

On the intensity and areal coverage of the northeast monsoon rains in the districts of Madras State

S. GASPAR

Regional Meteorological Centre, New Delhi

(Received 11 February 1960)

ABSTRACT. In this paper an attempt is made to establish the relationship between the intensity of rainfall recorded by the India Meteorological Department Observatories in the Madras State during the northeast monsoon season and the intensity and areal coverage of rainfall in the districts in which the observatories are situated. The daily rainfall recorded at the large number of provincial raingauge stations in the State during a period of five years, has been analysed for this purpose and the analysis shows that associated with the occurrence of different intensities of rain at the Observatory stations, herein called the 'Pilot' station, the district receives certain well-defined types of rainfall.

A number of other features of the intensity and areal coverage of the northeast monsoon rains in Madras State are also brought out in the paper.

1. Introduction

The rains associated with the northeast monsoon affect only the southern parts of the Indian Peninsula and occur during the period October to December. Towards the end of this period, the northeast monsoon current becomes absolutely dry and rains cease altogether.

Madras State as a whole, receives more than half its annual rainfall during the northeast monsoon season. The importance of these rains to the agriculturists in this part of the country cannot, therefore, be overemphasised. In forecasting rain for the farmers in Madras State during the season, the intensity of the rain and its areal coverage are two important factors to be reckoned with. Fig. 1 shows the boundaries of each district of Madras State together with its area in square miles and the number of rain-recording stations. Beebe (1952) and Rai Sircar and Hariharan (1954) have shown that about 40 well distributed rain reporting stations are required in a circular area of 50 miles radius, *i.e.*, an area of about 7800 sq. miles, to give a correct indication of precipitation coverage. It will be seen from Fig. 1

that the number of the rain-recording stations in the various districts of Madras State generally conforms to the density of distribution required for a proper appraisal of the areal coverage of rainfall. In this paper an attempt has been made to examine the relationship between the intensity of rainfall recorded at an India Meteorological Department Observatory in each district treating it as a 'Pilot' station with the intensity and areal coverage of rainfall in the district as a whole. In doing so wherever there are two observatories in a single district, one of them, depending on its relative importance was treated as the 'Pilot' station and the other was counted along with the rain-recording stations maintained by the State Government.

2. Data used and method of analysis

In this analysis, the daily rainfall data of all the State raingauge stations published by the Government of Madras in their *Daily Rainfall Reports* as well as the data of all the observatory stations during the 5 years—1945, 1946 and 1952 to 1954—were used. The years 1947 to 1951 witnessed a complete failure of the northeast monsoon rains in Madras State and hence this period



Fig. 1. Map of Madras State

Map shows the district boundaries, their areas in sq miles (shown in brackets) and number of rain-recording station in each district (shown between hyphens)

was omitted from the analysis. A rain recording station was considered to have had a rainy day if it had, in accordance with the usual convention, a rainfall of 10 cents or more. With this criterion, the daily rainfall of all the eleven pilot stations during the five northeast monsoon seasons were tabulated. A total number of 460 days (92 days for each year) was considered for this analysis.

The total rainfall of all rain-recording stations which had 10 cents or more in a day and the number of such stations in the district were also tabulated for each of the 460 days. This was done for all the eleven districts of Madras State. From this data the daily average rainfall and the areal coverage of rainfall in each district was computed. Following the convention adopted in the India Meteorological Department the areal coverage in the district was designated as (1) dry, (2) scattered, (3) local, (4) fairly widespread or (5) widespread when the number of stations which recorded 10 cents of rain or more was (1) nil, (2) upto 1/3 of

the total number of stations including the pilot stations, (3) 1/3 to 2/3 the total number of stations, (4) 2/3 and more but less than the total, and (5) same as the total number respectively. The average rainfall of the district or the intensity of rainfall in the district as a whole for each day was classified in accordance with the India Meteorological Department practice as Dry (D) 0-9 cents, Very Light (VL) 10-17 cents, Light (L) 18-37 cents, Moderate (M) 38-125 cents, Rather Heavy (RH) 126-249 cents, Heavy (H) 250-349 cents, Very Heavy (VH) 350 cents and above.

