Mausam, (1980), **31**, 2, 287-290

551.510.42 : 551.551.8 : 551.591 (547.1)

Deterioration of visibility at Bombay airport due to atmospheric pollutants

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(*Received* 15 *April* 1976)

ABSTRACT. As seen from round-the-clock current weather observations, the total number of occassions in the year when the visibility over Bombay airport deteriorated to less than 3000 metres was only 9 in 1956 whereas the figures rose to 574 in 1970. This large increase, it has been found, is mainly due to the markedly high frequency of visibility deterioration during recent years in the early hours of the morning of the cold weather period, December to February. The poor visibility conditions seem to develop generally not due to moist phenomena like mist or fog but due to suspended particulate matter and smoke factory chimneys and domestic fires which move or stagnate over the eastern side of the aerodrome under the prevailing and conditions. It has been shown that the conceneration of factories/population towards the east and north of the airport is is the source of these atmospheric pollutants. The conditions under which prolonged spells of poor visibility occur have also been discussed.

1. Introduction

Years ago, the deterioration of visibility over Bombay airport was not a common phenomenon. In 1956, for instance, there were only 9 occasions when the visibility deteriorated below 3 km over the airport. This information was collected from the available current weather records and the number of times MMMMM (at present SPECI) messages were issued for this element.

In recent years, however, the number of occasions when visibility less than 3 km was recorded has augmented considerably. Fig. 1 shows this remarkable increase from the year 1956 to 1970. From even a casual examination of weather records it can be seen that the sharp rise is contributed mainly by deterioration of visibilty in the early hours of the morning during the cold weather period, December to February. This phenomenon has become almost a daily feature in this season during the last few years. In the following paragraphs an attempt is being made to provide an explanation for this situation which is fast becoming a matter of concern to aviators.

2. Discussion

(*i*) *Frequency and time of occurrence of poor visibility*

The number of ocasions when visibility deteoriorate below 3km during the period December 1972 to February 1973 and December 1973 to February 1974 and the times of occurrence of such poor visibility are shown in Table 1. Visibility is generally good upto about 0100 GMT after which the deterioration begins rather rapidly, the lowest figures being recorded generally between 0130 and 0230 GMT. The improvement in visibility starts usually one or two hours after this time. Out of the total of 970 half hourly reports considered in two years it is significant to note that 772 indicated visibility between 3 km and 1.6 km, 166 between 1.5 and 0.9 km and only 32 in the range 0.8 km or less. It is hence obvious that in most cases the phenomenon is confined to the higher values between 1.6 km and 3 km.

(*ii*) *Poor visibility and humidity values*

With a view to examine whether the deterioration of visibility has any relationship to humidity values, scatter diagrams (Figs. 2a and 3a) were drawn for the hours 0200 and 0300 GMT with TT - T_dT_d against visibility for occasions when the visibility went below 3 km. It can be gathered from the large scatter of points that there is no direct correlation between the two parameters considered. A significant fact is that the decrease in visibility is not caused by high humidity in the atmosphere at that time. The lines indicating the lower limit of occurrence in Figs. 2(a) and 3(a) even reveal that very few of

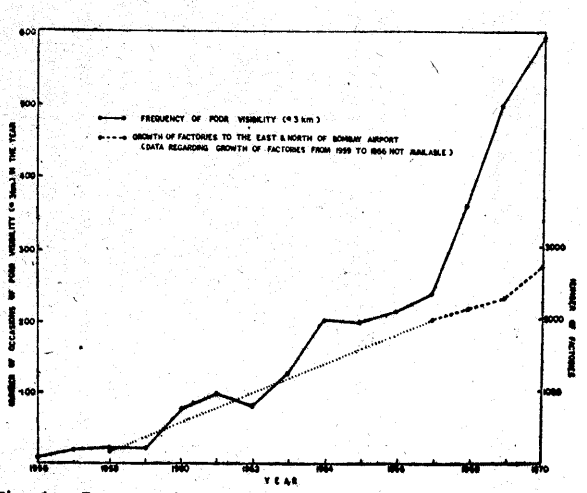


Fig. 1. Increase in frequency of poor visibility in relation to growth of factories

the occasions when lowering of visibility was observed were on days when the difference between TT and T^d T_d was less than 2° **C; in** other words when the relative humidity was above say 90 per cent. The poor visibility observed is, therefore, not generally due to moist phenomena like mist or fog, the more frequent visibility deterioration being caused by smoke or particulate matter.

