U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM-TR-256

Time-Resolved Aerosol Filter Sampler Instrument Handbook

F Mei L Goldberger

November 2020

ARM

DISCLAIMER

This report was prepared as an account of work sponsored by the U.S. Government. Neither the United States nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

DOE/SC-ARM-TR-256

Time-Resolved Aerosol Filter Sampler Instrument Handbook

F Mei
L Goldberger
Both at Pacific Northwest National Laboratory

November 2020

Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

AAF	ARM Aerial Facility
ACCESS	aerosol counting, composition, extinction, and sizing system
ADC	ARM Data Center
AMS	aerosol mass spectrometer
ARM	Atmospheric Radiation Measurement
ASCII	American Standard Code for Information Interchange
CPC	condensation particle counter
MCPC	mixing condensation particle counter
MIST	multiple instrument stackable tower
MOPC	mixing condensation particle counter
netCDF	Network Common Data Form
PC	personal computer
STAP	single-channel tricolor absorption photometer
UAS	unmanned aerial system
UAV	unmanned aerial vehicle
UTC	Coordinated Universal Time
VDC	volts direct current

Contents

Figures

Tables

1.0 Instrument Title

The U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility's aerosol counting, composition, extinction, and sizing system (ACCESS) includes a base module (9400), a filter sampler (9401), an advanced mixing condensation particle counter (MCPC, 9403), a miniaturized optical particle counter (MOPC, 9405), and a single-channel tricolor absorption photometer (STAP, 9406).

This handbook describes the principles and operations of the filter sampler.

2.0 Mentor Contact Information

Fan Mei
Pacific Northwest National Laboratory
902 Battelle Boulevard
P.O. Box 999, MSIN K4-28
Richland, Washington 99352
Tel: 509-375-3965
fan.mei@pnnl.gov

3.0 Vendor/Developer Contact Information

Fred Brechtel
1789 Addison Way
Hayward, California 94544
Tel: 510-732-9723
https://www.brechtel.com

4.0 Instrument Description

The miniaturized eight-channel filter sampler for time-resolved aerosol chemistry measurements is part of the ACCESS payload, ideal for deployment on unmanned aerial vehicles (UAVs) due to its small size, portability, low weight, and low power usage. The filter sampler is controlled by the base module, a ruggedized tablet PC with user interface software preinstalled. The sampler itself is an eight-channel filter sampler (Model 9401 FILT) for offline chemical composition measurements.

5.0 Measurements Taken

The Model 9401 sampler performs time-resolved filter sampling to acquire aerosol samples from UAV with remote control capability. With eight filter channels, multiple samples can be obtained with the time resolution tailored to the aerosol loading. The samples collected are then analyzed offline once the collection is complete.

6.0 Links to Definitions and Relevant Information

Product website: https://www.brechtel.com/products-item/filter-sampler/

Instrument webpage from arm.gov: https://www.arm.gov/capabilities/instruments/filteraerosol-air

6.1 Data Object Description

The raw data from the chemical filter are recorded in *.dat file with appropriate headers specifying the data and units of measurement. The diameter array is written as one of the header rows in the file. The data file column definitions are provided in Table 1.

Chemical filter data submitted as routine data is named ‘filteraerosol-air’. The ARM archived data are available in both netCDF format and ASCII format.

Table 1. Data file column definitions.

Variable name	Description
`YY/MM/DD HR:MN:S.C.`	Time, UTC
`cur_pos`	Current filter holder position, int
`cntdown`	Count down, int
`smp_flw`	Sample flow, ms^{-1}
`smp_tmp`	Sample temperature, C
`smp_prs`	Sample pressure, kPa
`pump_pw`	Pump power, W
`psvolts`	Power supply voltage, V
`err_rpt`	Error report, int
`pumpctl`	Pump control, int
`ctlmode`	Control Mode, int
`intervl`	Interval, int
`flow_sp`	Flow set point, ms^{-1}

6.2 Data Ordering

Data can be ordered at the ARM Data Center (ADC) via ADC Data Discovery. Data are organized by measurement location and campaign.

6.3 Data Plots

The Brechtel software records housekeeping data from the chemical filter. The filters are analyzed offline. Figure 1 shows the housekeeping plots that the ARM Aerial Facility (AAF) field crew use to check the instrument health during flight operation.

