

Observation of large scale air pollution and its long-range transport using the European passenger aircraft system (CARIBIC)

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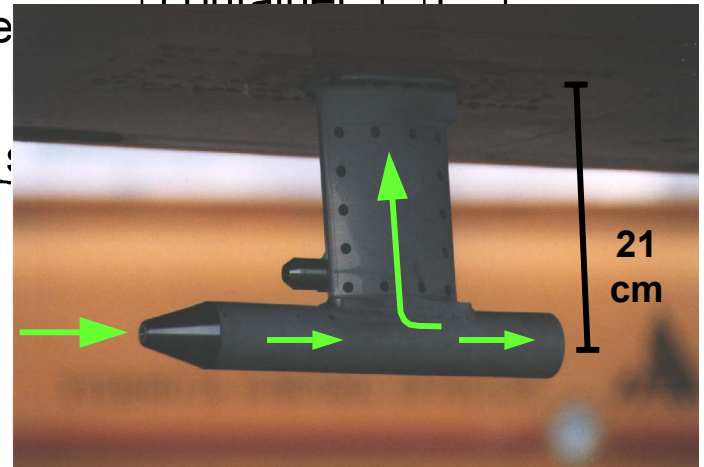
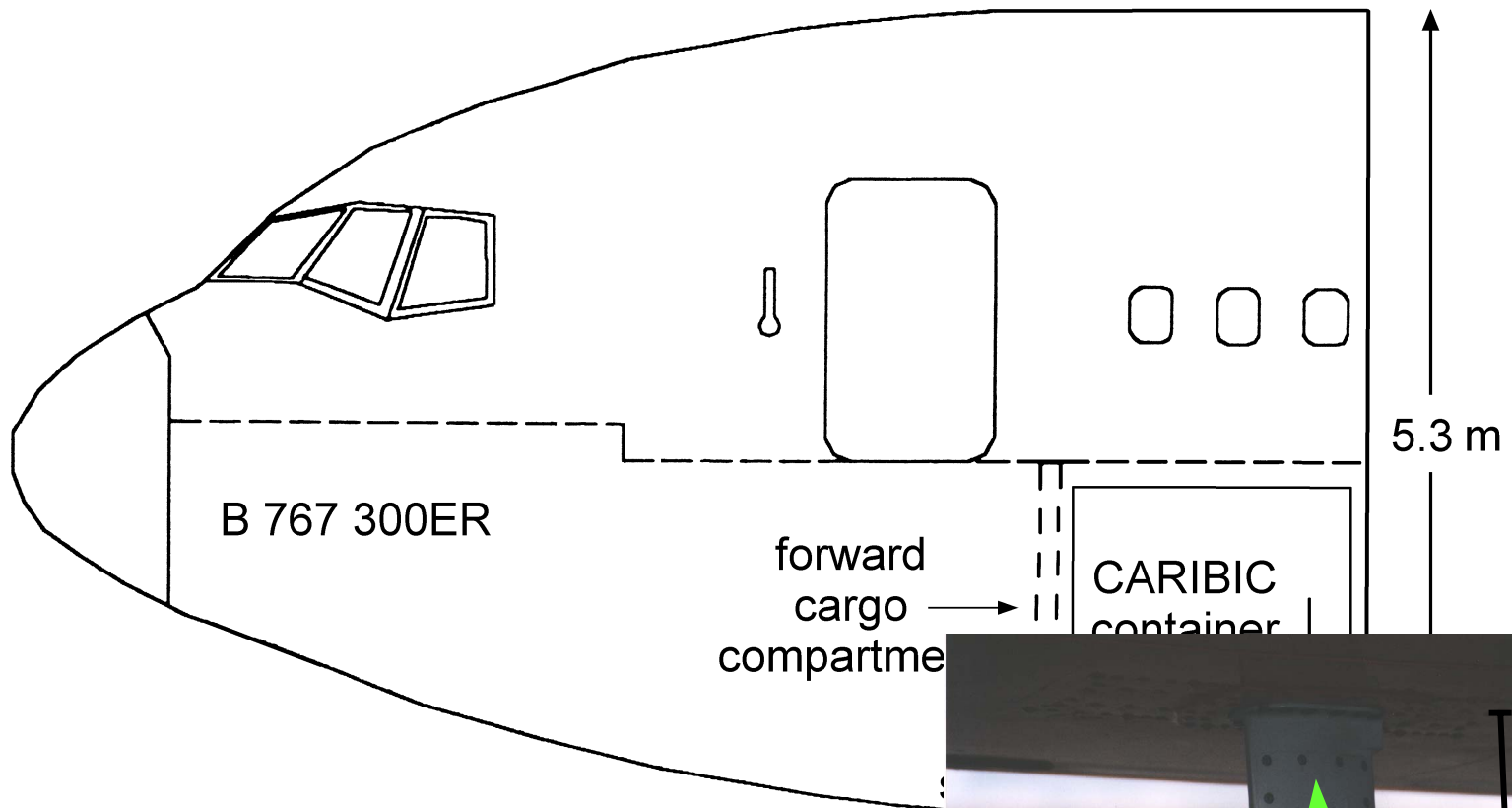
Bengt Martinsson and Giorgos Papaspiropoulos, U. Lund

