2018 WE-CAN/FIREX Data QA Document

Aerodyne Mobile Laboratory (AML) Dataset

Please direct general questions relating to this dataset to:

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Revised Nov Jun 6, 2022

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

Table of Contents

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, Idhaho 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).

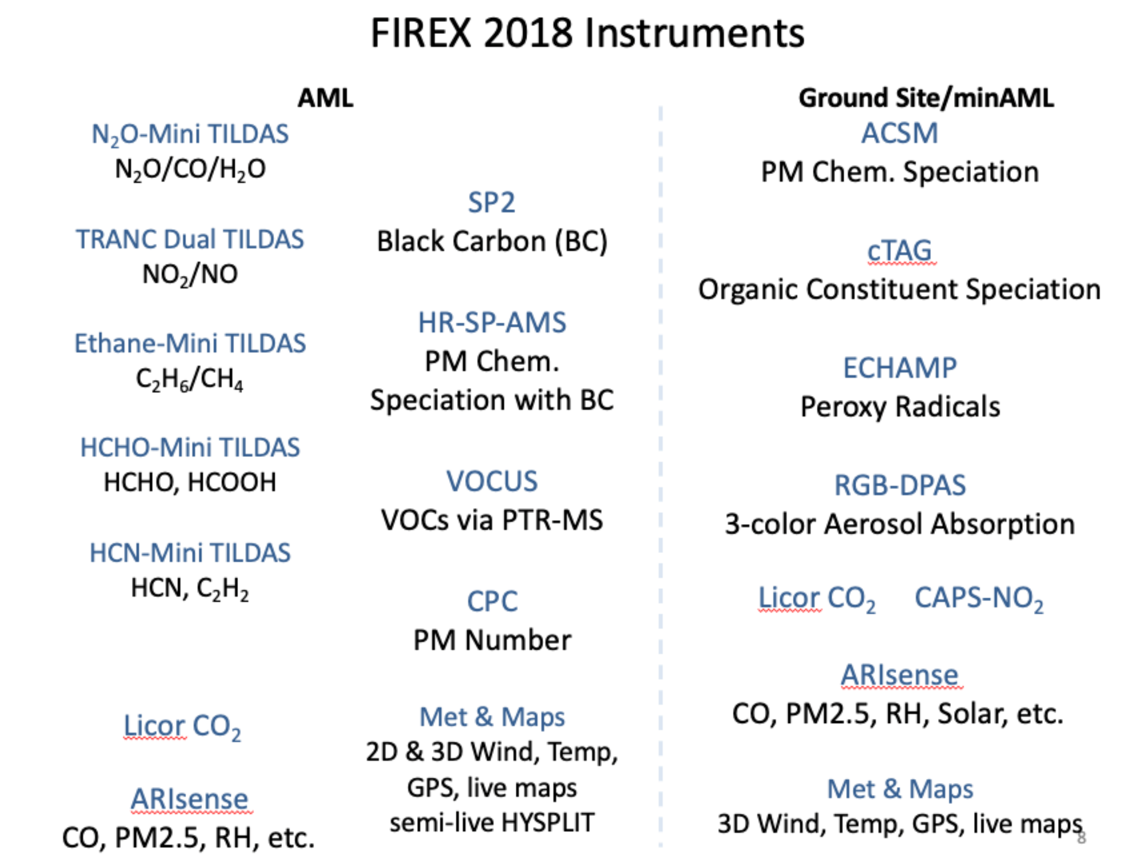


Figure 1. FIREX 2018 instrumentation. The cTAG and ECHAMP instruments were operated by collaborators.

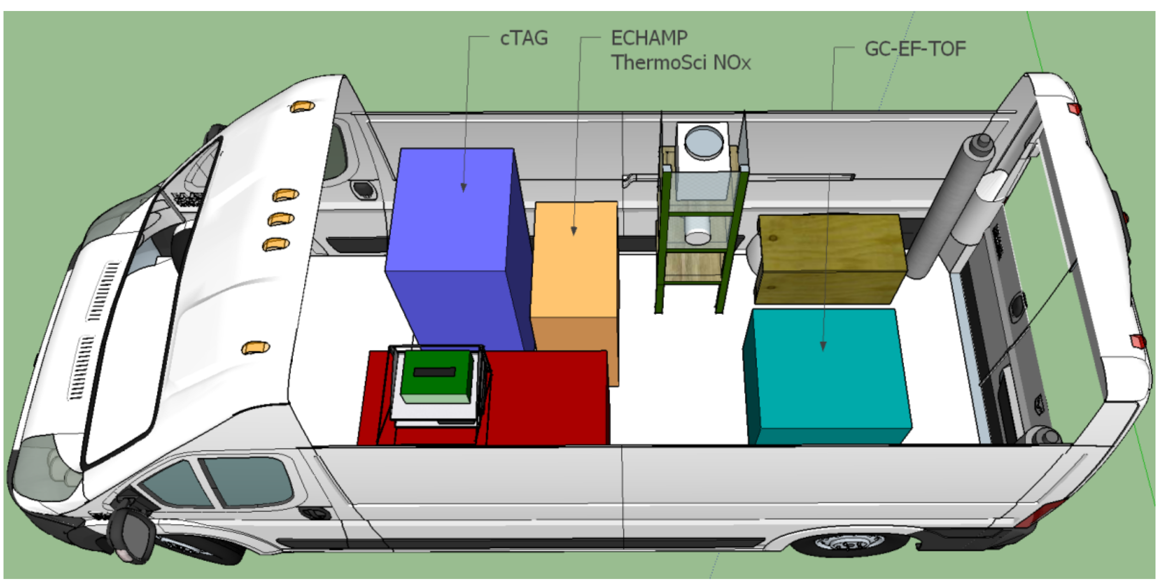


Figure 2. minAML layout for FIREX 2018. The cTAG and ECHAMP instruments were operated by collaborators. The GC-EF-ToF did not participate in FIREX

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.

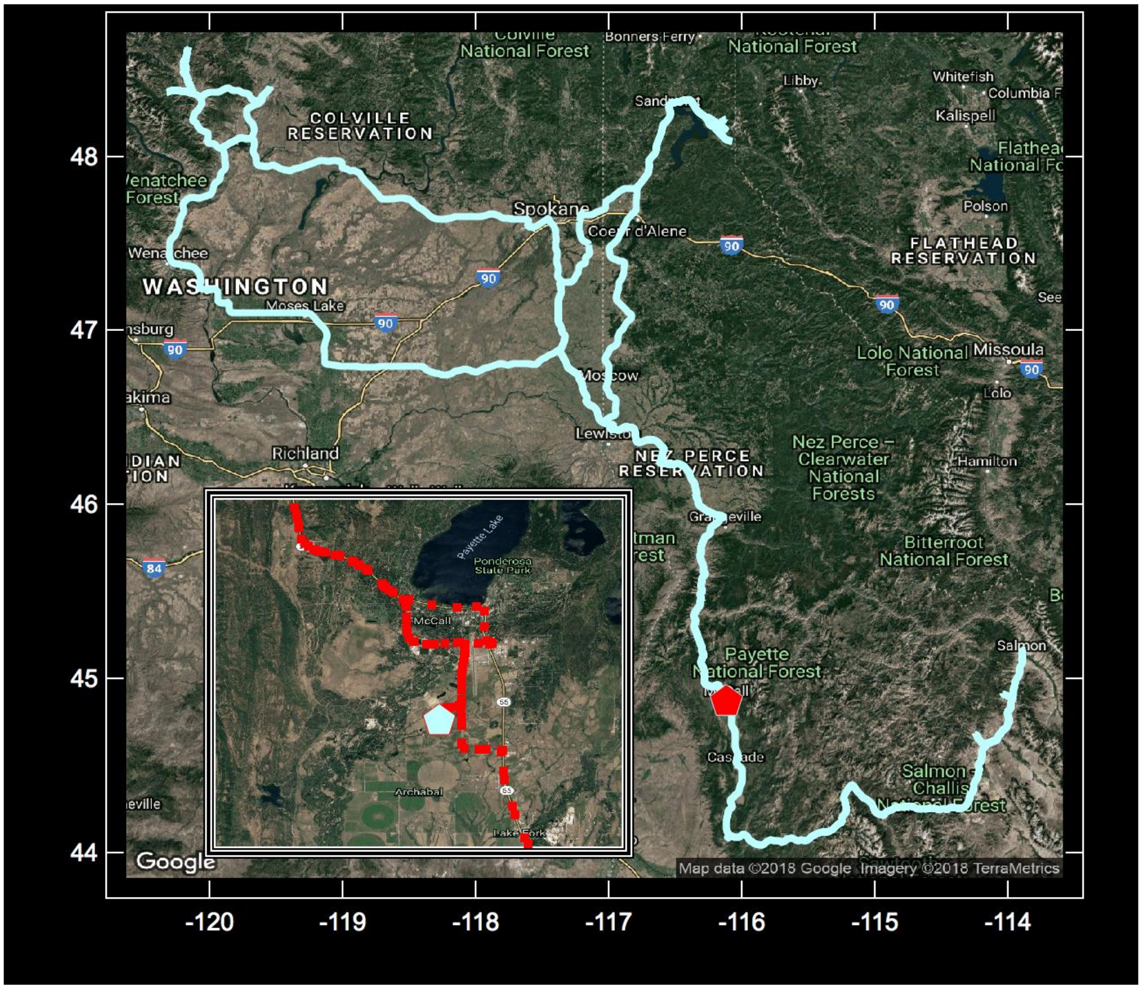


Figure 5. FIREX 2018 AML ground path, with inset map showing location of the McCall Activity Barn Ground Site

Associated Datasets

Comprehensive Thermal Desorption Aerosol Gas Chromatograph (cTAG)

Rebecca Wernis, UC Berkeley, rwernis@berkeley.edu

Yutong Liang, UC Berkeley, yutong.liang@berkeley.edu

ECHAMP

Ezra Wood, Drexel University, ew456@drexel.edu

GPS Coordinates, Wind Measurements, Outdoor Temperatures

Tara Yacovitch, tyacovitch@aerodyne.com

The Hemisphere GPS compass, model Vector V103, was mounted to the AML rooftop. Another unit 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.

