551.515.4

THUNDERSTORM ACTIVITY AROUND RANCHI AIRPORT – A CASE STUDY

1. In this paper the thunderstorm activity in terms of thunderstorm days, rainy days and their variation from climatological mean for the period December 2000 to November 2006 has been analysed. In addition to above, the monthly mean data of number of thunderstorm days (T_{hn}), number of rainy days (T_{nr}), rainfall amount in mm (T_{rr}), ratio of T_{hn} and T_{nr} and ratio of T_{rr} and T_{hn} have been computed and results are presented for different seasons (Pre-monsoon, monsoon, post monsoon and winter) for the period December 2000 to November 2006. The existence of convective regime during monsoon is very important for deciding the performance of southwest monsoon.

2. Thunderstorm is a meso-scale severe weather phenomenon which develops due to convective activity on the surface of earth and lower levels of atmosphere. They cause extensive damage to life, property and live stock. They are manifested in the form of line squall / lightening / thundershowers / rain and pose security threat to aircraft operations. The hot and humid weather is conducive for development of thunderstorm in any region. Also strong winds and vertical wind shear in the middle and upper troposphere are considered essential for growth of thunderstorm (Chaudhary and Mazumdar 1983). A thunderstorm associated with hailstorm causes considerable damage to crops.

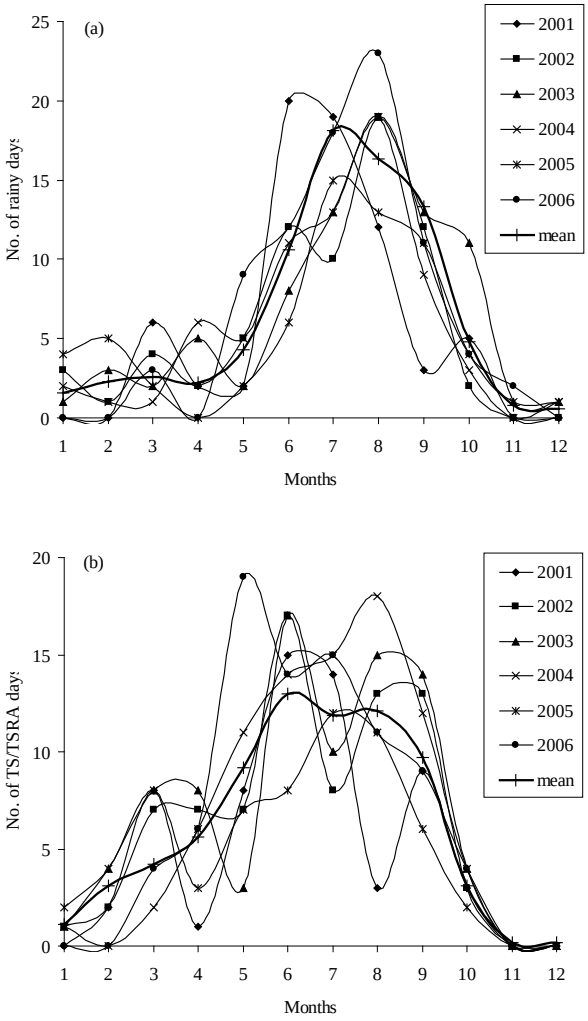
The favorable conditions for the occurrence of thunderstorms are as follows:

(*i*) Conditional and convective instability in the atmosphere.

(*ii*) Adequate supply of moisture, particularly in the lower levels.

(*iii*) A dynamical mechanism to realize the instability leading to convection in the atmosphere like uplift over hills and mountains, selective heating from below, convergence etc.

At a given time around 1800 thunderstorm occur in the world (Brooks, 1925). Manohar *et al.* (1999) studied thunderstorm days and the southwest monsoon rainfall over India. A climatological study of thunderstorm activity over Indian region was made by Manohar and Kesarkar (2003).



Figs. 1(a&b). Monthwise variation of (a) rainy days and (b) TS/TSRA days from climatological mean

In the present study an attempt has been made to analyse the thunderstorm activity in terms of thunderstorm days, rainy days, monthly rainfall and their variation from climatological mean and results are presented.

