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A STUDY OF A PRE-MONSOON SQUALL LINE SYSTEM OVER GUJARAT STATE

A severe squall line system with an extreme wind gust of 76 kmph passed through Ahmedabad at 2100 IST of 19 April 1988. This major squall system affected large areas of east and central parts of Gujarat State. Wind speed exceeded 40 kmph for approximately 90 minutes and widespread minor damages were reported around the city. As may be seen from the climatology of squalls in Ahmedabad, occurrence of such severe squall in April over Ahmedabad is a rare phenonmenon. In fact the frequency of thundersquall is the least over Saurashtra & Kutch in the country. On an average Ahmedabad gets 10.2 mm of rain during pre-monsoon season. Pre-monsoon rainfall contributes only 1.3% of annual total. Climatologically there are two thunderstorm days at Ahmedabad during pre-monsoon months.

Using the data of 18 years (1971-1988) average number of days with squalls monthwise were found out. In addition frequency of direction of squalls also were found out. The results are shown in Table 1.

TABLE 1

Statistics of squalls at Ahmedabad (1971-1988)

Month	Average number of days with squalls	Frequency of direction of squalls							
		N	NE	E	SE	S	SW	W	NW
Jan	0				—				
Feb	0				—				
Mar	0.4	—	—	1	1	2	3	1	—
Apr	0.3	—	2	—	2	1	1	—	—
May	0.6	2	3	1	1	—	—	1	3
Jun	3.3	5	8	16	8	8	4	2	9
Jul	1.8	4	6	2	2	5	6	5	2
Aug	1.6	6	2	2	1	8	4	4	3
Sep	0.7	4	1	2	—	2	—	1	4
Oct	0.1	1	—	2	—	1	—	—	—
Nov	0.1	1	1	—	—	—	—	—	1
Dec	0				—				

The period, December to February, is free from squalls at Ahmedabad. On an average there are about 9 days of squalls at Ahmedabad in a year. The average number of days of squalls is the largest in June followed by July. During the pre-monsoon months there is only one day of squalls.

During the pre-monsoon months the majority of squalls favour the direction NW to NE through north. During the month of June majority of squalls favour the easterly direction.

The direction of the squall which affected Ahmedabad on 19 April was SE, which is a favourable direction of squall for the month of April.

The severe thunderstorms which affected Ahmedabad in pre-monsoon months, (*i.e.*, from March to May) during the period 1982-1988 are given in Table 2.

Majority of severe storms affect Ahmedabad during evening/early night.

In this paper, we discuss the causes of development of the thundersquall system which affected Gujarat State on 19 April 1988 the structure of the system and changes in the atmospheric structure associated with its passage.

2. It is well known that severe thunderstorm activity are favoured by strong convective instability and a dynamical lifting mechanism for the extreme instability [Newton (1963)]. The necessary lifting mechanism for the extreme instability is provided by organized vertical motion.

To calculate the atmospheric instability, Showlter index, Total index and George index are used. These indices were calculated with evening (1200 UTC) radiosonde observations of Ahmedabad on 16th to 20th April and are shown in Table 3. The computations of the indices indicated the strong possibility of development of thunderstorms over Gujarat State on 17th and 18th and it was on 19th the severe squall struck the Gujarat State. This shows the limitations of these indices when these are utilised for a particular area in particular month. It may be mentioned that the indices are place and season dependent and their critical values are to be computed for a particular place and season considering large number of such observations. It could also be possible that such indices may not be possible to use over Gujarat State for thunderstorm forecast without modification. In absence of adequate data such calculations for the Gujarat State, however, could not be made.

TABLE 2

Details of severe thunderstorms which affected Ahmedabad in pre-monsoon months (March-May) (1982-1988)

Date	Time of occu-rrence (IST)	Associated wind (Speed/Dir.)	Date	Time of occu-rrence (IST)	Associated wind (Speed/Dir.)
26 Apr 82	1640	40 kmph/S	26 May 82	1600	64 kmph/NE
6 May 82	1515	56 kmph/N	1 Apr 85	1900	70 kmph/NE
7 May 82	1745	56 kmph/NE	19 Apr 88	2030	76 kmph/SE
8 May 82	1620	42 kmph/NW			

3. Figs. 1 (a & b) show the streamline pattern at 850 hPa and 200 hPa of 1200 UTC, 19 April. At 850 hPa an upper air cyclonic circulation was located over central Rajasthan. A trough from this system extended