Mobile (and duplicate stationary) wind was collected with a 2D RMYoung ultrasonic anemometer, model 86000, mounted to the AML rooftop above the driver at a height of 3.75 meters. Vehicle speed and heading from the GPS compass was used to correct the raw apparent wind into true wind.

A second 3D RMYoung ultrasonic anemometer, model 81000RE, was also mounted to the AML boom, and is used for outdoor temperature. Wind data from this unit is not reported because winds from the rear are shielded by the vehicle body.

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_Latitude	decimal degrees	AML	Mobile and stationary location of the AML
MM_Longitude	decimal degrees	AML	
MM_Northing	UTM meters north	AML	
MM_Easting	UTM meters east	AML	
MM_Zone	UTM zone	AML	Zones 10, 11 and 12 visited during the campaign.
MM_Elevation_m	meters	AML	Elevation of the AML relative to sea level, mobile and stationary. Measured by on-board GPS.
MM_truckHeading	degrees clockwise from true north	AML	Direction of the AML relative to true north. A heading of 45 degrees indicates that the AML is pointed north-east. Uses the HEHDT sentence type from the GPS compass
MM_truckSpeed_ kmph	kilometers per hour	AML	Uses the GPVTG sentence type from GPS compass
MM_truckTemperature_C	degrees Celsius	AML	Sonic temperature measured by the RMYoung 3D anemometer on the AML mast.
MM_AtmPressure	Atm	AML	Atmospheric pressure
MM_wind_dir_ degrees	degrees clockwise from true north	AML	Mobile or stationary incident wind direction aboard the AML, at 3.75 meters. A wind of 90 degrees indicates wind from the East.
MM_wind_speed_ metersPerSecond	m/s	AML	Mobile or stationary incident wind speed aboard AML, at 3.75 meters.
MM_wind_N_ metersPerSecond	m/s	AML	Vector representation of AML wind, with positive axis corresponding to wind with a component from the north.
MM_wind_E_ metersPerSecond	m/s	AML	Vector representation of AML wind, with positive axis corresponding to wind with a component from the east.
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 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.

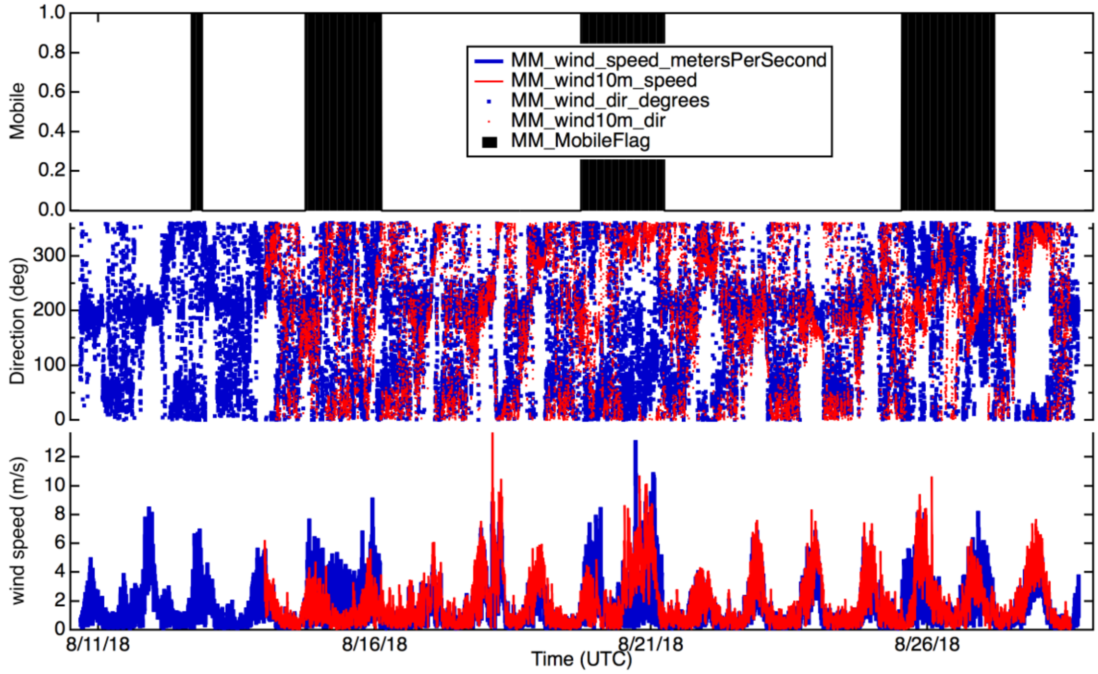
Estimates of GPS compass noise during the campaign were calculated by comparing the measured minAML location to its average location. The average deviation was 0.2 meters (1-second data). AML GPS accuracy will be similar, with possible degradations in areas with poor satellite reception.

The 1σ variation in measured wind speeds is 0.4 m/s at 1-minute for both the site's 3D anemometer (MM_wind10m_speed) and the AML's mobile wind (MM_wind_speed_metersPerSecond), 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).



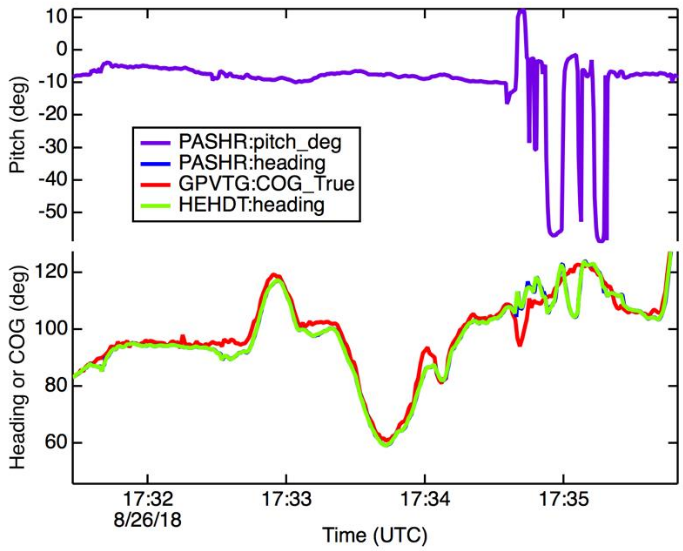
The algorithm used to subtract AML motion from apparent wind was exhaustively tested. Two versions of the algorithm were used. The first, appropriate for sea vessels or aircraft, subtracted course-over-ground and heading in two steps. The second, appropriate only for land vehicles with heading identical to course-over-ground, performed a simpler vector subtraction using heading. Both gave consistent results. The second algorithm was used to produce the data shown here due to its higher time resolution, and to glitches in the GPS compass-measured course over ground.

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.

Safe driving and legal height restrictions on the AML restrict how high the 2D anemometer can be lofted above the vehicle roof plane. The height of the wind sensor was a maximum of 6 inches above the rooftop. As a result, mobile wind measurements, particularly at high speeds, may be influenced by the aerodynamics of the vehicle. Winds during the campaign were often light and variable, making diagnosing issues with mobile wind difficult. Currently, use caution when interpreting mobile wind, particularly at low wind speeds and/or high truck speeds.

The GPS compass has an internal gyroscope which is used to measure pitch, roll, yaw and course over ground. Ground vehicles should have course over ground identical to their heading. A comparison of the two showed deviations in course over ground correlating to glitches in pitch, which may be due to malfunctioning of the gyroscope on bumpy roads. In the example below, pitch reaches an unphysical -50 degrees (equivalent to the AML climbing a too-steep-hill) following a glitch in the course over ground (red trace, around 17:34:40). For this reason, the course-over-ground was not used in calculation of mobile wind, using instead the more reliable heading.



