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THRESHOLD VALUES OF VARIOUS INDICES OF THUNDER STORM DURING PRE-MONSOON OVER MOHANBARI

1. The most important results of convective activity and thunderstorms are at its peak during pre-monsoon period from March to May which results in heavy rainfall as well as play a major role in the movement of aircrafts belongs to civil and defence air station at Mohanbari. As such the study of thunderstorms activity over Mohanbari for Six years (2000-2005) during pre-monsoon period has been taken by analyzing surface and upper air observations.

A number of studies using synoptic, synoptic objectives or purely objective techniques have been developed for forecasting of thunderstorm. Kumar (1972) developed a technique for forecasting of pre-monsoon thunderstorm/dust storm activities over New Delhi region by using the parameters *viz.*, Showalter index, convective condensation level (CCL), mean mixing ratio at 850, 800 & 700 hPa level, wind direction and the differences in height between CCL and freezing level. Lal (1990) indicated that Showalter level of 850 hPa of 45% or more and dew point above normal are favourable conditions for the occurrence of thunderstorm over Lucknow.

Many Scientist have studied various thermodynamics parameter such as corrective available potential energy (CAPE), static energy profiles Total Predictable water (TPW) along with conventional charts to obtain their charges prior, during and after the thunderstorm by using 4 hourly special Radio Sonde data for Delhi and Jodhpur taken during MONTBLEX-90. They have observed that CAPE profile and TPW profile provide significant clue for forecasting thunderstorm. Lal (1989) used the Total Total index to explore the possibility of forecasting thunderstorm activity around Delhi & Jodhpur during March and June. Higher values of TTI are associated with more favourable conditions of thunderstorm activities. Prediction of thunderstorm within a limited range of TTI is uncertain when the chances of occurrence and non occurrence of thunderstorm are equal.

The study by several researcher on forecasting of pre-monsoon thunderstorm/dust storm over Jodhpur reveals that combination of critical threshold value of lifted index, show alter index, cross total index, vertical total index, Jefferson's modified (JMJ), George k index in conjunction with lifting (availability) gives good indication of thunderstorm occurrence/non occurrence over Jodhpur during month of April and May. Dhawan *et al.* (2008) developed an expert system called Expert

system for thunderstorm forecasting (ESTF) to forecast thunderstorm activity over Delhi during pre-monsoon month by using Radio Sonde data of Delhi. The system process 0000 UTC Temp data of Delhi to make 14 hrs forecast. The rules are based on stability indices and other thermodynamic parameters evaluated from the said sounding.

Chakraborty *et al.* (2008) found that a particular orientation of the seasonal trough line causing increased incursion of moist air from the Bay of Bengal in to Assam area in the lower levels constitutes an essential condition while existence of upper divergence over Assam provides additional favourable condition for occurrence of thunder storm.

Sen and Basu (1961) studied the synoptic features associated with development of thunderstorm during the pre-monsoon in Assam with a view to find out the most favourable factor contributing to genesis of such storm.

No such study has been made to evaluate the threshold value of various indices related to thunderstorm activities such as LCL, CCL, lifted index (Li), K index (KI), Total Total index (TT) and Showalter index to forecast the occurrences of thunderstorm during pre-monsoon at Mohanbari.

2. *Physiography and climatology of Mohanbari* - Mohanbari is located at latitude 27° 29' N, longitude 95° 01' E and elevation 110 m above mean sea level in upper Brahmaputra valley. Dibrugarh town is about 13 km to the west of Mohanbari airport. No hilly obstruction exists in the immediate vicinity. The convective activity over place is a subject of great interest in meteorology, especially in the context of India. The thunderstorm being an important meso-scale phenomenon and it exhibits some dependence on the orography of the place and climatology, and thus distinctive appearance of it over a place has to be studied.

The climatologically features of Mohanbari (IMD Climatology 1963) during pre-monsoon (March-May) is that the surface winds remain calm or highly variables. Average low cloud amount is 3 - 4 octa and the base of the low clouds lies between 750 masl and 1500 masl. During thunderstorms the base of clouds lowers to 300 m. The average rainfall is 10 cm in March, 25 cm in April and 30 cm in May. The numbers of rainy days being 9, 14 and 16 respectively in these three months. The visibility is generally fair to good except mist on 2-4 days.

