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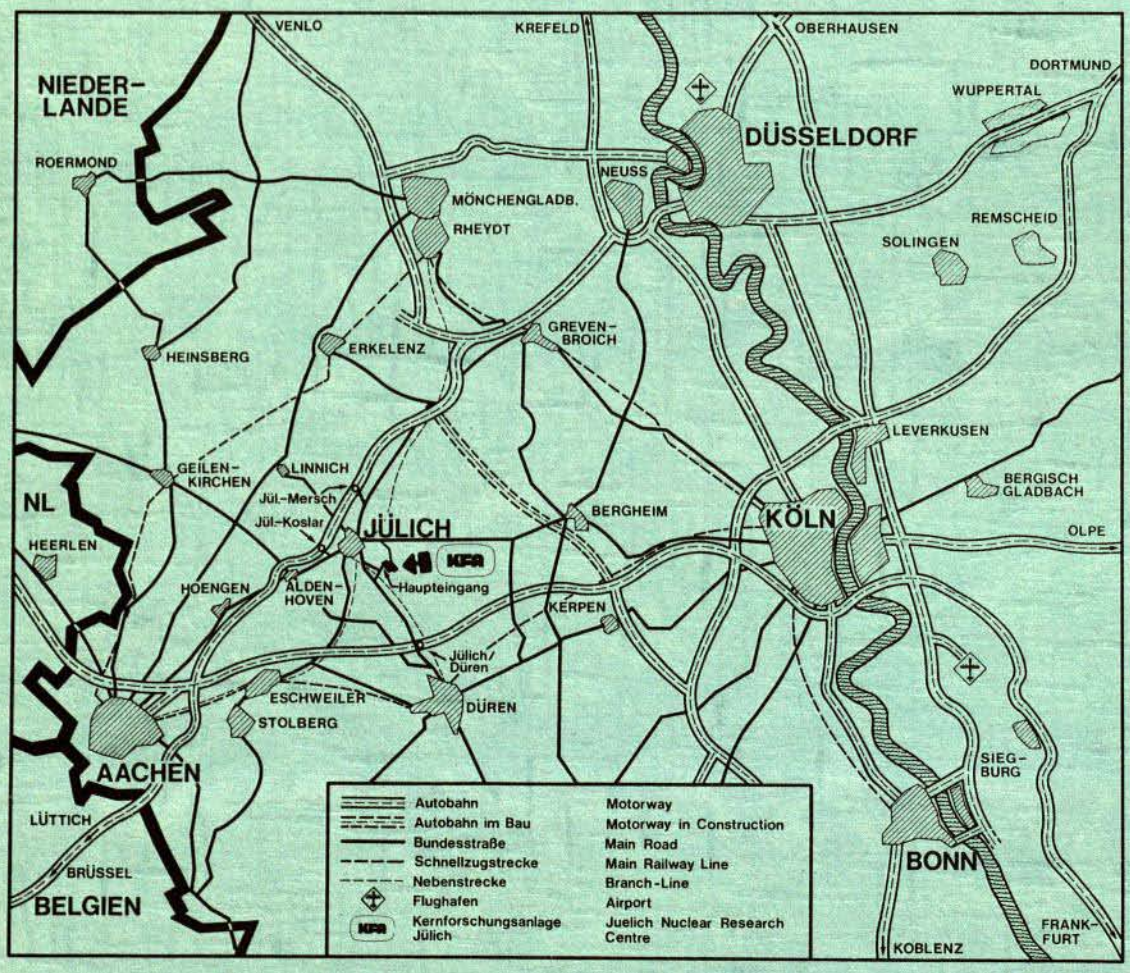

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Summary:

This report compiles gas-chromatographic measurements of the vertical profiles of the trace gases H_2, CO, CO_2, N_2O, CF_2Cl_2, $CFCl_3$, CH_3Cl, CH_4, C_2H_6, C_3H_8, and C_2H_2 performed at the KFA-Jülich on samples collected in the stratosphere and troposphere at midlatitudes (43° N - 51° N) during a joint project between the MPI für Aeronomie, Lindau, FRG, the MPI für Chemie, Mainz, FRG, and the KFA-Jülich (Institut für Chemie 3), as well as from a cooperation between the National Center of Atmospheric Research (NCAR), Boulder, Colorado, USA and the KFA - Jülich.

