

4. DISCUSSION

4.1. RESULTS IN BACKGROUND AREA

(1) Comparisons of Results in the Two Areas

The means and the standard deviations according to the sampling locations calculated from the results of measurements in August 2007 and January 2008 in Wakkanai and Nemuro are shown in **Table 4.1**. The means for CFC-11, CFC-12, and methyl bromide in Wakkanai are higher than in Nemuro out of the standard deviation ranges. The difference in these three substances between the two areas is quite small. The concentrations of the other substances in both areas agree within the standard deviation ranges. Therefore, the concentrations obtained from both areas were merged into a single set of data, and were handled in the same way as in the previous surveys.

Table 4.1. Means and standard deviations calculated from the results in Wakkanai and Nemuro August 2007 and January 2008 (Unit: pptv)

Substance	Sampling Locations	Wakkanai			Nemuro		
		Mean	SD	n	Mean	SD	n
CFC-11		243	1.7	7	240	0.5	5
CFC-12		546	1.5	7	543	1.1	5
CFC-113		76.8	0.6	7	76.3	0.9	5
CFC-114		14.9	0.28	7	14.8	0.25	5
CFC-114a		1.02	0.024	7	1.01	0.024	5
CFC-115		9.02	0.14	7	9.08	0.13	5
Halon-1211		4.65	0.055	7	4.68	0.078	5
Halon-1301		3.35	0.026	7	3.36	0.011	5
Halon-2402		0.47	0.014	7	0.47	0.016	5
Carbon tetrachloride		95.9	0.76	7	95.6	0.61	5
1,1,1-Trichloroethane		14.4	0.16	7	14.5	0.38	5
HCFC-22		198	1.8	6	201	2.6	5
HCFC-141b		22.1	1.6	7	20.7	0.69	5
HCFC-142b		20.1	0.51	7	19.9	0.35	5
Methyl bromide		9.90	0.62	7	9.15	0.10	5
HFC-134a		51.2	1.1	6	51.2	1.7	5

Note 1) "n" means the number of the data sets. "SD" means the standard deviation.

Note 2) Not all the figures mean significant figures.

(2) Time-dependent calculation

Results both in Wakkanai and Nemuro were merged and calculated into averages. The means and standard deviations are shown in **Table 4.2**.

Table 4.2. Means and standard deviations calculated from results in the background area
(Unit : pptv)

Substance	Date	August 2007			January 2008		
		Mean	SD	n	Mean	SD	n
CFC-11		243	2.3	6	241	0.6	6
CFC-12		545	1.7	6	544	2.2	6
CFC-113		76.1	0.55	6	77.1	0.52	6
CFC-114		14.8	0.25	6	14.9	0.31	6
CFC-114a		1.00	0.019	6	1.02	0.023	6
CFC-115		9.02	0.11	6	9.09	0.16	6
Halon-1211		4.65	0.038	6	4.68	0.085	6
Halon-1301		3.35	0.030	6	3.36	0.006	6
Halon-2402		0.48	0.008	6	0.46	0.014	6
Carbon tetrachloride		96.0	0.79	6	95.6	0.58	6
1,1,1-Trichloroethane		14.4	0.25	6	14.5	0.28	6
HCFC-22		200	1.9	5	198	3.0	6
HCFC-141b		22.3	1.7	6	20.7	0.52	6
HCFC-142b		20.3	0.46	6	19.7	0.23	6
Methyl bromide		9.8	0.69	6	9.4	0.49	6
HFC-134a		50.5	0.37	5	51.8	1.60	6

Note 1) "n" means the number of the data set. "SD" means the standard deviation.

Note 2) Not all the figures mean significant figures.

(3) Long-Term Variations in the Concentrations of the Measured Substances

The means for the atmospheric concentrations of the measured substances (CFC-11, CFC-12, CFC-113, CFC-114, halon-1211, halon-1301, halon-2402, carbon tetrachloride, 1,1,1-trichloroethane, HCFC-22, HCFC-141b, HCFC-142b, methyl bromide, and HFC-134a) calculated from the results of each surveys from January 1989 to the present are shown in **Table 4.3** (see Note 1- Note 3). The plots of the concentrations of the substances are shown in **Figure 4.1.1 – Figure 4.1.14**. CFC-114 and CFC-114a, halon-1211 and halon-1301 are shown in the same graph, respectively. Other substances are shown in distinct graphs for ease of viewing.

Note 1) The results for CFC-114, CFC-114a, CFC-115, halon-1211, halon-1301, halon-2402, and HCFC-142b before 1999 were obtained during 1999-2000 by measurements of the samples that had been preserved in containers (9).

Note 2) Results for methyl bromide before 1998 are absent due to the problems with its stability in the containers. The stability of methyl bromide in stainless steel containers is rather poor and this is one of the factors in the increase the variability of the measurement results for this substance. The problems in the measurement of methyl bromide have been resolved since March 1998 through improvements to the process of cleaning the container and a reduction in the time taken between sampling and analysis.

Note 3) HFC-134a was added to the program in 2001. The concentrations of HFC-134a during August 2000 - March 2001 were obtained in 2003 by measurement of the preserved samples.

Note 4) HCFC-141b was added to the program in 2002. The concentrations of HCFC-141b during August 2001 - March 2002 were obtained in 2006 by measurement of the preserved samples.

Table 4.3. Atmospheric concentrations of the measured substances in the background area (1)
CFC-11, CFC-12, CFC-113 (Unit : pptv)

Sampling Time	CFC-11			CFC-12			CFC-113		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
January 1989	246	4	6	486	3	6	69.8	2.2	4
March 1989	247	2	6	487	4	6	69.6	2.4	4
November 1989	254	6	6	499	9	6	73.1	2.3	4
January 1990	255	3	6	504	4	6	75.3	2.1	4
March 1990	252	3	6	503	3	6	75.4	1.4	4
October 1990	264	6	6	509	2	6	79.0	0.7	4
January 1991	264	4	6	510	2	6	78.6	1.1	4
March 1991	264	3	6	511	4	6	80.8	1.3	4
August 1991	262	2	6	516	5	6	80.0	1.0	4
January 1992	266	5	6	520	3	6	83.8	1.2	5
March 1992	267	2	6	519	5	6	84.7	1.7	4
August 1992	270	4	6	525	2	6	87.0	-	2
January 1993	271	6	6	530	3	6	84.6	0.8	3
March 1993	264	2	6	526	6	6	85.5	1.2	4
August 1993	264	2	6	529	3	6	84.8	0.8	4
January 1994	269	3	6	537	5	6	86.1	-	2
March 1994	266	6	6	534	3	6	86.3	0.9	3
July 1994	266	7	6	539	4	6	85.5	1.7	6
January 1995	266	2	6	541	5	6	86.2	1.5	4
March 1995	265	3	6	543	4	6	86.0	2.0	4
August 1995	262	4	6	543	5	6	86.2	1.4	4
January 1996	262	1	6	541	4	6	84.5	1.2	4
March 1996	262	2	6	541	4	6	85.4	1.1	4
August 1996	265	3	6	542	4	6	84.4	2.1	5
January 1997	261	1	6	549	3	6	84.9	1.6	4
March 1997	261	2	6	548	3	6	84.1	0.6	4
August 1997	263	3	6	552	6	6	84.5	1.2	4

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Table 4.3. Atmospheric concentrations of the measured substances in the background area (1)
CFC-11, CFC-12, CFC-113 (Continued) (Unit: pptv)

Sampling Time	CFC-11			CFC-12			CFC-113		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
January 1998	257	3	6	548	4	6	84.6	0.7	4
March 1998	256	1	6	547	4	6	84.6	0.4	4
November 1998	260	4	6	552	2	6	83.6	1.1	6
January 1999	256	3	6	546	1	6	82.6	0.9	6
March 1999	256	3	6	548	4	6	83.4	2.1	6
October 1999	258	4	6	547	3	6	83.3	0.7	6
January 2000	251	2	6	551	4	6	82.7	1.4	6
March 2000	253	3	6	550	2	6	82.9	1.3	6
August 2000	255	2	6	551	2	6	81.3	0.6	6
January 2001	255	2	6	551	4	6	82.4	0.7	6
March 2001	253	2	6	549	3	6	82.5	0.7	6
August 2001	254	1	6	549	2	6	81.4	0.7	6
January 2002	253	1	6	550	2	6	80.5	0.5	6
March 2002	252	1	6	550	2	6	80.8	0.2	6
August 2002	251	1	6	551	1	6	80.8	1.1	6
January 2003	250	1	6	551	4	6	79.6	0.7	6
March 2003	249	2	6	549	2	6	80.6	0.5	6
July 2003	247	1	6	554	2	6	79.7	0.2	6
January 2004	247	2	6	550	2	6	79.3	0.4	6
March 2004	247	1	6	550	3	6	79.7	0.4	6
August 2004	246	1	6	548	4	6	79.4	0.4	6
January 2005	246	1	6	549	1	6	78.8	0.5	6
March 2005	246	1	6	549	1	6	79.0	0.4	6
August 2005	244	1	6	549	2	6	78.9	0.3	6
January 2006	244	1	6	548	2	6	78.3	0.3	6
March 2006	244	1	6	549	1	6	78.7	0.6	6
August 2006	242	1	6	549	3	6	78.1	0.5	6
January 2007	244	2	6	549	4	6	76.4	0.4	6
August 2007	243	2	6	545	2	6	76.1	0.6	6
January 2008	241	1	6	544	2	6	77.1	0.5	6

Note 1) "SD" means standard deviation. The means and standard deviations are calculated from the results of each month (hereafter the same).

Note 2) Not all the figures mean significant figures (hereafter the same).

Table 4.3. Atmospheric concentrations of the measured substances in the background area (2)
CFC-114, CFC-114a (Unit : pptv)

Sampling Time	CFC-114			CFC-114a			CFC-114+CFC-114	
	Mean	SD	n	Mean	SD	n	Mean	n
January 1989	14.3	0.33	5	0.91	0.018	5	15.2	5
March 1989	14.3	0.25	4	0.91	0.026	4	15.2	4
November 1989	14.6	0.23	4	0.92	0.014	4	15.5	4
January 1990	14.7	0.24	4	0.94	0.019	4	15.6	4
March 1990	14.8	0.12	4	0.96	0.032	4	15.8	4
October 1990	14.8	0.09	4	0.94	0.009	4	15.7	4
January 1991	14.8	0.10	4	0.97	0.024	4	15.8	4
March 1991	14.9	0.33	4	0.95	0.015	4	15.8	4
August 1991	14.7	0.11	4	0.94	0.008	4	15.6	4
January 1992	14.9	0.26	4	1.00	0.037	4	15.9	4
March 1992	15.1	0.14	5	0.97	0.017	5	16.1	5
August 1992	15.0	0.10	5	0.98	0.023	5	16.0	5
January 1993	14.9	0.15	4	1.01	0.060	4	15.9	4
March 1993	15.0	0.27	4	1.00	0.021	4	16.0	4
August 1993	15.0	0.10	4	1.01	0.028	4	16.0	4
January 1994	15.1	0.22	4	1.02	0.025	4	16.1	4
March 1994	15.1	0.32	4	1.04	0.008	4	16.1	4
July 1994	15.1	0.25	5	1.04	0.026	5	16.1	5
January 1995	15.0	0.20	5	1.02	0.018	5	16.0	5
March 1995	15.1	0.35	6	1.04	0.031	6	16.1	6
August 1995	15.0	0.20	4	1.01	0.020	4	16.0	4
January 1996	15.2	0.16	4	1.00	0.031	4	16.2	4
March 1996	15.2	0.16	4	1.02	0.014	4	16.2	4
August 1996	15.0	0.21	6	1.03	0.035	6	16.0	6
January 1997	15.2	0.12	6	1.04	0.021	6	16.2	6
March 1997	15.2	0.21	6	1.04	0.024	6	16.2	6
August 1997	15.0	0.34	6	1.02	0.026	6	16.0	6

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Table 4.3. Atmospheric concentrations of the measured substances in the background area (2)
CFC-114, CFC-14a (Continued) (Unit : pptv)

Sampling Time	CFC-114			CFC-114a			CFC-114+CFC-114	
	Mean	SD	n	Mean	SD	n	Mean	n
January 1998	15.2	0.11	6	1.03	0.009	6	16.2	6
March 1998	15.2	0.22	6	1.04	0.018	6	16.2	6
November 1998	15.3	0.21	6	1.04	0.030	6	16.3	6
January 1999	15.1	0.16	6	1.05	0.026	6	16.2	6
March 1999	15.2	0.26	6	1.02	0.010	6	16.2	6
October 1999	15.2	0.26	6	1.02	0.020	6	16.2	6
January 2000	15.2	0.10	6	1.02	0.005	6	16.2	6
March 2000	15.2	0.15	6	1.03	0.012	6	16.3	6
August 2000	15.0	0.10	6	1.05	0.024	6	16.0	6
January 2001	15.1	0.15	6	1.05	0.021	6	16.2	6
March 2001	15.2	0.10	6	1.06	0.016	6	16.3	6
August 2001	15.1	0.21	6	1.04	0.021	6	16.1	6
January 2002	15.2	0.25	6	1.02	0.016	6	16.2	6
March 2002	15.0	0.16	6	1.02	0.015	6	16.0	6
August 2002	15.1	0.19	6	1.04	0.009	6	16.2	6
January 2003	15.2	0.19	6	1.05	0.020	6	16.2	6
March 2003	15.2	0.14	6	1.05	0.021	6	16.2	6
July 2003	15.1	0.15	6	1.05	0.015	6	16.2	6
January 2004	14.9	0.08	6	1.04	0.008	6	15.9	6
March 2004	15.0	0.06	6	1.03	0.008	6	16.0	6
August 2004	14.9	0.18	6	1.02	0.008	6	15.9	6
January 2005	14.9	0.23	6	1.03	0.020	6	15.9	6
March 2005	15.0	0.08	6	1.05	0.008	6	16.0	6
August 2005	15.0	0.10	6	1.04	0.010	6	16.0	6
January 2006	15.1	0.10	6	1.04	0.010	6	16.1	6
March 2006	15.0	0.04	6	1.04	0.005	6	16.0	6
August 2006	15.0	0.18	6	1.04	0.008	6	16.0	6
January 2007	15.1	0.12	6	1.04	0.026	6	16.1	6
August 2007	14.8	0.25	6	1.00	0.019	6	15.8	6
January 2008	14.9	0.31	6	1.02	0.023	6	15.9	6

Table 4.3. Atmospheric concentrations of the measured substances in the background area (3)
CFC-115, halon-1211, halon-1301 (Unit : pptv)