(*iii*) *Poor visibility and surface wind*

Values of visibility (Occasions equal to or less than 3 km) were plotted against surface wind speed (irrespective of direction) in Figs. 2(b) and 3(b) to examine the contribution of over-all ventilation to the deterioration of visibility. As more or less expected, the scatter of points indicate that on roughly 80 per cent of occasions deterioration of visibility occurred with wind speeds less than 5 kt at 0200 GMT while on 73 per cent of the occasions poor visibility occurred at 0300 GMT with wind speeds less than 5 kt.

(*iv*) *Poor visibility and surface wind direction*

Since 10 kt was more or less the upper limiting value as seen from Figs. 2(b) and 3(b), an attempt was made to find out whether there is any relationship between deterioration of visibility and the directions from which wind with speeds less than 10 kt was blowing. Fig. 4(a) shows the frequency of occurrence of winds with speeds equal to or less than 10 Kt from all directions correct to 10° of the compass for the period 00 to 06 GMT for the months December 1972 to February 1973 and December 1973 to February 1974. The occasions when the wind was calm have been excluded from the presentation. The general prevailing surface wind at Bombay during these hours in the season mentioned is from the northeast quadrant. It may, however, be seen that hills and elevated ground (*see* Fig. 5) are close to the airport between the rough bearings 360° and 050° and also between 090° and 120°. The frequency of winds blowing from these sectors is also low, probably due to the blocking effect of topography and modified flow around elevated ground. Fig. 4(b) shows the frequency of visibility deterioration with reference to various wind drections. The close resemblence of Figs. 4(a) and 4(b) only indicates that the direction of surface wind has an important role to play in the lowering of visibility over the airport.

(v) *Increase in the number of factories/industries*

In Fig. 5 the distribution of factories around the airport is also indicated. In the corporation Wards adjoining the airport on the east and the north more than 70 per cent of the factories are concentrated in the area shown double hatched. The same area is also highly populated. There is hence a reasonably good indication that smoke and other suspended particulate matter emitted by the factory chimneys and domestic fires are carried over the airfield by the local wind. There are also a large number of occasions when the wind is calm or very light with speeds not measurable with the conventional wind instruments and still the visibility had reduced. It is quite possible that even under such 'calm' condtions the peculiar topography of the area surrounding the airport could cause the pollutants to stagnate over the eastern end of the runway aided by a mild katabatic flow from the east and north, until with the progress of the day and the change in the stability of the atmosphere and the wind field, they are ultimately dispersed. The close relationship between the occurrence of poor visibility and industrial growth of factories in the corporation Wards to the east and north of the airfield is also shown in Fig. 1 for a few years for which data was readily available. It is interesting that around 1962-64 there was a sphere trend in the increase of the number of occasions of poor visibility. There is another sharp rise later from 1967 onwards. A study of the local terrain has revealed that a small hillock near the eastern end of the runway was cut and brought down to almost ground level around 1962-64. This probably helped more atmospheric pollutants from the factories and habitations in the east to slowly drift over the airfield, adding to the number of occasions of poor visibility, apart from the contribution of the increase in the number of factories themselves, details of which are not available at present. The sharp rise from 1967 onwards can, most probably be attributed to the marked growth of industries/factories and the resulting increase in population during this period over the area to the north and east of the aerodrome.