These data have been discussed in various publications by various authors (see below). However, the pictorial format in which the data are usually presented does not allow to extract the precise concentrations. For this purpose, our data are here compiled in form of tables. They give only the measurements performed at the KFA-Jülich, together with a discussion of the experimental techniques employed and their uncertainties.

Experimental:

Sampling:

The stratospheric whole air samples were collected cryogenically on a balloon. Liquid Ne at a temperature of 30 K served as a coolant. The cryogenic samplers used are described elsewhere [1, 2]. In general, the samples were collected during the slow decent of the balloon (50 m/min). During two fligths in 1979, some samples were also collected during ascent. This provided useful information on possible effects of contamination from the balloon or the package itself.

The cryogenic samplers had been tested for fractionation during the sampling process, as well as for changes in the trace gas concentrations during storage. Within the experimental precision no such changes nor fractionation could be detected. For CO, however, further tests showed, that it could be either produced or destroyed within the stainless steel inlet line (length ~ 6 m) if high concentrations of O_3 as they occur in the stratosphere are present. Therefore, in 1978 the inlet line was changed to an acid treated copper tube and eventually in 1979, silver wool was used in the inlet line in order to destroy the ozone. Although preflight tests showed, that the production of CO in the sampler was virtually reduced to zero by this procedure, further extended tests have to prove if the samples collected in 1979 really represent the true stratospheric CO mixing ratio. It was also shown in the laboratory that neither the presence of O_3 nor the changes in the inlet had any effect on the concentrations of the other trace gases measured. For the non methane hydrocarbons the respective tests have not been performed yet. However, at least the saturated hydrocarbons are expected to show a chemical stability very similar to that observed for CH_4.

Additional grab samples were collected in 2 l stainless steel cylinders aboard an aircraft to extend the profiles to lower altitudes.

Sample storage:

After the flight, the stratospheric samples were aliquoted into stainless steel cylinders of 0.5 l volume. These cylinders had been baked at 400 ^{o}C under vacuum as well as in an O_2 atmosphere for a one week period in order to prevent outgassing of CO and H_2. After baking, the cylinder walls were passivated with moist, clean synthetic air. After this treatment, all trace gases could be stored without noticeable changes in their concentrations for several months except for a minor but still observable contamination for CO and H_2, which increased in concentration by ~ 0-20 ppb per month. The usual storage time, however, was only between one day and two weeks.

In addition, comparative measurements were performed whenever possible on the original samples in the cryogenic sampler itself prior to aliquotting. In general, no systematic deviations were observed between these and the measurements performed on the aliquots.

Analyses:

The trace gas measurements were performed by gas-chromatography. In table 1 the different methods employed are summarized together with information about sensitivity and uncertainty.

Separation of the different compounds was performed by gas-solid chromatography (GSC), since solid absorbents like molecular sieve or the various types of silica gel used have extremely low vapor pressures even at elevated temperatures

Table 1: Analytical parameters for the gas-chromatographic trace gas analyses

trace gas	sample size (STP)	column material (temperature)	carrier gas	detector	detection limit (S/N = 2)	precision (± 1 σ)	estimated accuracy (± 1 σ)
H_2	5 ml	MS 5 Å (100 °C)	He	HID	20 ppb	± 2 %	± 5 %
CH_4	2-5 ml	MS 5 Å	synth. air purified	FID	4 ppb	± 1 %	± 5 %
CO		(120 °C)	through Hopcalite and MS 5 Å	(Ni-catal.)	5 ppb	± 2 %	± 5 %
C_2H_6	1-2 l (preconc. on Spherosil/Carbosieve at T = 77 K)	Spherosil (temp. progr. -90 to 65 °C)	He 99.9999 %	FID	2-5 ppt	± 5 %	± 10 %
C_3H_8					5-10 ppt		
C_2H_2					20-50 ppt		
CH_3Cl					10-20 ppt		
N_2O	2-5 ml	Porasil C (temp. progr. -30 to 150 °C)	N_2 (purified through MS 5 Å at 77 K)	ECD (T= 340 °C)	5 ppb	± 3 %	± 5 %
CF_2Cl_2					1 ppt	± 2 %	± 5 %
$CFCl_3$					1 ppt	± 3 %	± 10 %
CO_2	1 ml	MS 5 Å (100 °C)	synth. air	FID (Ni-catal.)	5 ppb	±0.2 %	± 1 %

and thus can be thoroughly purified by baking. Hence outgassing or bleeding, which could deteriorate the sensitivity of the detectors, is reduced to a minimum.