3. For the present study we have taken monthly data of number of thunderstorm/thunderstorm with rain (TS/TSRA) days, number of rainy days and rainfall for Ranchi airport for 6 years from 2001-2006. Fig. 1(a) shows monthwise variation of rainy days of years 2001-2006 from climatological mean (IMD, 1999). Fig. 1(b) shows monthwise variation of TS/TSRA days of years 2001-2006 from climatological mean. The monthly mean data of number of thunderstorm days (T_{hn}), number of rainy days (T_{nr}), and rainfall amount in mm (T_{rr}) has been computed and presented in Table 1 for different seasons

TABLE 1

Seasonal means of number of thunderstorm days (T_{hn}), rainy days (T_{nr}), rainfall (T_{rr}), Index R=T_{hn}/T_{nr} and Index S = T_{rr}/T_{hn}

	T_{hn}	T_{nr}	T_{rr}	R	S
			Winter		
Dec 2000 - Nov 2001	0.67	0.00	1.37	-	2.05
Dec 2001 - Nov 2002	1.00	1.33	10.97	0.75	10.97
Dec 2002 - Nov 2003	1.67	1.33	11.50	1.25	6.90
Dec 2003 - Nov 2004	0.33	1.33	11.07	0.25	33.20
Dec 2004 - Nov 2005	2.00	3.33	30.90	0.60	15.45
Dec 2005 - Nov 2006	0.00	0.33	1.00	0.00	-
			Pre-monsoon		
Dec 2000 - Nov 2001	5.67	3.33	42.87	1.70	7.56
Dec 2001 - Nov 2002	7.00	3.67	22.83	1.91	3.26
Dec 2002 - Nov 2003	6.33	3.00	38.87	2.11	6.14
Dec 2003 - Nov 2004	6.33	4.00	32.90	1.58	5.19
Dec 2004 - Nov 2005	6.00	1.33	7.77	4.50	1.29
Dec 2005 - Nov 2006	9.67	4.00	58.17	2.42	6.02
			Monsoon		
Dec 2000 -Nov 2001	10.25	13.50	283.80	0.76	27.69
Dec 2001 - Nov 2002	12.75	13.25	274.35	0.96	21.52
Dec 2002 - Nov 2003	14.00	13.25	272.48	1.06	19.46
Dec 2003 - Nov 2004	14.75	13.00	286.40	1.13	19.42
Dec 2004 - Nov 2005	9.25	11.25	218.85	0.82	23.66
Dec 2005 - Nov 2006	12.25	16.00	374.83	0.77	30.60
			Post monsoon		
Dec 2000 - Nov 2001	1.50	2.50	40.00	0.60	26.67
Dec 2001 - Nov 2002	1.50	1.00	24.85	1.50	16.57
Dec 2002 - Nov 2003	2.00	6.00	183.25	0.33	91.63
Dec 2003 - Nov 2004	2.00	1.50	72.05	1.33	36.03
Dec 2004 - Nov 2005	1.00	2.50	14.70	0.40	14.70
Dec 2005 - Nov 2006	2.00	3.00	18.95	0.67	9.48

(Pre-monsoon, monsoon, post monsoon and winter) for the period December 2000 to November 2006. An index R, introduced by Rao *et al.* (1971) is defined as ratio of T_{hn} and T_{nr} where T_{hn} and T_{nr} are number of thunderstorm days and number of rainy days respectively. Another index S, introduced by Zipser (1994) to study the relation between rainfall and number of thunderstorm days is defined as ratio of monthly rainfall (T_{rr}) and number of thunderstorm days (T_{hn}). The above indices have been adopted for the present study. The values of R and S have been computed for different seasons (Pre-monsoon, monsoon, post monsoon and winter) for the period December 2000 to November 2006 and plotted in Fig. 2(a) and Fig. 2(b) respectively. For the sake of continuity of winter season, the duration of year has been considered from December of preceding year to November of succeeding year.

4. (*i*) It is observed from Fig. 1(a) that maximum positive departure in the number of rainy days

from climatological normal is in the month of June 2001 and maximum negative departure is in the month of September 2001. The maximum number of rainy days occurred in August 2006 (23 Days) followed by 20 rainy days in June 2001. The minimum number of rainy days during monsoon period occurred in September 2001 (03 days) – a negative departure of 08 days is seen. The variation of rainy days of different years (2001-2006) from the climatological mean is large during all months.

(*ii*) It is seen from Fig. 1(b) that maximum positive departure in the number of thunderstorm/thunderstorm with rain (TS/TSRA) days from climatological normal is in the month of May 2006 and maximum negative departure is in the month of August 2001. The maximum number of TS/TSRA days occurred in May 2006 (19 days). The minimum number of TS/TSRA days occurred in August 2001 (03 days). The variation of TS/TSRA days of different years (2001-2006) from climatological mean is large from January to September.

