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On the periodicities in the tropospheric wind flow during the northeast monsoon season

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ABSTRACT. Several attempts were made in the past to track the disturbances that affect the weather over south Peninsula during the northeast monsoon season. But these had limited success mainly because of the lack of data over the oceans. Thus conventional synoptic analysis has its limitations in tracking these disturbances across the Bay of Bengal. Therefore to determine the periodic nature of these disturbances, the upper wind data of a few stations south of 15°N have been subjected to power spectrum analysis after applying suitable high pass filter.

The results indicate the existence of dominant periodicity of a week to about 16 days. Relatively weak waves of period around 4-5 days are also noticed. The periodicities are generally more marked in the zonal flow than in the meridional flow. The periodic nature of waves shows some variations from one northeast monsoon season to the other.

1. Introduction

Westward moving disturbances in the tropospheric wind field, often known as easterly waves have been found to influence the weather over southern parts of India during the northeast monsoon season. These disturbances which are embedded in easterly flow over the low latitudes, first appear as the changes in upper wind and the weather over Port Blair. Within a day or two they move westward to the east coast of India affecting weather over the south Peninsula. Sometimes when the wave has sufficiently large amplitude, it may affect the weather even over the central parts of the country, particularly when it happens to come in conjunction with a westerly trough in the north (Ranganathan and Soundararajan 1965). Due to the absence of observing stations between Port Blair and the east coast, tracking of these waves over the Bay of Bengal is often difficult. Still their existence can be noticed with reasonable certainty with the help of vertical time sections of stations like Port Blair, Madras and Trivandrum. Though these waves are known to move periodically from east to west, the precise nature of periodicities in their occurrence is not known. With the introduction of power spectrum analysis in the time series analysis of meteorological data, both the zonal and meridional component of wind at low latitudes have been found to exhibit periodic oscillations over different areas (Rosenthal 1960, Yanai and Murakami 1970, Burpee 1972). Over the Indian region also, power spectrum analysis has revealed periodicities in seasonal monsoon rainfall (Koteswaram and Alvi 1971) as well as in monsoon wind flow (Keshavamurty 1973). In the present study, the periodicities in the northeast monsoon flow have been examined by a similar analysis.

2. Data and method of analysis

As the influence of easterly waves is generally limited to the southern parts of the country, the daily 0000 GMT zonal and meridional components of wind of Port Blair, Madras, Trivandrum and Minicoy for the tropospheric levels of 900, 800, 700, 600, 500, 400 and 300 mb extending over three-month period from October to December were subjected to power spectrum analysis. As the nature of periodicities in the same season may differ from year to year, the data for four years (1968 to 1971) were analysed as separate series to obtain more reliable statistics. The data series often had some missing observations. No attempt was made to interpolate these data, though due care was taken to neglect the missing observations during the course of analysis. A preliminary analysis of unfiltered data with different maximum lags (20, 25 and 30 days) indicated generally the existence of waves of 8 to 12 days duration as well as of some shorter durations. In some samples, the waves of the period 17-20 days and sufficient amount of red noise were also noticed. As our interest was not in very low frequency waves, a 17-point high pass Gaussian filter was applied to filter out waves