The intensity of the rainfall recorded by the pilot station was also classified in a similar manner and a two-way table was prepared for each district, showing the number of occasions with different intensities of rainfall at the pilot station against the areal coverage and intensity of rainfall in the district on these occasions. Table 1 (a to k) shows the distribution of intensity and areal coverage of rainfall in the various districts of Madras State corresponding to the different intensities of rainfall at the observatory (pilot) stations in the district. Column 1 of this table shows the number of occasions when rainfall of different intensities occurred at the pilot stations. Columns 2 to 5 show the distribution of intensity and areal coverage of the rainfall in the district on these occasions. The total of column 1 is naturally 460, the total number of days considered. The totals under the different sub-columns showing different orders of rainfall intensity under columns 2 to 5, give the number of occasions of rainfall of different areal coverage and average intensity in the districts.

3. Discussion of results

A striking feature exhibited by the table is the fact that the intensity and the areal coverage of rainfall in districts associated with the different intensities of rainfall at the pilot stations are restricted to certain narrow limits. The number of 'dry' days at the pilot stations is considerably larger than the

TABLE 1

Intensity of at occasions the Pilot in Pilot Station Station	Number of Pilot Station	Intensity and areal coverage of rainfall over the district																							
		Scattered						Local						Fairly Widespread						Widespread					
		VL	L	M	RH	H	VH	VL	L	M	RH	H	VH	VL	L	M	RH	H	VH	VL	L	M	RH	H	VH
(a) District : CHINGLEPUT, Pilot Station : MENAMBAKKAM, Number of Provincial raingauge stations : 27																									
Dry	342	13	30	36	7	—	—	—	10	17	—	—	—	—	2	5	—	—	—	—	—	—	—	—	
Very Light (VL)	13	2	1	3	—	—	—	—	2	5	—	—	—	—	—	—	—	—	—	—	—	—	—		
Light (L)	19	—	1	4	—	—	—	—	3	4	—	—	—	—	1	5	—	—	—	—	—	1	—		
Moderate (M)	44	—	—	2	1	—	—	—	11	1	—	—	—	—	1	15	8	—	—	—	—	1	4		
Rather Heavy (RH)	24	—	—	—	—	—	—	—	—	2	—	—	—	—	7	6	1	—	—	—	—	6	1		
Heavy (H)	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—	3	2		
Very Heavy (VH)	8	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	2		
Total	460	15	32	45	8	—	—	—	15	39	1	—	—	—	4	32	20	2	—	—	—	2	13		
(b) District : SOUTH ARCOT, Pilot Station : CUDDALORE, Number of Provincial raingauge stations : 29																									
Dry	336	18	50	41	2	—	1	2	4	11	—	—	—	—	1	6	2	—	—	—	—	—	—		
Very Light (VL)	17	1	2	3	—	—	—	—	3	5	1	—	—	—	—	2	—	—	—	—	—	—	—		
Light (L)	27	—	5	1	—	—	—	—	2	8	1	—	—	—	—	8	—	—	—	—	—	1	—		
Moderate (M)	43	—	3	3	—	—	—	—	2	15	—	—	—	—	1	16	2	—	—	—	—	—	1		
Rather Heavy (RH)	19	—	—	—	—	—	—	—	—	2	—	—	—	—	11	1	—	—	—	—	—	4	1		
Heavy (H)	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1		
Very Heavy (VH)	13	—	—	—	—	—	—	—	—	1	—	—	—	—	1	3	2	1	—	—	—	1	2		
Total	460	19	60	48	2	—	1	2	11	42	2	—	—	—	3	44	8	2	1	—	—	7	3		
(c) District : NORTH ARCOT, Pilot Station : VELLORE, Number of Provincial raingauge stations : 26																									
Dry	357	11	40	37	6	1	—	—	8	20	2	—	—	—	3	2	—	—	—	—	—	—	—		
Very Light (VL)	26	2	2	2	—	—	—	—	7	5	—	—	—	—	2	6	—	—	—	—	—	—	—		
Light (L)	21	—	2	—	—	—	—	—	5	8	—	—	—	—	—	6	—	—	—	—	—	—	—		
Moderate (M)	35	—	—	3	—	—	—	—	1	5	1	1	—	—	—	20	1	—	—	—	—	2	1		
Rather Heavy (RH)	15	—	—	—	—	—	—	—	—	1	—	—	—	—	3	2	—	—	—	—	—	1	6		
Heavy (H)	4	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	1	1		
Very Heavy (VH)	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—		
Total	460	13	44	42	6	1	—	—	21	40	3	1	—	—	2	38	6	1	—	—	—	3	9		
(d) District : SALEM, Pilot Station : SALEM, Number of Provincial raingauge stations : 27																									
Dry	363	20	35	47	4	2	—	—	10	17	—	—	—	—	1	8	—	—	—	—	—	—	—		
Very Light (VL)	22	—	2	1	1	—	—	—	4	11	—	—	—	—	—	3	—	—	—	—	—	—	—		
Light (L)	21	1	1	3	—	—	—	—	—	9	—	—	—	—	—	7	—	—	—	—	—	—	—		
Moderate (M)	35	—	—	2	—	—	—	—	1	9	—	—	—	—	1	15	3	—	—	—	—	1	3		
Rather Heavy (RH)	14	—	—	1	—	—	—	—	—	5	—	—	—	—	4	3	—	—	—	—	—	1	—		
Heavy (H)	3	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1	—	—	—	—	—	—		
Very Heavy (VH)	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—		
Total	460	21	38	54	5	2	—	—	15	52	—	—	—	—	2	37	8	2	—	—	—	1	4		

