5 AMBIENT LEVELS OF PARTICULATE MATTER

Canadian PM data are typically collected over a 24 h averaging period on a one-day-in-six sampling regime. By operating on this schedule, given a long enough sampling period, each day of the week is equally well sampled, and hence all conditions during the week are represented. This chapter focuses primarily upon the 24 h data because it is most abundant and has formed the basis of most of the analyses in the epidemiological research.

5.1 BACKGROUND CONCENTRATIONS OF PM

Natural sources contribute to both fine and coarse particles in the atmosphere. 'Background' PM is generally defined as the distribution of PM concentrations that would be observed in the absence of anthropogenic emissions of PM and precursor emissions of VOC, NO_x, and SO_x in North America (US EPA, 1995).

Background levels of PM vary by geographic location and season. The natural component of background arises from: physical processes of the atmosphere that entrain small particles of crustal material (i.e., soil) and emissions of organic particles and nitrate precursors as a result of natural combustion sources (e.g., wildfires). Vegetation also emits fine organic aerosols and vapour phase precursors. Volcanoes and biogenic sources also emit sulphate precursors. The magnitude of the natural portion of PM for a given location is difficult to determine because of the influence of long-range transport of anthropogenic particles and precursors. The US EPA PM Criteria Document provides the estimates of regional PM_{10} and $PM_{2.5}$ background for annual, or longer averaging times, shown in Table 5.1. The lower bounds of the estimates are based on compilations of natural versus human-made emission levels, ambient measurements in remote areas, and regression studies using human-made and/or natural tracers (NAPAP, 1991; Trijonis, 1982; Malm et al., 1994). The upper bounds are derived from multi-year annual averages of the "clean" remote monitoring sites in the IMPROVE network (Malm et al., 1994) and reflect the effects of both background and anthropogenic emissions from within North America.

Table 5.1 PM_{10} and $PM_{2.5}$ Regional Background Levels (United States)

	Western US (µg/m^3)	Eastern US (µg/m^3)
PM_{10} , annual average	4 - 8	5 - 11
$PM_{2.5}$, annual average	1 - 4	2 - 5

The components of background PM as determined by Trijonis et al., (1990) are shown in Table 5.2. The eastern US is estimated to have more natural, organic fine particles and more water associated with hygroscopic fine particles than the west.

The range of expected background concentrations on a short-term basis is much broader. Specific natural events such as wildfires, volcanic eruptions, and dust storms can lead to very high levels of PM comparable to or greater than those observed in polluted urban atmospheres. Excluding extreme events, upper bound estimates of daily background as high as 12 µg/m^3 PM_{10} have been made based on short-duration studies in remote "clean" areas of the eastern US (Wolff et al., 1983). Based on 24 h peak to annual mean ratios for $PM_{2.5}$ data taken from four southeastern IMPROVE sites (Bachmann, 1996), EPA estimates that the highest background 24 h $PM_{2.5}$ levels over the course of a year could be 4 to 6 times higher than the annual average (i.e., on the order of 15 to 20 µg/m^3).

5.2 AVAILABLE MONITORING DATA

The majority of PM measurements in Canada have been made using hi-vol (TSP) or tape sampler (CoH) instruments. Manual measurements of PM_{10} using size selective hi-vols (SSI) and dichotomous samplers and manual measurements of $PM_{2.5}$ using dichotomous samplers began in 1984. Continuous instruments (Tapered Element Oscillating Microbalance or TEOM samplers) that have recently been installed at various sites throughout British Columbia and other regions of Canada are designed to provide hourly average estimates of PM_{10} mass. The data

Table 5.2 Components of Background PM

	Annual Average concentration (µg/m^3)		
	East	West	Error factor
Fine sulphates (as NH_4HSO_4)	0.20	0.10	2
Fine organic compounds	1.50	0.50	2
Fine elemental carbon	0.02	0.02	2-3
Fine ammonium nitrate	0.10	0.10	2
Fine soil dust	0.50	0.50	1.5-2
Water associated with the fine particles	1.00	0.25	2
Coarse particles	3.00	3.00	1.5-2
TOTAL "estimated natural background" PM_{10} (sum of the levels quoted by Trijonis 1990)	6.32	4.47	

Notes:

(1) Eastern USA is defined by Trijonis et al., (1990) as "the area up to one tier of states west of the Mississippi." Western USA includes "the mountain/desert regions of the western United States."

(2) "Fine" refers to aerosols of 2.5 µm in diameter.

(3) "Coarse" particles have diameter 2.5-10 µm.

records from these instruments are too short to provide much information regarding variability of PM_{10} concentrations on time frames of months or years. They do provide insight into short-term variability of PM_{10}, which may play an important role in determining personal exposure, health impacts, and information regarding source apportionment of PM_{10}.

5.2.1 National Air Pollution Surveillance (NAPS) Network

The NAPS network is a federal/provincial/municipal co-operative program that compiles data from all government monitoring programs across Canada. Data is stored in a unified database. In 1994, 93 provincial and municipal TSP monitoring sites and 41 CoH monitoring sites were included in the database. The CoH measurement sites were located in the cities of Montréal, Edmonton, Calgary and Vancouver and in the province of Ontario. The TSP data are collected over 24 hours every sixth day (on a unified national sampling schedule) whereas the CoH instruments are operated continuously and hourly averaged data are reported to the data base.

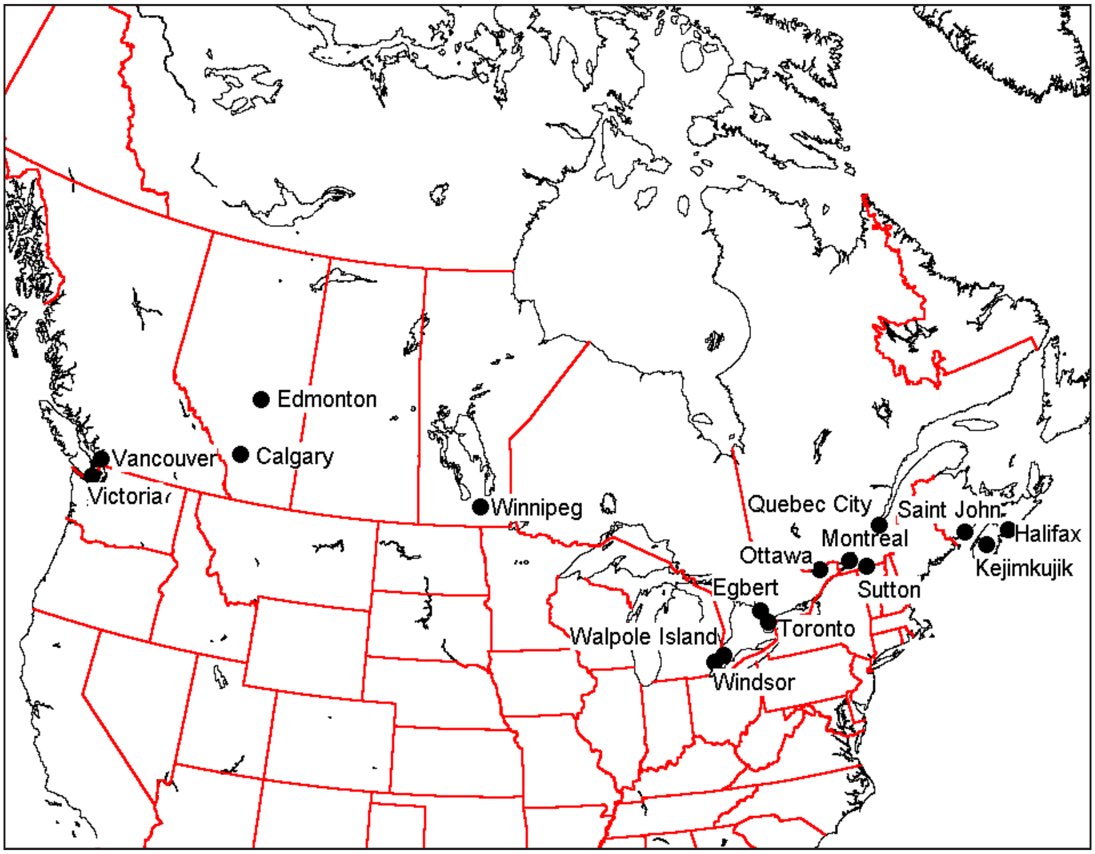
A national PM_{10} and $PM_{2.5}$ monitoring program has been in operation since 1984. Site details and dates of operation are shown in Table 5.3 and site locations are given in Figure 5.1. In 1984, there were 11 sites operating and in 1995, there were 24 samplers in operation. Data has only been collected at four rural locations (Kejimkujik, Sutton, Egbert and Walpole Island), the remainder being urban. The Walpole Island site is very close to metropolitan Detroit (25 km) and is influenced by nearby agricultural operations. Most sites are equipped with dichotomous samplers and report both fine (< 2.5 µm) and coarse (2.5 to 10 µm) mass results. The sum of fine and coarse represents PM_{10}. Some sites report only PM_{10} using SSI samplers. Samples are typically collected over 24 h sampling periods once every six days, although a number of eastern sites were operated daily during the summers of 1993 to 1995 as part of the Canadian Acid Aerosol Monitoring Program (CAAMP). Most dichotomous filter samples are analyzed by energy dispersive X-ray fluorescence (EDXRF) for approximately 50 elements and by high performance liquid chromatography (HPLC) for a number of anions and cations. Beginning in 1994, hourly PM_{10} data from TEOM instruments at NAPS sites are being reported to the database.

Table 5.3 PM_{10} and $PM_{2.5}$ Monitoring Locations and Available Data - National Network

NAPS ID	City	Address	Site Type	Available Data: Start Date	End Date	N	Sampler Type
10101	St. John's	Duckworth/Ordinance	Urban	21-Sep-84	16-Oct-85	39	D
40201	Saint John	110 Charlotte St.	Urban	04-Jan-88	28-Dec-94	268	S
40203	Saint John	Forest Hills	Suburban-Industrial	23-Jun-92	11-Nov-95	819	D,S
40204	Saint John	Police Station	Suburban	13-Jan-93	28-Dec-94	106	S
40205	Saint John	Regional Centre	Urban	01-Jan-93	31-Jul-94	85	S
30311	Sydney	Whitney Pier Fire Stn.	Urban-Industrial	04-Jan-88	28-Dec-94	269	S
30101	Halifax	N.S. Technical College	Urban	06-May-84	01-May-94	315	D
30118	Halifax	1657 Barrington St.	Urban	02-May-94	23-Dec-95	272	D
30119	Dartmouth	Harbor View School	Urban	10-Oct-93	03-Apr-95	83	D
30501	KejimkujiK	National Park	Rural	08-Jul-92	17-Dec-95	506	D
50104	Montreal	1125 Ontario Est	Urban	06-May-84	06-Oct-95	815	D
50109	Montreal	Duncan/Decarie	Urban-Roadway	03-Sep-84	21-Jan-95	367	D
50307	Quebec City	Parc Cartier Breboeuf	Urban	13-Apr-85	23-Oct-94	265	D
50308	Quebec City	Des Sables	Urban-Industrial	22-Nov-94	06-Sep-95	40	D
54101	Sutton		Rural	08-May-93	28-Sep-93	136	D
60104	Ottawa	Rideau/Wurtemburg	Urban	06-May-84	29-Dec-95	470	D,S
60204	Windsor	471 University Ave.	Urban	20-Jul-87	08-Apr-94	360	D
60211	Windsor	College/Prince	Urban	29-May-90	25-Aug-95	615	D
60417	Toronto	26 Breadalbane Street	Urban	12-May-84	17-May-90	272	D
60424	Toronto	Bay & Grosvenor	Urban	12-Jun-92	06-Sep-95	597	D
60403	Toronto	Evans & Arnold	Urban-Roadway	01-May-95	29-Dec-95	96	D
60512	Hamilton	Elgin & Kelly	Urban-Industrial	01-May-94	17-Dec-95	329	D
61901	Walpole Island		Rural	22-Jan-88	04-Mar-95	329	D
64401	Egbert		Rural	19-May-93	18-Oct-95	304	D
70119	Winnipeg	65 Ellen Street	Urban	06-May-84	11-Dec-95	550	D
80110	Regina	2505 11th Ave.	Urban	04-Jan-88	28-Dec-94	409	S
80209	Saskatoon	Idylwyld Dr./33rd. St.	Urban	06-Oct-88	02-Nov-92	217	S
80211	Saskatoon	511 1st. Ave. N.	Urban	08-Nov-92	28-Dec-94	121	S
90130	Edmonton	10255-104th Street	Urban	30-May-84	29-Dec-95	497	D,S
90204	Calgary	316-7th Ave.	Urban	28-Aug-84	27-Apr-87	144	D
90227	Calgary	611-4th Street	Urban	03-May-87	29-Dec-95	472	D
100106	Vancouver	2294 West 10th Ave.	Urban	06-May-84	17-Jan-86	108	D
100111	Vancouver	Rocky Pt. Park	Urban	28-Aug-84	17-Nov-95	442	D,S
100118	Vancouver	2550 West 10th Ave.	Urban	13-Dec-86	17-Dec-95	296	D,S
100109	Vancouver	970 Burrard	Urban	25-Sep-89	31-Jul-94	246	S
100303	Victoria	1250 Quadra St.	Urban	13-Jan-85	29-Dec-95	508	D

*D - Dichotomous Sampler, S - Size Selective Inlet Hi-vol Sampler

Figure 5.1 Location of Monitoring Sites – National PM_{10} and $PM_{2.5}$ Monitoring Network



5.2.2 British Columbia Network

The network of PM_{10} observing sites in British Columbia is dense: about 80 sites in the province have recorded 24 h average PM_{10} levels during the last decade using SSI samplers (Figure 5.2). Since 1992, collection of 1 h PM_{10} averages using TEOMs has also occurred at a number of sites in the province. The sites with the longest and most complete PM_{10} data records are summarized in Table 5.4. Only data from these sites will be discussed later in this section. A limited number of $PM_{2.5}$ measurements have been made in British Columbia. $PM_{2.5}$ is currently monitored at sites in Prince George, Quesnel, Williams Lake and Chilliwack using various sampling techniques. Short-term $PM_{2.5}$ monitoring studies have previously been conducted in Vernon and Nakusp. Additional $PM_{2.5}$ data are available from ten locations in southwestern BC which were part of the **RE**gional **V**isibility **E**xperimental **A**ssessment in the **L**ower Fraser Valley (REVEAL) study conducted during the summer of 1993 (Sakiyama, 1994). The REVEAL samples were also analyzed for metals, ions and organic and elemental carbon.

