2018 WE-CAN/FIREX Data QA Document

ARI Stationary Data at the Activity Barn Ground Site in McCall, ID

Please direct general questions relating to this dataset to:
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Revised Nov Jun 7, 2022

Instrument-specific questions should be directed to the instrument PIs listed within this document.

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Campaign overview

Data was collected on board the Aerodyne Mobile Laboratory [*Herndon et al.*, 2005; *Kolb et al.*, 2004; *Yacovitch et al.*, 2015] (AML).

Instruments were divided between the Aerodyne Mobile Laboratory (AML), which based out of McCall Idaho, and was deployed to numerous fires. Additional stationary instrumentation was operated at this same McCall, Idaho ground site out of the McCall Activity Barn. Stationary instruments were located both within the Activity Barn building and in the miniature Aerodyne Mobile Laboratory (minAML).

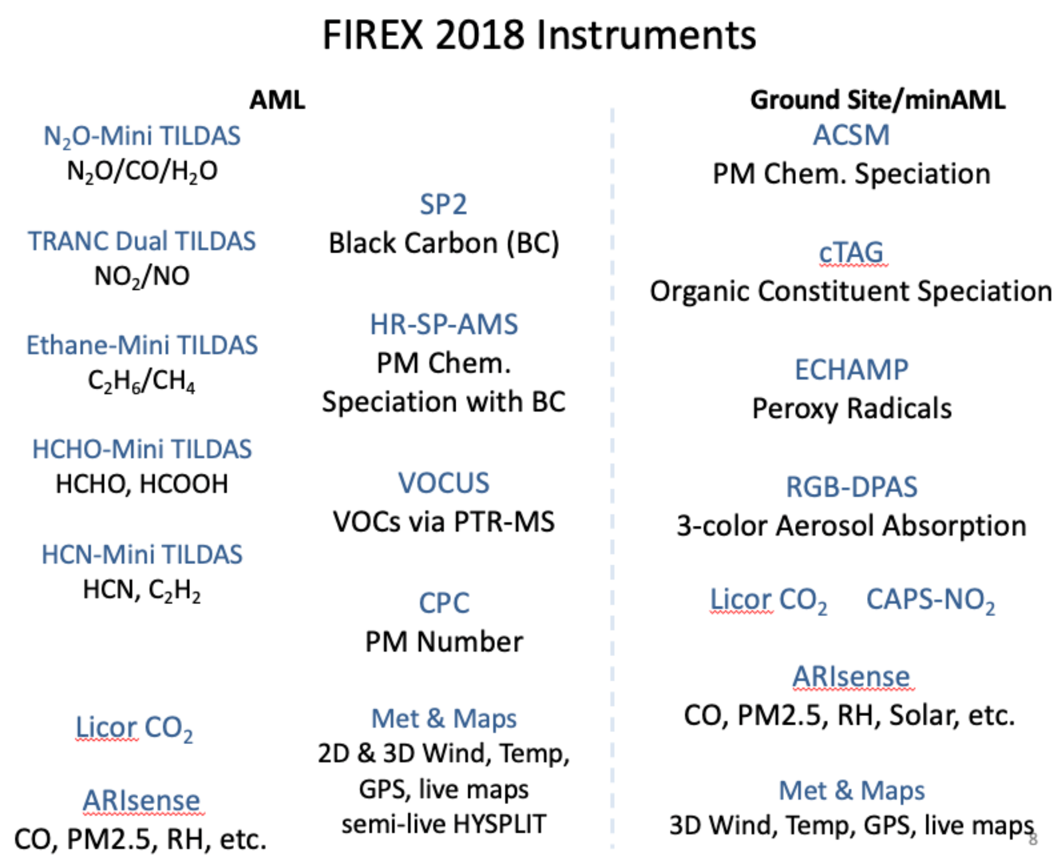

Figure 1. FIREX 2018 instrumentation. The cTAG and ECHAMP instruments were operated by collaborators.

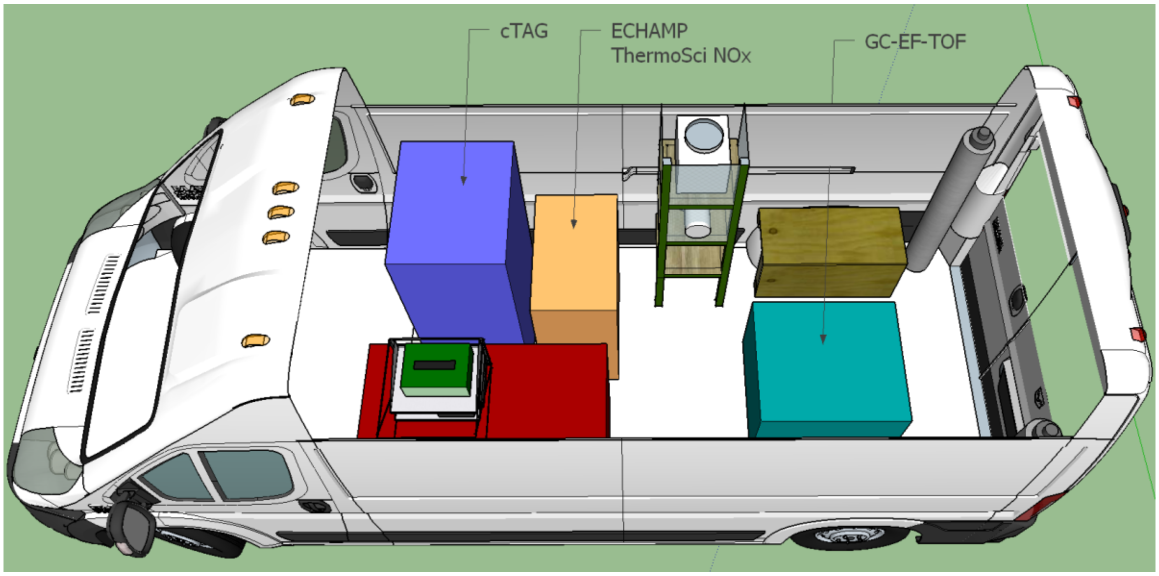

Figure 2. minAML layout for FIREX 2018. The cTAG and ECHAMP instruments were operated by collaborators. The GC-EF-ToF did not participate in FIREX