TABLE 1

Summary of periodicities in zonal and meridional components

Station	1968	1969	1970	1971
		(a) Zonal component		
Port Blair	7-8 days; above 800 mb level maximum intensity at 600 mb	7-8 days; throughout troposphere, maximum intensity at 600 mb 4-4.5 days; at 500 mb	Around 12·5 days; throughout troposphere, maximum intensity at 600 mb 7-8 days; at 300 mb	7-8 days throughout troposphere, strong between 800-900 mb and 400-600 mb; 4-5-5 days at 500 mb
Madras	8-10 days; throughout troposphere maximum intensity at 500 mb and 800-900 mb	7 days; throughout troposphere maximum intensity at 500-600 mb	No dominant periodicities except 10-12 days around 700 mb and 6-7 days at 600 mb and 900 mb	7-8 days. below 700 mb level 4 days; relatively weak at 600-700 mb
Trivandrum	8-12 days; at 500-600 mb 5-5·5 days; at 400 mb	12·5-17 days; below 500 mb level max. intensity at 700 mb. 6-8 days at 400-500 mb	8-10 days; throughout troposphere, max. intensity at 700 mb	8-10 days; throughout troposphere max. intensity at 500 and 700 mb
Minicoy	12·5-17 days; at 700 mb 6-7 days; isolated periodicities at 400, 700 and 900 mb	12·5-17 days; between 600-800 mb 7-8 days; at 400–500 mb around 3·3 days ; weak at 300-400 mb	8-10 days; between 400-800 mb	7-10 days; above 800 mb 5 days; at 500 mb and 800-900 mb
		(b) Meridional component		
Port Blair	8-10 days; above 700 mb level, maximum intensity at 600 mb 5 days at 300 mb	No dominant periodicities except : 8-10 days at 300 mb; 4·5 days at 500 mb	No dominant periodicities except 6-7days at 700 mb 4·5 days at 500 mb	8-13 days; at 900 mb between 400 and 600 mb; 4-5 days at 800 mb
Madras	7-10 days; between 600 and 800 mb	Isolated periodicities of 8-12 days at 700 mb; 7-8 days at 900 mb; 5·5-7 days at 400 mb	Isolated periodicities of 6-7 days at 400-500 mb and 800 mb; 4·5 days at 300 mb	7-10 days; above 600 mb level, max. intensity at 400 mb
Trivandrum	7·5-10 days; between 500 and 700mb and at 300 mb; 7-8 days at 900 mb; 3 days at 800 mb	7-10 days; throughout troposphere, max. intensity ar 600 mb	6-7 days; at 300-400 mb; around 3 days at 600-700 mb	8-10 days; 300-400 mb 6-8 days below 600 mb; max. intensity at 800 mb; 5 days at 400-500 mb
Minicoy	Isolated periodicities of 8-10 days at 300 and 600 mb; 4·5-5 days at 400 and 800 mb	7-10 days; between 400 and 800 mb levels; max. intensity at 700 mb	10-12 days; 800 mb; 6-8 days 400-500 mb; 4·5 5 days at 600-700 mb	6-8 days; between 400 and 800 mb level

of more than about two weeks' duration. Fig. 1 shows the frequency response of this filter. For the final analysis of filtered data, the maximum lag of 25 days was used.

3. Results

In order to save space, out of the data analysed the spectral analyses of only Port Blair and Madras wind for 1969 northeast monsoon season are shown in Fig. 2.

It may be seen that the periodicities are better defined in the zonal component where they extend nearly throughout the troposphere with maximum intensity in mid-troposphere between 700 and 500-mb levels. The most dominant periodicities, particularly in the zonal component range between 8-10 days. This feature was generally noticed at all the four stations in all the northeast monsoon seasons examined though there were variations in the strength and level of maximum intensity of these waves from station to station and year to year. Besides this, relatively weak waves of 4-5 days duration were also noticed in some years in both the components of wind. These periodicities, however, were of limited extent in the vertical. In a few cases, waves of longer duration (12-17 days) were also noticed particularly in the case of Minicoy and Trivandrum. The salient features of the analysis for different stations are summarised in Table 1.

