551·571·7 : 551·553·21

Precipitable water in the atmosphere over Trivandrum in relation to onset of monsoon

T. K. MUKERJI

Meteorological Office, New Delhi

(*Received 31 October 1961*)

ABSTRACT. The amounts of precipitable water in the atmosphere over Tivandrum have been computed for the period 15 May to 15 June for ten years, using the radiosonde data for these years. The results arrived at do not indicate any spectacular build up of precipitable water, before or on the date of onset of monsoon. The daily variations of precipitable water with height from May to June and its average vairation for the 12 months of the year are also discussed.

1. Introduction

The onset of the southwest monsoon along the west coast of India is marked by the sudden commencement of squally weather and rough seas accompanied by heavy rain. On the average this occurs in the last week of May or the beginning of June. It has been observed that the onset of the monsoon is associated with the movement of a disturbance, like a depression or a cyclonic storm, which increases the moisture content of the air. It can be reasonably expected that the depth of precipitable water in the atmosphere, in the transition from a dry to a rainy season, will show an increase and a downpour would occur when this reaches a critical value resulting in the sudden and spectacular onset of monsoon rains. Variations of the amount of precipitable water in the atmosphere are, therefore, studied in this note to detect any systematic increase before the onset of the monsoon.

2. Method of computation

The depth of precipitable water in a unit column of air extending from 1000 mb upwards was calculated following a method indicated by Solot (1939). The depth of precipitable water W between two arbitrary pressure levels p_o and p_n is given by $W = 0\cdot0004\ \overline{q}\ (p_o - p_n)$ inches, where $\overline{q}$ represents the average of the specific humidity between p_0 and p_n. In the present analysis, the precipitable water content of the layer from 1000 to 600 mb has been calculated. To obtain this we may express the precipitable water content (in inches) as

$$W = \Sigma\ 0\cdot0004 \left\{ \frac{q_o + q_n}{2} \right\} (p_0 - p_n)$$

$$= 0\cdot0002\ [(q_{1000} + q_{900})(1000 - 900) + (q_{900} + q_{850})(900 - 850) + \ldots + (q_{700} + q_{600})(700 - 600)]$$

The computations were done in a tabular form shown in Table 1. The standard pressure levels selected for this study are shown in the first column. Values of the humidity mixing ratio for these pressure levels were next calculated from radiosonde observations. Subsequently the specific humidity was obtained from the mixing ratio and entered in the third column. Finally, the value of the total precipitable water W between 1000 and 600 mb was entered at the bottom of column 4.

3. Data utilised

As the monsoon current normally strikes the Indian continent at Trivandrum late in May or the first week of June, the precipitable water content above this station for a

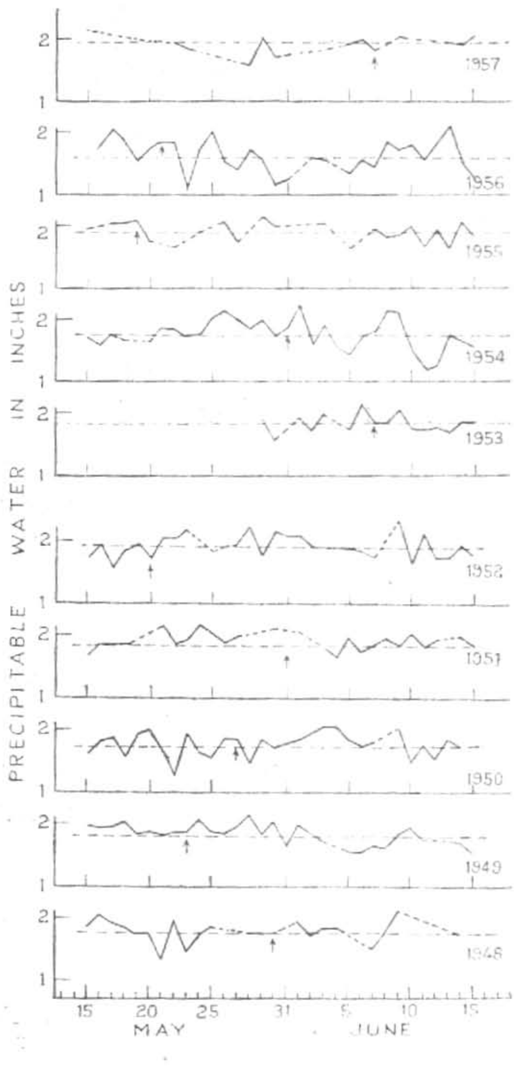

Fig. 1. Precipitable water over Trivandrum (May—June)

period centering round this week was computed by the method described above. The values of the water content for each of the 32 days from 15 May to 15 June, for a period of 10 years, was calculated by analysing the radiosonde data of Trivandrum for the years 1948 to 1957. The data for only the evening ascents were utilised. In almost all the ascents the highest level reached for humidity data was near 600 mb; consequently no information could be gathered about the moisture content above this level. Of the 10 years' data studied here, data for the period 15 to 28 May 1953 were not available. For the other years, on an average, observations for two days were missing on account of failure of flight. In a number of cases, temperature data for 600-mb level was absent owing to termination of the flight at a lower level. This constitutes a drawback on the method of computation. The same difficulty was experienced on a few occasions at 1000 mb, but this was overcome by substituting the data for the surface in place of 1000 mb. As Trivandrum is a sea level station, this is not expected to produce much error.