Figure 3. ECHAMP inlet box (foreground, PI: Ezra Wood), storage trailer, minAML and Mcall Activity Barn building (background, left to right)

Figure 4. The AML (truck, left) towing storage trailer, and followed by pickup truck (support vehicle) and the minAML.

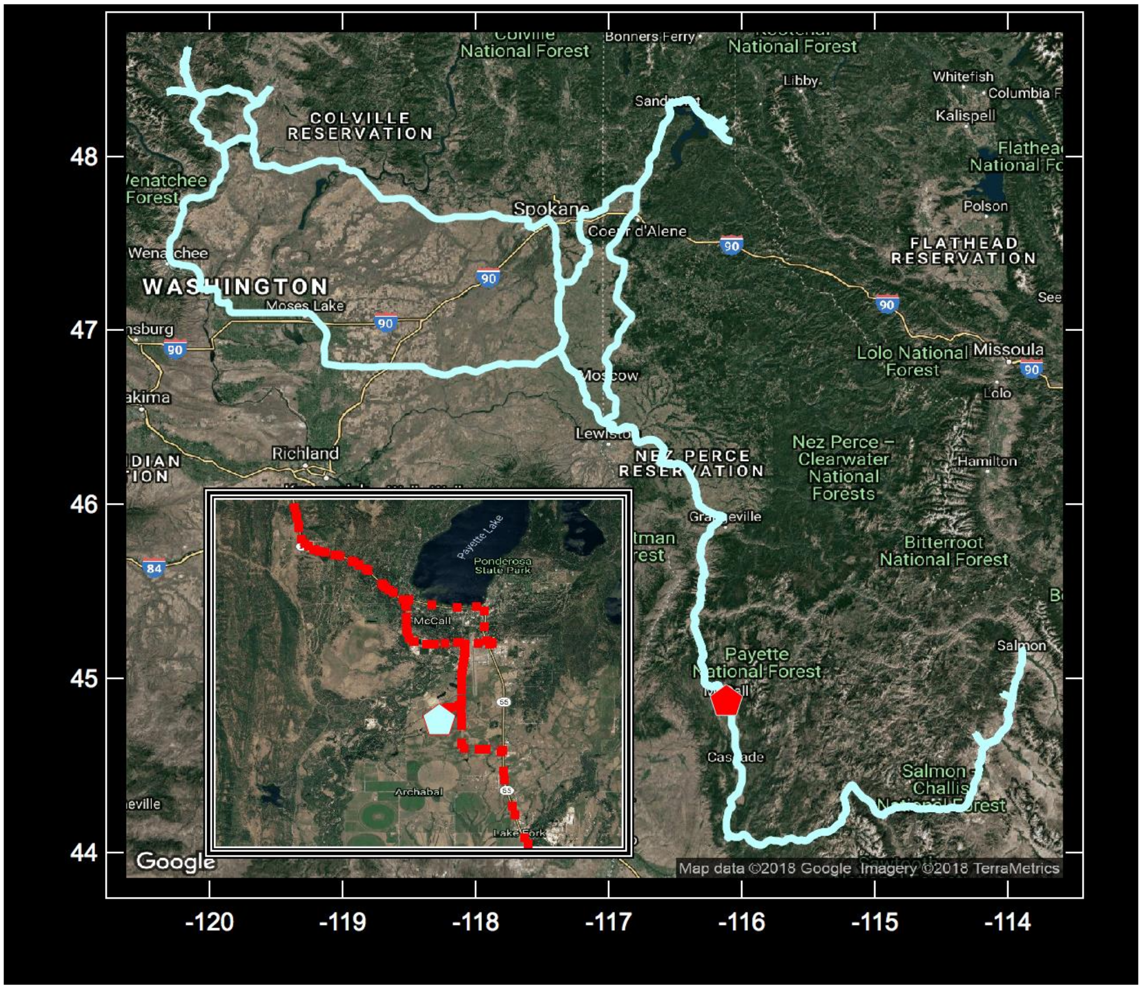

Figure 5. FIREX 2018 AML ground path, with inset map showing location of the McCall Activity Barn Ground Site

Associated Datasets

Aerodyne Mobile Laboratory Measurements (WeCanFIREX2018_AML)

Includes a significant amount of time co-located at the ground site, with a data flag indicating these periods.

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Comprehensive Thermal Desorption Aerosol Gas Chromatograph (cTAG)

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ECHAMP

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GPS Coordinates, Wind Measurements, Outdoor Temperatures

Tara Yacovitch, tyacovitch@aerodyne.com

A Hemisphere GPS compass, model Vector V103, was mounted to the minAML rooftop. Location data from the stationary minAML was averaged for the entire duration of the campaign to remove jitter in the GPS position. This site location has coordinates of 44.871646, -116.114854.

Stationary wind for the ground site was collected with a 3D RMYoung ultrasonic anemometer, model 81000RE, mounted at a height of 10 meters on the ground site's tower. Data began on 8/14/2018 12:14 UTC. The tower was positioned next to the minAML for the duration of the campaign, and the anemometer was oriented with its positive y axis facing north, requiring no further correction for orientation. This anemometer also reports sonic temperature.

