

CHARACTERISTICS OF THE SOUTHWEST MONSOON AIRMASS

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ABSTRACT. The main features of the southwest monsoon airmass, as derived from radiosonde ascents of Trivandrum, Madras and Calcutta for the year 1947, are summarised. The mean temperature curves of the three stations plotted on a tephigram do not support the prevalent view that the monsoon air mass is a homogeneous entity and has a saturated adiabatic lapse rate.

The southwest monsoon has been studied by various workers with the surface data and occasional upper air temperature data. Since 1944 daily radiosonde ascents are being made at a number of stations in India and it is now possible to study the characteristics of the southwest monsoon in greater detail. In this note the main features of this airmass as derived from the data of Trivandrum, Madras and Calcutta for the year 1947 are summarised.

Trivandrum is located on the west coast of India about thirty miles from Cape Comorin. This may be considered as the first station in India to be struck by the southwest monsoon after crossing the equator. At this stage the southwest monsoon is uninfluenced by any travel over land. Madras is situated on the east coast of the peninsula and hence is very suitable for studying the characteristics of the monsoon air after it has crossed the Ghats (with associated lifting and subsidence) and also travelled over 400 miles of land. Calcutta is located at the place of deflection of the southwest monsoon into a south-easterly current under the influence of the monsoon through over Gangetic plain and would thus give the characteristics of the deflected monsoon.

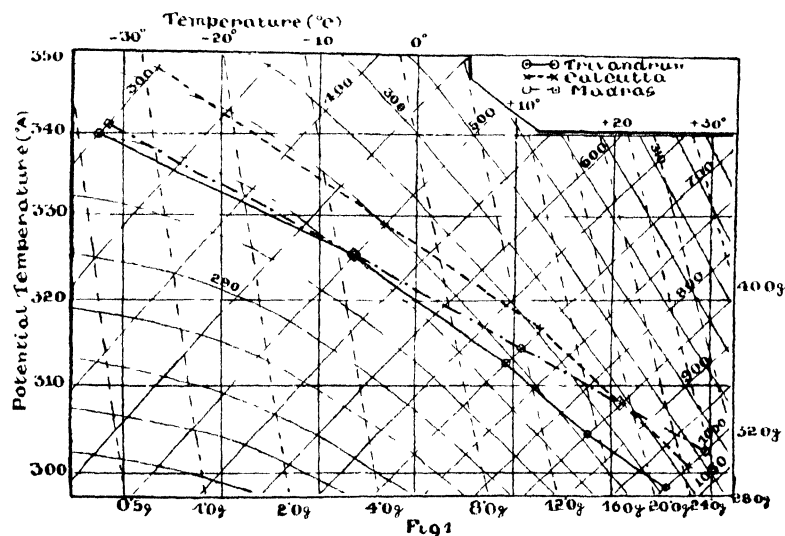


FIG. 1

Table I gives the variation of temperature at various levels, and also the mean temperature and the average variability. The monsoon at Calcutta is warmer at all levels than at Trivandrum by 2 to 5°C. At ground level Madras is warmest and at 850 mb, the temperature is the same as that over Calcutta. But from 700 mb. onwards the mean temperatures at Madras and Trivandrum are almost identical. This shows that the effect of the land travel in reaching Madras is confined only to levels below 700 mbs. and the Trivandrum characteristics are preserved aloft.

In Fig. 1, the mean temperature curves for the three stations are plotted on a tephigram. It will be seen that the lapse rates at both Trivandrum and Calcutta are distinctly greater than the saturated adiabatic. This does not agree with the prevalent view that the monsoon air mass has a saturated adiabatic lapse rate. At Madras the lapse rate between 1000 and 700 mbs. is greater than either of the other two stations but aloft the curve is identical with Trivandrum.