The various detectors used were:

- Flame Ionization Detector (FID) for the hydrocarbons, CH_3Cl, CO and CO_2. After separation on the column, CO and CO_2 were converted to CH_4 by using H_2 on a hot (350 ^{o}C) Ni-catalyst prior to entering the FID.

- Electron Capture Detector (ECD) at a temperature of 340 ^{o}C for N_2O, CF_2Cl_2, and $CFCl_3$.

- Helium Ionization Detector (HID) for hydrogen.

All the carrier- and auxiliary gases used were of high purity or research grade and were further purified with hopcalite and molecular sieve traps if necessary.

Sample injection was performed through a stainless steel vacuum line equipped with a Valco gas-sampling valve (5 ml sample loops) and a Setra pressure transducer. For the non methane hydrocarbons (NMHC) about 1-2 l (STP) of the samples were preconcentrated at 77 K on a precolumn containing Spherosil and Carbosieve [15].

Calibration:

For quantitative analysis, the samples were compared to external standards, which consisted of large samples of tropospheric air stored under high pressure in stainless steel cylinders equipped with all stainless steel valves. For CO, CO_2, and the NMHC, mixtures in synthetic air were used for standards.

The external standards were repeatedly compared to calibration mixtures, which were prepared each time by static dilution of the pure gases with 'zero-air' in a calibrated stainless steel vacuum line. From the repeated calibration, no significant changes of the trace gas concentrations in the external standards could be detected, with the exception of CO.

During 1976 the CO concentration in the standard was found to decrease by a few percent per month. The problem was solved by storing the mixture in a 'Spectra Seal' aluminium cylinder.

Our N_2O concentrations reported in the publications [2-8] had been measured against a laboratory standard which was later found to be 7 % too high. The values given here are properly corrected. They correspond to a tropospheric N_2O mixing ratio of 314 $\pm$ 10 ppb. From several comparisons of our standards with other laboratories it was shown, that there is general agreement within $\pm$ 5 % or better (c.f. [9]).

The CO_2 standard was compared to the Scripps Manometric Scale at the Institute of Meteorology, University of Frankfurt, FRG, in 1976. Later comparisons with the Scripps Institute for Oceanography indicated that there might be a small change in our CO_2 standard over the time period of four years. However, the observed discrepancy of 3 ppm could also be attributed to changes of the CO_2 concentration in the comparison samples during shipping and storage. On this basis the absolute accuracy for our CO_2 measurements is conservatively estimated to be 3 ppm. Further comparisons are in progress.

Altitude data:

The altitudes given in tables 2-12 give the altitude interval over which each sample was collected. They are based on pressure measurements provided by the CNES during the flights employing two different Rosemont pressure transducers for high

and low pressures, respectively. The transducers were calibrated prior to and after each flight. Geometric altitudes were then calculated from the pressures by using temperature profiles according to the U.S. Standard Atmosphere. Due to the accuracy quoted for the Rosemont transducers (0.2 mbar) and the uncertainty of the actual temperature profile, the accuracy for the corresponding altitudes is about 1 km. The altitudes for the two flights over Canada (table 13 and 14) were provided by NCAR and have the same accuracy.

Results:

The final results of the gas-chromatographic measurements from 13 balloon flights together with the data from supporting aircraft flights are listed in tables 2-14.

A total of 11 flights were performed in the period from September 1976 to November 1979 over Southern France (43-44^{o}N) during a joint stratospheric sampling program of the MPI for Aeronomy, Lindau, the MPI for Chemistry, Mainz, and the KFA Jülich (Inst. for Atmospheric Chemistry). These data have been discussed in detail in various publications [2-8, 10-13]. Aliquots of samples collected during two flights launched in August 1977 and 1978 over Canada (51^{o}N) were provided by NCAR. They have been discussed in [10, 13, 14].