In addition to the noted issues with measured pitch, unreasonable values for roll (sideways tilt) and yaw (rotation about a vertical axis, should be zero for a ground vehicle) were also noted. Such issues were not noted when using the GPS compass on a boat. This further suggests that the nature of the bumps encountered in the AML may be causing problems with the gyroscope. No data is reported for pitch, roll or yaw.

AML Interior Temperatures

An Omega RDXL4SD 4-channel Datalogger Thermometer was used to record interior temperature in the AML. Sensors were located in the pump box, in the front of the truck (in the aisle near the VOCUS) and in the rear of the truck (in the aisle near the AMS). These tracers should be used for instrument diagnostics. See MM_siteTemperature_C and MM_truckTemperature_C for outside air temperatures.

Name	**Unit**	**1 σ**
MM_AMLfrontTemp_C	degrees Celsius	< 0.1 °C at 1 min
MM_AMLrearTemp_C	degrees Celsius	< 0.1 °C at 1 min
MM_AMLpumpsTemp_C	degrees Celsius	0.1 °C at 1 min

Sharp spikes in the data were removed by filtering points with high values for the derivative of temperature. Noise performance was measured using Allan variance plots of temperature at a representative mid-day stable high period. The thermometer reports data at 0.1 °C, and 1σ noise performance exceeds or matches this metric at 1-minute timescales. No calibration was done on these diagnostic measurements.

CO_2_ppm

Licor 6262 CO2A

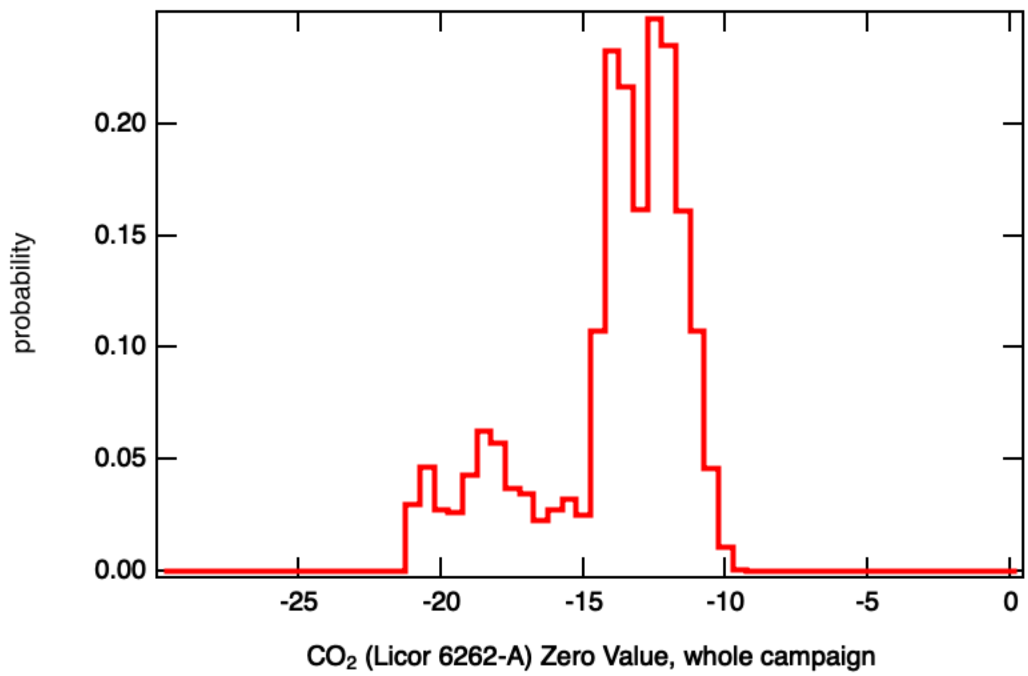
Concatenate all data files
sed away the lines with leading quote character
load into igor

run script found at CO2A adhoc-mask-zoz.ipf
    note that this contains manual index entries to tidy up found problems

correct for the contemporaneous zero

entry in the notes file from the 13th ….
using FIREX CO2 overblow single point
zero: -20.01ppm
cal: 355.4
span: 375.4, so cal = 375.4/401 = 0.936 cal factor

CAST procedure generated MM_CO2 and MM_CO2_ppm from this data source.



O_3

Rob Roscioli, Aerodyne Research, Inc, roscioli@aerodyne.com.

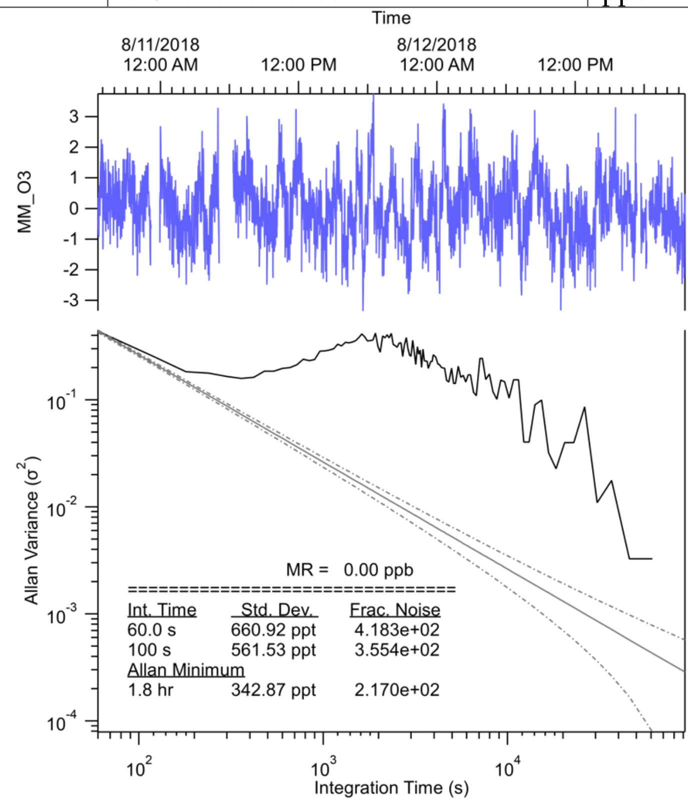
2B Tech Ozone

This instrument measures O3 concentrations using direct absorption of a UV lamp output. The instrument reports the difference between a sample measurement and an O3-scrubbed measurement. More information about principleof operation is here: https://twobtech.com/model-205-ozone-monitor.html. In this configuration, the instrument is acquiring a data point every 2 seconds, which is then average to 1 minute.

This instrument was mounted on the gas-phase lines of the AML

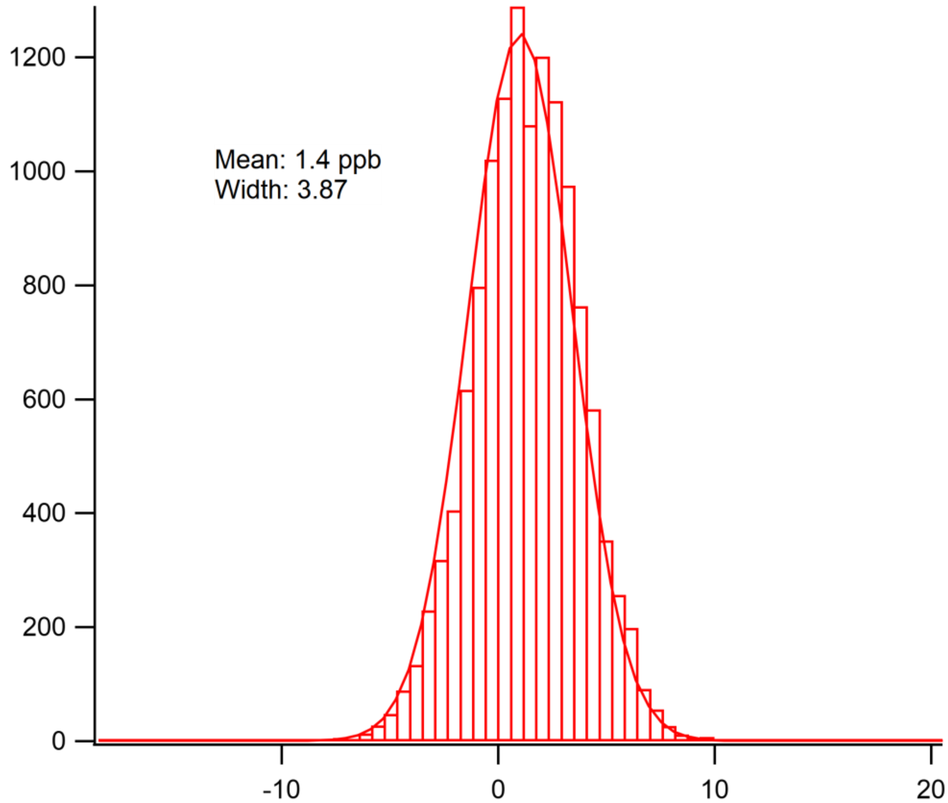
Data

Name	Description	Units	1 σ noise
MM_O3	UV Ozone Sensor	ppb	0.66 ppb



Calibration, Zeroing, Corrections

The O_3 measurement is uncalibrated. The zero level of the instrument was corrected by overblow the inlet with ultra-zero air every 15 minutes. For reference, the zero level is well-described by a normal distribution (below), with a bias (mean) of 1.40 ppb (and a 1-second width of 3.87 ppb).