intensities at pilot stations the areal coverage and the average intensity of rainfall in the districts also show a gradual shift to higher ranges, indicating that the rainfall of the pilot stations becomes an increasingly representative index on the rainfall in the district.

3.1. Occurrence of rainfall of different intensities at the pilot stations and in the districts

Another striking feature brought out by Table 1 is that, with the exception of Tiruchirapalli, the number of occasions when the pilot stations recorded moderate rain is of a distinctly higher order than the number of occasions when they recorded rainfall of other intensities (*vide* col. 1). In the case of Tiruchirapalli light rain is of the most frequent occurrence. However, considering the rainfall in the district as a whole regardless of the areal coverage moderate rain is most frequent in all the districts, including Tiruchirapalli. The occurrence of very light, light and rather heavy rain at the pilot stations comes next in importance. But taking together all types of areal distribution, the number of occasions of average light rain in the districts predominates over the frequency of occurrence of very light or rather heavy rain. The number of occasions of heavy or very heavy rain are, as may be expected, least in the order, both in respect of the pilot stations and the average rainfall in the districts.

3.2. Comparison of rainfall in coastal with interior districts

An examination of the number of rainy days and the average rainfall per rainy day in the coastal districts reveals that the districts of Chingleput, South Arcot and Tanjore which are directly exposed to the northeast monsoon current have a larger number of rainy days with more rain per rainy day, the numbers progressively increasing southwards as the coast-line comes more and more under the influence of the westward moving low latitude disturbances while there is a

reversal in the number of rainy days in the rain shadow districts of Ramanathapuram and Tirunelveli with less rain per rainy day. The latter, however, shows again an increase in the number of rainy days southwards apparently due to the fact that the low pressure waves which in the later part of the season move at very low latitudes, after precipitating rainfall over Ceylon, occasionally revive in the Gulf of Mannar and produce increasing amount of rain as one proceeds towards the tip of the Peninsula. This is no doubt assisted to some extent as in the case of the Nilgiris district by their nearness of the Western Ghats which act as an effective barrier to the moisture-bearing easterly winds.

A similar examination of the rainfall of the interior districts reveals that the rainfall decreases progressively towards the interior of the State. The above observations are also borne out in a general way by the average rainfall of the season in each district and the India Meteorological Department Observatories shown in Fig. 2.

3.3. Classification of the districts into groups with homologous pattern of rainfall distribution

Considering each district as a whole, it is found that the number of dry days in the northern districts of Chingleput, North and South Arcot and Salem is definitely higher than in the remaining districts. Further, among the days when the weather is dry according to the reports of the pilot stations the southern districts have rain on a larger number of occasions than the northern districts.

The percentage number of days in the districts when not even one station recorded 10 cents of rain varies from 43 per cent (South Arcot) to 49 per cent (North Arcot) of the total 460 days in the northern districts comprising Chingleput, North and South Arcot and Salem and from 31 per cent (Madurai) to 39 per cent (Nilgiris) in the

remaining districts of Madras State. It is also found that the above grouping of the districts of Madras State is also justified in a general way by the percentage frequencies of the occurrence of the different types of rainfall worked out districtwise from Table 1(a to k).