In tables 2-14, only the final results from the measurements performed at the KFA are reported. They were corrected for changes in calibration (e.g. N_2O), and might, therefore, deviate slightly from the data given in earlier publications. In addition these data which are likely to be contaminated and thus may not represent the real atmospheric concentrations are quoted in brackets (e.g. all stratospheric CO measurements, samples collected during ascend or float, and samples with too small amounts of air collected). They should not be used to calculate average profiles or for interpretational studies. The uncertainties given with the concentrations reflect the precision of the analyses. The estimated accuracy of the calibration is listed in table 1.

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Table 2: FKW Flight No: 7601

Location: Aire sur l'Adour 43°N; 1°N Tropopause height: 11.5 km

Date : 9/7/76

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
18.0*)	(520±20)	(1.48±0.02)	(33±5)	(291±15)	(100±5)	(217±5)

*)
collected during float (failure of balloon)

Table 3: FKW Flight No: 7701

Location: GAP TALLARD 44°N; 2°E

Tropopause height: 12 km

Date : 6/7/77

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
35.3*)	(410±20)	(0.48±0.02)	(159±12)	(21± 2)	(1.5±0.1)	(5±1)
33.9-34.2	460±20	0.55±0.02	(182±14)	31± 3	<0.2	8±1
32.5-32.8	450±20	0.63±0.02	–	51± 2	<0.2	15±1
31.0-31.5	450±20	0.68±0.02	(183±13)	61± 3	0.2±0.1	21±2
29.3-30.7	490±20	0.77±0.02	(227±17)	97± 7	<0.2	30±2
27.5-28.5	450±30	0.73±0.02	(168±12)	83± 3	0.2±0.1	25±1
24.9-25.6	470±40	0.91±0.02	(140± 7)	127±14	3±1	53±2
22.9-23.7	490±10	0.98±0.02	(139±10)	157±16	8±1	63±3
12.3	540±20	1.53±0.01	83± 3	291± 7	114±3	223±2
12.3	510±10	1.57±0.01	83± 3	273±20	111±29	210±3
11.9	540±10	1.57±0.01	102± 5	287±25	114± 7	220±8
11.2	580±10	1.67±0.01	122±17	308±15	126± 5	250±3
10.6	540±10	–	–	308± 5	140±10	258±3
9.9	560±20	1.63±0.02	144± 6	315± 7	146± 3	267±2
9.0	560±20	1.65±0.01	172± 7	309± 3	128± 4	247±2
5.2	540±20	1.63±0.02	137± 5	313± 9	133± 5	243±4

*) collected during float

Table 4: FKW Flight No: 7702
Location: GAP-TALLARD 44°N; 2°E Tropopause height: 12.2 km
Date : 6/16/77

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
34.8*)	(430±20)	(0.50±0.02)	(39±10)	(23±2)	(<0.2)	(3±0.2)
34.6-34.8	490±20	0.56±0.02	(101±10)	23±1	<0.2	3±0.1
32.8-33.8	440±20	0.56±0.02	(<10)	37±2	<0.2	6.4±0.2
27.3-27.8	480±20	0.78±0.02	(<10)	101±1	0.2±0.1	33±0.5
23.1-23.7	480±10	1.06±0.02	(<10)	172±10	4 ±0.2	66±1.0

*) collected during float

Table 5: FKW Flight No: 7704

Location: Aire s/l Adour $44^{o}N$; $0^{o}W$ Tropopause height: 13.2 km

Date : 9/12/77

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
33.5*)	(460±10)	(0.61±0.01)	(100±2)	(49±5)	(0.7±0.1)	(7±1)
32.2	460±10	0.69±0.01	(235±4)	73±8	<0.1	12±1
29.9	490±10	0.63±0.01	(214±2)	79±6	–	14±1
26.9	480±10	0.81±0.01	(149±4)	105±10	0.1±0.1	31±3
23.7	500±10	1.03±0.01	(208±2)	164±5	9±0.4	71±9
20.7	490±10	1.12±0.05	(57±2)	205±12	28±1	80±9
18.1	530±10	1.57±0.02	22±2	295±25	95±3	169±4
13**)	550±10	1.73±0.02	35±3	308±15	125±1	206±5

