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An analytical study of thunderstorms over Madras

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सार — 1981-90 के दौरान मद्रास (मीनामबक्कम) में झंझावतों की पृथक घटनाओं की विवेचनात्मक जांच की गई और झंझावात की घटना तथा दैनिक परिवर्तनों की आवृत्ति भी ज्ञात की गई। चंडवातों से संबद्ध झंझावातों की प्रकृति, तापमान तथा आर्द्रता में परिवर्तन की व्याख्या की गई है। मद्रास में झंझावात सक्रियता के लिए उत्तरदायी सिनॉटिक परिस्थितियों का उल्लेख किया गया है। स्थानीय प्रचंड झंझाओं का पूर्वानुमान ज्ञात करने के लिए सम्भावित दिशानिर्देश/सामान्य नियमों का प्रयोग किया गया और परिवर्तनों पर चर्चा की गई है।

ABSTRACT. Individual thunder occasions at Madras (Meenambakkam) during 1981-1990 have been critically examined and the frequency of thunder occurrence as well as the diurnal variations have been derived. Nature of thunderstorms as revealed in the release of squalls, change of temperature and humidity have been explained. Synoptic situations causing the thunder activity at Madras are outlined. Possible guidelines/thumb rules to forecast local severe storms have been attempted and the results are discussed.

Key words — Thunderstorm, Squalls, Monsoon, Frequency, Thunder, Humidity, Index.

1. Introduction

Thunderstorm is an important meso-scale system. Thunderstorms exhibit some dependence on the orography of a place and the climatology and signatures of thunderstorms over a place have to be studied specifically and critically. Madras (13° N, 80.2° E) is an important metropolis of peninsular India and lies in east coast. It has an international airport and a considerable amount of industrial activity goes on in and around Madras. Occurrence of thunderstorms is relevant to the various activities in this place. Hence a detailed study of the thunderstorms over Madras was taken up and the results are presented. A few statistical studies (Ramakrishnan and Ganapathiraman 1953, Sundararajan and Raghavan 1962, Raghavan *et al.* 1981, Sivaramakrishnan *et al.* 1985) on the occurrence of convective clouds around Madras are available. However, these are based on the radar observations upto about 50 nautical miles (92.6 km) around and a clearer picture can be derived only from the data collected from the *in situ* weather records at Madras.

2. Data

The current weather register of Meenambakkam airport observatory gives full details of the occurrence of thunderstorms over the place. The current weather registers for the period 1981 through 1990 were consulted. The autographic charts for the corresponding period have also been studied critically to derive the characteristics of the thunderstorms of the place.

3. Method of analysis

The thunderstorm occasions from the records were noted with full details. The frequency distribution over the months and the diurnal periods were computed. The occurrence of squalls among these thunder occasions were detected and the nature of the squalls was studied. Synoptic features responsible for the occurrence of thunderstorms over Madras were identified. Since local forecast for the metropolitan area is one of the services provided by the Regional Meteorological Centre, Madras, an attempt was also made to develop forecast criteria for the local thunderstorms.

An initial inspection of the data so collected revealed that the thunderstorm occurrence over Madras is least over the months January-March. During the study period of one decade only one thunder occasion in January and two occasions in March and four occasions in February were reported. Hence thunderstorms during April through December were critically studied in all years. While the convective development during pre-monsoon and southwest monsoon months is dominantly land-based (Raghavan *et al.* 1981) during the northeast monsoon months of October to December, convective clouds in association with cyclones

TABLE 1

Total frequency of thunderstorms weekwise

Month	Week				Total
	I	II	III	IV	
April	1	0	4	4	9
May	6	7	6	6	25
June	15	16	11	4	46
July	12	8	12	14	46
August	17	11	13	14	55
September	18	10	18	16	62
					243

TABLE 2

Occurrence of squalls

Month	Total thunder occasions	Squall frequency	%
April	9	1	11
May	25	4	16
June	46	8	17
July	46	7	15
August	55	5	9
September	62	7	11

and low pressure areas move from Bay of Bengal and give copious rainfall over Madras and neighbourhood.

4. Results and discussion

4.1. *Frequency distribution*

Table 1 presents the frequency distribution of thunderstorms during April-September. It can be seen that the frequency of thunder is more during southwest monsoon months. The later portion of southwest monsoon, *i.e.*, August and September, has got comparatively higher number of thunder days. Monsoon arrives over Madras latitude latest by mid-June. There is a temporary decrease in thunder frequency once the southwest monsoon airmass is established. Thunder frequency increases again from late July.

