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AN ANALYTICAL STUDY OF THUNDERSTORMS OVER SRIHARIKOTA

1. One of the mesoscale systems in meteorology is the thunderstorm. The potential of danger with the thunderstorm lies in the lightning and squall associated with it and to a lesser extent, in the sudden shower it can give. In meteorology as a process which can bring about energy changes in shorter time scale that manifest in the environmental parameters, and also from climatological point of view, study of thunderstorms is important. However, for airfields and rocket ranges, the study has got a direct practical implication, as lightning can cause severe damages to aircraft and cause accidents in ranges. Again squall is a phenomenon wherein wind force increases suddenly and may affect physical structures and installations. Besides, the air-traffic and launch campaigns are put out of gear by sudden and prolonged thunder activity.

Thunderstorms show some dependence on the orography of the place. Hence the climatology and signatures of thunderstorms of each location have to be studied specifically. Study of squall and thunderstorms over several airfields in India, like Nagpur, Calcutta, Bombay, Hyderabad, Madras etc (Ramamurthy 1952, Ramakrishnan and Ganapathyraman 1953, Sunderarajan and Raghavan 1962, Dekate and Bajaj 1966, Mukherjee *et al.* 1983, Sivaramakrishnan 1987) are

TABLE 1

Frequency of thunderstorms

	Total occasions	Occasions when rain/squall occurred
Apr	3	2
May	6	4
Jun	6	3
Jul	10	3
Aug	7	2
Sep	12	3

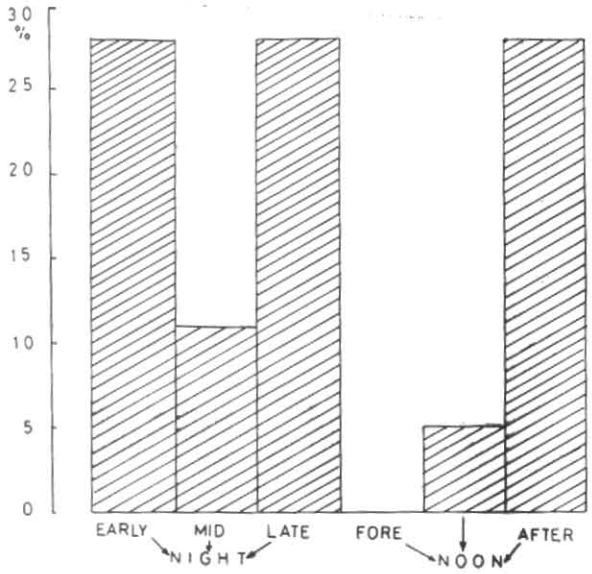

Fig. 1. Time distribution of thunderstorms

available. Sriharikota, located at 13.7° N, 80.2° E, is the major launching centre of the Indian Space Research Organisation. In order to support the planning and campaign activities for the launches detailed information on the thunderstorms/lightning occurrences is required. Hence a programme of intense weather watch for lightning/thunderstorms was conducted during April to September 1988 and the observational results are presented here.

2. During April/May thunderstorms develop over most parts of India and affect the weather. During the southwest monsoonal months of June to September also, Tamilnadu and coastal Andhra get thundershowers as per Indian climatology. Hence the program was confined to April to September 1988 when there was good chance of local thunder development. Days of lightning occurrence either over the station or nearby were noted with time. Again days of squall were also noted. Sometimes before lightning could be observed the convective cloud might have moved over the station and rained. Such occasions were also recorded. All the above observations were noted with time. The change and trend of meteorological parameters, like temperature, wind, humidity and pressure in association with these thunderstorms were also examined. As there is no instrument to measure the atmospheric electricity or the ground potential no quantitative measurement regarding lightning could be made. Only the occurrence has been recorded. Finally the occurrence of thunderstorms over Sriharikota has been compared with their occurrence at Madras which is about 70 km south and which has a Class 1 Meteorological Observatory.

3. *Results* — In all there were 44 days when thunder/lightning occurred over Sriharikota during the period. It was seen that all thunderclouds did not give rise to rain or squall. Some dissipated after exhibiting the lightning for sometime. Table 1 presents the picture of this fact. It could be seen that while in summer (April/May) more than 50% of lightning clouds give rise to rain or squall, it is 50% or less in the southwest monsoon season. Thus out of 44 occasions only in 18 occasions we had the rain either with or without squall. Our further discussion will be restricted to these 18 occasions, in detail, to derive the full signatures of the thunderstorms over the region.

Fig. 1 gives the histogram of the thundershowers during six periods of the day, *i.e.*, forenoon (6-10 IST), noon (10-14 IST), afternoon (14-18 IST), early night (18-22 IST), midnight (22-02 IST) and late night (02-06 IST). The time division is arbitrary. It is seen that afternoon, early night and late night seem to be the preferred periods for thundershowers while the forenoon (6-10 IST) is fully free from any thunderstorms. Raghavan *et al.* (1981), who studied convective activity around Madras using radarscope pictures, have also found the period up to 12 noon to be free from any convective activity in summer months of April to June which is in agreement with our results.