As a result of the differences noticed between the northern and southern districts during the analysis it is felt that it would be appropriate to divide the districts of Madras State into the following groups from the point of view of rainfall—

- (1) The northern districts comprising Chingleput, North and South Arcot and Salem, and
- (2) The southern districts comprising Tanjore, Tiruchirapalli, Coimbatore, Madurai, Ramanathapuram, Tirunelveli and Nilgiris.

3.4. Relationship between rainfall distribution in the districts and intensity of rainfall at the pilot stations

3.4.1. *Dry weather at pilot stations*—The percentage frequencies of the predominant types of intensity-cum-areal coverage of rainfall in the districts for different intensities of rainfall at pilot stations, including dry days were worked out from Table 1(a to k). From these computations, it is seen that there are five significant combinations of intensity-cum-areal coverage of rainfall in the districts, on occasions of dry weather at the pilot stations. It is seen that if any rain occurs in the district when the pilot station in the district reports dry weather, such rain will be scattered in areal coverage on three out of four occasions and on the remaining one occasion, the greatest chance is that it will be local. Whether the rainfall be scattered or local, the average intensity is mostly light to moderate. We may conclude that on such days the northeast monsoon as a whole is not dry but is weak over the area.

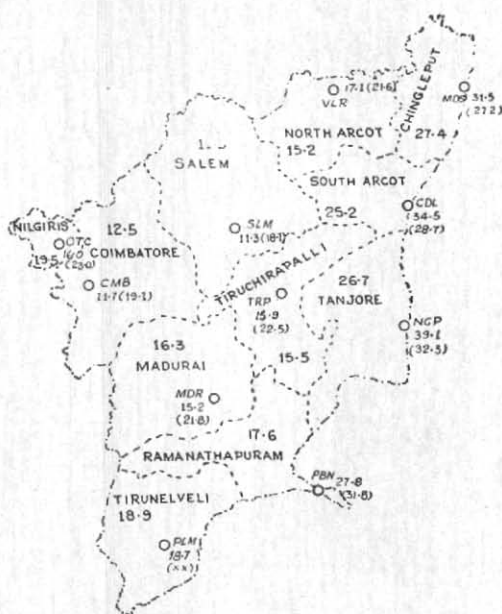


Fig. 2. Average rainfall of the northeast monsoon season in Madras State

3.4.2. *Very light rain at pilot station*—Frequency distribution of the intensity and areal coverage of rainfall in the districts when the pilot stations recorded very light rain was likewise worked out. On such occasions the intensity-cum-areal coverages of rainfall in the district fall into (i) Local—light to moderate, (ii) Scattered—light to moderate, (iii) Fairly widespread—moderate and (iv) Scattered—very light.

Local light to moderate rain is the most frequent type of rainfall in the northern districts of Chingleput, North and South Arcot and Salem whereas in south Madras State, local light to moderate rain is most frequent in some districts and scattered light to moderate rain in others. However, in all the districts, these two types of rainfall, together covers about 60 to 90 per cent of the frequencies of occurrence of rainfall of all types. Fairly widespread moderate rain generally comes next in the order of importance with a few exceptions. Occasions of