3. *Data and analysis* - The current weather register of Mohanbari observatory give full details of occurrence of thunderstorms over the place, hence the current weather register for the six years period (2000 to

2005) was consulted. The Temp data based on RS/RW observations of both 0000 UTC and 1200 UTC of given period were computed for the date of occurrence of thunderstorm. Total 132 numbers of thunderstorms found recorded in current weather register during pre-monsoon of the said period. The autographic charts and other data of surface and upper air observations were analyzed and studied, critically to derive the characteristics of thunderstorms. Some data were collected from NDC Pune to study surface weather parameters.

The analysis for threshold value for different indices has been done to arrive at some meaningful conclusion. Blanchard, (1998) though has indicated that each of these indices has strength and weakness and no single index can be thought to provide a complete characterization of the state of atmosphere, however value obtained from the present study give a sufficient indication for occurrence of thunderstorm. The methods for calculating different indices are given below. These indices have been computed using computer algorithms but can also be determined graphically.

(a) *Lifted index*

$$LI = T500 - TP 500$$

Where LI is the lifted index, T500 is the 500 hPa environmental Temperature, TP500 is the 500 hPa Temperature which a parcel will achieve if it is lifted dry adiabatically from the surface to its condensation level (LCL) and then moist adiabatically at 500 hPa. From several studies, it is found that if value of lifted index is 6 or greater, atmosphere is very stable and if less than -6 the atmosphere is very unstable. The value of Lifted index tends to be somewhat lower than those of Showalter and the interpretation depends to some extent on how the lifted parcel is defined (Galway1956).

(b) *K index*

$$KI = T850 - T500 + Td850 - (T700 - Td700).$$

Where KI is the K index, T850 is the temperature at the 850 hPa level. T500 is the Temperature at 500 hPa level, Td850 is the dew point Temperature at the 850 hPa level, T700 is the Temperature at the 700 hPa level and Td700 is the dew point Temperature at the 700 hPa level. The K index is a poor indicator of severe thunderstorms since dry air at 700 hPa may indicate convective instability. As this index increases from a value of 20 or so, the shower and thunderstorms are likely to occur and expected to increase (George 1960).

(c) *Total Total index (TT)*

$$TT = Td850 + T850 - 2(T500) \text{ or } (Td850 - T500) + (T850 - T500),$$

Where TT is the Total totals index, Td850 is the dew point Temperature at the 850 hPa level, T850 is the Temperature at the 850 hPa level and T500 is the Temperature at the 500 hPa level. Total Total index (TT) is the arithmetic sum of two other indices *i.e.*, vertical total index (Temp at 850 hPa - Temperature at 500 hPa) and the cross totals index (dew point temperature at 850 hPa - Temperature at 500 hPa). The showers and thunderstorms are likely to increase, if the value of TT is about 30, and severe thunderstorms are considered likely, if values of TT are 50 or more (Miller 1972).

(d) *Showalter index = T500 - Tp500*

Where T500 is the 500 hPa environmental Temperature, Tp500 is the 500 hPa Temperature which is parcel will achieve if it is lifted dry adiabatically from 850 hPa to its condensation level and then moist adiabatically to 500 hPa. Showalter index is the simplest measure to determine the local static stability of atmosphere. It is similar to the computed lifted index except that it always uses the parcel characteristic at the 850 hPa level. It is found that cumulonimbus cloud structures do not usually form when Showalter index is greater than +4 but if value of SI decreases to 0 and below the shower and thunderstorm is considered to increase (Showalter 1947).

(e) *Lifting condensation level (LCL)*

It is defined as the level to which a parcel of moist air can be lifted adiabatically before it becomes saturated with respect to a plane surface of water (Wallace and Hobbs 1977). During lifting the mixing ratio (ω) of the air and its potential temperature (θ) remain constant, but the saturation mixing ratio (ω_s) decreases until it becomes equal to mixing ratio (ω) at LCL. Therefore, the lifting condensation level is located at the intersection of potential temperature line passing through the temperature T and pressure P of the parcel of air and the saturation mixing ratio (ω_s) line which passes through the pressure P and dew point temperature (Td) of air parcel. If the air parcel is lifting further beyond the LCL, water vapour in the air will begin condensation, forming cloud droplets.