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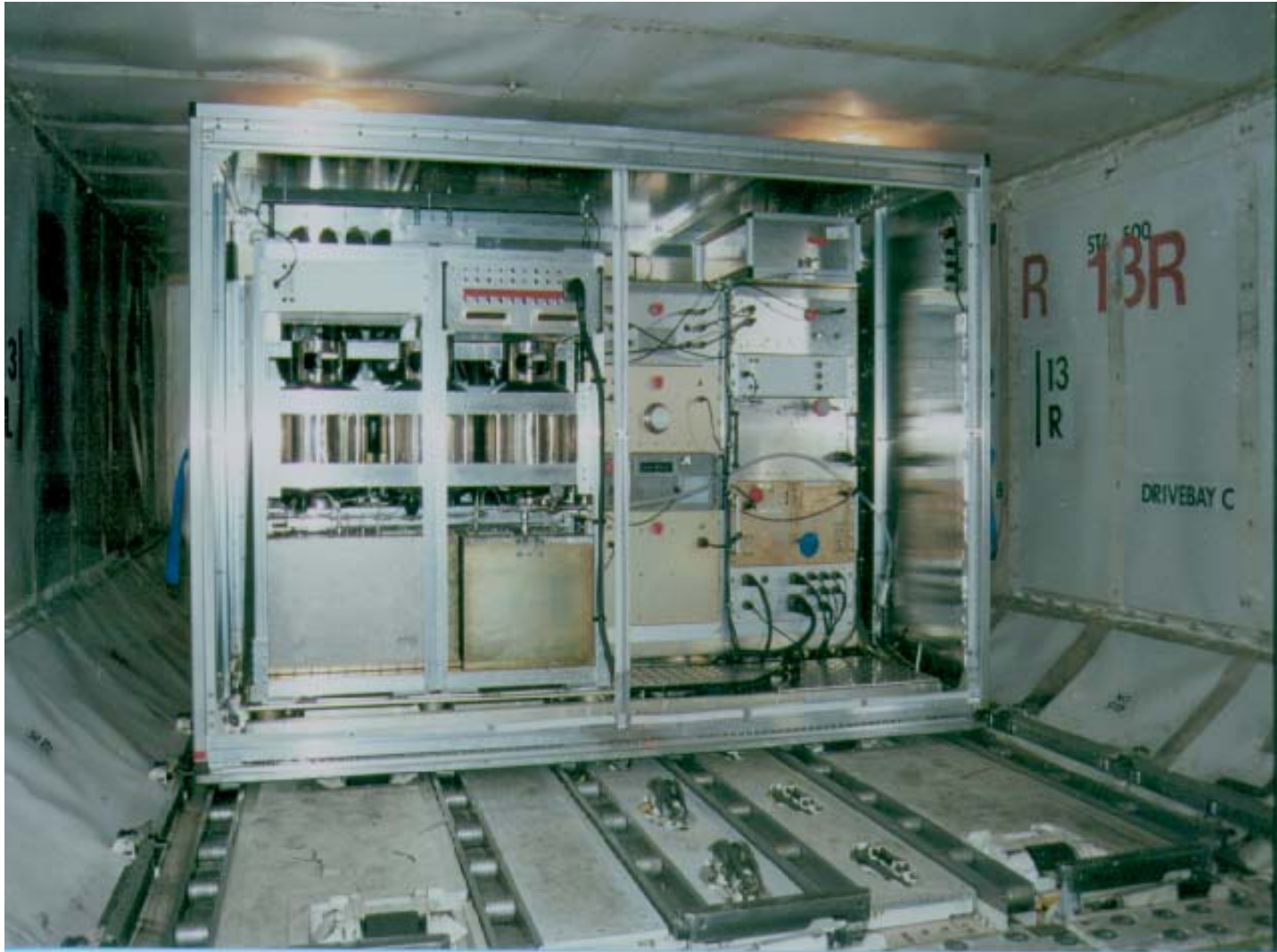


CARIBIC Aircraft





CARIBIC Container



CARIBIC: Currently Measured Species

A. In situ monitoring: O_3 , CO, H_2O , NO, NO_y , and aerosol concentration

B. Aerosol samples (14):

Aerosol elemental composition Si, S, K, Ca, Ti, Mn, Fe, Ni, Cu, Zn, ...

C. Air samples (12, extended to 30 samples, no isotopes) :

Greenhouse gases CO_2 , CH_4 , N_2O , SF_6

Stable isotopes and Carbon-14 CO: ^{13}C , ^{18}O , ^{14}CO , CO_2 : ^{13}C , ^{18}O

NMHCs: ethane, ethene, propane, propene, iso-butane, butane, acetylene, trans-2-butene, 1-butene, cis-2-butene, 2-methylbutane, pentane, propine, 1,3-butadiene, trans-2-pentene, cis-2-pentene, cyclohexane, 2-methylpentane, 3-methylpentane, hexane, isoprene

Halogenated compounds:

CFCs -11, -12, -13, -113, -114, -114a, -115,

HCFCs -21, -22, -141b, -142b, -123, -124,

HFCs -23, -134a, -143a, -152a, -125,

Halons -1202, -1211, -1301, -2402,

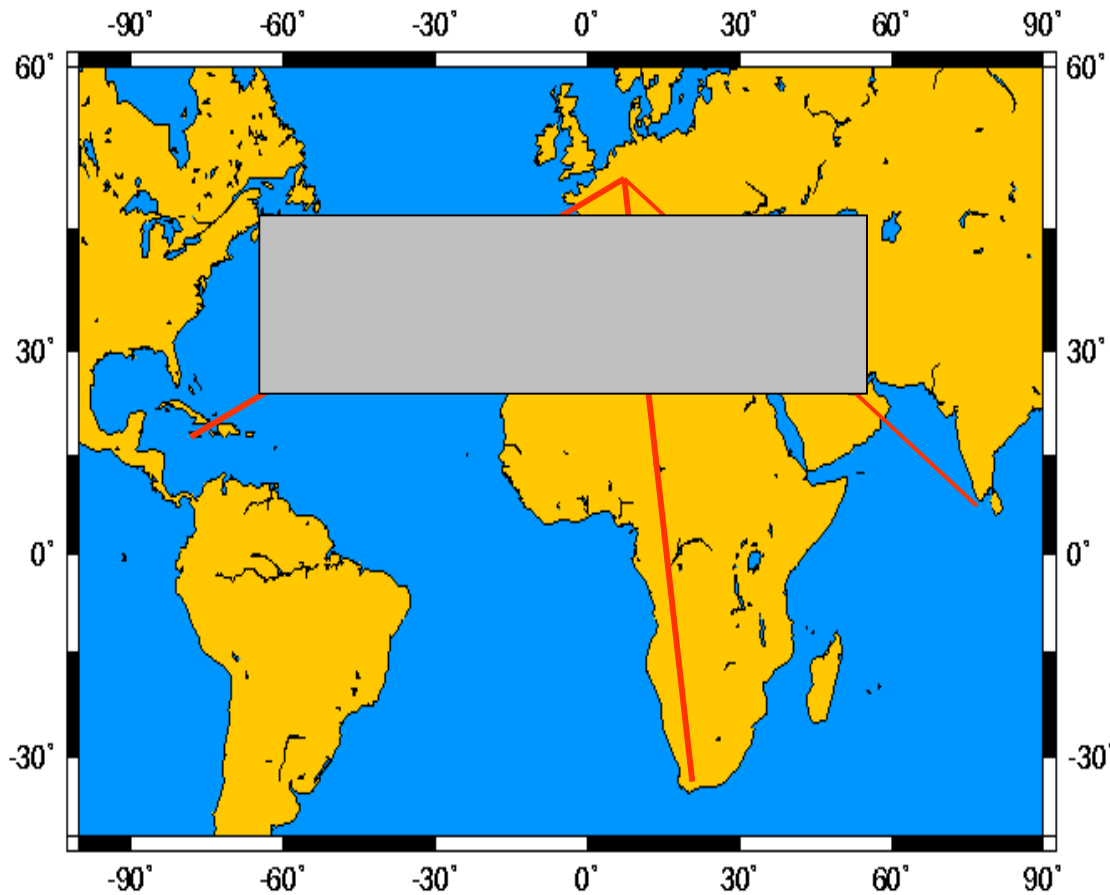
CH_3Br , $CHBr_3$, CH_2Br_2 , CH_2BrCl , $CHBrCl_2$, $CHBr_2Cl$, COS

