551.515.4 : 551.509.22(541–1)

Premonsoon thunderstorms in Assam and synoptic conditions favourable for their occurrence

S. N. SEN and S. C. BASU

Meteorological Office, Calcutta

ABSTRACT. Synoptic features associated with development of thunderstorms during premonsoon season in Assam have been studied with a view to finding out the most favourable factors contributing to genesis of such storms. It is found that a particular orientation of the seasonal trough line causing increased incursion of moist air from the Bay of Bengal into Assam area in the lower levels constitutes an essential condition, while existence of upper divergence over Assam provides additional favourable condition for occurrence of thunderstorms. The hours of occurrence of premonsoon thunderstorms in Assam and the characteristics of associated squalls have also been examined.

1. Introduction

It is well known that during the premonsoon season (March to May) severe thunderstorms locally known as "Nor'westers" occur over northeast India. Various authors have attempted to explain the mechanism of these thunderstorms (Sen 1931, India met. Dep. 1944, Desai 1950, Koteswaram and Srinivasan 1958).

The previous studies on nor'westers have mostly been made with special reference to storms in Gangetic West Bengal. However, the frequency of thunderstorms during this season is appreciably higher in Assam than in Gangetic West Bengal. Examination of available data for Assam stations during the years 1955-59 has shown that the number of days of thunderstorms at Assam stations is of the order of 13 days in April and 20 days in May, as against 7 days in April and 11 days in May in Gangetic West Bengal. On many occasions, widespread thunderstorms occur over Assam and sometimes such occurrence repeats for days together.

From detailed examination of the weather charts of April and May during the years 1955-59, an attempt has been made in this paper to find out the synoptic features as favourable for occurrence of premonsoon thunderstorms over Assam and also to bring out the special characteristics of these thunderstorms in Assam area.

2. Characteristics of premonsoon thunderstorms in Assam

Number of occasions of thunderstorms at individual stations, with different durations, in the forenoon (06-12 IST), afternoon (12-18 IST), night (18-24 IST) and early morning (24 to 06 IST) hours based on observations during 5 years, 1955-1959, are shown in Table 1. It will be seen that large majority of the thunderstorms occur during night and early morning hours. These thunderstorms during night hours also generally have longer duration, the majority lasting more than 3 hours with a good percentage continuing for as long as 7-10 hours. Citing Gauhati as an example, for which available data are more complete, it will be seen from Table 1 that out of 143 occasions of thunderstorms, 73 (*i.e.*, over 50%) commenced during 1800-2400 IST and 39 (27%) during 2400-0600 IST. Except Agartala, where an appreciable number of thunderstorms occur in afternoon hours, the number of thunderstorms occurring in forenoon and afternoon hours at Assam stations is generally small compared to those occurring at night and early morning hours.

Direction and speed of all squalls recorded at different stations in Assam during the 5-year period under study have been examined, and it is found that large majority of these squalls (over 90% at Gauhati) come from NW with only a few from W and rarely

TABLE I

Number of occasions of premonsoon thunderstorms at individual Assam stations, with different durations, in the forenoon, afternoon, night and early morning hours of April and May (1955-59)

Station	No. of occa-sions	Duration of (hours) thunderstorms commencing in the period															
		0300–1200 IST				1200–1800 IST				1800–2400 IST				2400–0600 IST			
		<3	3-6	7-10	>10	<3	3-6	7-10	>10	<3	3-6	7-10	>10	<3	3-6	7-10	>10
Mohanbari North	85	8	8	—	—	11	5	2	1	8	19	8	—	10	2	2	1
Lakhimpur	40	6	2	—	—	6	2	—	—	6	7	1	—	6	4	—	—
Jorhat	82	6	2	—	—	11	4	1	1	16	11	7	1	11	11	—	—
Tezpur	92	5	5	1	—	1	1	—	—	16	23	14	2	14	9	—	1
Gauhati	143	11	5	1	—	10	3	1	—	19	40	14	—	14	24	1	—
*Rupsi	59	10	1	1	—	6	3	1	—	9	12	—	—	8	7	1	—
Agartala	92	12	7	—	—	15	14	2	—	14	17	1	—	7	3	—	—
*Kumbhigram	88	13	3	—	1	15	4	4	2	8	9	5	2	10	12	—	—
Imphal	86	7	4	1	—	13	7	1	—	19	15	4	—	9	5	1	—

*Based on available data for the premonsoon months of 1957-1959

from SW. In lower Assam, such as at Silchar, squalls come from NW and W almost in equal number. The speed of squalls on most occasions is 35-40 kt, the highest recorded during this period being 75 kt at Gauhati.