Figure 5.2 Map of PM_{10} Monitoring Sites in BC

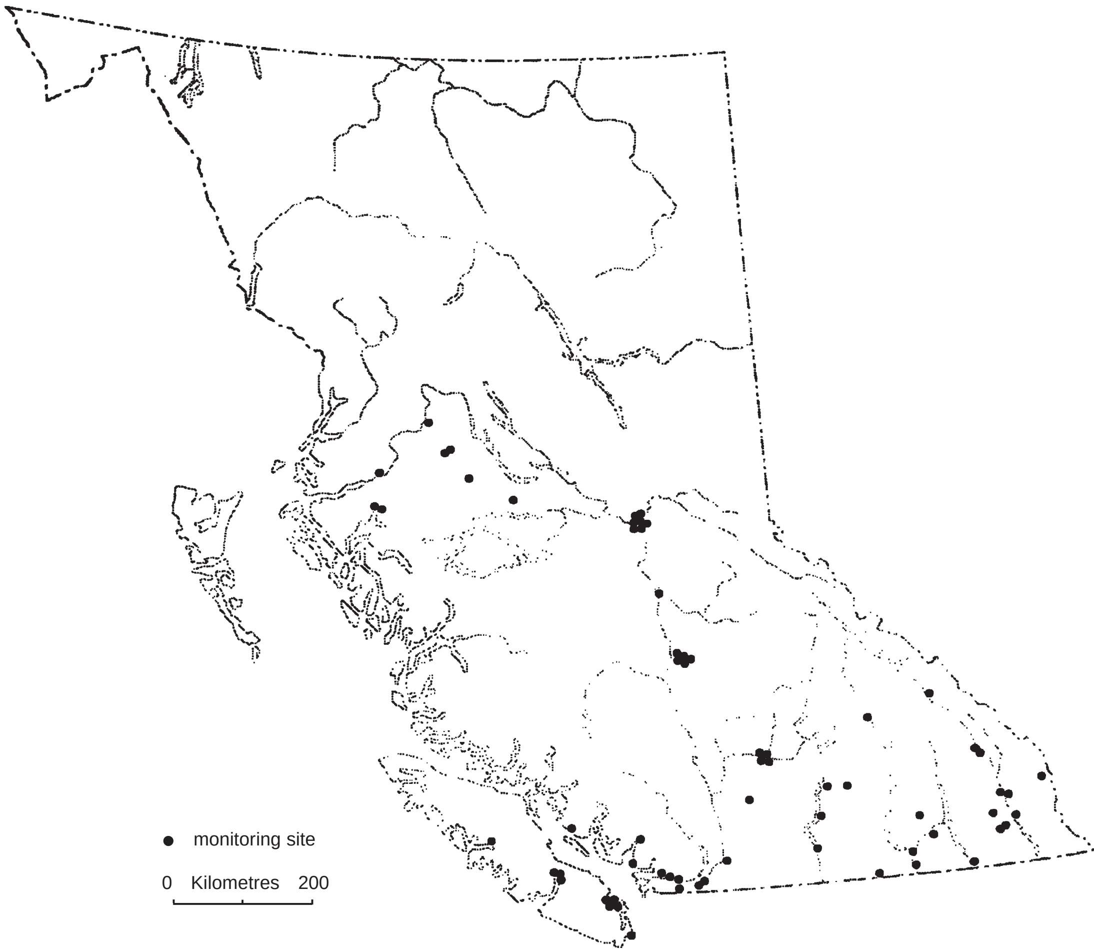


Table 5.4 Locations of PM_{10} Monitors in British Columbia

Site #	City	Lat	Long	Dates of operations Start	Dates of operations Last sample	# of samples
110264	Port Alberni	491401	1244810	6/2/85	24/8/94	389
605001	Kamloops	504220	1202636	5/1/90	27/12/93	214
E206112	Williams Lake	not given	not given	20/5/87	30/8/94	207
E206113	Quesnel	not given	not given	1/11/90	30/8/94	185
E206169	Pitt Meadows	491232	1224223	17/2/91	29/9/84	177
E206241	Cranbrook	493021	1154553	19/5/85	31/3/91	155
E206304	Kelowna	495138	1192833	1/9/89	20/4/94	234
E206589	Smithers	544652	1271037	16/7/90	26/4/94	194
E206725	Kamloops	not given	not given	10/2/90	30/8/94	240
E206931	Castlegar	491936	1173949	23/4/90	30/8/94	158
E208805	Weyside	not given	not given	5/5/90	30/8/94	240
E213056	Creston	not given	not given	20/9/90	27/11/94	199
E213114	Chilliwack	not given	not given	1/11/90	8/5/94	198

5.2.3 Ontario Network

The Ontario Inhalable Particulates Network commenced data collection in 1989 at sites in Windsor, Hamilton, Toronto, Thunder Bay and Sault Ste. Marie. Since 1989, the network has expanded and, as of January 1994, incorporates 18 sites at the locations detailed in Table 5.5. PM_{10} data are collected at these sites using SSI samplers and are collected over 24 hours on a one-in-six-day sampling schedule. Eleven TEOM instruments were operating in the province in 1996.

5.2.4 Quebec Network

Monitoring for PM_{10} has been carried out at 17 sites in the province between the years 1991 and 1995. Site locations are provided in Figure 5.3. PM_{10} data are collected at these sites using SSI samplers and are collected over 24 hours on a one-in-six-day sampling schedule.

Table 5.5 Locations of PM_{10} Monitors in the Ontario Inhalable Particulates Network

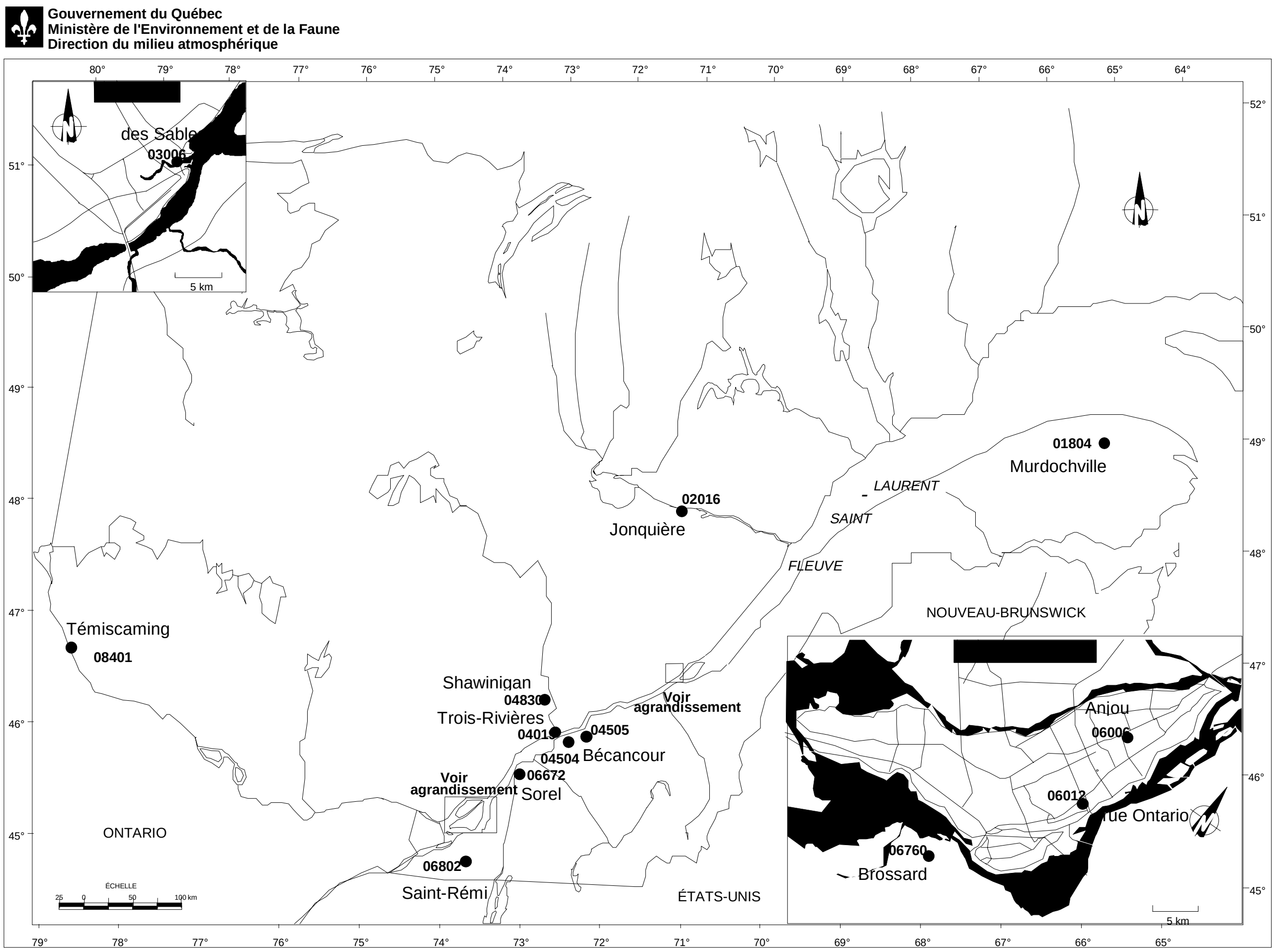
Site #	City	Station name	Lat	Long.	Type	Year
12507	Windsor	Wright/Water St.	42:17	82:16	UI	90
12508	Windsor	467 University Ave. W.	42:19	83:02	C	89
15516	London	801 Commissioners Rd. E.	42:57	81:13	UI	90
22304	Nanticoke	Walpole SPS. Sandusk Rd.	42:50	80:02	RI	92
27308	St. Catherines	King St.	43:10	79:15	C	91
27352	Thorold	185 Queen St., S.	43:07	79:12	UI	90
29300	Hamilton	Elgin/Kelly St.	43:15	79:52	UI	90
29302	Hamilton	Beach Blvd.	43:17	79:47	UI	89
29313	Hamilton	Gertrude/Depew St.	43:15	79:49	UI	90
29324	Hamilton	Buchanan Park P.S.	43:14	79:53	UI	92
31127	Toronto	Bay St./Grovernor Ave.	43:40	79:23	C	89
33127	Scarborough	Kennedy Rd./Lawrence Ave.	43:45	79:16	U	90
35127	Etobicoke	Evans/Arnold Ave.	43:37	79:31	I	90
44127	Oakville	Bronte Rd./Woburn Cres.	43:24	79:44	UI	92
63201	Thunder Bay	615 James St. S.	43:23	89:17	U	89
71342	Sault Ste. Marie	Pumphouse, Bonney St.	46:31	84:23	I	89
71368	Sault Ste. Marie	W.M. Merrifield School	46:32	84:21	UI	90
77326	Sudbury	Lisgar St.	46:29	80:59	UI	91

(1) Year indicates the year data collection commenced.

(2) The sites are designated as U, I, C, UI, RI based upon the environment surrounding the monitoring location.

(3) Key to site designations: U=urban, I=industrial, C=commercial, UI=urban/industrial, RI=rural/industrial.

Figure 5.3 Map of PM_{10} Monitoring Sites in Québec (1996)



5.3 MEASURED PM CONCENTRATIONS IN CANADA

5.3.1 General Characteristics of PM

PM data exhibit a strongly skewed distribution as shown in Figure 5.4 for PM_{10} and $PM_{2.5}$ data from a typical site (Montréal-Duncan/Décarie). The figure shows a histogram and a cumulative frequency distribution of the observations. The data is best fit using a Weibull distribution rather than a lognormal distribution. PM records are dominated by a large number of low values, which can “mask” trends in PM concentrations or the frequency or magnitude of “extreme” events. However, the upper portion of the PM frequency distribution may not be well represented in the data sets from Canadian observing sites because of the limited number of observations available to characterize the extremes of the distribution. The normal sampling frequency for the PM_{10} program has been once every six days. As shown in Table 5.6 the accuracy of the estimate of annual mean concentrations degrades with decreasing sampling frequency (Nehls and Ackland, 1973). The effect of sampling frequency on annual maximum values is provided in Table 5.7 (Nehls and Ackland, 1973). Errors of the estimates of the annual maximum are typically 4 to 6 times larger than the errors in the mean.

Note also that when comparing pollutant statistics or standards from different sampling sites/networks or regulatory agencies, care should be given to ensuring equality of the statistics or standards. Average PM_{10} and $PM_{2.5}$ concentrations are commonly calculated using the arithmetic mean while TSP averages have traditionally been reported using the geometric mean.

PM concentrations exhibit variation on a number of temporal scales: diurnal, hebdomadal (day of week), seasonal and annual (Dann, 1994; Pryor and Steyn, 1994a; Pryor and Barthelmie, 1996). The causes of these variations are multi-faceted and are related to emission variability and variations in geophysical variables such as mixed layer depth, wind speed and humidity levels. Anthropogenic factors affect cycles of pollutant concentrations on a number of time scales, but it is hard to prove causality. If present, the cycle that can most readily be ascribed to anthropogenic causes is the hebdomadal cycle. Given a large enough data set, geophysical conditions should be randomly distributed by day of the week (i.e., no geophysical variable "takes the weekend off"), but emission patterns may be strongly dependent upon the day of the week (Pryor and Steyn, 1995a).