*) collected during float

**) collected during parashute descent

Table 5: continued

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
13.0	530±10	1.66±0.01	47±2	307± 4	128±4	229±12
12.6	520±10	1.66±0.01	45±2	319±17	121±8	231±10
12.0	530±10	1.66±0.01	49±2	307±10	122±9	222± 5
11.9	550±10	1.65±0.01	50±2	308±10	132±4	226± 5
11.6	530±10	1.65±0.01	55±2	293±10	133±2	237± 3
11.1	530±10	1.65±0.01	58±2	300± 7	134±2	238± 2
10.5	530±10	1.66±0.01	64±2	—	—	—
10.0	540±10	1.66±0.01	57±2	—	—	—
9.0	530±10	1.66±0.01	72±2	304±10	141±8	240± 4
8.8	550±10	1.66±0.01	83±3	307± 7	141±2	246± 4
7.7	550±10	1.66±0.01	76±2	298±13	137±2	243± 4
7.5	550±10	1.66±0.01	78±3	304± 7	146±5	242± 5
6.4	520±10	1.66±0.01	78±2	—	—	—
6.1	560±10	1.67±0.01	70±2	—	—	—
4.5	550±10	1.67±0.01	87±2	307± 7	143±2	353±10
2.8	570±20	1.67±0.01	80±2	—	—	—

Table 6: FKW Flight No: 7705

Location: Aire s/l Adour $44^{o}N$; $0^{o}W$ Tropopause height: 12.1 km

Date : 9/26/77

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ	CO_2 ppm±σ
32.8*)	(500±10)	(0.91±0.01)	(147±3)	(100±5)	(<0.1)	(26±1)	(334±2)
32.8*)	(520±20)	(0.84±0.02)	(191±6)	(96±5)	(<0.1)	(27±1)	(329±2)
32.8*)	(500±10)	(0.92±0.01)	(256±5)	(99±11)	(<0.1)	(29±1)	(328±3)
27 - 32**)	510±30	0.96±0.01	(15±2)	106±10	2±1	15±1	323±2
22 - 24**)	510±20	0.98±0.01	(108±8)	—	9±1	71±2	323±4
19 - 20**)	520±10	1.24±0.01	(81±2)	216±13	46±1	121±2	319±4
17 - 18**)	510±10	1.53±0.02	31±2	280±10	99±5	189±6	320±2
15 - 15.5**)	530±10	1.64±0.02	37±2	304±13	122±11	228±9	323±3

*) collected during float

**) collected during parashute descent

Table 7: FKW Flight No: 7801

Location: GAP TALLARD 44°N; 2°E

Tropopause height: 10.5/12.8/16.2 km

Date : 6/6/78

Altitude (km)	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
30.4-30.7***)	(0.61±0.01)	(38±5)	(52±2)	(< 1)	(18±1)
31.0*)	(0.61±0.02)	(53±7)	(46±3)	(< 1)	(16±1)
28.6-28.2	0.74±0.02	(36±2)	70±3	< 1	26±1

*) collected during float

***) collected during ascent

inlet line: acid treated copper tube

Table 8: FKW Flight No: 7802

Location: GAP TALLARD $44^{o}N$; $2^{o}E$ Tropopause height: 11.2/13.5 km

Date : 6/14/78

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
33.3-33.2*)	(458±5)	(0.56±0.01)	(68±2)	(39±1)	(<0.5)	(5)
32.3-31.5	468±6	0.45±0.01	(92±2)	24±1	1±0.5	15±2
26.8-26.6	488±9	1.01±0.01	(14±2)	166±1	6±1	90±2
18.3-18.0	481±4	1.31±0.01	27±2	254±3	65±5	178±3
16.0-15.9	508±10	1.54±0.01	28±2	295±3	112±1	221±11