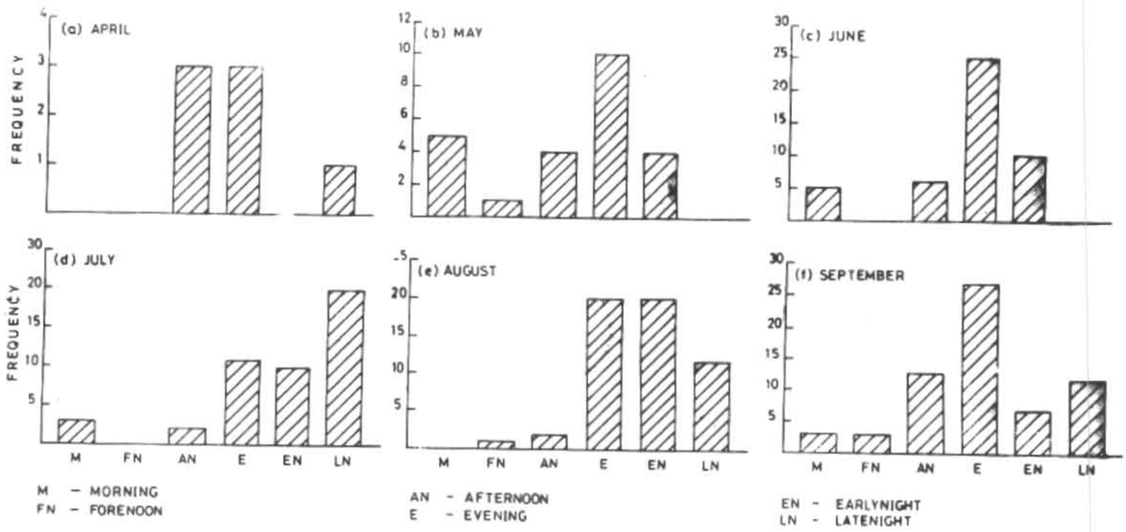
4.2. *Diurnal trend*

Figs. 1 (a-f) present the diurnal variation of thunderstorm occurrence. Since the thunderstorms over this place are essentially heat thunderstorms, mornings and forenoons have the least frequencies. The peak activity is in the evening during the pre-monsoon months (April/May) and June. This shifts to late night in July. By August the peak is evenly distributed between evening and night. The peak activity comes back to evening again in September when southwest monsoon is in receding phase. This is in agreement with the finding by Raghavan *et al.* (1981) and Venkateswara Rao *et al.* (1961) using the radar data. This tendency is also similar to the thunder occurrence over Sriharikota and island 70 km north of Madras (Sivaramakrishnan 1990).

4.3. *Temperature and winds*

One of the immediate effects of thunderstorm over any location is the fall of temperature and rise in humidity because of the cold downdraft released by the thunder clouds. This brings about thermal comfort to human beings also. During the pre-monsoon months of April/May, on about 24% of occasions, the fall of temperature was less than 2°C. The maximum fall observed was 5.7°C in pre-monsoon months and 8°C in monsoon months. The temperature fall was less than 2°C on about 56% of occasions in monsoon period. Thus, there appears to be some difference in the behaviour of thunderstorms of the pre-monsoon and monsoon seasons. One interesting point to note is that the temperature fall in all the months does not seem to have any correlation either with the time of occurrence of thunderstorm within a day or the rain amount or the prevailing ambient temperature just at the time of occurrence of thunderstorm. The increase in humidity is generally 10% or more in thunderstorms of southwest monsoon months.

The manifestation of kinetic energy in association with severe thunderstorm is the squalls. A squall is defined as sudden increase in wind speed by at least 28 kmph reaching 44 kmph or more and lasting at least for one minute. A squall of 80 kmph is generally categorised as severe squall. In all, 32 squalls were encountered during the decade. Table 2 gives the monthly frequency of squalls. June gets the highest number of squalls and it forms 17% of thunderstorms of June because the arrival of monsoon airmass is bound to react with the existing airmass. While no squall was recorded in the F/N, nearly



Figs. 1 (a-f). Thunder frequency (April-September)

60% of squalls were reported during night time only. Anytime in night seems equally probable for squall occurrence. Highest peak wind speed in association with squall was recorded as 99 kmph. While the squalls from east to south sector appear to be rare. 47% of the squalls occur from northwest direction. Fig. 2 gives the distribution of squall direction during the period of study.