Data issues

There appears to be some periods in motion where the monitor reports rapid (single-point) excursions that are negative or in the hundreds of ppb. These have been filtered out, as have periods where the inlet maintenance was performed or the flow was arrested for some other reason.

It is possible that in future revisions we will have a calibrated ozone source to perform a direct calibration of this instrument.

CO and N_2O

Scott Herndon, Aerodyne Research Inc., herndon@aerodyne.com
Tara Yacovitch (2021 and later) tyacovitch@aerodyne.com

CO and N_2O TILDAS-CS

This instrument measures CO, N_2O and water using tunable infrared laser direct absorption spectrometry (TILDAS). The instrument was mounted on AML during FIREX/WECAN 2018.

Note that during the initial portion of this measurement campaign, it was noted that a computer clock was still sat in the east coast time zone. The correction was made only to the recorded time, casting those data into UTC. All data reported is in UTC.

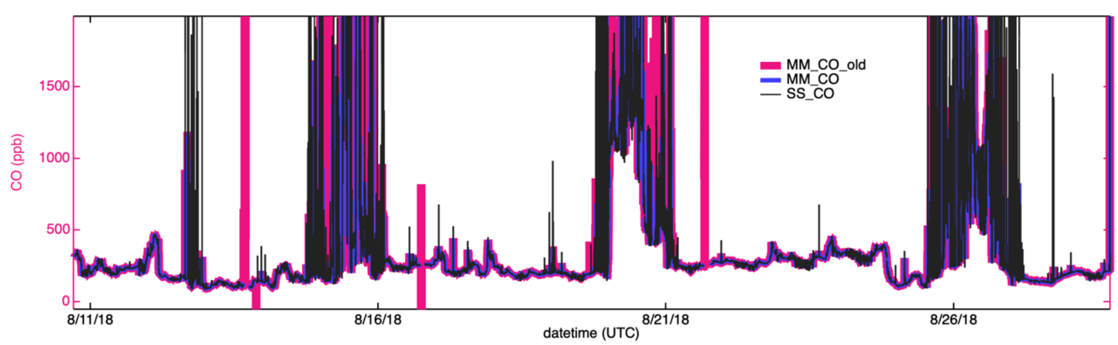
Data

Name	**Description**	**Unit**	**1-sigma noise**
MM_CO	Carbon Monoxide Mixing Ratio	ppb	
MM_N2O	Nitrous Oxide Mixing Ratio	ppb	
MM_H2O	Water Mixing Ratio	ppb	

Calibration, Zeroing, Corrections

Zero-air spectra were recorded automatically every 15 minutes by flushing the instrument with zero air.

The CO was calibrated using two flow controllers to dilute a certified cylinder. These tank-based calibrations were very close to 1.0. Based on tabulation of the various calibrations, a correction factor of 0.5% was be applied: divide data by 1.005. As of 01/12/2021, CO data is calibrated.



The present well-mixed ambient N_2O is 325-326 ppbv depending on season and proximity to sources. The unmodified ambient N_2O mixing ratios during the project were 323-324 ppb. We therefore postulate that a correction factor for the original data fits run on the live instrument would be ~ 326/323 = 1.009 or 1%. This factor should be applied multiplicatively. This compares favorably to the calibration of CO, which was measured using its absorption line in the same frequency window.

MM_CO Data output on 01/21/2021 also has had global SS_blacklist applied, which removes many instances of self-sampling, calibrations, etc.

Final Data

As of 01/12/2021, N_2O data is not calibrated.

No correction for inlet time has been made.

Data issues

HCN

HCN   TILDAS-CS

Rob Rocioli, Aerodyne Research Inc., roscioli@aerodyne.com.

Christoph Dyroff, Aerodyne Research Inc., cdyroff@aerodyne.com.

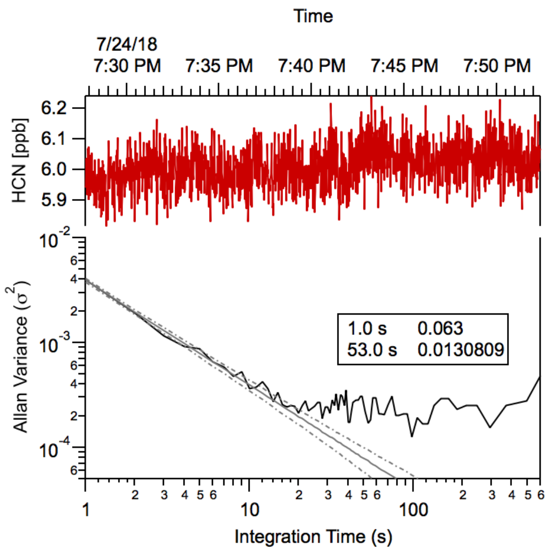
Hydrogen Cyanide (HCN) was measured with a tunable infrared laser direct absorption spectrometer (TILDAS) at 3287 cm-1. The instrument was operated in the Aerodyne Mobile Lab (AML).

Data

Name	**Description**	**Unit**	**1-sigma noise**
MM_HCN	HCN mixing ratio	ppb	≤ 0.013 (1 min)

Data provided from this instrument are HCN mixing ratios in parts per billion (ppb).

Instrumental uncertainty at the 1-sigma level for each produced data wave were derived from Allan-Werle analysis during “quiet” atmospheric conditions while sampling ambient air. Uncertainty is provided for 1 minute averages.



Calibration, Zeroing, Corrections

Zero-air spectra were recorded automatically every 15 minutes by flushing the instrument with zero air.

Calibrations were performed in the field using a 2 ppm HCN tank. Post-campaign calibration was performed using a 10 ppm and 1 ppm tank. Tank air was diluted into a high flow of zero air via a set of flow controllers. Cal gas was injected at tip of AML inlet line. The calibrations were not consistent, and further validation of the instrument response is required.

Data were filtered based on the "AML blacklist" that was produced during the campaign. This blacklist mostly covered vehicle emissions while the AML was mobile. Further filtering was performed by *visual inspection* to remove data artefacts due to sticky nature of HCHO and HCOOH.

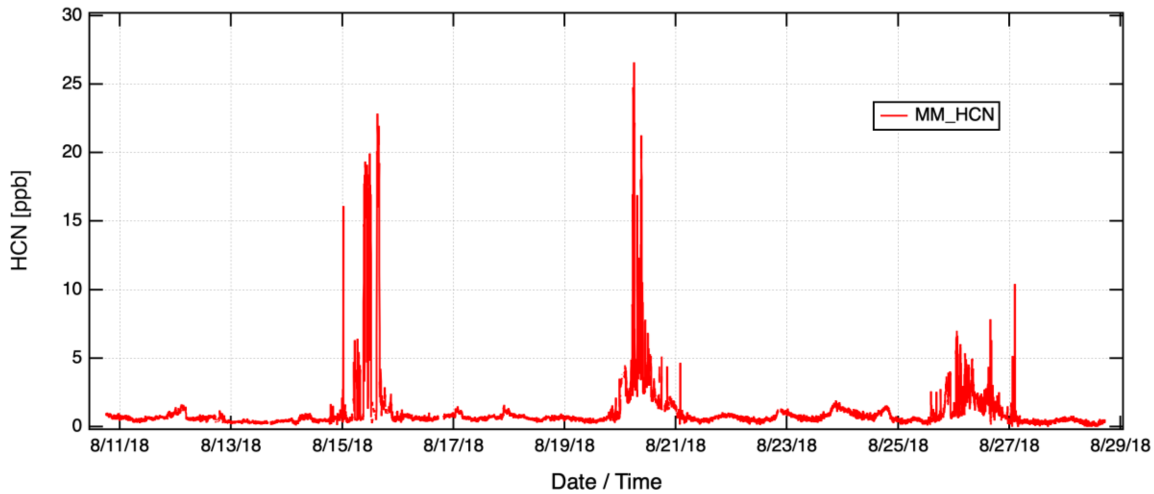
Igor history for QA on 10/16/2018 is provided in:

2018-10-18_HCHO_QA_IgorHistory.txt

Additional Igor QA wave is provided in:

2018-10-16_QA_wave_CD.ibw

Final Data



Data issues (R.R.)

1) HCN compact TILDAS had an incorrect tuning rate for the first few days. Corrected by floating fit instead, and pulled out data where the HCN peak position was not in the range of 62.5-65.2. The tuning rate was corrected on Aug 13 when we did a cal, so data after that has a fine tuning rate.