The variability of PM concentrations on diurnal, hebdomadal, seasonal and annual time frames complicates the search for trends within PM time series. However, detection of trends (or the absence of trends) is central to monitoring the success of emission control strategies.

Figure 5.4 Distribution of 24 h PM_{10} and $PM_{2.5}$ Concentrations for a Typical Site (Station 50109 – Montréal)

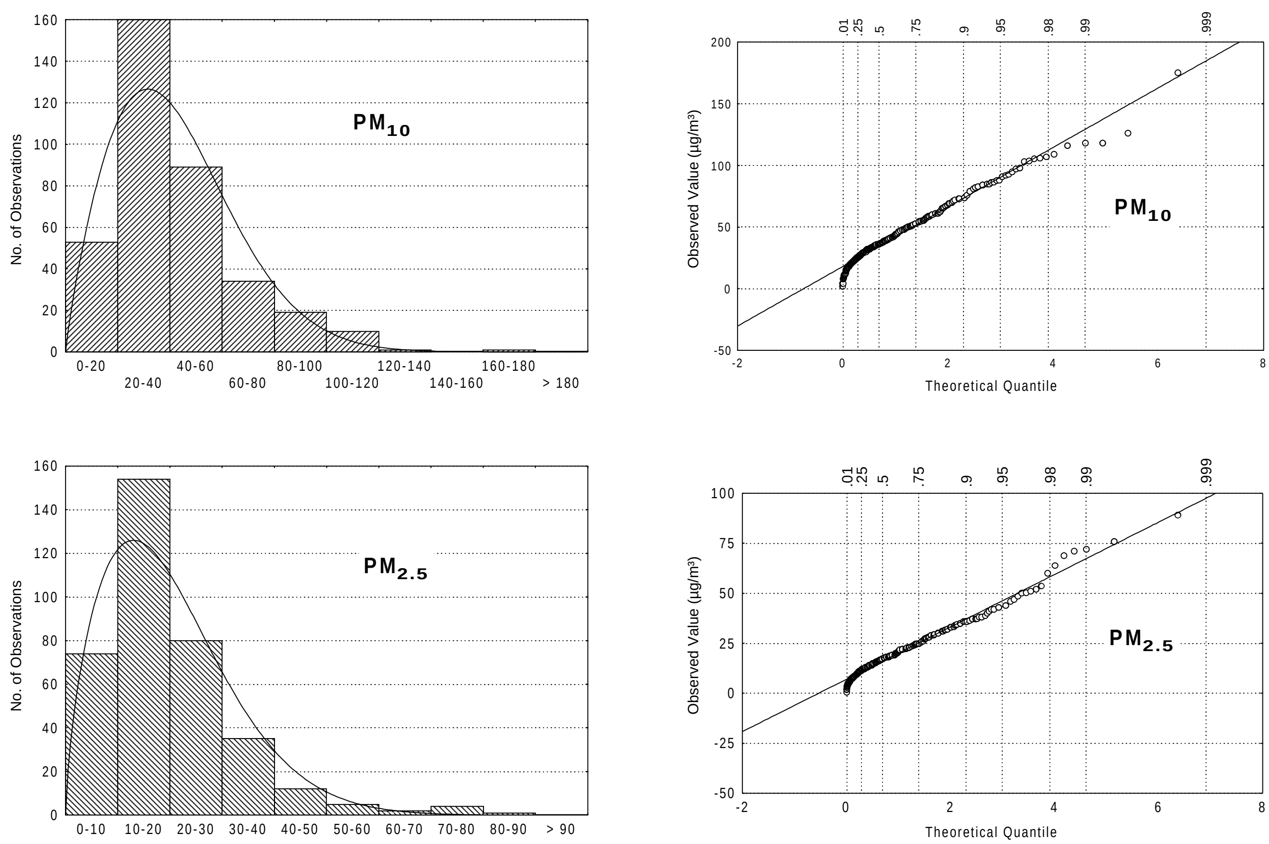


Table 5.6 Error Estimates as a Function of Sampling Frequency

Sampling Frequency (days)	Percent error compared to daily sampling		
	Yearly	Quarterly	Monthly
2	1.4	2.3	3.9
3	1.7	3.2	6.5
4	2.3	4.6	8.7
5	2.7	6.0	10.3
6	3.2	6.5	12.0
7	8.7	10.7	15.1
8	3.8	8.1	14.9
9	5.0	8.9	16.0

Table 5.7 Deviation of the Observed Annual Mean and Maximum from True Values for 42 US TSP Sites

Sampling frequency (days)	Average percentage error (%)	
	Mean	Maximum
1 in 12	7.1	30.1
1 in 6	4.1	22.0
1 in 3	2.1	13.6
1 in 2	1.9	8.9

Notes:

(1) Nehls and Akland (1973) found that the percent error of annual average particulate concentrations calculated based upon data collected every six days compared to that generated from a data set of daily samples was 3.2%.

(2) Dann (1994) estimated that measured and calculated maximum 24 h average PM_{10} concentrations at the NAPS sites differed by up to 61 μgm^{-3} and 88 μgm^{-3} at sites with few data samples (site 60104 in Ottawa and 61901 at Walpole Island, respectively). Sites with more observations showed a smaller discrepancy between calculated and measured maximum 24 h average PM_{10} concentrations (e.g., for data from site 60211 in Windsor the difference was only 16 μgm^{-3}).

5.3.2 TSP and CoH Concentrations

Summary statistics for TSP for NAPS sites for the year 1994 are provided in Table 5.8. Only sites that met annual completeness criteria (at least 8 samples in each quarter of the year) are shown. The highest 24 h value reported was 809 $\mu g/m^3$ at the Yellowknife site. The Calgary industrial site recorded the highest annual geometric mean TSP value of 71 $\mu g/m^3$.

Based on the analysis by Furmanczyk (1994), composite averages of the annual geometric mean TSP concentrations have decreased by 34% between 1981 and 1990. In Ontario, annual geometric mean TSP concentrations have declined by 58% between 1971 and 1994 (OMEE, 1995).

Table 5.9 provides summary statistics for one hour and 24 h CoH values for NAPS network sites for 1994. Maximum 1 h values of 4.7 CoH units were measured at the Toronto-Evans and Arnold site and the Windsor-University Ave. site. A maximum 24 h value of 2.7 CoH units was also recorded at the Toronto-Evans and Arnold site. Most sites recorded 95th percentile hourly values of less than 1.0 CoH unit. Annual means ranged from 0.1 to 0.5 CoH units. There are no NAAQOs for CoH but many Air Quality Index systems have used CoH as a surrogate for PM mass.

Based on trend analysis of NAPS sites (Furmanczyk, 1994), the composite average of station annual means has changed little from 1981 to 1990. For Ontario sites, composite annual means declined from 0.37 CoH units in 1971 to 0.29 CoH units in 1994.

Table 5.8 Summary Statistics for TSP (µg/m³) – 1994 (All NAPS Sites with Complete Data)

Station	C/R/I	City	Location	No. of Samples	Percentiles 10	30	50	70	90	MAX	Geometric Mean	Geometric Std. Dev.	Days > Acc. AQO
10102	C	St. John's	354 Water Street	53	14	18	21	24	30	54	20	1.7	0
20101	C	Charlottetown	56 Fitzroy St.	54	10	14	17	19	27	39	16	1.4	0
30101	C	Halifax	Technical University of N.S.	53	15	20	23	30	40	59	24	1.5	0
30102	R	Halifax	Dalhousie University	54	11	15	17	20	24	31	16	1.5	0
30115	I	Halifax	CFB Shearwater	56	8	12	14	16	18	26	13	1.4	0
40102	C	Fredericton	York Street	61	11	17	22	27	34	55	21	1.6	0
40201	C	Saint John	110 Charlotte Street	50	15	21	26	36	47	51	26	1.6	0
40203	R	Saint John	Forest Hills	41	11	14	21	29	35	40	20	1.6	0
50103	R	Montreal	Pointe-Aux-Trembles	47	19	24	34	38	44	57	31	1.4	0
50104	C	Montreal	1125 Ontario Est	51	27	32	39	49	60	88	39	1.4	0
50109	C	Montreal	Duncan & Decarie	47	26	36	51	65	90	174	50	1.6	2
50110	C	Montreal	Parc Pilon, Mtl.-Nord	48	25	28	32	39	49	57	33	1.3	0
50113	R	Montreal	Chomedey	61	19	25	29	34	40	61	28	1.4	0
50116	R	Montreal	3161 Joseph, Verdun	44	24	33	41	45	66	88	38	1.5	0
50119	R	Montreal	Bourassa	61	22	26	29	32	37	42	28	1.2	0
50120	R	Montreal	4th. Ave. South, Roxboro	51	18	26	31	41	62	96	32	1.6	0
50203	R	Hull	Gamelin & Joffre	58	11	19	25	33	50	73	25	1.7	0
50306	R	Quebec	Gomin	51	15	21	28	36	47	72	27	1.6	0
50307	C	Quebec	Parc Cartier Breboeuf	56	16	26	32	43	63	86	32	1.6	0
50403	C	Sherbrooke	Parc Webster	60	21	28	35	45	55	112	35	1.5	0
50503	C	Chicoutimi	Racine	54	14	24	33	47	73	121	32	1.8	1
50701	C	Sept-Iles	Dequen	46	8	15	21	29	36	83	19	1.8	0
50801	R	Trois-Rivieres	Ursulines	58	17	30	36	46	55	68	34	1.5	0
51201	I	Shawinigan	Frigon	46	25	32	41	53	83	242	43	1.7	1
51302	R	Baie Comeau	39 Ave. Mance	55	9	13	17	21	35	55	17	1.7	0
60101	C	Ottawa	88 Slater St.	60	19	28	33	42	72	172	35	1.6	1
60104	C	Ottawa	Rideau & Wurtemburg	60	15	22	27	36	56	92	27	1.6	0
60203	R	Windsor	9725 Riverside Dr. East	52	26	33	43	51	68	111	42	1.5	0
60204	C	Windsor	467 University Ave. West	53	43	45	54	66	91	136	58	1.4	2
60212	I	Windsor	Wright & Water St.	48	41	52	61	76	101	143	64	1.4	3
60424	C	Toronto	Bay & Grosvenor	60	34	47	58	71	90	137	57	1.5	2
60501	I	Hamilton	Barton & Wentworth	58	32	45	62	78	117	146	60	1.5	5
60503	I	Hamilton	Chatham & Frid	56	37	57	71	88	124	158	68	1.6	6
60511	I	Hamilton	467 Beach Blvd.	55	32	54	72	88	120	183	66	1.6	5

Table 5.8 Summary Statistics for TSP (µg/m³) – 1994 (All NAPS Sites with Complete Data) – *continued*

Station	C/R/I	City	Location	No. of Samples	Percentiles 10	30	50	70	90	MAX	Geometric Mean	Geometric Std. Dev.	Days > Acc. AQO
60512	C	Hamilton	Elgin & Kelly	47	33	46	58	71	120	204	60	1.6	4
60513	R	Hamilton	Vickers Rd. & East 18th. St.	52	23	34	39	51	63	83	39	1.5	0
60605	C	Sudbury	19 Lisgar Street	53	18	25	33	39	55	77	31	1.6	0
60707	I	Sault Ste. Marie	Wm. Merrifield School	56	16	25	34	49	71	107	35	1.8	0
60807	R	Thunder Bay	615 James Street South	52	17	25	32	42	53	70	31	1.6	0
60901	C	London	King & Rectory	52	28	41	53	68	109	147	52	1.7	3
61004	R	Sarnia	Front St. At C.N. Tracks	55	26	34	44	51	72	91	42	1.5	0
61303	C	St. Catharines	71 King Street	50	34	45	53	63	89	104	51	1.4	0
70119	C	Winnipeg	65 Ellen Street	58	19	28	40	49	74	110	37	1.7	0
80102	R	Regina	3211 Albert Street	58	7	12	16	25	40	61	17	1.9	0
80110	C	Regina	2505 11th. Avenue	61	14	24	39	50	70	112	34	1.9	0
80210	R	Saskatoon	1020 Ave I North	57	12	19	26	34	47	72	25	1.7	0
80211	C	Saskatoon	511 1st Avenue North	58	17	26	32	41	54	114	31	1.6	0
90121	I	Edmonton	17 Street & 105 Avenue	58	16	32	46	67	116	198	44	2.1	3
90122	R	Edmonton	127 St. & 133 Avenue	59	14	29	41	52	77	130	38	1.8	1
90130	C	Edmonton	10255 - 104th Street	60	20	32	43	63	97	258	45	1.8	4
90218	I	Calgary	Bonny Brk & 18A St. S.E.	61	43	54	67	86	130	245	71	1.6	8
90222	R	Calgary	39 St. & 29 Ave. N.W.	56	15	21	28	42	56	104	29	1.7	0
90227	C	Calgary	611-4th Street S.W.	60	22	38	47	63	94	301	47	1.7	3
90601	R	Fort Saskatchewan	100 Avenue & 98th Street	57	9	19	24	35	52	73	24	1.8	0
100102	R	Vancouver	100 Richmond Street	53	20	26	34	43	60	91	34	1.6	0
100104	R	Vancouver	4251 Ontario St.	47	14	20	25	32	45	68	25	1.6	0
100110	R	Vancouver	6400 E. Hastings & Kensington	59	10	14	23	29	37	45	20	1.7	0
100111	I	Vancouver	Moody & Esplanade, Port Moody	60	13	17	25	31	40	51	23	1.6	0
100113	I	Vancouver	Annacis Island, Delta	55	18	28	39	55	77	113	39	1.7	0
100114	C	Vancouver	Municipal Hall, Richmond	55	14	20	25	31	39	66	25	1.5	0
100116	R	Vancouver	163 East 48th St., N. Vancouver	55	11	14	19	26	33	41	19	1.6	0
100117	R	Vancouver	3700 Willingdon Ave., Burnaby	54	11	18	27	31	41	67	23	1.7	0
100118	R	Vancouver	2550 West 10th Avenue	54	14	20	25	31	41	66	25	1.5	0
100202	C	Prince George	1011 4th Avenue	60	17	23	35	51	90	174	36	1.9	3
100303	C	Victoria	1250 Quadra St.	52	18	27	34	39	48	61	32	1.5	0
100401	C	Kamloops	301 Seymour St.	61	24	34	41	64	96	134	45	1.7	2
100701	C	Kelowna	1000 Klo Rd.	58	11	22	29	39	69	118	28	1.9	0
119001	C	Whitehorse	Federal Building	51	6	15	22	34	41	82	19	2.1	0
129001	C	Yellowknife	50th Ave. & 49th Street	57	20	37	61	87	232	809	62	2.4	13