4.4. *Thunderstorms during the northeast monsoon season*

October continues to get a good number of thunder occasions. By late October northeast monsoon sets in over this area and hence there is a sharp decline in thunder activity in November and during December there were only 5 thunder occasions in the study period. Table 3 brings out the thunder frequency during these months. Sometimes southwest monsoon continues to be present in the first week of October and normally there is a dull period of rainfall activity of about a week to ten days before northeast monsoon arrives in any year over this place (Sivaramakrishnan and Prakasam 1989). By the end of third week or so northeast monsoon rainfall activity starts with the active convective clouds from the Bay moving over the land. This behaviour is clearly revealed from the high thunder frequency in the first week of October falling down in the subsequent two weeks and again rising in the last week. Years of late onset of northeast monsoon can have the thunder frequency spilling over to the beginning of November also.

Fig. 3 presents the diurnal behaviour of northeast monsoon thunderstorms over Madras.

TABLE 3

Thunderstorm frequency during northeast monsoon

Month	Week				Total
	I	II	III	IV	
October	15	8	7	17	47
November	12	5	1	0	17
December	4	0	0	1	5

An important point to note is the near uniform distribution of local storms frequency over all parts of the day. While practically no thunderstorm occurs in morning and forenoon hours during southwest monsoon months. October and November have good probability of occurrence of thunder in morning and forenoon also. While a fall of temperature by 1 to 1.5°C is possible in association with thunderstorms in the first half of October, no cognizable fall of temperature or appreciable change in humidity could be noticed during the thunderstorms after mid-October. Thunder cells mostly approach from north in the early part of October. However the direction of approach was northeast or east after mid-October. While severe windspeeds in association with the passage of cyclones have been recorded during October to December, no thunder squall has been recorded during the period of study.

4.5. *Synoptic features and forecast criteria*

The weather charts of the ACWC, Madras for the thunder days were studied to see the synoptic

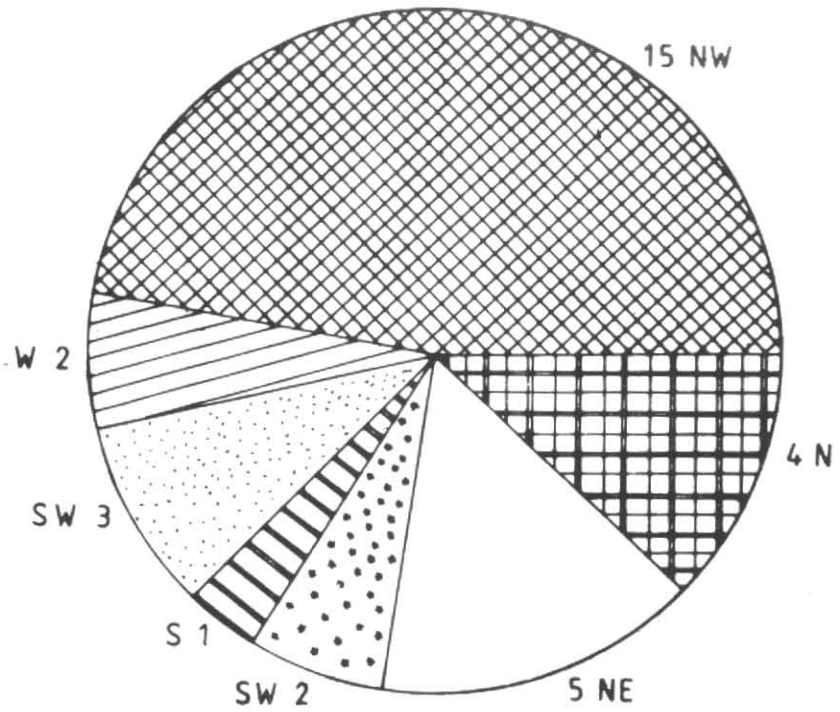


Fig. 2. Squall frequency (distribution of directions)

