Trace Organic Gas Analyzer (TOGA) Instrument Description

A gas chromatograph/mass spectrometer (GC/MS) instrument will measure volatile organic (VOC) compounds including oxygenated VOCs, non-methane hydrocarbons (NMHCs) and halocarbons listed in Table 1.

Air samples are drawn into the introduction system, via ¼" fused-silica coated stainless steel tubing , where preconcentration occurs. A three-stage trapping sequence is used to prepare the sample prior to separation and detection. Helium carrier gas transfers the preconcentrated compounds to a custom-built, miniaturized gas chromatograph fitted with an HP-624 column. The VOC compounds of interest elute from the column and into the detector, a Hewlett-Packard 5973 mass spectrometer operating in the single ion monitoring mode. The GC/MS method provides unambiguous identification because the compounds are chromatographically separated and mass selected. The limit of detection is less than or equal to 20 pptv for all compounds measured with an uncertainty of ≤ ±20% for all compounds. LODs for specific compounds are listed in Table 2. Sampling frequency will be either 2.0 minutes or 2.5 minutes.

In-flight calibration and zeroing (system blanks) are necessary for quality MS-based VOC measurements. The calibration system consists of a custom-built compressor/zero air generator/dilution system. High-efficiency Teflon diaphragm pumps are used to draw in ambient air. The zero air generator scrubs the air it free of VOCs while maintaining ambient humidity. For calibration, standard alcohol/carbonyl mixtures are added to the scrubbed diluent gas stream. The system is capable of diluting the standard mixtures by factors of 100 to 10,000 and is very accurate because it contains only two, previously calibrated, flow controllers. The zeros and diluted standard samples enter the analytical system near the sampling inlet tip and follow a path identical to the ambient air samples through the analytical system. To help ensure the precision of our VOC measurements we also analyze one or two long-lived CFCs present in the atmosphere during each chromatographic run. By analyzing atmospherically stable compounds such as CFC-11, CFC-12, CFC-113 and carbon tetrachloride - which have retention times within our chromatographic window - we can account for small variations in mass spectrometer response. This augments our on-board analysis of diluted alcohol and carbonyl standards.

Table 1. TOGA-ARCTAS full compound list

Compound	Compound
OVOCs	
Methanol	Propanal
Ethanol	Butanal

Acetone	Pentanal
Butanone	2-Pentanone
Methyl tert. Butyl Ether	3-Pentanone
Acetaldehyde	
NMHCs	
Isoprene	Benzene
Propane	Toluene
Butane	Ethyl Benzene
Isobutane	*m*-Xylene
Pentane	*o*-Xylene
Isopentane	1,3,5-Trimethylbenzene
1,3-Butadiene	1,2,4-Trimethylbenzene
Halocarbons	
Tetrachloroethylene	CFC-113
Tetrachloromethane	Chloromethane
Chloroform	Methyl Bromide
Methylene Chloride	Methyl Iodide
Chloroacetaldehyde	Chloroacetone
Bromoacetaldehyde	Bromoacetone
Other	
Dimethyl Sulfide (DMS)	Acetonitrile

Table 2. Limits of detection and uncertainty for a subset of TOGA-measured compounds

Compound	Quant. Ion	Uncertainty	LOD pptv
i-butane	42	≤ ± 20%	1.4
Methyl chloride	50	≤ ± 20%	6
Butane	29	≤ ± 20%	1.9
Acetaldehyde	29	≤ ± 20%	6.3
Methyl bromide	94	≤ ± 20%	0.4
i-pentane	42	≤ ± 20%	0.8
Methanol	31	≤ ± 20%	16.9
Pentane	42	≤ ± 20%	0.8
Isoprene	67	≤ ± 20%	0.5
Ethanol	45	≤ ± 20%	16.2
Propanal	58	≤ ± 20%	1.6
DMS	62	≤ ± 20%	0.7
Acetone	58	≤ ± 20%	3.9
Methylene chloride	84	≤ ± 20%	0.9
Acetonitrile	41	≤ ± 20%	1.4
MTBE	73	≤ ± 20%	0.2
MEK	72	≤ ± 20%	0.7
Chloroform	83	≤ ± 20%	0.1
Tetrachloromethane	117	≤ ± 20%	0.2
Benzene	78	≤ ± 20%	0.3
Toluene	91	≤ ± 20%	0.1