Table 5.9 Summary Statistics for Coefficient of Haze (CoH Units per 1000 Lineal Feet) – 1994

Station	C/R/I	City	Location	ID	10	30	50	70	90	95	Max	% Data	Annual Mean	Std. Dev.
50109	C	Montreal	Duncan & Decarie	1 HR	0.0	0.2	0.4	0.7	1.2	1.5	3.6	91.8	0.5	0.5
				24 HR	0.1	0.3	0.5	0.7	1.0	1.2	2.0	91.1		
50110	C	Montreal	Parc Pilon Mtl.-Nord	1 HR	0.0	0.0	0.1	0.2	0.5	0.7	2.1	89.2	0.2	0.2
				24 HR	0.0	0.1	0.1	0.2	0.4	0.5	0.9	89.9		
50115	C	Montreal	1001 Boul Maisonneuve O.	1 HR	0.1	0.2	0.3	0.4	0.7	0.8	3.2	90.0	0.4	0.3
				24 HR	0.2	0.3	0.3	0.4	0.6	0.7	1.4	91.4		
50116	R	Montreal	3161 Joseph Verdun	1 HR	0.0	0.0	0.1	0.1	0.3	0.4	1.2	84.0	0.1	0.1
				24 HR	0.0	0.1	0.1	0.1	0.2	0.3	0.6	83.3		
50120	R	Montreal	4th. Ave. South Roxboro	1 HR	0.0	0.0	0.1	0.2	0.4	0.7	2.4	87.9	0.2	0.3
				24 HR	0.0	0.1	0.1	0.2	0.3	0.5	1.1	86.3		
60104	C	Ottawa	Rideau & Wurtemburg	1 HR	0.1	0.1	0.2	0.3	0.5	0.6	1.8	97.6	0.2	0.2
				24 HR	0.1	0.1	0.2	0.3	0.4	0.5	1.0	97.3		
60204	C	Windsor	467 University Ave. West	1 HR	0.1	0.2	0.2	0.3	0.5	0.7	4.7	98.6	0.3	0.2
				24 HR	0.1	0.2	0.3	0.3	0.5	0.5	2.1	98.1		
60211	R	Windsor	College & South St.	1 HR	0.1	0.2	0.3	0.4	0.6	0.8	4.1	98.6	0.3	0.3
				24 HR	0.2	0.2	0.3	0.4	0.5	0.7	2.1	98.0		
60302	R	Kingston	Napier St.	1 HR	0.1	0.1	0.2	0.3	0.9	1.4	3.6	98.6	0.4	0.4
				24 HR	0.1	0.2	0.3	0.4	0.8	0.9	1.7	97.9		
60403	I	Toronto	Evans & Arnold Ave.	1 HR	0.1	0.3	0.4	0.6	1.0	1.2	4.7	97.7	0.5	0.4
				24 HR	0.2	0.3	0.4	0.6	0.8	0.9	2.7	97.6		
60410	R	Toronto	Lawrence & Kennedy	1 HR	0.1	0.2	0.3	0.4	0.7	0.8	4.5	97.3	0.3	0.3
				24 HR	0.2	0.2	0.3	0.4	0.6	0.7	2.5	97.1		
60413	R	Toronto	Elmcrest Road	1 HR	0.1	0.2	0.3	0.4	0.8	1.1	3.2	97.9	0.4	0.4
				24 HR	0.1	0.2	0.3	0.4	0.7	0.9	1.9	97.4		
60415	R	Toronto	Queensway W & Hurontario	1 HR	0.1	0.2	0.3	0.5	0.8	1.1	3.8	98.5	0.4	0.4
				24 HR	0.2	0.3	0.4	0.5	0.7	0.8	1.6	98.4		
60424	C	Toronto	Bay & Grosvenor	1 HR	0.1	0.2	0.3	0.5	0.7	0.9	2.5	98.2	0.4	0.3
				24 HR	0.2	0.3	0.3	0.5	0.6	0.7	1.5	97.9		
60501	I	Hamilton	Barton & Wentworth	1 HR	0.2	0.3	0.4	0.6	1.1	1.4	4.0	97.7	0.5	0.4
				24 HR	0.2	0.4	0.5	0.6	0.9	1.2	2.3	97.5		
60511	I	Hamilton	467 Beach Blvd.	1 HR	0.1	0.3	0.5	0.8	1.2	1.4	3.6	96.0	0.6	0.5
				24 HR	0.2	0.4	0.6	0.7	1.0	1.1	2.2	95.7		
60512	C	Hamilton	Elgin & Kelly	1 HR	0.1	0.2	0.3	0.5	1.0	1.3	3.7	98.8	0.5	0.4
				24 HR	0.2	0.3	0.4	0.5	0.9	1.1	1.9	98.8		
60513	R	Hamilton	Vickers Rd. & East 18th. St.	1 HR	0.1	0.1	0.2	0.3	0.6	0.8	2.6	98.8	0.3	0.3
				24 HR	0.1	0.2	0.2	0.3	0.5	0.6	1.2	98.8		
60607	R	Sudbury	Science Centre North	1 HR	0.0	0.1	0.1	0.2	0.4	0.5	2.5	92.9	0.2	0.2
				24 HR	0.1	0.1	0.2	0.2	0.3	0.4	0.9	91.7		
60707	I	Sault Ste. Marie	Wm. Merrifield School	1 HR	0.0	0.1	0.2	0.3	0.6	0.9	2.6	91.6	0.3	0.3
				24 HR	0.1	0.2	0.3	0.4	0.5	0.6	1.1	91.4		

Table 5.9 Summary Statistics for Coefficient of Haze (CoH Units per 1000 Lineal Feet) – 1994 – *continued*

Station	C/R/I	City	Location	ID	10	30	50	70	90	95	Max	% Data	Annual Mean	Std. Dev.
60807	R	Thunder Bay	615 James Street South	1 HR	0.0	0.1	0.2	0.3	0.6	0.7	3.3	94.8	0.2	0.3
				24 HR	0.1	0.1	0.2	0.3	0.5	0.6	1.7	94.4		
60901	C	London	King & Rectory	1 HR	0.1	0.1	0.2	0.3	0.5	0.7	3.2	96.1	0.2	0.2
				24 HR	0.1	0.1	0.2	0.3	0.5	0.5	1.7	95.8		
61004	R	Sarnia	Front St. At C.N. Tracks	1 HR	0.0	0.1	0.2	0.3	0.4	0.5	2.4	99.2	0.2	0.2
				24 HR	0.1	0.1	0.2	0.2	0.4	0.4	1.1	99.8		
61201	R	Cornwall	Bedford & Third St.	1 HR	0.0	0.1	0.1	0.2	0.4	0.6	3.8	97.9	0.2	0.2
				24 HR	0.1	0.1	0.1	0.2	0.4	0.5	1.3	97.8		
61302	C	St. Catharines	Argyle Crescent	1 HR	0.1	0.1	0.2	0.3	0.5	0.6	2.7	97.7	0.3	0.2
				24 HR	0.1	0.2	0.2	0.3	0.4	0.5	1.0	97.6		
61502	C	Kitchener	West Ave. & Homewood	1 HR	0.1	0.1	0.2	0.3	0.5	0.6	2.8	99.0	0.3	0.2
				24 HR	0.1	0.2	0.2	0.3	0.4	0.5	1.4	99.0		
61602	R	Oakville	Bronte Rd. & Woburn Cres.	1 HR	0.1	0.2	0.3	0.4	0.7	0.9	2.8	98.7	0.3	0.3
				24 HR	0.1	0.2	0.3	0.4	0.6	0.8	1.7	98.8		
61701	R	Oshawa	Ritson Rd. & Olive Ave.	1 HR	0.1	0.2	0.3	0.4	0.8	1.0	4.1	94.7	0.4	0.3
				24 HR	0.1	0.2	0.3	0.4	0.6	0.8	1.8	94.8		
62001	R	North Bay	O.P.P. Station	1 HR	0.0	0.1	0.1	0.2	0.4	0.6	2.4	91.3	0.2	0.2
				24 HR	0.1	0.1	0.2	0.2	0.4	0.4	0.8	90.1		
64501	R	Fort Frances	Portage/Church St.	1 HR	0.0	0.1	0.1	0.2	0.5	0.6	2.0	98.6	0.2	0.2
				24 HR	0.1	0.1	0.2	0.3	0.4	0.5	0.9	97.8		
70118	R	Winnipeg	Jefferson & Scotia	1 HR	0.0	0.0	0.0	0.1	0.1	0.2	0.9	70.6	---	
				24 HR	0.0	0.0	0.0	0.1	0.1	0.1	0.2	70.9		
70119	C	Winnipeg	65 Ellen Street	1 HR	0.0	0.1	0.1	0.2	0.3	0.3	2.0	80.5	0.1	0.1
				24 HR	0.1	0.1	0.1	0.2	0.2	0.3	0.4	78.6		
90121	I	Edmonton	17 Street & 105 Avenue	1 HR	0.0	0.1	0.1	0.3	0.6	0.9	3.1	99.7	0.2	0.3
				24 HR	0.0	0.1	0.2	0.3	0.5	0.6	1.1	99.6		
90122	R	Edmonton	127 St. & 133 Avenue	1 HR	0.0	0.1	0.2	0.3	0.7	0.9	4.4	98.6	0.3	0.3
				24 HR	0.1	0.2	0.2	0.3	0.6	0.7	2.2	98.2		
90130	C	Edmonton	10255 - 104th Street	1 HR	0.1	0.1	0.2	0.3	0.5	0.7	3.1	99.9	0.3	0.2
				24 HR	0.1	0.2	0.2	0.3	0.4	0.5	0.9	99.8		
90218	I	Calgary	Bonny Brk & 18a St. S.E.	1 HR	0.0	0.1	0.2	0.3	0.6	0.8	4.5	99.5	0.3	0.3
				24 HR	0.1	0.2	0.2	0.3	0.5	0.6	2.2	99.3		
90222	R	Calgary	39 St. & 29 Ave. N.W.	1 HR	0.0	0.0	0.1	0.1	0.2	0.4	2.1	99.8	0.1	0.1
				24 HR	0.0	0.1	0.1	0.1	0.2	0.2	0.8	99.6		
90227	C	Calgary	611-4th Street S.W.	1 HR	0.0	0.1	0.1	0.2	0.4	0.6	2.8	99.2	0.2	0.2
				24 HR	0.1	0.1	0.2	0.2	0.3	0.4	1.5	98.9		
100110	R	Vancouver	6400 E. Hastings & Kensington	1 HR	0.1	0.1	0.2	0.3	0.5	0.6	3.3	90.1	0.2	0.2
				24 HR	0.1	0.1	0.2	0.3	0.4	0.5	0.9	90.0		
100111	I	Vancouver	Moody & Esplanade Port Moody	1 HR	0.1	0.2	0.3	0.4	0.7	0.9	2.0	97.9	0.4	0.3
				24 HR	0.2	0.2	0.3	0.4	0.6	0.7	1.4	98.0		
100112	C	Vancouver	Robson/Hornby	1 HR	0.1	0.2	0.3	0.5	0.7	0.9	2.9	94.6	0.4	0.3
				24 HR	0.2	0.3	0.4	0.5	0.6	0.7	1.5	94.2		

5.3.3 24 h Average PM_{10} Concentrations

National Network (NAPS)

Table 5.10 summarizes the frequency distributions of PM_{10} data from dichotomous and SSI samplers operated at the sites listed in Table 5.3. At the urban sites, with multiple years of data, mean 24 h PM_{10} concentrations range from 9 to 42 µg/m³ with most sites in the range of 20 to 30 µg/m³. The highest PM_{10} concentrations (in terms of means and 90th percentiles) were measured at the Montréal-Duncan/Décarie, Windsor University Ave., Windsor College, Hamilton, Walpole Island and Calgary 7th Ave. The three rural sites of Kejimkujik, Sutton and Egbert record mean PM_{10} concentrations of 11, 11 and 17 µg/m³ respectively, although observations were only available for 1992-1995 for Kejimkujik and Egbert and for May-September, 1993 for Sutton. As noted, relatively high PM_{10} values were recorded at the other rural site at Walpole Island. This may be due to the effect of windblown dust from nearby agricultural operations and due to its proximity to metropolitan Detroit.

