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A STUDY OF DIURNAL VARIATION OF MONSOON LOW CLOUDS OVER CHHATRAPATI SHIVAJI INTERNATIONAL AIRPORT, MUMBAI

1. The height of the base of the low clouds affect the decision altitude/decision height which is one of the parameter of Met. Minima. Met. Minima are the lowest value of cloud ceiling below which takes off or landing of aircraft is not permitted. At Chhatrapati Shivaji International (C.S.I.) airport, Mumbai the hazard due to presence of low clouds covering half and more of the sky assumes special importance during monsoon months (June to September). In view of its frequency of incidence and the existence of certain obstructions in the vicinity of the airport such situations are required to be documented and studied. Several studies in cloud ceiling over India have been reported by Krishnan (1962), Siromoni (1966) and Narayanan (1970) based on pilot balloon, ceilometers and current weather observations. But these observations are not so systematic and numerous. An attempt has been made to study the diurnal variation of monsoon low clouds over C.S.I. airport, Mumbai based on current weather observations when low cloud amount equals or exceeds 4 octa. The synoptic situation(s) responsible for the occurrence of low clouds 4 octa or more has also been identified.

2. Records used for the study are current weather registers of Meteorological Office Mumbai for the period from 1994 to 1998. Occurrence of low clouds for the preparation of this study have been taken from routine half hourly observations and also special observations as

TABLE 1

Frequency distribution of low cloud ceiling heights (feet) [1994-98]

Time (UTC)	June				July				August				September			
	≤1000	1001 to ≤1500	1501 to ≤2000	Total	≤1000	1001 to ≤1500	1501 to ≤2000	Total	≤1000	1001 to ≤1500	1501 to ≤2000	Total	≤1000	1001 to ≤1500	1501 to ≤2000	Total
0	13	31	32	76	33	77	17	127	32	74	33	139	14	32	23	69
1	14	28	29	71	42	72	18	132	32	69	33	134	16	34	22	72
2	14	29	30	73	55	69	19	143	35	68	27	130	19	41	25	85
3	16	25	32	73	53	57	27	137	34	67	30	131	16	43	30	89
4	18	24	31	73	52	61	34	147	28	73	36	137	15	45	35	95
5	18	21	30	69	41	66	44	151	28	73	42	143	15	42	36	93
6	16	24	25	65	41	69	41	151	28	62	47	137	20	31	41	92
7	15	20	33	68	47	68	40	155	25	63	49	137	17	29	33	79
8	15	23	41	79	41	69	41	151	20	72	51	143	15	32	34	81
9	16	23	42	81	37	72	39	148	15	76	50	141	15	29	32	76
10	14	25	44	83	31	68	40	139	16	76	45	137	13	29	31	73
11	12	25	41	78	33	66	38	137	19	67	45	131	12	26	30	68
12	13	27	38	78	38	74	29	141	20	64	48	132	13	27	32	72
13	12	28	34	74	39	70	27	136	20	65	47	132	14	25	29	68
14	11	30	31	72	39	71	24	134	21	65	40	126	10	27	27	64
15	10	27	25	62	33	75	26	134	19	67	39	125	9	29	26	64
16	12	27	20	59	29	65	26	120	14	66	33	113	8	28	28	64
17	14	24	19	57	32	62	26	120	15	56	36	107	6	26	18	50
18	12	26	20	58	25	65	25	115	15	58	32	105	8	29	21	58
19	9	29	19	57	22	66	21	109	13	58	35	106	9	29	19	57
20	10	31	18	59	22	68	20	110	12	59	35	106	7	27	20	54
21	8	30	23	61	22	70	22	114	15	60	36	111	7	29	19	55
22	7	27	24	58	30	69	20	119	17	64	33	114	5	27	21	53
23	5	26	24	55	31	67	23	121	21	63	27	111	7	27	21	55

available when the base of the low clouds come down to 2000 feet or less covering half or more of the sky. Cloud heights reported are visual estimates. This has been done as instrumental ceilograph data for the entire period was not available. Hour-wise ceiling height frequency has been computed for different orders (≤1000 feet, 1001 to ≤ 1500 feet and 1501 to ≤2000 feet) and tabulated month-wise in Table 1. The diurnal variation of the ceiling height is shown in Fig. 1.

3. From Table 1 it is seen that in general frequency of such occurrences (4 octa or more) of low cloud is maximum during July and August. Both the months are following a similar pattern of frequencies.

3.1. *Frequency distribution of cloud ceiling during 0000 to 0600 UTC* - During June the lowest ceiling height (≤1000 feet) occurs during 0400 to 0600 UTC. The ceiling height ranges from 1001 feet to 1500 feet occurs most frequently during 0000 to 0200 UTC. While for the ceiling height ranges from 1501 feet to 2000 feet, the highest frequency is evenly distributed during 0000 to 0600 UTC.

During July and August, which is the peak monsoon period shows similar pattern in respect of cloud frequency. The lowest ceiling height (≤1000 feet) occurs during 0200 to 0400 UTC. The frequency of ceiling height ranges from 1001 feet to 1500 feet is the most frequent during 0000 to 0200 UTC. Whereas the frequency of ceiling height ranges from 1501 to 2000 feet is the highest during 0400 to 0600 UTC.