(*iii*) It is seen from Fig. 2(a) that variation of R is maximum in pre-monsoon and minimum in monsoon season.

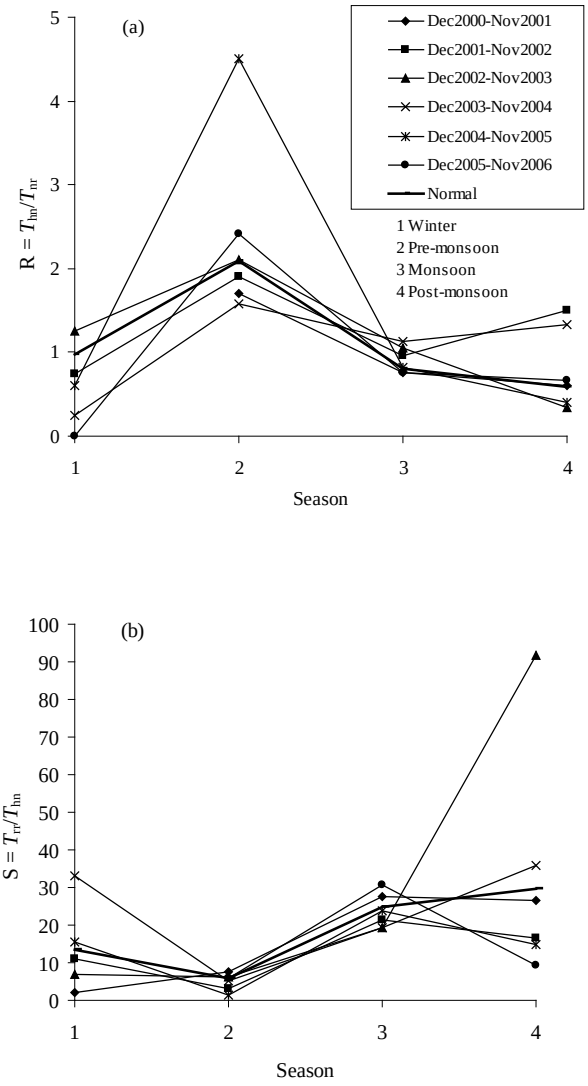
(*iv*) It is seen from Fig. 2(b) that variation of S is maximum in post monsoon and minimum in pre-monsoon season.

(*v*) (a) *Winter season (Dec-Feb)* – Table 1 shows that the value of T_{hn} is 2.0 for the winter season of the period December 2004 to November 2005 with a maximum positive departure of 36% from climatological normal value for the entire period under study while for the winter season of the period December 2005 to November 2006, T_{hn} is zero *i.e.*, there were no thunderstorms during this period. Further examination of Table 1 shows that the value of T_{nr} is 3.33 for the winter season of the period December 2004 to November 2005. During this period it is observed that T_{nr} has maximum positive departure of 122% from climatological normal value for the entire period under study. Two abnormal features observed are

– There was no rain during winter season of December 2000 to November 2001.

– There were no thunderstorms during winter season of December 2005 to November 2006.

(b) *Pre-monsoon season (March-May)* – From Table 1 it is seen that values of R in pre-monsoon season in all the years are higher than other seasons (*i.e.*, monsoon, post monsoon and winter). The value of R is highest (4.50) in pre-monsoon season in the year December 2004 to November 2005. For other years the



Figs. 2(a&b). Seasonal variation of (a) R (T_{hn}/T_{nr}) and (b) S (T_{rr}/T_{hn})

value of R varies from 1.58 to 2.42. The value of R for all the years in pre-monsoon season are within -24.4% to +15.8% from climatological normal value (2.09) except for the year December 2004 to November 2005 for which an unusual departure of +115% from climatological normal value is noticed in the value of R. The highest value of R is due to the lowest number of rainy days (T_{nr} = 1.33). Further a careful examination of Table 1 reveals that value of S in pre-monsoon during December 2004 to November 2005 is lowest (1.29) and a negative departure of 78% is noticed from climatological normal value while for other years it is within - 45.1% to + 27.3% of climatological normal. The lowest value of S in pre-monsoon during December 2004 to November 2005 is due to minimum rainfall (T_{rr} = 7.77 mm) during the season with a departure of – 79.3 % from climatological normal

value. For other years the value of S varies from 3.26 to 7.56 for pre-monsoon. The above analysis suggests that both extreme values of these indices (highest and lowest) in pre-monsoon as well as extreme % departure (negative and positive) from climatological normal are indicators of subdued rainfall activity (due to convective regime) in pre-monsoon.