2·1. *Time sequence of occurrence of thunderstorms*—Time sequence of occurrence of premonsoon thunderstorms in Bengal was studied (India met. Dep. 1944) earlier by drawing isochrones in some typical cases. A similar study has been made in respect of thunderstorms in Assam. A few typical maps showing isochrones of time of commencement of thunderstorms are shown in Fig. 1. It is seen that in majority of cases, the thunderstorms which originate in afternoon/evening in West Bengal move eastwards giving thunderstorms in adjoining Assam stations after 7 A.M. and extend to eastern stations later in the night. These types are depicted in Figs. 1(a) to 1 (d). Figs. 1(e) and 1 (f) illustrate different type of thunderstorms which originate in northeast Assam and apparently move westwards. These occasions are also associated with almost simultaneous development of a separate series of thunderstorm in West Bengal areas which move eastwards. From available records it appears that westward moving thunderstorms are not associated usually with any marked squalls. In any case, no squall with easterly component was recorded during the 5-year period under examination.

3. Synoptic analysis

3·1. Weather charts, surface and upper air, for the days of thunderstorm activity over Assam during the premonsoon months of April and May were carefully analysed with a view to deriving possible objective methods for forecasting premonsoon thunderstorms over Assam. Preliminary examination revealed that incursion of moist air in the lower levels over Assam influenced by extension of the seasonal trough, existence of wind discontinuity in lower levels and existence of upper divergence associated with passage of upper troughs in the westerlies, or occurrence of jet maxima constitute favourable conditions for occurrence of thunderstorms in Assam.

3·2. *Seasonal synoptic features*—The main seasonal feature over north India in April and

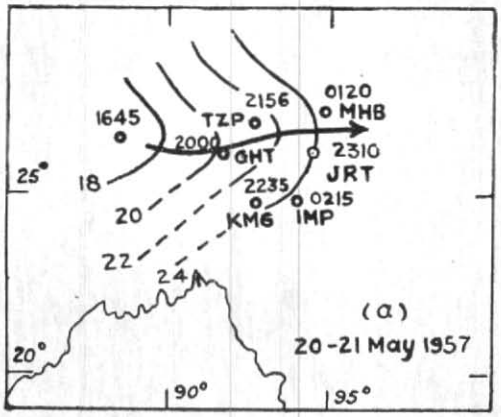


Fig. 1(a)

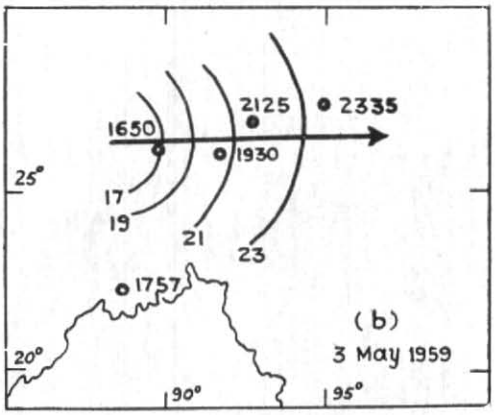


Fig. 1(b)

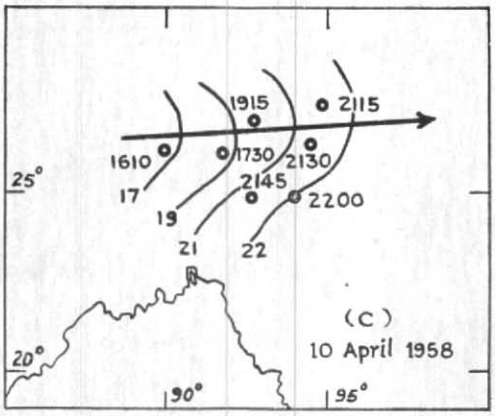


Fig. 1(c)