In Figure 5.5 selected dichotomous sampler sites are compared in terms of monthly variations in PM_{10} concentrations using a boxplot analysis of medians, 25th and 75th percentiles (inter-quartile range) and non-outlier minimums and maximums. The Montreal and Vancouver/Victoria sites record higher PM_{10} concentrations in the winter months and in particular during January and February. The Ontario sites record the highest concentrations in the summer months with a peak median in August. The Prairie sites experience their highest median concentrations in the spring, presumably due to lack of snow and vegetation cover, higher wind speeds and influence of street-sanding debris. The Maritime sites show variable seasonal variation in PM_{10} concentrations with Saint John and Kejimkujik showing a summer maximum and Halifax a winter maximum. In Figure 5.6, a similar analysis of day of week variations in PM_{10} concentrations is provided. Most urban sites show minimum PM_{10} concentrations on Sunday with maximum concentrations usually occurring during the middle of the week. Using results for all sites, mean midweek (Tuesday/Wednesday) PM_{10} concentrations were 30% higher than Sunday means. For the roadway sites, the differences were larger – up to a 50% increase in PM_{10}. This suggests that there are large day of week differences in anthropogenic emissions and indicates a substantial contribution to PM_{10} from transportation sources.

Yearly variations in PM_{10} concentrations during the 1984 to 1995 sampling period (1995 incomplete for most sites) are examined for the sites in Figure 5.7. There is an apparent decrease in PM_{10} concentrations at most sites with a complete data record with the largest percentage decreases occurring at the Montréal-Duncan/Décarie, Edmonton and Vancouver sites. A trend analysis of PM_{10} data carried out by Dann, 1994 for the period 1984-93 showed a statistically significant ($p < 0.001$) decreasing trend in PM_{10} on a national basis averaging 2% per year. In the US (Curran, 1993), the national composite average PM_{10} concentrations decreased by 17% between 1988 and 1992 (3.4% decrease per year).

The contrast between PM_{10} measurements at the two sites in Montréal (sites 50104 and 50109) and between sites 50109 and 54101 (Sutton) exemplifies one of the problems of monitoring PM_{10}. PM_{10} is not spatially homogeneous. Monitoring site characteristics and the existence (or absence) of significant local sources of PM_{10} may have considerable impact upon the PM_{10} concentration recorded at a given location.

To examine the statistical significance of the variability of PM_{10} concentrations, the chi-squared (χ^2) statistic was calculated for the data conditionally sampled by year, month and weekday. The χ^2 statistic involves comparing an observed distribution with a hypothetical expected distribution. In the current example, a contingency table was constructed for studying the distribution of PM_{10} concentrations (in four “bins”: 0–20, 21–40, 41–60, >60 µg/m^3) by year, month and day of the week. A χ^2 test was performed to test the hypothesis that the “columns” (i.e., year/month/day of the week) and “rows” (number of counts in the PM_{10} concentration bin) are not related (Hoel, 1975). In this type of analysis, the χ^2 value produced must be greater than tabulated values of χ^2 at a given significance level for the hypothesis to be rejected. As shown in Table 5.11, the inter-annual variability of the PM_{10} concentrations was significant at greater than the 90% confidence level for all but three of the sites where there were at least 20 observations available for each year.

Table 5.10 Frequency Distributions of 24 h Average PM_{10} Concentrations (µg/m³) from Dichotomous Sampler Sites (1984-1995) and SSI Sites (1988-1994) – National Network

				Percentiles							
NAPS ID	City	N	Min.	10	30	50	70	90	Max.	Mean	Std. Dev.
Dichotomous Sampler Sites											
10101	St. John's	39	2	5	12	16	22	29	34	17	8
40203	Saint John	819	1	5	8	12	18	28	70	15	10
30101	Halifax	315	6	12	18	23	29	40	81	25	11
30118	Halifax	272	3	8	11	13	16	22	52	15	7
30119	Dartmouth	83	2	7	9	11	14	19	36	12	6
30501	Kejimkujik	506	1	4	6	8	11	21	60	11	9
50104	Montréal	815	3	11	17	23	30	45	99	26	14
50109	Montréal	367	2	18	28	36	49	74	175	42	24
50307	Québec City	265	2	9	15	18	27	40	71	22	13
50308	Québec City	40	1	5	12	16	20	33	70	18	13
54101	Sutton	136	2	5	7	9	13	21	42	11	7
60104	Ottawa	470	3	8	14	18	24	38	76	21	12
60204	Windsor	360	4	13	20	27	36	55	110	31	18
60211	Windsor	615	5	14	21	27	35	52	105	31	16
60417	Toronto	272	3	13	19	24	32	48	96	28	15
60424	Toronto	597	3	11	16	23	30	47	102	26	15
60403	Toronto	96	6	11	18	25	32	44	63	26	12
60512	Hamilton	329	4	12	19	26	37	54	177	31	19
61901	Walpole Island	329	3	9	16	24	35	61	149	30	23
64401	Egbert	304	1	5	9	13	21	32	77	17	12
70119	Winnipeg	550	3	12	18	24	32	46	112	27	17
90130	Edmonton	497	4	10	16	23	30	45	86	25	14
90204	Calgary	144	6	14	20	27	35	59	114	32	19
90227	Calgary	472	5	10	16	21	29	43	84	24	13
100106	Vancouver	108	8	13	18	25	30	51	84	28	15
100111	Vancouver	442	3	11	17	22	29	43	82	25	13
100118	Vancouver	296	4	9	14	19	23	36	69	21	11
100303	Victoria	508	2	8	11	15	20	30	71	17	10
SSI Sites											
40201	Saint John	268	1	9	15	19	26	38	64	21	11
40203	Saint John	246	1	6	11	14	19	28	59	16	10
40204	Saint John	106	1	3	5	8	11	16	50	9	7
40205	Saint John	85	3	6	9	12	16	25	77	14	10
30311	Sydney	269	5	11	14	18	24	39	111	22	15
60104	Ottawa	405	3	8	12	15	22	32	77	19	11
80110	Regina	409	4	8	13	19	28	48	367	25	24
80209	Saskatoon	217	2	8	13	17	23	35	76	20	13
80211	Saskatoon	121	4	8	12	15	20	28	75	18	11
90130	Edmonton	404	5	12	17	23	33	49	132	28	16
100111	Vancouver	249	5	9	14	17	22	34	53	19	9
100118	Vancouver	183	4	9	12	15	21	30	58	18	10
100109	Vancouver	246	5	12	17	22	28	40	70	24	11

Figure 5.5 Monthly Variation in PM_{10} Concentrations for Selected Monitoring Locations (1984-1995). The Box Plots Indicate the Median, 25th and 75th Percentiles and the Non-Outlier Minimum and Maximum Concentrations.

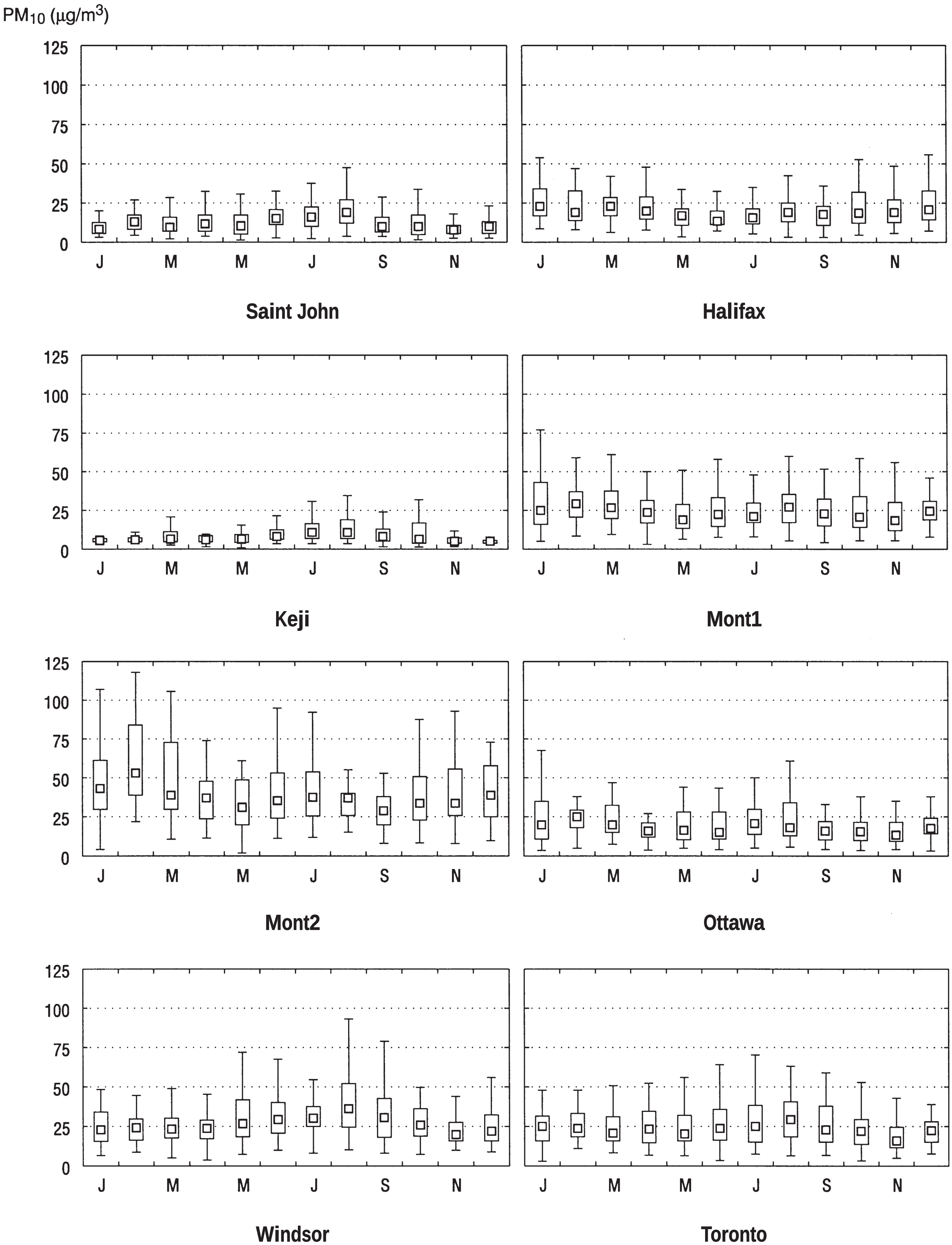


Figure 5.5 Monthly Variation in PM_{10} Concentrations for Selected Monitoring Locations (1984-1995). The Box Plots Indicate the Median, 25th and 75th Percentiles and the Non-Outlier Minimum and Maximum Concentrations. ***(continued)***

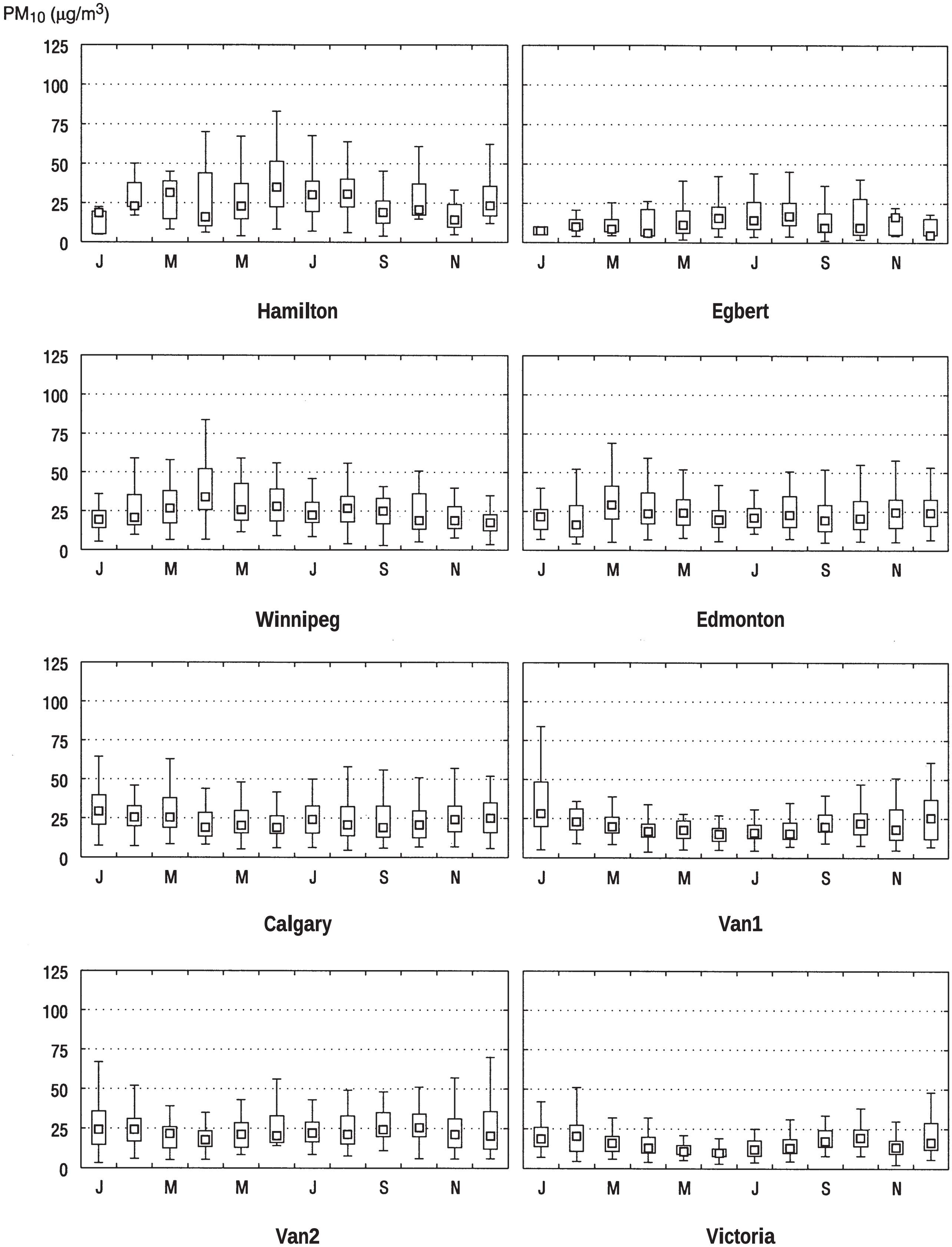


Figure 5.6 Day of Week Variation in PM_{10} Concentrations for Selected Monitoring Locations (1984-1995). The Box Plots Indicate the Median, 25th and 75th Percentiles and the Non-Outlier Minimum and Maximum Concentrations.

