Characterization of Aeris MIRA Ultra CH_4/C_2H_6 and N_2O/CO Analyzers

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Introduction

The Aeris MIRA Ultra CH_4/C_2H_6 (Ultra 460) and N_2O/CO (Ultra 505) Gas Analyzers are new, lightweight, state-of-the-art laser spectrometers recently aquired by the Department of Atmospheric Science. Their full characterization is necessary for deployment in future projects, work which is well underway. This is primarly done through comparison with reference instruments, in this case a Picarro G2401-m (CO_2, CH_4, CO, H_2O), an Aerodyne C_2H_6 TILDAS, and an Aerodyne N_2O TILDAS (pictured below).

Benchtop Tests

The first test of the instruments took place in the lab, sampling ambient air, from June 5th through June 15th (Figure 1). Calibrations were conducted on the 5th and the 7th while connected to a reference cylinder. Unlike the reference instruments, the Aeris instruments calibrate internally via the user interface. Post-calibration data from the day of the 10th were used to compute linear regressions in Python (Figure 2), in which all species but Nitrous Oxide performed reasonably well. Data from the first hour of the 11th were used to compute Allan Variances in Igor Pro (Figure 3), the results of which are discussed later. On-off tests were performed on the 14th and 15th, ranging from 15min to 18hr. These found that both Aeris instruments need significant time (~1hr) to fully warm up.

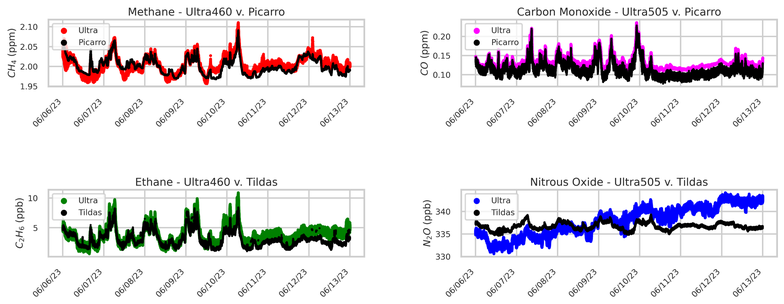

Figure 1. Raw data from the Aeris instruments compared with reference instruments from June 6th to June 13 , trimmed to exclude warmup and on-off tests

Mobile Lab Tests

After installation of the Aeris and reference instruments on the Mobile Lab, test deployments were undertaken on August 23rd, 24th, and 29th, to Medicine Bow Peak, Rodger's Canyon, and Greely, CO respectively. The fourth deployment (Figure 3) deployment took place on September 29th, sampling air around three concentrated animal feeding operations (CAFOs) and through oil and gas fields, where there is sufficient variation in CH_4 and C_2H_6. Ambient temperature and pressure were sampled and were not found to have significant impact on concentration measurements.

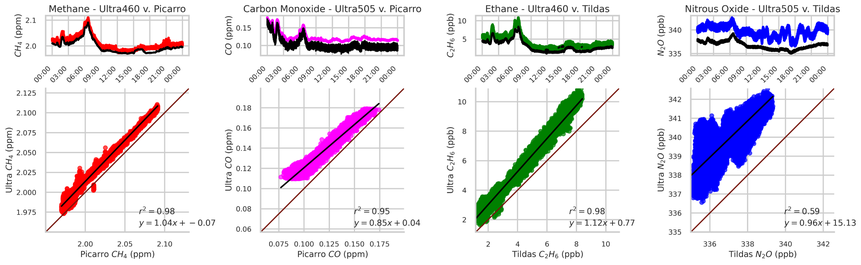

Figure 2. Correlations of Aeris to reference for benchtop data sampled from midnight June 10th to midnight June 11th , with comparisons from these times displayed above

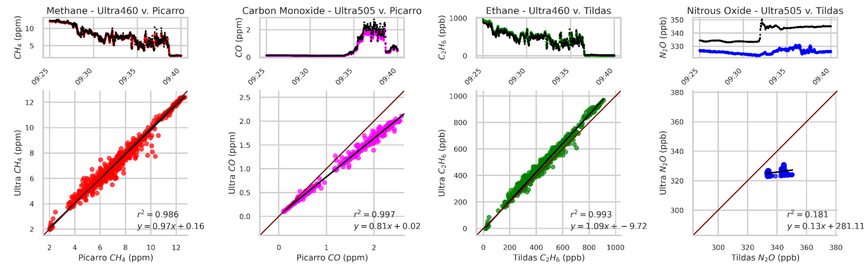

Figure 3. Correlations of Aeris to reference for mobile lab data sampled from September 29th