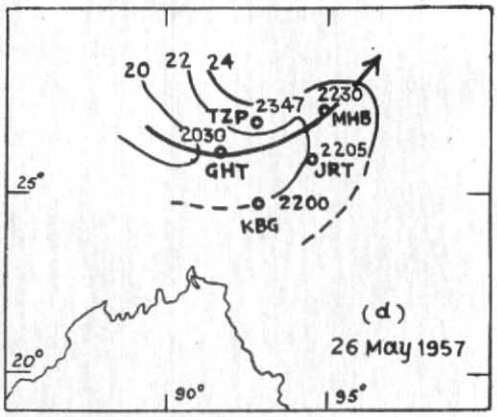


Fig. 1(d)

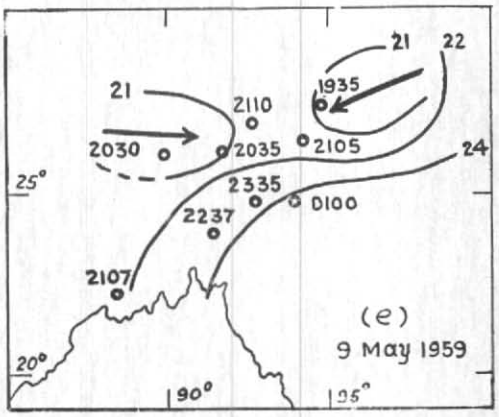


Fig. 1(e)

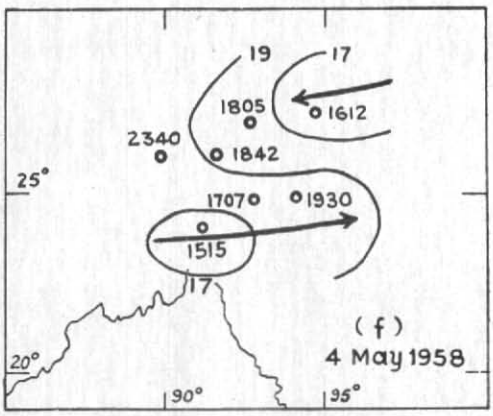


Fig. 1(f)

Fig. 1. Isochrones of thunderstorms

May on lower level charts upto 3000 ft a.s.l. is the existence of a trough of low pressure over Uttar Pradesh and north Bihar, with its axis or trough line running in a WNW—ESE direction. Around this trough, WSW/W-ly current normally blows over Assam in the lower levels. With the passage of western disturbances or otherwise, the seasonal trough often gets accentuated and extends southeastwards into Gangetic West Bengal and neighbourhood or eastwards into north Bengal, causing incursion of moist SW/S-ly air from the Bay of Bengal into Assam. Quite often from extreme northeast Assam, ENE/E-ly current, which is relatively dry and somewhat cooler blows westwards across the foot of the Himalayas. The existence of this ENE/E-ly air over extreme north Assam and warm moist SW/S-ly air from the south results in a E-W line of wind discontinuity over upper Assam. This wind discontinuity shows some north-south oscillation in its day-to-day position. Day-to-day location of the seasonal trough over north India and associated orientation of trough line, and the actual position of E-W wind discontinuity referred to above can be conveniently studied by streamline analysis of upper wind chart for 3000 ft a.s.l.

In the upper troposphere, westerly wind prevails over north India. Passage of upper troughs in the westerlies or jet maxima across upper Assam can be detected on the streamline charts for 30,000—40,000 ft levels, provided adequate wind observations from such levels are available.