2) The original fit used a wide fit range for HCN, but we found that motion sickness (and general wander) was greatly reduced when we narrowed the fit to a 25-bin range around the HCN peak. So all data was refit with that fit setup.

The resulting 1-s data is stitched from 2 pieces: from 8/10-8/13 (21:00) the fit was narrow (25 bins) and peak position was floated; after 8/13 (21:00), the fit was narrow, but peak position relied on the original flk4 position (i.e. was fixed in playback).

The floated peak positoin during 8/10-8/13 usually converged in the 62.5-65.4 range, but when it didn't it was eliminated. Average position over a 36-hr period was 63.95, with an SD of 0.39. The 62.5-65.4 range contains 99.99% of the actual data. In addition there are occasional 1-s spikes even with a correct fit position resulting in concentration values that were unreasonable and clearly not real. These 1-s spikes were eliminated if they were above 3 ppb, or less than 0.05 ppb. This filtering range was based on observed concentrations of the rest of the dataset during this time. Over a typical, quiet 15 hr time frame the mean [HCN] was 0.336 ppb, with a SD of 0.077. This low end cutoff of 0.05 ppb was therefore 3.7 SD's away from the mean, corresponding to >99.99% retention of the data.

for data refit with floated position 8/10-8/13

```
HCN_poscor=HCN
HCN_poscor[]=(stc_pos1[p]>65.4)||(stc_pos1[p]<62.5) ? nan : HCN[p]
HCN_poscor[]=HCN[p]<0.05 ? nan : HCN_poscor[p]
HCN_poscor[]=HCN[p]>3 ? nan : HCN_poscor[p]
```

Stitching time is 180813, 21:05:00, point 256432

```
duplicate/o root:fixedpos:str_source_rtime root:stitchedtime
root:stitchedtime[0,256432]=root:pb_floatedpos:str_source_rtime[p]
root:stitchedtime[256433,]=root:fixedpos:str_source_rtime
duplicate/o root:fixedpos:HCN root:stitchedHCN
root:stitchedHCN[0,256432]=root:wd_floatedHCN_strstc:HCN_poscor[p]
root:stitchedHCN[256433,]=root:fixedpos:HCN
```

Finally, there are a few [HCN] values within the fixed position data that gives very negative or very positive values. Removing those using

```
duplicate/o stitchedHCN stitchedHCN_filt
stitchedHCN_filt[]=(stitchedHCN_filt[p]<50 && stitchedHCN_filt[p]>-1) ? stitchedHCN_filt[p] : nan
```

Further QA (C.D.)

- HCN data cleaned up with 1-sec AML blacklist wave.
- Visual inspection and cleaning up of zero air data and data where abg was bad, i.e. bias artefact.
- Generated MM_HCN wave.

C_2H_2

TILDAS HCN/C2H2 instrument

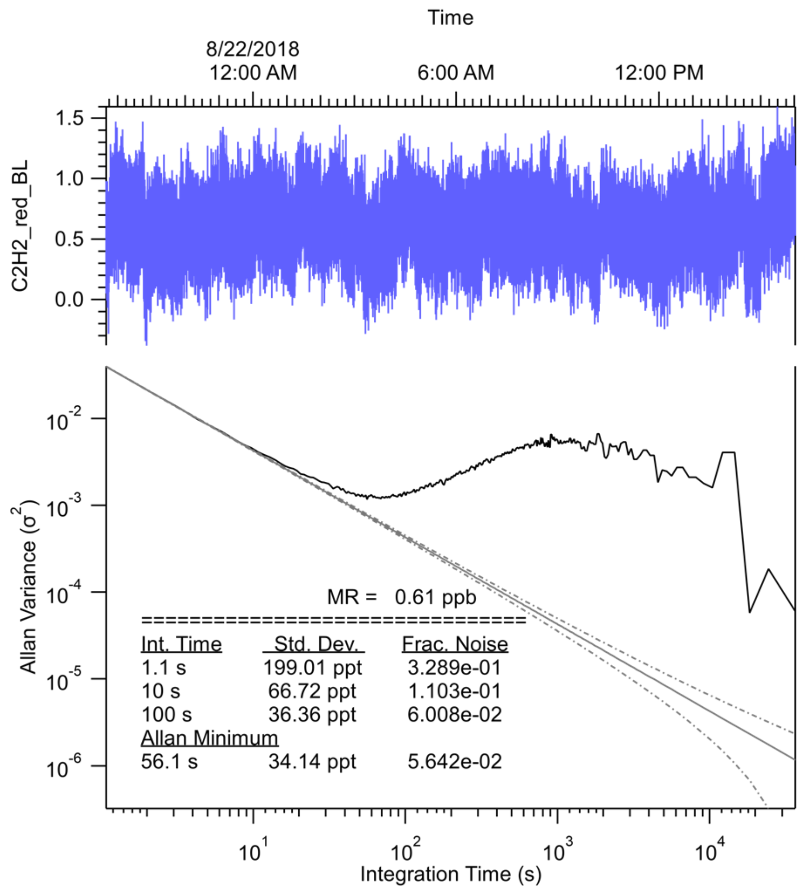
Rob Roscioli, Aerodyne Research, Inc., roscioli@aerodyne.com.

This instrument measures HCN and C_2H_2 (discussed here) at 3 microns using tunable infrared laser direct absorption spectrometry (TILDAS). The instrument was mounted on AML during FIREX/WECAN 2018.

Data

Name	**Description**	**Units**	**1 σ noise**
MM_C2H2	Acetylene	ppb	0.038 ppb

Notably, the C2H2 exhibited some drift due to temperature fluctuations (while stationary) and motion sickness (while in motion). This leads to jumps every 15 minutes (on the auto-zeroing schedule) that can sometimes be in excess of 100 ppt.



Calibration, Zeroing, Corrections

The instrument was calibrated at the beginning and end of the campaign, with nearly identical values (1.08 and 1.11). The reported data is therefore corrected by 1/1.095. The instrument was zeroed every 15 minutes by overblowing the communal inlet with ultra zero air.

Data issues

In addition to the calibration correction, data was filtered during period of extreme motion sickness (typically resulting in mixing ratios less than zero), during times of instrument maintenance and calibrations, or when flow was arrested.

On Aug 13th, a calibration was performed that allowed us to correct the tuning rate of the laser. Prior to this, the C_2H_2 peak position was <1/4 peak width incorrect. As such, the during this time mixing rations may be biased slightly low by roughly 10%.

C_2H_6, CH_4

C2H6 TILDAS-CS

Scott Herndon, Aerodyne Research Inc., herndon@aerodyne.com.
Dan Anderson, Drexel.

Ethane (C_2H_6) was measured with a tunable infrared laser direct absorption spectrometer (TILDAS). The instrument was operated in the Aerodyne Mobile Lab (AML).

Data

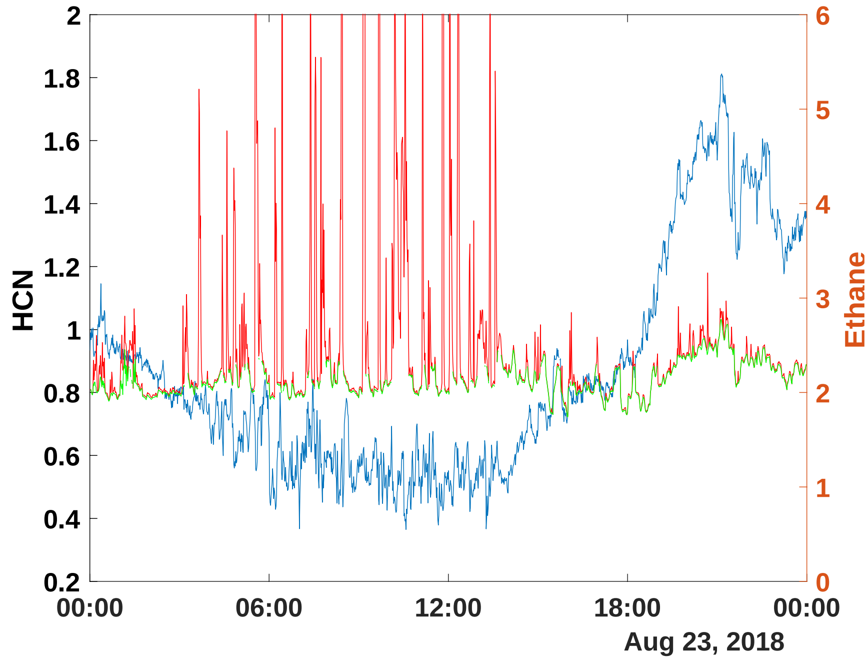
Name	**Description**	**Unit**	**1-sigma noise**
MM_C2H6	Ethane mixing ratio	ppb	
MM_CH4	Methane Mixing Ratio	ppb	

Calibration, Zeroing, Corrections

Zero-air spectra were recorded automatically every 15 minutes by flushing the instrument with zero air.