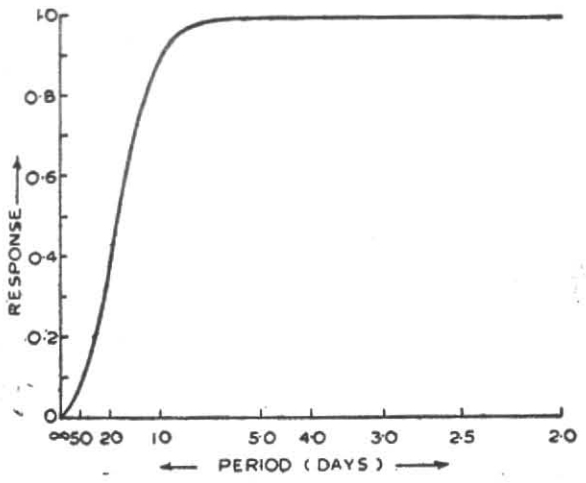

Fig. 1. Response of high pass filter

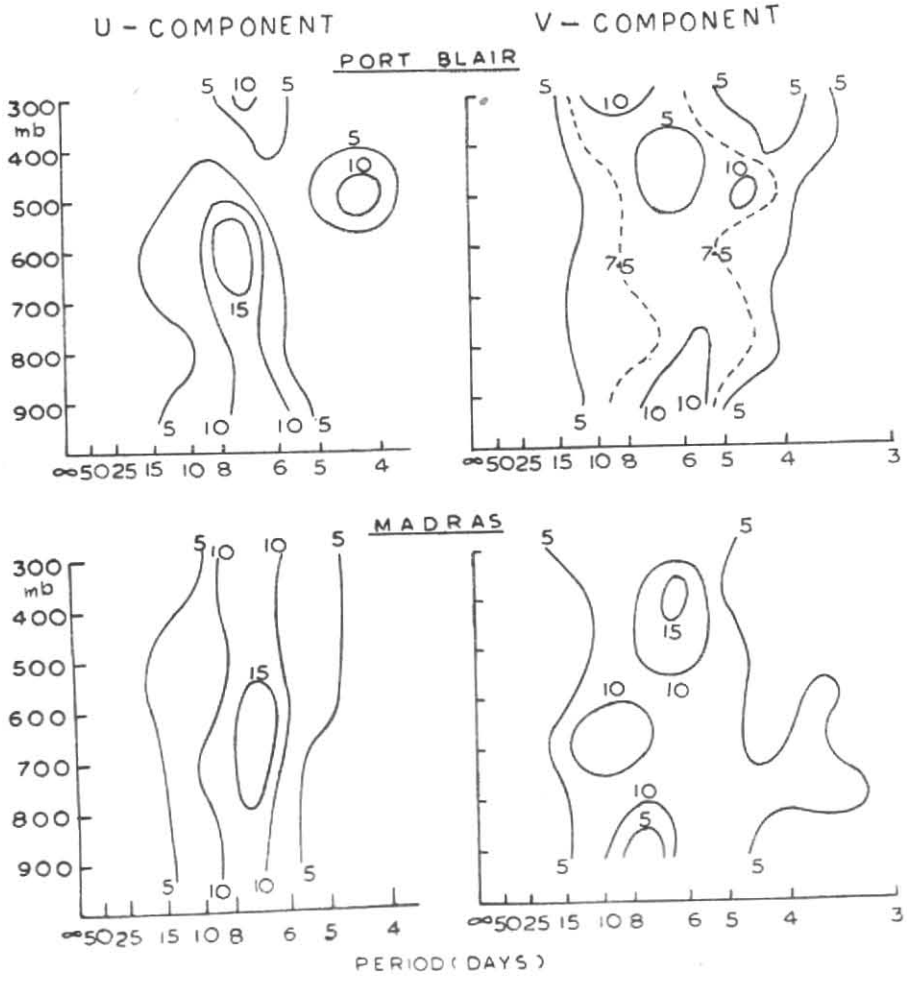

Fig. 2. Power spectrum analysis of u and v components of wind for 1969 northeast monsoon season (Unit : % of total power)