(c) *Monsoon season (Jun to Sep)* – Though the values of R and S in monsoon during December 2004 to November 2005 are very close to climatological normal value, however during monsoon this station received -24 % deficient rainfall. It is due to decrease in number of thunderstorm days (T_{hn}), number of rainy days (T_{nr}) and rainfall (T_{rr}) during the period in comparison to climatological normal values. For this period the % departure of number of rainy days from climatological normal is -22.8% and that for number of thunderstorm days from climatological normal is -20.8%. Both of these departures are negative maximum for the entire period under study. Since the station received -24% deficient rainfall, these extreme percentage departures of number of rainy days and number of thunderstorm days during monsoon of December 2004 to November 2005 from climatological normal suggest subdued monsoonal convective regime. For other years rainfall was either near normal or excess. In 2006 Ranchi received 30% excess rainfall. The percentage departure for T_{nr} from climatological normal during monsoon for December 2005 to November 2006 is 9.7% which is positive maximum. Therefore the above analysis suggests the existence of convective regime during monsoon is very important for deciding the performance of southwest monsoon. The result is in agreement with the result of Manohar and Kesarkar (2004).

(d) *Post monsoon season (Oct-Nov*) – During post monsoon season of December 2004 to November 2005 maximum negative departure of 39.4% from climatological normal value has been observed in the value of T_{hn}. For rest of the period the variation in T_{hn} is from –9.1% to +21.2%. The variation in T_{nr} from climatological normal value in post monsoon season is positive maximum (+114.3%) for the year December 2002 to November 2003 and is negative maximum (-64.3%) for the year December 2001 to November 2002.

5. From the above study, the following conclusions are drawn:

(*i*) The maximum number of rainy days (23 days) occurred in August 2006 and minimum number of rainy days (03 days) occurred in September 2001 with maximum positive departure in June 2001 and maximum negative departure in September 2001 from climatological normal.

(*ii*) The maximum number of TS/TSRA days (19 days) occurred in May 2006 and minimum number of rainy days (03 days) occurred in August 2001 with maximum positive departure in May 2006 and maximum negative departure in August 2001 from climatological normal.

(*iii*) The variation of index R is found to be maximum in pre-monsoon and minimum in monsoon for the entire period of study. The variation of index S is found to be maximum in post monsoon and minimum in pre-monsoon for the entire period of study.

(*iv*) The extreme values (highest and lowest) of indices R and S in pre-monsoon as well as extreme % departure (negative and positive) from climatological normal are indicators of subdued rainfall activity (due to convective regime) in pre-monsoon.

(*v*) The existence of convective regime during monsoon is very important for deciding the performance of southwest monsoon.

References

Brooks, C.E.P., 1925, "The distribution of thunderstorms over the globe", *Geophys. Mem.*, London, 147-164.

Choudhary, A. K. and Mazumdar, A. B., 1983, "Nor'westers and the synoptic climatology of hot-weather season in northeast India", *Vayu Mandal*, **13**, 48-55.

India Meteorological Department, 1999, "Climatological Normals 1951-1980".

Manohar, G. K. and Kesarkar, A. P., 2003, "Climatology of thunderstorm activity over the Indian region: A study of East-West contrast", *Mausam*, **54**, 4, 819-828.

Manohar, G. K. and Kesarkar, A. P., 2004, "Climatology of thunderstorm activity over the Indian region: II. Spatial distribution", *Mausam*, **55**, 1, 31-40.

Manohar, G. K., Kandalgaonkar, S. S. and Tinmaker, M. I. R., 1999, "Thunderstorm activity over Indian and the Indian southwest monsoon", *J. Geophys. Res.*, **104**, 4169-4188.

Rao, K., N., Danial, C. E. J. and Balsubramaniam, L. V., 1971, "Thunderstorms over India", *IMD Sci. Rep.*, **153**, 1-22, India Met. Deptt., Pune.

Zipser, E. J., 1994, "Deep cumulonimbus cloud systems in the tropics with and without lightning", *Mon. Wea. Rev.*, **122**, 1837-1851.

J. K. SHARMA
K. SRIVASTAVA*

India Meteorological Department, New Delhi, India
(*23 March 2007*)
e mail : *kulsrivas@gmail.com