A first look at the Jan 2020 CrIS TVAC PFL gas cell tests

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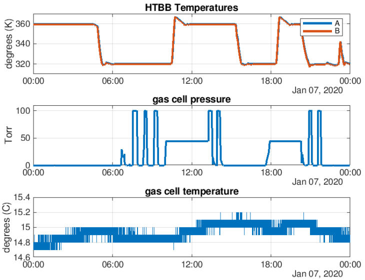
Introduction

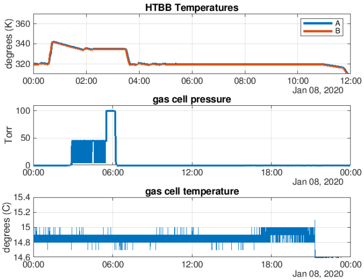
- We present an analysis of the PFL Plateau 20 CH_4, CO_2, and CO gas cell tests, and compare these with calculated reference truth from LBLRTM and UMBC-LBL.
- This is a reanalysis with more careful harvesting of the individual test legs and better calculated transmittances. The resulting changes to the metrology laser relative residuals were less than 1 ppm.
- Examples of monitoring test logs (the CSS, CMD, and TCR files) are given in the form of plots of HTBB temperature, gas cell temperature, and gas cell pressure over time.
- The J2 tests continue to be done at the older 866/1052/799 point resolutions.

Methods

- For each gas we partition the data stream into four test legs, FT1, FT2, ET1, and ET2 (cell full, HTBB temperature T1, etc.)
- For test each leg, we take the mean of the associated count spectra, calculate the transmittance as $(FT2 - FT1)/(ET2 - ET1)$, apply our standard processing filters, and do the SA correction, all at the sensor grid. Expected transmittance values are also calculated at the sensor grid.
- This is similar in some ways to the "ratio first" calibration algorithm used as an option in UMBC CCAST processing, but note that we do not do a full radiance calibration, or any nonlinearity correction, for the analysis here.
- Measured and calculated transmittances are compared first as is, and then by fitting obs to calcs and examining fitting weights and residuals.
- This approach, with fitting adjustments, is acceptable for our application because our main task is spectral calibration and our fitting methods are robust in the face of radiometric uncertainty.

7-8 Jan 2020 TVAC PFL Plateau 20



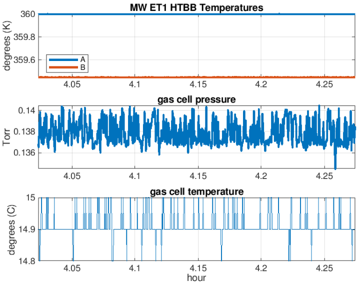


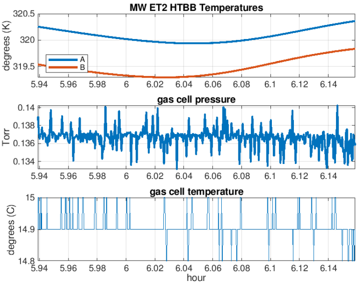
HTBB temperatures, gas cell pressure and gas cell temperature from the CCS files, for 7-8 Jan 2020. This data is used along with a scan of the CMD and SQL files for an overview and to find the test stages.

CH_4 MW PFL side 1 test parameters

- PFL Plateau 20, 7-8 Jan 2019
- side 1, sweep direction 0
- fitting interval 1220 to 1380 cm^{-1}
- metrology laser 771.97035 nm, from neon 703.44765 nm
- ATBD default focal plane
- SA correction from ILS with periodic sinc at the sensor grid
- HTBB nominal T1 360 K, T2 320 K
- gas cell pressure 44.64 torr
- gas cell temperature 14.90 C
- gas cell length 12.59 cm

CH_4 PFL side 1 cell empty test legs

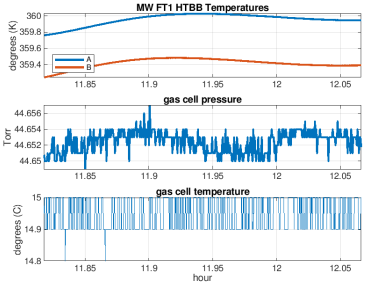


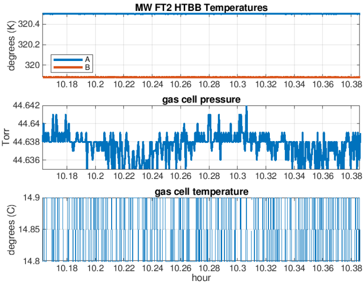


ET1 "empty high" leg of the the 7 Jan CH_4 transmittance test. The x-axis is hour of the day. This looks good.

