*Mausam*, (1985), **36**, 1 ,87-90

551.524.7 : 551.577 : 551.509.51

# A study of 300 and 200 mb temperature and wind over India in relation to forecasting onset of monsoon

H. N. GUPTA and HAMID ALI
*Meteorological Office, Safdarjung Airport, New Delhi*

(*Received 4 April 1981*)

**सार** — त्रिवेन्द्रम, मद्रास, बंबई, नागपुर, अहमदाबाद, जोधपुर और दिल्ली स्टेशनों के 1961-77 के अप्रैल मास के 300 तथा 200 मि० बार वायुमण्डलीय दाब पर मासिक पवन और तापमान आंकड़ों का अध्ययन किया गया है। तापमान के अक्षांशीय वंटन से पता चलता है कि 200 मि० बार स्तर पर जिन वर्षों में मानसून देर से आया (1964, 1967, 1968, 1972 तथा 1973), उनमें बंबई, उन वर्षों के मुकाबले (1961, 1962, 1970 तथा 1971) जिनमें मानसून जल्दी आया और औसत ज्यादा ठण्डा रहा। 300 मि० बार स्तर पर (17 वर्षों के आंकड़ों पर आधारित) बंबई, नागपुर की तुलना औसतन लगभग 0.9° से० अधिक गर्म है फिर भी जिन वर्षों में मानसून देर से आता है, बंबई, नागपुर से 0.1°से० अधिक ठण्डा होता है और जब मानसून जल्दी आता है उन वर्षों में बंबई, नागपुर से 2.3° से अधिक गर्म होता है। 300 मिलीबार पर शीघ्र मानसून वाले वर्षों के लिए बंबई में माध्य रेखांशीय पवन घटक उत्तरी होता है, जबकि विलम्बित मानसून वाले वर्षों में दक्षिणी होता है। इस शोध-पत्र में वर्ष 1979 (मॉनेक्स वर्ष) में दक्षिण-पश्चिमी मानसून की भी चर्चा की गई है।

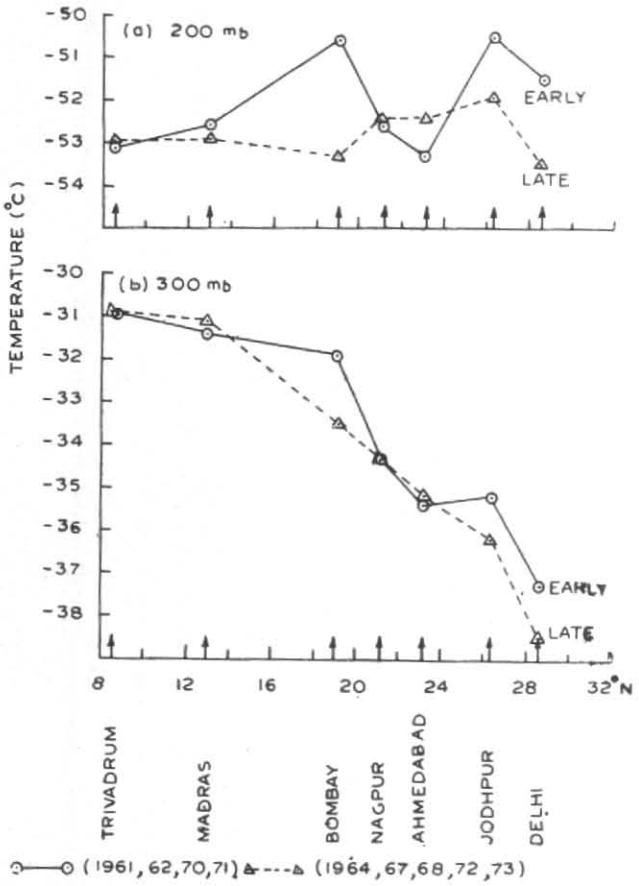
ABSTRACT. Monthly wind and temperature data at 300 mb and 200 mb for the month of April, for the years 1961-77 for the stations, *viz.*, Trivandrum, Madras, Bombay, Nagpur, Ahmedabad, Jodhpur and Delhi have been studied. Latitudinal distribution of temperature shows that at 200 mb level Bombay is on the average colder for the years of late onset of monsoon (1964, 1967, 1968, 1972 and 1973) than the years of early onset (1961, 1962, 1970 and 1971). At 300 mb level on an average (based on 17 years data) Bombay is warmer than Nagpur by about 0.9 deg. C. However for the years of late onset of monsoon Bombay is colder than Nagpur by 0.1 deg. C and for early onset Bombay is warmer than Nagpur by 2.3 deg. C. Mean meridional wind component at 300 mb over Bombay is northerly for the years of early onset and it is southerly for the years of late onset. Onset of southwest monsoon for 1979 (MONEX year) is also discussed.