In the month of September, the frequency of lowest ceiling height is evenly distributed in the morning hour of the day. The frequency of ceiling height ranging from

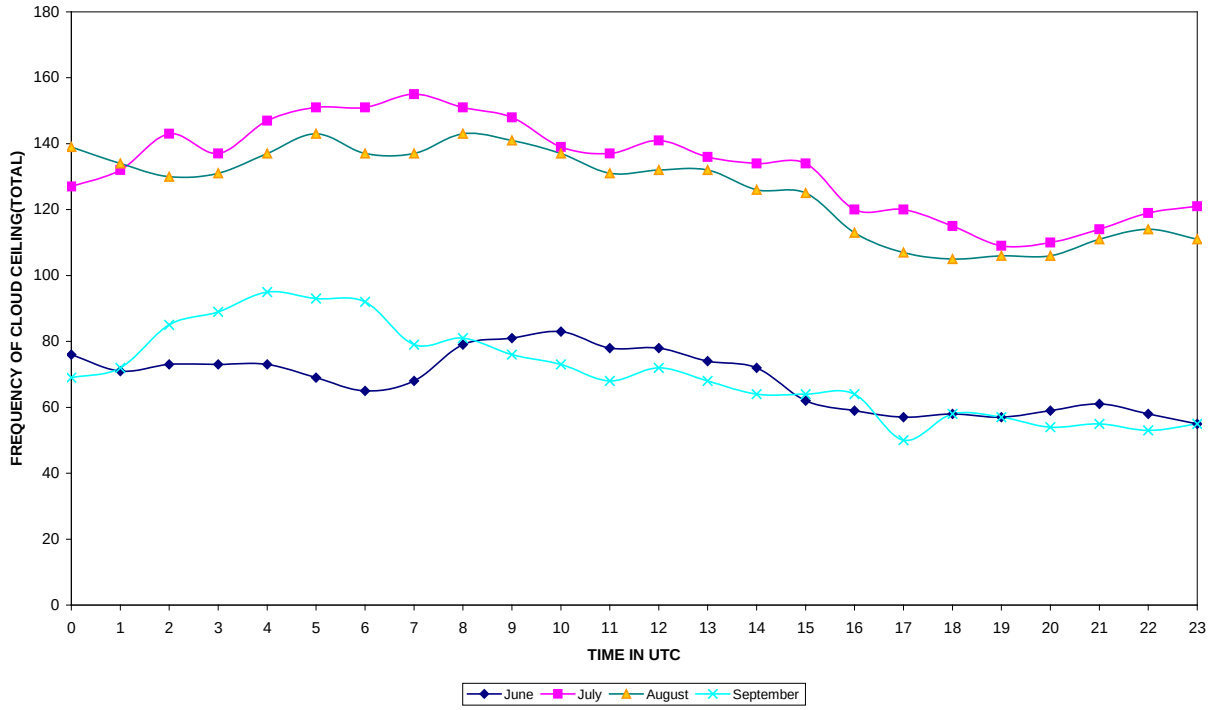

Fig. 1. Diurnal variation of ceiling heights (≤2000 feet) during 1994-98

1001 to 1500 feet is maximum during 0200 to 0600 UTC. Whereas the ceiling height frequency from 1501 to 2000 feet occurs maximum during 0400 to 0600 UTC.

3.2. *The frequency distribution of cloud ceiling during 0600 to 1200 UTC* - During June the ceiling height frequency is uniformly distributed up to 1500 feet, whereas the frequency of ceiling height ranges from 1501 to 2000 feet is maximum during 0800 to 1200 UTC.

In the month of July and August, the lowest ceiling height (≤1000 feet) is maximum during 0600 to 0900 UTC. The frequency of ceiling height ranges from 1001 to 1500 feet and that of 1501 to 2000 feet are evenly distributed.

During September the frequency of cloud ceiling is comparatively less but uniformly distributed during 0600 to 1200 UTC.

3.3. *The frequency distribution of cloud ceiling during 1200 to 2400 UTC* - From the Table 1 it is seen that the frequency distribution of the lowest ceiling height (≤1000 feet) gradually decreases from 1200 UTC reaching to minimum at 2400 UTC in the months of June and September. But in July and August it decreases up to 2000 UTC and then again increases. However the frequency of ceiling height ranging from 1001 to 1500 feet and that of 1501 to 2000 feet for the period from 1200 to 2400 UTC are evenly distributed in all the four months of SW monsoon season.

4. The following synoptic situations are associated with the occurrence of 4 octa or more low clouds over Mumbai during SW monsoon season :

(*i*) A trough of low pressure off west coast and off shore vortex.

(*ii*) Formation of a depression or a low-pressure area over north Bay of Bengal.

(*iii*) Its (low or depression in Bay) west northwest wards movement across the country.

(*iv*) Cyclonic circulation off Konkan or Karnataka coast or over south Gujarat state particularly between 700 and 500 hPa level.

(*v*) Strong pressure gradient along the west coast and

(*vi*) East-West trough axis at 700 hPa level between latitude 18º N and 21º N.

5. The following conclusions can be drawn from the study:

(*i*) In comparison with July and August the occurrence of low cloud frequency in June and September show a very sharp decline. Months of June and September being associated with onset and withdrawal of monsoon which includes many occasions of clear to partly clear sky condition and hence these frequencies are decreased.

(*ii*) On the other hand during July and August the sky is usually overcast due to frequent formation of monsoon systems and hence frequencies of low cloud ceiling are more. During July and August frequencies of such occurrences are more during 0000 to 1200 hours local time and then decrease rapidly after 1800 hours.

(*iii*) The decrease in frequency starts gradually after 1200 hours local time indicate that there is either a partial clearing of the clouding or due to lifting of the base of the cloud height. These are associated with the local scale circulation like land and sea breeze and in increased turbulence in land in the boundary layer.

6. The author is grateful to Dr. U. S. De, retired Additional Director General of Meteorology (Research) for going through the manuscript and giving valuable suggestions. The author is thankful to the referee for his valuable remarks and suggestions on the study. Thanks are also due to Dr. M. Satya Kumar, Ex-Director in-Charge Meteorological Office, Mumbai for his guidance and extending necessary facilities to carry out the study.

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(*23 April 2004, Modified 16 December 2004*)