ET2 "empty low" leg of the the 7 Jan CH_4 transmittance test. We see some HTBB drift.

CH_4 PFL side 1 cell full test legs

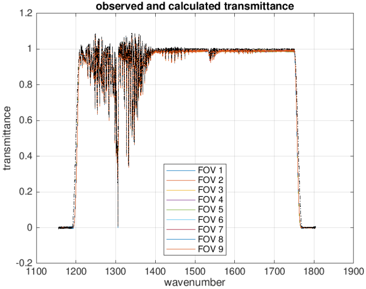


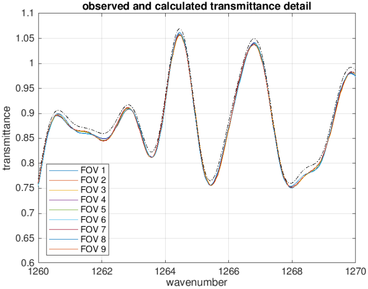


FT1 “full high” leg of the the 7 Jan CH_4 transmittance test. The x-axis is hour of the day. As in the empty low leg we see some HTBB drift.

FT2 “full low” leg of the the 7 Jan CH_4 transmittance test. This looks good.

CH_4 side 1 data before fitting

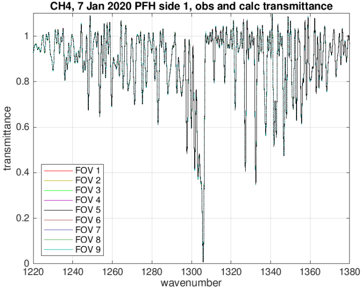


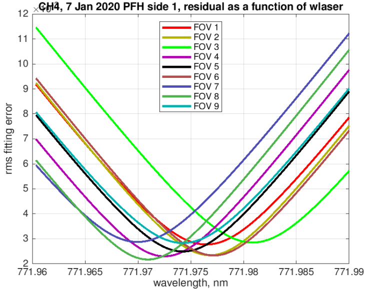


Observed and calculated transmittance after the SA correction but before fitting. We see some bias in the observed data, possibly due to problems with the HTBB stability.

A detail from the previous plot. Despite the bias, the FOV to FOV consistency of the observed data is relatively good.

CH_4 side 1 fitting overview

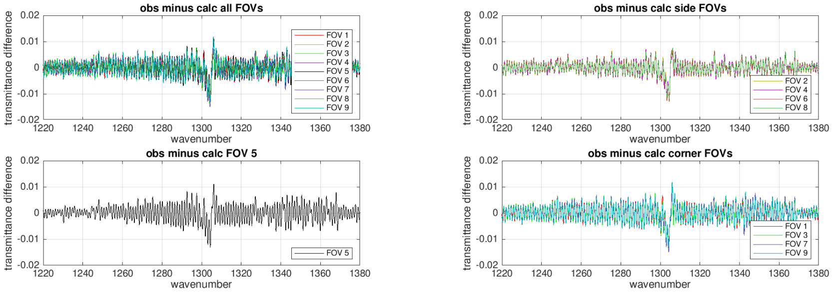




Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength, for each FOV.

CH_4 side 1 obs minus calc breakouts



Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.

Observed minus calculated transmittance for side and corner FOVs, over the fitting interval.