Sampling Time	CFC-115			Halon-1211			Halon-1301		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
January 1989	5.32	0.07	3	2.45	0.087	5	1.89	0.034	4
March 1989	5.81	0.13	3	2.51	0.14	4	1.91	0.049	4
November 1989	5.67	0.34	4	2.72	0.066	6	2.04	0.10	4
January 1990	5.98	0.31	2	2.73	0.043	5	2.06	0.057	6
March 1990	5.93	0.12	3	2.76	0.011	5	2.14	0.022	4
October 1990	6.17	0.28	3	2.81	0.043	4	2.21	0.044	4
January 1991	6.23	0.49	3	2.93	0.085	5	2.25	0.033	4
March 1991	6.26	0.33	3	2.94	0.046	6	2.33	0.047	5
August 1991	6.40	0.04	3	2.91	0.052	4	2.25	0.021	4
January 1992	6.59	0.24	3	3.14	0.082	5	2.42	0.022	4
March 1992	6.53	0.11	3	3.20	0.099	4	2.44	0.059	4
August 1992	7.14	0.37	4	3.15	0.032	5	2.41	0.068	4
January 1993	7.02	0.20	4	3.38	0.070	4	2.56	0.030	4
March 1993	7.13	0.14	3	3.39	0.075	6	2.55	0.064	4
August 1993	7.17	0.30	3	3.34	0.026	4	2.58	0.015	6
January 1994	7.58	0.37	6	3.52	0.12	6	2.70	0.014	4
March 1994	7.51	0.40	3	3.54	0.041	6	2.64	0.062	5
July 1994	7.57	0.24	4	3.58	0.074	4	2.68	0.051	4
January 1995	7.61	0.23	4	3.67	0.080	6	2.72	0.050	5
March 1995	7.67	0.19	4	3.75	0.054	6	2.74	0.045	4
August 1995	7.76	0.11	3	3.78	0.10	4	2.74	0.089	4
January 1996	7.89	0.09	3	3.88	0.042	6	2.80	0.071	4
March 1996	8.04	0.29	3	3.87	0.090	6	2.82	0.058	4
August 1996	8.04	0.18	4	3.91	0.083	6	2.79	0.019	4
January 1997	8.38	0.08	4	4.02	0.099	4	2.86	0.039	4
March 1997	8.32	0.07	4	4.00	0.044	6	2.83	0.031	5
August 1997	8.33	0.03	6	4.08	0.094	6	2.87	0.046	6

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Table 4.3. Atmospheric concentrations of the measured substances in the background area (3)
CFC-115, halon-1211, halon-1301 (Continued) (Unit : pptv)

Sampling Time	CFC-115			Halon-1211			Halon-1301		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
January 1998	8.27	0.39	4	4.20	0.050	6	2.94	0.077	6
March 1998	8.56	0.12	5	4.25	0.079	6	2.96	0.069	6
November 1998	8.64	0.19	6	4.20	0.048	6	2.86	0.048	6
January 1999	8.36	0.29	6	4.34	0.030	6	2.94	0.064	6
March 1999	8.56	0.48	6	4.26	0.058	6	2.90	0.043	6
October 1999	8.55	0.13	6	4.31	0.025	6	2.90	0.034	6
January 2000	8.48	0.13	6	4.43	0.056	6	2.93	0.032	6
March 2000	8.58	0.25	6	4.40	0.073	6	2.94	0.058	6
August 2000	8.44	0.10	6	4.51	0.029	6	2.99	0.036	6
January 2001	8.56	0.22	6	4.60	0.047	6	3.04	0.024	6
March 2001	8.48	0.16	6	4.56	0.059	6	3.03	0.034	6
August 2001	8.65	0.17	6	4.58	0.077	6	3.08	0.034	6
January 2002	8.72	0.16	6	4.62	0.039	6	3.12	0.010	6
March 2002	8.70	0.12	6	4.68	0.026	6	3.11	0.062	6
August 2002	8.79	0.22	6	4.60	0.061	6	3.12	0.048	6
January 2003	8.83	0.23	6	4.73	0.061	6	3.16	0.021	6
March 2003	8.79	0.25	6	4.69	0.052	6	3.18	0.028	6
July 2003	8.90	0.20	6	4.68	0.015	6	3.22	0.025	6
January 2004	8.82	0.23	6	4.71	0.058	6	3.26	0.027	6
March 2004	8.87	0.19	6	4.69	0.022	6	3.27	0.013	6
August 2004	8.85	0.24	6	4.70	0.029	6	3.26	0.016	6
January 2005	8.86	0.16	6	4.74	0.029	6	3.30	0.022	6
March 2005	8.87	0.23	6	4.78	0.020	6	3.30	0.018	6
August 2005	8.89	0.13	6	4.73	0.010	6	3.29	0.021	6
January 2006	8.93	0.11	6	4.76	0.031	6	3.32	0.018	6
March 2006	8.92	0.08	6	4.77	0.028	6	3.32	0.013	6
August 2006	8.92	0.13	6	4.75	0.069	6	3.33	0.020	6
January 2007	8.91	0.08	6	4.71	0.024	6	3.34	0.044	6
August 2007	9.02	0.11	6	4.65	0.038	6	3.35	0.030	6
January 2008	9.09	0.16	6	4.68	0.085	6	3.36	0.006	6

Table 4.3. Atmospheric concentrations of the measured substances in the background area (4)
Halon-2402, CCl₄, CH₃CCl₃ (Unit : pptv)

Sampling Time	Halon-2402			Carbon tetrachloride			1,1,1-Trichloroethane		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
January 1989	0.45	0.024	3	108	3	6	165	2	6
March 1989	0.47	0.012	3	104	1	6	166	4	6
November 1989	0.46	0.008	3	114	4	6	178	13	6
January 1990	0.47	0.034	3	112	5	6	176	6	6
March 1990	0.48	0.023	3	106	1	6	175	2	6
October 1990	0.50	0.024	3	111	4	6	179	12	6
January 1991	0.49	0.015	3	111	1	6	176	2	6
March 1991	0.48	0.025	3	108	1	6	177	2	6
August 1991	0.48	0.008	3	116	4	6	172	8	6
January 1992	0.51	0.017	3	113	3	6	177	3	6
March 1992	0.52	0.015	3	111	1	6	177	1	6
August 1992	0.52	0.025	3	116	2	6	177	4	6
January 1993	0.51	0.010	3	110	2	6	177	10	6
March 1993	0.54	-	2	113	4	6	174	9	6
August 1993	0.50	0.011	3	110	5	6	146	4	6
January 1994	0.52	0.023	5	105	2	2	147	6	6
March 1994	0.51	0.028	3	109	2	6	143	2	6
July 1994	0.53	0.012	3	108	2	6	144	11	6
January 1995	0.54	0.006	3	104	3	6	129	2	6
March 1995	0.53	0.015	4	105	3	6	130	2	6
August 1995	0.54	-	2	-	-	0	120	2	6
January 1996	0.54	-	2	-	-	0	112	1	6
March 1996	0.54	0.013	3	-	-	0	111	2	6
August 1996	0.53	0.013	3	104	1	2	102	7	6
January 1997	0.53	-	2	-	-	0	95.6	0.7	6
March 1997	0.54	-	2	107	1	2	95.4	0.4	6
August 1997	0.54	0.016	3	110	5	6	88.3	4.3	6

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Table 4.3. Atmospheric concentrations of the measured substances in the background area (4)
Halon-2402, CCl₄, CH₃CCl₃ (Continued) (Unit : pptv)

Sampling Time	Halon-2402			Carbon tetrachloride			1,1,1-Trichloroethane		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
January 1998	0.53	-	1	106	4	6	78.1	1.8	6
March 1998	0.52	0.012	3	106	3	6	76.0	1.5	6
November 1998	0.53	0.029	6	108	2	6	76.5	1.5	6
January 1999	-	-	0	103	1	6	70.1	1.6	6
March 1999	0.53	0.036	6	108	3	6	71.5	1.6	6
October 1999	0.52	0.020	6	110	4	6	64.2	0.8	6
January 2000	0.53	0.018	6	103	2	6	58.7	0.7	6
March 2000	0.51	0.018	6	106	1	6	57.5	1.9	6
August 2000	0.52	0.021	6	108	1.3	6	50.1	1.5	6
January 2001	0.51	0.028	6	105	0.5	6	50.4	0.5	6
March 2001	0.51	0.018	6	105	1.4	6	50.7	0.5	6
August 2001	0.50	0.013	6	105	0.8	6	43.0	0.7	6
January 2002	0.50	0.028	6	104	0.8	6	37.6	0.1	6
March 2002	0.51	0.026	6	104	0.8	6	37.1	0.2	6
August 2002	0.50	0.027	6	106	1.0	6	35.7	0.6	6
January 2003	0.51	0.020	6	104	2.1	6	32.5	0.4	6
March 2003	0.50	0.012	6	103	0.4	6	31.8	0.8	6
July 2003	0.50	0.018	6	100	0.7	6	28.4	0.4	6
January 2004	0.50	0.004	6	99.5	0.8	6	26.6	0.3	6
March 2004	0.50	0.024	6	99.3	0.8	6	26.6	0.4	6
August 2004	0.49	0.013	6	99.0	0.7	6	23.8	0.6	6
January 2005	0.50	0.008	6	98.0	0.7	6	21.9	0.3	6
March 2005	0.50	0.008	6	99.4	0.7	6	21.9	0.9	6
August 2005	0.49	0.010	6	97.5	0.7	6	20.8	0.3	6
January 2006	0.49	0.019	6	96.7	0.4	6	19.2	0.2	6
March 2006	0.50	0.021	6	96.0	1.1	6	18.6	0.3	6
August 2006	0.48	0.006	6	97.0	0.6	6	16.2	0.4	6
January 2007	0.48	0.021	6	96.5	0.4	6	16.2	0.1	6
August 2007	0.48	0.008	6	96.0	0.8	6	14.4	0.2	6
January 2008	0.46	0.014	6	95.6	0.6	6	14.5	0.3	6

Table 4.3. Atmospheric concentrations of the measured substances in the background area (5)
 HCFC-22, HCFC-141b, HCFC-142b (Unit : pptv)

Sampling Time	HCFC-22			HCFC-141b			HCFC-142b		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
August 1992	111	2	5	-	-	--	4.54	0.75	3
January 1993	112	6	5	-	-	-	5.35	0.37	4
March 1993	114	7	5	-	-	-	5.37	0.44	2
August 1993	114	5	6	-	-	-	6.27	0.70	3
January 1994	120	5	4	-	-	-	7.00	0.54	4
March 1994	121	2	5	-	-	-	6.61	0.27	4
July 1994	120	3	6	-	-	-	7.45	1.1	4
January 1995	123	4	6	-	-	-	7.78	0.68	4
March 1995	124	2	6	-	-	-	7.68	0.38	5
August 1995	125	4	5	-	-	-	8.52	0.64	6
January 1996	128	3	6	-	-	-	8.94	0.96	4
March 1996	127	5	6	-	-	-	9.60	0.43	4
August 1996	133	5	5	-	-	-	9.94	0.86	5
January 1997	134	3	6	-	-	-	9.88	0.40	6
March 1997	133	5	6	-	-	-	10.0	1.1	6
August 1997	137	3	6	-	-	-	10.4	2.1	5
January 1998	136	2	5	-	-	-	11.2	0.59	4
March 1998	138	3	6	-	-	-	10.8	1.1	6
November 1998	142	3	6	-	-	-	11.6	0.57	4
January 1999	150	2	6	-	-	-	12.0	0.43	6
March 1999	150	2	6	-	-	-	12.2	0.59	3
October 1999	149	7	6	-	-	-	11.5	0.45	5
January 2000	150	3	6	-	-	-	13.2	0.39	6
March 2000	150	1	6	-	-	-	12.8	1.1	6
August 2000	153	2	6	-	-	-	13.4	0.64	6

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Table 4.3. Atmospheric concentrations of the measured substances in the background area (5)
 HCFC-22, HCFC-141b, HCFC-142b (Continued) (Unit : pptv)

Sampling Time	HCFC-22			HCFC-141b			HCFC-142b		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
January 2001	157	2	6	-	-	-	14.4	0.26	6
March 2001	158	2	6	-	-	-	14.1	0.55	6
August 2001	157	3	6	17.2	0.54	6	14.1	0.17	6
January 2002	158	2	6	17.7	0.37	6	15.3	0.47	6
March 2002	158	2	6	18.1	0.28	6	15.4	0.47	6
August 2002	163	2	6	19.0	0.28	6	15.2	0.59	6
January 2003	166	1	6	18.6	0.12	6	15.4	0.64	6
March 2003	163	1	6	19.1	0.18	6	15.9	0.58	6
July 2003	168	3	6	20.2	0.71	6	15.5	0.64	6
January 2004	168	1	6	20.0	0.63	6	15.9	0.44	6
March 2004	169	1	6	20.0	0.42	6	16.5	0.32	6
August 2004	171	2	6	19.6	0.20	6	16.6	0.18	6
January 2005	174	2	6	19.6	0.11	6	16.4	0.08	6
March 2005	174	1	6	20.1	0.78	6	16.6	0.20	6
August 2005	179	3	6	20.2	0.29	6	17.1	0.26	6
January 2006	179	2	6	20.2	0.11	6	17.4	0.23	6
March 2006	183	1	6	20.4	0.29	6	17.2	0.26	6
August 2006	186	2	5	20.8	0.55	6	17.6	0.35	6
January 2007	190	2	6	21.0	0.54	6	18.4	0.18	6
August 2007	200	2	5	22.3	1.7	6	20.3	0.46	6
January 2008	198	3	6	20.7	0.52	6	19.7	0.23	6

Note 3) The observations of HCFC-22, HCFC-141b, and HCFC-142b began August 1992, August 2002, and August 1992, respectively.

Note 4) The concentrations of HCFC-141b before August 2002 were obtained through the measurements of the preserved samples in 2006.

Table 4.3. Atmospheric concentrations of the measured substances in the background area (6)
Methyl bromide, HFC-134a (Unit : pptv)

Sampling Time	Methyl bromide			HFC-134a		
	Mean	SD	n	Mean	SD	n
March 1998	11.2	0.52	6	-	-	-
November 1998	11.7	0.55	3	-	-	-
January 1999	11.2	0.59	6	-	-	-
March 1999	10.6	0.00	3	-	-	-
October 1999	10.4	0.68	6	-	-	-
January 2000	9.4	0.35	6	-	-	-
March 2000	9.5	0.78	6	-	-	-
August 2000	10.0	0.65	6	17.0	0.45	5
January 2001	9.2	0.39	6	20.1	1.0	4
March 2001	10.2	0.90	6	19.5	1.2	4
August 2001	9.4	0.99	6	21.3	0.60	6
January 2002	9.5	0.52	6	24.1	0.98	6
March 2002	8.9	0.33	6	24.4	1.3	6
August 2002	10.0	0.56	6	25.8	0.42	6
January 2003	9.5	0.11	6	29.4	0.84	6
March 2003	9.5	0.28	6	28.9	2.0	6
July 2003	9.6	0.80	6	30.7	1.0	6
January 2004	10.3	0.62	6	32.3	1.1	6
March 2004	9.6	0.51	6	33.1	0.58	6
August 2004	9.4	0.39	6	34.8	1.4	6
January 2005	9.4	0.38	6	36.9	1.0	6
March 2005	9.8	0.29	6	37.5	1.2	6
August 2005	10.2	0.45	6	40.0	1.5	6
January 2006	9.1	0.15	6	41.8	1.0	6
March 2006	9.5	0.21	6	43.5	1.4	6
August 2006	9.5	0.17	5	44.8	0.85	6
January 2007	9.4	0.42	6	46.8	0.91	6
August 2007	9.8	0.69	6	50.5	0.37	6
January 2008	9.4	0.49	6	51.8	1.6	6

Note 5) Methyl Bromide was added to the program in 1993. Reliable results for this substance have been obtained since March 1998 due to the problems in the measurement.

