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Letters to the Editor

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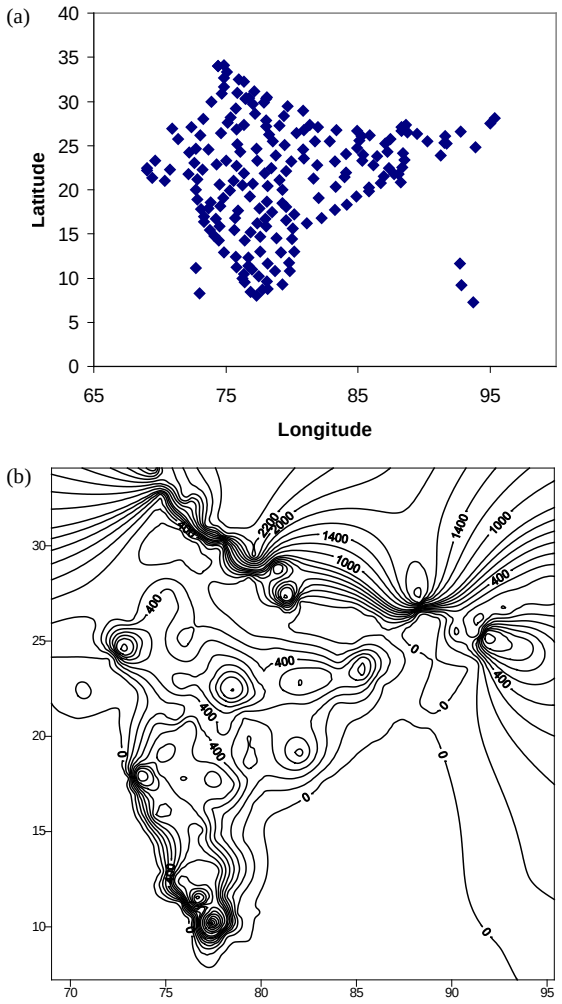
STUDY ON THE FREQUENCY OF THUNDER-STORM OCCURRENCES DURING PRE-MONSOON SEASON FOR THE YEARS 1994-2003 OVER INDIAN REGION