4. Analysis of results

4.1. *Day to day variations*—Values of the precipitable water content W for the 32-day period are shown in Fig. 1. Consecutive observations are joined by solid lines and missing data are indicated by dotted lines. The date of onset of the monsoon as published in the *Indian Daily Weather Report* or the *Annual Summary*, Part A, are indicated by arrows. Average values of W for each year are given in Table 2 and shown in Fig. 1 by solid horizonal lines. From Fig. 1, it will be noticed that there is an increase in the precipitable water content on a few days round the date of onset of the monsoon. This is what one might normally expect, but the highest value of W during the onset is usually less than other peak valves attained during the whole 32-day period. In other words, the amount of precipitable water in the atmosphere is not necessarily the largest on the date of onset of the monsoon, or a few days preceding the date of onset.

The figures do not indicate a gradual increase in the value of precipitable water content W with the approach of the monsoon. However, due to the large variations in the daily values shown in Fig. 1, the presence of

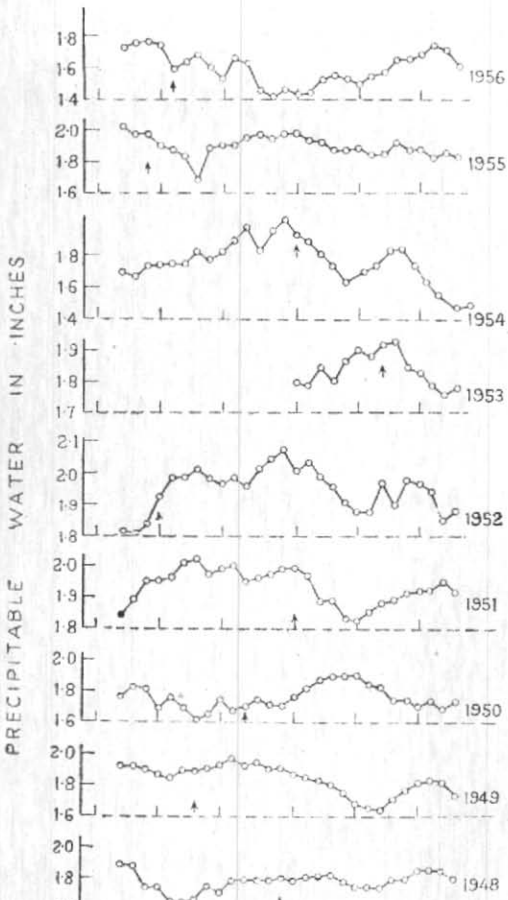

Fig. 2. Moving averages of precipitable water

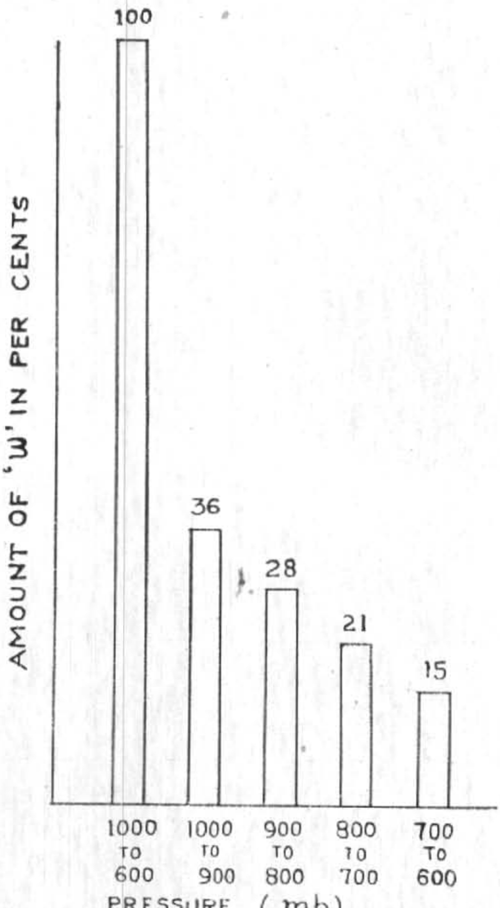

Fig. 3

TABLE 1

Method of calculation of W

Pressure (mb)	Mixing ratio (gm. kg⁻¹)	Specific humidity (gm. kg⁻¹)	W (inch)
1000	19·0	18·65	
			0·72
900	17·6	17·29	
			0·33
850	16·5	16·23	
			0·29
800	13·0	12·83	
			0·35
700	4·6	4·58	
			0·18
600	4·3	4·33	
Total			1·87