TABLE I
(a) Ground level

| Temperature (°C) | Trivandrum | | Calcutta | | Madras | |
|-----------------------------|--------------------|------------------|--------------------|------------------|--------------------|------------------|
| | No of occasions | Frequency (%) | No of occasions | Frequency (%) | No of occasions | Frequency (%) |
| 24 | 5 | 8.7 | . | ... | .. | .. |
| 25 | 20 | 31.5 | 2 | 3.5 | 1 | 0.9 |
| 26 | 49 | 53.5 | 7 | 11.6 | 3 | 2.6 |
| 27 | 5 | 5.4 | 17 | 28.2 | 11 | 9.5 |
| 28 | 1 | 1.1 | 19 | 32.2 | 15 | 12.9 |
| 29 | . | ... | 7 | 11.6 | 33 | 28.4 |
| 30 | .. | .. | 4 | 6.7 | 20 | 17.2 |
| 31 | .. | .. | 3 | 5.0 | 15 | 12.9 |
| 32 | .. | .. | 1 | 1.7 | 7 | 6.0 |
| 33 | .. | .. | . | . | 1 | 0.9 |
| 34 | ... | ... | . | . | .. | .. |
| 35 | ... | ... | .. | .. | 3 | 2.6 |
| 36 | ... | ... | ... | ... | .. | .. |
| 37 | ... | ... | . | . | 1 | 0.9 |
| Total No of Observations | 92 | | 60 | | 116 | |
| Mean Temperature (°C) | 25.6 | | 27.9 | | 29.6 | |
| Average Deviation | 0.6 | | 1.1 | | 1.6 | |

TABLE I (contd.)

(b) 850 mb. level

| Temperature (°C) | Trivandrum | | Calcutta | | Madras | |
|-----------------------------|--------------------|------------------|--------------------|------------------|--------------------|------------------|
| | No of occasions | Frequency (%) | No of occasions | Frequency (%) | No of occasions | Frequency (%) |
| 13 | | ... | | | 1 | 0.9 |
| 14 | 1 | 4.4 | | ... | . | ... |
| 15 | 10 | 11.1 | 1 | 1.7 | 1 | 0.9 |
| 16 | 11 | 12.2 | 1 | 1.7 | 1 | 3.4 |
| 17 | 18 | 19.7 | 2 | 3.3 | 4 | 3.4 |
| 18 | 26 | 28.9 | 7 | 11.7 | 11 | 9.5 |
| 19 | 18 | 19.7 | 6 | 10.0 | 12 | 10.4 |
| 20 | 2 | 2.2 | 14 | 23.5 | 19 | 16.3 |
| 21 | 2 | 2.2 | 10 | 17.2 | 23 | 19.8 |
| 22 | | | 9 | 15.0 | 15 | 12.9 |
| 23 | | | 5 | 8.3 | 20 | 17.2 |
| 24 | | . | 1 | 1.7 | 3 | 2.6 |
| 25 | | . | 1 | 1.7 | 3 | 2.6 |
| 26 | | | 1 | 1.7 | . | ... |
| 27 | | | 1 | 1 | ... | |
| 28 | | | 1 | 1.7 | . | . |
| Total No of Observations | 91 | | 60 | | 116 | |
| Mean Temperature (°C) | 17.1 | | 20.0 | | 20.6 | |
| Average Deviation | 1.3 | | 1.5 | | 1.8 | |

TABLE I (contd.)

(c) 700 mb. level

| Temperature (°C) | Trivandrum | | Calcutta | | Madras | |
|------------------------------|---------------------|------------------|---------------------|------------------|---------------------|------------------|
| | No. of occasions | Frequency (%) | No. of occasions | Frequency (%) | No. of occasions | Frequency (%) |
| 3 | 1 | 1.1 | .. | ... | ... | .. |
| 4 | .. | .. | .. | ... | 1 | 0.9 |
| 5 | 3 | 3.4 | .. | ... | 6 | 5.5 |
| 6 | 6 | 6.7 | .. | .. | 4 | 3.7 |
| 7 | 6 | 6.7 | 1 | 1.8 | 6 | 5.5 |
| 8 | 7 | 7.9 | 1 | 1.8 | 11 | 12.9 |
| 9 | 23 | 26.0 | 1 | 1.8 | 18 | 16.6 |
| 10 | 11 | 12.4 | 9 | 16.4 | 22 | 20.2 |
| 11 | 22 | 24.8 | 1 | 7.3 | 18 | 16.6 |
| 12 | 7 | 7.9 | 11 | 25.1 | 14 | 12.0 |
| 13 | 3 | 3.4 | 9 | 16.4 | 2 | 1.8 |
| 14 | .. | .. | 11 | 25.1 | 1 | 0.9 |
| 15 | .. | .. | 2 | 3.6 | 1 | 1.8 |
| 16 | .. | .. | .. | .. | 2 | 1.8 |
| Total No. of Observations | 89 | | 55 | | 109 | |
| Mean Temperature (°C) | 9.4 | | 12.2 | | 9.6 | |
| Average Deviation | 1.6 | | 1.4 | | 1.8 | |