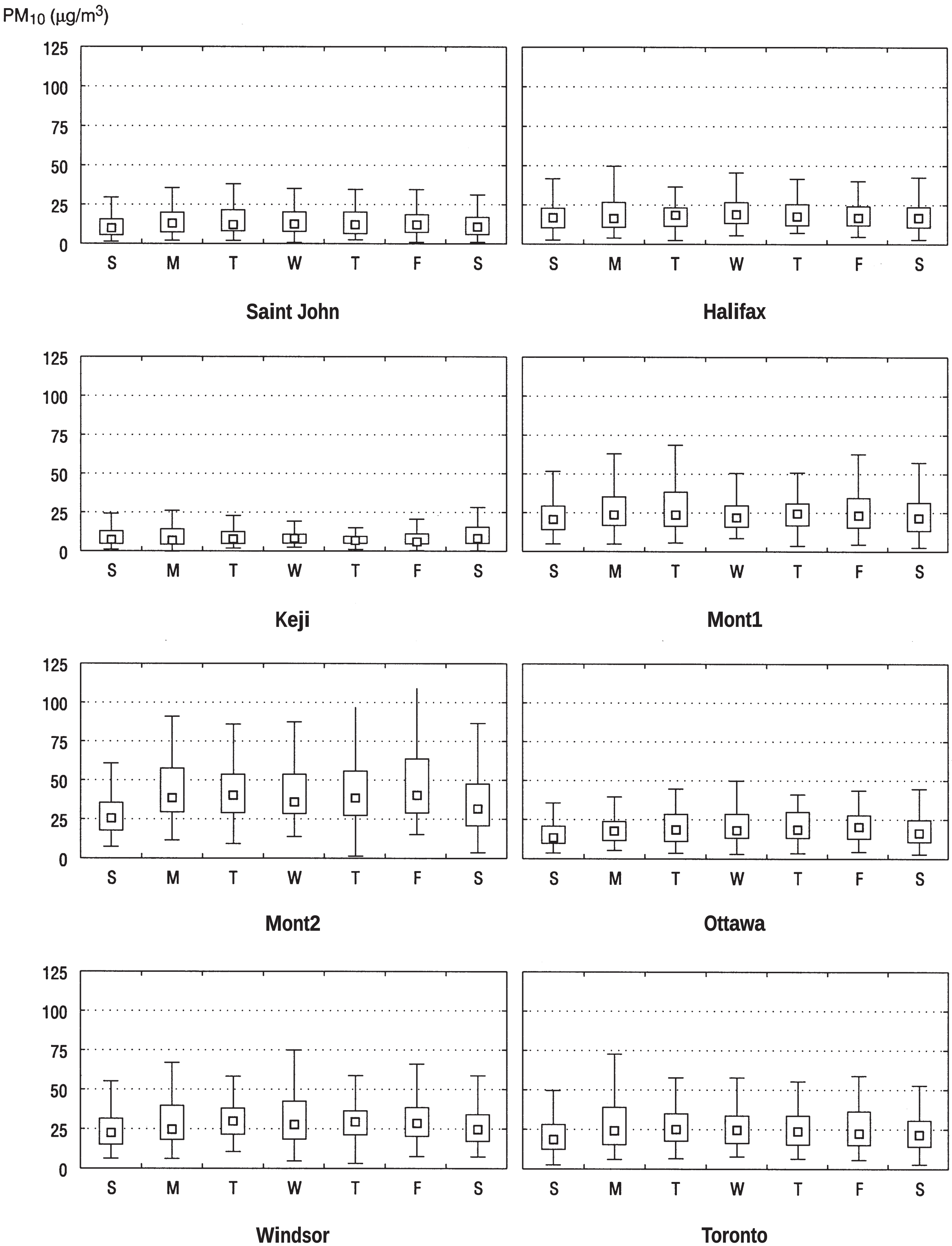


Figure 5.6 Day of Week Variation in PM_{10} Concentrations for Selected Monitoring Locations (1984-1995). The Box Plots Indicate the Median, 25th and 75th Percentiles and the Non-Outlier Minimum and Maximum Concentrations. ***(continued)***

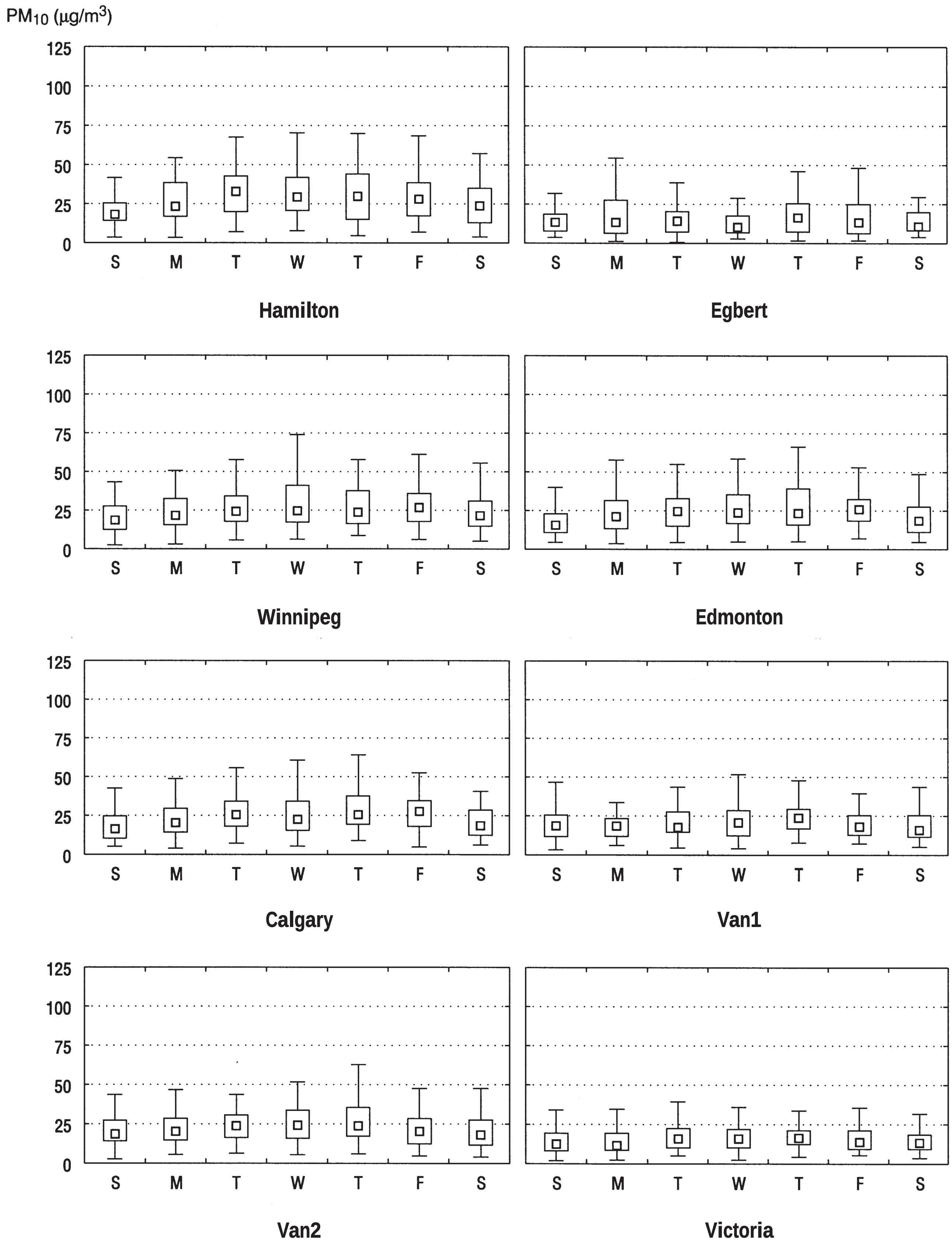


Figure 5.7 Yearly Variation in PM_{10} Concentrations for Selected Monitoring Locations (1984-1995). The Box Plots Indicate the Median, 25th and 75th Percentiles and the Non-Outlier Minimum and Maximum Concentrations.

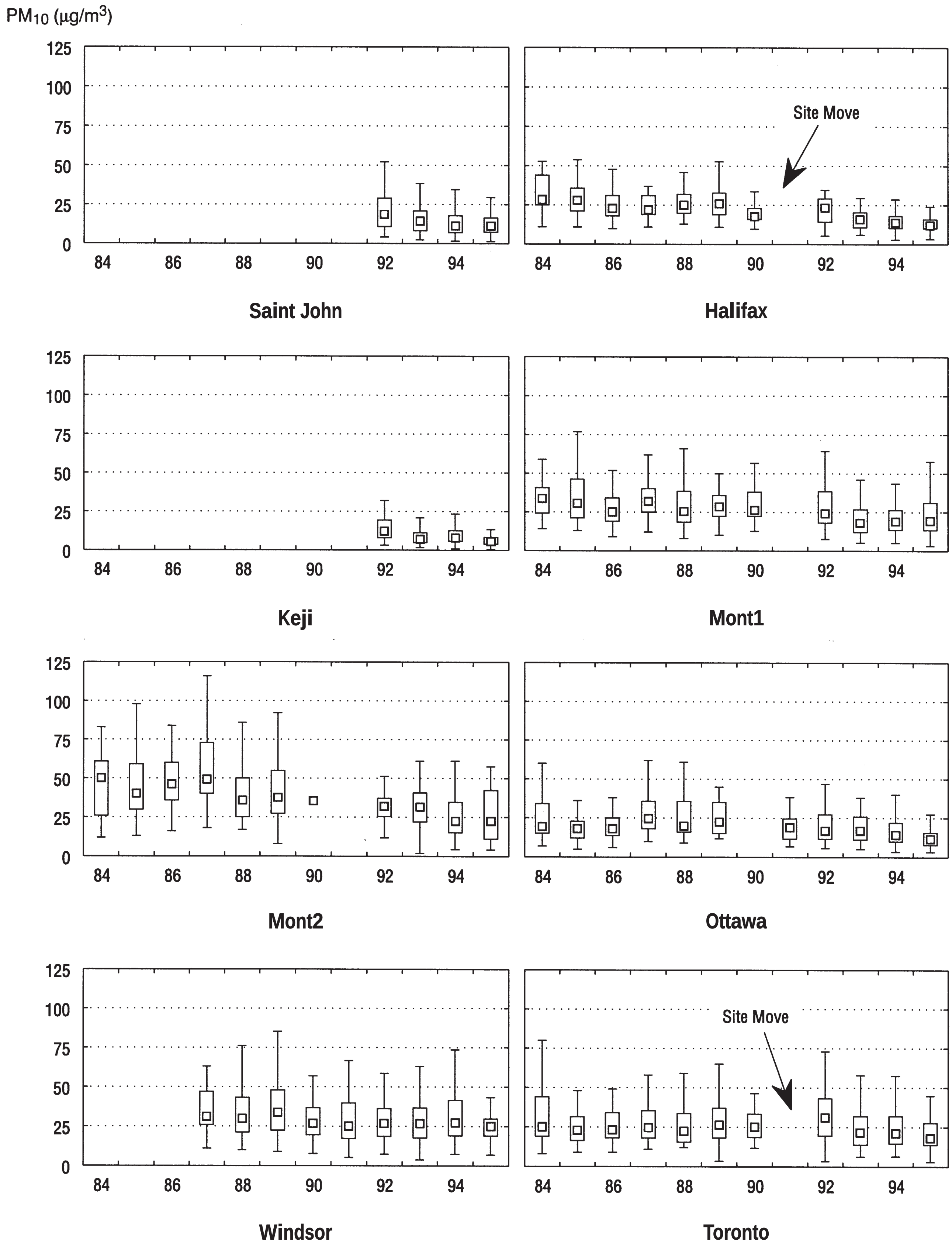


Figure 5.7 Yearly Variation in PM_{10} Concentrations for Selected Monitoring Locations (1984-1995). The Box Plots Indicate the Median, 25th and 75th Percentiles and the Non-Outlier Minimum and Maximum Concentrations. ***(continued)***

