551.501.7 : 551.513 (540)

BAROTROPIC INSTABILITY OF ZONAL FLOW IN THE INDIAN REGION

1. Over the Indian sub-continent we come across the sub-tropical westerly jet stream (STJ) at 200-mb level in winter and the tropical easterly jet stream (TEJ) at 150 mb level in summer. In this study it is examined whether the zonal flow in the Indian region is barotropically unstable.

It has been shown by Kuo (1949) that a necessary condition for the occurrence of barotropic instability is that at some value of y

$$\frac{d}{dy}\left(-\frac{dU}{dy}+f\right)=0$$

which states that the absolute vorticity must be an extremum at some latitude. Kuo considered a symmetrical jet and showed that the above condition is both necessary and sufficient for the existence of amplifying waves and that there exists a spectrum of neutral, amplified and damped waves.

2. 1200 GMT observations at 19 rawin stations in India and nearly an equal number of rawin stations in the neighbouring countries for the period 1966-70 have been utilised for the study. Mean zonal components (U) for levels 1·5, 3·0, 6·0, 9·0, 12·0, 14·1 and 16·2 km which nearly correspond to 850, 700, 500, 300, 200, 150 and 100-mb levels have been worked out for four representative months, January, April, July and October and plotted in charts On analysing these charts, values of zonal wind component (U) at $2\frac{1}{2}°$ interval along 75°E meridian have been picked up. Mean horizontal wind shears (dU/dy) and the corresponding absolute vorticity ($f-dU/dy$), along 75°E meridian were worked out. The sign convention for wind component is that the wind component from west is positive.

The mean zonal flow and the corresponding absolute vorticity observed over the region, equator to 40°N, along 75°E meridian at various levels for January, April, July and October, based on the 5-year period (1966-70) are shown in Figs. 1 to 4. The data have been picked up at grid points from analysed charts, hence considerable smoothing has been introduced. Therefore the kinks in the profiles of absolute vorticity appear to be genuine.

3. The possibility of barotropic instability in the zonal flow and its seasonal variation, in the Indian region is examined. The profiles of the mean zonal wind are not symmetric and the existence of maxima in the absolute vorticity profiles may indicate only a possibility of barotropic instability. In view of the approximations involved in the analysis, only the distinct maxima are considered here.

It may be noticed (Fig. 1) that in January, which represents the winter period, there are distinct maxima in the absolute vorticity over Lat.

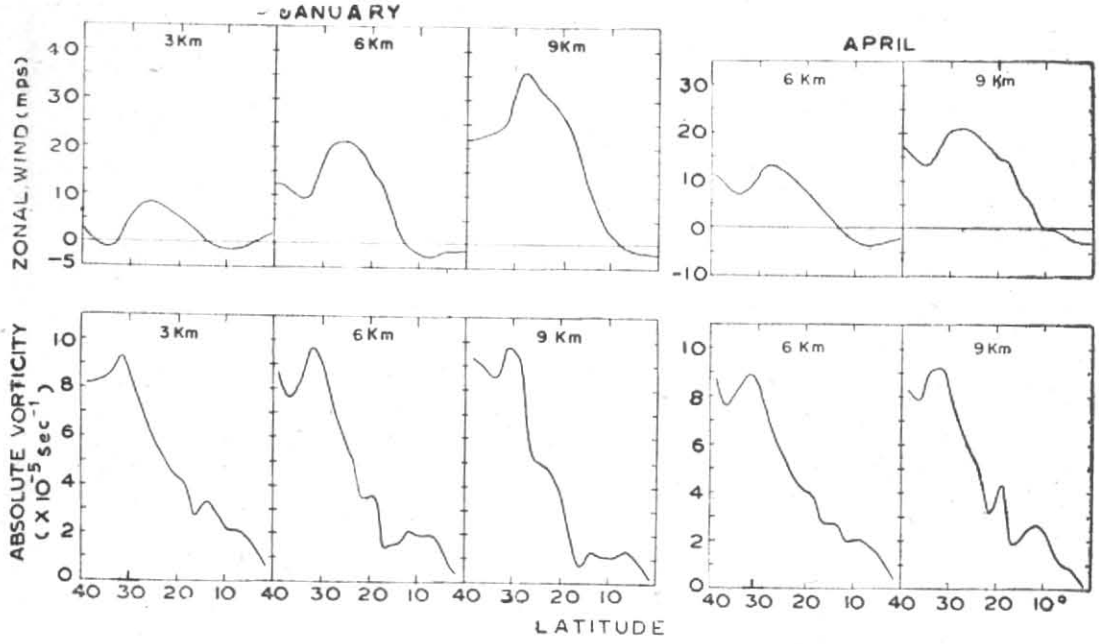

Fig. 1 Fig. 2

Latitudinal variation of the mean zonal wind and the corresponding absolute vorticity

