Secular Increases in Summer Haziness in the Atlantic Provinces

R.E. Munn
Atmospheric Environment Service, Toronto
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ABSTRACT

Since 1953, there has been a significant increase in the number of hours (May to October) of reported haze, smoke and/or dust at synoptic observing stations in the Atlantic Provinces and Eastern Quebec. Because the increase is associated mainly with south to southwest winds, and because there has in fact been a decrease in particulate emissions in eastern North America during this period, the suggestion is made that the increase in haziness is due to increasing photochemical activity, resulting from greater emissions of gases such as SO_2 and NO_x from sources along the United States eastern seaboard.

1 Introduction

Meteorological observations are made at hourly intervals at a large number of stations around the world. These reports include estimates of visibility and occurrences of haze, smoke and dust. In this connection, it should be noted that observing procedures for reporting visibility and the presence of haze have not altered in many years. Thus, the historical files of hourly observations can be interrogated to investigate long-term trends in visibility and haziness. When attempting to explain any trends that may be found, however, a number of factors must be considered.

There are many sources for suspended particulate matter in the lower atmosphere:

(a) man-made emissions in cities, as well as in the countryside (from slash burning, etc.);
(b) natural emissions such as forest fires;
(c) entrainment of surface dust during dry windy weather;
(d) the particulate products of photochemical reactions in the atmosphere.

The first and last components are of particular interest when studying secular trends; natural emissions do not change on the average, although they exhibit substantial year-to-year variations.

Man-made emissions of particulates are decreasing due to the implementation of pollution control programs and due to socio-economic factors. Downward trends in haziness are to be expected, therefore, unless one or more of the following changes has taken place:

(1) increased production of photochemical products, thus implicating distant sources;

(2) local changes in land use (for example, an airport observing location that once was rural might now be within a built-up area);
(3) secular fluctuations in climate (for example, a secular increase in the frequencies of southerly winds would result in an increase in haziness, because southerly flows generally contain more suspended particles than do northerly ones).

2 Winter haziness

There is no doubt that *winter* haziness is decreasing in populated regions. The black skies of the last century over Birmingham, England and Pittsburgh, Pa. have disappeared. Even in the last 20 years there have been some spectacular trends, as illustrated in Figs. 1 and 2. For the winter half of the year (defined here as the months January–April and November–December) the haziness decreased substantially between 1953 and 1971, at both Windsor and Vancouver Airports, even though the metropolitan areas have expanded towards the observing sites in both cases. These secular winter trends are typical of those in all Canadian cities.

3 Summer haziness

In summer, evidence is accumulating in several parts of the world that haziness is actually increasing. Lovelock (1972) suggests that this is happening in the rural parts of the United Kingdom while Miller *et al.* (1972) have documented the increases at the airports of Akron, Ohio, Lexington, Ky. and Memphis, Tenn. For the period 1962–1971 and excluding hours with rain and/or relative humidities of 70% or more, Miller *et al.* have obtained the trends shown in Table 1. At all three airports, there have been three- to five-fold increases in the frequencies of reduced visibilities. The authors have examined climatic changes in wind-roses during the period of record, and have concluded that visibility trends could not be explained by this mechanism. In their conclusion, they express the hope that their statistical results "will stimulate photochemical research and standardized tropospheric monitoring and analysis."

Referring again to Figs. 1 and 2, the number of hours with haze in summer did not increase at Windsor and Vancouver Airports during the period of record, although the downward trend at Windsor levelled off in 1962. Possible explanations for a behaviour different from that found in Ohio (see Table 1) are as follows:

(a) Major sources for particulates in the Vancouver area in summer are tepee-burning in the Fraser River valley, and slash burning in the surrounding forests. These sources have slowly diminished over the last 10 years, producing the downward trend in summer haziness.
(b) The Detroit-Windsor metropolitan area is heavily industrialized. The continuing effort to control particulate emissions in the last 20 years may be responsible for the decreasing frequency of haze in summer as well as in winter.