Note 6) HFC-134a was added to the program in 2001. The concentrations of HFC-134a before August 2001 shown in this table were obtained through the measurements of preserved samples in 2003.

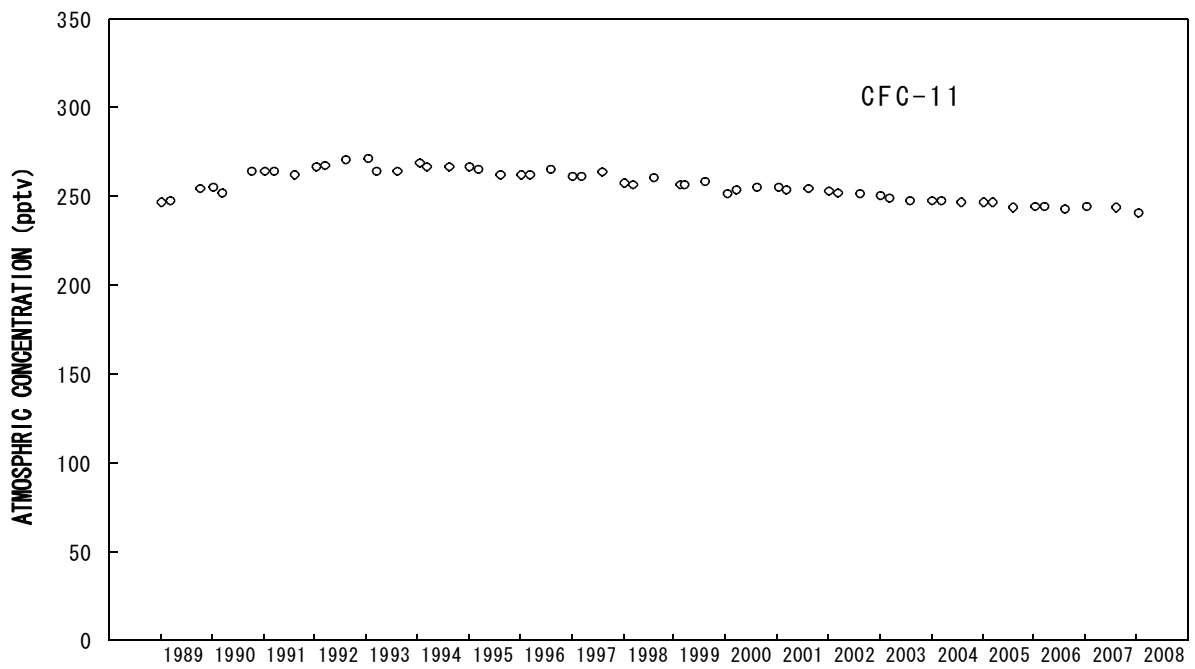


Figure 4.1.1. Atmospheric concentrations of CFC-11 in Hokkaido since 1989
Circles represent the means for 6 samples.

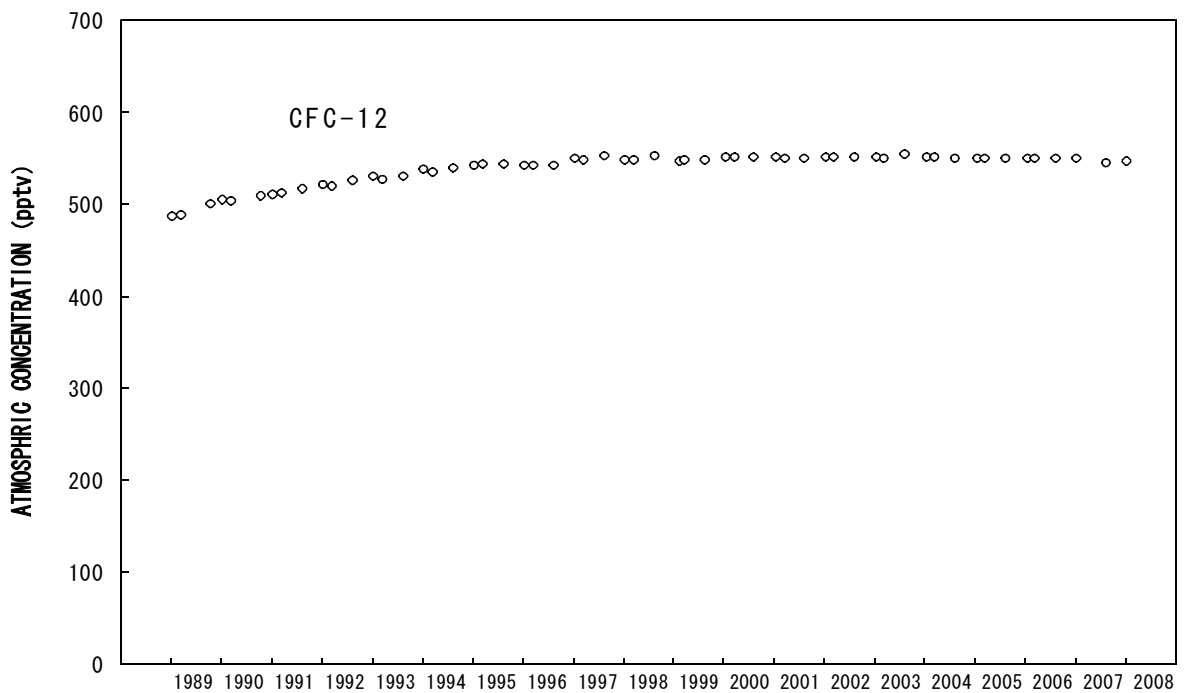


Figure 4.1.2. Atmospheric concentrations of CFC-12 in Hokkaido since 1989
Circles represent the means for 6 samples.

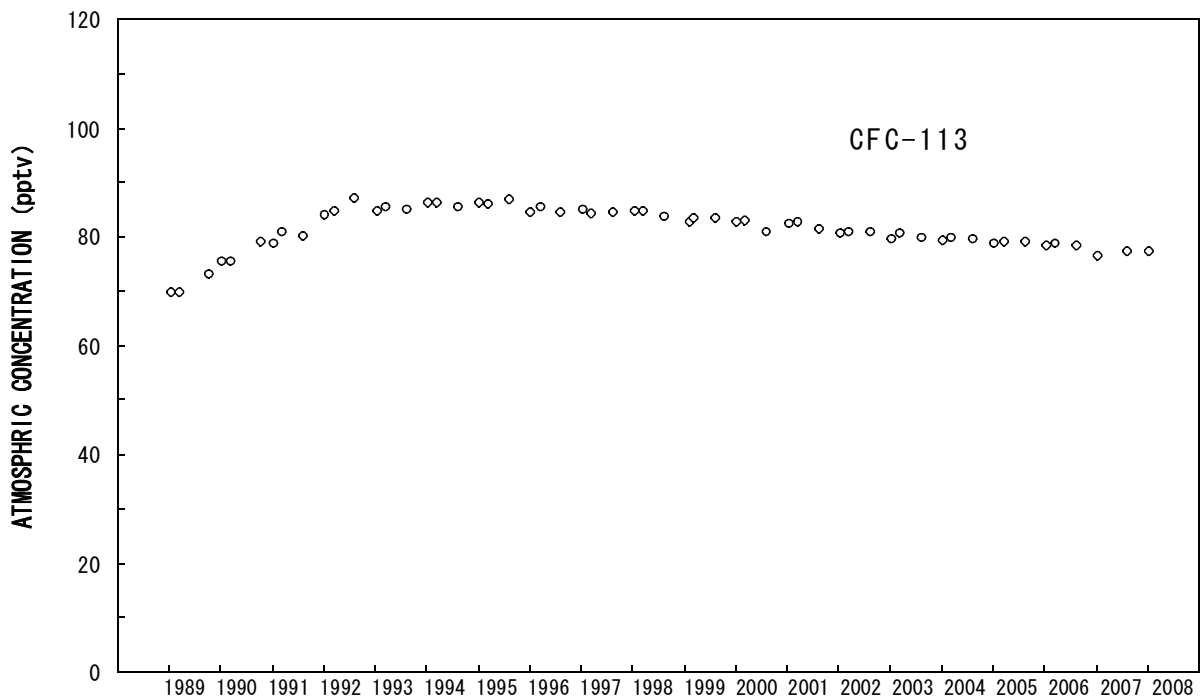


Figure 4.1.3. Atmospheric concentrations of CFC-113 in Hokkaido since 1989
 Circles represent the means for 2-6 samples.

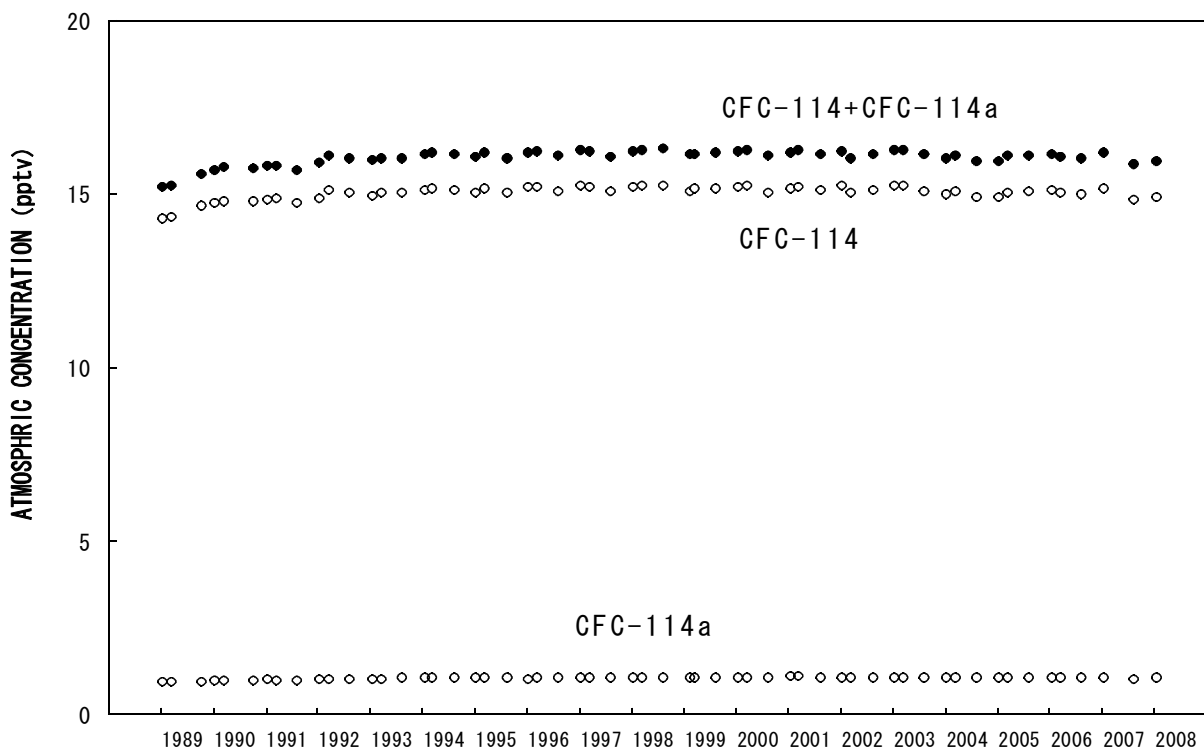


Figure 4.1.4. Atmospheric concentrations of CFC-114 and CFC-114a in Hokkaido since 1989
 Open circles represent the means of each substance both for 4-6 samples.
 Solid circles represent the sums of CFC-114 and CFC-114a.

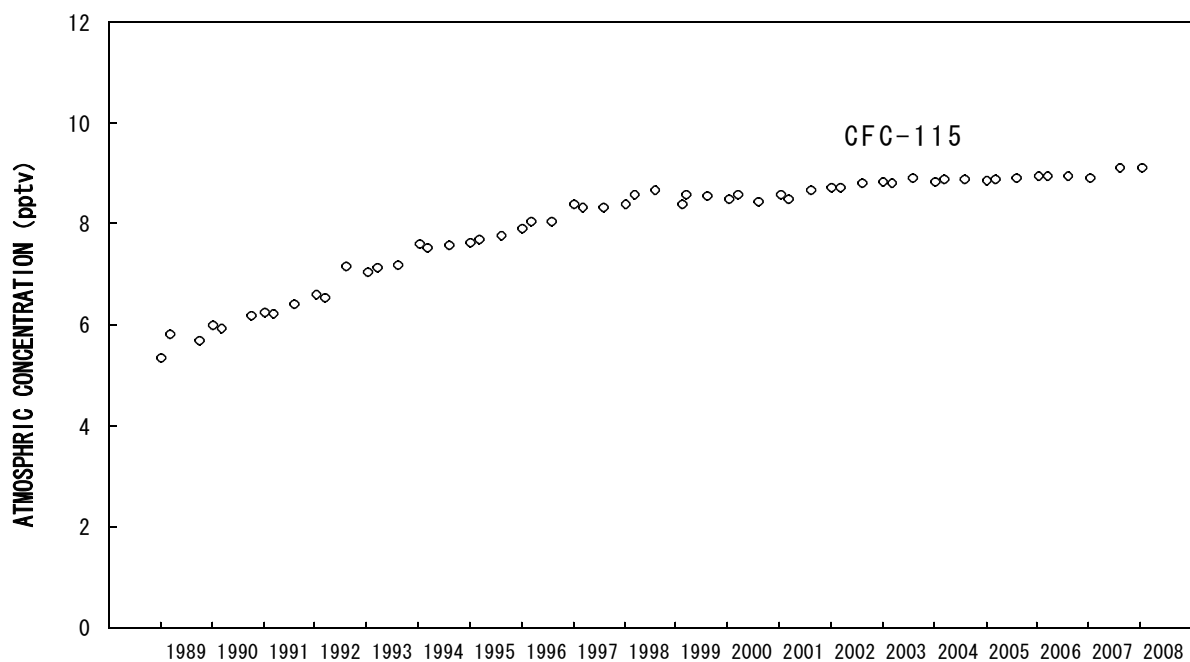


Figure 4.1.5. Atmospheric concentrations of CFC-115 in Hokkaido since 1989
Circles represent the means for 2-6 samples.

