Advanced Whole Air Sampler (AWAS) on the C-130 during FRAPPE

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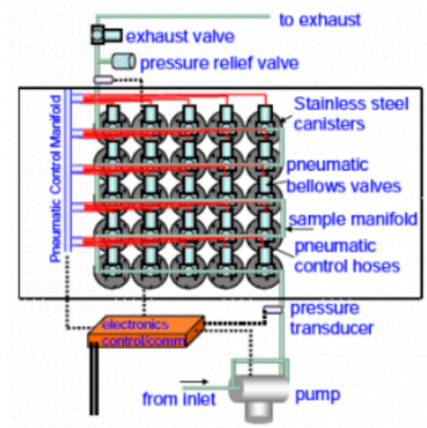
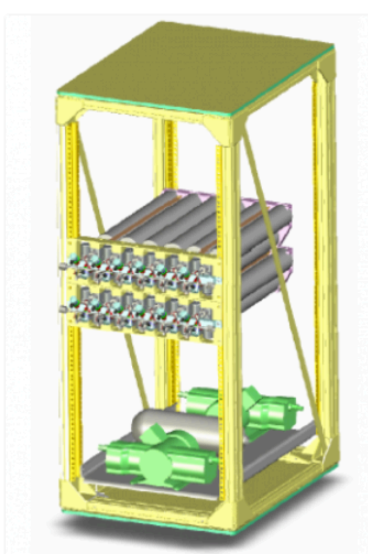
General Description:

During FRAPPE the Advanced Whole Air Sampler (AWAS) is set up to collect gas samples in canisters. The samples are then sent for subsequent analysis by Gas Chromatography for a large suite of hydrocarbons at the University of California – Irvine (UCI) and for stable isotope analysis of methane at the University of Cincinnati (UC).

Samples are collected through an inlet located in the underside of the C-130. The air is pumped through a metal bellows pump through a manifold. On the command of an operator, air-actuated valves fill each canister. Up to 5 banks of 12 previously evacuated metal canisters (60 samples) are collected during each flight.



Basic components of the whole air sampler



Whole air sample modules and pump/pneumatic plate in standard HIAPER rack.

Location of electronics control box TBD.

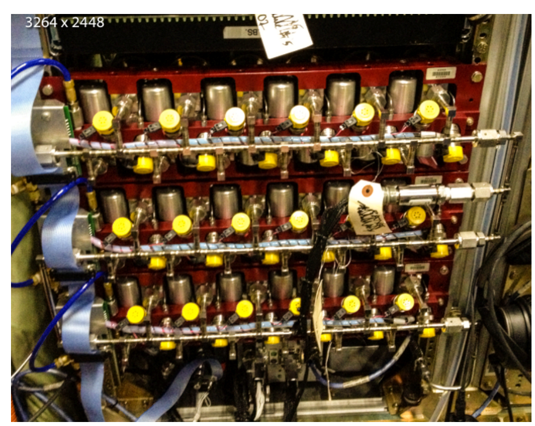


Photo of the front of the AWAS rack installed for FRAPPE

Whole Air Sample Analysis

The overall goal of the AWAS sampling is to conclusively establish sources of hydrocarbons that cause air pollution. Our laboratory analyses will help determine the relative proportion of different human activities to air pollution in the Denver area, including agriculture (cattle feedlots), industrial activities (oil refining, electricity generation, landfills, and wastewater treatment), urban emissions (cars and trucks), and oil and gas mining (including hydraulic fracturing or “fracking”).

UC - Irvine

Once the samples get to UC-Irvine more than 70 trace gases will be identified and quantified at our laboratory, including C_2-C_{10} NMHCs, C_1-C_2 halocarbons, C_1-C_5 alkyl nitrates, and selected sulfur compounds (Table 1). This will be achieved using our established technique of airborne whole air sampling followed by laboratory analysis using gas chromatography (GC) with flame ionization detection (FID), electron capture detection (ECD), and mass spectrometric detection (MSD). Our experimental procedures are built on those that have been successfully employed for numerous prior field missions (e.g., *Blake et a*l., 1999, 2001, 2003a, 2003b, 2003c, 2004, 2008; *Colman et al.,* 2001; *Simpson et al.,* 2001, 2003, 2010, 2011; *Barletta et al*., 2009).

University of Cincinnati

Canisters from the aircraft are also subsampled to measure the carbon and hydrogen isotopic composition of methane (*Townsend-Small et al*., 2012). This method takes advantage of naturally occurring differences in atomic weight of carbon and hydrogen atoms. Sources like fossil fuels and cars have a high proportion of the heavier carbon and hydrogen atoms, while cows and landfills emit methane with more of the lighter atoms. We can compare polluted air sampled in the airplane with measurements of all of the different sources sampled on the ground in our field vehicle.

Table 1. Compounds to be measured and archived by UC-Irvine during FRAPPE.