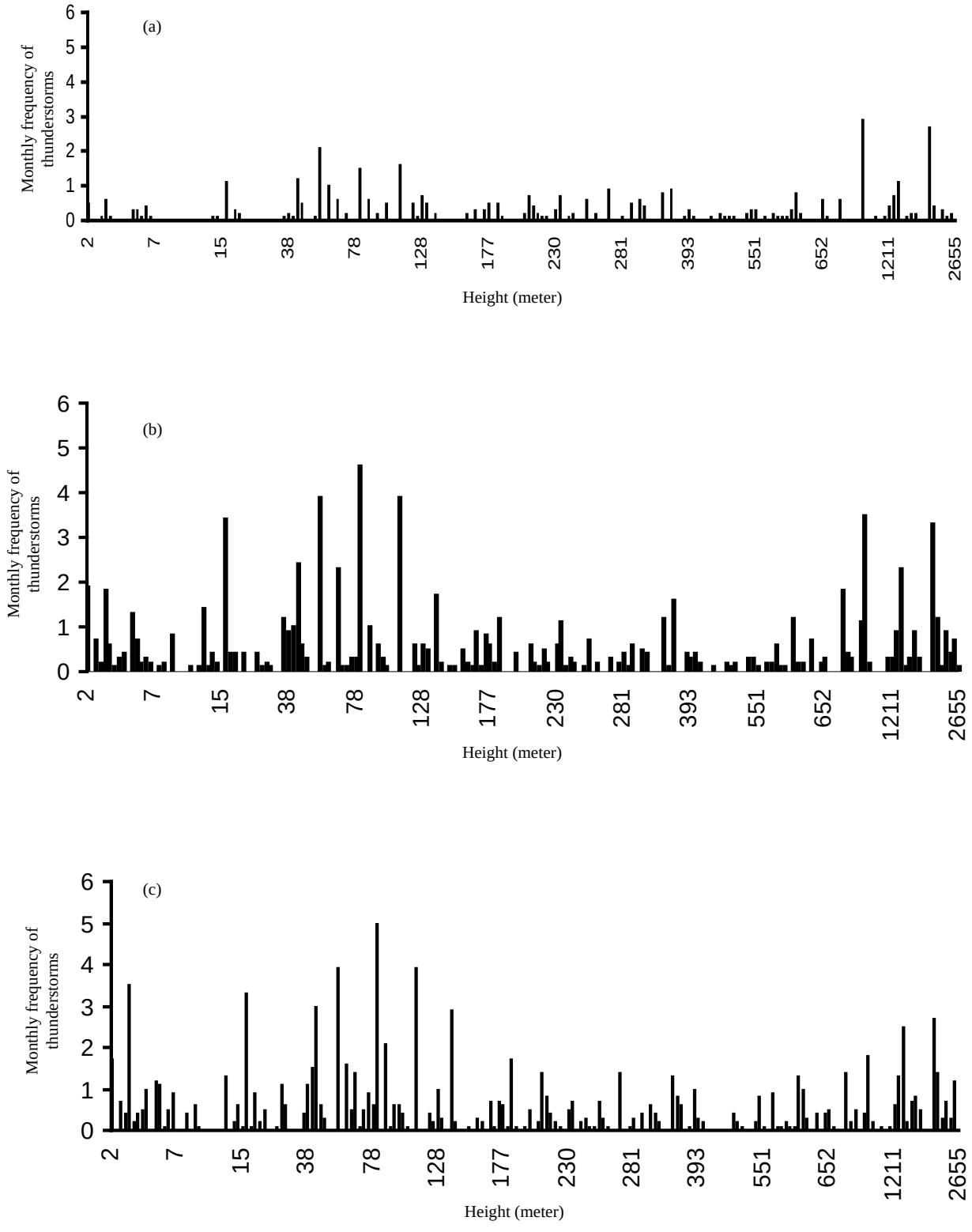
1. Thunderstorms being a prime agencies participating in the atmospheric electricity and also playing an important role for the occurrence of heavy precipitation, the study of thunderstorms has drawn the attention of researchers globally. Many regions of India are benefited by the heavy precipitation due to thunderstorm activity and are some times responsible for heavy flooding especially over the northeastern parts of India (catchment of Brahmaputra). Many earlier studies have highlighted understanding and evolution of thunderstorms, conditions favourable for the occurrence of thunderstorm, thunderstorm response to temperatures, role of upper tropospheric water vapour in the development of thunderstorms and the role of climatic extremes on the frequencies of the occurrence of the thunderstorms (Srinivasan *et al*., 1973; Manohar *et al*., 1999; Williams and Stanfill, 2002 etc). Srinivasan *et al*., (1973) have discussed the climatological features of pre-monsoon (March to May; MAM) season over India and the associated thunderstorm activity over different regions of the country. The occurrence of thunderstorms over Indian region can be associated with the migration of the Inter Tropical Convergence Zone, local heating and convective instability etc. (Manohar and Kesarkar, 2003, 2004 & 2005). Mukhopadhyay *et al*., (2003) have discussed the objective forecast techniques of occurrence of thunderstorm. The study by Ohsawa *et al*., (2001) on diurnal variation of convective activity and rainfall in tropical Asia have shown that the maximum convective activity tend to occur during afternoon and early evening hours centered at 17 hrs of local time (around 1200 UTC) or during the late night or early morning hours centered at 4 hrs of local time (around 2230 UTC).

The present study focuses the attention on the variation of mean monthly thunderstorm activity over Indian region during the pre-monsoon season (MAM). The variation of mean monthly frequency of thunderstorm occurrences at morning time and afternoon time has been studied for a period of 10 year from 1994 to 2003. The categorization of thunderstorm reporting stations is made based on the time of occurrence of thunderstorms and also based on the percentage ratio of number of thunderstorms occurred at 0300 UTC to that at 1200 UTC. Efforts have been made to compare the occurrence of thunderstorm activity at these timings on various perspectives. Further, the study has been carried out to understand the influence of topography on thunderstorm occurrences and their regional associations.