Data

Name	Unit	Location	Note
MM_siteLatitude	decimal degrees	ground site	Stationary site latitude of 44.871646
MM_siteLongitude	decimal degrees	ground site	Stationary site longitude of -116.114854
MM_siteNorthing	UTM meters north	ground site	Universal Transverse Mercator (UTM) coordinate system used for all easting, northing and zone data.
MM_siteEasting	UTM meters east	ground site	
MM_siteZone	UTM zone	ground site	Stationary site zone of 11
MM_siteElevation_m	meters	ground site	Elevation of the stationary site. Constant at 1525.07 meters.
MM_SolarElevAng	azimuthal degrees	ground site	Calculated solar elevation angle at the ground site coordinates
MM_wind10m_dir	degrees clockwise from true north	ground site	10 m wind direction in the x,y plane only

MM_wind10m_speed	m/s	ground site	10 m wind speed in the x,y plane only
MM_wind10m_N	m/s	ground site	Positive components indicate winds from the north
MM_wind10m_E	m/s	ground site	Positive component indicates wind from the east
MM_wind10m_Z	m/s	ground site	Positive z axis indicates winds from below.
MM_siteTemperature_C	degrees Celsius	ground site	Sonic temperature measured by the ground site's 3D anemometer at a 10 meter height after 8/14/2018 12:14 UTC. Prior to this time, the AML 3.75 meter 3D anemometer data was used.
MM_MobileFlag	unitless	AML	This flag is present in the AML-MOBILE dataset, and should be used to identify periods of time where the AML was present at the Activity Barn Site (0) or was offsite (1). A combination of truck latitude/longitude and elevation was used to identify these mobile periods.

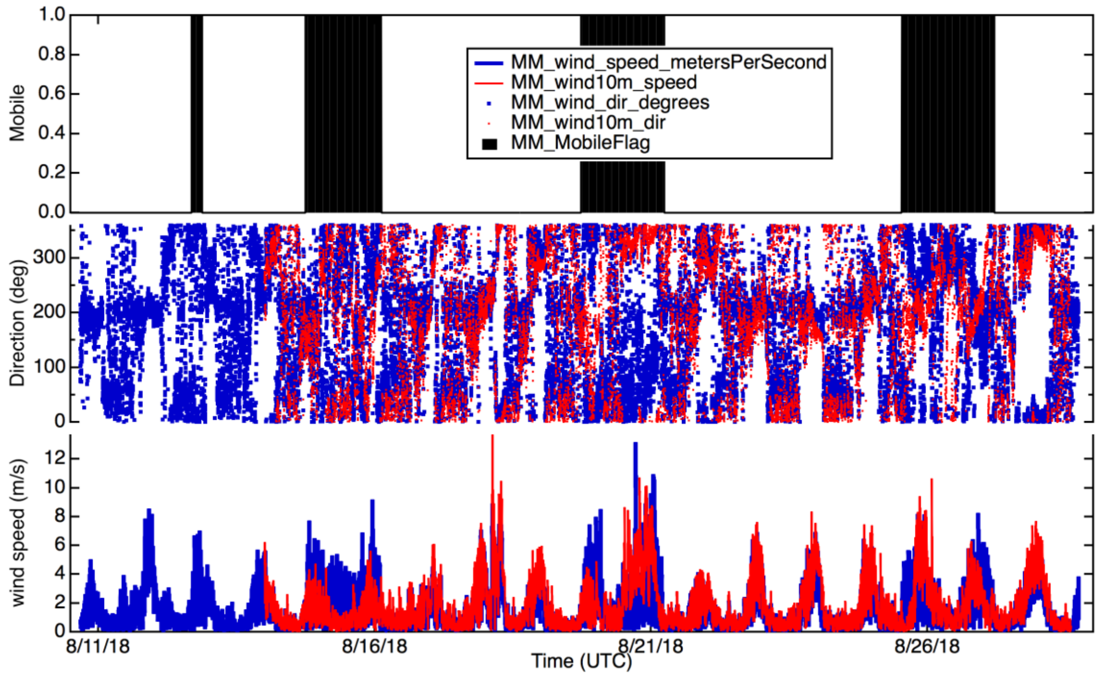
Estimates of GPS compass noise during the campaign were calculated by comparing the measured minAML location to its average location. The average deviation was 0.2 meters (1-second data).

The 1σ variation in measured wind speeds is 0.4 m/s at 1-minute for the site's 3D anemometer (MM_wind10m_speed), measured via an Allan variance plot of true wind speeds at full time resolution. This 1σ metric should be considered an upper limit for the true 1σ noise because it includes real variation in wind speeds.

Zeroes, Calibrations, Corrections

Interpolation of polar values: Since a heading of 360 degrees is the same as a heading of 0 degrees, interpolation cannot be done directly without causing artifacts (e.g. averaged headings of ~180 when true heading is 0/360). Instead, a unit vector pointing in the direction of heading was calculated in x and y coordinates. Those x and y coordinates were averaged onto the 1-minute time base, and the result re-converted into a heading in degrees. Similarly, all wind measurements were interpolated onto a 1-minute time base using their vector components, and only then transformed back into speed and direction.

Winds: No calibration of the various anemometers was performed. A comparison between 10 m stationary and 3.75 m mobile/stationary winds shows good qualitative agreement between both anemometers when co-located (AML mobile periods indicated by the black bars in figure below).



Data issues

Sonic temperatures may have a slight humidity dependence. However, previous campaigns have shown good comparisons with other temperature measurements with no obvious humidity effects.

