mb level the variance is more in the monsoon trough area and least over central peninsula (Fig.3). The large values in the monsoon trough are due to the monsoon lows and depressions which generally form at the monsoon trough area during the summer monsoon period.

The low values in the central peninsula indicates that the monsoon westerlies are fairly steady. The proportion of the short period variance is somewhat lower in the poor monsoon years over peninsular India, hence the proportion due to large period fluctuations was greater.

At the 500 mb level (Fig.3), the variance at the eastern station is more and less at the western stations, due to the easterly disturbances moving from the Bay which gradually weaken as they progress westward. The proportion of the long period variance in general, is more in the poor monsoon years. The feature is however, confined to southern peninsula at the lower levels as mentioned earlier.

The variances in the upper troposphere are considerably greater than those at the lower troposphere at all the stations. The variances are in general, large in the north and in the extreme southern part of the country and the lowest value over the central part of the country in the area north of the axis of the easterly jet stream. It may therefore, be understood that the winds to the south of the jet stream are less stable and those quite to the north are more affected by the systems in the subtropical westerlies. In the poor monsoon years it can be seen that the variance was more at New Delhi and consistently higher at Trivandrum. In the middle troposphere the proportion of long period variance is more in the poor monsoon years at all the stations.

Variance (August to October)

In the lower troposphere the variance is less in the south and more in the north. In the middle troposphere, stations in the east and the north show more variance while the stations in the west show lowest values. The variance in the upper troposphere is quite high as in the pre-monsoon period.

The above study reveals the following results :

1. The variance of the winds is very much small over peninsular India and relatively large in North India in the lower troposphere indicating the monsoon westerlies to be a steady current.
2. The variance is more to the south of the easterly jet stream and less to the north over the Indian area indicating the easterlies south of the jet are less stable.
3. The variances are consistently higher at New Delhi and Trivandrum in the upper troposphere in poor monsoon years.

4. The proportion of variance due to long period fluctuations of wind has been found to be large in poor monsoon years in the lower troposphere over south India and at all places in the middle and upper troposphere.

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