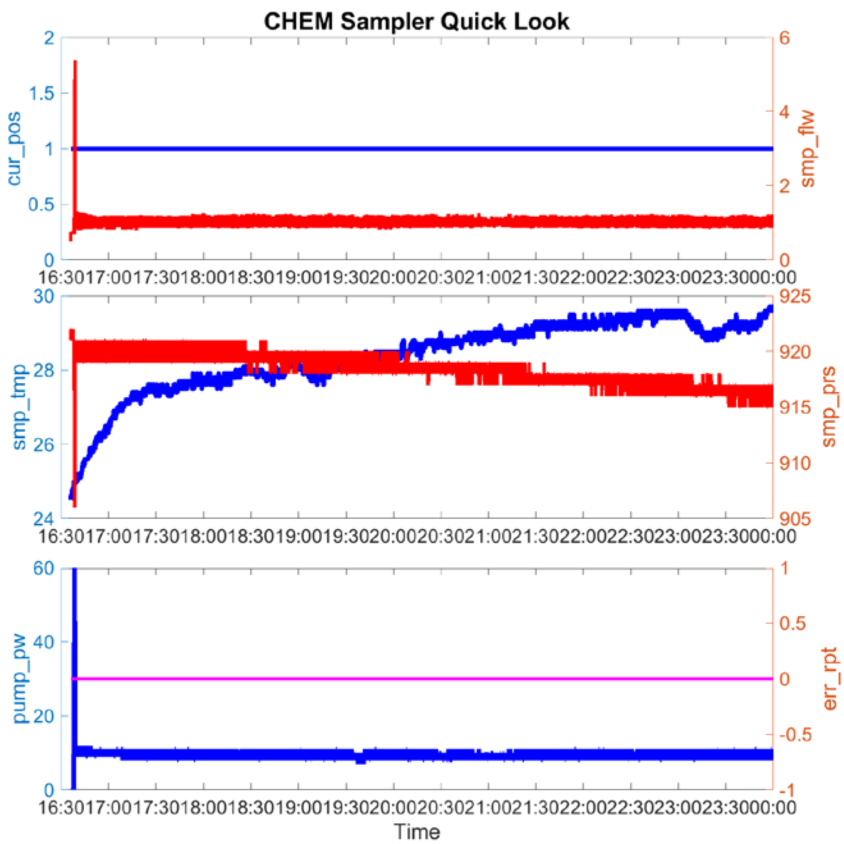

Figure 1. The chemical filter's housekeeping data during a laboratory bench test.

6.4 Data Quality

The ACCESS suite of instrumentation was tested in the laboratory during a wildfire event on 4 August 2018. An inlet connected the ACCESS suite to the ambient air 10 m above the ground. Figure 2 shows the total number concentration observed by two condensation particle counters. One is a water-based particle counter (Magic CPC), and the other one also belongs to the ACCESS suite, which is an advanced mixing CPC. The difference between the two CPCs was less than 20% during this sampling period. The filter samples collected simultaneously were analyzed using a unique extraction-aided aerosol mass spectrometer(AMS). Dr. Zhang's group operated this AMS from the University of California, Davis, https://etox.ucdavis.edu/zhang-qi. As shown in Figure 3, aerosol particles collected were primarily made of organic matters. The analysis information can be found in http://www.asrc.cestm.albany.edu/qz/AMS%20organic%20data%20and%20analysis.pdf.

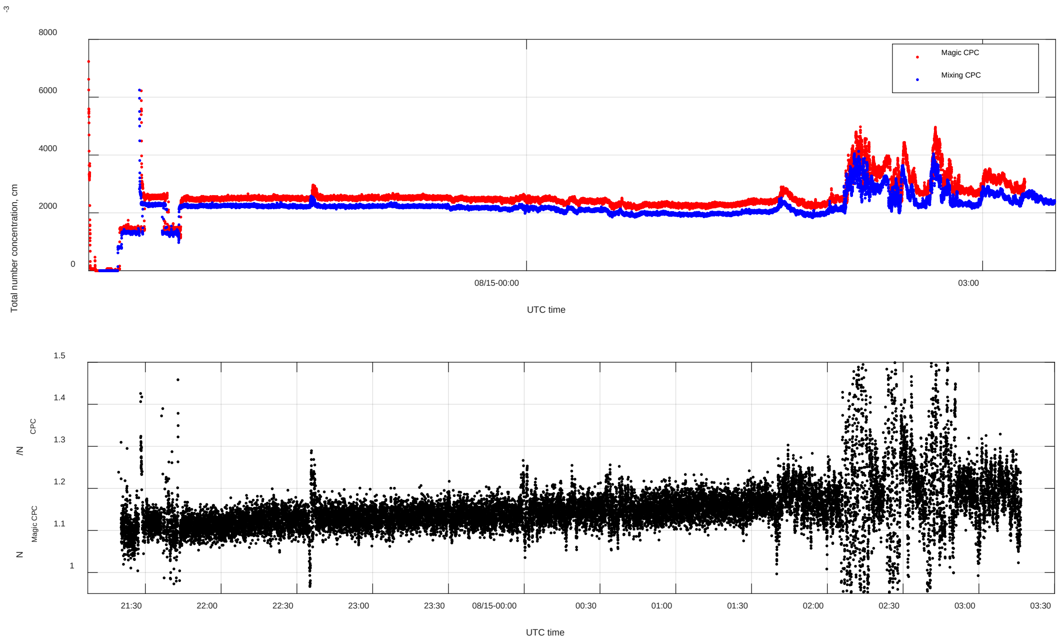

Figure 2. Context for the chemical sampler. Ambient aerosol measured by Magic condensation particle counter (CPC) and the ACCESS mixing CPC during a wildfire event on 8/14/2018. Top: total aerosol number concentration recorded both by the ACCESS mixing CPC and a Magic CPC. Bottom: an agreement between the CPCs.