*) collected during float

inlet line: acid treated copper tube

Table 9: FKW Flight No: 7803

Location: GAP TALLARD 44°N; 2°E

Tropopause height: 8.0/16.0 km

Date : 6/26/78

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
32.6*)	(435±4)	(0.56±0.01)	(138±2)	(35±2)	(<0.1)	(7±1)
30.8-31.8	471±2	0.52±0.01	(108±5)	35±2	0.3±0.1	8±1
28.1-28.7	470±3	0.70±0.01	(54±4)	60±2	0.4±0.1	20±1
19.6-19.8	492±5	1.26±0.01	15±2	228±5	66±5	155
17.4-17.5	488±4	1.32±0.01	24±2	256±3	68±5	179±2
13.8	495±3	1.49±0.01	32±2	300±3	100±4	223±3

*) collected during float
inlet line: acid treated copper tube

Table 10: FKW Flight No: 7901

Location: GAP TALLARD 44°N; 2°E

Tropopause height: 9.1/12.9 km

Date : 6/16/79

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ	CO_2 ppm±σ
34.1*)	(460±10)	(0.58±0.01)	(19±2)	(31±1.2)	–	(5±0.4)	(326.4±0.5)
31.7	517±10	0.73±0.01	(12±2)	62±1.3	–	18±0.6	325.8±0.5
28.9	505±10	0.92±0.01	(7±3)	105±1.6	–	44±0.9	325.8±0.5
26.1	500±10	0.91±0.01	(6±3)	124±2	1±0.5	59±1.2	327.2±0.5
22.1	485±10	1.00±0.01	(7±2)	155±2	17±1	88±1.4	327.6±0.6
17.9	500±10	1.44±0.01	12±3	277±3	98±1.8	207±2.2	330.5±0.6
15.1	513±10	1.54±0.01	25±2	301±3	100±1.8	232±2.3	331.6±0.7
13.2	515±10	1.55±0.01	35±2	304±3	123±2	240±2.4	332.9±1.1
11.3	530±10	1.63±0.01	101±2	314±3.1	144±1.6	266±2.5	–
8.2	530±10	1.63±0.01	101±2	313±3.2	147±1.6	263±2.6	–
6.1	530±10	1.62±0.01	106±2	314±3	148±1.5	270±2.5	–
6.1	530±10	1.62±0.01	95±2	314±3.1	148±1.6	272±2.7	–
4.7	530±10	1.64±0.01	111±2	313±3.1	146±1.6	267±2.7	–
2.9	540±10	1.69±0.01	150±2	313±3.1	166±1.7	286±2.9	–

*) collected during float

silver wool stopper used in inlet line for ozone removal

Table 10a: FKW Flight No. 7901, continued

Altitude (km)	C_2H_6 ppb	C_3H_8 ppt	C_2H_2 ppt	CH_3Cl ppt
31.7	0.01	-	-	20
28.9	0.003	-	70	80
26.1	0.008	-	30	50
22.1	0.095	-	100	200
17.9	0.023	10	180	400
15.1	0.35	30	150	380
13.2	0.33	40	210	610
11.3	1.0	160	220	-
8.2	2.0	180	200	690
6.1	1.3	150	300	630
6.1	1.3	130	280	640
4.7	1.9	230	330	700
2.9	1.8	240	600	630

Table 11: FKW Flight No: 7902

Location: GAP TALLARD 44°N; 0°W

Tropopause heigt: 11.9 km

Date : 6/28/79

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ	CO_2 ppm±σ
25.7***)	(600±10)	(0.93±0.02)	(33±2)	(130±2.6)	(3 ±0.9)	(67 ±1.3)	(326.7±0.6)
32.8*)	(500±10)	(0.64±0.02)	(39±2)	(42±1.4)	(1.3±0.2)	(12.4±0.3)	(326.6±0.5)
30.8	510±10	0.80±0.01	(18±2)	80±2	0.5±0.5	28±0.6	324.9±0.5
27.9	420±10	0.91±0.01	-	123±2	0.7±0.5	56±0.8	326.3±0.4
22.9	490±10	0.97±0.01	(16±2)	153±2.6	13±0.4	85±1.3	326.2±0.6
19.9+)	550±10	1.31±0.02	11±2	244±3.7	-	170±2.6	328.6±0.5
16.6	530±10	1.38±0.01	21±2	269±4	92±1.4	200±3	330.7±0.5

(silver wool in inlet line) see table 10

*) collected during float

***) collected during ascent

+) contamination possible (sample pressure below 1 bar)