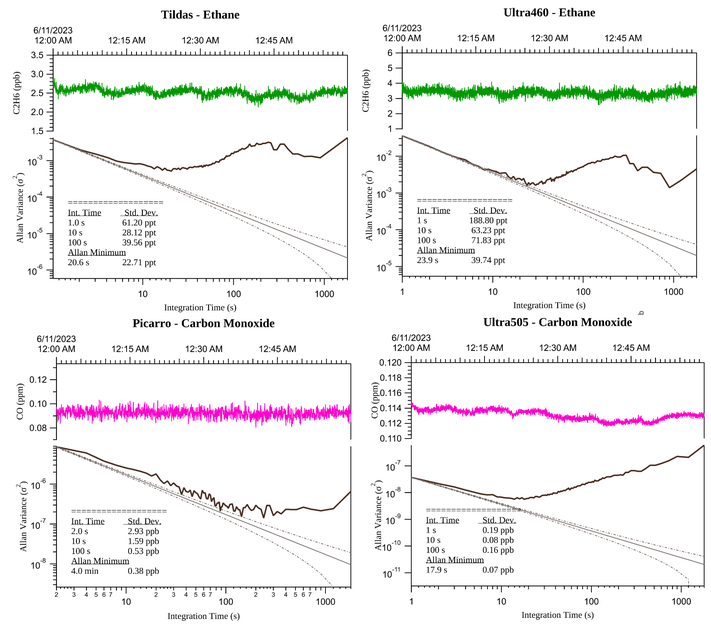

Figure 4. Allan Variances for Ethane and Carbon Monoxide, computed over a one hour period (0000 – 0100 MST) on June 11th

Results

To compare with reported specifications from Aeris, lab data and mobile data were analyzed. The mobile data were included for some analysis to examine if the Aeris performance changed in expected real world sampling conditions. Precision was computed Allan Variances (Figure 4) at 1s, since the instruments sample at 1Hz. Drift was calculated by taking hourly means, subtracting the reference instrument mean, and then subtracting the first hourly mean from the last for every day in the June 6th to 13th period. The maximum value was taken as the 24hr drift. Results from this analysis are reported in Table 1. All species are sampled at finer precision than reported save for CH_4, while all species showed significantly greater drift than reported. A drift value for C_2H_6 was not reported by Aeris in available documentation.

Table 1. Comparison of reported and computed precision and 24hr drift

Species	Reported 1s Precision (ppbv)	Calculated Benchtop 1s Precision (ppbv)	Calculated Mobile 1s Precision (ppbv)	Calculated Reference Instrument Precision (ppbv)	Reported 24-hour Drift (ppbv)	Calculated Benchtop 24-hour Drift (ppbv)	Reported Reference Instrument 24-hour Drift (ppbv)
CH_4	<1	1.6	1.5	0.1	1-2	10	<1.5
C_2H_6	<0.5	0.19	0.17	0.08	Not reported	0.4	Not reported
CO	0.5	0.19	0.76	3	1	8	<15
N_2O	0.5	0.23	0.19	0.07	<1	1.1	Not reported

Current Problems and Future Work

Moving forward, the most pressing issue is troubleshooting the Aeris N_2O performance. In general, the ambient N_2O conditions we encountered were quite stable and did not offer a large range in concentrations for our comparison. One source of uncertainty is the internal calibration, which is not fully explained in the manual. We are in the process currently of conducting a typical dilution calibration which will offer a greater range of concentrations to assess the Aeris N_2O performance. After resetting the internal calibration, we will let it run in the lab as we did before, to see if correlation improves. We will also connect the Ultra 505 to the roof, to draw in air from the outside and compare with the data we currently have. This will be conducted in the winter, which will provide opportunity for comparison with the results of Commane et al. 2023, who determined that low water vapor conditions have detrimental impacts on Aeris performance If nothing can be found, we will contact Aeris directly to ensure that the instrument is working properly.

Another area of future investigation are two Aeris Strato instruments, which are being characterized alongside the Ultra with the methods described in this poster. They are smaller than the Ultras and are intended for drone deployment (shown below). However, the Strato instruments have been demonstrated to have internal plumbing that is not air-tight, so this must be addressed before work can continue. The leaking internal plumbing affects the shape of peaks and also make direct comparison to the reference instruments more challenging.

References & Acknowledgements

Commane et al. 2023

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