(f) *Convective condensation levels (CCL)*

The environment lapse rate near the earth's surface undergone changes during the day time and night time which lead to the formation of temperature inversions. The other effects arise due to solar radiation heating the

TABLE 1
Pre monsoon month wise Mean, Standard deviation, Skewness and Kurtosis value of various indices of thunderstorm during the years 2000-2005

Month	Para meters	Freezing level (masl)	LFC (masl)	CCL (masl)	LCL (masl)	Lifted Index (LI)	Total Totals Index	K Index (KI)	Show Alter Index	CAPE Total energy (J/kg)
March	Mean	3266.4	2092.4	1227.0	261.6	0.7	49.6	33.9	-0.3	562.6
	Stdvep	296.6	544.9	475.6	161.2	3.2	4.4	4.7	4.0	316.9
	Skewness	0.6	- 1.1	0.2	1.4	-0.2	0.0	-0.2	-0.7	1.2
	Kurtosis	0.2	3.3	- 0.5	2.0	-0.1	0.0	0.5	0.8	3.0
April	Mean	3798.9	2422.5	1374.3	292.2	0.2	47.5	34.9	-0.7	815.9
	Stdvep	758.9	1044.1	571.2	367.2	8.3	4.4	7.2	2.5	516.1
	Skewness	- 3.0	1.8	1.0	2.7	5.5	-1.3	-1.5	0.0	1.8
	Kurtosis	13.4	9.5	0.8	6.9	33.9	3.4	3.0	-0.2	5.6
May	Mean	4154.9	2091.4	1437.5	331.6	-2.0	46.0	35.0	-1.0	988.7
	Stdvep	469.3	1167.7	526.1	241.7	3.4	5.1	4.1	2.6	592.0
	Skewness	0.6	0.9	- 0.1	1.7	-0.7	0.3	0.0	-0.4	1.4
	Kurtosis	1.5	3.6	- 1.0	4.1	1.4	2.7	0.2	0.0	3.0

LFC = Level of free convection.

CCL = Convective condensation level.

LCL = Lifting condensation level.

TABLE 2

Frequency of thunderstorms during pre-monsoon (Year 2000 to 2005)

Month	Ist week	IInd week	IIIrd week	IVth week	Total
March	9	8	10	11	38
April	7	14	14	18	53
May	12	9	11	9	41

Total thunder storms occurred during these months = 132

TABLE 3

Average number of thunderstorms week wise (Year 2000 – 2005)

Month	Ist week	IInd week	IIIrd week	IVth week	Total
March	2	1	2	2	7
April	1	2	3	3	9
May	2	2	2	1	7

Average thunderstorms occurred (Total) = 23

earth's surface. As the day advances, this heat is transferred from ground to the lower layers of the atmosphere. The depth of air heated is indicated by the thickness of the layer, through which the environment lapse rate become equal to the dry adiabatic lapse rate. As the temperature rises during the daytime, a stage is eventually reached when the dry adiabatic lapse rate extends up to the level at which condensation takes place. This level is known as the Convective condensation level.

4. Severe thunderstorm starts from 1st April and last till the end of May when the South West monsoon hits NE India (Chakraborty *et al.* 2008). The pre-monsoon month wise Means, Standard deviation, Skewness and kurtosis of freezing level in m.a.s.l., Level of Free

Convection (LFC) in m.a.s.l., Convective Condensation Level (CCL) in m.a.s.l., Lifting condensation level (LCL) in m.a.s.l., Lifted index (LI), Total Total Index (TTI), K Index (KI), Showalter Index and CAPE total energy (J/kg) and their variation for the years 2000-2005 have been derived and given in Table 1. The monthwise and weekwise frequency of thunderstorm shows in total 132 thunderstorms occurred during the period under study (Table 2). As per frequency of weekly average, 23 thunderstorm occurred during the said period (Table 3). The maximum number of thunderstorm occurred in mid of the pre-monsoon period, *i.e.*, in the month of April, which is an agreement with climatology of aerodrome at Mohanbari.