CH_4 side 1 tabulated residuals

metrology laser absolute residuals, ppm

-0.52	2.72	7.90	7	4	1
0.78	5.05	8.42	8	5	2
5.05	8.94	13.60	9	6	3

metrology laser relative residuals, ppm

-5.57	-2.33	2.85	7	4	1
-4.27	0.00	3.37	8	5	2
0.00	3.89	8.55	9	6	3

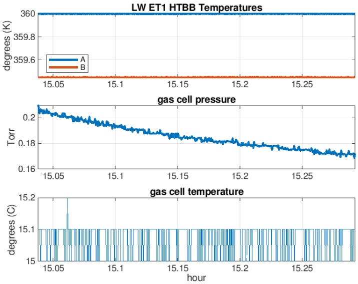
regression fitting weights and residuals

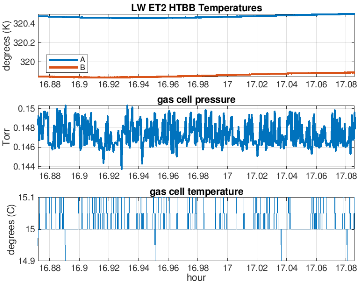
FOV	"a"	"b"	dmin	wmin	wfov
1	0.999	0.0115	0.0028	7.90	771.9765
2	1.001	0.0096	0.0023	8.42	771.9769
3	0.999	0.0110	0.0029	13.60	771.9809
4	1.000	0.0097	0.0023	2.72	771.9725
5	0.999	0.0109	0.0025	5.05	771.9743
6	1.002	0.0088	0.0023	8.94	771.9773
7	0.999	0.0101	0.0029	-0.52	771.9700
8	0.998	0.0110	0.0022	0.78	771.9710
9	1.000	0.0099	0.0028	5.05	771.9743

CO_2 LW PFL side 1 test parameters

- PFL Plateau 20, 7-8 Jan 2019
- side 1, sweep direction 0
- fitting interval 672 to 712 cm^{-1}
- metrology laser 771.97047 nm, from neon 703.44765 nm
- ATBD default focal plane
- SA correction from ILS with periodic sinc at the sensor grid
- HTBB nominal T1 360 K, T2 320 K
- gas cell pressure 45.05 torr
- gas cell temperature 15.02 C
- gas cell length 12.59 cm

CO_2 PFL side 1 cell empty test legs

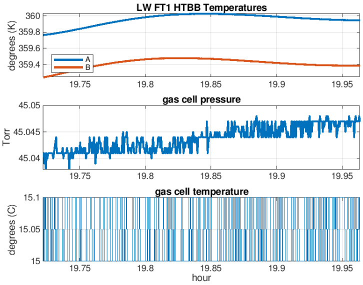


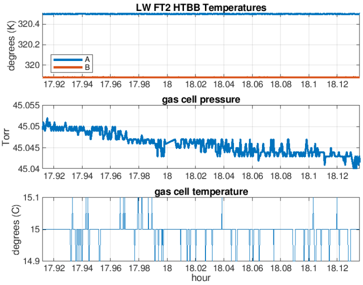


ET1 “empty high” leg of the the 7 Jan CO_2 transmittance test. The x-axis is hour of the day. The HTBB temps are stable but we see a vestigal pressure drift.

ET2 “empty low” leg of the the 7 Jan CO_2 transmittance test. We see a small HTBB drift.

CO_2 PFL side 1 cell full test legs

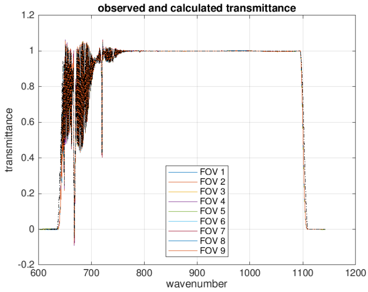




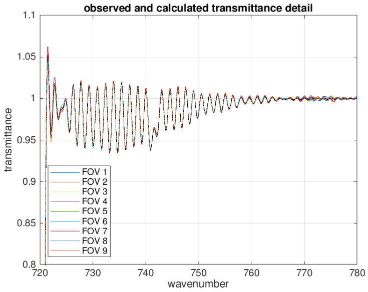
FT1 "full high" leg of the the 7 Jan CO_2 transmittance test. The x-axis is hour of the day. There is significant HTBB drift.

FT2 "full low" leg of the the 7 Jan CO_2 transmittance test. This looks good.