NO_2

Andrew Lindsay, Drexel University, ajl384@drexel.edu

A CAPS instrument measures NO_2 at 450 nm using cavity attenuated phase shift (CAPS) spectroscopy. The instrument was mounted on the minAML during FIREX/WECAN 2018.

Data

Name	**Description**	**Units**	**1 σ noise**
MM_NO2_minAML	Nitrogen Dioxide	ppb	~20 ppt

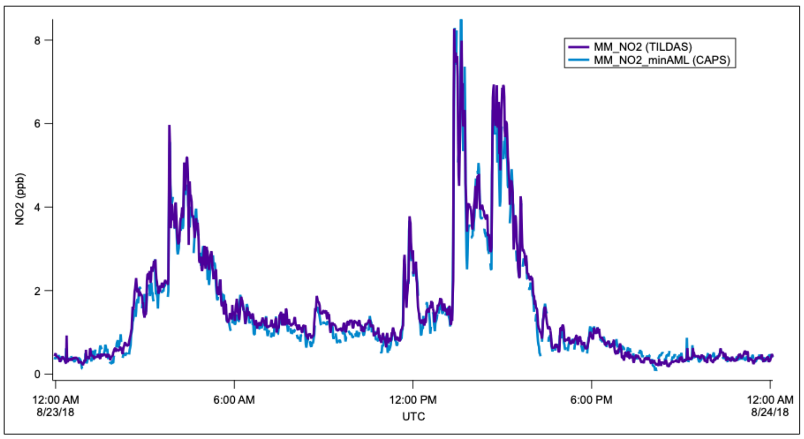
Calibration, Zeroing, Corrections

Instrument was zeroed using ambient air sent through a charcoal/purafil scrubber. The duration of the background cycle was 13 minutes with 10 minutes of sampling followed by 3 minutes zeroing.

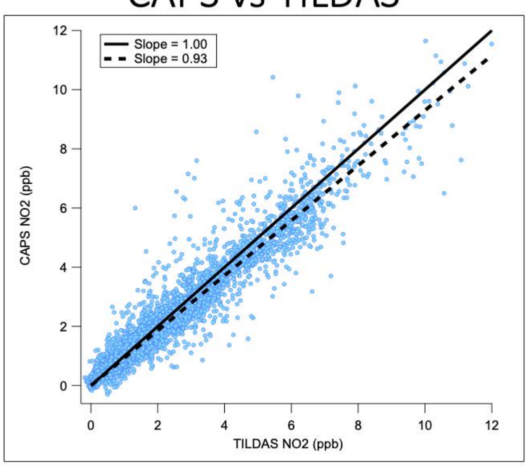
This instrument was calibrated on August 26th. The resulting calibration factor of 1/0.946 was applied to the dataset. Calibrations were performed using a 2B Technologies Model 306 Ozone Calibration Source. Ozone calibrant was mixed with excess NO using an Alicat mass flow controller. The mixture was allowed ample time to react through ~125 feet of tubing at a flow rate of less than 1 lpm.

Comparison to AML TILDAS data

Follow same trends



CAPS vs TILDAS



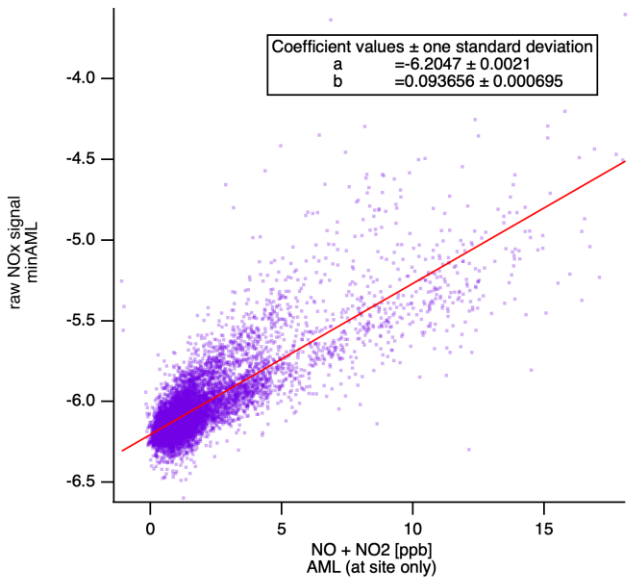
Mobile data is not included in this figure.
Looks about 7% low (dashed line)