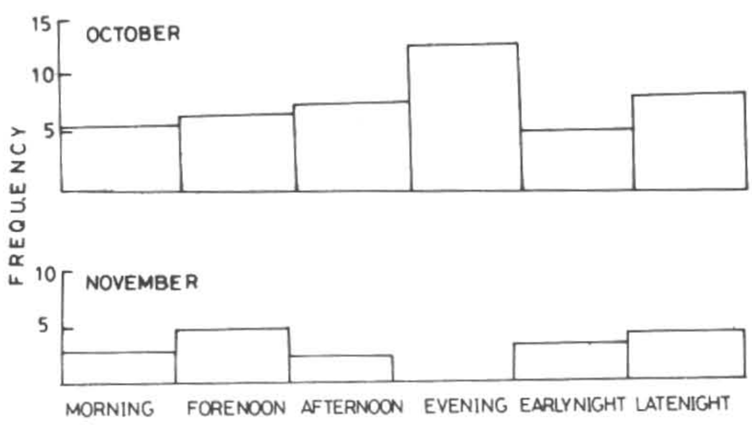


Fig. 3. Thunder frequency (October-November)

features of the day. It was observed that in April/May no notable synoptic feature could be identified either in surface or in upper air charts in about 56% of occasions. Hence on those days the thunder development was purely local. The occasions of such local thunderstorms during southwest monsoon months form 53% of total occasions. To the northwestern sector of Madras are located a few hillocks like Nagari and Nagalapuram Hills. Since the hills can provide the necessary vertical motion of air, convection could have been facilitated. These convective clouds can drift over Madras and rain. The dominant direction of the squalls being from northwest is significant in this respect.

A trough of low or a wind discontinuity could be seen to pass through either close to or over Madras, in about 19% occasions during April/May and in about 35% of thunder occasions during June to September. Upper air cyclonic circulations at any level upto 4.5 km above sea level over Tamil Nadu or adjoining areas seem to predict the thunder occurrence over this place, on about 1/4th of occasions during April/May and on 12% occasions during June to September. During southwest monsoon months cyclonic circulations at low or at mid tropospheric level over west central Bay and Andhra-north Tamil Nadu coast was the dominant feature on considerable days of thunder activity over Madras.

The forecasting of the thunderstorm, when there is no cognizable synoptic feature, is really a challenging job to the forecaster. Unfortunately occasions of occurrence of purely local thunderstorms form a little over 50% of total occasions both during pre-monsoon and monsoon over this place. Hence developing of possible thumb rules or guidelines was tried. Since mesoscale phenomena like sea breeze play a dominant part in deciding the daily maximum temperature and moisture incursion in the afternoon over the coastal stations, relationship, if any, between the occurrence of sea breeze and the thunder in evening/night hours was critically examined. It was found that neither the time of arrival of sea breeze nor the occurrence of sea breeze over this place has any relevance to the occurrence of thunderstorm over this place. Similarly the maximum temperature or the minimum temperature of the day also has no relation with the occurrence of thunder. Since Madras has got an aerological observatory, upper air data of 0000 UTC was used to get any clues regarding the nowcasting of thunderstorms. The Showalter (1953) index computed from the data was already established to be successful only in 65% occasions of thunder (Joseph 1957). George's index was also able to give only 50% success in thunderstorm forecasting (Reddy and Prakash Rao, 1977). SWEAT index (WMO 1992) which takes into account temperature, moisture and wind was above the threshold level on all the occasions of thunder occurrence. However, this index was above the threshold value on considerable occasions of non-thunder days also.

When the shear aspect was alone considered, on most of the thunder days in July and August, the wind shear between surface and 850 hPa level was 10 sec^{-1} or more, whereas, on clear days the value was less. Nevertheless this rule is not applicable during June and September. Shear at other levels upto 500 hPa or in the jet stream altitudes during monsoon months do not seem to give meaningful clue regarding the occurrence of thunder.

However, a somewhat reliable parameter from the available data appears to be the relative humidity at 600 hPa level. On about 95% of occasions of thunderstorms the relative humidity at 600 hPa was 60% and above in the morning. The value of 40% or less at this level suggests the remote possibility of thunder occurrence over the station till night 20 hours. Perhaps a judicious use of the above informations may help the forecaster to nowcast the local thunder occurrence. The radar observations in the afternoon hours, say 0900 UTC, may be helpful in this respect as a confirmatory test. However, the forecast of thunderstorms during October to December appears to be easy because most of the times the low pressure area or trough and the associated shear lines or circulations could be identified from the charts.

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