

Global features of upper-tropospheric zonal wind and thermal fields during anomalous monsoon situations

L S HINGANE, S D PATIL and K RUPA KUMAR

Indian Institute of Tropical Meteorology, Pune 411 005, India

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Abstract. Global analyses of mean monthly zonal wind component and temperature at 200, 150 and 100 mb levels have been made for the region between 60°N and 60°S, for the months May through September during two poor monsoon years (1972 and 1979) and a good monsoon year (1975). Prominent and consistent contrasting features of the zonal wind and thermal fields have been identified, with reference to the monsoon performance over India. It has been noticed that the areal spreading of easterlies over the tropics and extratropics is significantly more during a good monsoon year. Shifting of the axis of the tropical easterly jet stream to a higher level and generally stronger easterlies also characterize good monsoon activity. The upper troposphere has been found to be considerably cooler during poor monsoon years.

Keywords. Southwest monsoon; drought; upper troposphere; zonal winds

1. Introduction

Strong easterlies and the tropical easterly jet stream (TEJ) at the 100–150 mb level have since long been recognized to be among the main features of the Asian summer monsoon. Some regional-scale studies were made to bring out the anomalies in the upper wind and thermal fields associated with below normal monsoon activity leading to large-scale droughts (Ananthakrishnan and Ramakrishnan 1963; Keshavamurty and Awade 1974; Prakasa Rao 1975; Verma 1980). Continued presence of strong easterlies during the breaks and significant cooling of the upper troposphere during poor monsoon years are some of the important features noted in these studies. Kanamitsu and Krishnamurti (1978) contrasted the 200 mb flow regimes during a drought year (1972) with those during a normal monsoon year (1967) over the global tropics for the period 1 June to 31 August. Their study indicates that the spreading of the easterly wind field in the tropical belt is more pronounced in a normal monsoon year than in a poor monsoon year. Hingane (1984) analysed the thermal and wind fields at 200, 150 and 100 mb levels in the month of July for a good monsoon year (1975) and a poor monsoon year (1979) and noted similar features. As a continuation of the above study in a more extensive manner, the present paper deals with the analysis of mean monthly zonal winds and thermal fields during the months May through September at 200, 150 and 100 mb levels, for the years 1975 (flood) and 1972 and 1979 (drought). The reason for specifying these three levels for the study is that they represent certain characteristic features of the upper troposphere, viz, the presence of an extratropical westerly jet stream (ETWJ) at 200 mb, that of TEJ at 150 mb and that of the tropopause at 100 mb.

2. Data and analysis

Mean monthly data of wind and temperature at 200 mb, 150 mb and 100 mb levels for about 250 stations around the globe between 60°N and 60°S (see figure 1 of Hingane 1984) have been collected from the Monthly Climatic Data for the World (NOAA/WMO) for the months May through September of 1972, 1975 and 1979. Though the data concerned are only for three years, in view of the extreme anomalies in these years, it is expected that an idea of the characteristic features associated with them can be obtained. The zonal components of the wind at all the above levels have been calculated for each station. These data have been plotted and 90 maps giving the zonal wind field and the thermal field have been prepared. These maps have been examined in detail to identify the consistent contrasting features associated with good and poor monsoon years.

3. Results

The salient features observed in the analysis for contrasting summer monsoon situations are briefly noted below.

3.1 Upper-air zonal wind field during May through September

In the zonal wind field maps presented in this section, the areas covered by negative values of zonal component, which represent the easterly field, have been shaded by hatching to give a better contrast.

- i) *May*:—During May 1975 the latitudinal as well as longitudinal extent of the easterly wind field at 100 mb in the tropical and extratropical regions is considerably more (figures 1 and 2). The easterlies at 150 mb (normal level of the axis of TEJ) were stronger during 1975 than during 1972 and 1979. Westerlies over Australia at all the three levels (viz, 100, 150 and 200 mb) were weaker in 1975 than in 1972 and 1979.
- ii) *June*:—In 1975 at 100 mb level although the easterlies are found at more northern latitudes over the Pacific Ocean, they extend round the globe except between 50°W

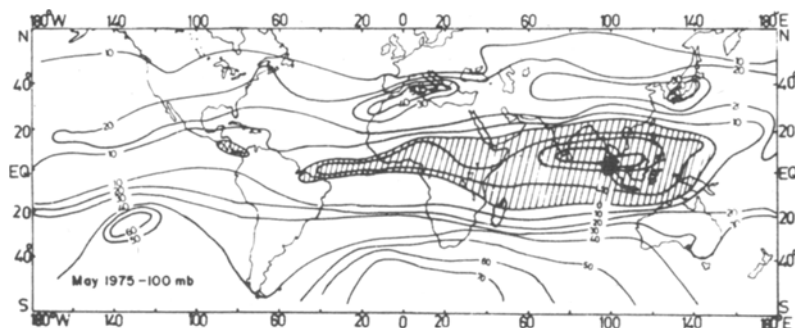


Figure 1. May 1975: zonal wind field at 100 mb (m sec^{-1}).