C_2H_5Br , $C_2H_4Br_2$, CH_3Cl , CH_2Cl_2 , $CHCl_3$, C_2Cl_4 , CH_3CCl_3 ,

CF_4 , CCl_4 , C_2F_6 , C_3F_8 , c- C_4F_8 , CH_3I , C_2H_5I , CH_2ClI , CH_3CN , CH_3ONO_2 , $C_2H_5ONO_2$

CARIBIC flights

LTU Boeing 767



Flight Routes

- a. Maldives, Sri Lanka
- b. South Africa, Namibia
- c. Cuba, Dominican Republic, Margerita

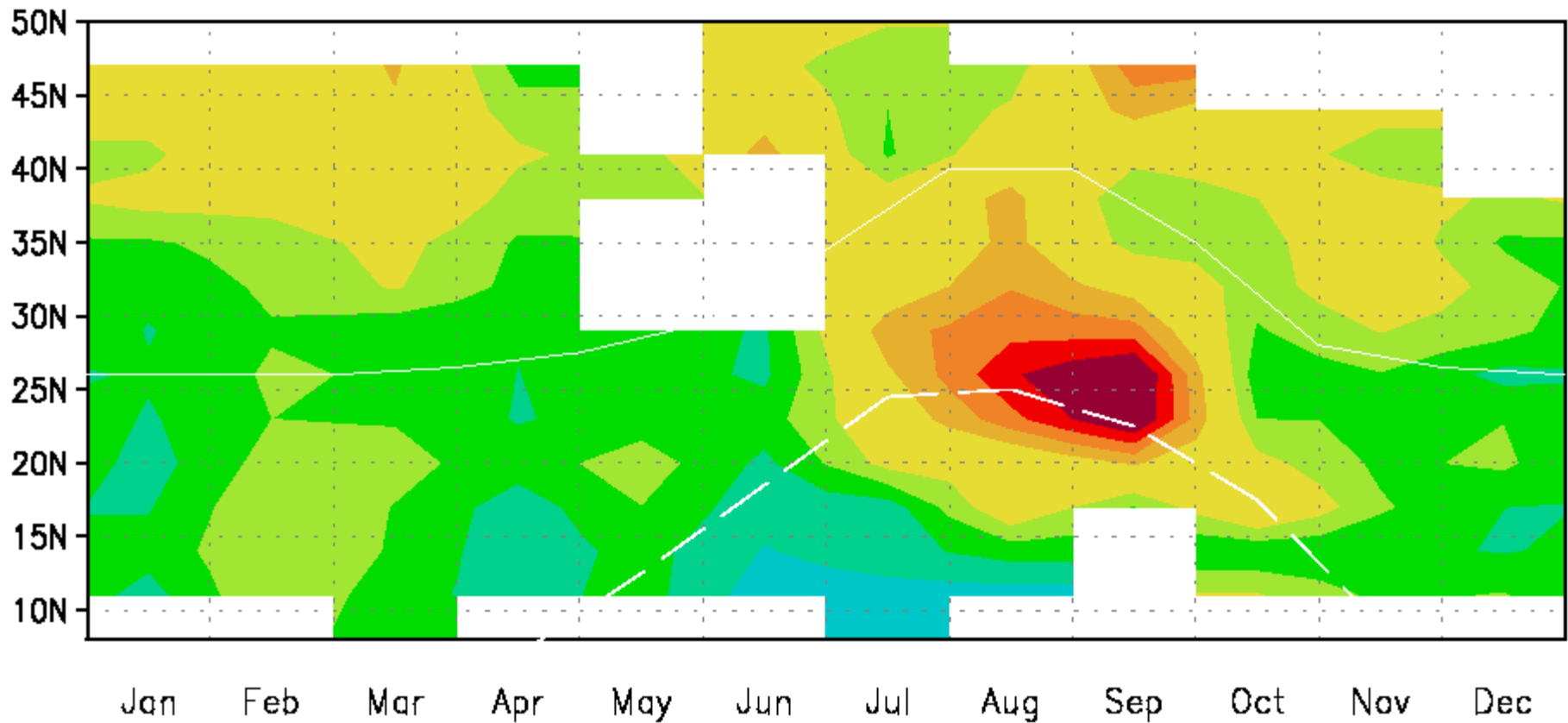
Air Masses

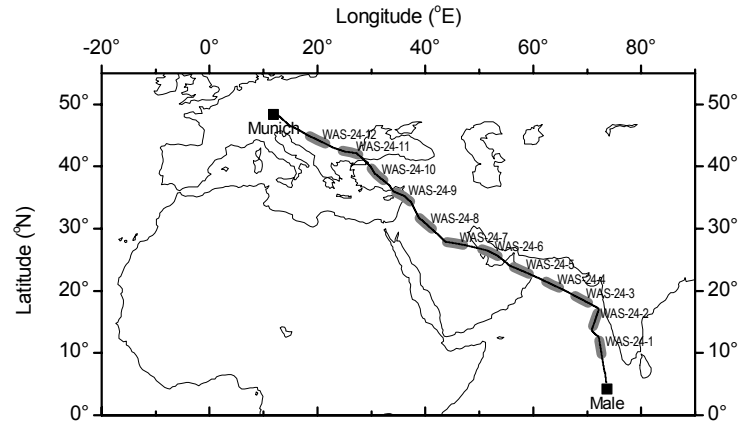
tropospheric air: ~83 %

stratospheric air: ~17 %

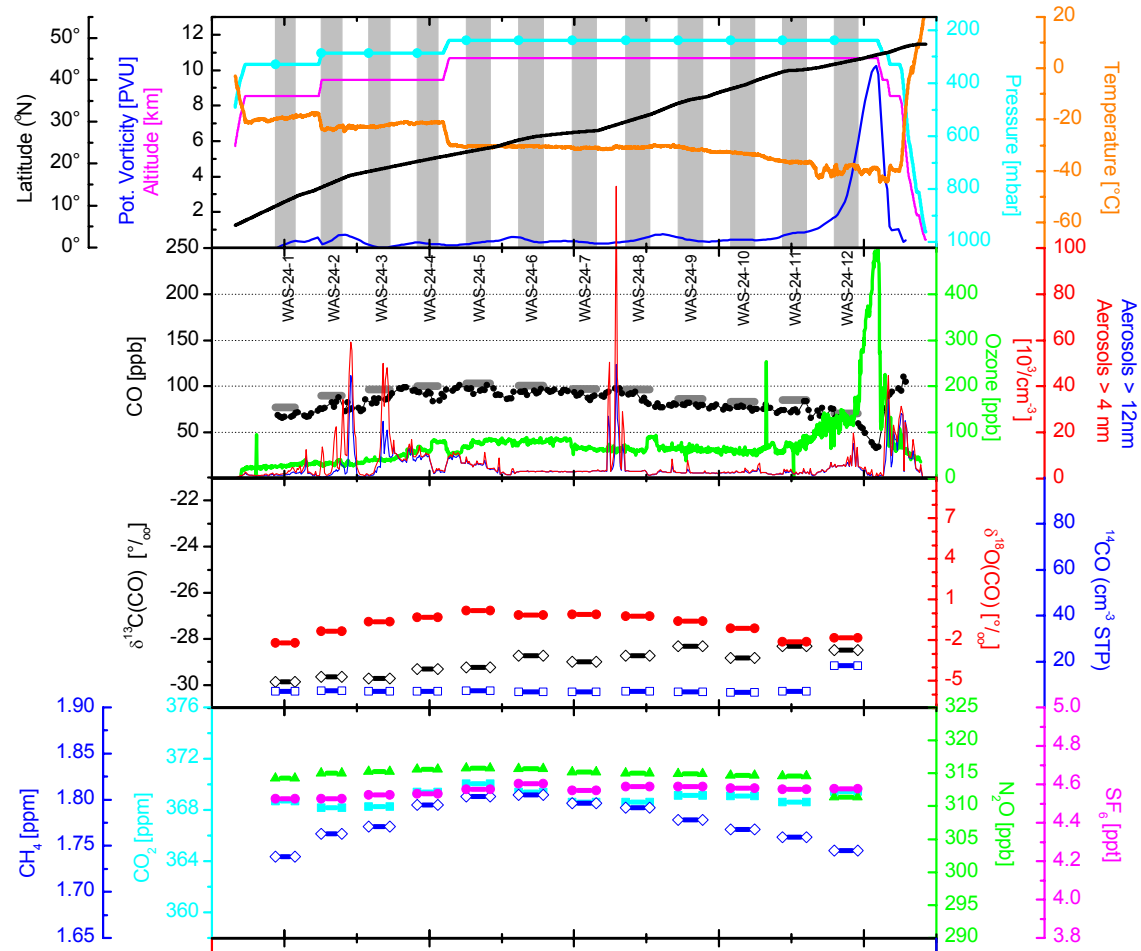
Tropospheric CH₄ (ppbv), CARIBIC, Germany – Indian Ocean, Nov 1997 to Apr 2001