Data has been calibrated by dividing by 0.856 and is updated as of 01/15/2021.

Spikes in the data were present due to waste ethane emitted by the ECHAMP system. This data was filtered by D. Anderson to remove spikes.



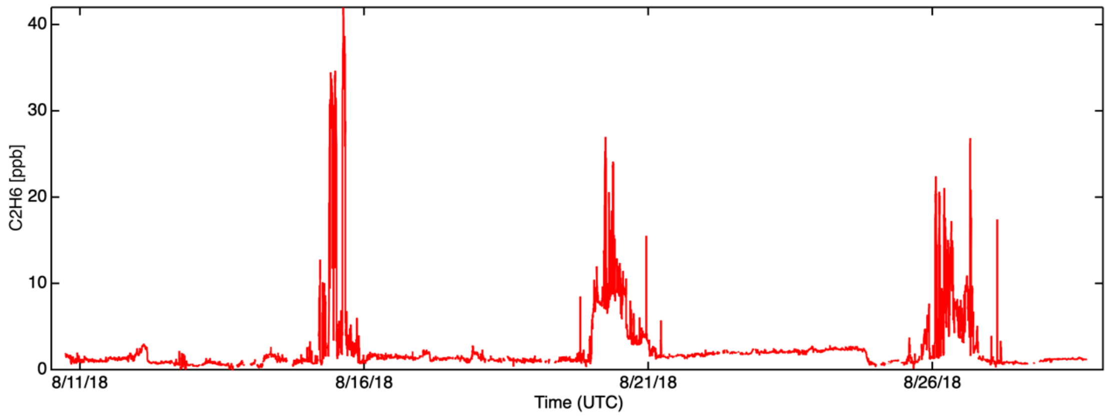
To filter out the influence from the ECHAMP exhaust, all ethane values above a daily-dependent threshold were filtered out. This was determined by eye to remove obviously adulterated samples and facilitated easier filtering later on in the process. The cut off value was dependent on the day because the background C_2H_6 value changed throughout the course of the campaign. Next, using a regression of the 1-minute HCN values and 1-minute C_2H_6, C_2H_6 values were removed that were higher than a daily dependent threshold where HCN was less than a certain value (normally about 0.8 ppbv). Then, a 5-minute running median was used to remove all data above the 80th percentile. Finally, data was manually removed data for times that the above process failed to remove the obvious ECHAMP influence. This was only done for times where HCN indicated no significant biomass burning influence.

No spikes were removed for Aug.10-12 because there was no discernible influence from ECHAMP. No spikes were removed for the 15th, 20th, or 26th because AML was not at the Activity Barn.

Particularly on the 13th and 14th, there are large periods where data negative or near zero. No changes by D. Anderson with this since it's an instrumental issue.

Select other portions of the data (spikes, spurious zeroes) were manually removed from the 1-minute wave by T. Yacovitch.

Final Data



Data issues

None

HCHO / HCOOH

HCHO / HCOOH   TILDAS-CS-068

Christoph Dyroff, Aerodyne Research Inc., cdyroff@aerodyne.com.

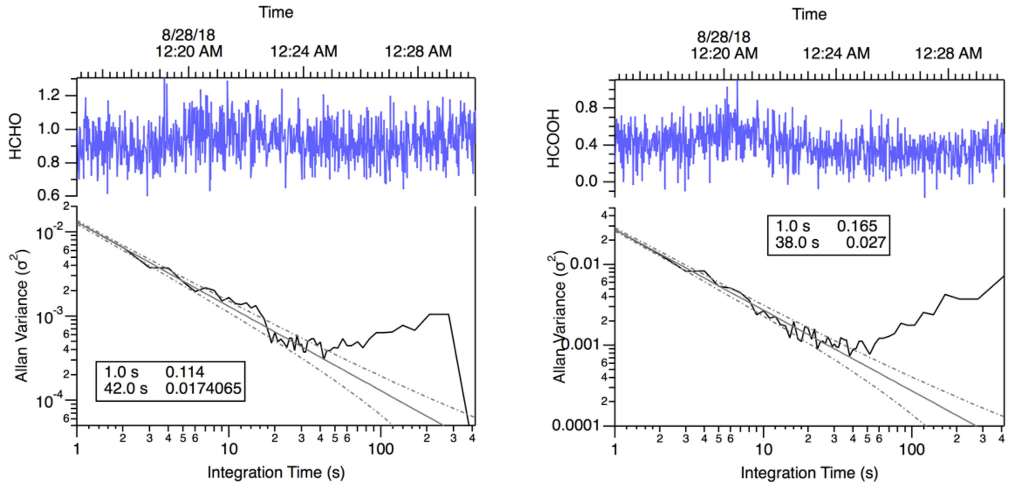
Formaldehyde (HCHO) and Formic Acid (HCOOH) were measured with a tunable infrared laser direct absorption spectrometer (TILDAS) at 1765 cm-1. The instrument was operated in the Aerodyne Mobile Lab (AML).

Data

Name	**Description**	**Unit**	**1-sigma noise**
MM_HCHO	HCHO mixing ratio	ppb	≤ 0.017 (1 min)
MM_HCOOH	HCOOH mixing ratio	ppb	≤ 0.027 (1 min)

Data provided from this instrument are HCHO and HCOOH mixing ratios in parts per billion (ppb).

Instrumental uncertainty at the 1-sigma level for each produced data wave were derived from Allan-Werle analysis during “quiet” atmospheric conditions while sampling ambient air. Uncertainty is provided for 1 minute averages.



Calibration, Zeroing, Corrections

Zero-air spectra were recorded automatically every 15 minutes by flushing the instrument with zero air.

Briefly describe calibration procedure. State any calibration factors or response factors applied.

Data were filtered based on the "AML blacklist" that was produced during the campaign. This blacklist mostly covered vehicle emissions while the AML was mobile. Further filtering was performed by *visual inspection* to remove data artefacts due to sticky nature of HCHO and HCOOH.

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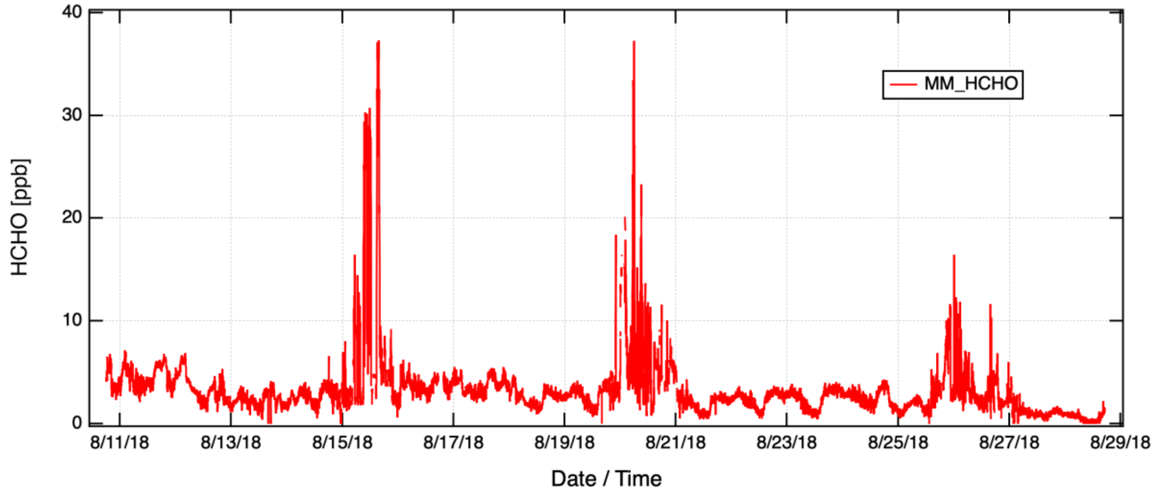
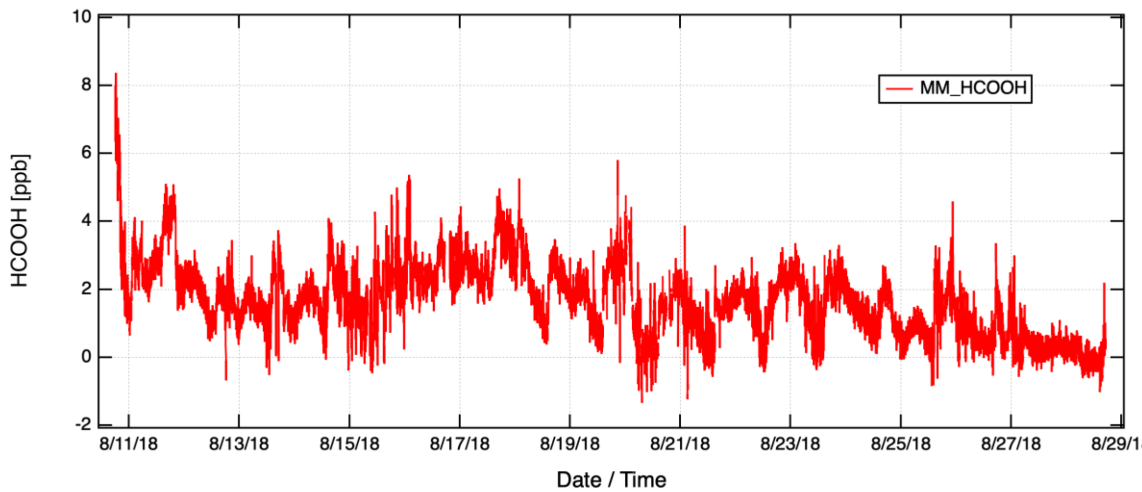
2018-10-16_QA_wave_CD.ibw

Final Data





Data issues

During some time periods, HCOOH is showing artefacts after switching back from Zero air to ambient air. Possible filter desorption? This was manually cleaned up but might deserve a deeper look, see 2018-10-16_QA_wave_CD.ibw.