NOx

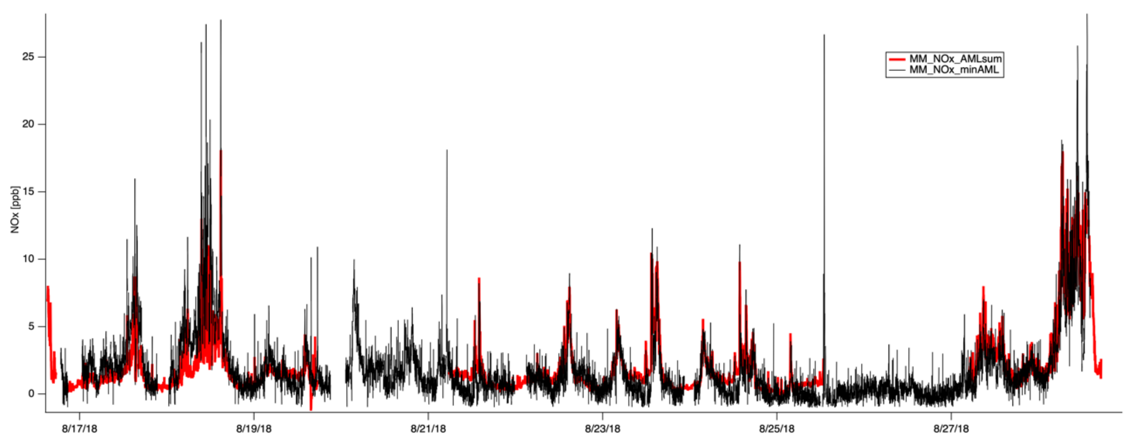
Tara Yacovitch, tyacovitch@aerodyne.com

NOx was measured by a ThermoFischer 42i NOx Box running in NOx mode in the minAML. The flow rate through the instrument was 0.5 SLPM, and it shared an inlet with the CAPS-NO_2 instrument in the minAML. Zeroes were removed according to the same cycle as the CAPS-NO_2 in the minAML, with considerable slop. No data is available prior to 8/16/2018.

The raw NOx response of the unit was calibrated based on the sum of TILDAS NO and NO_2 measured in the Mobile lab while at the Activity Barn site:



The resulting NOx trace is shown below, and compared to the sum of AML-measured NO and NO_2.



The full quality assurance and analysis code for the NOx trace is reproduced below:

```
// minAML NOx Box QA
QAQCw_ResetAllWaves()
QAQCw_zeroWaveReset(); QAQCw_zeroDefine("NOx",15,"00:07:35",780,120)
QAQCw_NaNmarquis(token="NOx",startTime=3617298192.9,stopTime=3617317286
.3,minY=33.6083,maxY=810.654) //08/16/2018 21:03:12, 08/17/2018 02:21:26
QAQCw_NaNmarquis(token="NOx",startTime=3618310038.0,stopTime=3618310890
.2,minY=7.38472,maxY=23.7104) //08/28/2018 14:07:18, 08/28/2018 14:21:30
QAQCw_NaNmarquis(token="NOx",startTime=3617297362.5,stopTime=3617311261
.6,minY=-7.19974,maxY=-3.76519)   //08/16/2018   20:49:22,   08/17/2018
00:41:01
```

```
QAQCw_NaNmarquis(token="NOx",startTime=3617739925.3,stopTime=3617751597
.5,minY= -7.219,maxY=-3.16962) //08/21/2018 23:45:25, 08/22/2018 02:59:57
QAQCw_NaNmarquis(token="NOx",startTime=3617385879.3,stopTime=3617397321
.0,minY=-7.09493,maxY=-3.20573)   //08/17/2018   21:24:39,   08/18/2018
00:35:20
QAQCw_NaNmarquis(token="NOx",startTime=3617557416.9,stopTime=3617572442
.6,minY=-7.35516,maxY=-2.35793)   //08/19/2018   21:03:36,   08/20/2018
01:14:02
QAQCw_NaNmarquis(token="NOx",startTime=3617908094.2,stopTime=3617917953
.0,minY=-7.27978,maxY=-3.56469)   //08/23/2018   22:28:14,   08/24/2018
01:12:33
QAQCw_averageZeroHearts("NOx", useNandata=1)
QAQCw_NaNZeroes(61,55) // time not totally right so need a lot of slop
here.
//  QAQCw_zeroCorrection("NOx",3) // this isn't working. we will just use
intercept below.
QAQCw_NaNmarquis()

setdatafolder root:unifieddata;
Cast_AnyXYontoPilot(MM_datetimeUTC,      root:a_NOxBox_NOx:source_rtime,
root:a_NOxBOx_NOx:col1_conc_NaNed, "MM_NOx_minAML_raw", "")

// compare to AML TILDAS data for calibration and zeroes.
duplicate/o MM_NO MM_NOx_AMLsum; MM_NOx_AMlSum = MM_NO+MM_NO2
MM_NOx_AMLsum = MM_mobileFlag == 1 ? NaN : MM_NOx_AMLsum
CurveFit/M=2/W=0/TBOX=(0x300) line, MM_NOx_minAML_raw/X=MM_NOx_AMLsum/D
//   W_coef=(-6.2047,0.093656)
duplicate/o MM_NOx_minAML_raw MM_NOx_minAML
MM_NOx_minAML -= W_coef[0]
MM_NOx_minAML /= W_coef[1]
MM_NOx_minAML = MM_NOx_minAML <= -1 ? NaN : MM_NOx_minAML
```

CO_2

A data logging issue led to no CO_2 data being collected on the minAML. See CO_2 measured on the AML while co-located at the ground site (AML-MOBILE dataset).

ARISense

Tara Yacovitch (tyacovitch@aerodyne.com)

An ARISense small sensor unit (SN:018) was mounted to the AML rooftop.

A second ARISense small sensor unit (SN:025) was mounted to the minAML and stationed at the activity barn ground site. There were several data gaps for this second unit.

The ARIsense measured particulate matter number in 16 size bins between 0.4 – 16 μm with an optical particle counter (Alphasense model OPC-N2). Subsequent analysis provided measures of integrated size-dependent particulate matter mass, like PM_2 and PM_{10} (see Appendix B).

The OPC reports data as particle counts (number concentration). Internal firmware (not controlled by Aerodyne) classifies each raw scattered light signal into 16 distinct particle size bins (0.4 to 16 microns). The size distribution is then further analyzed to provide integrated number and mass concentration metrics. PM1, PM2.5 and PM10 waves were calculated by first assuming that all detected particles were spherical with a density of 1.65 grams per cubic centimeter. The resultant mass distributions were then integrated between 0.4-2 µm for PM2 and 0.4-10 µm for PM10. No size-dependent collection efficiency corrections were applied to the PM1, PM2 and PM10 outputs. Additional size distributions are available from the SP2 instrument situated at the Activity Barn ground site.