TABLE 3

Comparative values of W

	Mean dew point at 1000 mb (°C)	W (inches) From Tables	W (inches) Computed
1948	24·0	2·28	1·78
1949	24·0	2·28	1·81
1950	23·8	2·24	1·74
1951	24·0	2·28	1·84
1952	24·2	2·31	1·92
1953	23·8	2·24	1·84
1954	24·2	2·31	1·73
1955	24·2	2·31	1·88
1956	23·3	2·17	1·61
1957	24·8	2·41	1·94

TABLE 2

Values of W in inches

	Pressure level (mb)				
	1000-900	900-800	800-700	700-600	1000-600
1948	0·68	0·52	0·35	0·23	1·78
1949	0·66	0·51	0·37	0·27	1·81
1950	0·66	0·49	0·35	0·24	1·74
1951	0·68	0·55	0·41	0·20	1·84
1952	0·69	0·54	0·40	0·29	1·92
1953	0·66	0·53	0·38	0·27	1·84
1954	0·65	0·48	0·35	0·25	1·73
1955	0·64	0·53	0·40	0·31	1·88
1956	0·62	0·44	0·32	0·23	1·61
1957	0·68	0·53	0·43	0·30	1·94
Average	0·66	0·51	0·38	0·26	1·81

TABLE 4

Monthly values of the precipitable water content W in inches

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1·44	1·46	1·60	1·80	1·87	1·77	1·71	1·69	1·69	1·73	1·63	1·49

any increasing or decreasing tendency in the value of W is not brought out very clearly. To obtain this clearly the method of moving averages was employed. This process has the property of smoothening out the large fluctuations and so is very suitable for testing the presence or absence of trends. This method, however, presents a few difficulties because of the absence of observations on intermediate dates. As an approximation the missing data were substituted by the averages for the years, as indicated in Table 2. The five-day moving averages were then calculated and are depicted in Fig. 2. Among the period of study of ten years there is a continuous series of observations for fairly long periods for the years 1949, 1950 1952, 1954 and 1956. These may be considered more representative of the true state of affairs than the other five years. The curves indicate the absence of any marked build up of the precipitable water content in the atmosphere with the approach of the onset of the monsoon. They however, bring out the pulsating nature of W which is in agreement with the fluctuating character of the monsoon rainfall.

4.2. *Variation with height*—It is of interest to know whether the increase of precipitable water during this period is confined to any particular layer in the atmosphere. To assess this, the daily values of W were computed for different layers of the atmosphere for all the years during this period. It is found that, for every increase or decrease in W at the lowest layer, there is generally a corresponding increase or decrease at all the layers upto 600 mb. This shows that the influx of monsoon air in the atmosphere takes place at all heights upto at least 600 mb. The average values of W for different layers are shown in Fig. 3 as a percentage of its average amount between 1000 and 600 mb. It will be observed that the precepitable water content of the layers goes on diminishing with increasing height.

4.3. *Variation from month to month*—Apart from short period variations described above, there are seasonal variations in W. To study this the values of W for different months of the year were computed using normal values of temperature at standard pressure levels. These are shown in Table 4. It will be seen that there is a gradual increase in W over the months, with a maximum in the month of May and a minimum in January. There is a second increase of precipitable water in the month of October indicating the contribution of the northeast monsoon.

5. Estimation of W from dew point temperature

Tables are available to calculate the precipitable water content in the atmosphere as a function of dew point temperature at 1000 mb. These are computed on the assumption of a pseudo adiabatic lapse rate in the atmosphere. In Table 3, we have compared values of W based on this assumption with those computed by the method employed in this study. It will be noticed that the values in column 4 are always less than those in column 3, which implies that the precipitable water content does not reach the theoretical upper limit indicated by pseudo adiabatic lapse rate.

6. Summary

We may summarise the more important features brought out by this study as follows—

(1) There is no marked build up of the precipitable water in the atmosphere with the advance of monsoon.

(2) The maximum moisture level in the atmosphere is not generally reached on the date of the onset of monsoon. It may be attained before or after the date of onset.

(3) The transport of moisture during a 15-day period before and after the date of onset is not confined to any particular level in the atmosphere.

(4) The moisture content of the atmosphere is generally much less than that expected on the basis of pseudo adiabatic lapse rate.

REFERENCE

Solot, S. 1939 *Mon. Weath. Rev., Wash*, **67**, p. 100.