1730 1740 1750 1760 1770 1780 1790 1800 1810 1820

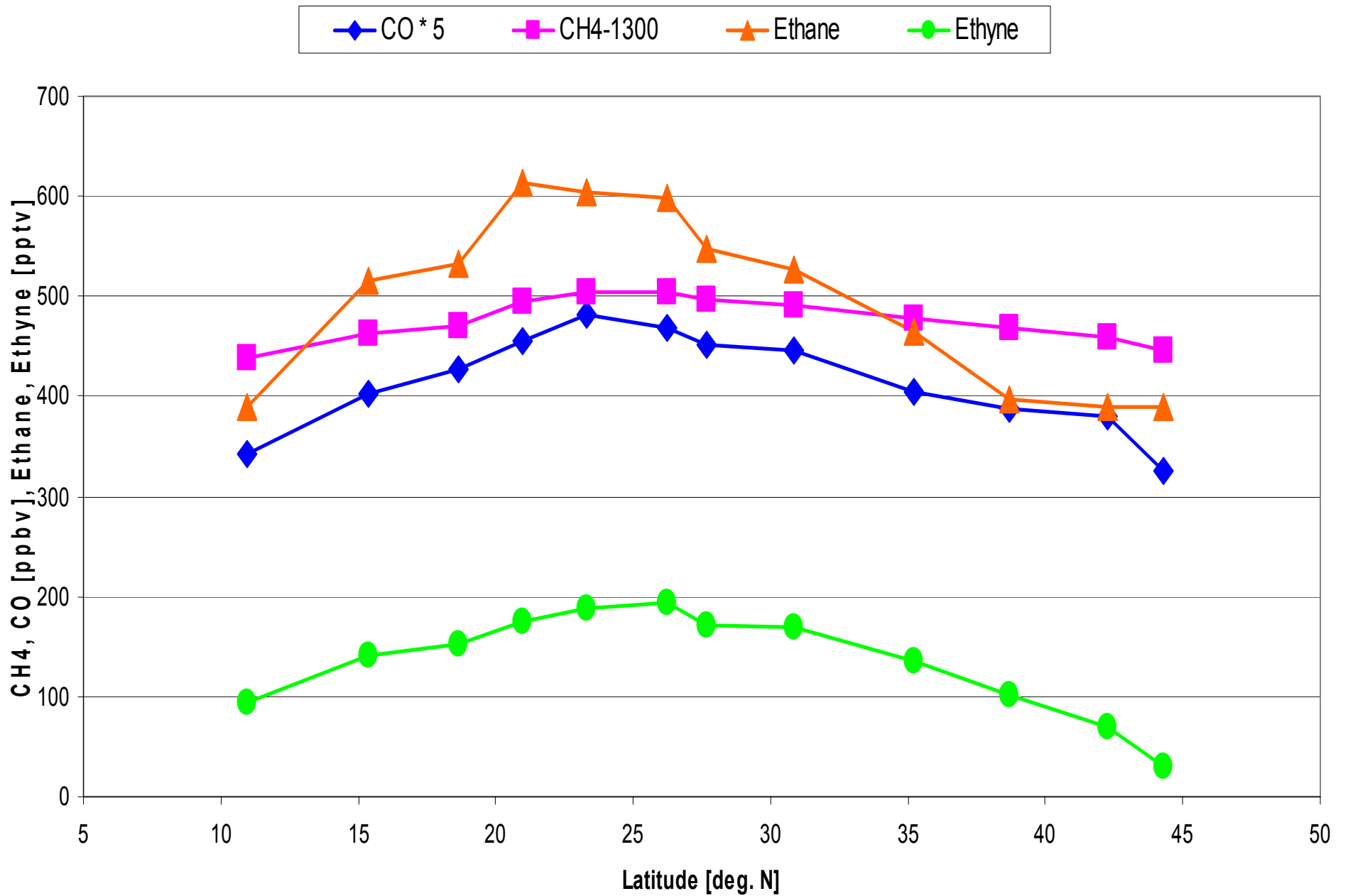




CARIBIC Flight Male --> Munich, 12 July 2000



Flight 24: Male - Munich, July 12, 2000

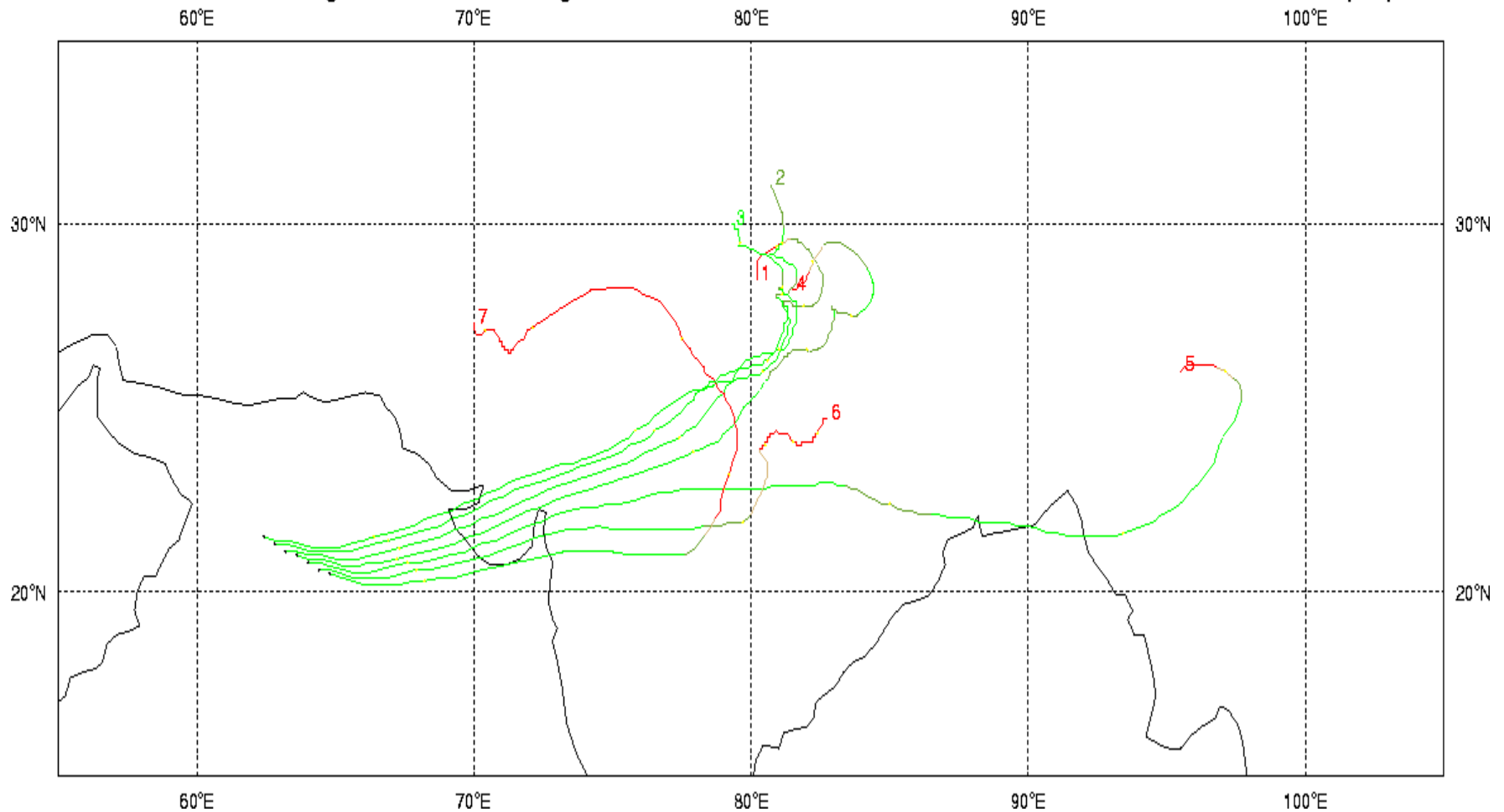


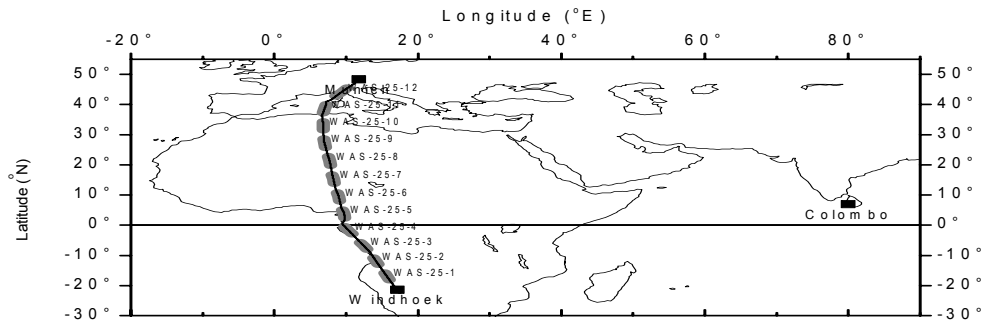
KNMI/ECMWF trajectories: 7 from:120700_B_04

begindate: FRIDAY 7 JULY 2000 15 GMT