The larger particle measurements will include the droplet mode. It is recommended to use the relative humidity measurement from the ARISense, or the water mixing ratio measurement (MM_H2O) from the AML gas phase inlet, to understand and identify these droplet mode time periods and distinguish them from dust.

Two CO sensors were run in the SN025 unit mounted at the field site. However, baseline variations were orders of magnitude greater than enhancements in CO and the data is not reported. See instead the laser-based CO measured on board the AML while co-located at the ground site (AML-MOBILE file)

Name	**Description**	**Units**	**site**
MM_ARIsense_solar_ArbUnit_minAML	insolation	Arbitrary units	AML
MM_ARIsense_RH_minAML	Relative humidity	%	AML
MM_ARIsense_PM1_minAML	Integrated mass concentration < 1 µm	$\mu m/m^3$	AML
MM_ARIsense_PM2_minAML	Integrated mass concentration < 2 µm	$\mu m/m^3$	AML
MM_ARIsense_PM10_minAML	Integrated mass concentration < 10 µm	$\mu m/m^3$	AML

Photolysis Frequencies (J_{NO2}, etc)

This description is taken from [*Lindsay et al.*, 2022]: The National Center for Atmospheric Research (NCAR) Tropospheric Ultraviolet and Visible (TUV) model was used to acquire J_{NO2} and J_{O3} in 1-minute intervals. Notable TUV inputs included latitude and longitude of 44.9^o and -116.1^o, elevation of 1.53 km, the daily O_3 column value, surface albedo of 0.2, and single scattering albedo of aerosols of 0.99. Daily O_3 column values were input as 295, 297, and 291 Dobson units for the 16 to 18 August period, respectively, and 316, 326, 306, and 315 for the 21 to 24 August period. These daily values were sourced using Ozone Monitoring Instrument (OMI) data.

The TUV photolysis outputs were then scaled using ARISense solar irradiance data at the stationary site in order to account for fluctuations due to clouds and BB smoke. TUV outputs were first synchronized in time to align with daily peak ARISense readings. We considered the ARISense solar cycle of 21 August as the standard profile as there were essentially no interferences. This standard profile was scaled to match the peak values of each day and better align with overall ARISense observations. We then implemented any relative changes in solar irradiance measurements compared the standard profile into our TUV model J_{NO2} and J_{O3} outputs. ARISense data was not collected for most of 18 August so TUV outputs were not scaled.

Name	Description
MM_jAcetone	Photolysis rate coefficient for reaction CH3COCH3 (acetone) + hv → CH3CO + CH3
MM_jCH3CHO_CH3	Photolysis rate coefficient for the acetaldehyde reaction CH3CHO + hv → CH3 + CHO
MM_jCHOCHO	Photolysis rate coefficient for the glyoxal reaction CHOCHO + hv → CHO + CHO
MM_jCl2	Photolysis rate coefficient for reaction Cl2 + hv → Cl + Cl
MM_jClNO2	Photolysis rate coefficient for reaction ClNO2 + hv → Cl + NO2
MM_jH2O2	Photolysis rate coefficient for reaction H2O2 + hv → OH + OH
MM_jHCHO_H	Photolysis rate coefficient for reaction CH2O + hv → H +HCO
MM_jHONO	Photolysis rate coefficient for reaction HNO2 + hv → OH + NO
MM_jMeCOCHO	Photolysis rate coefficient for methyl glyoxal reaction CH3COCHO + hv → CH3CO + HCO
MM_jno2	Photolysis rate coefficient for reaction NO2 + hv → NO + O(3P)
MM_jO1D	Photolysis rate coefficient for reaction O3 + hv → O2 + O(1D)

Aerosol Chemical Speciation Monitor (ACSM)

Philip Croteau, Aerodyne Research, Inc., croteau@aerodyne.com

An Aerodyne Quadrupole Aerosol Chemical Speciation Monitor (ACSM) was deployed in the activity barn shelter adjacent to the minAML. The monitor measured chemically speciated mass loadings of non-refractory particulate matter with an approximate maximum diameter of 1 µm using thermal vaporization, electron impact mass spectrometry. The instrument co-sampled with a Scanning Mobility Particle Sizer (SMPS) through a 3/8” copper tube inlet with a 2.5 µm 3 L/min cyclone

N. L. Ng, S. C. Herndon, A. Trimborn, M. R. Canagaratna, P. L. Croteau, T. B. Onasch, D. Sueper, D. R. Worsnop, Q. Zhang, Y. L. Sun & J. T. Jayne (2011) An Aerosol Chemical Speciation Monitor (ACSM) for Routine Monitoring of the Composition and Mass Concentrations of Ambient Aerosol, Aerosol Science and Technology, 45:7, 780-794, DOI: 10.1080/02786826.2011.560211

Data

Data was acquired with 1-minute time-resolution, but averaged to 10 minutes to reduce noise. The 10-minute data was interpolated onto the MM timebase

Name	Description	Units	1 σ noise
MM_Org_ACSM	Organic aerosol mass loading	μg m^{-3}	
MM_NO3_ACSM	Nitrate aerosol mass loading	μg m^{-3}	
MM_SO4_ACSM	Sulfate aerosol mass loading	μg m^{-3}	
MM_NH4_ACSM	Ammonium aerosol mass loading	μg m^{-3}	
MM_Chl_ACSM	Chloride aerosol mass loading	μg m^{-3}	

Calibration, Zeroing, Corrections

The ACSM NO_3 response factor was calibrated by introducing a known mass of NH_4NO_3 aerosol. This same data was also used to determine the relative response of NH_4. $(NH_4)_2SO_4$ aerosol was also measured in order to determine the SO_4 relative response. Organic and chloride aerosol relative response were taken as the standard reference value.