(*vi*) *Prolonged spells of poor visibility at Bombay airport*

Some of the spells of poor visibility during the

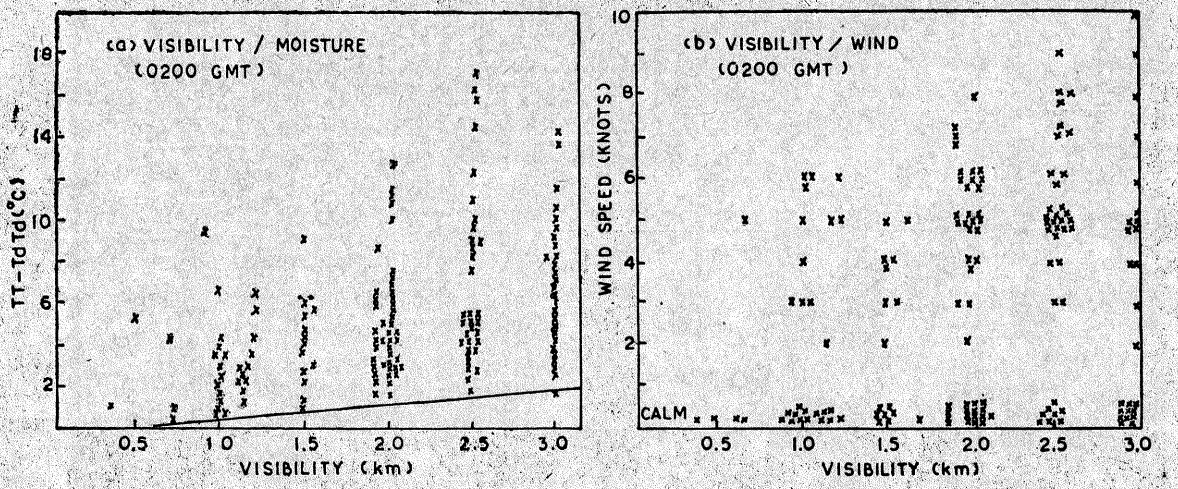
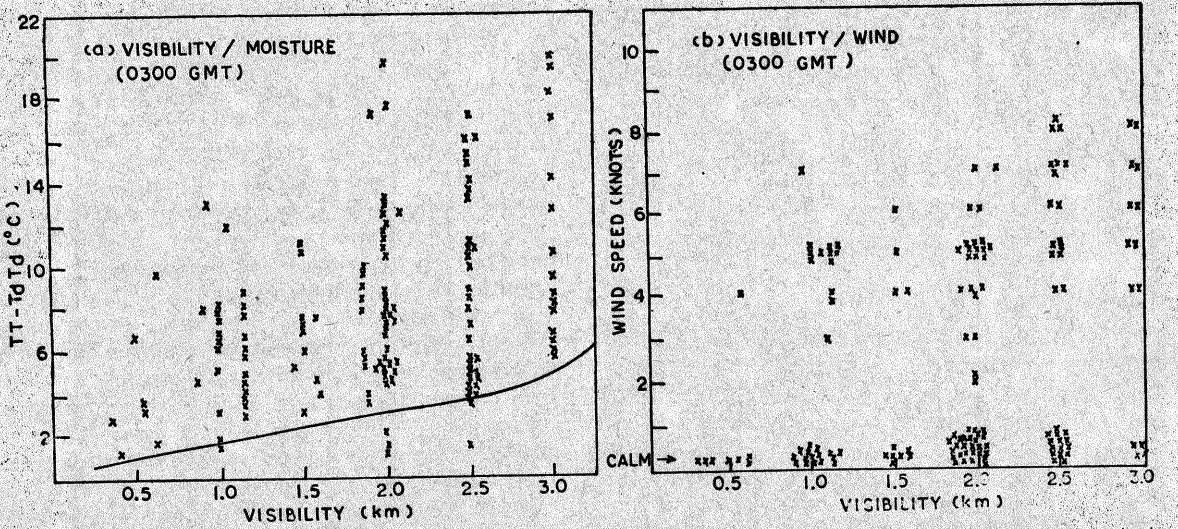


Fig. 2. Scatter diagrams of visibility (a) Moisture (b) wind as at 0200 GMT period analysed : December, January, February, 1972/73



Fig, 3, Scatter diagrams of visibility (a) Moisture (b) at 0300 GMT period analysed : December, January, February 1973/74

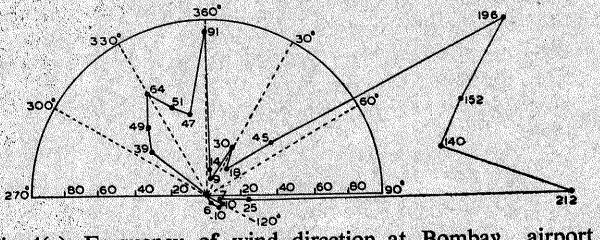


Fig. 4(a). Frequency of wind direction at Bombay airport. Number of half hourly occasions between 00 & 06 GMT when surface wind was from N & E quadrants during the periods Dec to Feb 1972/73 & 1973/74.

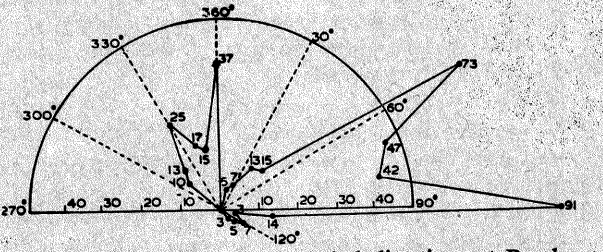


Fig. 4(b) Visibility in relation to wind directions at Bombay airport. Number half of ihourly occasions between 00 & 06 GMT when visibility was $\leq$3 km with surface wind from N & E quadrants (speed $<$ 10 knots) during the period December to February 1972/73 & 1973/74.

period considered lasted for several hours and visibility improved beyond 3 km only close to midday. All cases in January 1974 were studied in detail and the following points observed:

(*a*) The duration of poor visibility (below 3 km) is generaly longer if the wind is calm or it is light (<3kt) easterly or northerly.