The prominent effect of thunderstorms in any location is the fall of temperature and rise in humidity. This brings about thermal comfort to human beings on those days. Some of the thunderstorms were accompanied by squall while some were not. Whenever the squall had occurred the fall of temperature was quick, *i.e.*, within about 20 minutes. However, when no squall occurred, the fall of temperature was steady and occurred within about an hour or so accompanied by the spreading of cold airmass with the rain. The lowest fall of temperature found was 2°, while the highest was 8°. Table 2 gives the temperature fall in details. Whenever the ambient temperature was greater than 35° C, the fall due to the arrival of thunderstorm was more than 5°. The temperature fall does not seem to have any correlation with the time of occurrence of thunderstorm, the rain amount or the wind speed in accompanying

TABLE 2

Temperature and humidity changes with the thunderstorms

Date (1988)	Temp. fall (°C)	Humidity rise (%)	Remarks
17 Apr	2.7	8	
21 Apr	5.7	6	
01 May	—	—	
03 May	4.0	12	
18 May	8.0	18	Squall
25 May	3.0	8	Squall
01 Jun	3.0	10	Squall
02 Jun	2.0	14	
21 Jun	4.7	14	
30 Jun	2.0	17	
03 Jul	2.7	10	
11 Jul	3.5	—	
12 Jul	3.0	—	
19 Jul	2.0	5	Squall
17 Aug	2.5	10	Squall
07 Sep	3.0	17	
15 Sep	4.4	—	
25 Sep	4.8	10	Squall

TABLE 3

Squalls over Sriharikota

Date (1988)	Pressure change (mb)	Peak wind (kmph)
18 May	1.7	50
25 May	4.0	57
1 Jun	2.0	59
2 Jun	2.0	58
19 Jul	1.2	51
17 Aug	1.0	44
25 Sep	0.0	50

squall, if squall had occurred. Table 2 also gives the details of humidity change due to thunderstorm occurrence. The increase in humidity is generally 10% or more in thunderstorms of southwest monsoon months.

A squall has been defined as a sudden increase in wind speed by at least 28 kmph (8 mps) reaching 44 kmph or more and lasting at least for one minute. A squall of 80 kmph has been classified as a severe squall. In all, 7 of these thunderstorms caused squalls. All the squalls occurred during nights. Any time in night seems to be equally probable for squall occurrence. Table 3 gives the details of the squalls. The peak wind speed in the squalls is very important and that is also shown here.

It is seen that the maximum wind speed touched was 59 kmph and thus all the squalls can be called as 'moderate'. The squalls were found to occur throughout the period May to September with a greater percentage in the earlier. None of the squalls was found to approach from east.

The weather charts of Regional Meteorological Cen tre Madras for the thunderstorm days were studied to identify the synoptic features of the day. On five days there is no significant synoptic system either at surface level or at higher levels. Hence on those days the thunder development must be purely 'local'. To the west of Sriharikota is located Sullurpet and some hillocks are nearby. As hillslopes can provide the necessary vertical motion for air, convection must have started. This feature can be fully understood if we have radiosonde ascent at Sriharikota with which we can construct the energy diagram (tephigram) and discuss the stability in the atmosphere. Unfortunately no such data are available. However, radiosonde ascents are already planned and when we get routine temperature data, the local development of thunderstorm may be well understood.

Of the remaining two occasions, an upper air cyclonic circulation over Telangana and neighbourhood up to 1.5 km a.g.l. with a trough extending or running near Sriharikota was noted on the thunderdays during April and May. In fact a trough line over Andhra coast could be seen even on surface charts on 25 May 1988, when thunder activity took place over SHAR and Madras. During the southwest monsoon months of June to September, a cyclonic circulation at low and mid-tropospheric levels over west central Bay and the Andhra coastal areas was the dominant feature on days when thunder activity took place over Sriharikota. There were occasions when trough line ran from Andhra coast to south Tamilnadu when thunderstorm occurred over Sriharikota. This information may help the forecaster for thunder warning purposes.

India Meteorological Department is having a Class 1 Observatory at Madras which is about 70 km south of Sriharikota. Daily weather report of the Regional Meteorological Centre and the weather charts were consulted for the days when thunderstorm occurred over Sriharikota. It was seen that the thunderstorm had occurred at Madras also on about 2/3rd of occasions though the amount of rainfall varied.

4. *Summary and conclusions* — Thunderstorms and lightning do occur on a considerable number of days over Sriharikota during April to September. Some thunderstorms cause 'squalls' also which can be called moderate squalls. Night followed by afternoon are the preferred periods for thunderstorms occurrence. The temperature fall associated with the squall can be as high as 8° while at least 2° fall is brought about in the environment by any thunderstorm. On about two third of occasions thunderstorms over Sriharikota occur simultaneously with the thunder activity at Madras.

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