The ACSM measurement is based on taking a difference between particle-laden and particle-free air. The system switches between the two every ~30 seconds.

Data are corrected for changes in sensitivity and/or flow rate by using the measured signal at m/z 28, assumed to be dominated by N_2^+. This quantity varies proportionally with changes in both sensitivity and flow rate.

Single Particle Soot Photometer (SP2)

Tim Onasch, Aerodyne Research Inc., onasch@aerodyne.com

The Brookhaven National Laboratory Single Particle Soot Photometer (SP2, Droplet Measurement, Inc.) was deployed on the Aerodyne Mobile Lab (AML). This instrument measured the number (total and distribution) and mass (total and distribution) of refractory black carbon (rBC) particles. The instrument belongs to Art Sedlacek at Brookhaven National Laboratory and was deployed by Leonid Nichman under supervision of Sedlacek and Onasch. It sampled through the particulate inlet line through a copper tube with a 2.5 μm cyclone on the exterior tip. It sampled behind a filter-diluter for part of the time to ensure that the SP2 did not saturate with respect to coincidence issues. The SP2 operated from 8/10 to 8/18, due to time constraints on BNL's side and Leonid's availability.

Data

(1 σ noise for 1 second data converted to 60 s results by dividing by sqrt(60))

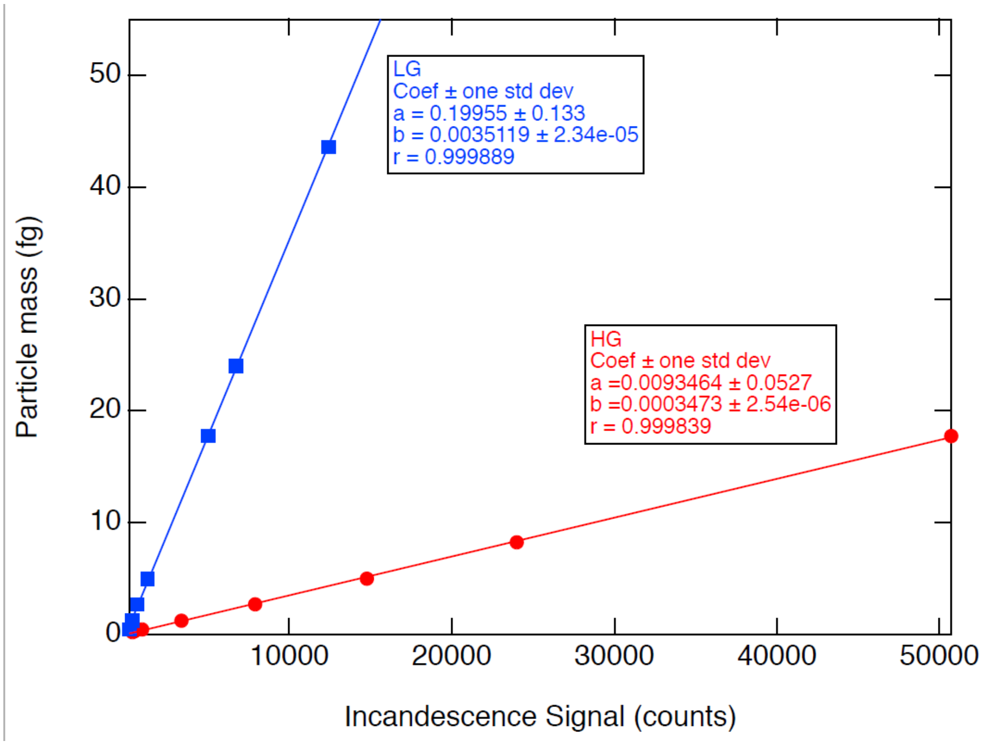
Name	Description	Units	1 σ noise
MM_SP2_MassIncand2	Particulate rBC	ng m^{-3}	2 to 45 ng m^{-3}
MM_SP2_NumConcIncand2	Particulate rBC	# cm^{-3}	0.3 to 3 # cm^{-3}
MM_SP2_IncandNumStepSelectedByLogDp	Particulate rBC	# cm^{-3} μm^{-1}	0.3 to 3 # cm^{-3}

The LOD on the particulate rBC mass concentrations (3 σ, 60s) ranged from 0.3 to 6 ng m^{-3}. The ranges in the noise and LOD levels comes from the various settings on the filter-diluter that was inline upstream of the SP2 for some of the sample time. The lower range values were when sampling direct line, whereas the highest range values were when the filter-diluter was set to dilute the sample air significantly

Calibration, Zeroing, Corrections

The instrument sampled periodic filter periods performed on the particle inlet line during the study to verify zeros and obtain LOD values.

The SP2 was calibrated in the field on 8/13/2018 with mobility size selected fullerene soot particles. See calibration plot below.