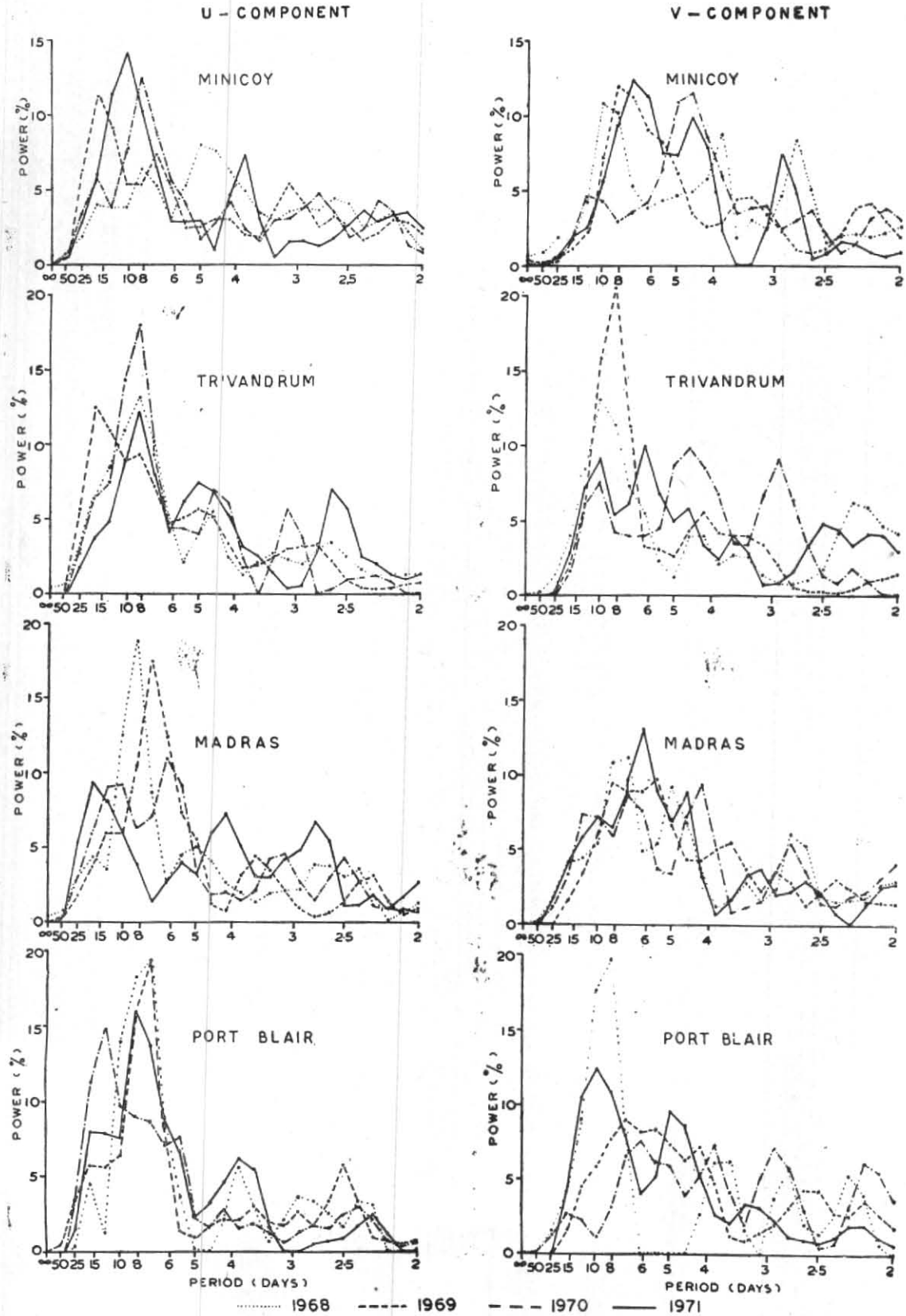

Fig. 3. Spectrum analysis of u and v components of wind at 600-mb level

Fig. 3 shows the power spectrum for all the stations for the four seasons at 600 mb level around which the periodicities are noticed to have generally maximum intensity.

From Table 1 and Fig. 3 it is seen that the power spectrum of both the wind components shows large variations from one station to the other as well as from one season to the other. From these the salient features of the waves in the wind field during northeast monsoon can be summarised as follows :

(*i*) The predominant periodicity noticed within the zonal and meridional components lies in the range of 7-10 days.

(*ii*) These waves have a tendency to attain maximum intensity in the mid-troposphere around 600-mb level.

(*iii*) As seen from the concentration of energy, these waves are better revealed in the zonal component than in the meridional component.

(*iv*) Periodicities of 4-5 days are also noticed on a few occasions.

(*v*) Periodicities as high as 12 to 17 days and as low as 3 days are also observed on a few occasions particularly on the Arabian Sea side.

(*vi*) The periodicities observed in the northeast monsoon wind field over the Bay of Bengal and southern Peninsula are different from the predominant periodicity (4-5 days) observed over the tropical Atlantic and Pacific (Riehl 1954, Yanai *et al.* 1968, Yanai and Maruyama 1970).

(*vii*) It is recognised that the amplitude of the tropical waves revealed by measured parameters like temperature, wind etc is small and maximum variation associated with these waves is revealed by precipitation.

Studies of rainfall at Madras (Krishna Rao 1953) have shown that during the period of 75 days of the northeast monsoon season, there are about 25 to 30 rainy days and the rainfall occurs in spells of 2 to 4 days. From these data it can broadly be inferred that the duration of the dry period in between 2 rainy spells is about 5 to 6 days on the average. The resultant periodicity in the rainfall approximately agrees with the periodicity of 7 to 10 days observed in the wind field.

The important feature brought out by this investigation is that the waves of periodicity of 7-10 days appear to be associated with weather development over the Bay of Bengal and the south Peninsula during winter monsoon (northeast monsoon). Waves of 4-5 day period commonly observed over the Atlantic and Pacific are weak and less frequent in this area.

REFERENCES

Burpee, R. W.	1972	*J. Appl. Met.*, **29**, 1, pp. 77-90.
Keshavamurty, R. N.	1973	*Indian J. Met. Geophys.*, **24**, 2, pp. 117-124.
Koteswaram, P. and Alvi, S. M. A.	1971	Secular Trends and Periodicities in Indian Rainfall-*IDO JARAS*-Centenary Vol. pp. 176-183.
Krishna Rao, P. R.	1953	Mem. India met. Dep, **30** pt. 1, 63 pp.
Ranganathan, G. and Soundararajan, K.	1965	*Indian J. Met. Geophys.*, **16**, 4, pp. 607-616.
Riehl, H.	1964	*Tropical Meteorology*, McGraw Hill Book Co., 392 pp.
Rosenthal, S. L.	1960	*J. Met.*, **17**, 3, pp. 259-263.
Yanai, M, Maruyama, T, Nitta, T,. and Hayashi, Y.	1968	*J. Met. Soc. Japan*, **46**, 4, pp. 308-323.
Yanai, M. and Murakami, M.	1970	*Ibid.*, **48**, 4, pp. 331-359.