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TABLE I (contd.)

(at 500 mb level)

| Temperature (°C) | Tiruvandrum | | Calcutta | | Madras | |
|------------------------------|---------------------|------------------|---------------------|------------------|---------------------|------------------|
| | No. of occasions | Frequency (%) | No. of occasions | Frequency (%) | No. of occasions | Frequency (%) |
| 0 | 2 | 2.5 | 3 | 6.2 | | |
| -1 | 2 | 2.5 | 1 | 2.1 | 2 | 1.9 |
| 2 | 2 | 2.5 | 9 | 18.8 | 3 | 2.9 |
| 3 | 5 | 6.3 | 7 | 14.6 | 7 | 6.5 |
| 4 | 5 | 6.3 | 11 | 22.9 | 9 | 7.9 |
| 5 | 17 | 21.3 | 7 | 14.6 | 20 | 20.5 |
| 6 | 8 | 10.0 | 9 | 18.8 | 14 | 13.2 |
| 7 | 1 | 1.3 | | | 11 | 9.7 |
| 8 | 5 | 6.3 | 1 | 2.1 | 9 | 7.9 |
| 9 | 7 | 8.8 | | | 5 | 4.7 |
| 10 | 1 | 1.3 | | | 5 | 4.7 |
| -11 | 2 | 2.5 | | | | |
| -12 | 1 | 1.3 | | | | |
| -13 | 1 | 1.3 | | | | |
| -14 | | 5 | | | | |
| -15 | | | | | 1 | 0.9 |
| -16 | | | | | | |
| -17 | 1 | 1.3 | | | | |
| Total No. of Observations | 8 | | 15 | | 15 | |
| Mean Temperature (°C) | 6.3 | | 5.5 | | 6.3 | |
| Average Deviation | | | 1.5 | | 2.1 | |

TABLE I (contd.)

(c) 300 mb. level

| Temperature (°C) | Trivandrum | | Calcutta | | Madras | |
|------------------------------|---------------------|------------------|---------------------|------------------|---------------------|------------------|
| | No. of occasions | Frequency (%) | No. of occasions | Frequency (%) | No. of occasions | Frequency (%) |
| -19 | | | 1 | 3.7 | ... | .. |
| -20 | | | | | ... | .. |
| -21 | | | 1 | 3.7 | ... | .. |
| -22 | | | 1 | 3.7 | ... | .. |
| -23 | | | | | 1 | 1.5 |
| -24 | | | 1 | 3.7 | | |
| -25 | | | 5 | 18.5 | 1 | 1.5 |
| -26 | 1 | 1.8 | 4 | 14.8 | 1 | 1.5 |
| -27 | 4 | 7.4 | 4 | 14.8 | 6 | 8.9 |
| -28 | 3 | 5.5 | | | 2 | 3.0 |
| -29 | 3 | 5.5 | 7 | 25.9 | 4 | 6.0 |
| -30 | 3 | 5.5 | 2 | 7.4 | 9 | 13.4 |
| -31 | 10 | 18.5 | 1 | 3.7 | 14 | 20.9 |
| -32 | 7 | 13.0 | | | 9 | 13.4 |
| -33 | 6 | 11.2 | | | 9 | 13.4 |
| -34 | 2 | 3.6 | | | 3 | 5.5 |
| -35 | 6 | 10.9 | | | 5 | 7.5 |
| -36 | 1 | 1.8 | .. | | 1 | 1.5 |
| -37 | 4 | 7.3 | | | .. | .. |
| -38 | 2 | 3.7 | | | 1 | 1.5 |
| -39 | 1 | 1.8 | | | 1 | 1.5 |
| -40 | | | | | .. | .. |
| -41 | | | | | .. | .. |
| -42 | | | | | .. | .. |
| -43 | 1 | 1.8 | | | | .. |
| Total No. of Observations | 54 | | 27 | | 67 | |
| Mean Temperature (°C) | -32.4 | | 26.6 | | -31.1 | |
| Average Deviation | 2.8 | | 3 | | 2.2 | |