At both sites, therefore, secular increases in the photochemical production

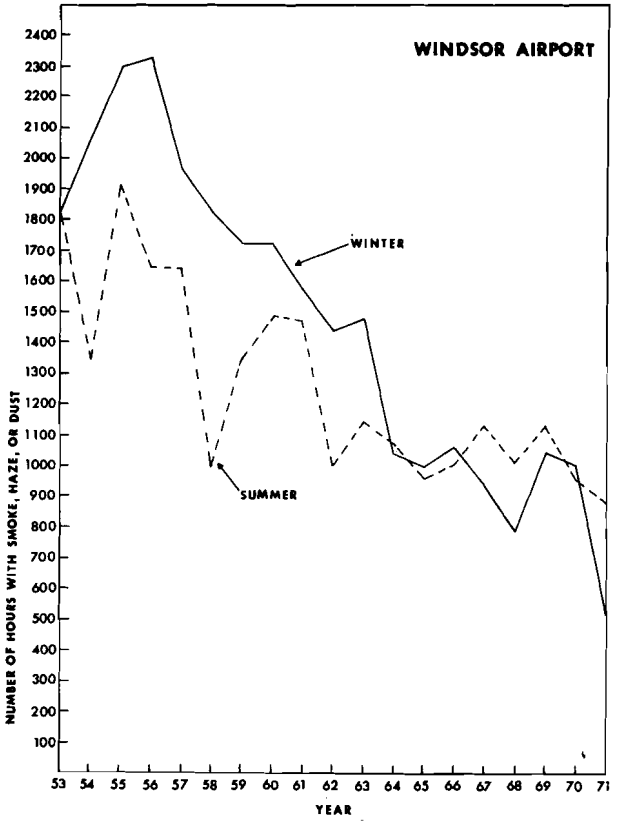

Fig. 1

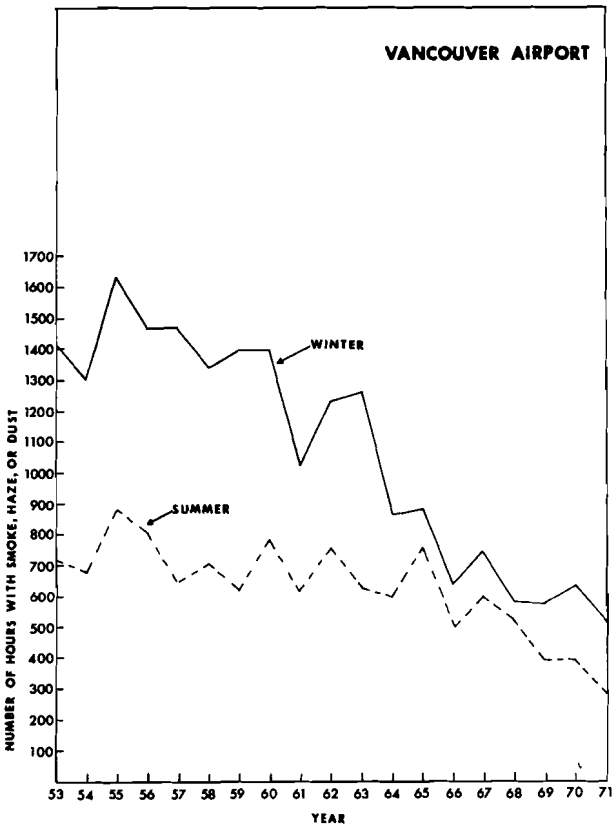

Fig. 2

Fig. 1 Secular trends in the number of hours of smoke, haze or dust at Windsor Airport in the period 1953 to 1971. Summer totals are for the months May to October; winter totals are for the months Jan. – April and Nov. – Dec.

Fig. 2 Same as Fig. 1, except for Vancouver Airport.

TABLE 1. Frequencies of visibilities of 0–10 km (0–6 mi) during the months June–September, inclusive, excluding hours with rain and with relative humidity of 70% or more (Miller *et al.*, 1972).

Station	Hour (EST)	Years				
		62–63	64–65	66–67	68–69	70–71
Akron, Ohio	1300	9.1	12.5	22.7	24.3	36.9
	1600	6.4	5.5	22.7	24.5	31.0
Lexington, Ky.	1300	6.7	11.7	23.8	20.7	25.6
	1600	6.5	12.8	26.2	18.4	29.5
Memphis, Tenn.	1200	6.0	8.7	15.1	7.4	13.4
	1500	1.6	6.3	10.1	7.2	10.5

of particulates might be hidden by secular decreases in direct emissions of particulates.

These questions were of sufficient interest to warrant study of haziness trends at all stations (about 80) in the Canadian hourly weather observing network. To summarize the results for the summer months (May–Oct.):

(a) In the arctic and sub-arctic, haze and smoke occurrences were rare except during a few individual summers when forest fires were burning.

(b) Elsewhere, the most notable trends occurred in the Atlantic Provinces and Eastern Quebec. Here, the summer haze frequencies generally doubled between 1953 and 1971. Fig. 3 displays the trends for Fredericton, Gander and Mont Joli airports. That the upward summer trends are not the result of changes in the atmospheric general circulation is indicated in Table 2, which shows for each wind direction at Fredericton Airport, the percentages of hourly observations with haze, smoke and/or dust. Four-year periods have been selected to provide some smoothing of the data. For north and northwest winds, there has been little change in haze frequencies between 1953–56 and 1968–71. For south and southwest winds, on the other hand, there has been a six-fold increase.[1] Amongst other things, these results confirm that there has been no change in observational procedures over the years; otherwise, the trends would be similar for all wind directions.

The Fredericton results suggest that there has been a strengthening of the urban and industrial gaseous plumes in the United States Eastern Seaboard, transporting photochemical products to the Atlantic Provinces and Eastern Quebec. An alternative explanation, an increase in particulate emissions, can be ruled out because of the downward trends in haziness during the winter months in Eastern Canada and because of the evidence (Spirates and Levin,

[1]The increases are smeared across some of the other directions because: (a) the surface wind is not always representative of the main flow (due to local effects and a general veering with height); and (b) the surface wind is only moderately correlated with regional streamlines and particle trajectories.