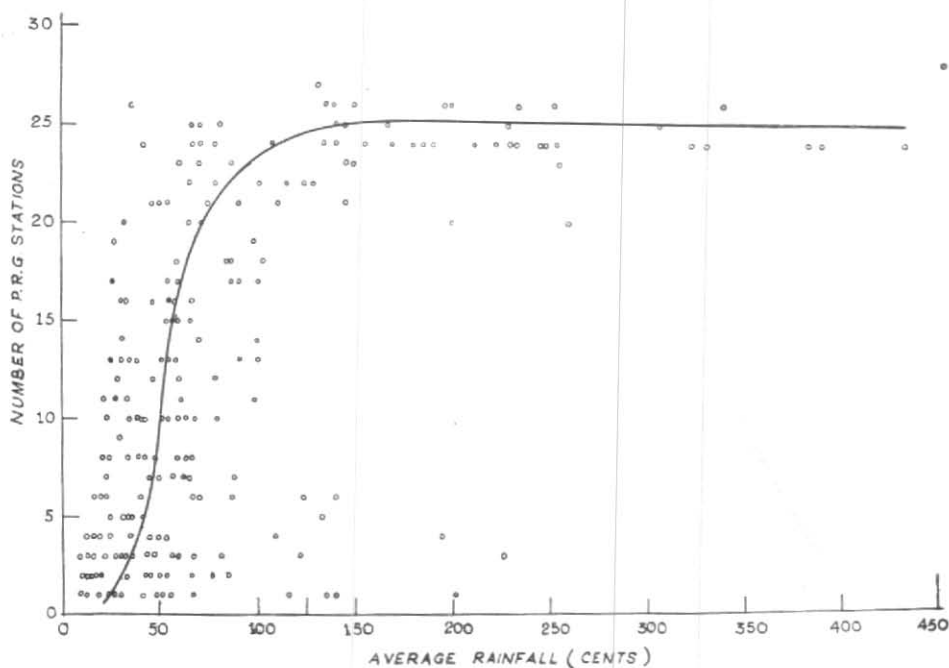


Fig. 3. District—Chingleput, Observatory—Madras

scattered very light rain, are generally least frequent. Ramanathapuram and Chingleput districts had this type of rainfall more often than the other districts and four districts namely, Salem, Madurai, Tirunelveli and Nilgiris did not have scattered very light rain at all when their pilot stations recorded very light rain.

3.4.3. *Light rain at pilot station*—In association with light rain at the pilot stations only three types of rainfall distribution are in common occurrence in the districts. These in the decreasing order of importance, are generally—(i) Local—light to moderate rain, (ii) Fairly widespread—moderate rain and (iii) Scattered—light to moderate rain.

3.4.4. *Moderate rain at pilot stations*—A reference to Table 1 (a to k) shows that rainfall of moderate intensity is most frequent during the northeast monsoon season in Madras State both at the individual station and in the district as a whole. Such rainfall

may be expected in active northeast monsoon conditions possibly in association with westward-moving low pressure waves. When the intensity of rain at the pilot station is moderate, three types of rainfall distribution are common in the district. These are, in decreasing order of importance—(i) Fairly widespread to widespread—moderate to rather heavy rain, (ii) Local—light to moderate rain and (iii) Scattered—light to moderate rain. The low frequency of scattered—light to moderate rain, shows that with the increase of the intensity of rainfall at the pilot stations the district average rain as well as areal coverage show an upward tendency.

3.4.5. *Rather heavy rain at pilot stations*—Although the number of occasions of rather heavy rain at the pilot station is small, the associated prominent types of rainfall in the district are only two, viz., (i) Fairly widespread to widespread—moderate to rather heavy rain and (ii) Local—moderate rain.