Compound	Formula	Lifetime	LOD (pptv)	Precision (%)	Accuracy (%)
Hydrocarbons					
Ethane	C2H6	47 d	3	1	5
Ethene	C2H4	1.4 d	3	3	5
Ethyne	C2H2	12-17 d	3	3	5
Propane	C3H8	11 d	3	2	5
Propene	C3H6	11 hr	3	3	5
Propyne	C3H4	2 d	5	30	20
n-Butane	C4H10	4.9 d	3	3	5
i-Butane	C4H10	5.5 d	3	3	5
1-Butene	C4H8	8.8 hr	3	3	5
i-Butene	C4H8	5.4 hr	3	3	5
cis-2-Butene	C4H8	4.9 hr	3	3	5
trans-2-Butene	C4H8	4.3 hr	3	3	5
1,3-Butadiene	C4H6	4.2 hr	3	3	5
n-Pentane	C5H12	5 d	3	3	5
i-Pentane	C5H12	5 d	3	3	5
Isoprene	C5H8	2.8 hr	3	3	5
2-Methylpentane	C6H14	2-3 d	3	3	5
3-Methylpentane	C6H14	2-3 d	3	3	5
Benzene	C6H6	9.5 d	3	3	5
Toluene	C7H8	2.1 d	3	3	5
m+p-Xylene	C8H10	12-19 hr	3	3	5
o-Xylene	C8H10	20 hr	3	3	5
Ethylbenzene	C8H10	1.7 d	3	3	5
2-Ethyltoluene	C9H12	23 hr	3	3	5
3-Ethyltoluene	C9H12	15 hr	3	3	5
4-Ethyltoluene	C9H12	24 hr	3	3	5
1,2,3-Trimethylbenzene	C9H12	8.5 hr	3	3	5
1,2,4-Trimethylbenzene	C9H12	8.5 hr	3	3	5
1,3,5-Trimethylbenzene	C9H12	4.9 hr	3	3	5
α-Pinene	C10H16	5.3 hr	3	3	5
β-Pinene	C10H16	3.7 hr	3	3	5
Alkyl Nitrates					
Methyl nitrate	CH3ONO2	1 mo	0.02	5	10
Ethyl nitrate	C2H5ONO2	2-4 wk	0.02	5	10
1-Propyl nitrate	C3H7ONO2	1-2 wk	0.02	5	10
2-Propyl nitrate	C3H7ONO2	1-3 wk	0.02	5	10
2-Butyl nitrate	C4H9ONO2	1-2 wk	0.02	5	10
2-Pentyl nitrate	C5H11ONO2	4-5 d	0.02	5	10
3-Pentyl nitrate	C5H11ONO2	4-5 d	0.02	5	10

Table 1 continued. Compounds to be measured and archived by UC-Irvine during FRAPPE.

Compound	Formula	Lifetime	LOD (pptv)	Precision (%)	Accuracy (%)
Halocarbons					
CFC-11	$CFCl_3$	45 yr	10	1	3
CFC-12	CF_2Cl_2	100 yr	10	1	3
CFC-113	CCl_2FCClF_2	85 yr	5	1	3
CFC-114	$CClF_2CClF_2$	300 yr	1	1	10
Methyl chloroform	CH_3CCl_3	5.0 yr	0.1	1	5
Carbon tetrachloride	CCl_4	26 yr	1	1	5
Halon-1211	$CBrClF_2$	16 yr	0.1	1	5
Halon-2402	$CBrF_2CBrF_2$	20 yr	0.01	1	5
HCFC-22	CHF_2Cl	12 yr	2	2	5
HCF-134a	CH_2FCF_3	14 yr	1	3	10
HCFC-141b	CH_3CCl_2F	9.3 yr	0.5	3	10
HCFC-142b	CH_2CClF_2	18 yr	0.5	3	10
Methyl bromide	CH_3Br	0.7 yr	0.5	5	10
Methyl chloride	CH_3Cl	1.0 yr	50	5	10
Methyl iodide	CH3I	4 d	0.005	5	20
Dibromomethane	CH_2Br_2	3-4 mo	0.01	5	20
Dichloromethane	CH_2Cl_2	3-5 mo	1	5	10
Chloroform	$CHCl_3$	3-5 mo	0.1	5	10
Trichloroethene	C_2HCl_3	5 d	0.01	5	10
Tetrachloroethene	C_2Cl_4	2-3 mo	0.01	5	10
1,2-Dichloroethane	$C_2H_4Cl_2$	1-2 mo	0.1	5	10
Bromoform	$CHBr_3$	11 mo	0.01	10	20
Bromodichloromethane	$CHBrCl_2$	2-3 mo	0.01	10	50
Dibromochloromethane	$CHBr_2Cl$	2-3 mo	0.01	10	20
Bromochloromethane	CH_2BrCl	5 mo	0.01	10	20
Sulfur Compounds					
Carbonyl sulfide	OCS	2.5 yr	10	2	10
Dimethyl sulfide	CH_3SCH_3	1-2 d	1	10	20
Dimethyl disulfide	CH_3SSCH_3	1 hr	10	2	10
Carbon disulfide	CS_2	2-3 d	10	2	10

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