3·3. *Periods of widespread thunderstorms over Assam*—After a general examination of weather charts relating to all occasions of thunderstorm activity over Assam in April and May during 1955-1959, the occasions of widespread thunderstorms over Assam were sorted out, and corresponding synoptic factors referred to above, namely, location and orientation of the seasonal trough line, associated incursion of moist air into Assam in lower levels, location of the E-W wind discontinuity, were analysed carefully on the 3000-ft level wind chart. Also, existence or otherwise of upper divergence was examined with reference to the upper level (30/40,000 ft) wind chart. The observed conditions were suitably tabulated, as per samples shown in Table 2 relating to two spells of widespread thunderstorm activity over Assam.

As regards upper divergence, inadequacy of wind data at higher levels made it difficult sometimes to identify with certainty the passage of upper trough or jet maxima across upper Assam. The only rawin station in Assam is at Gauhati making two ascents a day at 00 and 12 GMT. Based on wind data for this station upto 30,000 ft and above vertical time-sections were drawn for selected occasions, to facilitate identification of passage of upper trough or jet maxima in the westerlies. Such time-sections drawn, for the two situations of widespread thunderstorms are shown in Figs. 2(a) and 2(b). These spells illustrate typical cases noticed during this analysis, as stated below—

(*i*) Fig. 2(a) illustrates a case where a trough in the westerlies definitely moved across Gauhati area and fairly widespread thunderstorms with moderate to heavy rain were recorded in Assam in association with this condition. Thunderstorms and rain decreased after the upper trough moved away.

(*ii*) Fig. 2(b) illustrates a case when passage of jet maxima and an upper trough was associated with scattered thunderstorms and light rain over Assam.

4. Conclusion

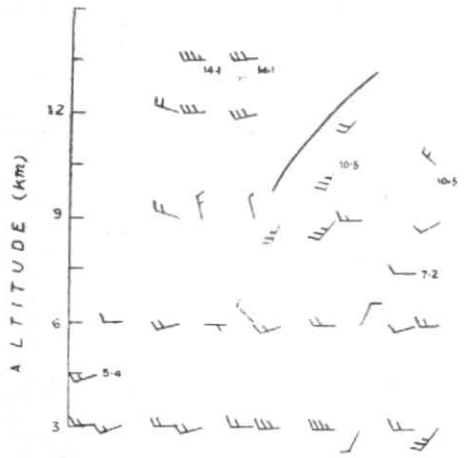
From the present analysis of premonsoon thunderstorm activity in Assam, it is seen that incurions of warm moist SW/S-ly air upto at least 3000 ft a.s.l. is essentially necessary for occurrence of widespread thunderstorms in the area. Such incursion of moist air is caused by extension of the

TABLE 2

Distribution of premonsoon thunderstorms in Assam and the associated synoptic features on two selected spells during 1956 and 1958

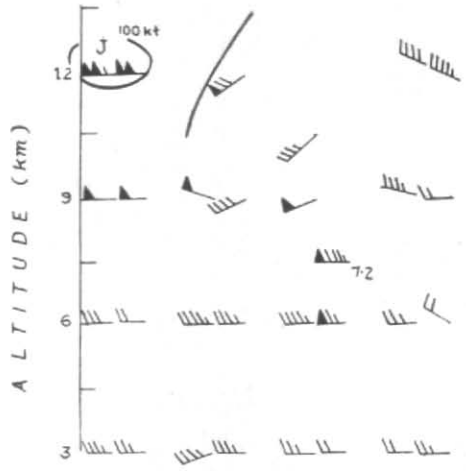
Date	Distribution of thunderstorms during 24 hours ending at 0830 IST of date	Associated intensity of rainfall recorded during the same period	Synoptic features based on morning charts of previous date
May 1956 2 to 4	Fairly widespread	Moderate	Seasonal trough at 3000 ft a.s.l. accentuated and extends into north Bengal causing pronounced incursion of moist SW/S current into Assam upto 5000 ft a.s.l. E-W discontinuity at 3000 ft a.s.l. close to the foot of Himalayas on 1st and 2nd and over upper Assam on 3rd. Upper trough apparently over upper Assam on 1st, moved away eastwards thereafter.
May 1956 5	Do.	Moderate with scattered heavy falls	Seasonal trough extends southwards at 3000 ft a.s.l. causing further increase of moist incursion upto 5000 ft a.s.l. into Assam. Upper level divergence not traceable.
May 1956 6	Widespread	Moderate to heavy	Increased incursion of moist air into Assam maintained but extends upto 7000 ft a.s.l. E-W discontinuity exists over upper Assam at 3000 ft a.s.l. Well marked upper trough moving across upper Assam.
7	Fairly widespread	Do.	
8	Scattered	Light to moderate	Seasonal trough shifted back northwards with marked decrease of moist feed into Assam. E-W discontinuity at 3000 ft a.s.l. persists over upper Assam. Upper level trough moved away eastwards.
Apr 1958 16 to 18	Scattered	Light	Influx of feeble moist current upto 3000 ft a.s.l. into Assam. Diffuse E-W discontinuity over upper Assam. Upper trough apparently moving across upper Assam.
Apr 1958 19	Fairly widespread	Moderate	Seasonal trough extends southeastwards into Gangetic West Bengal causing increased incursion of moist southerlies into Assam upto 5000 ft a.s.l. E-W discontinuity over upper Assam now more marked. Fresh upper trough apparently approaching upper Assam.
Apr 1958 20 and 21	Scattered	Light	Seasonal trough shifted northwest with decrease of moist feed into Assam. E-W discontinuity less marked. Upper trough apparently moving across upper Assam. Straight jet maxima passing over upper Assam on 20th.