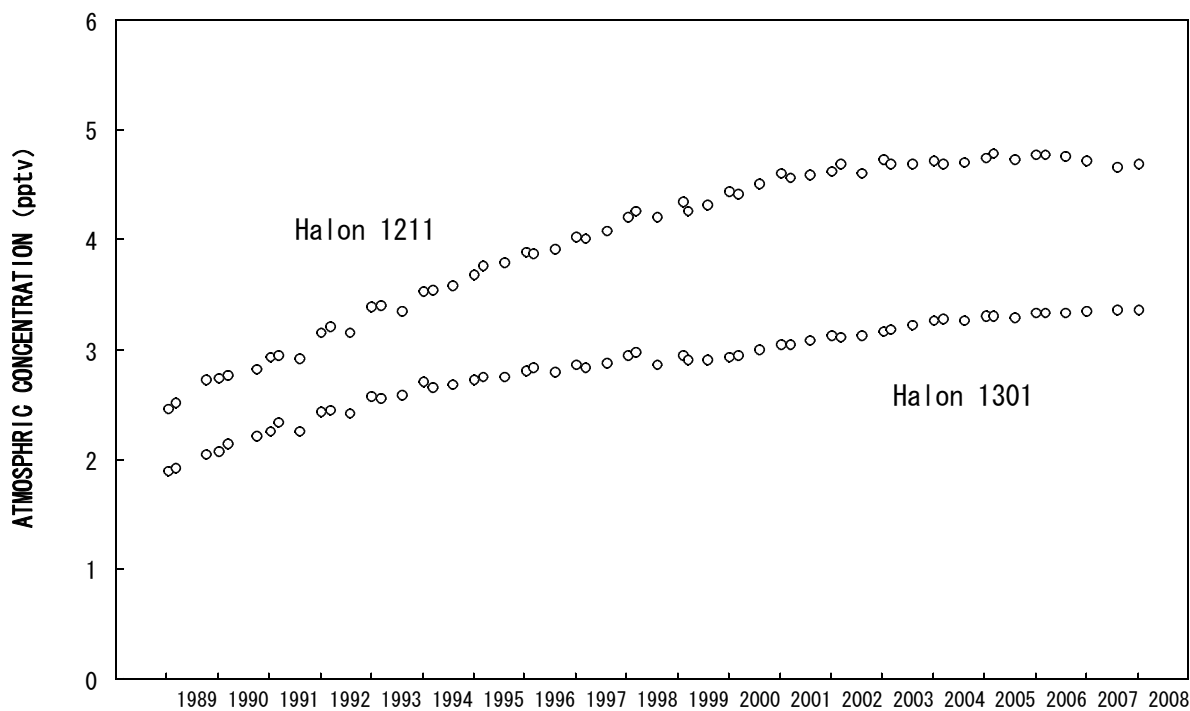


Figure 4.1.6. Atmospheric concentrations of halon-1211 and halon-1301 in Hokkaido since 1989
Circles represent the means for 4-6 samples.

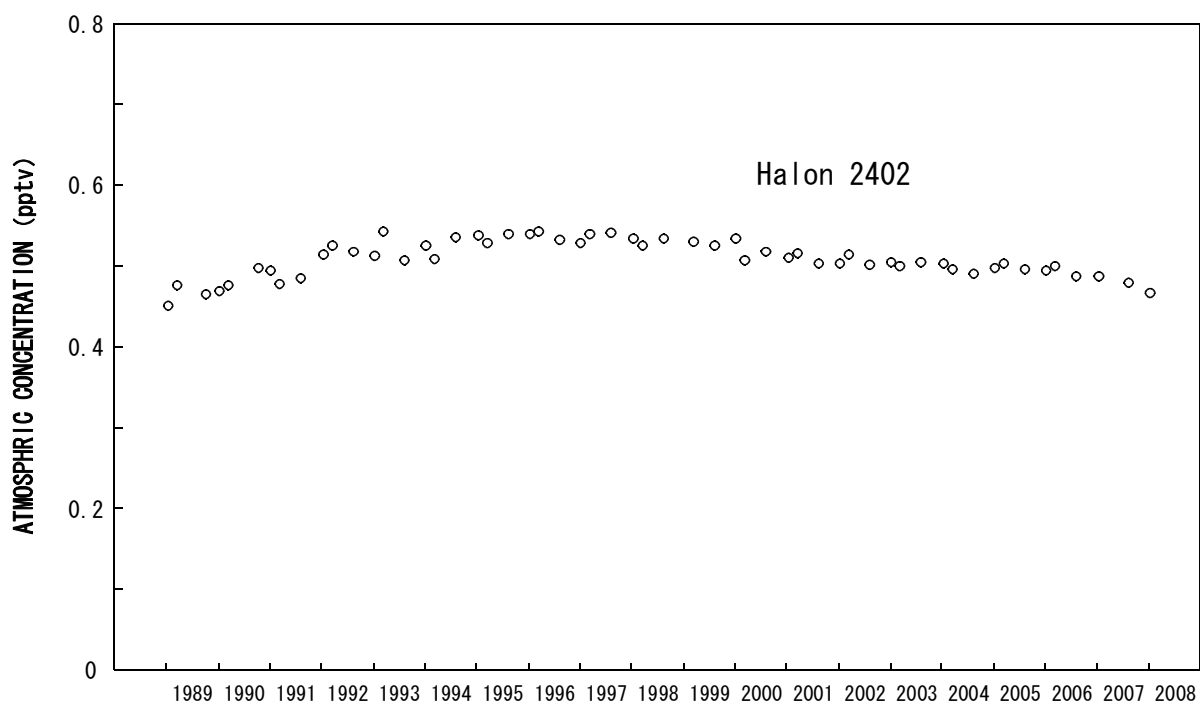


Figure 4.1.7. Atmospheric concentrations of halon-2402 in Hokkaido since 1989
Circles represent the means for 1-6 samples.

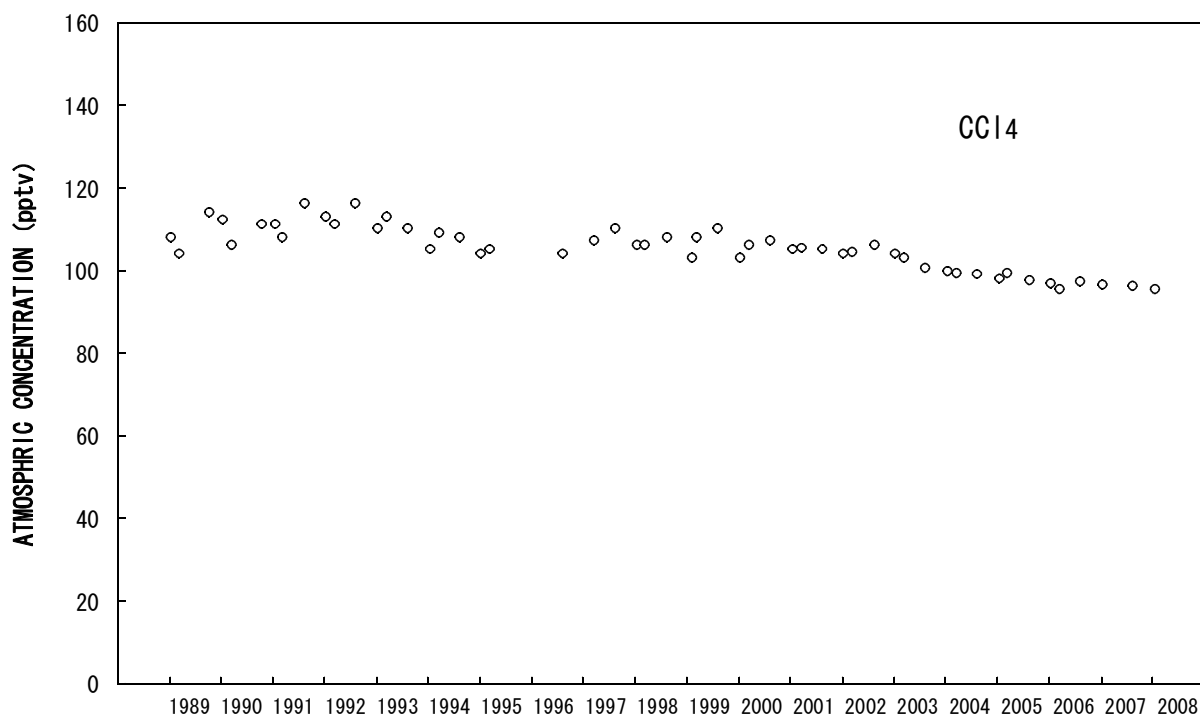


Figure 4.1.8. Atmospheric concentrations of carbon tetrachloride in Hokkaido since 1989
Circles represent the means for 2-6 samples.

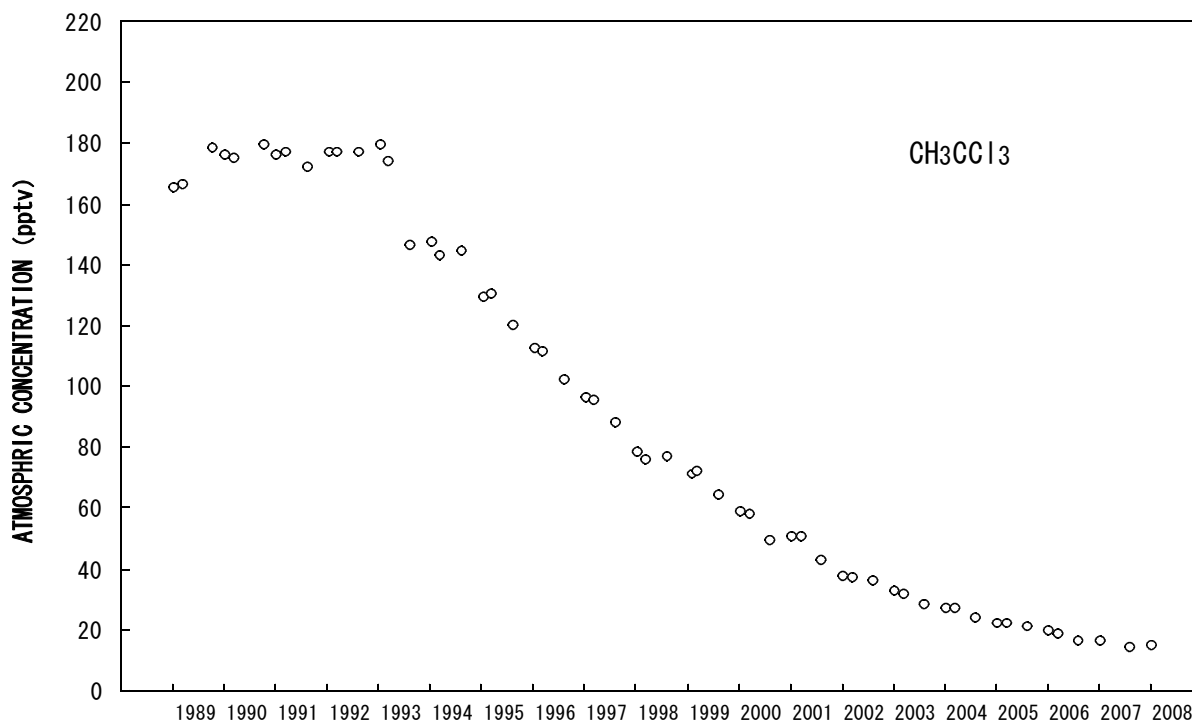


Figure 4.1.9. Atmospheric concentrations of 1,1,1-trichloroethane in Hokkaido since 1989
Circles represent the means for 6 samples.

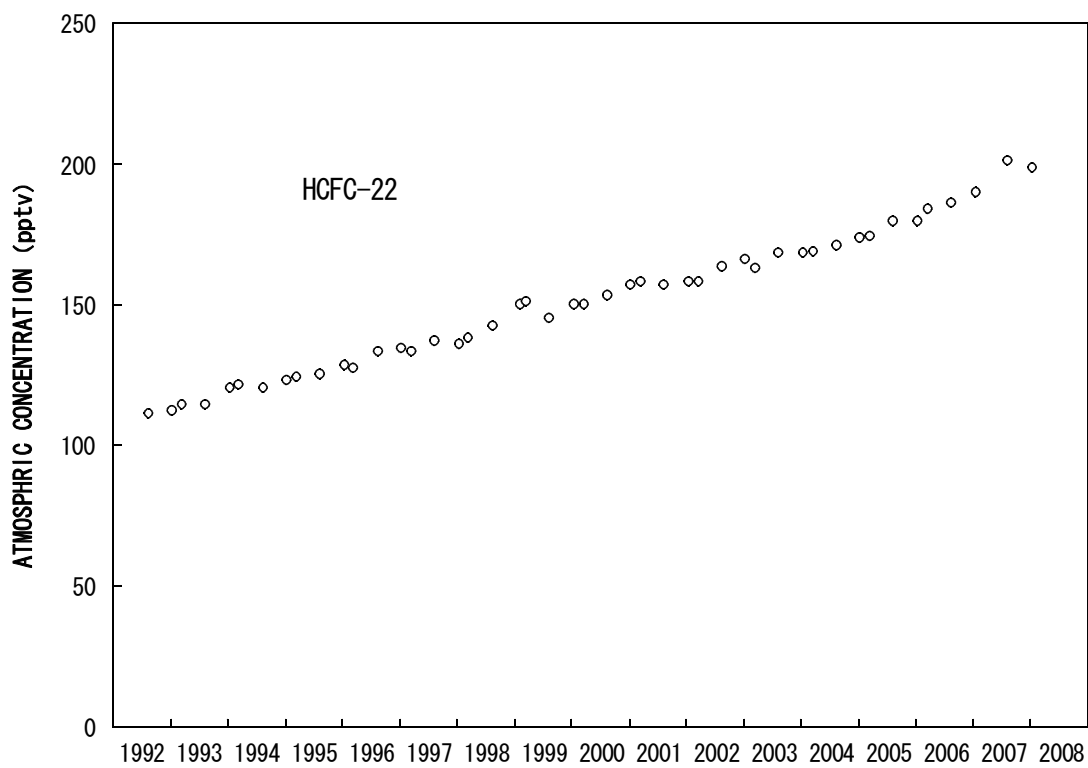


Figure 4.1.10. Atmospheric concentrations of HCFC-22 in Hokkaido since 1992
Circles represent the means for 4-6 samples.