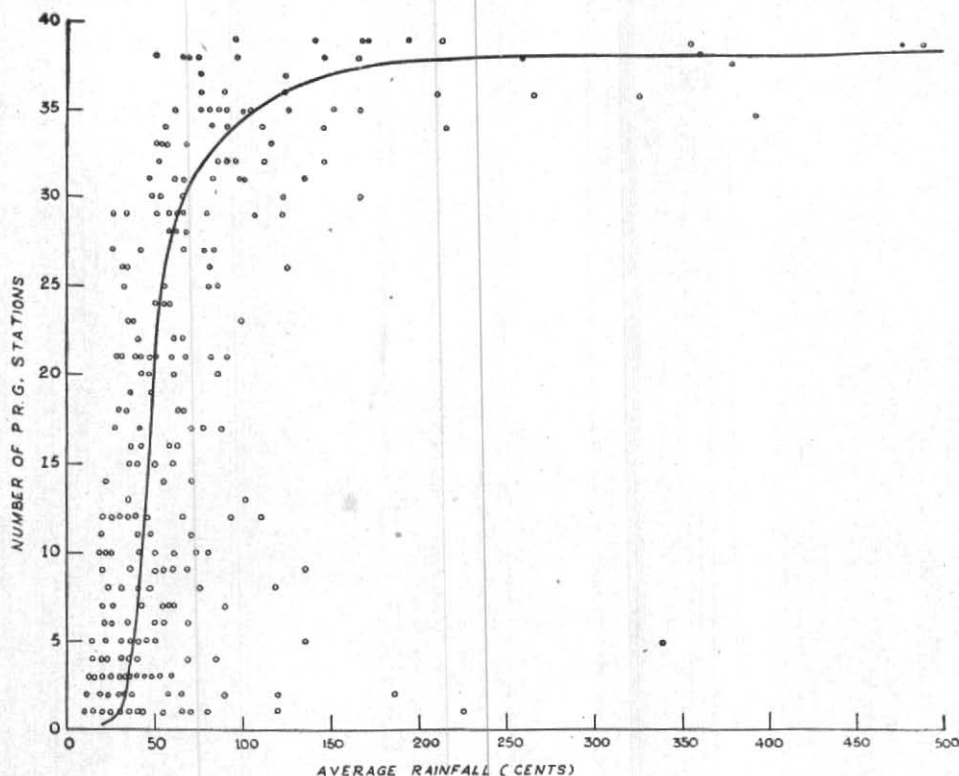


Fig. 4. District—Tanjore, Observatory—Nagapattinam

3.4.6 *Heavy or very heavy rain at pilot station*—Occasions of heavy or very heavy rain at the pilot stations in the period under study are too few to lend themselves to an analysis of this type. These require a separate study by themselves extending over a large number of years*.

4. Areal coverage in relation to average rainfall in the district

Scatter diagrams showing the number of rain-gauge stations reporting rain against average rainfall recorded by them were prepared for a number of districts (Figs. 3 to 7). It is seen from these diagrams that the curves take a hyperbolic shape becoming asymptotic when the average rainfall in the district is between 1.50 to 2.00 inches. The rise of the curve is steep in certain districts, e.g., Tanjore, showing that for the

same average rainfall in the district, different areal coverages are possible and in others, e.g., Tirunelveli, it is more gradual indicating that the areal coverage increases with the increase of average rainfall in the districts in the lower ranges of rainfall. In most districts, the density of the rain-gauge stations is sufficient to show that with an average rainfall of 2 inches, every station gets rain, or rainfall is widespread, the exceptions being Nilgiris and Tirunelveli districts where the density of rain-recording station is inadequate for proper appraisal of the areal coverage of rainfall. The graphs also show that scattered or local falls of heavy rain also occur in the districts where the density of rain-recording station is inadequate for proper appraisal of the areal coverage of rainfall. The graphs also show that scattered or local falls of