## 1. Introduction

Advance information about onset of southwest monsoon and its activity over the country is very helpful to farmers as monsoon rains are of paramount importance to agriculture. The burst of the monsoon over Kerala has received considerable attention being the start for further advance over the rest of the country. The date of onset of southwest monsoon varies from year to year. The India Meteorological Department (India Met. Dep. 1943) has fixed the dates of normal onset of southwest monsoon and according to it the monsoon should burst over Kerala on 1 June, over West Bengal on 7th, over Bihar on 12th, over west Uttar Pradesh on 25 June and cover the entire country by the middle of July.

According to Ananthakrishnan (1970) transition from the winter to the summer type conditions, across the Peninsula, occurs by the middle of March at the surface and the transition moves up with time. At 100 mb it occurs by the end of April and the transition moves down with time. Desai (1971) has shown that the circulation in the upper troposphere would not appear to give rise to the lower tropospheric monsoon circulation; although there might be simultaneous development of both, there being no cause and effect relation between the two. Rai Sircar and Patil (1962) have concluded that at 9.0 km decrease of westerly component over the country from the beginning to the end of the month of April indicates early onset and increase of westerly winds the opposite. According to Thiruvengadathan (1966) westerlies over Trivandrum slowly increase in depth and extend to about 1.5 km about three pentads before the onset of monsoon.

Ananthakrishnan and Thiruvengadathan (1968) studied the reversal of meridional thermal gradients as derived from thermal winds (10 days means) at Trivandrum, Nagpur and Delhi in relation to onset of monsoon. They have shown that reversal starts in the upper troposphere about six weeks before the onset of monsoon at each of these stations and the onset of




Figs. 1 (a & b). Latitudinal distribution of mean temperature at (a) 200 mb and (b) 300 mb

monsoon rains at each of these stations takes place after the meridional thermal gradients have reversed at all the tropospheric levels between 200 and 700 mb. According to Ramamurthy and Keshavamurthy (1964) a more northerly position of the Arabian Sea anticyclone in April or early May appears to be associated with early commencement of the monsoon rains over Kerala.

In the present paper we have studied the monthly mean wind and temperature data at 300 and 200 mb for the month of April for the stations Trivandrum, Madras, Bombay, Nagpur, Ahmedabad, Jodhpur and New Delhi, in association with the onset of southwest monsoon, for the years 1961-77 and the results are presented. These have been applied to the onset of monsoon in 1979, the Monsoon Experiment year (MONEX) as a test case.

## 2. Data

*Monthly climatic data for the world* published by Environmental Service, Department of Commerce, Washington, U.S.A. and *Aerological Data* published by the India Meteorological Department are the source of data. Mean monthly values of temperatures for the stations Trivandrum, Madras, Bombay, Nagpur, Ahmedabad, Jodhpur and Delhi for the four years of early onset of monsoon (1961, 1962, 1970 and 1971) and for the five years of late onset (1964, 1967, 1968, 1972 and 1973) at 200 mb and 300 mb have been worked out. These are plotted in Figs. 1 (a) & 1 (b) respectively. The remaining 8 years during 1961-1977 had normal onset of monsoon.

Table 1 (a) gives the mean meridional wind component $V$ over Bombay and the mean temperature difference between Nagpur and Bombay '$t$ = temperature at Bombay *minus* temperature at Nagpur' at both the levels, *viz.*, 300 and 200 mb for the years of early onset (1961, 1962, 1970 and 1971) and for the years of late onset (1964, 1967, 1968, 1972 and 1973). Mean meridional wind components at these two levels over Bombay for 17 years (1961-77) and also the mean temperature difference between Bombay and Nagpur for these 17 years are also given in Table 1 (a). Table 1 (b) gives $V$ and $t$ values for individual years of early onset, *viz.*, 1961, 1962, 1970 and 1971 ; and of late onset, *viz.*, 1964, 1967, 1968, 1972 and 1973.