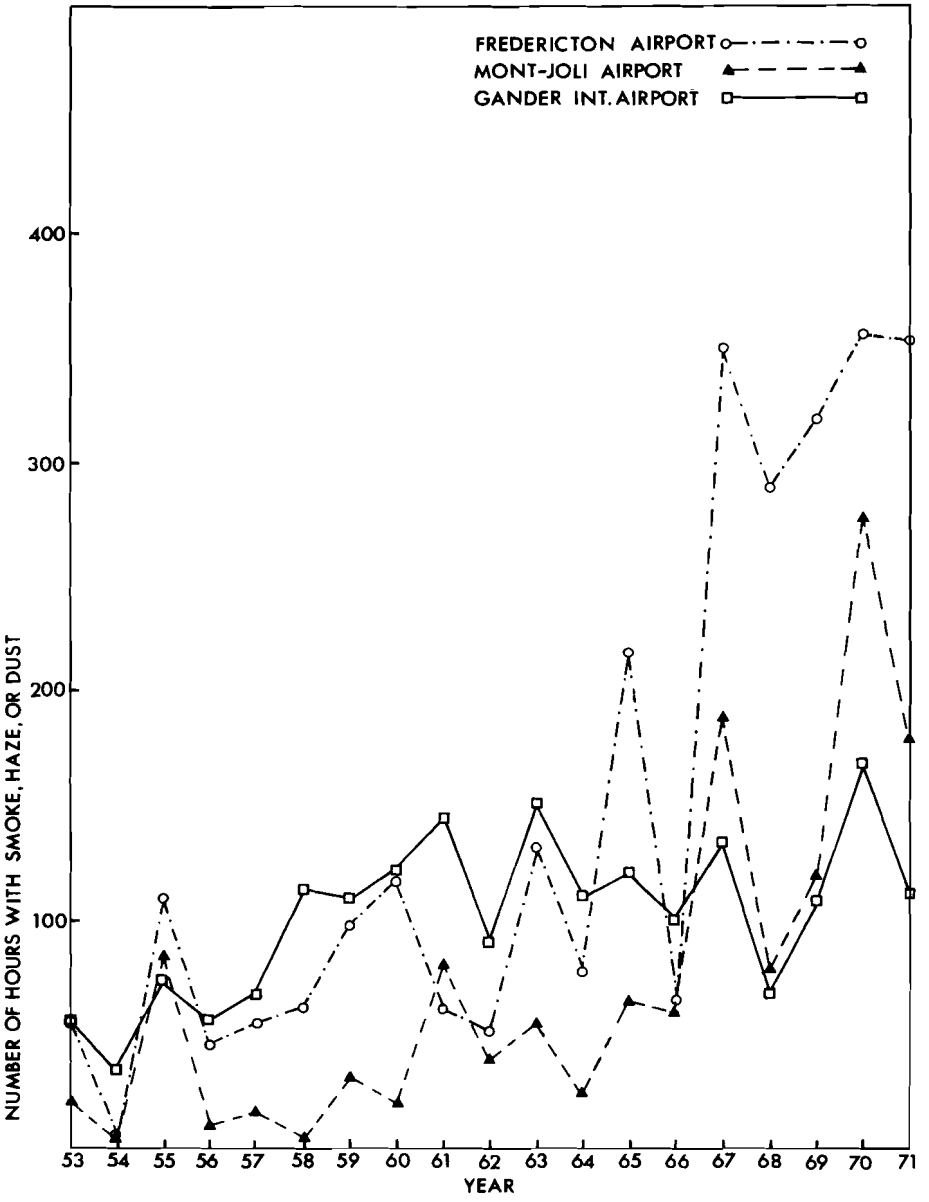

Fig. 3 Secular trends in the number of hours of smoke, haze, or dust at Fredericton, Gander and Mont Joli airports for the months May to October for the period 1953 to 1971.

TABLE 2. For the summer months (May to October) and for each wind direction, the percentages of hourly observations at Fredericton Airport with haze, smoke or dust, separately for the years 1953–56 and 1968–71.

	Wind Direction									
Years	N	NE	E	SE	S	SW	W	NW	Calm	All Cases
1953–56	1.1	0.4	0.5	0.6	2.2	1.7	0.4	1.0	1.3	1.2
1968–71	1.3	1.2	2.2	6.4	13.9	13.0	4.3	1.6	4.7	7.4

1970) that particulate loadings are decreasing within cities across the United States. It is more likely that increased emissions of gases such as SO_2 and NO_x from industrial power-plant and transportation sources in the Eastern USA are participating in photochemical reactions.

4 Conclusion

Winter frequencies of haziness have been decreasing in recent years in the populated parts of Canada due to air pollution abatement programs and socio-economic factors. In summer, haze frequencies are no longer decreasing, and have, in fact, doubled in the Atlantic provinces and Eastern Quebec since 1953. An analysis of wind frequencies at Fredericton airport supports the hypothesis that this increase is due to a strengthening of the urban and industrial gaseous plumes from the Eastern United States, transporting the particulate products of photochemical reactions to the Atlantic Provinces.

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