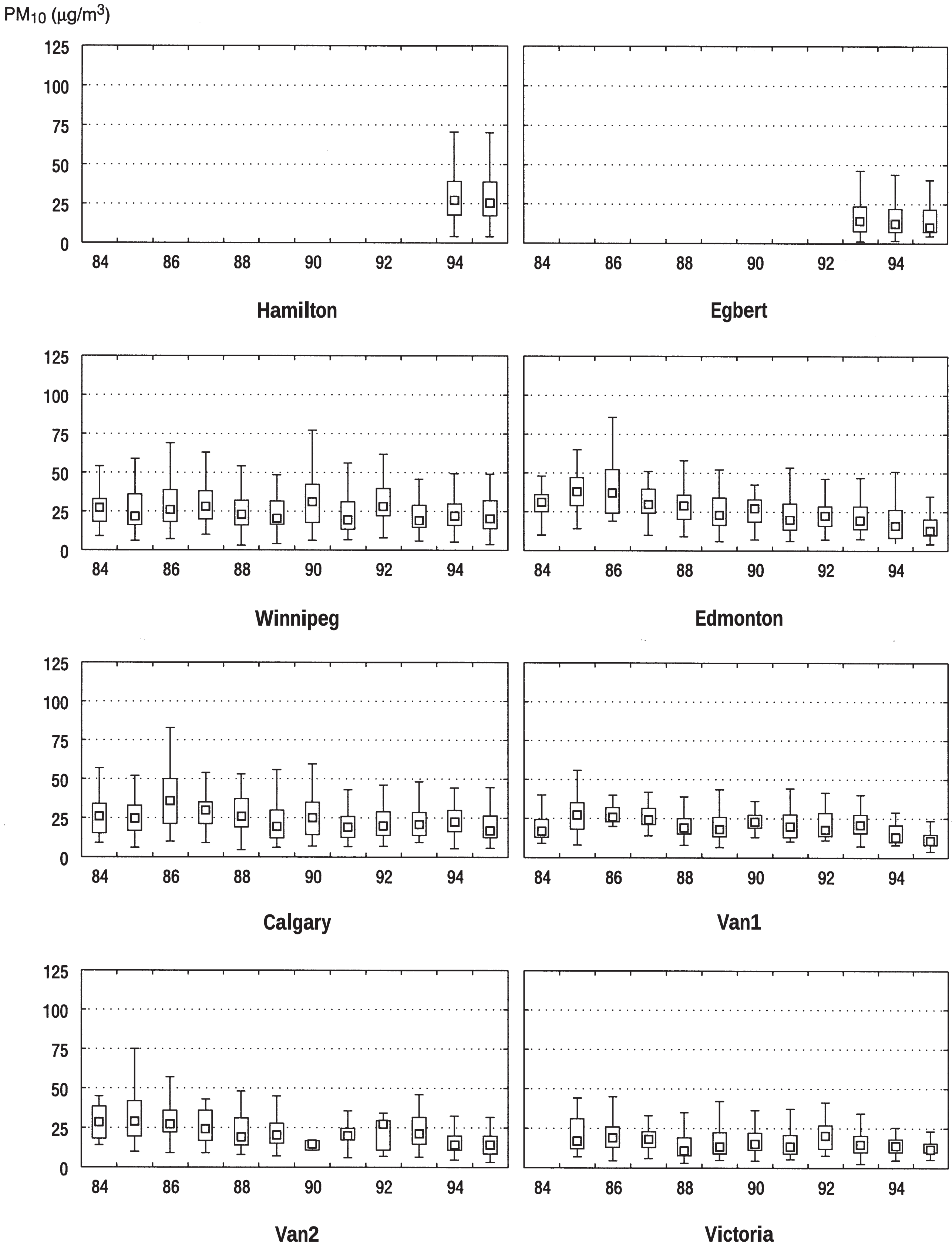


Table 5.11 The Results of a Chi-Squared (χ^2) Test Applied to PM_{10} from Selected Dichotomous Sampler Sites

Station number and location		Data grouped by year		Data grouped by week day (weekend v mid-week)
			years used	
010101	Saint John	insufficient data		sign. at 95%
030115	Halifax	sign. at 99%	1985-1989, 1993	not sign.
030501	Kejimkujic	sign. at 99%	1984-1993	not sign.
05104	Montréal	insufficient data		sign. at 99%
05109	Montréal	sign. at 95%	1985-1989, 1993	not sign.
050307	Québec City	not sign.	1984-1992	not sign.
054101	Sutton	insufficient data		sign. at 90%
060104	Ottawa	sign. at 95%	1990-1993	not sign.
060204	Windsor	not sign.	1984-1989	not sign.
060211	Windsor	insufficient data		not sign.
060417	Toronto	sign. at 99%	1988-1993	not sign.
060424	Toronto	insufficient data		not sign.
061901	Walpole Is.	sign. at 95%	1984-1993	sign. at 99%
064401	Egbert	insufficient data		sign. at 99%
070119	Winnipeg	insufficient data		not sign.
090130	Edmonton	sign. at 90%	1987-1993	sign. at 99%
090204	Calgary	insufficient data		sign. at 95%
090227	Calgary	sign. at 99%	1985-1991	sign. at 95%
100106	Vancouver	sign. at 99%	1987-1989,1993	sign. at 99%
100111	Vancouver	not sign.	1985-1993	not sign.

Notes:

(1) only station 70119 in Winnipeg had sufficient data to calculate the χ^2 statistic by month. The result was significant at the 95% confidence level.

(2) The following categories of PM_{10} concentrations were used to group the observations of PM_{10} concentrations: 0-20, 21-40, 41-60, >60.

(3) χ^2 statistics were calculated only if all periods (i.e., every year, month and day) had >20 observations.

(4) Mid-week is defined here as Wednesday and Thursday.

The results of the test for differences between the PM_{10} concentration on weekends and mid-week (Wednesday and Thursday) were less uniform. One might expect sites in or near large cities with significant industrial activity to exhibit clear hebdomadal cycles of PM_{10} concentrations owing to the influence of the workweek upon emissions. This pattern was observed somewhat in the data from the NAPS sites, with most of the remote rural and urban non-industrial locations showing "not significant" in Table 5.11, indicating the absence of a significant day of week cycle. However, data from some sites located within major industrial centres also fail to exhibit a statistically significant day of week cycle according to this statistical test. Box plots of day of week variations in PM_{10} for selected sites were provided in Figure 5.6.

To further examine variability of PM_{10} concentrations on these time scales, the upper quartile mean (UQM) concentrations of the PM_{10} data were calculated. The statistics of PM_{10} records are dominated by a large number of low concentrations (see Figure 5.4), which can "mask" trends, or sample differences that are apparent only in the higher concentrations. Cleveland and McRae (1978) proposed a method for examining day-of-the-week variations of ozone concentrations that can be readily applied to PM_{10} data sets and on other time scales. They suggested calculating a "robust upper quartile mean of the daily maxima for each day of the week." The robust UQM of a data set is approximately equal to the average of the highest 25% of the observations and was calculated for the PM_{10} data sets using the following methodology, taken from Cleveland and McRae (1978):

1) The square root of each of the PM_{10} concentrations at a given site on a given year/month/day was calculated (denoted by X_i, i=1-n, where n is the number of days of observations). The square root of the PM_{10} concentrations is approximately normally distributed.

2) The median (m) of each X_i for each period and site was calculated.

3) The median of abs(X_i-m), was estimated for each time period and site. If any value of X_i-m is >3.5s, then that value was replaced by m+3.5s for positive values of X_i-m and m-3.5s for negative values of X_i-m, so that extreme values do not bias the analysis.

4) An average of the values above the 75th percentile of the X_i was calculated, and the result squared to return a value in mg/m^3. This is the robust mean of the upper quarter of the PM_{10} data.

In this way, a robust mean was calculated for each day of the week, month and year for data from each site. This value was then standardized by subtracting the average of the UQM calculated without stratification by day of the week, month or year and then dividing by this number. (This standardization facilitates comparison between sites that have different robust mean PM_{10} concentrations.) Each standardized UQM of the PM_{10} concentration shown in Figures 5.8 a, b and c represents a robust mean of about 10 values for each year, five for each month and day of the week. The results portrayed in Figure 5.8 confirm the findings of the χ^2 analysis. The UQM PM_{10} concentrations are typically, but not uniformly, lower on the weekends. Seasonality of the PM_{10} concentrations is evident, but the form of the seasonality is regionally variable. Inter-annual variability of the UQM PM_{10} concentrations is also evident, but it is difficult to determine any regional homogeneity at this time scale.

British Columbia

Thirteen monitoring locations that had more than 150 observations of 24 h average PM_{10} concentrations were selected to be discussed here (for locations see Table 5.4). Figure 5.9 summarizes the data from six of these sites by showing the interquartile range of PM_{10} concentrations by year, month and day of the week. Table 5.12 shows the frequency distribution of the PM_{10} data from all 13 sites. The range of the extreme PM_{10} concentrations is similar to that from the NAPS sites. Table 5.13 shows the results of χ^2 statistics as applied to PM_{10} concentrations conditionally sampled by year, month and weekday. From Figure 5.9 and Table 5.13, it is clear that several of the sites show variability of PM_{10} concentrations on annual, seasonal and hebdomadal (weekly) time scales.

Figure 5.8 Standardized Upper Quartile Mean (UQM) PM_{10} Concentrations at National Network Sites by a) Year b) Month and c) Day of Week.

(a)

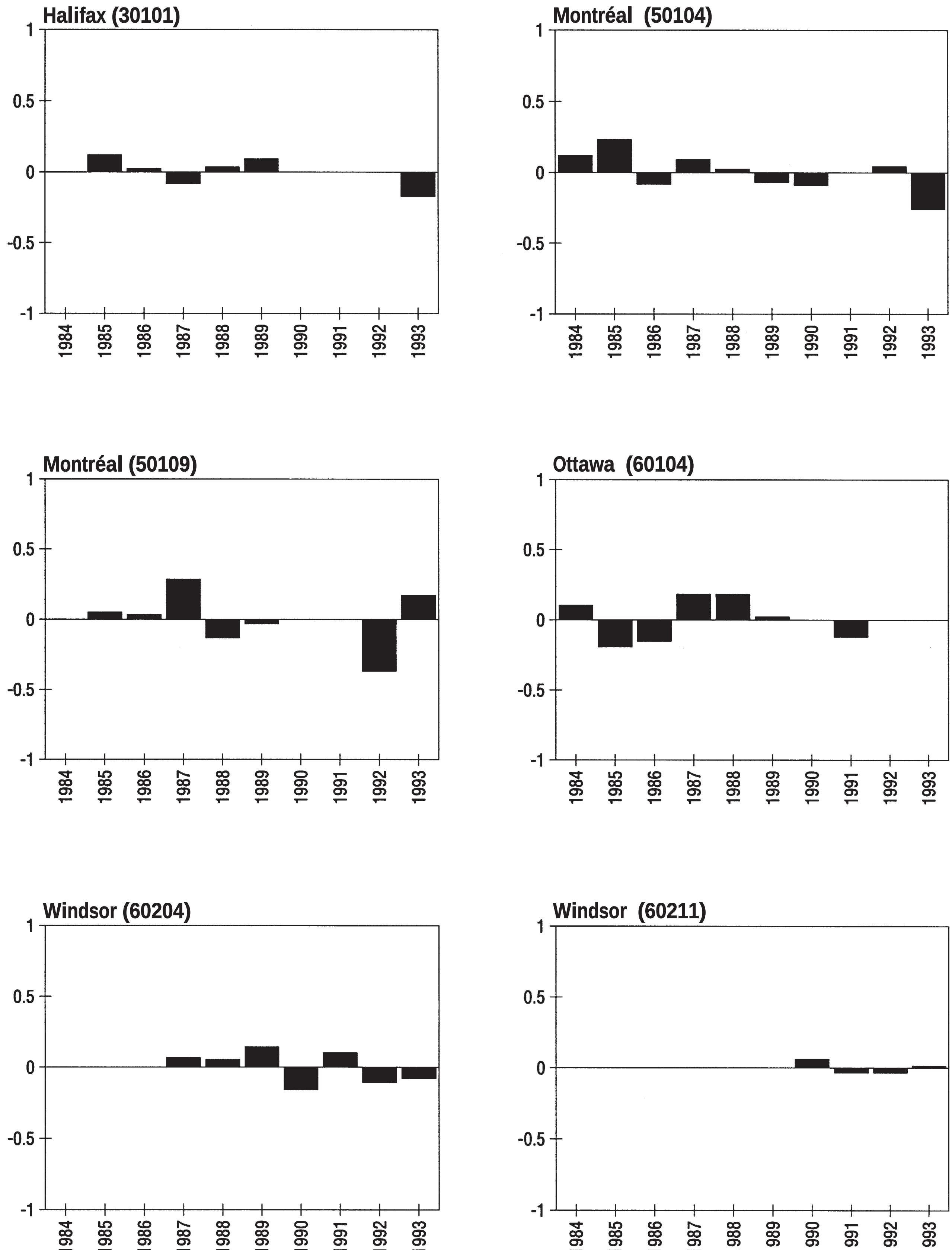


Figure 5.8 Standardized Upper Quartile Mean (UQM) PM_{10} Concentrations at National Network Sites by a) Year b) Month and c) Day of Week. ***(continued)***

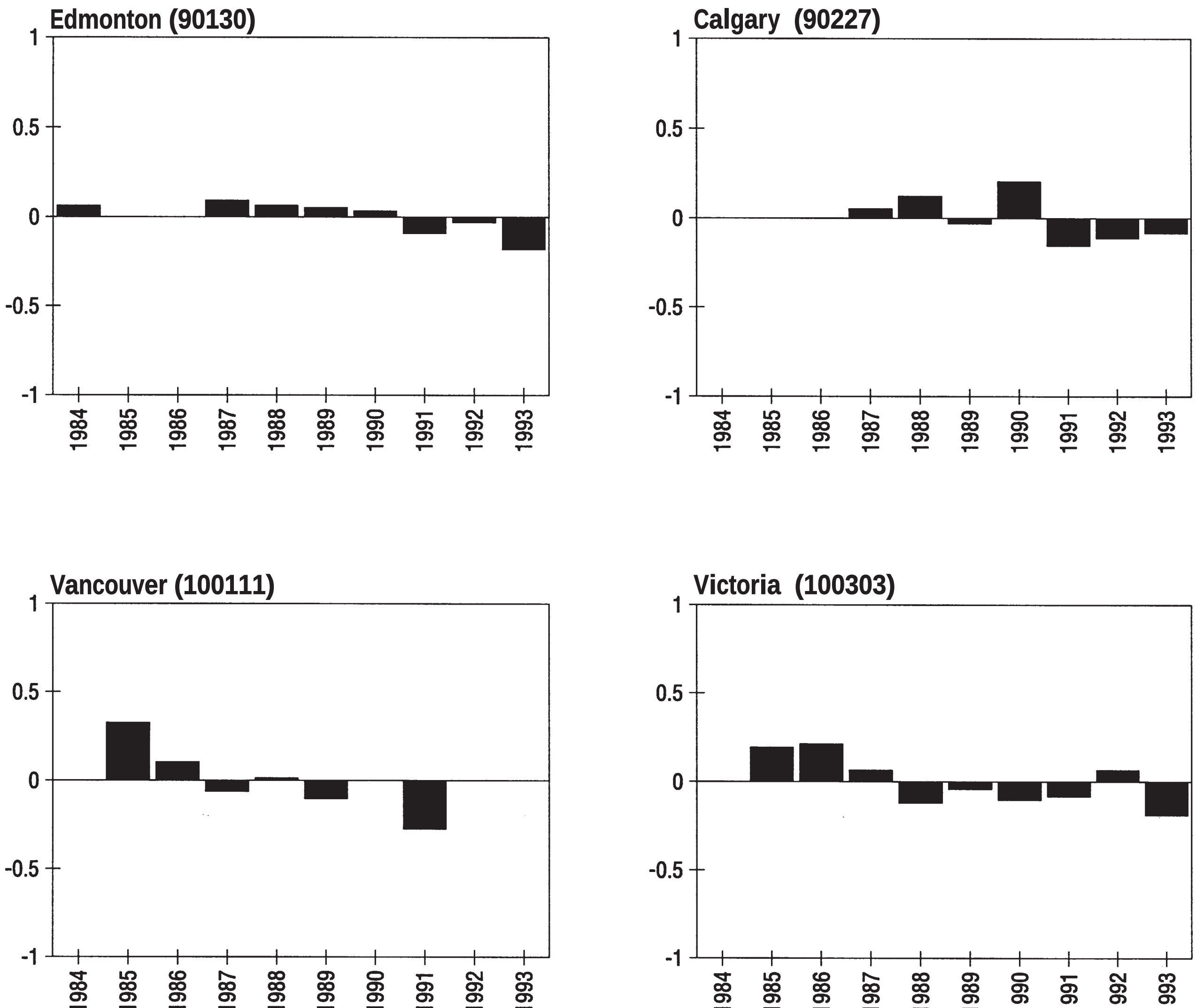


Figure 5.8 Standardized Upper Quartile Mean (UQM) PM_{10} Concentrations at National Network Sites by a) Year b) Month and c) Day of Week. ***(continued)***