CO_2 side 1 data before fitting

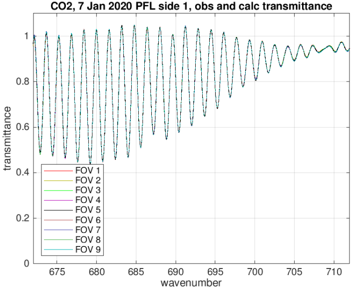


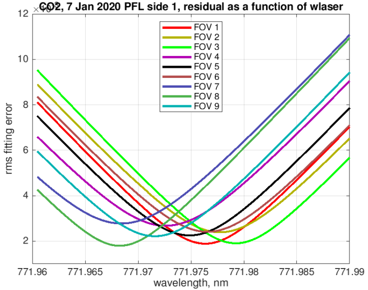
Observed and calculated transmittance after the SA correction but before any fitting. This looks good, at this level of detail.



A detail from the previous plot. FOV to FOV consistency and agreement with calculated transmittance is relatively good.

CO_2 side 1 fitting overview

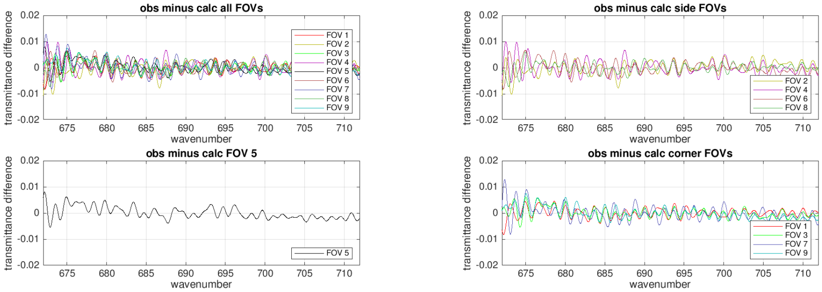




Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

Residuals $\mathrm{RMS}(a \cdot \tau_{\mathrm{obs}} + b - \tau_{\mathrm{calc}})$ over the fitting interval as a function of metrology laser wavelength, for each FOV.

CO_2 side 1 obs minus calc breakouts



Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.

Observed minus calculated transmittance for side and corner FOVs, over the fitting interval.

CO_2 side 1 tabulated residuals

metrology laser absolute residuals, ppm

-2.59	2.85	7.51	7	4	1
-2.85	5.70	9.46	8	5	2
1.42	7.90	11.40	9	6	3

metrology laser relative residuals, ppm

-8.29	-2.85	1.81	7	4	1
-8.55	0.00	3.76	8	5	2
-4.27	2.20	5.70	9	6	3

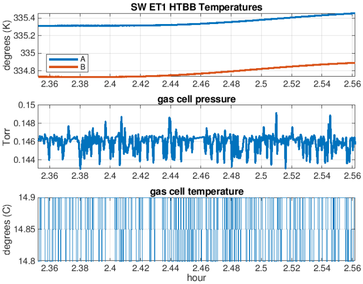
regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	0.992	0.0065	0.0019	7.51	771.9763
2	1.002	-0.0011	0.0024	9.46	771.9778
3	0.985	0.0128	0.0019	11.40	771.9793
4	0.991	0.0061	0.0027	2.85	771.9727
5	0.980	0.0171	0.0023	5.70	771.9749
6	0.985	0.0131	0.0024	7.90	771.9766
7	0.990	0.0064	0.0028	-2.59	771.9685
8	0.999	0.0001	0.0018	-2.85	771.9683
9	0.984	0.0119	0.0022	1.42	771.9716

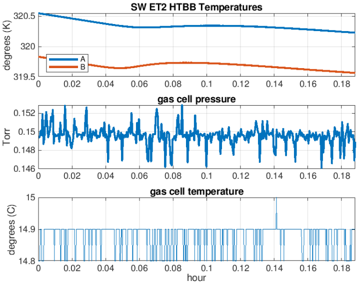
CO PFL side 1 SW test parameters

- PFL Plateau 20, 8 Jan 2019
- side 1, sweep direction 0
- fitting interval 2160 to 2240 cm^{-1}
- metrology laser 771.97050 nm, from neon 703.44765 nm
- ATBD default focal plane
- SA correction from ILS with periodic sinc at the sensor grid
- HTBB nominal T1 335 K, T2 320 K
- gas cell pressure 45.92 torr
- gas cell temperature 14.85 C
- gas cell length 12.59 cm

CO PFL side 1 cell empty test legs

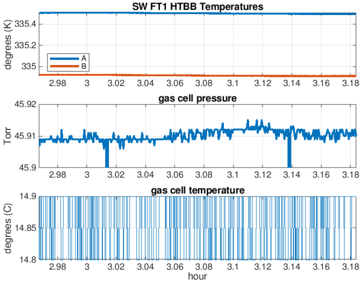


ET1 “empty high” leg of the the 8 Jan CO transmittance test. The x-axis is hour of the day. We see some HTBB drift.