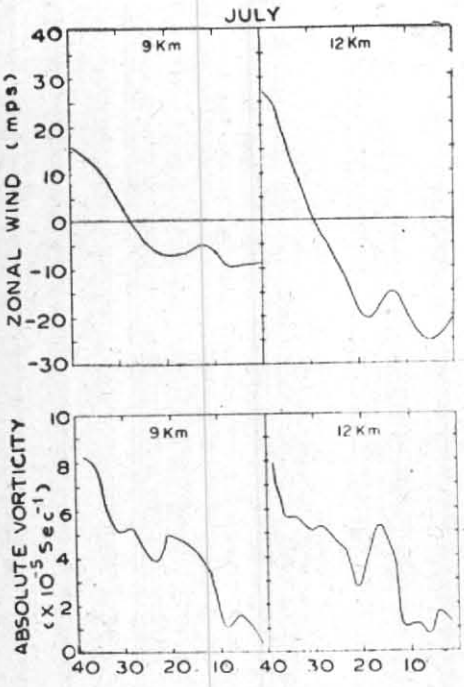

Fig. 3

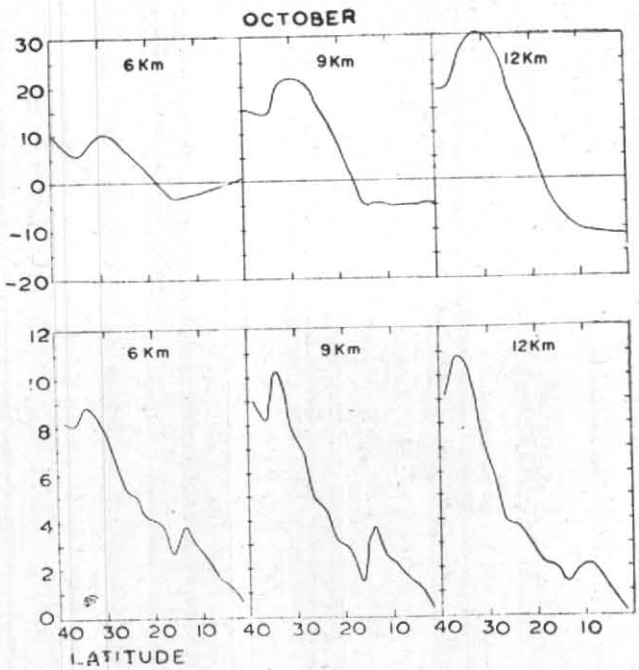

Fig. 4

Latitudinal variation of the mean zonal wind and the corresponding absolute vorticity

30°N at 3 km (700 mb), 6 km (500 mb), and 9 km (300 mb) levels. Such maxima are also seen in the month of April, which represents the hot period (Fig. 2), over 31½°N latitude at 6 km and 9-km level. Inflection points can be observed in the curves of the zonal components at these levels and against the latitudes in question.

In July, which represents the monsoon season, maxima in the absolute vorticity over Lat. 20°N at 9 km and over Lat. 15°N at 12 km (200 mb) levels are observed as can be seen from Fig. 3. These may also lead to waves in the easterlies. The cause for these maxima in the absolute vorticity may perhaps be due to the existence of two cores of maximum wind in the zone of the tropical easterly jet (TEJ), one over Lat. 6°N and the other over Lat. 15°N (Mokashi 1974).

In October, which is the transition month between the monsoon and the winter season, we come across absolute vorticity maxima over Lat. 14°N at 6 and 9 km over Lat. 10°N at 12 km (Fig. 4).

The levels of maxima in the absolute vorticity for the cardinal months are 3, 6 and 9 km for January ; 6 and 9 km for April; 9 and 12 km for July and 6, 9 and 12 km for October.

It is interesting to note that the maxima in the absolute vorticity is observed at levels increasing in height from January to July through April and decreasing in height in October.

Thus there appears to be a possibility of growth of disturbances by the barotropic instability in the upper tropospheric westerlies over North India during winter and spring and in the upper tropospheric easterlies over Peninsular India during the monsoon and post monsoon season.

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