seasonal trough southeastwards into Gangetic West Bengal and neighbourhood or eastwards into north Bengal. Accentuation of the trough, or appearance of cyclonic circulation in the lower level over West Bengal — East Pakistan area within the extended trough, provides more favourable condition for increased incursion of moist air. It is also noticed that the E-W wind discontinuity over upper Assam between warm moist SW/S-ly air and drier, cooler easterlies from northeast is a favourable, though not essential, condition for



TIME (GMT)	15 02	15 02	15 02	15 02	15 02
DATE (1956)	8 MAY	7 MAY	6 MAY	5 MAY	4 MAY
WEATHER OVER ASSAM	SCATTERED		F.W.		
	LIGHT TO MOD. RAIN		MOD. TO HEAVY RAIN		

Fig. 2(a). Vertical time-section of upper winds over Gauhati



TIME (GMT)	12 00	12 00	12 00	12 00
DATE (1958)	20 APRIL	19 APRIL	18 APRIL	17 APRIL
WEATHER OVER ASSAM	SCATTERED		F.W.	SCTTD.
	LIGHT RAIN		MOD. RAIN	LIGHT RAIN

Fig. 2(b). Vertical time-section of upper winds over Gauhati

occurrence of widespread thunderstorm in Assam.

Existence of upper divergence, when associated with incursion of moist air in lower levels, appears to be very favourable for intense and widespread thunderstorm activity. There were, however, some occasions of widespread thunderstorm activity when the existence of upper divergence could not be detected, or available upper level wind data were inadequate to permit such detection. There were also occasions when upper divergence could be detected but thunderstorm activity was not sufficient apparently due to less favourable lower level condition.

A study of the distribution of thunderstorm occurrences in Assam during different hours of day and night has shown that a large majority of them occur during night and early morning hours. This suggests that katabatic flow from the hills may be undercutting the warm moist SW/S-ly air resulting in increased vertical ascent of the moist air. It appears that while mere incursion of moist air from the Bay of Bengal at least upto 3000 ft a.s.l. assisted by local orography, could lead to development of premonsoon thunderstorms over Assam, the existence simultaneously of upper divergence would favour more intense and widespread thunderstorms with moderate to heavy rains.

REFERENCES

Desai, B. N. 1950 *Indian J. Met. Geophys.*, **1**, 1, p. 74.

India met. Dep. 1944 Nor'westers of Bengal, *Tech. Note*, 10.

Koteswaram, P. and Srinivasan, V. 1958 *Indian J. Met. Geophys.*, **9**, 4, p. 301.

Ramaswamy, C. 1956 *Tellus*, **8**, 1, p. 26.

Sen, S. N. 1931 *Nature*, **127**, p. 128.