(b)

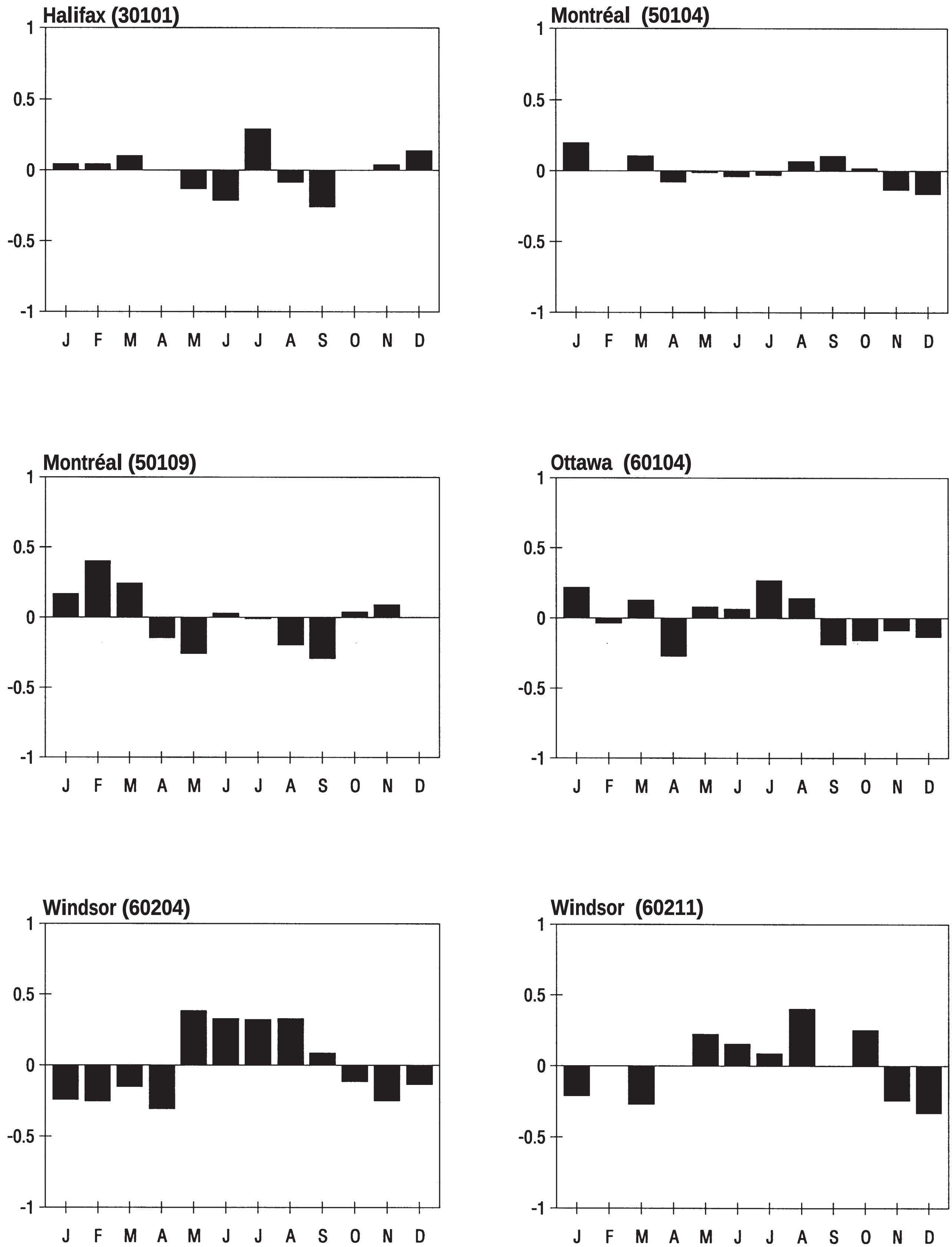


Figure 5.8 Standardized Upper Quartile Mean (UQM) PM_{10} Concentrations at National Network Sites by a) Year b) Month and c) Day of Week. ***(continued)***

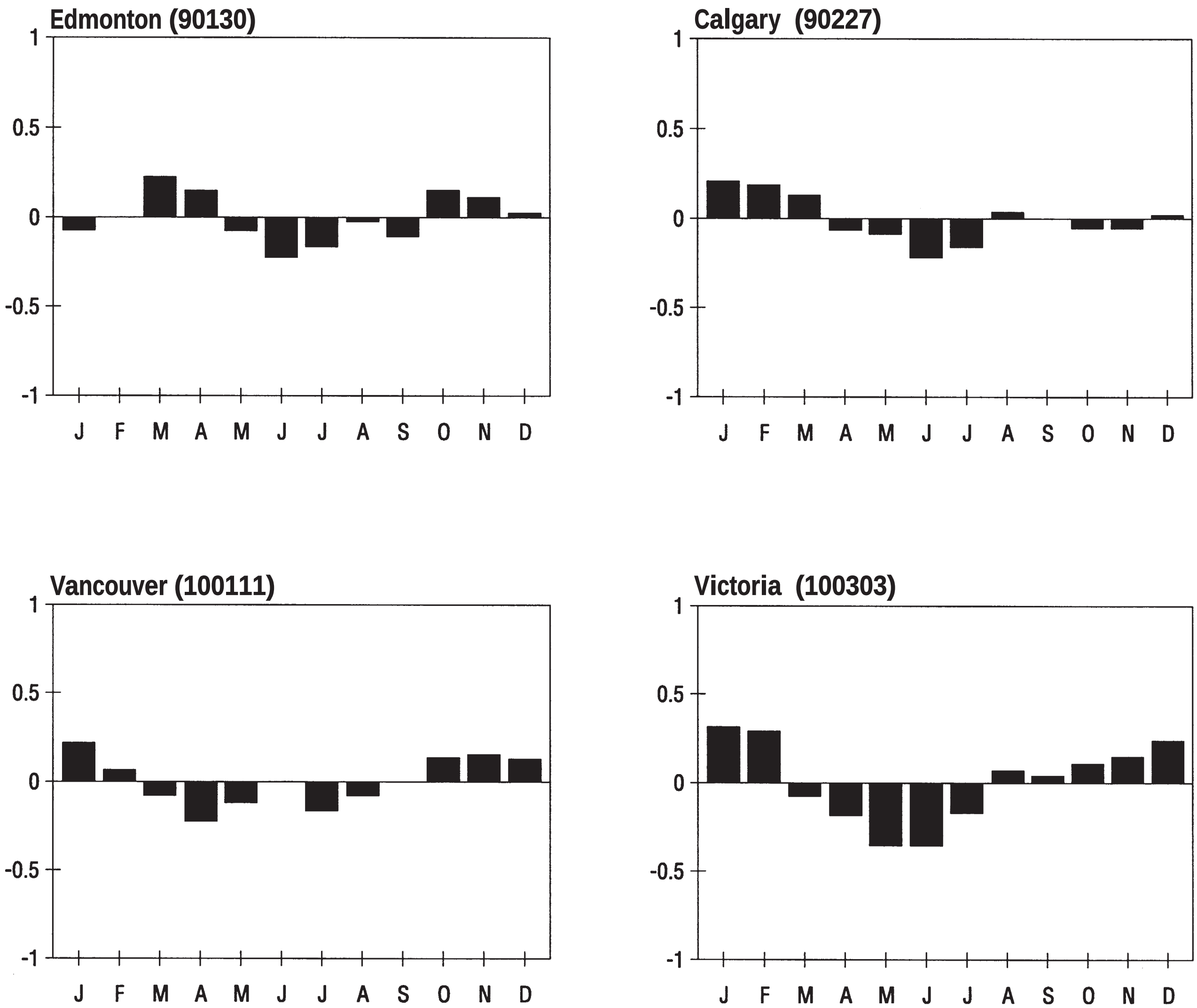


Figure 5.8 Standardized Upper Quartile Mean (UQM) PM_{10} Concentrations at National Network Sites by a) Year b) Month and c) Day of Week. ***(continued)***

(c)

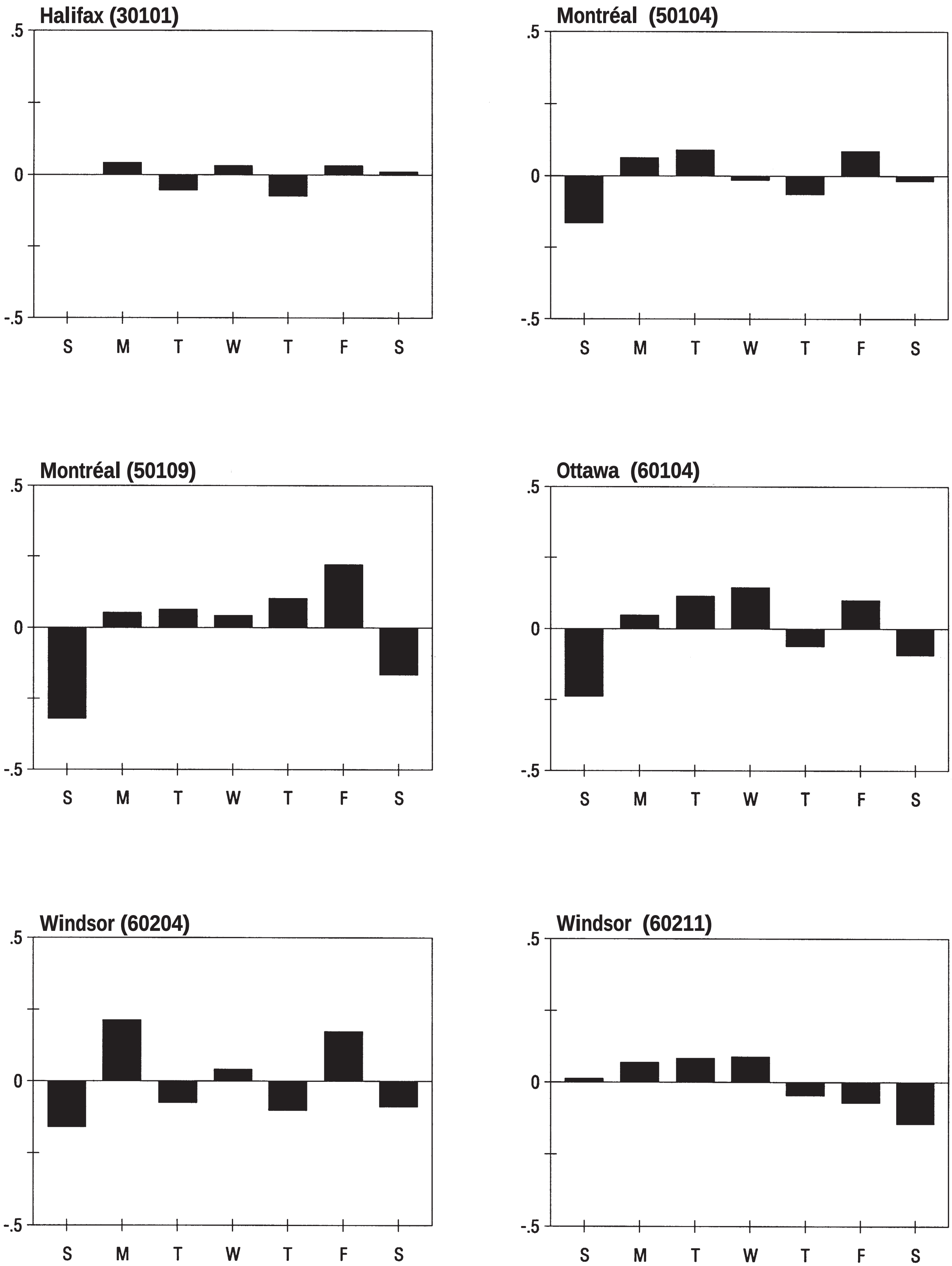


Figure 5.8 Standardized Upper Quartile Mean (UQM) PM_{10} Concentrations at National Network Sites by a) Year b) Month and c) Day of Week. ***(continued)***