## 3. Discussion

### 3.1. *Normal upper air temperature and wind at 300 and 200 mb levels for the month of April*

In April, at 300 mb level a weak thermal high occurs over the south Peninsula and the temperature falls from 20 deg. N to 30 deg. N by 6 deg. C. The temperature is very flat at 200 mb, *i.e.*, -- 50 deg. C $\pm$ 2 deg. C. The sub-tropical ridge appears near about 10 deg. N at 300 mb. It shifts southwards to 8 deg. N, at 200 mb. At 200 mb level the anti-cyclone from the east extends upto Sri Lanka. Both at 300 and 200 mb levels winds are dominated by westerlies at 10 deg. N and higher latitudes (Rao 1976).

### 3.2. *Early onset of monsoon* (1961, 1962, 1970 *and* 1971)

The southwest monsoon advanced in 1961 in south Kerala on 18 May, in Bihar and east Uttar Pradesh on 6 June, in Himachal Pradesh on 13th and it covered the entire country by 21 June. In 1962, monsoon set in along the west coast in the second half of May. Monsoon extended upto Gujarat on 18 June and covered the entire country by about 21 June. Southwest monsoon set in over south Kerala on 26 May, in 1970. It advanced into Bihar State on 9 June and covered upto central Uttar Pradesh by 16th. The monsoon covered the entire country outside west Rajasthan by the end of June. In 1971, southwest monsoon set in over Kerala on 27 May. By 8 June it covered Gujarat, southeast Rajasthan, Madhya Pradesh, northeast India and east Uttar Pradesh. It covered the entire country outside Jammu and Kashmir by 26 June.

### 3.3. *Late onset of monsoon* (1964, 1967, 1968, 1972 *and* 1973)

In 1964, the southwest monsoon set in over Kerala on 5 June and advanced into northeast India by 15 June. It extended upto Uttar Pradesh by 25 June and covered the entire country by 5 July. In 1967

**TABLE 1(a)**

**Mean meridional component of wind at Bombay, and mean temperature difference between Nagpur & Bombay at 300 and 200 mb levels**

| Level (mb) | Early onset (1961, 62, 70 & 71) | | Late onset (1964, 67, 68, 72 & 73) | | 17 years (1961-77) | |
|---|---|---|---|---|---|---|
| | $V$ (mps) | $t$ (°C) | $V$ (mps) | $t$ (°C) | $V$ (mps) | $t$ (°C) |
| 300 | +3.4 | +2.3 | +1.5 | −0.1 | +0.3 | +0.9 |
| 200 | +1.1 | +1.9 | +3.7 | −0.9 | +3.4 | +0.1 |

$V$ is mean meridional component of wind and $t = t_B - t_N$ where $t_B$ and $t_N$ are temperatures at Bombay and Nagpur respectively

**TABLE 1(b)**

**Mean meridional component of wind at Bombay and mean temperature difference between Nagpur and Bombay at 300 and 200 mb levlels**

| Year | $V$ (mps) 300 mb | $t$ (°C) at 300 mb | $t$ (°C) at 200 mb | Remarks |
|---|---|---|---|---|
| 1961 | −9.5 | 4.4 | 5.5 | Early onset |
| 1962 | −1.1 | 4.0 | 4.7 | |
| 1970 | +6.2 | −0.5 | −1.0 | |
| 1971 | −9.0 | 1.4 | −1.6 | |
| 1964 | +1.0 | 0.0 | −0.5 | Late onset |
| 1967 | 0.0 | +1.6 | +0.5 | |
| 1968 | +1.5 | −1.9 | −4.0 | |
| 1972 | +1.7 | +0.2 | −0.3 | |
| 1973 | +6.5 | −0.4 | −0.2 | |