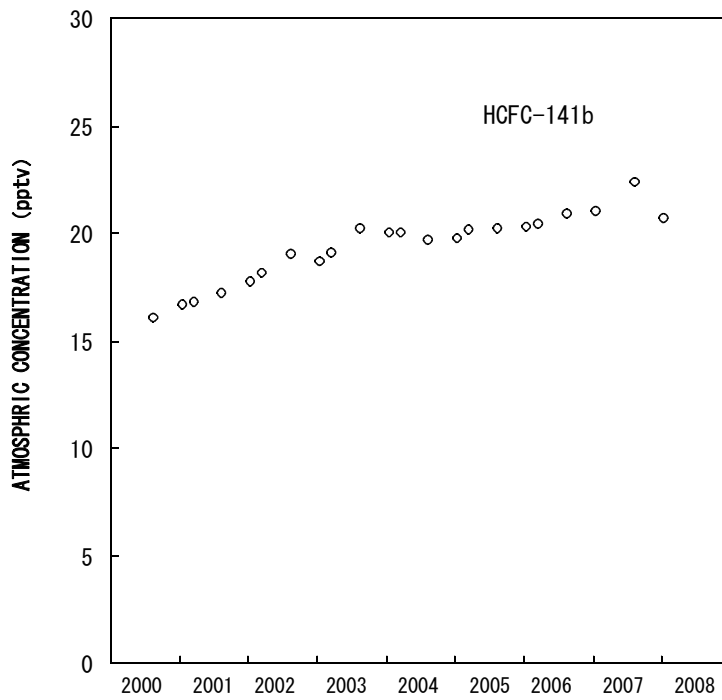


Figure 4.1.11. Atmospheric concentrations of HCFC-141b in Hokkaido since 2000
Circles represent the means for 6 samples.

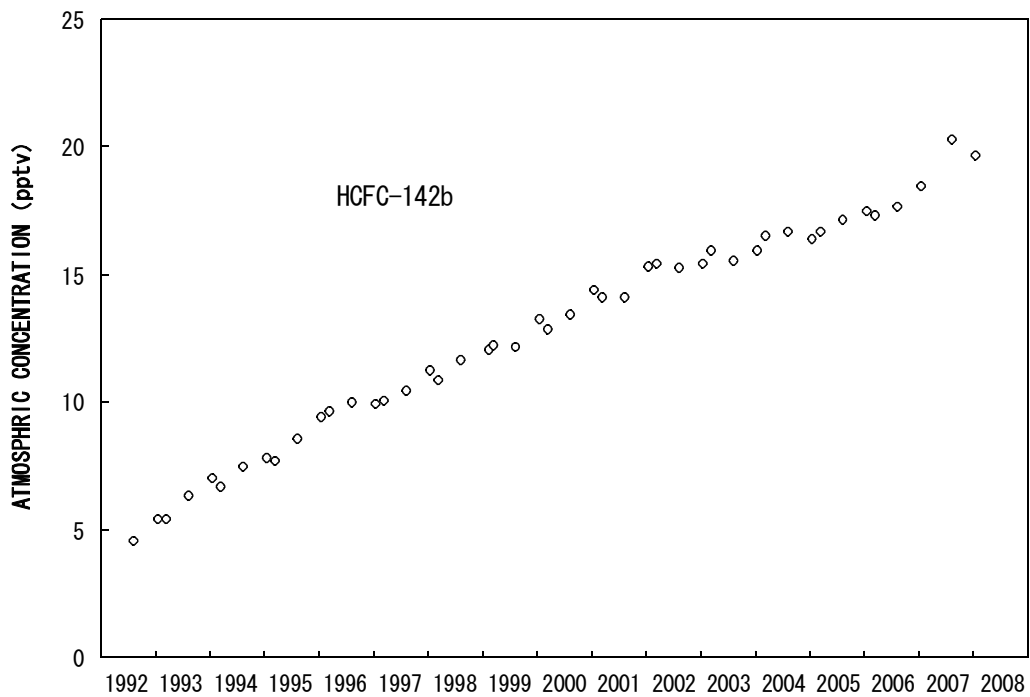


Figure 4.1.12. Atmospheric concentrations of HCFC-142b in Hokkaido since 1992
Circles represent the means for 2-6 samples.

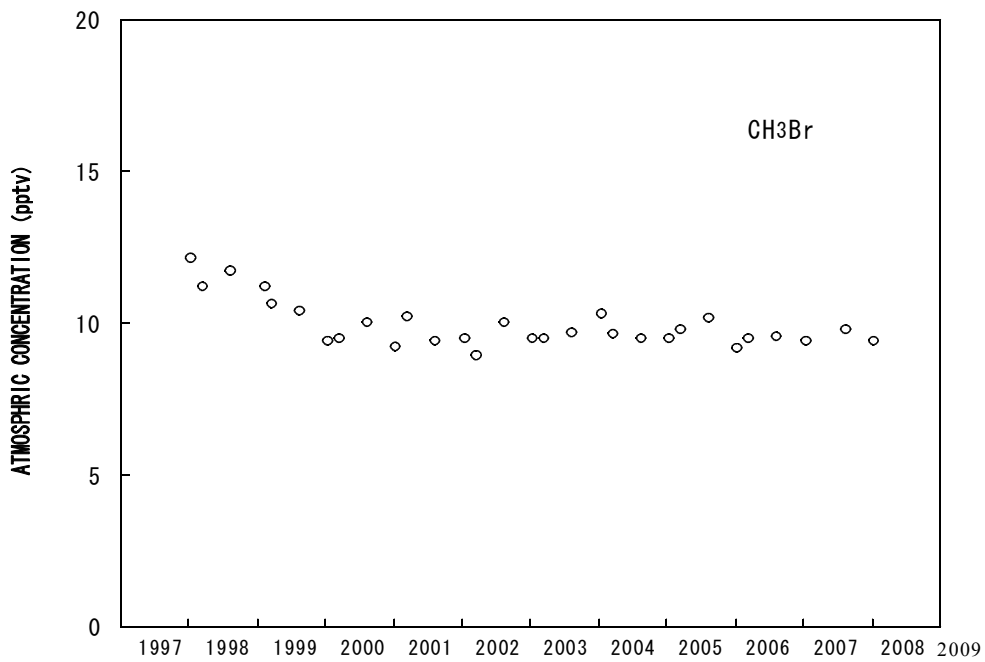


Figure 4.1.13. Atmospheric concentrations of methyl bromide in Hokkaido since 1997
Circles represent the means for 3-6 samples.

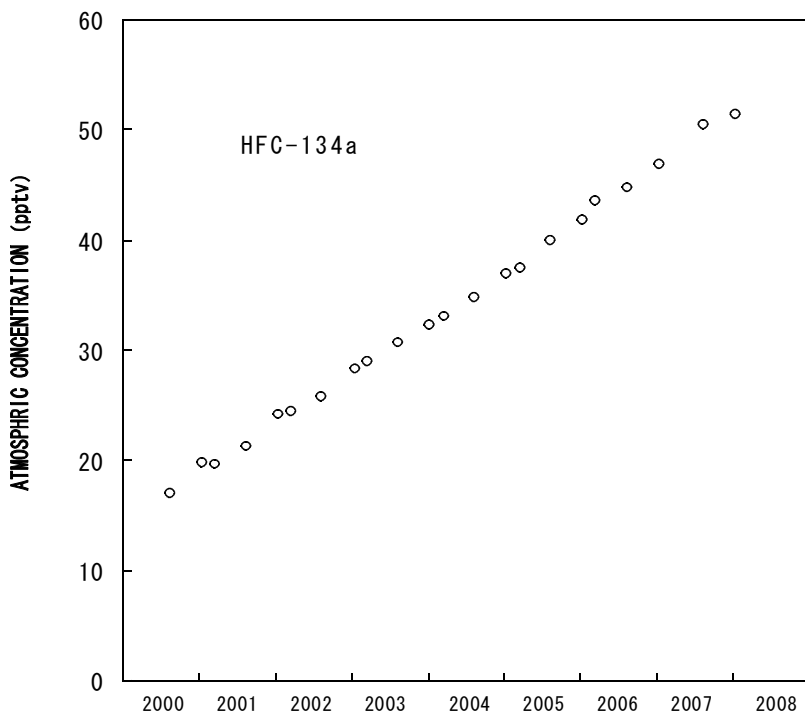


Figure 4.1.14. Atmospheric concentrations of HFC-134a in Hokkaido since 2000
Circles represent the means for 4-6 samples.

(4) Rate of Change in the Concentrations of Measured Substances

The results from a series of the surveys in the background area were statistically evaluated to obtain the recent trends in the atmospheric concentrations. The evaluation method used was as follows.

(A) Evaluation Period

The period of the evaluation was principally about 12 years, from January 1996 to the present (January 2008). On January 1, 1996, the manufacture of the major CFCs (group I of Annex A of the Montreal Protocol) was prohibited in developed countries. Although the manufacture of halons (group II of Annex A of the Protocol) in developed countries was already prohibited in January 1994, the evaluation periods of these substances was taken as the same for convenience. Since trends in the atmospheric concentrations of many substances do not obviously appear to change markedly over this period, it is possible to assume that the trends in concentrations of many substances were constant over the period (**Figure 4.1.1 - Figure 4.1.15**). The evaluation periods for several substances were nevertheless reduced as follows.

- i) The evaluation period for CFC-12 was reduced to be from January 1997, because the trend in the concentrations changed around 1996 (see **Figure 4.1.2**).
- ii) The evaluation period for CFC-115 was reduced to be from January 1998, because the trend in the concentrations changed around 1997 (see **Figure 4.1.5**).
- iii) The evaluation period for halon-1211 was reduced to be from January 2001, because the trend in the concentrations changed around 2000 (see **Figure 4.1.6**).
- iv) The evaluation period for carbon tetrachloride was reduced to be from August 1996 due to the lack of the results for early 1996.
- v) Since the rate of decline in the concentrations of 1,1,1-trichloroethane has steadily changed, it is difficult to determine a long evaluation period for this substance. The evaluation period was limited to that from August 2002 to the present. It is possible to assume that the trend was approximately straight for this period (see **Figure 4.1.9**).
- vi) The evaluation period for HCFC-141b was reduced to be from January 2003, because the trend in the concentrations changed around 2000 (see **Figure 4.1.11**).
- vii) The evaluation period for methyl bromide was reduced to be from January 2000, because the trend in the concentrations changed around 1999 (see **Figure 4.1.13**).
- viii) The evaluation period for HFC-134a was from 2000 since the measurement of HFC-134a began in this year.

(B) Method of Analysis

The statistical analysis was carried out under following conditions.

- i) The analysis used the raw results of the measurements instead of averaged values.
- ii) The analysis calculated a straight-line regression with the assumption that the change in the trend in concentrations over the evaluation period was constant.
- iii) The analysis calculated 95% confidence intervals for the inclinations of the regression.
- iv) The analysis calculated the rates of change in the concentrations per year (annual growth rates) using the present (January 2008) concentrations calculated from the regressions and the inclinations of the regression.

(C) Results of Analysis

The calculated annual growth rates (pptv per year) and 95% confidence intervals are shown in **Table 4.4**. The plots of each substance are also shown in **Figure 4.2.1 – Figure 4.2.15**. Each figure is based on the results of measurements that are the same as those in **Figure 4.1.1 - Figure 4.1.15**. The ordinates (concentration) of almost all the graphs are magnified for ease of detecting changes in the concentrations. To display the variability of the measurements, a standard deviation range (1σ , short cross-bars) is plotted above and below of each average. A regression line is also shown as a solid line. The means that are within the evaluation period are shown by solid circles (●) and those that are out of the period are shown by open circles (○).

Table 4.4. Trends in the atmospheric concentrations of measured substances in the background area
Evaluation periods are principally from January 1996 to January 2008

Substance	Annual Growth		Period of Evaluation ~ Jan 2008 (Note 1)	Concentration at Jan 2008 (Note 2) (pptv)	Annual Growth Rate (%) (Note 3)
	pptv/year	95 % Confidence Intervals (pptv)			
CFC-11	-1.9	± 0.1	Jan 1996~	240	-0.8
CFC-12	-0.1	± 0.2	Jan 1997~ (Note4)	549	0.0
CFC-113	-0.73	± 0.04	Jan 1996~	77	-0.9
CFC-114	-0.02	± 0.008	Jan 1996~	15.0	-0.1
CFC-115	0.06	± 0.01	Jan 1998~ (Note4)	9.1	0.7
Halon-1211	0.02	± 0.005	Jan 2001~	4.8	0.4
Halon-1301	0.05	± 0.002	Jan 1996~	3.4	1.5
Halon-2402	-0.005	± 0.001	Jan 1996~	0.48	-1.0
Carbon tetrachloride	-1.3	± 0.1	Aug 1996~ (Note5)	96	-1.4
1,1,1-Trichloroethane	-3.9	± 0.2	Aug 2001~ (Note4)	12	-32
HCFC-22	5.4	± 0.1	Jan 1996~	193	2.8
HCFC-141b	0.44	± 0.1	Jan 2003~ (Note4)	21	2.1
HCFC-142b	0.84	± 0.03	Jan 1996~	20.0	4.2
Methyl bromide	-0.02	± 0.06	Jan 2000~ (Note4)	9.4	-0.2
HFC-134a	4.7	± 0.2	Aug 2000~ (Note6)	52	9.0

Note 1) The results in this table are calculated from the results of measurements of previous 12 years (January 1996 - January 2008). See Note 4 ~ Note 6 for the periods of evaluation of CFC-12, halon-1211, carbon tetrachloride, 1,1,1-trichloroethane, HCFC-141b, methyl bromide, and HFC-134a.

Note 2) The concentrations at January 2008 were calculated from the regression equations. Thus, these are not the measured values.

Note 3) The annual growth rates are based on the concentrations at the present.

Note 4) The evaluation periods for CFC-12, CFC-115, halon-1211, 1,1,1-trichloroethane, HCFC-141b, and methyl bromide are from January 1997, January 1998, January 2001, August 2002, January 2003, and January 2000 to the present, respectively.

Note 5) The evaluation period for carbon tetrachloride is from August 1996 to the present due to the lack of the results in January 1996 and March 1996.

Note 6) The evaluation period for HFC-134a was from 2000 since the measurement of HFC-134a began in this year.

(D) Evaluation of the Results of the Analysis

The conclusions for the trends in the concentrations of the measured substances in the background area are as follows according to **Table 4.4**, and **Figure 4.2.1 - Figure 4.2.15**.