TABLE 3

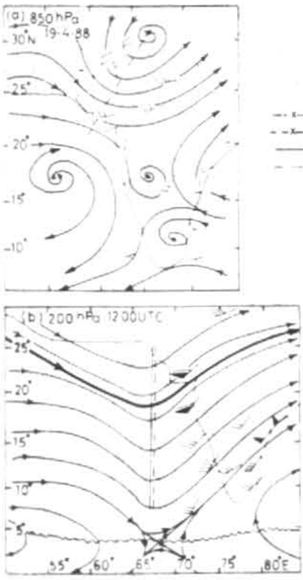
Total values of Showlter, George and Total indices on 16 to 20 April calculated using 1200 UTC observations

Date (April)	Indices		
	Showlter	George	Total
16	6	17	46
17	—4	27	55
18	—3	21	54
19	—1.5	20	53
20	5	14	39

southwards across Gujarat State. The anticyclonic circulation over Arabian Sea resulted in considerable moisture influx over Gujarat State. The flow in the upper troposphere was characterized by a north-south trough line and the axis of the trough was along 68° E, north of 10°N. The sub-tropical westerly jet was well marked at 200 hPa and the jet core lay roughly along 20°N over west coast. It is to be noted that the convective activity was observed over the left hand exist region of the jet core.

On 18th the cyclonic circulation in the lower troposphere was lying over north Pakistan and adjoining Punjab. The southward extension of the trough line from the cyclonic circulation was not seen. The jet stream and the westerly trough were also not observed. On the morning of 19th the cyclonic circulation in the lower troposphere lay over Punjab and neighbourhood with trough line extending southwards up to south Gujarat coast. The upper tropospheric trough in westerlies was noticed at 250 hPa roughly along 68°E and north of 15°N. Though the atmospheric instability was favouring more on 17th and 18th, the convective activity took place only on 19th when synoptic forcing also favoured.

4. The vertical structure of the atmosphere before and after the squall line had been deduced respectively from 1200 UTC of 19th and 0000 UTC of 20th April radiosonde data of Ahmedabad. The vertical profile of temperature and dew point are shown in Fig. 2. The pre-squall sounding showed the usual convective unstable structure, typical of the tropics. The lifting condensation level (LCL) was at 880 hPa and level of free convection was at 780 hPa. A dry layer between 2.5 km and 4.5 km favoured initiation of strong downdrafts associated with the squall line (Asplinden *et al.* 1976). The post-squall sounding has the 'diamond'



Figs. 1 (a&b). Stream line pattern

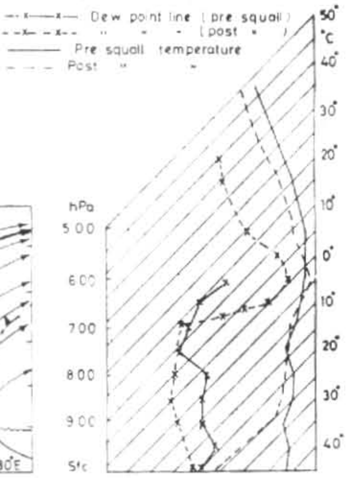


Fig. 2. Vertical profile of pre and post-squall temperature sounding

or 'onion' shape as described by Zipser (1977), as being typical of post-squall condition. This sounding consists of a warm dry air above a marked stable air from the surface up to 900 hPa. The relative humidity at the top of the stable layer is just 18%. The onion shape is completed in middle level where dew point depression decreased to 5°C, around 600 hPa. The moist air below and dry air above increases lapse rate which is favourable for violent convective development.

The profiles of zonal component before the storm and after the storm were computed using 1200 UTC observations of 19th and 0000 UTC of 20th. It was found that the lower level westerlies were reduced and the tropospheric wind shear (between 12 km and 1.5 km) was enhanced due to passage of the storm. The tropospheric wind shear before the storm was 19 kt and after the storm was 36 kt. This is the evidence of the up-gradient momentum transport due to the passage of the storm.

5. (*i*) The diagnosis of the synoptic evolution clearly revealed the severe convective development on 19 April over Gujarat State had taken place in association with the low level convergence and upper level divergence due to the favourable combination of factors like southward extension of upper tropospheric trough, presence of jet maxima and low level cyclonic circulation over Gujarat.

(*ii*) The upper air and surface changes associated with the passage of squall line system clearly indicated the presence of two downdrafts, one of the convective scale and another a mesoscale downdraft. These are consistent with the model as proposed by Zipser (1977) and Houze (1977).

S. K. ROY BHOWMIK

Regional Meteorological Centre, Bombay

M. RAJEEVAN

Meteorological Centre, Ahmedabad

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