Table 11a: FKW Flight No: 7902, continued

Altitude (km)	C_2H_6 ppb	C_2H_2 ppt	CH_3Cl ppt
25.7***)	(0.016)	(55)	(80)
32.8*)	—	—	(20)
30.8	0.018	—	40
27.9	0.007	30	25
22.9	0.025	60	65
19.9+)	(0.08)	(180)	(320)
16.6	0.15	180	350

*) collected during float

***) collected during ascent

+) contamination possible (sample pressure below 1 bar)

Table 12: FKW Flight No: 7903
Location: Aire s/l Adour 44°N; 0°W Tropopause height: 9 km
Date : 11/9/79

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ	CO_2 ppm±σ
11.2-11.4***)	(510±10)	(1.60±0.04)	(34±2)	(307±3.1)	(50.2±5)	(258±2.6)	(323.0±1.6)
15.9-16.3***)	(520±10)	(1.52±0.03)	(27±)	(299±3)	(121 ±1.8)	(226±16)	(332.4±0.6)
19.8-20.8***)	(560±10)	(1.22±0.04)	(16±2)	(226±5)	(64.4±1.3)	(156±4)	(324.1±1.5)
23.0-25.6***)	(560±10)	(0.93±0.03)	(16±2)	(139±2)	(6.4±0.3)	(74±1)	(326.0±0.6)
26.6-28.2***)	(560±10)	(0.85±0.04)	(40±3)	(104±2)	(2.1±0.2)	(42±2)	(324.8±0.6)
30.4-33.0***)	(570±10)	(0.51±0.02)	(29±2)	(28±1)	–	(5.3±1)	(326.4±0.6)
33.0*)	(1260±20)	(0.40±0.01)	(29±2)	(12±0.6)	–	(1.4±1)	(326.7±1.0)
33.0*)	(420±10)	(0.40±0.01)	(28±2)	(12±0.6)	–	(5.3)	(324.3±0.5)

*) collected during float
***) collected during ascent
balloon gas was H_2
copper wool in inlet line

Table 13: NCAR Flight No: 19

Location: Yorkton 51°N; 102°28'W Tropopause height: 10.4/15.5 km

Date : 8/10/76

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ	CO_2 ppm±σ
38.9-39.8	400±20	0.38±0.01	(63±2)	5±0.5	<0.5	1.5±0.5	323±2
38.1-38.9	380±20	0.43±0.01	(73±2)	8±0.4	(80±1.5)	(6.8±1)	320±2
34.7-35.4	410±20	0.54±0.02	(55±2)	19±0.4	0.5±0.5	2.4±0.3	320±2
33.5-34.0	490±20	0.57±0.02	(43±2)	24±0.5	0.6±0.5	5.0±1	318±2
32.2-32.6	450±20	0.66±0.02	(35±2)	33±0.7	<0.5	7.2±0.4	325±2
32.6	520±20	0.67±0.02	(46±2)	38±0.8	0.5±0.5	8.5±1	317±2

Table 14: NCAR Flight No: 20

Location: Yorkton 52°N; 102°W Tropopause height: ∿10.5 km

Date : 8/14/77

Altitude (km)	H_2 ppb±σ	CH_4 ppm±σ	CO ppb±σ	N_2O ppb±σ	$CFCl_3$ ppt±σ	CF_2Cl_2 ppt±σ
39.2-39.3*)	–	(0.40±0.01)	(145±2)	(5±0.5)	(11.5±0.5)	(24.7±1)
34.1-34.8	(670±10)	0.50±0.01	(186±2)	24±0.5	–	3±0.5
30.5-31.7	(610±10)	0.65±0.01	(160±2)	38±1	–	19±1
26.4-27.6	(720±10)	0.94±0.01	(61±2)	123±2	–	38±1
24.6-25.4	(570±10)	0.85±0.01	(70±2)	120±2	2.3±0.5	49±1
22.2-23.0	(610±10)	1.02±0.01	(57±2)	145±3	9.7±0.5	67±1
21.2	(760±10)	1.02±0.01	(66±2)	186±3	15.0±0.5	82±2

*) collected during float

CO and H_2 possibly contaminated during sample storage

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