Shift of quasi-stationary flow features during active and break monsoons

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Abstract. During our search for dynamical differences in monsoon flows between the active and break phases of the monsoon, we noticed some interesting differences which may have some dynamical significance and do not appear to have been highlighted so far. There appear to be shifts of quasi-stationary flow features both in the lower and upper tropospheres.

Keywords. Active and break monsoons; east-west shift of quasi-stationary features; monsoon cyclogenesis.

1. Introduction

July mean winds at 200 mb level during good monsoon years 1964, 1967, 1973, 1975, 1976 and the drought years 1965, 1966, 1968, 1972, 1974 are considered. Figures 1 (a) and 1 (b) show the July mean winds at 200 mb during 1972 and 1976 respectively and the departures of the zonal and meridional components from their respective ten-year mean values. In July 1972 the Tibetan anticyclone appears to be centred east of the longitude of Lucknow (81° E), whereas in 1976 this anticyclone lies west of the longitude of New Delhi (76° E). This east-west shift of this quasi-stationary feature is in addition to its north-south oscillations referred to in literature on Indian monsoon (see for instance Ramamurthy 1969; Ramamurthy *et al* 1965). Figure 2 shows the departure from 10-year mean of the meridional wind components over north-western and central India at 200 mb during July of the good monsoon years and the drought years considered. The stations shown are Srinagar, New Delhi, Lucknow (or Allahabad), Jodhpur, Ahmedabad, Nagpur and Bombay. It is seen that there is some bunching of the observations indicating anomalous northerly winds during good monsoon years and southerly winds during drought years. Out of 24 observations of meridional wind at the above stations during drought years 19 have southerly components and 5 have northerly components; and out of 31 observations during good monsoon years, 24 show northerly components and 7 show southerly

Figure 1. Mean winds at 200 mb in July (a) during 1972 and (b) during 1976. The shafts indicate the July mean wind at 200 mb. The upper numbers give the departures (m/sec) of the July mean zonal winds from the ten year mean zonal wind. Similarly the lower numbers give the departures (m/sec) of the July mean meridional winds from the ten year mean meridional winds.

Figure 2. Departure from mean meridional winds during July at 200 mb over north-western and central India for good and bad monsoon years.

components. Such a difference in meridional winds in the upper troposphere over northwest India has also been noted by Joseph (1978) in some years. This therefore indicates that the east-west shift of the quasistationary feature has some association with monsoon performance.

Figures 3 (a) and 3 (b) show respectively the composite wind flow anomalies at the time of formation of monsoon disturbances and at the time of start of breaks in the monsoon. For details of the composites please refer to Alexander *et al* (1977). Besides the well-known differences in the lower tropospheric monsoon flow, i.e., cyclonic anomaly during the former cases and anticyclonic anomaly during the latter, subtle differences in the upper level flow features are seen. At the time of formation of monsoon disturbances, at 300 mb and 200 mb, there is anticyclonic flow (in the anomaly or departure) to the north-west of India thus leading to weakening of the easterlies and also of the vertical shear of the zonal wind. The decrease of vertical shear at the time of formation of monsoon disturbances has been documented by Keshavamurty *et al* (1978) and before the formation of monsoon disturbances by Raman *et al* (1978). On the other hand around the time of beginning of breaks and during breaks we have cyclonic flow (in the anomaly field) at 300 mb and 200 mb to the north-west of India and increased easterly flow at 200 mb over Bay of Bengal and hence increased vertical shear as mentioned by Keshavamurty *et al* (1978).

Figure 3 a. Composite wind flow anomalies at the time of formation of monsoon disturbances.

The east-west shift of the quasi-stationary feature over Tibet and neighbourhood could be part of the east-west shifts of the global monsoon of wave number two scale induced by anomalies in land-ocean heating contrasts as postulated by Keshavamurty *et al* (1978) or may be induced by local diabatic heating anomalies caused by anomalies of radiation, latent heat or advection fields. In 1972 both

appear to have played a part. To the north-west of India tropospheric temperatures were below normal during pre-monsoon and monsoon seasons. There also appears to have been an anomaly in land-ocean heating contrast, the Asian continent being cooler than normal and the atmosphere over Pacific Ocean being warmer than normal. Such shifts of quasi-stationary flow features and the associated changes in meridional and vertical shears may have a bearing on monsoon cyclogenesis as well as on the interaction of the monsoon circulation with the mid-latitude westerly regime.

References

- Alexander G, Keshavamurty R N, De U S, Chellappa R, Das S K and Pillai P V 1977 *Proc. Int. Symp. Monsoons* 1978 India, New Delhi *J. Meteorol. Hydrol. Geophys.* **29** 76
- Joseph P V 1978 *Vikram Sarabhai Lecture* (Ahmedabad : Physical Research Laboratory)
- Keshavamurty R N, Asnani G C, Pillai P V and Das S K 1978 *Proc. Indian Acad. Sci. (Earth Planet Sci.)* **87** 81
- Keshavamurthy R N, Satyan V and Goswami B N 1978 *Nature (London)* **274** 576
- Ramamurthy K 1969 *Forecasting Manual Unit* Indian Meteorological Department Rep. **4** 18
- Ramamurthy K M, Keshavamurty R N and Jambunathan R 1965 *Proc. Symp. Meteorol. Results* (Bombay : IIOE)
- Raman C R V, Rao Y P, Subramanian S K and Sheikh Z 1978 *Nature (London)* **276** 51