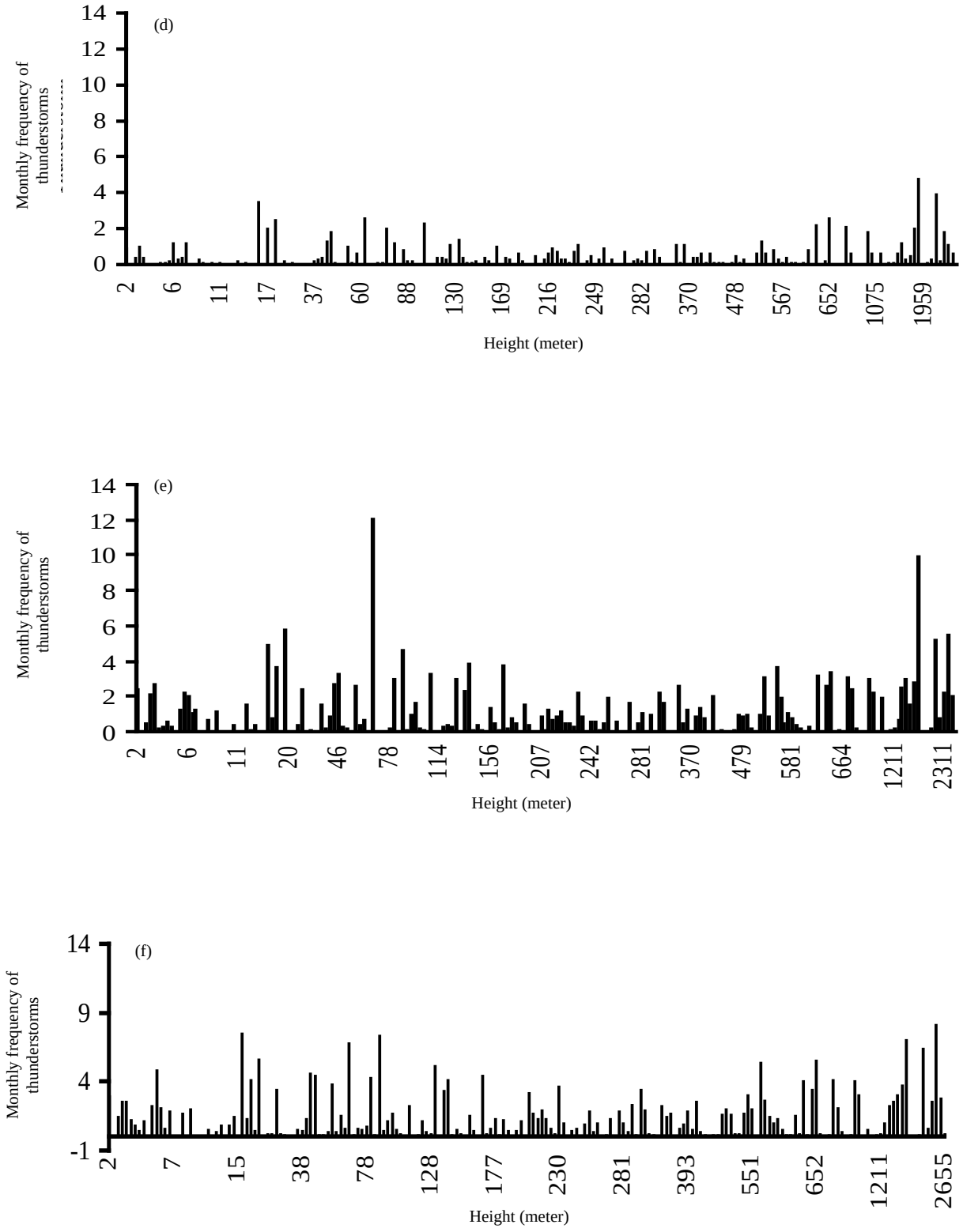


Figs. 1(a&b). (a) Network of Meteorological stations and (b) contour plots of topography of India

2. For the present study, the data for total 199 meteorological stations have been collected from Indian Daily Weather Report (IDWR), which is published by India Meteorological Department (IMD), Pune, India (IDWR, 1994 to 2003). The network of the stations is shown in the Fig. 1(a). The climatological normal of different parameters over these stations are also obtained from the publication of climatological normal prepared by



Figs. 2 (a-c). Variation of 10 years (1994-2003) averaged frequency of thunderstorm with respect to surface elevation during the month of (a) March (b) April and (c) May respectively at 0300 UTC



Figs. 2 (d-f). Variation of 10 years (1994-2003) averaged frequency of thunderstorm with respect to surface elevation during the month of (d) March (e) April and (f) May respectively at 1200 UTC

India Meteorological Department (IMD, 1999). The dates and timings of occurrences of pre-monsoon thunderstorms for all 199 Indian meteorological stations, during the years 1994-2003 are collected from the past and present weather data reported surface observations of 0300 UTC and 1200 UTC. Fig. 1(b) shows the variation of topography of India. To study the spatial behaviour of the thunderstorm occurrences over India the 10 yrs mean thunderstorm frequencies are calculated for the month of March, April and May. Also to understand the influence of topography the plots of average frequency *versus* surface elevation above mean sea level are plotted.