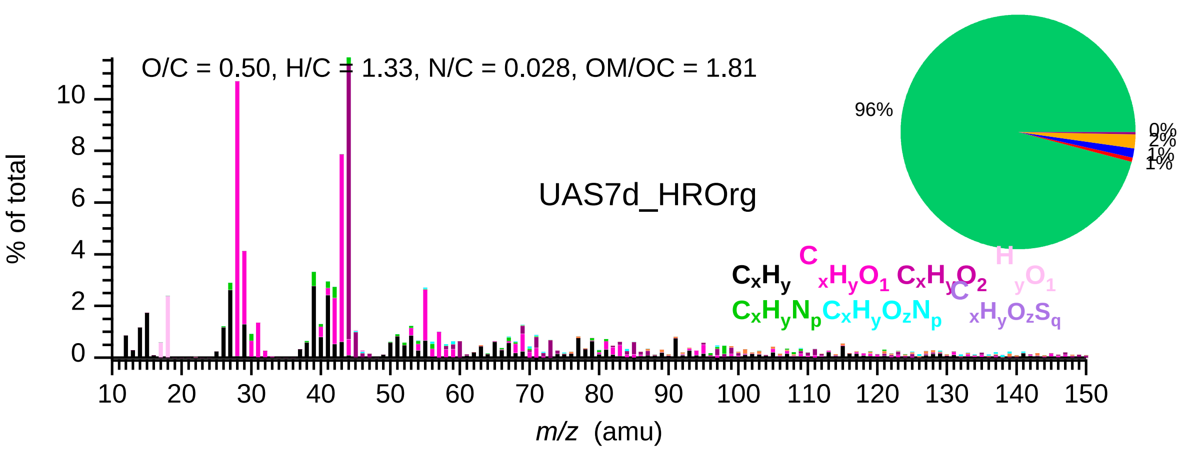

Figure 3. Ambient aerosol chemical information collected by the filter sampler during a wildfire event on 8/14/18.

6.5 Calibration Database

The instrument mentors periodically verify the filter sampler calibration.

7.0 Technical Specification

Table 2. Filter sampler specification parameters.

PARAMETER	VALUE
Number of filter channels	8
Filter type	Teflon, 1 µm pore
Filter size	13 mm diameter
Sample flow	0.1-3 lpm
Size: Main body	3"dia x 3.5" high/7.6 x 8.9 cm
Size: Pump assembly	3.5 x 2.3 x 2.5 in/8.9 x 5.8 x 6.6 cm
Weight	1.5 lbs/0.7 kg
Supply voltage	12 VDC
Power	10 watts

The filters or substrates will be analyzed offline, and the offline analysis determines the data accuracy.

7.1 Input Values

Depending on the flight plan, this filter sampler can run with the "manual" mode or "auto" mode. Under manual mode, the user will need to input the sampling spot location and duration. Under auto mode, the sampler will sample through each spot based on the set duration.

7.2 Output Values

Filter position – sample flow – temperature – pressure – error report

8.0 Instrument System Functional Diagram

Figure 4. Image of aerosol chemical filter sampler from the manufacturer's website.

9.0 Instrument/Measurement Theory

The aerosol chemical filter sampler draws air from a universal inlet over a single filter installed in one of eight of its filter holders. The aerosol and sticky gases are trapped on the Teflon filter, while the remaining gases are exhausted out a port on the other side. After a preprogrammed time, the filter holders rotate, and aerosol is collected onto a new filter. Accounting for filter cross-sectional area, sample flow rate, and time, the air volume collected onto the filter is calculated.

The filters can be analyzed offline in several ways. The aerosol and sticky gases collected from the filter can be extracted into a solution and characterized using aerosol mass spectroscopy for chemical information.

10.0 Setup and Operation of Instrument

Deployment on a TigerShark or ArcticShark unmanned aerial system (UAS)

The ACCESS aerosol chemistry filter is installed on the multiple instrument stackable tower (MIST) in the main payload bay of the ArcticShark UAS. The MIST itself is seated in the payload bay connected by four vibration isolators to reduce noise. Outside air is brought into the payload via a universal inlet installed on the nose of the UAS. The inlet is pumped actively via a scroll pump and controlled with a mass flow controller. The instrument is initialized by an onboard data acquisition system that operates the Brechtel LabVIEW software. The data is transmitted to scientists on the ground in real time.