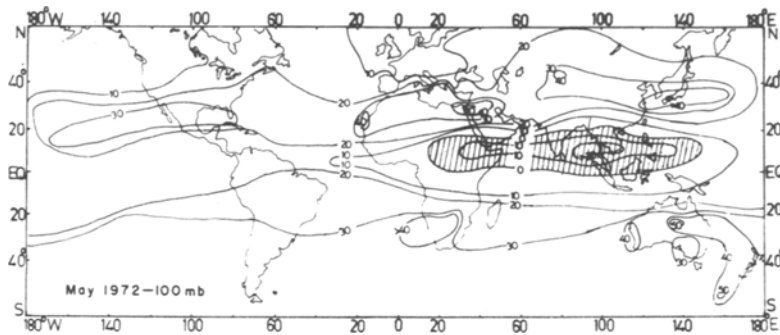


Figure 2. May 1972: zonal wind field at 100 mb (m sec^{-1}).

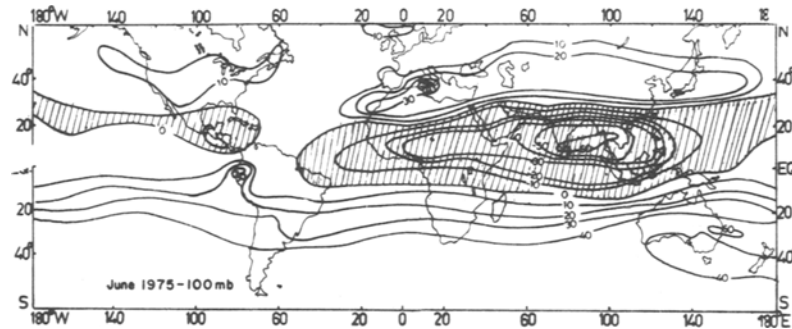


Figure 3. June 1975: zonal wind field at 100 mb (m sec^{-1}).

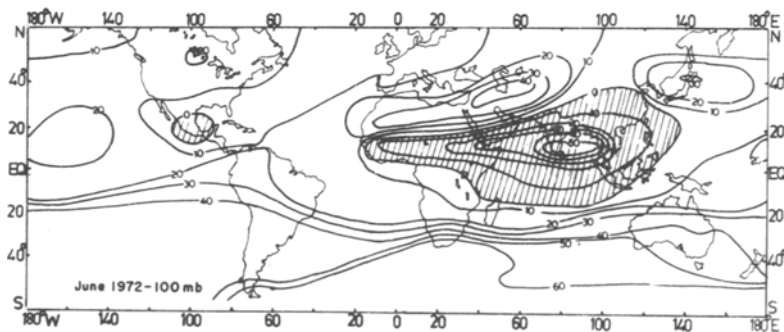


Figure 4. June 1972: zonal wind field at 100 mb (m sec^{-1}).

and 70°W , whereas in 1972 and 1979 they are mainly in the Eastern Hemisphere (figures 3 and 4). The easterlies over South Asia were significantly stronger in 1975 when compared to 1972 and 1979. Fairly strong westerlies are seen over north central Pacific in 1972 and 1979, whereas the same region has been covered by easterlies in 1975. No well-marked differences could be noticed at 150 mb and 200 mb levels.