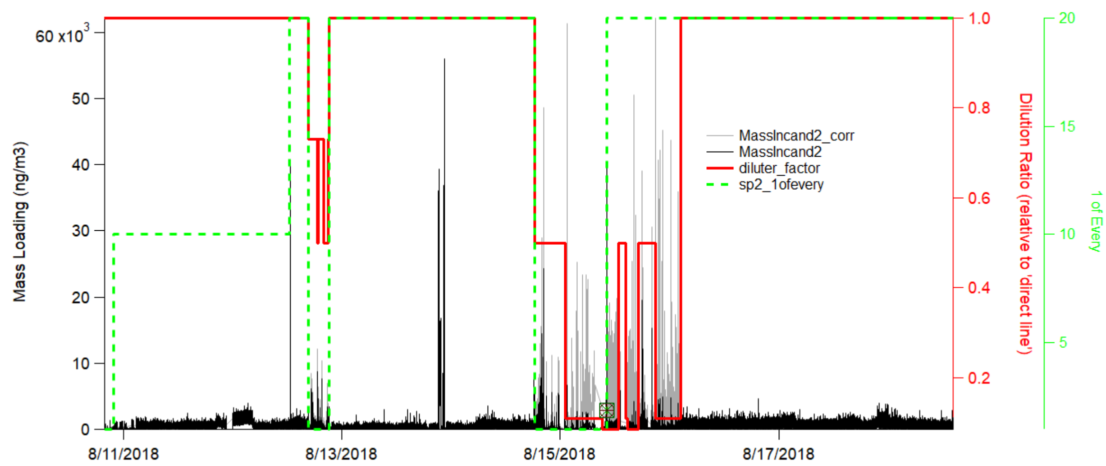
The SP2 was operated with a filter-diluter inline upstream during part of the study. The filter-diluter was calibrated in the field, using both ambient and size selected fullerene soot particles 5 different times. The average dilution factors have been applied to the data. A table summarizing the filter-diluter calibrations here shown below covering all filter-diluter conditions.

Point	filter_cal	filter_diluter_setup	diluter_avg	scat_avg	incand_avg	filter_mask
0	cal4	(bypass0.5 filter1)/(bypass1 filter0)	0.14	0.2	0.075	1
1	cal5	(bypass0.5 filter1)/(bypass1 filter0)	0.11	0.143	0.07	1
2	cal5	(bypass0.5 filter1)/direct line	0.085	0.1	0.07	1
3	cal1	(bypass1 filter0)/direct line	0.7	0.7	0.7	1
4	cal5	(bypass1 filter0)/direct line	0.68	0.69	0.66	1
5	cal3	(bypass1 filter0)/direct line	1.07	1.08	1.067	0
6	cal2	(bypass1 filter0)/direct line	0.8	0.81	0.79	1
7	cal2	(bypass1 filter1)/(bypass1 filter0)	0.73	0.72	0.741	1
8	cal4	(bypass1 filter1)/(bypass1 filter0)	0.81	0.846	0.78	1
9	cal3	(bypass1 filter1)/(bypass1 filter0)	0.42	0.545	0.29	0
10	cal5	**(bypass1 filter1)/(bypass1 filter0)**	0.75	0.75	0.75	1
11	cal1	(bypass1 filter1)/(bypass1 filter0)	0.67	0.68	0.66	1
12	cal2	(bypass1 filter1)/direct line	0.58	0.581	0.588	1
13	cal1	(bypass1 filter1)/direct line	0.47	0.48	0.46	1
14	cal5	(bypass1 filter1)/direct line	0.51	0.52	0.5	1
15	cal3	(bypass1 filter1)/direct line	0.45	0.59	0.31	1
16	cal3	(bypass1.0 filter1)/(bypass1 filter0)	0.12	0.16	0.07	1
17	cal5	(bypass1.0 filter1)/(bypass1 filter0)	0.15	0.16	0.15	1
18	cal4	(bypass1.0 filter1)/(bypass1 filter0)	0.51	0.72	0.31	0
19	cal3	(bypass1.0 filter1)/direct line	0.12	0.17	0.07	1
20	cal5	(bypass1.0 filter1)/direct line	0.1	0.11	0.1	1
21	cal4	(bypass1.5 filter1)/(bypass1 filter0)	0.69	0.82	0.56	1
22	cal4	(bypass2.0 filter1)/(bypass1 filter0)	0.75	0.82	0.69	1

The SP2 data was QA'd by the creation and application of a masking wave that removed all zeros, calibrations, and other time periods, based on notes and loading observations.

Data issues

One worry when deploying a single particle system in a field study to measure biomass burning plumes is the potential for the instrument to saturate due to coincidence issues. Saturation in this case is when two or more particles are in the laser at the same time, confusing the ultimate single particle measurement of mass and number and when the system is busy saving data on one particle event, thereby missing one or more particles. In an attempt to correct for these issues, but not change the sample flow rate (which is commonly done) as this can affect the single particle mass signals when there is sufficient coating on the particles, we opted to run with two different controls. The first is how many particles are saved. Under nominal ambient conditions, the SP2 save 1 of every 10 particle sampled. This reduces the data file sizes, though it can reduce the signal to noise levels. During FIREX-WeCAN, the SP2 saving rate (1ofevery) was changed between 1ofevery1 (when in mobile mode) to 1ofevery20 during high loading stationary periods. This parameter affects the S/N ratios. The other control was to operate with a filter-diluter inline in front of the SP2. This filter system dilutes the particle number concentrations prior to being sampled by the SP2, thereby reducing the potential for saturation/coincidence. This control also affects the S/N ratios. Both parameters need to corrected in the final data to obtain the actual ambient concentrations. Here is a plot of the two parameters (right axes) and the uncorrected and corrected mass loadings (ng m^{-3}) in black and grey, respectively (left axis), for the full sample period.



SMPS – Particulate Matter Sizing

The 2018 SMPS data was plagued by instrumental issues. No data is submitted. Please contact Philip Croteau, croteau@aerodyne.com, for additional details.

References

Herndon, S. C., et al. (2005), Characterization of urban pollutant emission fluxes and ambient concentration distributions using a mobile laboratory with rapid response instrumentation, *Faraday Discussions*, *130*, 327-339, doi:10.1039/b500411j.

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