$V$ = Mean meridional component of wind,
$t_B$ = Temperature at Bombay,
$t_N$ = Temperature at Nagpur,
$t = t_B - t_N$

although the southwest monsoon advanced temporarily into Kerala on 13 May, it actually set in there on 8 June. It extended into Bihar by 18 June. Monsoon advanced progressively and covered the entire country by 2 July. In 1968, monsoon advanced into Kerala on 8 June. It extended into West Bengal, Bihar, Madhya Pradesh and east Uttar Pradesh by 20 June. Monsoon set in over west Uttar Pradesh by the end of June and covered the entire country by 9 July. In 1972, the monsoon set in temporarily over south Peninsula towards the second week of May, but retreated from there by the end of the third week of May. Monsoon revived over Kerala as late as 18 June. It advanced into Gujarat, south Madhya Pradesh and northeast India by 23 June and upto east Uttar Pradesh by 24th. It covered the entire country outside Jammu & Kashmir by the end of June. In 1973 also monsoon advanced temporarily on 23 May, but actually set in over south Kerala on 4 June. It covered northeast India, Gujarat, southeast Rajasthan and Madhya Pradesh by 13 June. Monsoon advanced into Uttar Pradesh, northeast Rajasthan on 3 July and covered the entire country by 6 July.

### 3.4. *Latitudinal distribution of mean temperature at* 200 *and* 300 *mb levels*

Figs. 1 (a) and 1 (b) show the distribution at 200 mb and 300 mb. It is seen from these figures that Bombay, Jodhpur and Delhi are colder in the years of late onset of monsoon than in the years of early onset. But Bombay is significantly colder. At 300 mb in both cases (*i.e.*, late as well as early onset) the temperature is decreasing as we go from lower latitude to higher latitude but at 200 mb no particular trend is appearing. It is significant to note that at 200 mb in case of early onset temperature is decreasing from Bombay to Nagpur while it is increasing in the case of late onset of monsoon.

### 3.5. *Meridional component of wind over Bombay at* 300 *and* 200 *mb*

Table 1 (a) shows that the mean meridional components of wind at Bombay for 17 years (1961-77) are *plus* 0.3 m/sec and *plus* 3.4 m/sec for 300 and 200 mb respectively. At 300 mb the mean meridional component of wind over Bombay is *minus* 3.4 metres per second (northerly) for the years of early onset (1961, 1962, 1970 and 1971) while the mean meridional component of wind for the years of late onset of monsoon (1964, 1967, 1968, 1972 and 1973) is *plus* 1.5 m/sec (southerly). At 200 mb the component of wind is less southerly, *i.e.*, 1.1 m/sec for the years of early onset than the years of late onset, *i.e.*, *plus* 3.7 m/sec.

From Table 1 (b) it is clear that except for the years 1967 and 1970, the years of late onset of monsoon show southerly component of wind over Bombay while the years of early onset show northerly component.

### 3.6. *Temperature difference between Bombay and Nagpur*

Table 1 (a) shows that on an average Nagpur is colder than Bombay at 300 mb as well as 200 mb in the years of early onset while it is warmer than Bombay for the years of late onset.

The mean difference of temperatures over Bombay and Nagpur, *i.e.*, $t = t_{\text{Bombay}} - t_{\text{Nagpur}}$ for 17 years (1961-1977) are *plus* 0.9 deg. C and *plus* 0.1 deg. C at 300 mb and 200 mb respectively. These $t$ values at these two levels are *plus* 2.3 deg. C and *plus* 1.9 deg. C respectively for the years of early onset whereas the $t$ values at 300 mb and 200 mb are *minus* 0.1 deg. C and *minus* 0.9 deg. C respectively for the years of late onset.

At 300 mb, except for the year 1967, the $t$ values for the years of late onset of monsoon are less than the mean $t$ values for 17-year period, *viz.*, *plus* 0.9 deg. C while the $t$ values for the years of early onset of monsoon except 1970 are higher than the mean value of *plus* 0.9 deg. C. At 200 mb the $t$ values do not exhibit any particular trend (In the year 1967 there was a temporary advance of monsoon over Kerala on 23 May, earlier than the normal date although it had actually set in on 8 June. In 1970 the onset was only 5 days earlier than the normal date).