TABLE 1

The number of stations indicating thunderstorm occurrences only at 0300 UTC and only at 1200 UTC and the stations showing no thunderstorms on either timings

Thunderstorm occurrence	Mar	Apr	May
0300 UTC	7	16	3
1200 UTC	35	16	27
No thunderstorms at (0300 & 1200 UTC)	61	46	32
Thunderstorms at (0300 & 1200 UTC)	88	119	133

3. *Variation of monthly averaged frequency of thunderstorms with respect to surface elevation* - To understand the influence of topography the plots of average frequency *versus* surface elevation above mean sea level are plotted in Figs. 2(a-f). Figs. 2(a-c) show the variation of monthly averaged thunderstorm frequency with respect to surface elevation during the months of March, April and May over all the stations of India at 0300 UTC. Similar plots at 1200 UTC are shown in Figs. 2(d-f) respectively. Most of the stations of India selected for the study are at an altitude below 750 m (above mean sea level) and few stations are having altitude more than 750 m throughout the India as shown in Fig. 1(b). It is seen from Figs. 2(a-c) that two clear peaks of thunderstorm activity during 0300 UTC, one lies in the elevation range of 38-130 m and the other on the 1200-2650 m range. It also seen from Figs. 2(a-c) that the locations of maximum monthly averaged frequency of thunderstorm at 0300 UTC are at Imphal (24.77° N, 93.9° E, 781 m), Tezpur (26.62° N, 92.78° E, 79 m) and again at Tezpur during 0300 UTC in the month of March, April and May respectively. The corresponding values of monthly averaged frequencies are 2.9, 4.6 and 5.0 respectively. The occurrences of maximum monthly averaged frequency of thunderstorm at 0300 UTC (morning local time) over Imphal and Tezpur may be associated with the passage of trough in westerlies and or due to orography. Orography provides forced lifting of the low level moist air. Again the katabatic flow from the mountain in to the valleys during the night time provides under-cutting of low level moist air.

Similar analysis for 1200 UTC [Figs. 2(d-f)] shows that the locations of maximum monthly averaged frequency of thunderstorms are at Gangtok (27.33° N, 88.62° E, 1812 m), Thiruvananthapuram (8.48° N, 76.85° E, 64 m) and at Kodaikanal (10.23° N, 77.47° E, 2343 m) during the month of March, April and May respectively. The corresponding values of maximum monthly averaged frequencies are 4.8, 12.1, 8.1 respectively. Further during the month of May the station Agartala (23.88° N, 91.25° E, 16 m) shows the value of mean monthly frequency of thunderstorm equal to 7.5 which is comparable to that of at Kodaikanal. The occurrence of maximum monthly averaged frequency of thunderstorms over Thiruvananthapuram at 1200 UTC during the month of April may be associated with the sufficient moisture influx due to it's coastal location and location of the wind discontinuity line in the Peninsula in the month of April and east west direction arising due to land heating. The wind discontinuity is the region of high convection and increases the frequency of thunderstorm over Thiruvananthapuram during the month of April. Kodaikanal gets more thunderstorm activity in the month of May at 1200 UTC due to it's high elevation and also it's location in lee-ward side of eastern ghats. When the north-south trough moves to this location it provides additional forcing for thunderstom activity. Hence there is occurrence of maximum thunderstorms in this region. Gangtok gets more thunderstorm activity at 1200 UTC may be associated with the passage of trough in westerlies and due to orography. The occurrence of maximum monthly averaged frequency of thunderstorms over Agartala at 1200 UTC in the month of may be due to moisture influx from anticyclone over Bay or associated with the passage of trough in westerlies.

In order to compare the frequency of occurrence of thunderstorm at 0300 UTC and 1200 UTC the stations indicating thunderstorm occurrences only at 0300 UTC, only at 1200 UTC and the stations showing no thunderstorms on either timings & the thunderstorms during both the times are classified and given in Table 1. It is seen from Table 1 that, only at 0300 UTC,

thunderstorm occurs at more places during April than that during March and May, whereas, at only 1200 UTC thunderstorm occurs over more places during March followed by that during May and April. At both 0300 UTC and 1200 UTC, thunderstorm occurs at most of the places during May than that during April and March but thunderstorm occurrences in March and April are quite high. The occurrences of thunderstorm frequency during March to May for both the timing (0300 UTC and 1200 UTC) are much higher than that of occurrence of thunderstorm on either time (0300 UTC or 1200 UTC) and it is gradually increasing from March to May. Thus, thunderstorm can occur at both 0300 UTC and 1200 UTC and there is no preferred time of occurrences of thunderstorm at either 0300 UTC or 1200 UTC. Again it is also seen from Table 1 that occurrence of thunderstorm at only 1200 UTC is much higher than that at of only 0300 UTC during the month of March and May, whereas it is identical during the month of April.

4. The thunderstorm occurrence is highest over Thiruvananthapuram among all the 199 stations in India considered in the present study. The highest average thunderstorm frequency over the station Thiruvananthapuram having lower elevation is located in south coast of India, where as the other higher values of average thunderstorm frequency are observed over the stations in northeast India having lower elevation. The higher values of average thunderstorms frequency are also reported over the stations with higher elevation. Thus, it is indicated that the frequency of occurrences of thunderstorm is depended not only on the topography but also on the prevailing synoptic conditions and land heating.

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