- (i) The atmospheric concentrations of CFC-115, halon-1301, HCFC-22, HCFC-141b, HCFC-142b, and HFC-134a have continued to increase since the observation program began. The rate of increase in the concentrations of HFC-134a is the highest of these substances.
- (ii) The atmospheric concentrations of CFC-12 and CFC-114 were increasing until the first half of the 1990s, however, they have been almost stable since then.
- (iii) The concentrations of halon-1211 were increasing until about 2005, but no significant change has been observed since then.
- (iv) The atmospheric concentrations of CFC-11, CFC-113, halon-2402, carbon tetrachloride, and 1,1,1-trichloroethane were increasing for several years from the beginning of the observation, but they have been declining for the past 10 or more years. The rate of decline in the concentrations of 1,1,1-trichloroethane is the highest of these substances.
- (v) No significant change has been observed in the concentrations of methyl bromide in recent years.

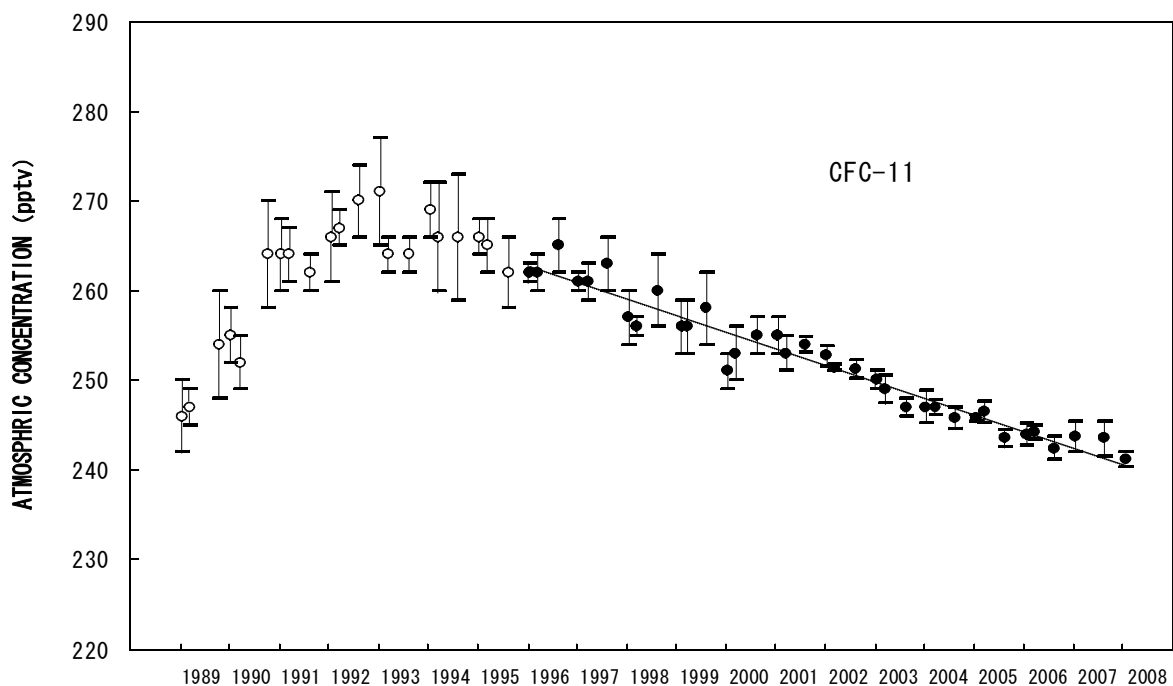


Figure 4.2.1. Long-term trend in CFC-11 concentrations in Hokkaido fitted with a regression line. Circles represent means for 6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

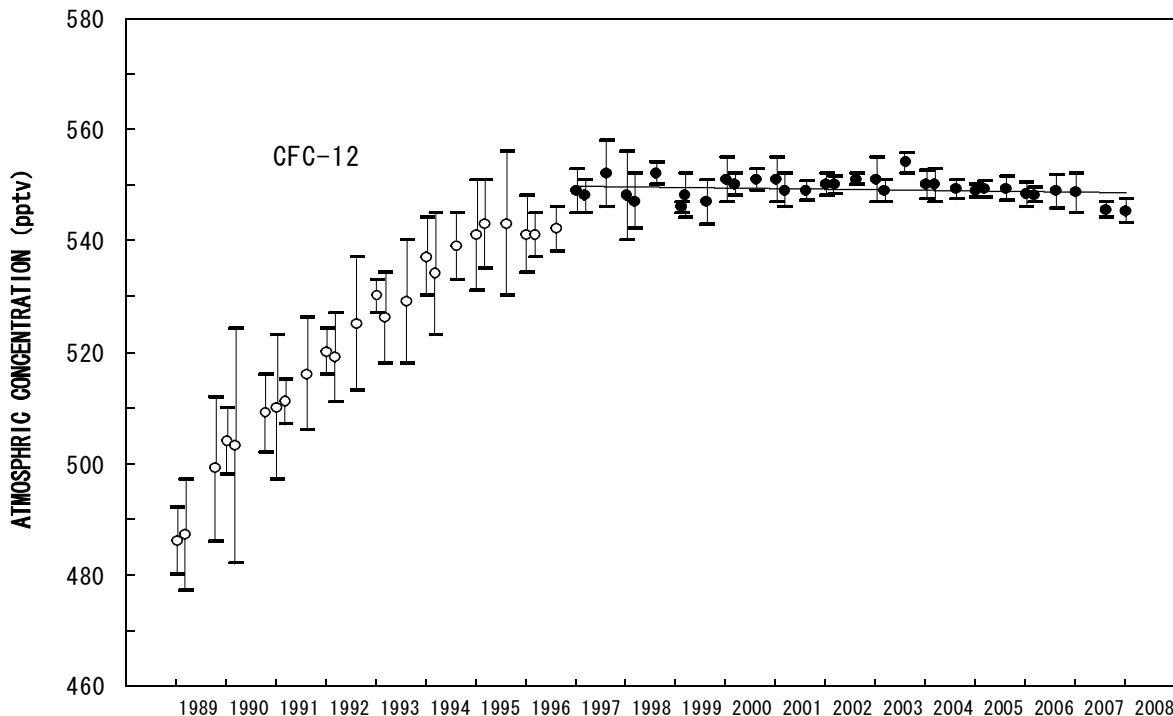


Figure 4.2.2. Long-term trend in CFC-12 concentrations in Hokkaido fitted with a regression line. Circles represent means for 6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

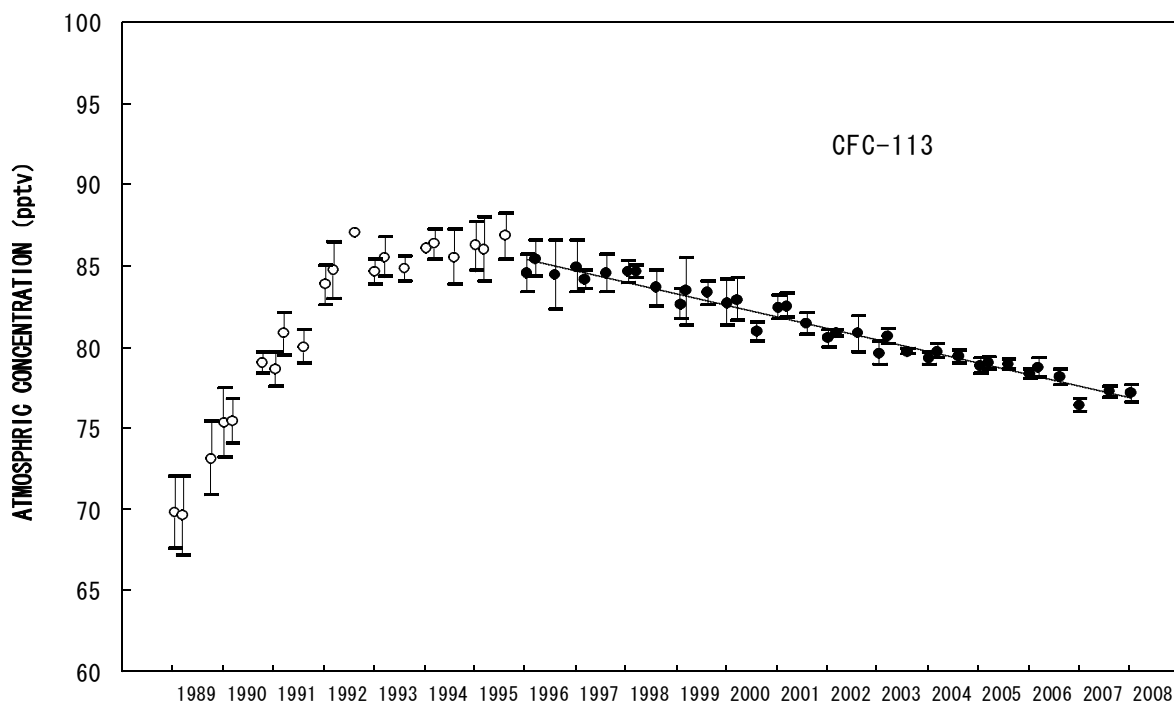


Figure 4.2.3. Long-term trend in CFC-113 concentrations in Hokkaido fitted with a regression line
 Circles represent means for 2-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

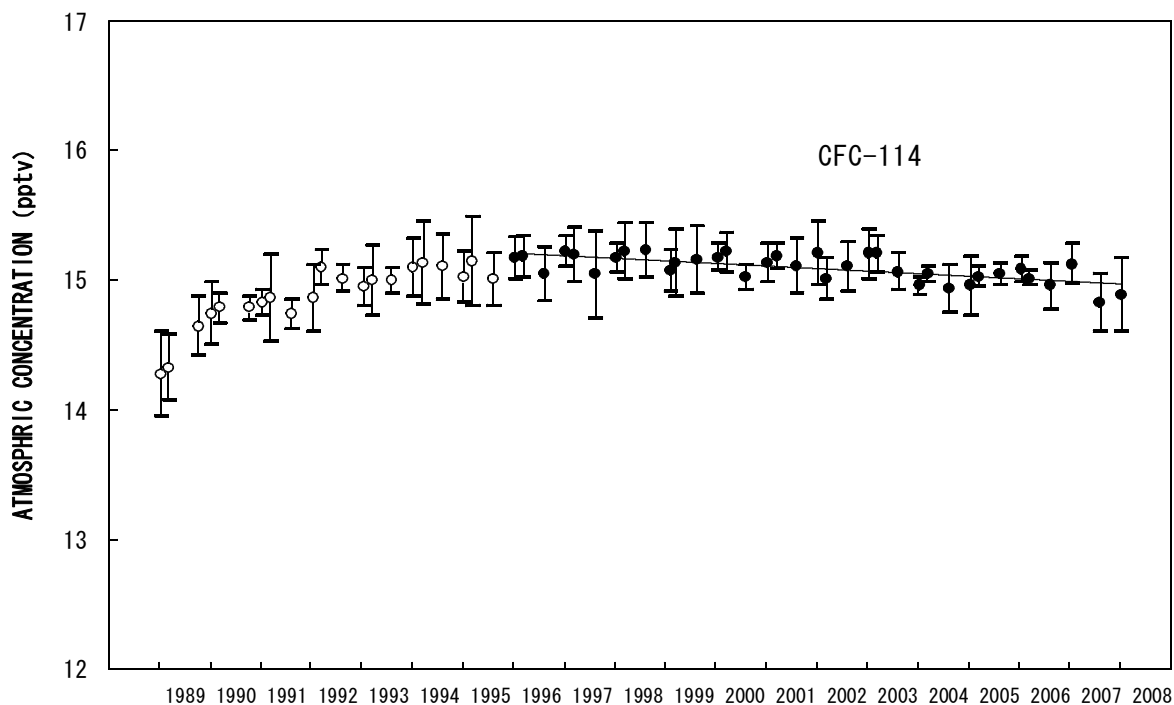


Figure 4.2.4. Long-term trend in CFC-114 concentrations in Hokkaido fitted with a regression line
 Circles represent means for 4-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

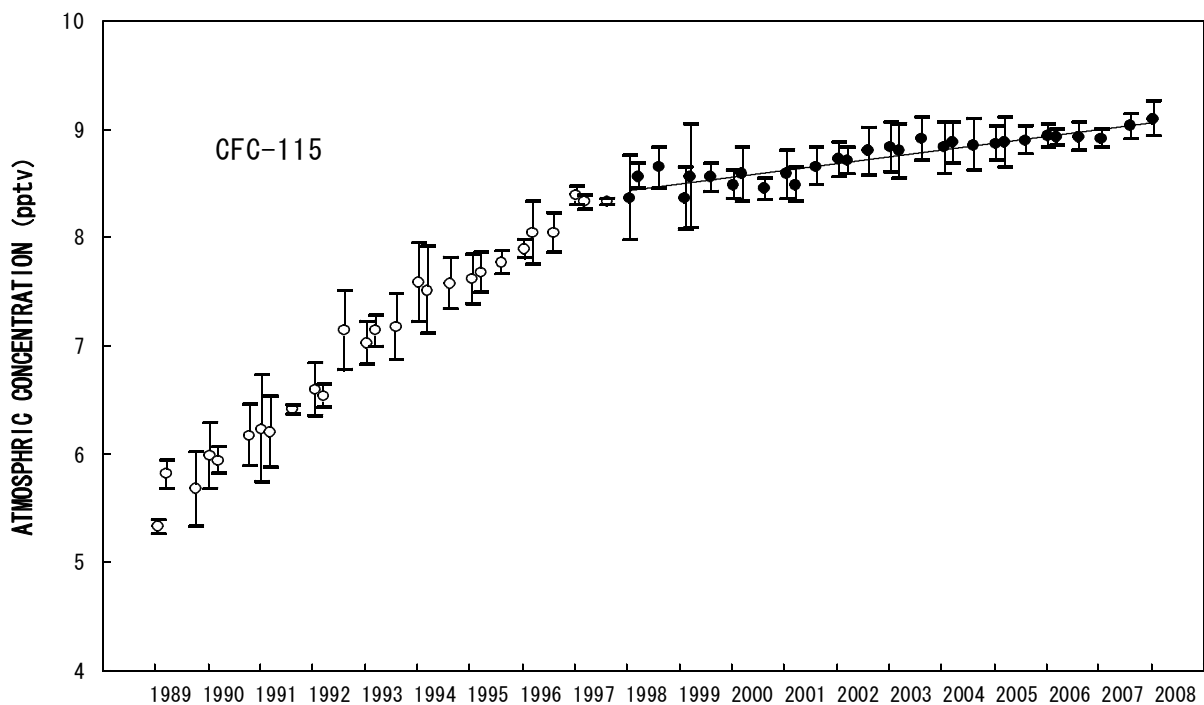


Figure 4.2.5. Long-term trend in CFC-115 concentrations in Hokkaido fitted with a regression line
 Circles represent means for 2-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