* Such a study has been taken up and will be discussed separately

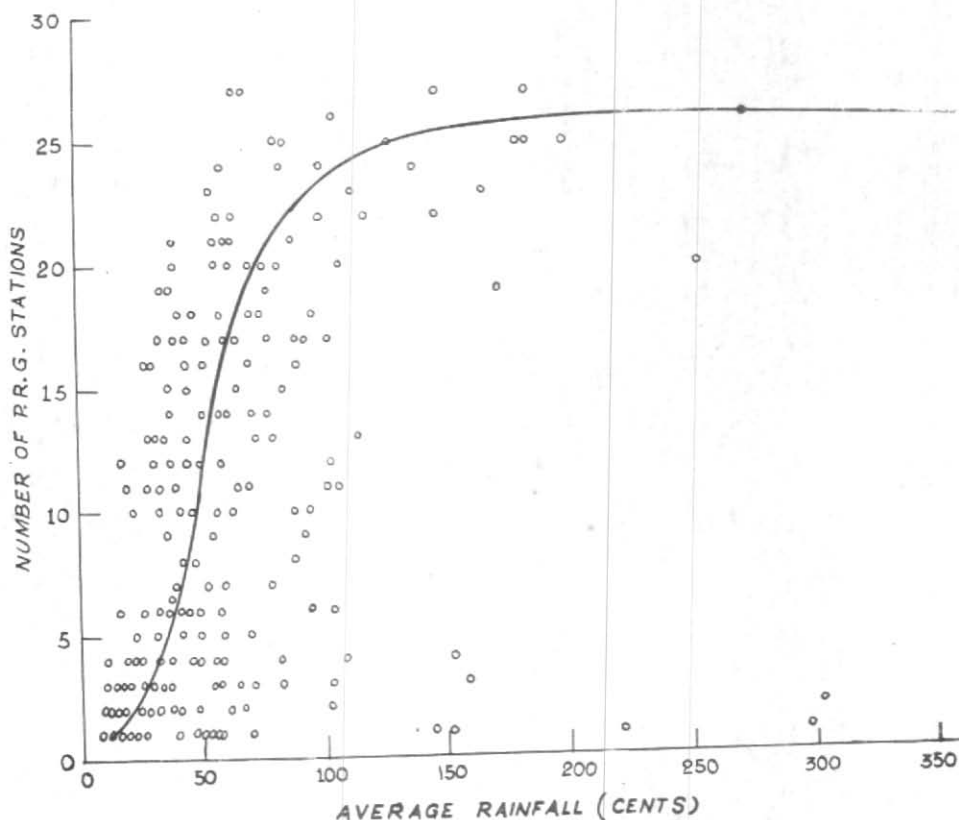


Fig. 5. District—Salem, Observatory—Salem

heavy rain also occur in the districts particularly in the interior districts although the number of occasions is comparatively small. Generally when average heavy rain occurs in a district, the whole district gets rain with intensity possibly varying by one stage on either side of the average rainfall, *viz.*, rather heavy in some places and heavy in some others and very heavy in the remaining places. However, the number of occasions of average heavy rain in each district during the period under consideration were too few to permit a detailed analysis.

5. Percentage frequencies of areal coverage and average intensity of rainfall in districts, considered independently of each other

Analysis was also made of the percentage frequencies of different types of areal coverage of rain in the districts during the period under consideration without reference to the

average intensity of rainfall in the districts and rainfall at the pilot stations. A similar analysis was also made of the frequency distribution of average rainfall in the districts without regard to the areal coverage, during the period.

It is found that in the northern districts of Chingleput, North and South Arcot and Salem, weather is dry on nearly half the number of days in the season. Scattered rain is the most frequent type of areal distribution occurring on about 22 to 28 per cent of the days. The frequencies of local and fairly widespread rain are of the same order and are together comparable to the frequencies of scattered rain. Widespread rain is comparatively rare. In the southern districts, frequencies of days with scattered rain are generally comparable with but slightly higher than

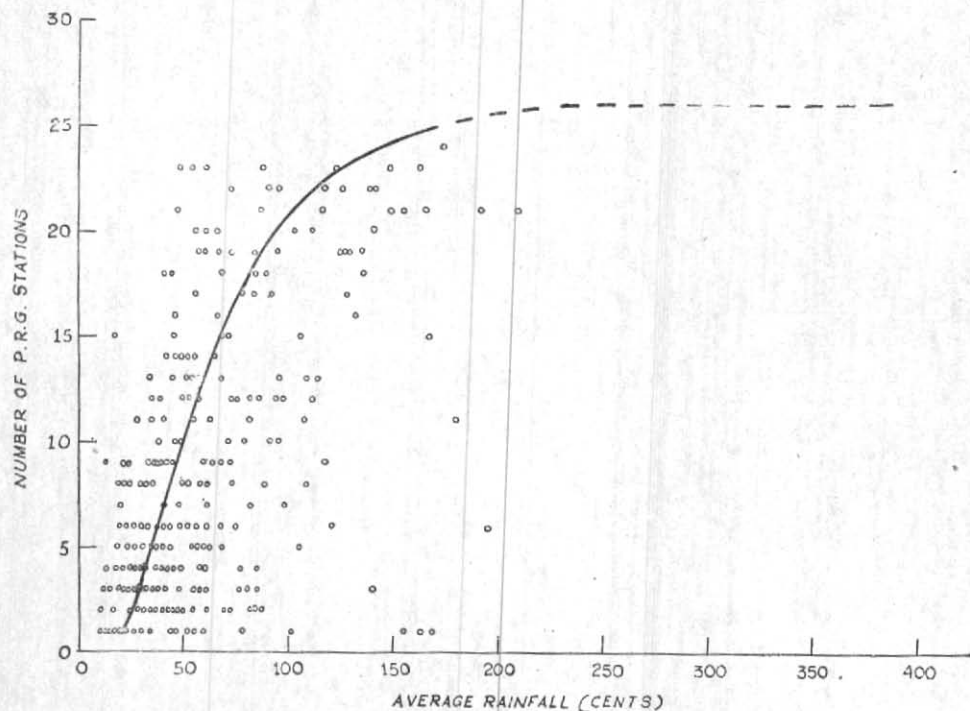


Fig. 6. District—Tirunelveli

those of dry days with the solitary exception of Nilgiris. Local rain is more frequent in the southern districts than in the northern districts, being 14.6 to 19.8 per cent of the total number of days. Frequencies of fairly widespread rain are comparable in magnitude to those pertaining to the northern districts. Frequencies of widespread rain are, however, distinctly lower than in the northern districts with the singular exception of Nilgiris. It is also seen that generally speaking, the average intensities of rainfall in the decreasing order are—

(i) Moderate rain, (ii) Light rain., (iii) Very light rain, (iv) Rather heavy rain, (v) Heavy rain and (vi) Very heavy rain.