TABLE 1

Frequency of occurrence of poor visibility in various ranges at Bombay airport between 00 and 06 GMT during the period December to February 1972/73 and 1973/74

Visibility Range (km.)	Number of occasions of poor visibility at Bombay airport at time (GMT)													Total
	0000	0030	0100	0130	0200	0230	0300	0330	0400	0430	0500	0530	0600	
3.0-1.6	9	14	30	98	113	109	99	102	78	53	37	18	12	772
1.5-0.9	1	1	3	11	35	40	34	21	14	6	—	—	—	166
0.8 and less	—	—	—	1	6	9	9	5	1	1	—	—	—	32
Total	10	15	33	110	154	158	142	128	93	60	37	18	12	970

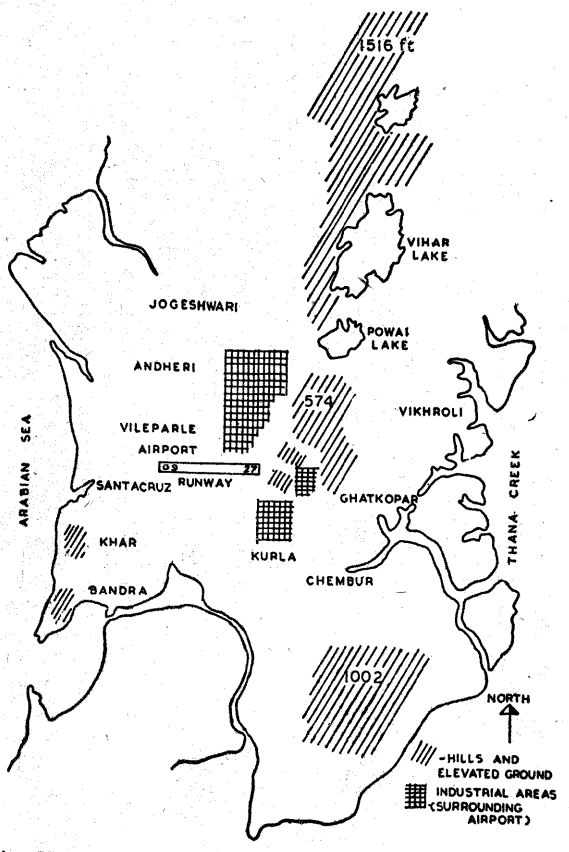


Fig. 5. Location map of Bombay airport & surroundings.

(*b*) The poor visibility spells last longer if the depth of inversion is large and/or the temperature difference between the surface and the top of the inversion layer is large.

On the 25 days considered in January 1974 the average depth of inversion at 00GMT was about 500 metres and the average difference in temperature between the surface and the top of the inversion layer was 7° C. The prolonged spells of poor visibility (> 5 hours) were found to occur when the wind was calm and the depth of inversion exceeded about 750 metres and/or the difference in temperature between the ground and the top of the inversion layer exceeded 10°C.

These observations only confirm the fact that the atmospheric pollutants and smoke that cause poor visibility get dispersed only when the wind shifts or strengthens introducing turbulent mixing or when the inversion layer is destroyed by ground heating and low-level convection.

3. Conclusion

(*i*) It is apparent that poor visibility over Bombay airport in the mornings of the cold weather period from December to February is not generally caused by moist phenomena like mist or fog. Rangarajan (1952) and Viswanathan and Faria (1963) had studied the occurrence of fog over Bombay airport which as seen from the climatological records is a rare phenomena for Bombay. The present study definitely indicates that the poor visibility in 1972-73 and 1973-74 during the season December-February was caused mainly by atmospheric pollutants in the form of suspended particulate matter and not due to mist or fog.

(*ii*) The deterioration of visibility occurs when either it is calm or when a light wind is blowing from the north or east quadrants. The marked concentration of factories and population in these quadrants seems to indicate that the poor visibility is caused by smoke and atmospheric pollutants, from domestic fires and factory chimneys, which slowly drift towards or stagnate over the eastern side of the aerodrome near the 27-end of the main runway. The visibility is generally lowest over the eastern side of the airfield. As the smoke and pollutants drift slowly towards the west they thin out and the visibility over the western portions of the airfield is usually better.

(*iii*) The close relationship between poor visibility during the winter mornings over Bombay and the industrial/population growth is further emphasised by the similarity in the curves that indicate factory growth in the north and east quadrants and the incidence of poor visibility.

(*iv*) *The* spells of poor visibility last as long as either the wind speed remains low <5 kt or it is calm and/or as long as the inversion layer over the area remains undestroyed. Visibility improves only with the progress of the day and the consequent ground heating and/or with the strengthening or marked change in direction of wind.

References

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