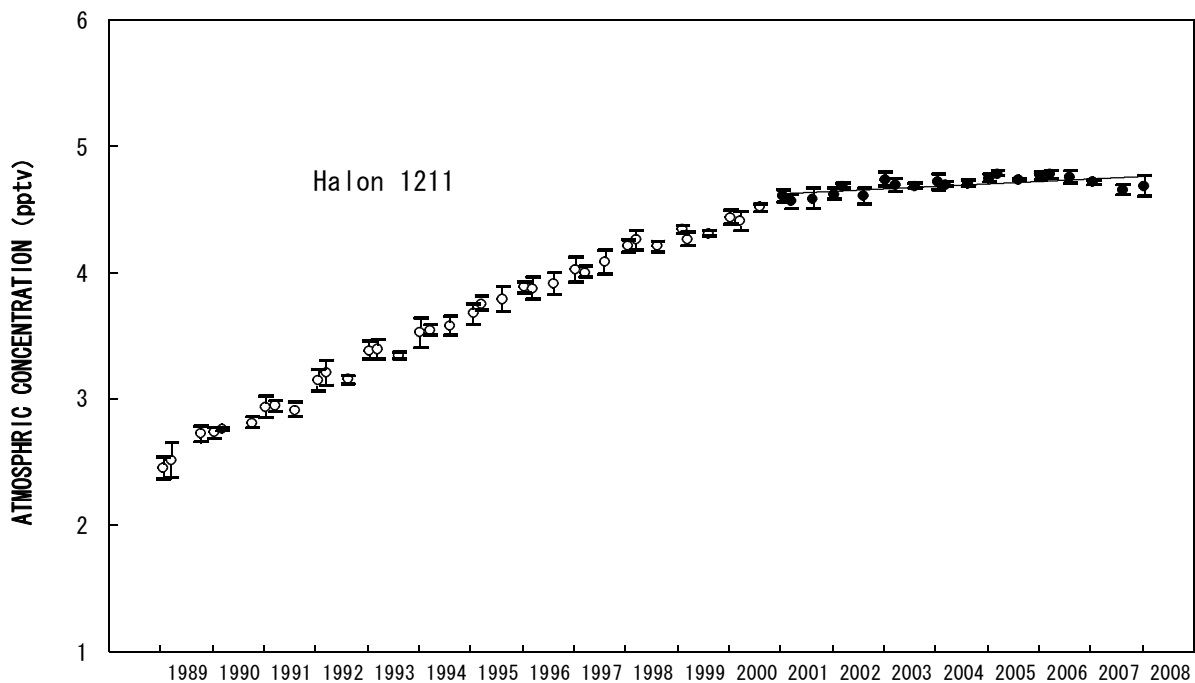


Figure 4.2.6. Long-term trend in halon-1211 concentrations in Hokkaido fitted with a regression line
 Circles represent means for 4-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

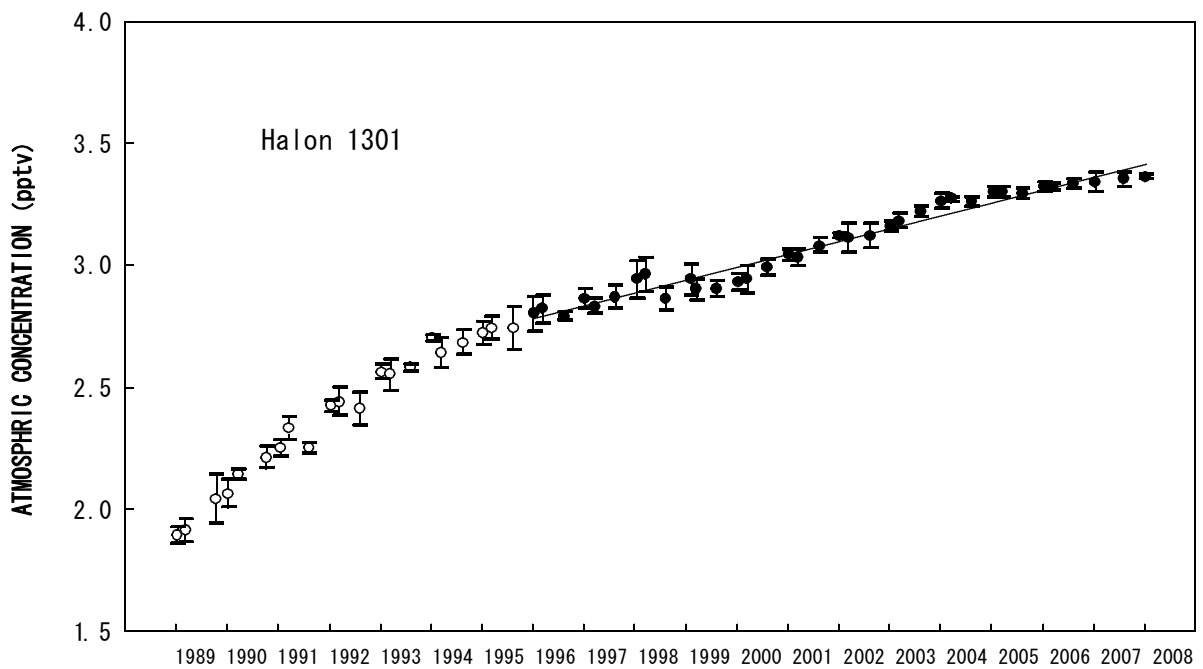


Figure 4.2.7. Long-term trend in halon-1301 concentrations in Hokkaido fitted with a regression line. Circles represent means for 4-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

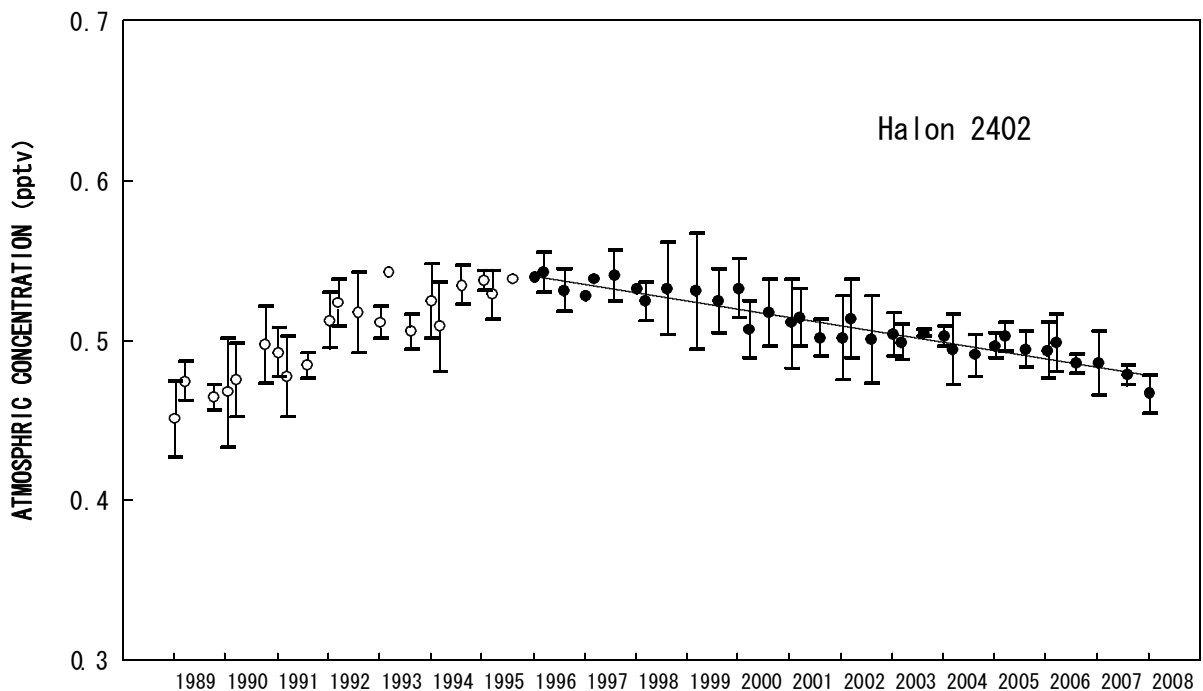


Figure 4.2.8. Long-term trend in halon-2402 concentrations in Hokkaido fitted with a regression line. Circles represent means for 1-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

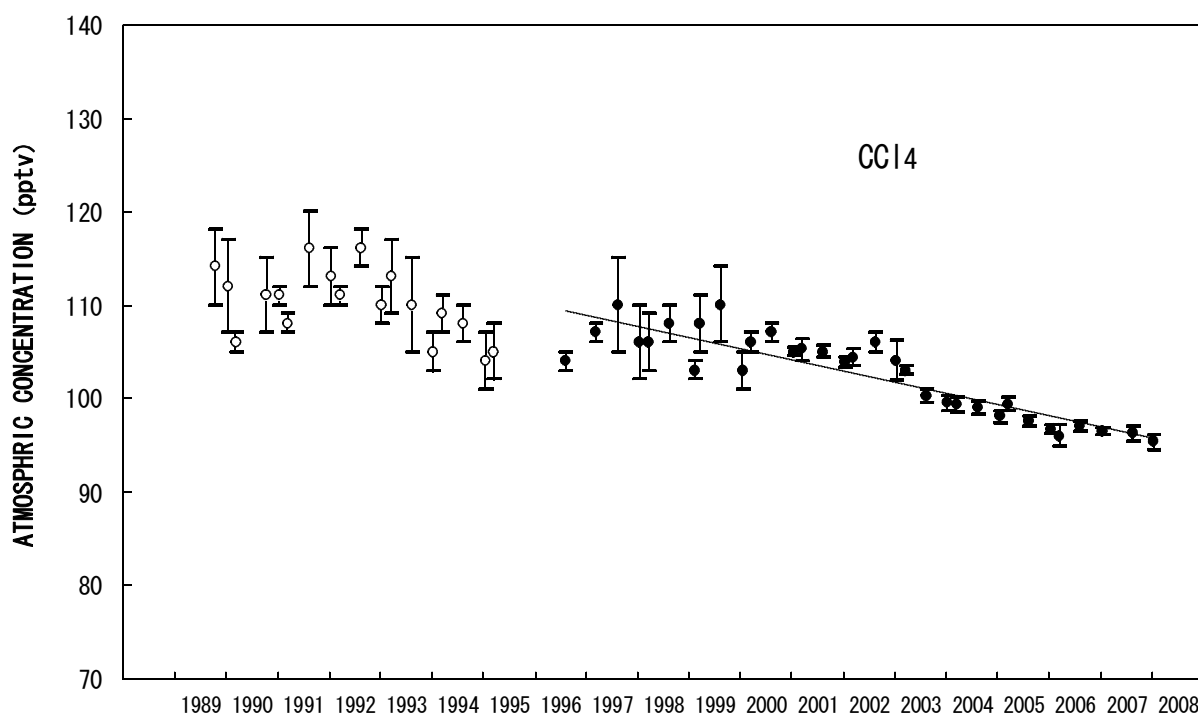


Figure 4.2.9. Long-term trend in carbon tetrachloride concentrations in Hokkaido fitted with a regression line
 Circles represent means for 2-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

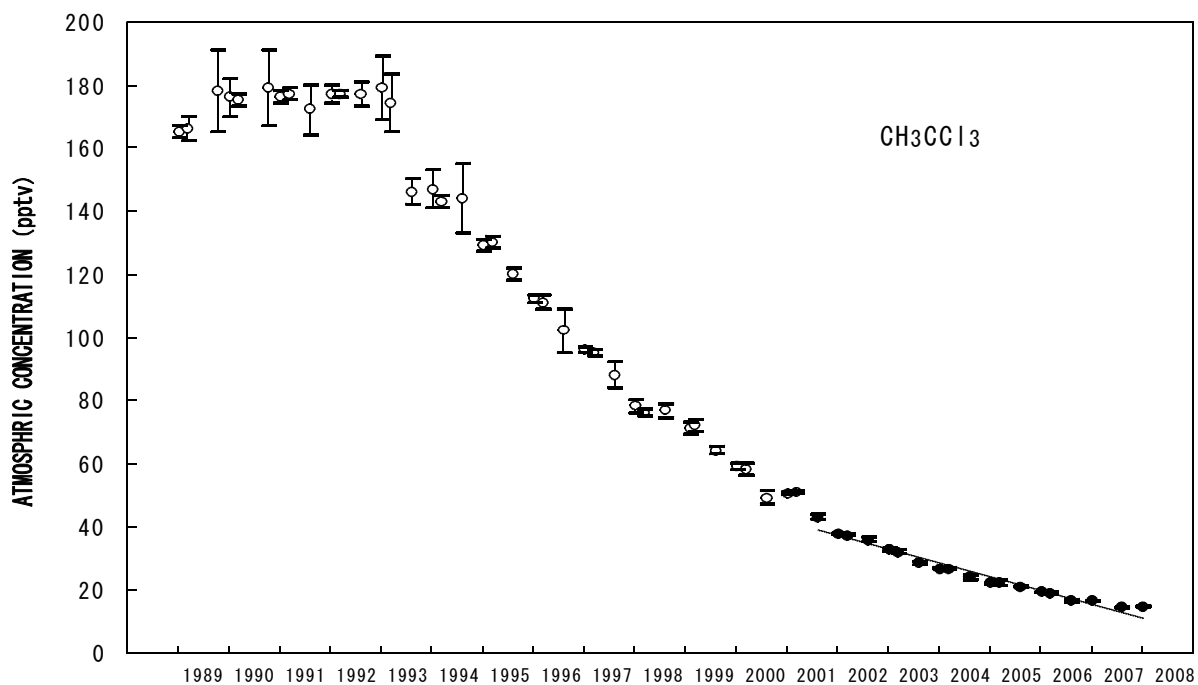


Figure 4.2.10. Long-term trend in 1,1,1-trichloroethane concentrations in Hokkaido fitted with a regression line
 Circles represent means for 6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