NO/NO_2

"TRANC" NO/NO_2

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This instrument measures NO @ 1900 cm-1 and NO2 at 1626 cm-1 using tunable infrared laser direct absorption spectrometry (TILDAS). The instrument was mounted on AML during FIREX/WECAN 2018.

Data

Name	Description	Units	1 σ noise
MM_NO	Nitric Oxide (1-s)	ppb	0.026 ppb
MM_NO2	Nitrogen Dioxide	ppb	0.034 ppb

Notably, the NO in particular exhibited some drift due to temperature fluctuations (while stationary) and motion sickness (while in motion). This leads to jumps every 15 minutes (on the auto-zeroing schedule) that can be in excess of 100 ppt.

Calibration, Zeroing, Corrections

Instrument was zeroed every 15 minutes using an auto-backgrounding routine.

NO was calibrated at the beginning and end of the campaign, with cal values of 1.002 and 1.015 respectively. A calibration factor of 1/1.0085 was therefore applied to the dataset. Multipoint dilution calibrations were performed using a pair of Alicat mass flow controllers.

While the NO2 measurement was more robust during the campaign, the NO measurement was susceptible to an optical fringe that cause a temperature and motion dependence. As such, the spectrum has been refit using a 0.0225 cm-1 fringe fit included. The result is somewhat less drift in NO.

In order to remove short, transient sources of NO and NO2 (i.e. traffic or self-sampling), a filter was applie: if the NO was >10 ppb or <-3 ppb, then the data within 5 seconds of that was removed. In addition, if NO2 was greater than 25 ppb or less than -3 ppb, it was also removed. This effectively removed transient NO2 spikes and dips due to instrument maintenance while the instrument was recording data.

SPAMS

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The Aerodyne Soot Particle Aerosol Mass Spectrometer (SPAMS) was operated on board the Aerodyne Mobile Laboratory (AML) from 08/11 – 08/28. The instrument sampled approximately 1/3 of the time with the 1064 nm laser on enabling detection of refractory particles such as black carbon while the other 2/3 of the time the instrument was run as a conventional HR-ToF-AMS with the laser off. During mobile measurements the SPAMS was frequently operated in 1 second mode (FMS) while the remainder of the measurements produced 1 minute data points. Data products are chemically speciated

Organic, Sulphate, Nitrate, Ammonia, and Chloride particulate matter with the laser off. With the laser on Black Carbon is measured in addition to the previously mentioned species. The units of measurement are ug/m3.

Data is reported at STP, but in reference to the pressure and temperature of the location of the flow calibration. This measurement was done in Diamond Bar, CA, elev 660 ft. T = 295 Kelvin P = 992 mbar.

Noise determination

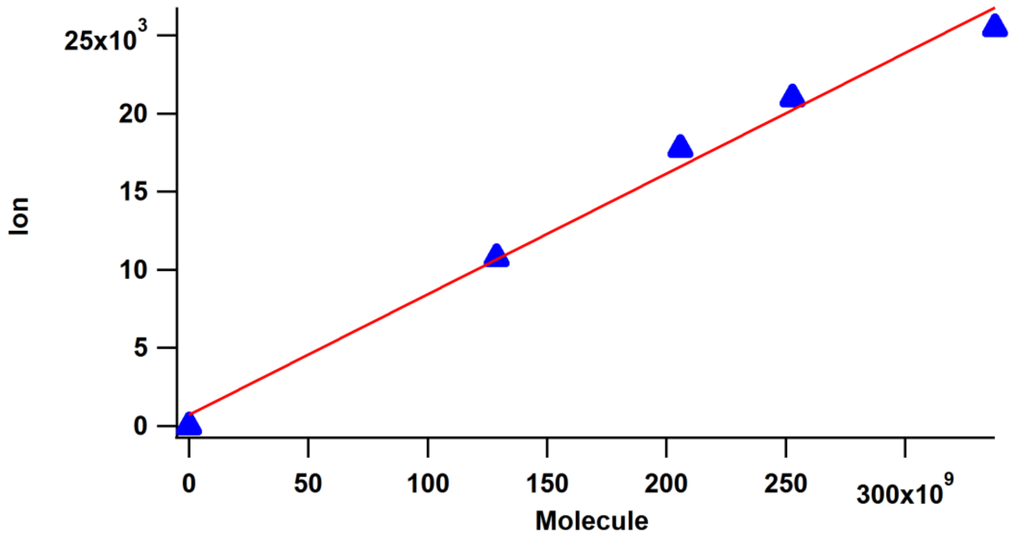
Noise values for each species measured are depicted in the table below. They were determined through filter application to the front of the particle inlet conducted roughly on a daily basis.

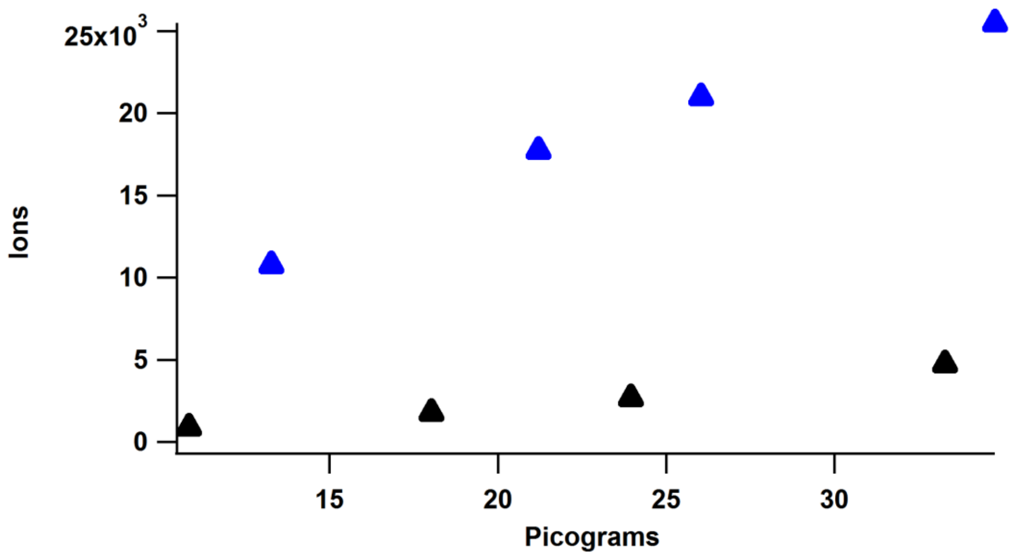
Name	Description	Units	1 Sigma Noise
MM_SP_Chl	Particulate matter Chloride mass	ug/m3	0.00675
MM_SP_NH4	Particulate matter Ammonium mass	ug/m3	0.024
MM_SP_SO4	Particulate matter Sulfate mass	ug/m3	0.0124
MM_SP_NO3	Particulate matter Nitrate mass	ug/m3	0.00805
MM_SP_Org	Particulate matter Organic mass	ug/m3	0.196
MM_SP_BC	Particulate matter Black Carbon mass	ug/m3	0.0294
MM_AMS_Chl	Particulate matter Chloride mass	ug/m3	0.00626
MM_AMS_NH4	Particulate matter Ammonium mass	ug/m3	0.00778
MM_AMS_SO4	Particulate matter Sulfate mass	ug/m3	0.0136
MM_AMS_NO3	Particulate matter Nitrate mass	ug/m3	0.0107
MM_AMS_Org	Particulate matter Organic mass	ug/m3	0.0927
MM_AMS_CPC	Particulate number	#/cm3	0.00506

Table 1: Noise values for each measured species.