A comparison of the frequencies in relation to the northern and southern districts of the state leads to the following interesting inference—

(i) Dry days are most frequent in northern districts.

(ii) Frequency of dry days and days in the moderate rain are greater in the northern districts than in the southern.

6. Conclusion

In conclusion, the results of the above investigation can be summarised as follows—

(1) The daily rainfall reports of India Meteorological Department Observatories of Madras State give a fair indication of the intensity and areal coverage of the NE monsoon rainfall in the districts in which they are situated.

(2) Occasions when some rainfall has been forecast for a district, but none was subsequently recorded by the India Met. Dept. Observatories are not to be treated as a failure of the forecast. Indeed, on more than 75 per cent of the occasions when the observatory had no rain and the district had some rain, scattered or local light to moderate rain occurred in the district.

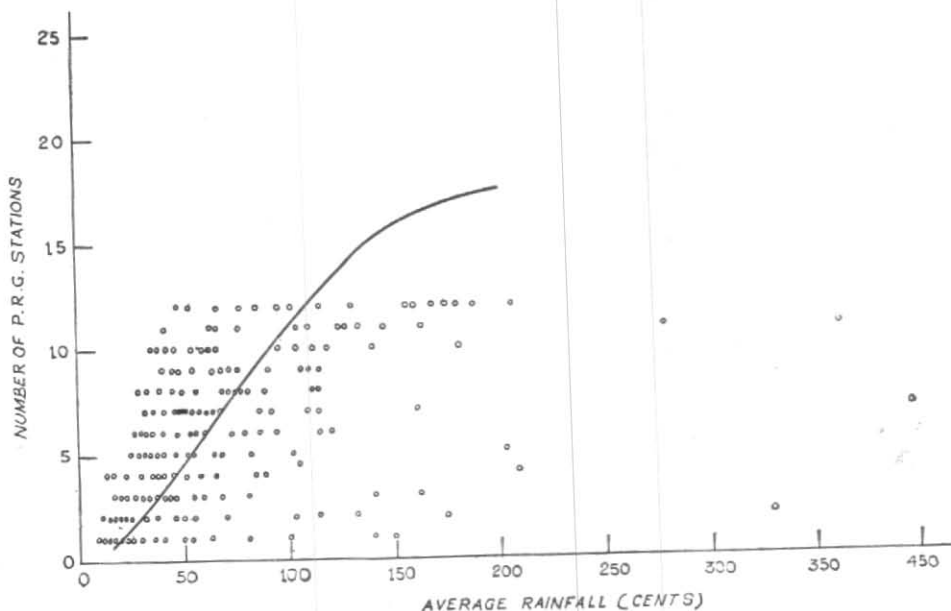


Fig. 7. District—Nilgiris

(3) When very light rain is reported by the pilot station, the district generally gets scattered or local light to moderate rain on 60 to 90 per cent of the occasions.

(4) When light rain is reported by the India Met. Dep. Observatory, local or fairly widespread light to moderate rain occurs in the district on nearly 75 per cent of the occasions and scattered light to moderate rain on the remaining occasions.

(5) When moderate rain is reported by the observatory, the district receives fairly widespread or widespread moderate to rather heavy rain on 56 per cent of the occasions on an average and local or scattered light to moderate rain generally on the remaining occasions.

(6) When rather heavy rain is reported by the observatory, the district as a whole

receives fairly widespread or widespread moderate to rather heavy rain on nearly 70 per cent of the occasions on an average and local moderate rain on above 20 per cent of the occasions.

Together, the above results indicate that the districts generally received higher weighted average rain than is indicated by the intensity of rainfall reported by the observatory. If the latter can be anticipated quantitatively, the utility of the above results is obvious.

The above investigation also shows that the districts of Madras State can be classified into two distinct contiguous groups with homologous patterns of rainfall, viz., 'northern districts' comprising Chingleput, North and South Arcot, and Salem and the 'southern districts' comprising the rest.

REFERENCES

- | | | |
|--|------|---|
| Beebe, R. G. | 1952 | <i>U.S. Weath. Bur. Mon. Weath. Rev.</i> , 80 , 6. |
| Rai Sircar, N. C. and Hariharan, P. S. | 1954 | <i>Indian J. Met. Geophys.</i> , 5 , 3, p. 219. |