last enddate: WEDNESDAY 12 JULY 2000 9 GMT

dark blue<=200hPa<light blue<=250hPa<green<=300hPa<olive<=400hPa<brown<=500hPa<red<=850hPa<purple





CARIBIC Flight Windhoek --> Munich, 28 July 2000

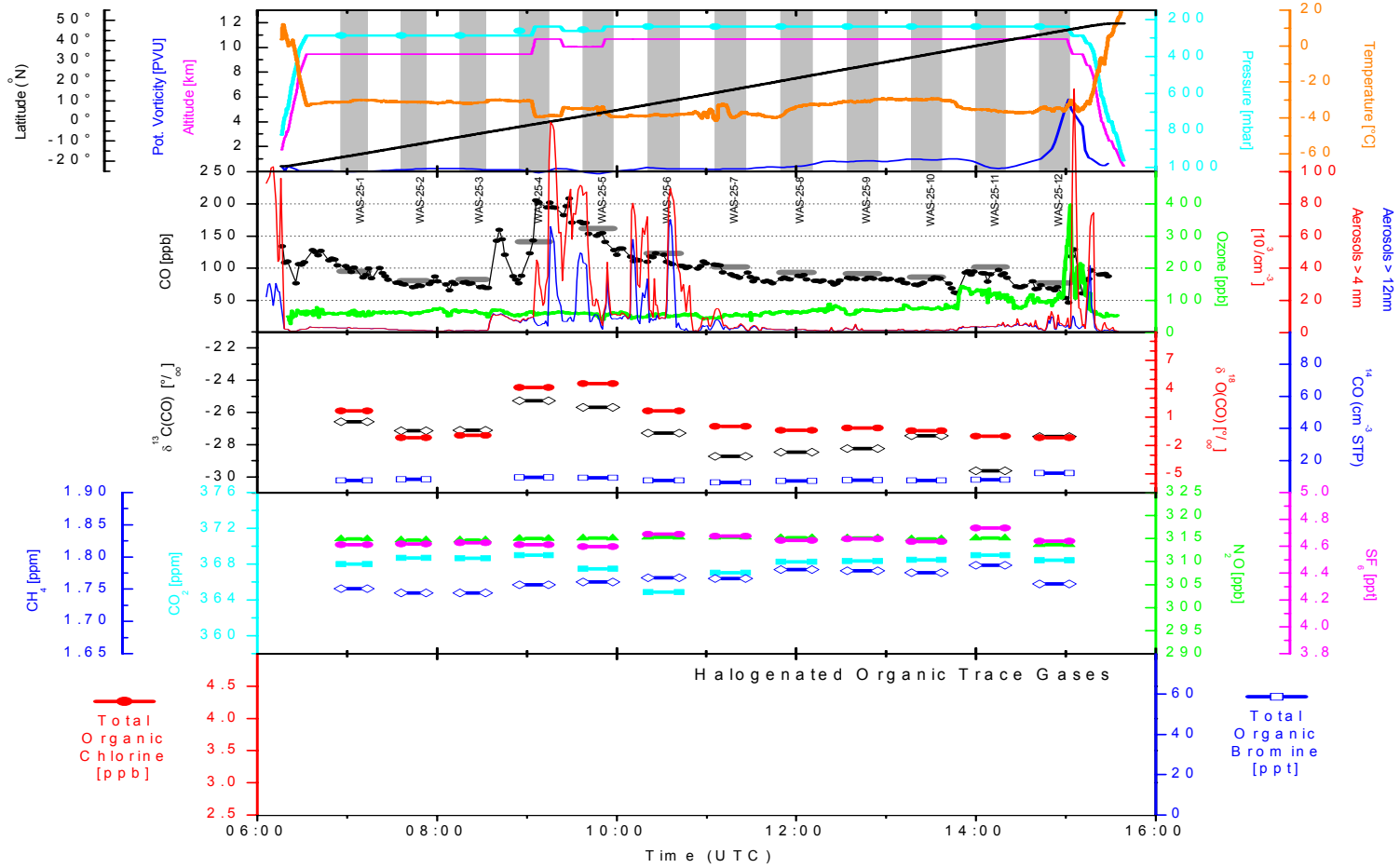


Table 1: Comparison of CO enhancement ratios of samples 4 - 6 with previous results reported for fresh plumes of biomass burning.