- iii) *July*:—In 1975 (figure 3 of Hingane 1984), the easterlies at 100 mb level extend over a broader belt of latitudes covering the whole of the tropics and parts of the extratropical region and occur round the globe, compared to the narrow bands in 1972 (figure 5) and 1979 (figure 2 of Hingane 1984). At the 150 mb level, the longitudinal extent of the easterly wind field is more in 1975 than the others. An interesting feature that can be seen in 1975 is that the easterlies are weaker at 150 mb than those at 100 mb (see figure 6 of the present paper and figure 3 of Hingane 1984). This feature suggests that the position of TEJ axis could have shifted to the 100 mb level. The wind shears also support this aspect. Westerlies were weaker at 150 mb over Australia in 1975 while they were stronger over the southern tip of South Africa at both 150 and 200 mb levels.
- iv) *August*:—A majority of the Japanese stations show easterly wind components in 1975, in contrast to the other years. Westerlies are weaker over Australia at 100 mb as well as 150 mb levels in 1975 than in 1972 and 1979. However, no significant differences could be observed at 200 mb zonal wind field.
- v) *September*:—At the 100 mb level, the easterlies were extending into the equatorial Atlantic in 1975, whereas in 1972 and 1979 there was westerly wind field in that area, separating the Afro-Asian and Mexican easterly fields. At 200 mb, the westerly jet stream was well-established, fairly stronger and continuous over central Asia and Europe in 1975, when compared to the other years.

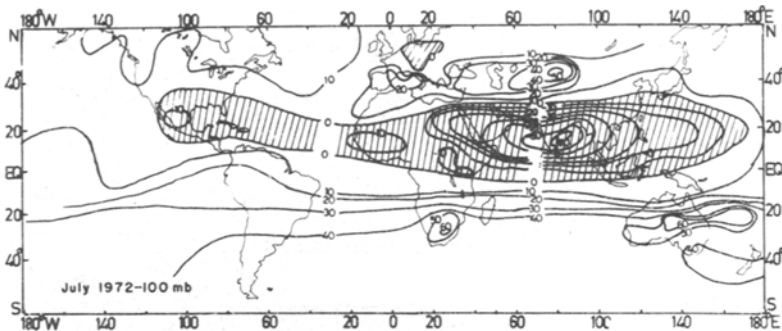


Figure 5. July 1972: zonal wind field at 100 mb (m sec^{-1}).

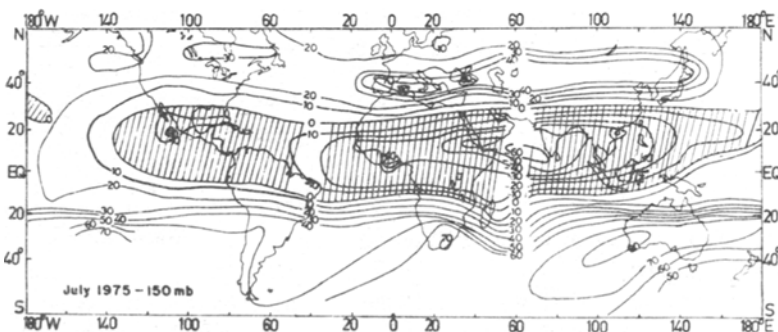


Figure 6. July 1975: zonal wind field at 150 mb (m sec^{-1}).

3.2 Upper-air thermal features during May through September

- i) *May*:—Temperatures over India were markedly higher at all the three levels in 1975 when compared to 1972 and 1979 (see for example, figures 7 and 8).
- ii) *June*:—Temperatures over India, particularly over the northern parts, continued to be higher at all the three levels in 1975, than in 1972 and 1979. At the 200 mb level, south Japan, southern Europe and adjoining USSR and North America were warmer in 1975 (figures 9 and 10) than in the other years.
- iii) *July*:—The Indian region shows warmer conditions at both 100 mb and 150 mb levels in 1975, than in 1972 and 1979, the latter year showing the lowest temperatures. The European stations north of 40°N were having lower temperatures at 100 mb and 150 mb levels during 1975 than during 1972 and 1979. The equatorial eastern Pacific region was cooler at 150 mb and 200 mb levels in 1975 than in 1972 and 1979. At 200 mb, the whole of Australia and adjoining New Zealand and the poleward regions of North America were markedly cooler both in 1972 and 1979 than in 1975.
- iv) *August*:—North India was slightly but definitely warmer at all the three levels in 1975, whereas Europe and South Africa were cooler during the same year at 100 and 150 mb levels.
- v) *September*:—No significant contrast in the thermal field at any level could be noticed for this month.