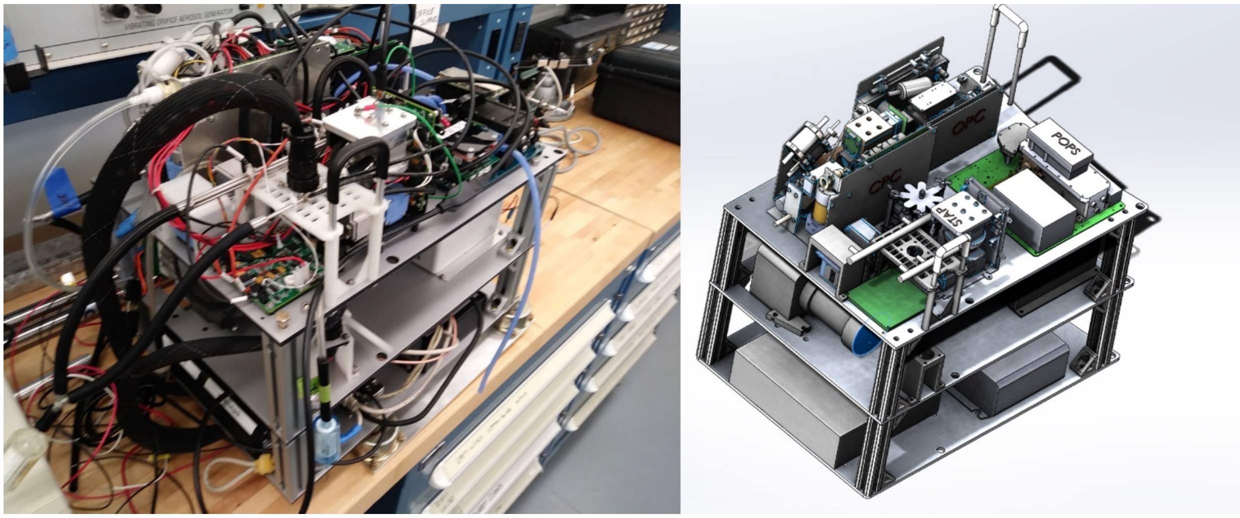

Figure 5. MIST instrument payload tower. Left: on laboratory bench. Right: Schematic with instrument placement clarified.

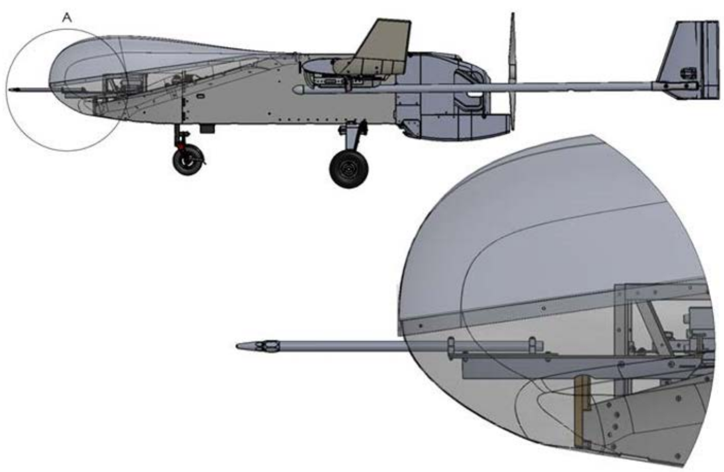

Figure 6. ArcticShark with nose inlet installed.

11.0 Software

The data acquisition unit on the ArcticShark is installed with the manufacturer's LabView software.

For further details, consult the manufacturer's manual.

12.0 Calibration

The filter sampler flow needs to be checked weekly during the field study and calibrated at least before and after each field campaign or as needed.

13.0 Maintenance

The filter holders and connective tubing require periodic cleaning to remove impurities. One maintenance kit is included with the sampler.

14.0 Safety

This unit has no safety concerns during regular operation.

15.0 Citable References

[1] Filter Sampler Model 9401. https://www.brechtel.com/products-item/filter-sampler/. Accessed 08/25/2020.

[2] Bates, TS, PK Quinn, JE Johnson, A Corless, FJ Brechtel, SE Stalin, C Meinig, and J Burkhart. 2013. “Measurements of atmospheric aerosol vertical distributions above Svalbard, Norway using unmanned aerial systems (UAS).” *Atmospheric Measurement Techniques* 6(8): 2115−2120, https://doi.org/10.5194/amt-6-2115-2013

www.arm.gov

U.S. DEPARTMENT OF
ENERGY
Office of Science