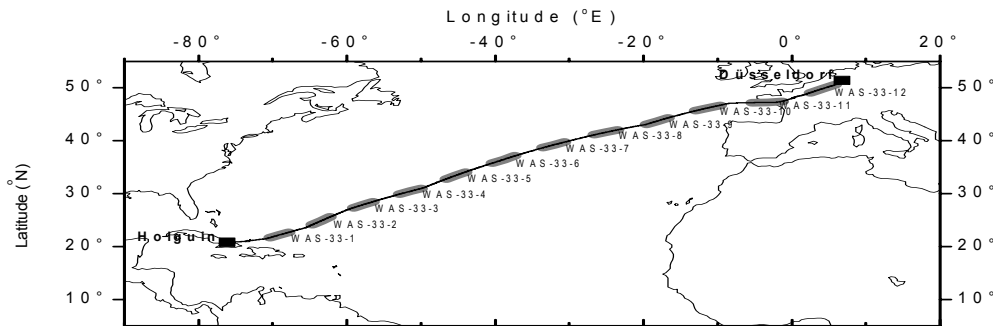
Species	Background ^{a)}		ER ($\Delta X/\Delta CO$) ^{b)}				
	SH (Samples 2, 3)	NH (Samples 7,8,9)	Sample 4 (SH)	Sample 5 (SH)	Sample 6 (NH)	Literature ^{d)}	Literature ^{e) f) g)}
CO	75 ± 1	89 ± 5					
CH ₄	1744.3 ± 0.1	- ^{c)}	0.159 ± 0.016	0.227 ± 0.035	- ^{c)}	0.16 - 0.37	0.08 ^{d)} - 0.12 ^{e) f)}
C ₂ H ₆	427 ± 14	465 ± 15	3.4 ± 0.2	5.1 ± 0.3	5.1 ± 1.3	4 - 9	4.5 ^{d) e)} - 8.9 ^{f)}
C ₃ H ₈	32 ± 3	52 ± 2	0.68 ± 0.05	1.58 ± 0.08	0.78 ± 0.20	0.9 - 2.4	0.9 ^{d) e)} - 1.7 ^{f)}
C ₄ H ₁₀	4.6 ± 1.4	7.9 ± 1.0	0.07 ± 0.03	0.43 ± 0.04	0.1 ± 0.1	0.1 - 0.4	0.15 ^{d)} - 0.23 ^{e) f)}
iC ₄ H ₁₀	1.3 ± 0.7	2.9 ± 0.2	0.04 ± 0.01	0.24 ± 0.02	0.09 ± 0.03	-	0.04 ^{d)} - 0.07 ^{e) f)}
C ₂ H ₂	101 ± 5	113 ± 13	3.9 ± 0.2	3.6 ± 0.3	2.9 ± 0.9	1 - 10	2.0 ^{e)} - 4.8 ^{d) f)}
C ₆ H ₆	36 ± 3	45 ± 5	0.9 ± 0.1	1.0 ± 0.1	1.3 ± 0.4	0.8 - 1.5	1.3 ^{d)} - 1.7 ^{e) f)}
CH ₃ Br	10.3 ± 0.3	10.5 ± 0.2	(6 ± 5)·10 ⁻³	(10 ± 5)·10 ⁻³	(67 ± 19)·10 ⁻³	-	(5.5 - 10.3)·10 ^{-3 d) e) f)}
CH ₃ Cl	584 ± 13	594 ± 18	0.2 ± 0.2	0.3 ± 0.2	0.2 ± 0.8	0.7 - 1.1	0.12 - 0.57 ^{d) e) f)}
CH ₃ I	0.12 ± 0.02	0.12 ± 0.02	(6 ± 1)·10 ⁻³	(7 ± 1)·10 ⁻³	(11 ± 3)·10 ⁻³	-	(1.2 - 14)·10 ^{-3 d) e) f)}

a) Units are ppbv for CO and CH₄ and pptv for all other compounds

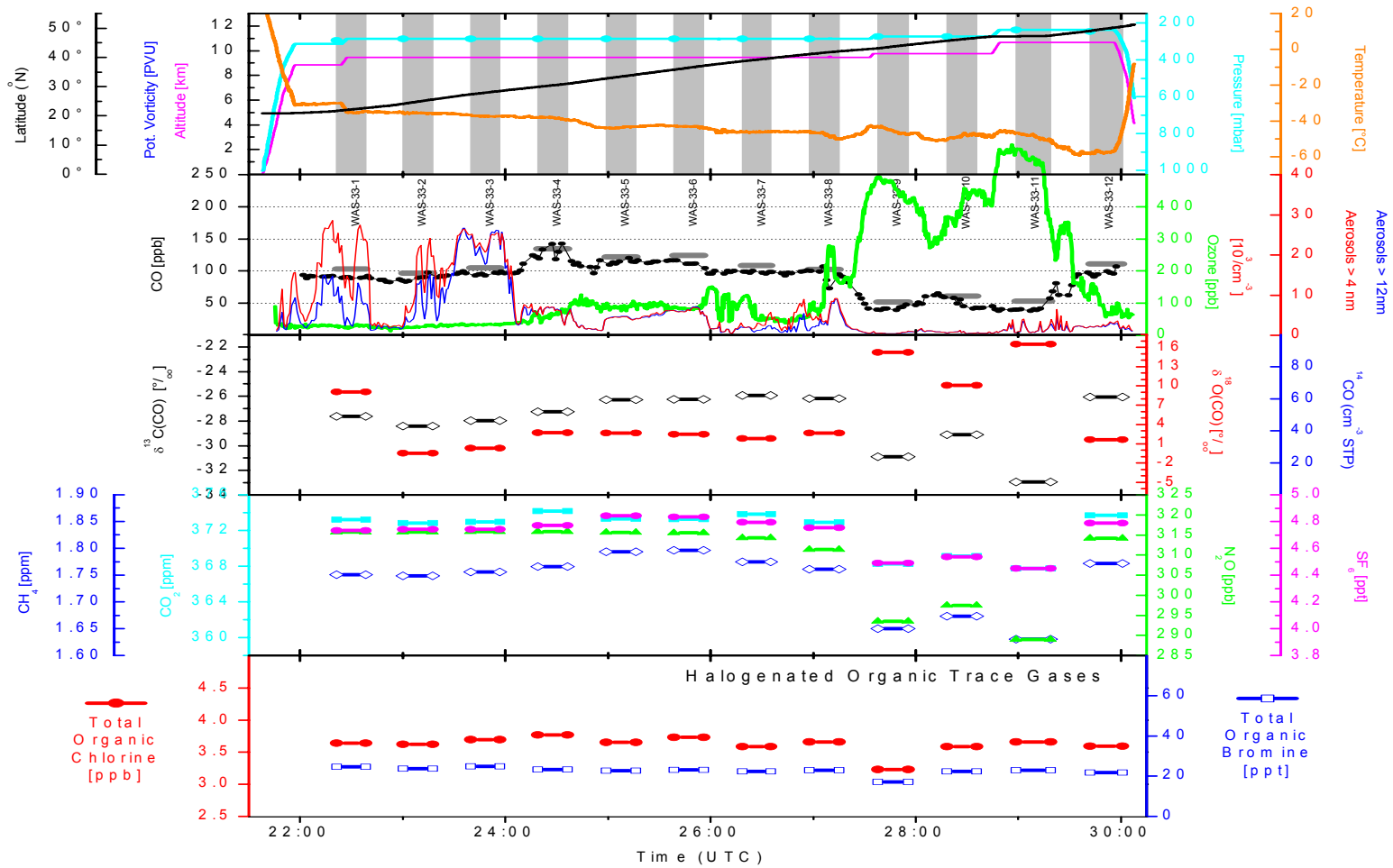
b) Units are ppbv/ppbv for $\Delta CH_4/\Delta CO$ and pptv/ppbv for all other ratios.