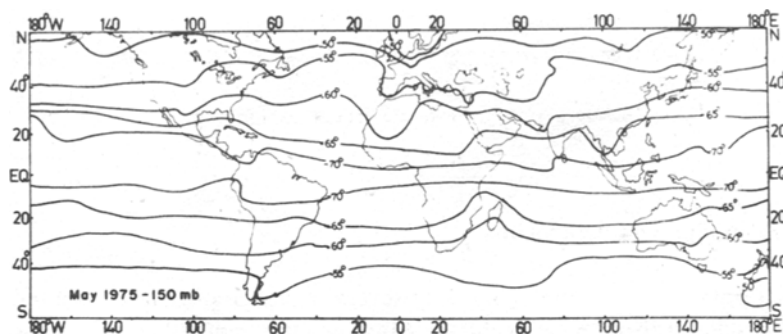


Figure 7. May 1975: temperature field at 150 mb (°C).

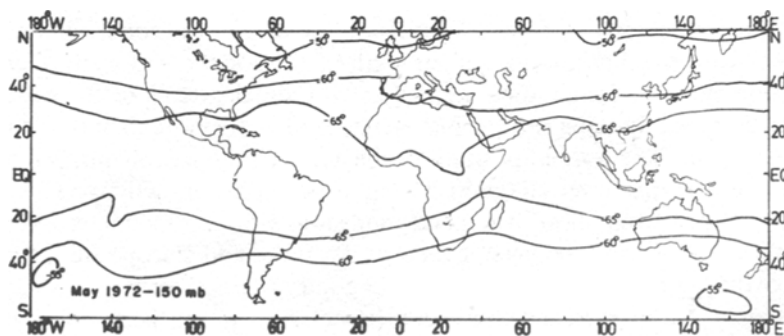


Figure 8. May 1972: temperature field at 150 mb (°C).

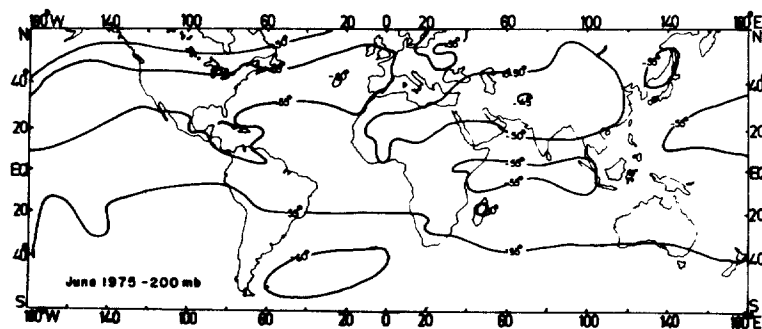


Figure 9. June 1975: temperature field at 200 mb ($^{\circ}\text{C}$).

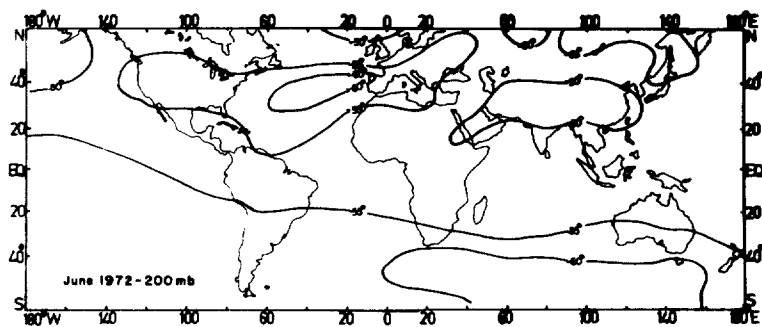


Figure 10. June 1972: temperature field at 200 mb ($^{\circ}\text{C}$).

4. Discussion and conclusions

Results obtained from the analysis of several charts representing the monthly mean zonal wind and thermal fields during May through September indicate some definite contrasting upper-air features for poor and good monsoon years. The features noted for May, the month preceding the commencement of the southwest monsoon season over India, could be used to obtain an outlook of the monsoon performance.

The major contrasting features noticed in the case of the zonal wind field are with respect to the areal spreading and strength of the zonal component. During a good monsoon year, the longitudinal as well as latitudinal extents of the easterlies in the tropics and the adjoining extratropics were significantly more than that during a poor monsoon year. The normal position of the axis of TEJ (viz, 150 mb) is found to have shifted to a higher level (100 mb) during good monsoon activity. This fact is also reflected in the wind shear. The good monsoon is further characterized by stronger easterlies. At 150 mb level, westerlies over Australia and Europe were conspicuously weaker during most of the months in the good monsoon year.

The only well-marked and consistent characteristic of the thermal field in almost all the months was that the upper troposphere over India, particularly over the northern parts, was cooler during the poor monsoon years than during the good monsoon year.

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