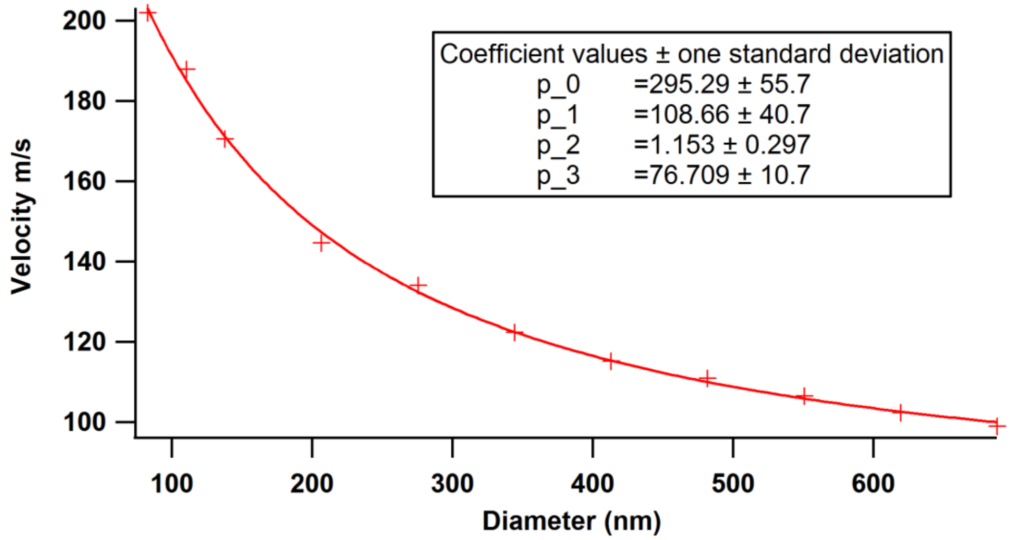
Calibration Methods

Calibrations were conducted on 3 occasions during this field campaign, 8/13, 08/21 and 08/27. Ammonium Nitrate (NH_4NO_3) in solution (.005M/100ml) with H_2O was atomized, dried, size selected for 300 nanometers (nm) and then sampled by the SPAMS with laser off (in normal AMS mode). The overall ionization efficiency (IE) of the SPAMS was determined by these NH4NO3 calibrations to be 7.54e-8 ions/molecule. Black Carbon (BC) calibrations with Regal Black at (.01M/100ml) in solution and size selected for 300 nm were also conducted on these 3 occasions with the SP laser on. A relative ionization efficiency of .333 for BC was determined by comparison of the Regal black and NH_4NO_3 calibrations. A CE of .5 was applied to all species. The calibration of 08/13/18 is depicted in figure 1.





A velocity calibration was conducted at McCall ID and subsequent velocity calibrations were conducted at Aerodyne post campaign to duplicate the pressure conditions encountered during the Clear Creek and Twisp mobile deployments. The Rabbit Foot deployment was at a pressure similar to McCall. The Velocity Calibration from Mcall is depicted below.



Comparison with ACSM:

A quadrupole ACSM also measured at McCall for the duration of the campaign and comparison with ACSM yielded a slope of approximately 1.3 for Organics. This is expected due to the different lenses on the 2 instruments. The ACSM had a PM 1 Lens installed while the PSAMS had a PM2.5 lens installed. During clean periods with a smaller size mode agreement approached 1:1.

Data Issues

This SPAMS has a PM 2.5 lens installed. Between 100 nm 2.5 um transmission through the lens is close to 100% but smaller and larger particles will have lower transmission efficiencies and this is always important to consider when comparing this measurement to other aerosol measurements of mass. When conducting laser on measurements we are still learning why we typically get a higher Org value and to a lesser extent other species then we do when sampling as a regular AMS. This is particularly pronounced with biomass particles and we are currently researching whether this difference is due to particle size (biomass particles during this campaign tended to be large) or chemistry (are some of these organics actually refractory so they wouldn't be seen with AMS) or some mixture of the two. On the other hand there are time periods during this campaign which are cleaner where laser on and laser off Organic appear to line up closely.

CPC

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A TSI Model 3775 CPC was operated in low flow mode (300 cc/min) for the duration of the campaign with the inlet flow being pulled from a tee just upstream of the SPAMS. The data reported was saved by the SPAMS coincident with SPAMS data saves. CPC background was determined coincident with SPAMS background during the aforementioned filter periods. The 1-sigma noise values for the CPC are 0.005 cm^{-3}, as reported in the table above.

Vocus PTR-MS

Data PI: Jordan Krechmer (krechmer@aerodyne.com)
Contact person: Tara Yacovitch (tyacovitch@aerodyne.com)

The Vocus Proton Transfer Reactor Time of Flight Mass Spectrometer (Vocus PTR-TOFMS) was deployed on the Aerodyne Mobile Laboratory (AML). This instrument measured the time of flight of several gas-phase volatile organic compounds (VOCs), converting them to mass-to-charge ratios using mass calibration parameters. Each of the signals was detected as a voltage and converted to ions per second.

Data

The table below lists the compounds that were output as part of the field data. The raw data collected was processed using custom software based on Igor Pro (Tofware, by TOFWERK and Aerodyne Research Inc). The updated data output includes high-resolution ions reported in parts-per-billion (ppb) concentrations. The concentrations of high-resolution ions as a function of time are identified by their wave names. Select species were calibrated based on their concentration in a quantified standard calibration tank (Apel-Riemer Environmental).

For species that were not explicitly calibrated with an external standard, the measured signal in ion counts per second (cps) were converted to ppb using calculated calibration factors using the method defined in Sekimoto et al. [*Sekimoto et al.*, 2017]. For each species that was calibrated, the sensitivity (cps/ppb) with the proton capture rate constant from the literature was plotted. A linear regression was fit to the plot and the slope was used to calculate sensitivities for the uncalibrated species whose capture rate constants were estimated from elemental properties.

The high-resolution ion formulas listed in the table could correspond to several potential species of interest. It is important to note that there may be other species or isomers not listed at that mass that may contribute to signal enhancements. Fragments or clusters from other compounds may also contribute to the signal.

WaveName	**Vocus Chemical Formula**	**m/z**	**Other Known Contributors***	**ICARTT Standard Name**
MM_Acetonitrile	C2H3NH+	42.034		Gas_CH3CN_InSitu_S_AMF
MM_Acetaldehyde	C2H4OH+	45.033		Gas_CH3CHO_InSitu_S_AMF
MM_Acrylonitrile	C3H3NH+	54.034		Gas_Acrylonitrile_InSitu_S_AMF
MM_Acrolein	C3H4OH+	57.033		Gas_Acrolein_InSitu_S_AMF
MM_Acetone	C3H6OH+	59.049	propanal	Gas_AcetoneAndPropanal_InSitu_M_AMF
MM_AceticAcid	C2H4O2H+	61.028	glycolaldehyde	Gas_CH3COOH_InSitu_S_AMF
MM_Furan	C4H4OH+	69.033		Gas_Furan_InSitu_S_AMF
MM_Isoprene	C5H8H+	69.070	hydrocarbon fragments	Gas_Isoprene_InSitu_S_AMF
MM_MEK	C4H8OH+	73.065		Gas_MEK_InSitu_S_AMF
MM_Benzene	C6H6H+	79.054		Gas_benzene_InSitu_S_AMF
MM_Diacetyl	C4H6O2H+	87.044	2,3-butanedione, methyl acrylate, others.	Gas_C4H6O2_InSitu_M_AMF
MM_Toluene	C7H8H+	93.070		Gas_Toluene_InSitu_S_AMF
MM_Phenol	C6H6OH+	95.049		Gas_Phenol_InSitu_S_AMF
MM_Furfural	C5H4O2H+	97.028		Gas_Furfural_InSitu_S_AMF
MM_C2Benzene	C8H10H+	107.086		Gas_C8Aromatics_InSitu_M_AMF
MM_Catechol	C6H6O2H+	111.044	other isomers	Gas_C6H6O2_InSitu_M_AMF
MM_hydroxyfurfural	C5H4O3H+	113.023	5-hydroxy 2-furfural, 2-furoic acid	Gas_C5H4O3_InSitu_M_AMF
MM_C3Benzene	C9H12H+	121.101		Gas_C9Aromatics_InSitu_M_AMF
MM_Guaiacol	C7H8O2H+	125.060		Gas_Guaiacol_InSitu_S_AMF
MM_Terpenes	C10H16H+	137.132	monoterpenes	Gas_Monoterpenes_InSitu_M_AMF

* For a more complete list of potential contributors see [*Koss et al.*, 2018] and https://tinyurl.com/PTRLibrary

ARISense

Data PI: Eben Cross.
Contact person: 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.

Name	**Description**	**Units**	**site**
MM_ARIsense_solar_ArbUnits	insolation	Arbitrary units	AML
MM_ARIsense_RH	Relative humidity	%	AML
MM_ARIsense_PM1	Integrated mass concentration < 1 µm	$\mu m/m^3$	AML
MM_ARIsense_PM2	Integrated mass concentration < 2 µm	$\mu m/m^3$	AML
MM_ARIsense_PM10	Integrated mass concentration < 10 µm	$\mu m/m^3$	AML

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