The temperatures at ground level at Trivandrum are remarkably uniform, being on 85% of occasions either 25 or 26°C. This has given rise to the impression that the monsoon is a very homogeneous current. Table I, however, shows that *it is not so*. The temperatures at higher levels are not at all uniform, and vary between fairly wide limits. The average variability (which represents a measure of the degree of variation of temperature) steadily increases from 0.6 at the ground level to 2.8 at 300 mb. level. Thus even at Trivandrum the southwest monsoon is not a homogeneous airmass at upper levels and shows appreciable temperature variations. The average variability for Calcutta is more than that for Trivandrum at ground level and 850 mb. but less than Trivandrum aloft. This shows that the air at Calcutta is less heterogeneous than at Trivandrum at upper levels. The average variability at Madras is the highest at ground level and the same as at Calcutta at 850 mb. level. At 700 and 500 mb. it is nearly the same as at Trivandrum

which supports the view arrived at before that the air at Madras above 700 mb. is unmodified by the intervening land travel.

High relative humidity is an important property of the monsoon air mass. Table II gives the number of occasions when the relative humidity at 700 mb. level was less than 50%.

TABLE II

| Station | No. of ascents that reached 700 mb. level | No. of occasions when relative humidity at 700 mb. was less than 50% | Percentage of occasions when R. H. at 700 mb. was less than 50% |
|------------|---|--|---|
| Trivandrum | 80 | 15 | 18% |
| Madras | 109 | 9 | 8% |
| Calcutta | 55 | 4 | 7% |

Though at Trivandrum the monsoon is 'fresh' from the source region of the moisture, the relative humidity there at 700 mb. level is less than 50% more frequently than either at Madras or Calcutta. This seems to be all the more strange when we take into consideration a special feature pertaining to the year 1947. During this year there were fairly prolonged break in the monsoon and as such one would naturally expect that Trivandrum, being located at the southernmost point of India, would be more frequently under the sway of genuine southwest monsoon current than Calcutta and hence should show greater occasion of high humidities at 700 mb. than at Calcutta. In spite of this we find that on significantly greater number of occasions Trivandrum had a lower relative humidity at 700 mb level than Calcutta. As high humidity is the chief characteristic of the monsoon air mass, it may be concluded that the depth of the monsoon airmass at Trivandrum or Madras is less than at Calcutta.

An oft repeated statement is that the monsoon air, in crossing the Western Ghats and owing to any precipitation in its travel over Deccan, is denuded of moisture. Table III gives the mixing ratio (gm/kg) at Madras and Trivandrum at 850 and 700 mb. levels. Strangely the mixing ratio is greater at Madras than over Trivandrum. How the intervening land between Trivandrum and Madras acts as a source for moisture is a matter for further study.

TABLE III

| Average mixing ratio at Station | 850 mb 700 mb | |
|---------------------------------|---------------|------|
| | Madras ... | 13.6 |
| Trivandrum ... | 12.1 | 7.0 |

TABLE IV

| Station | No. of inversions or isothermal layers | Total No. of observations |
|--------------|--|---------------------------|
| Trivandrum | 22 | 92 |
| Madras | 21 | 116 |
| Calcutta ... | 4 | 60 |

The number occasions of occurrence of inversions or isothermal layers between 900 and 500 mbs. at the three stations is given in Table IV. Thus resistance to convection is more frequent at Trivandrum and Madras than at Calcutta.

Investigation of the monsoon characteristics at other stations and the significance of the day to day variations in temperature and humidity are in progress.

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