TABLE 4

Month wise mean value of various indices

Month	Lifted Index (LI)	Total Index (TT)	K index KI	Showalter Index	LFC (masl)	Freezing level (masl)	LCL(masl)	CCL(masl)
March	0.7	49.6	33.9	- 0.3	2092.4	3266.4	261.6	1227.0
April	0.2	47.5	34.9	- 0.7	2422.5	3798.9	292.2	1374.3
May	-2.0	46.0	35.0	- 1.0	2091.4	4154.9	331.6	1437.5

TABLE 5

Threshold value and variation of various indices

Parameters	Threshold Value	Variation
LCL	261.6 masl	261.6 to 331.6 masl
CCL	1227masl	1227 to 1437.5 masl
Lifted index (LI)	-2.0	-2.0 to 0.7
K index (KI)	33.9	33.9 to 35.0
Total Total index (TT)	46.0	46.0 to 49.6
Showalter index	-1.0	-1.0 to -0.3

The Maximum thunderstorms occur in the mid of pre-monsoon and found that lifting condensation levels (LCL) were at 292.2 m.a.s.l. when more than 40% thunderstorms occur; LCL varies from 261.6 to 331.6 m.a.s.l. (Table 1). The convective condensation level (CCL) varies from 1227 to 1437.5 m.a.s.l. during the period and more than 40 %, thunderstorm came when CCL is 1374.3 m.a.s.l. Relative humidity varies from 60% to 98% during pre-monsoon and maximum thunderstorms occur when relative humidity is about 85%. The mean value of lifted index (LI), Total Total index (TT), K index (KI), Showalter index were found to be 0.2, 47.5, 34.9 and -0.7 respectively when maximum thunderstorms occur at Mohanbari *i.e.*, in the month of April (Table 1). The CAPE Total Energy (J/kg) varies from 562.6 in March to 988.7 in May and its value found to be 815.9 (J/kg) during occurrence of maximum thunder activities in the month of April. During maximum thunderstorm activity in April, the value of LFC and Freezing level found to be 2422.5 and 3798.9 m.a.s.l. respectively (Table 4). Lifted index varies from 0.7 to -2.0, Total Total index varies from 49.6 to 46.0, K index varies from 33.9 to 35.0 and Showalter index varies from -0.3 to -1.0 during pre-monsoon season. The mean value of LCL varies from 261.6 to 331.6 and CCL varies from 1227.0 to 1437.5.

The threshold values and variation of various indices of convective activities occurred at Mohanbari during the

year 2000-2005 Table 5. The mean value of the lifting free condensation (LFC) level varies from 2092.4 to 2091.4 m.a.s.l. and freezing level varies from 3266.4 to 4154.9 m.a.s.l.

5. (i) Threshold values of LCL, CCL, Lifted index (LI), K index (KI), Total Total Index (TT), Showalter Index and CAPE total energy are 261.6 masl, 1227.0 masl, -2.0, 33.9, 46.0, -1.0 and 562.6 J/kg respectively.

(ii) More than 40% thunderstorms occur during the month of April for which the mean values of Lifted index, K index, Total Total index and Showalter index were 0.2, 34.9, 47.5 and -0.7 respectively.

(iii) Total number of thunderstorms occurred during the year 2000-2005 were 132.

(iv) Relative humidity varies from 60% to 98% and maximum thunderstorms occur when relative humidity is about 85%.

(v) The ranges of mean value of Lifting condensation Level (LCL), Convective Condensation Level (CCL), Lifted Index (LI), K index (KI), Total Total index (TT), Showalter index and CAPE total energy during the months of March, April and May are 261.6 to 331.6 m.a.s.l, 1227.0 to 1437.5 m.a.s.l, 0.7 to -2.0, 33.9 to 35.0, 46.0 to 49.6, -1.0 to -0.3 and 562.6 to 988.7 J/kg respectively.

(vi) The mean value of various indices computed in this study almost match with the scale values, found earlier during studies of various thunder activities.

(vii) The dry bulb temperature varies between 21 deg C and 31 deg C before convective activities.

(viii) Surface winds prior to thunderstorm either remained calm or variable with north-easterly direction up to 0.9 km from surface.

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