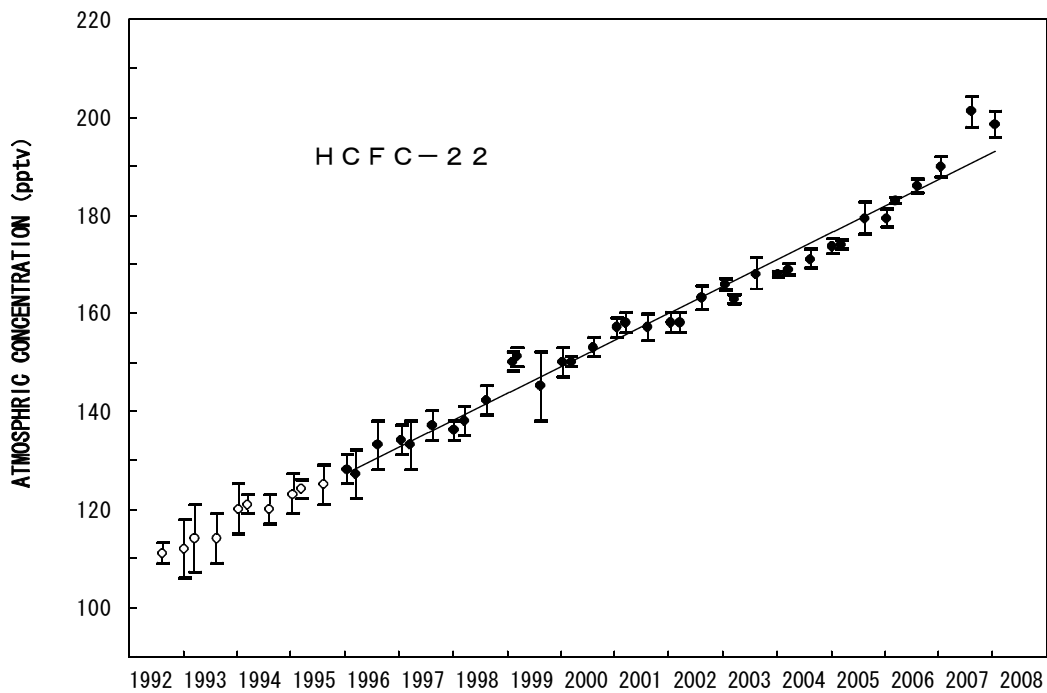


Figure 4.2.11. Long-term trend in HCFC-22 concentrations in Hokkaido fitted with a regression line
 Circles represent means for 4-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

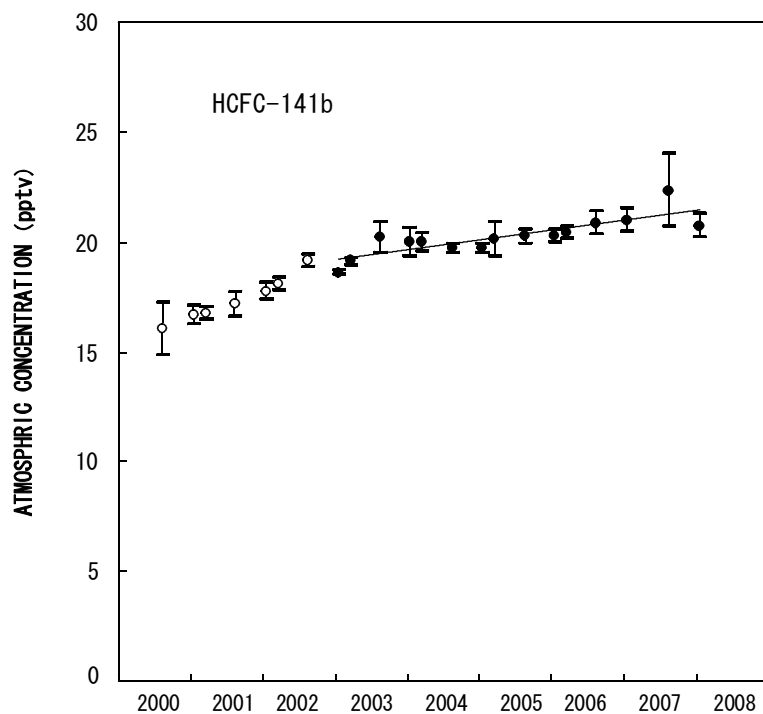


Figure 4.2.12. Long-term trend in HCFC-141b concentrations in Hokkaido fitted with a regression line
 Circles represent means for 6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

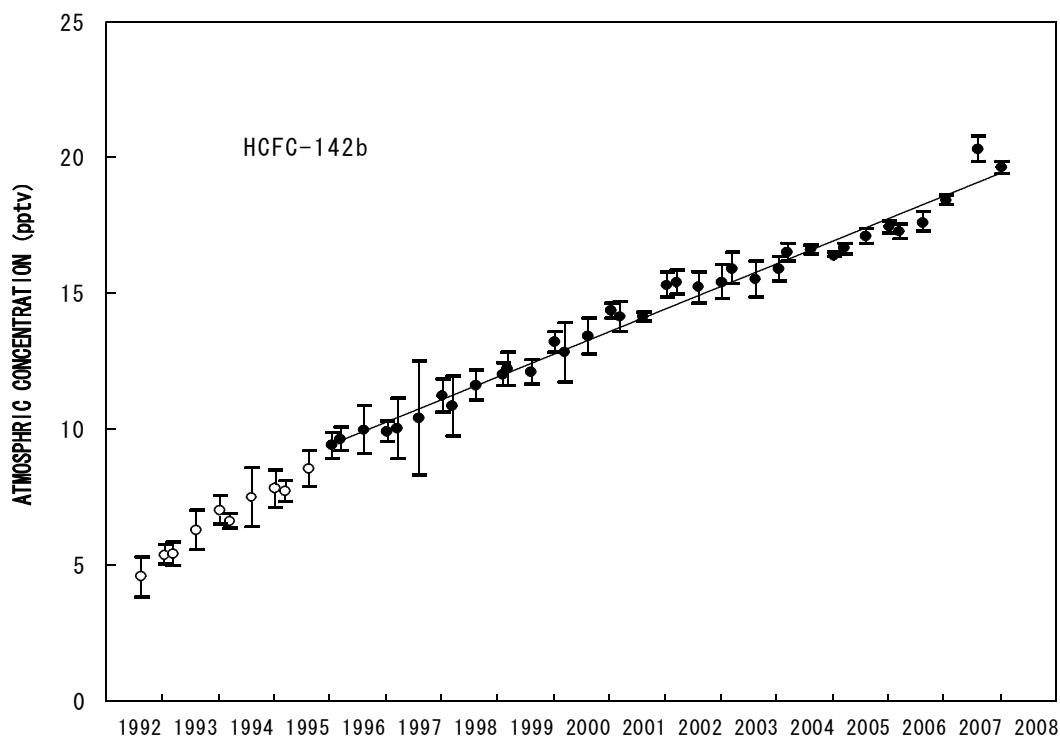


Figure 4.2.13. Long-term trend in HCFC-142b concentrations in Hokkaido fitted with a regression line
 Circles represent means for 2-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

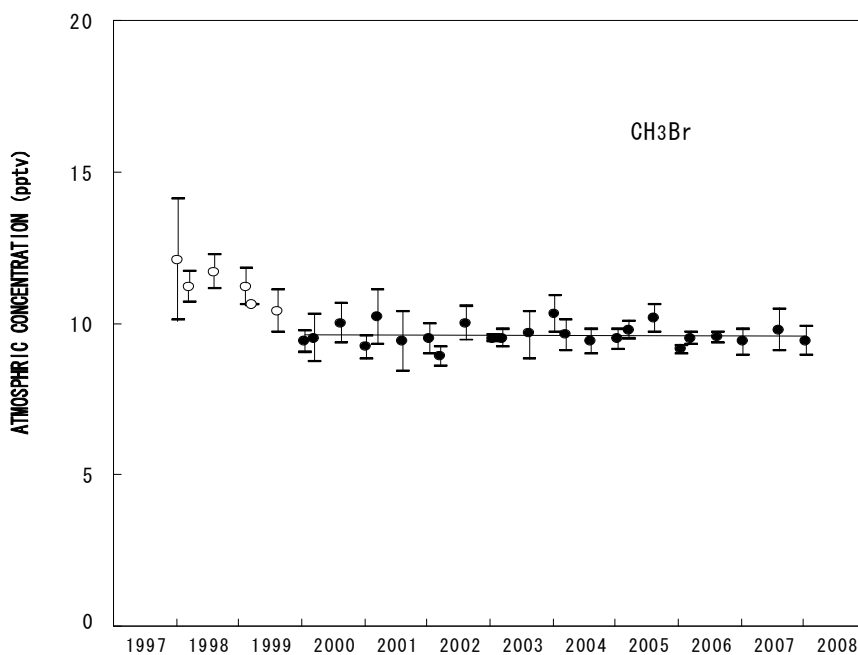


Figure 4.2.14. Long-term trend in methyl bromide concentrations in Hokkaido fitted with a regression line
 Circles represent means for 3-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

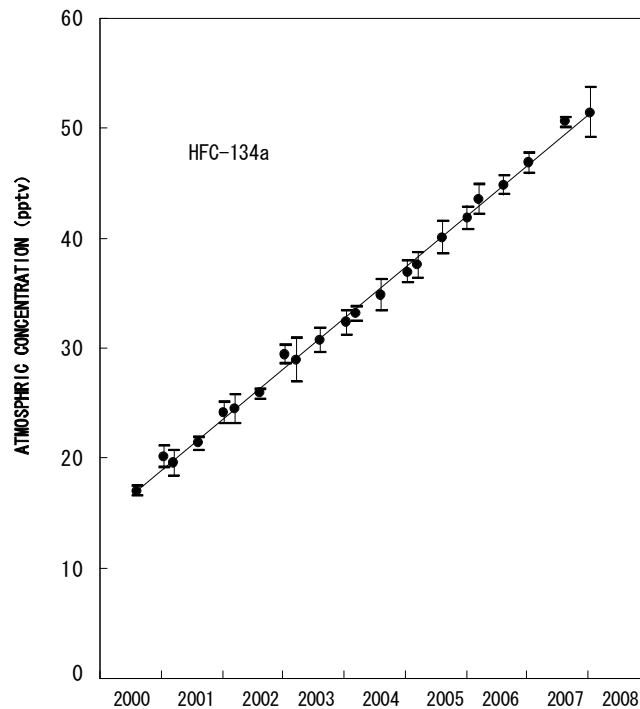


Figure 4.2.15. Long-term trend in HFC-134a concentrations in Hokkaido fitted with a regression line. Circles represent means for 4-6 samples (solid circles "●" represent the means within the evaluation period, open circles "○" represent the means out of the period), error bars represent ranges of the standard deviation.

(5) Estimation of the Impact of the Measured Substances on the Ozone Layer

To estimate the effect of the measured substances on the ozone layer, products between the concentrations and the ozone depleting potential of each substance (ODP values, (13)) were calculated. The product between the concentration in the background area in January 1993 and January 2007 and the ODP value of the measured substances are shown in **Table 4.5** and the plots are shown in **Figure 4.3**. Since its ODP value is estimated to be approximately 0, HFC-134a was excluded. Since methyl bromide and HFC-134a were added to the program later than August 1992, these two substances were excluded as well. The atmospheric concentrations of CFC-11, CFC-113, and 1,1,1-trichloroethane reached peaks in around 1993, and these concentrations began to decline thereafter. Although CFC-12 has not yet reached a peak, the concentration x ODP value reached a peak around 1993.

The decline in the concentrations of CFC-11, CFC-113, carbon tetrachloride, and 1,1,1-trichloroethane has reduced the sum of the concentration x ODP value, however, the growth in the concentrations of CFC-12, halons, and HCFCs has raised the sum. The decline was greater than the growth as a whole, and the sum of the concentration x ODP value has decreased at present compared to 1993 as a result.

Table 4.5. Products between concentrations and ODP values of measured substances (Comparisons between January 1993 and January 2008)

Substance	Time	Jan. 1993		Jan. 2008	
	ODP value	Concentration (pptv)	Conc. × ODP value	Concentration (pptv)	Conc. × ODP value
CFC-11	1.0	271	271	241	241
CFC-12	1.0	530	530	544	544
CFC-113	0.8	84.6	68	77.1	62
CFC-114	1.0	14.9	15	14.9	15
CFC-114a	1.0	1.00	1	1.02	1
CFC-115	0.6	7.02	4	9.01	5
Halon-1211	3.0	3.38	10	4.64	14
Halon-1301	10.0	2.56	26	3.36	34
Halon-2402	6.0	0.51	3	0.46	3
Carbon tetrachloride	1.1	110	121	95.6	105
1,1,1-Trichloroethane	0.1	177	18	14.5	1
HCFC-22	0.055	112	6	198	11
HCFC-141b	0.11	-	-	20.7	(2)
HCFC-142b	0.065	5.35	0	19.7	1
Methyl bromide	0.6	-	-	9.4	(6)
Sum of concentration × ODP value (Note)			1,073	-	1,037

Note) HCFC-141b and methyl bromide are excluded from the summation.

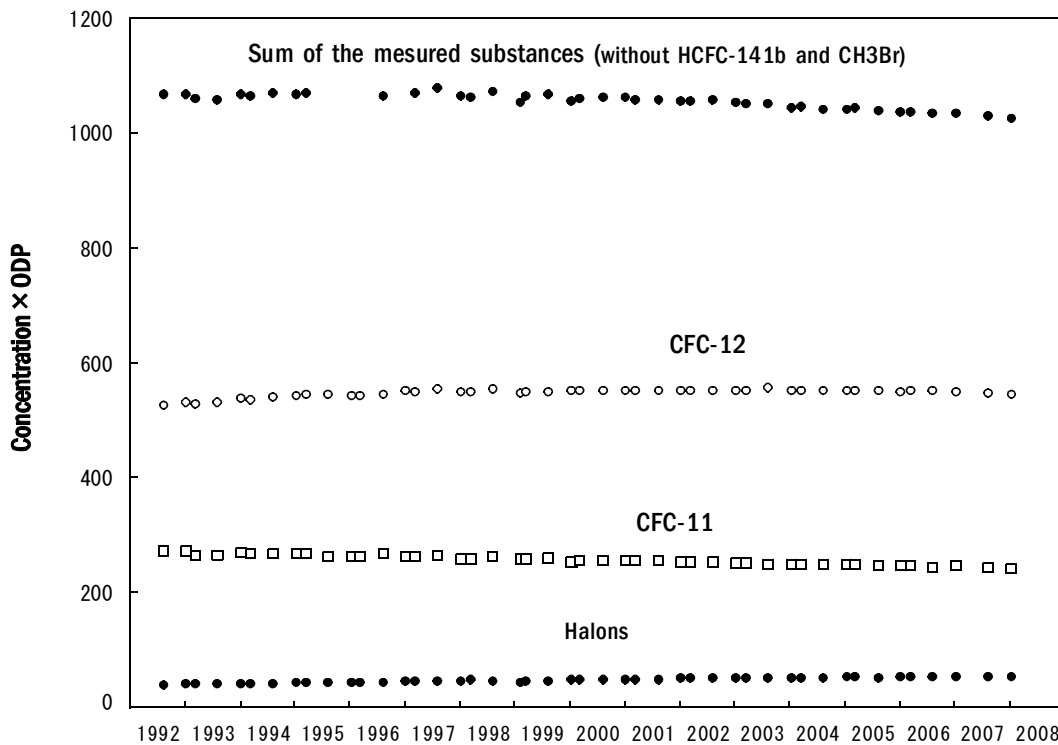


Figure 4.3. Plots of CFC-11 equivalent concentrations of the measured substances (1989 - 2008) (Product between atmospheric concentrations and the ozone depleting potentials (ODP values))