c) No background value could be defined for CH₄ in the NH.

d) Mauzerall *et al.* [1998] and Andreae *et al.* [2001] and references therein) e) Blake *et al.* [1996b] f) Ferek *et al.* [1998] g) Blake *et al.* [1997]



CARIBIC Flight Holguin --> Düsseldorf, 14 May 2001

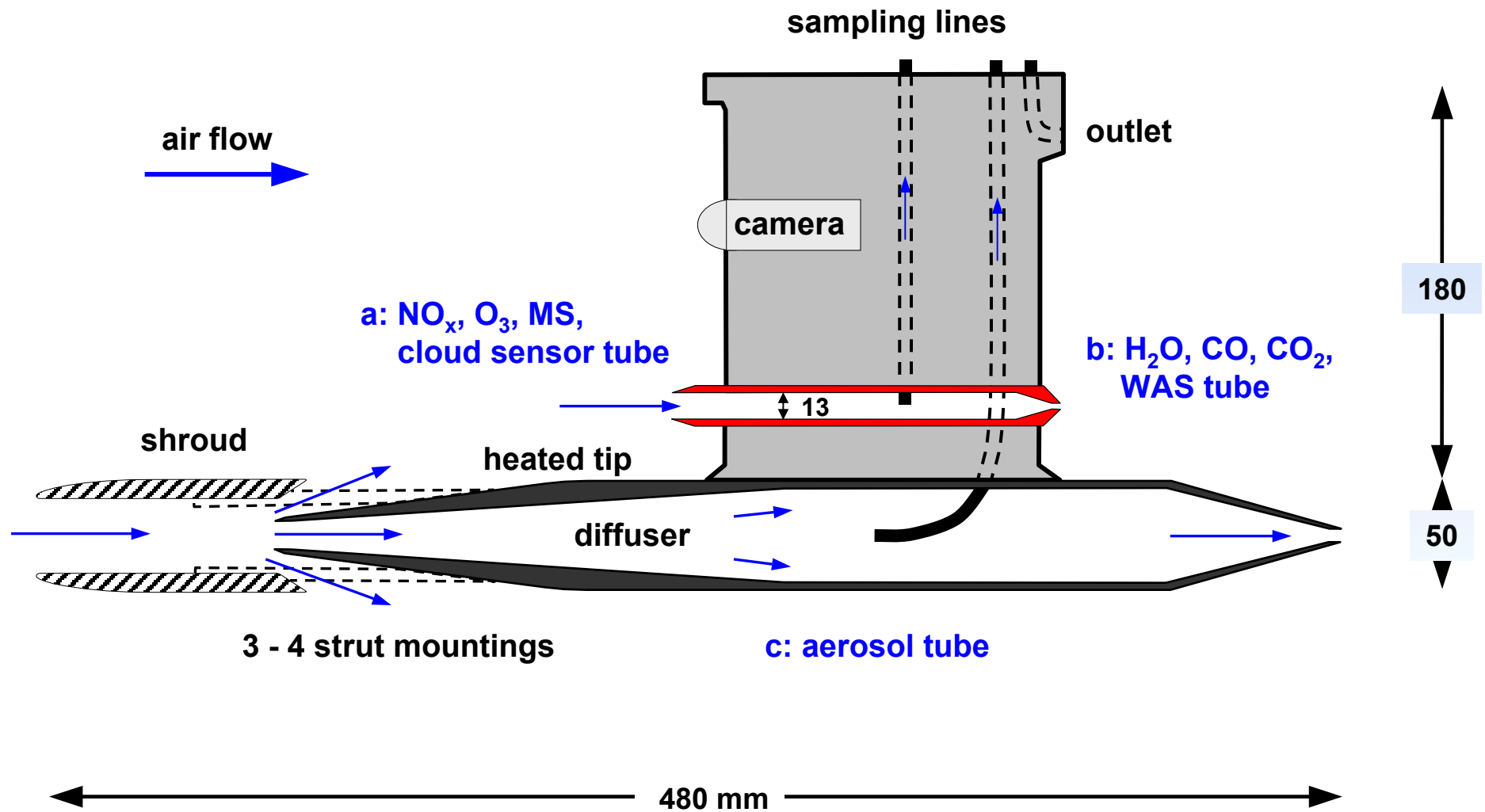




**From Frankfurt: the new LUFTHANSA
Airbus A340-600 Aircraft**



CARIBIC inlet system: Inlet side view



CARIBIC partners

MPI-Chemistry:	coordination, container operation, CO and H₂O continuously, trace gas, isotope, and NMHC analysis of air samples
IMK, Karlsruhe:	O₃, selected organic compounds continuously by PTR-MS
IFT, Leipzig:	aerosols by 3 CNCs and optical particle counter
DLR, Oberpfaffenhofen:	NO and NO_y continuously
GKSS, Geesthacht:	Hg semicontinuously
CEA/CNRS, Paris:	CO₂ continuously
UEA, Norwich:	halocarbon analysis of air samples
U. Lund:	analysis of aerosols for elements and organic compounds
KNMI, de Bilt:	meteorological analysis and trajectories