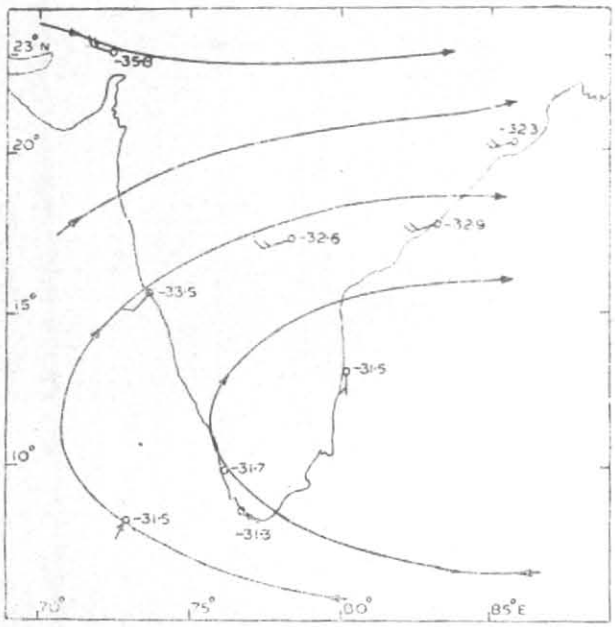



Fig. 2. Mean wind & temperature at 300 mb for April 1979

### 3.7. *Monsoon onset in* 1973

Joseph (1978) found that one of the causes for large scale monsoon failure is the delayed advance of monsoon over India in June although a delayed advance need not make a monsoon deficient in rainfall. He showed that in a large scale monsoon failure, a persistent and deep southward intrusion of sub-tropical westerlies of the upper troposphere occurs into areas immediately west of India and adjoining Indian areas during the monsoon season and that this intrusion has persistence of a few months prior to the monsoon season. Such an intrusion of sub-tropical westerlies associated with their colder temperature explains the stronger westerlies and southerlies over Bombay in April in a year of late onset and also the colder Bombay temperatures compared to Nagpur. In 1973 although the monsoon set in late, it was good. During 1973 the westerlies in upper troposphere from Bombay to Delhi were stronger as compared to that of the year of early onset and southerly component of meridional wind was dominating. The $t$ value for 1973 is $-0.4$ in comparison to $+0.9$ (the 17 years mean $t$ value).

### 4. Onset of southwest monsoon in 1979 (MONEX year)

Southwest monsoon advanced in Kerala on 11 June and it set in over northwest India outside Jammu & Kashmir and southwest Rajasthan as late as 11 July. The onset of monsoon was late over Kerala as well as over the rest of the country. The temperature data of Bombay and Nagpur for the month of April 1979 are not available (no ascents). On the basis of available data round the stations (Fig. 2) it is obvious that wind at 300 mb over Bombay is having southerly meridional component and also Bombay is colder than Nagpur. So the wind and temperature conditions in April 1979 at 300 mb according to the criterion shown in Table 1 (a) were not favourable for early onset of southwest monsoon in that year.

### 5. Conclusion

(*i*) Northerly mean meridional component of wind at 300 mb over Bombay in April is favourable for early onset of monsoon while southerly component is favourable for late onset.

(*ii*) Nagpur is colder than Bombay at 300 mb and 200 mb in April in the years of early onset while it is warmer than Bombay at these two levels for years of late onset.

*Acknowledgement*

The authors would like to thank Shri Subash Chander for preparing the diagrams and to Smt. Sneh Lata for typing the manuscript.

### References

Ananthakrishnan, R. and Thiruvengadathan, A., 1968, *Cur. Sci.*, **37**, 7, p. 184.

Ananthakrishanan, R., 1970, *Quart. J.R. met. Soc.*, p. 539.

Desai, B.N., 1971, *Indian J. Met. Geophys.*, **22**, p. 421.

India Met. Dep., 1943, *Climatological Atlas for Airman.*

Joseph, P.V., 1978, *Indian J. Met. Hydrol. Geophys.*, **29**, p. 412.

Ramamurthy, K.M. and Keshavamurthy, R.N., 1964, *Indian J. Met. Geophys.*, **15**, 2, p. 227.

Rai Sircar, N.C. and Patil, C.D., 1962, *Indian J. Met. Geophys.*, **13**, p. 468.

Rao, Y.P., 1976, *India Met. Dep. Met. Monogr.*, Synop. Met. 1/1976.

Thiruvengadathan, A., 1966, Mannual of 5th Forecasting Officers Conference at Pune, India Met. Dep.