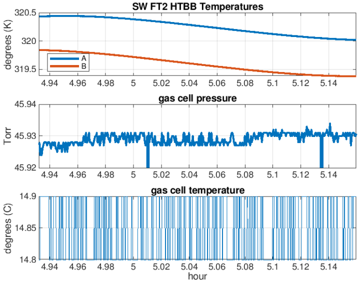


ET2 “empty low” leg of the the 8 Jan CO transmittance test. We see a significant HTBB drift.

CO PFL side 1 cell full test legs

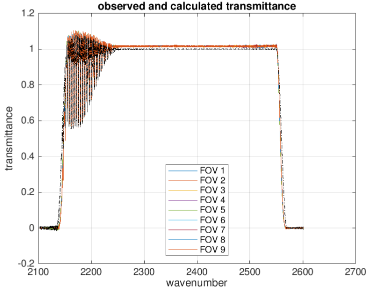


FT1 “full high” leg of the the 8 Jan CO transmittance test. The x-axis is hour of the day. This looks good.

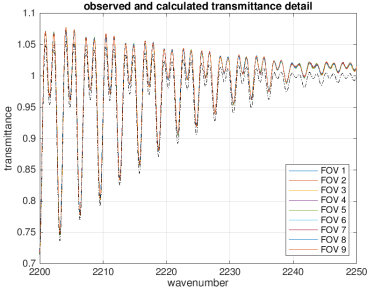


FT2 “full low” leg of the the 8 Jan CO transmittance test. There is significant HTBB drift.

CO side 1 data before fitting

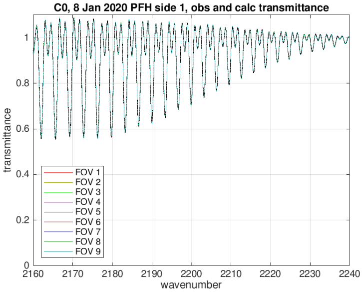


Observed and calculated transmittance after the SA correction but before fitting. We see some bias in the obs.

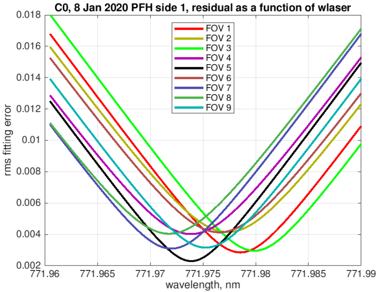


A detail from the previous plot. Although we see some bias in the obs, the FOV to FOV consistency is relatively good.

CO side 1 fitting overview

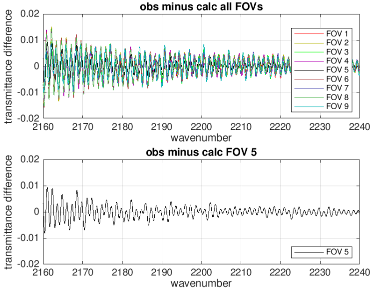


Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

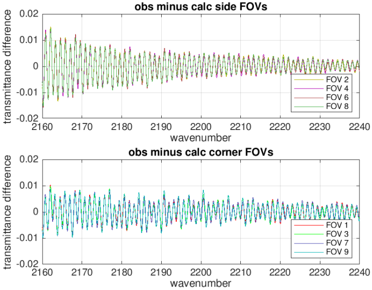


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength, for each FOV.

CO side 1 obs minus calc breakouts



Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.



Observed minus calculated transmittance for side and corner FOVs, over the fitting interval.

CO side 1 tabulated residuals

metrology laser absolute residuals, ppm

1.94	4.40	10.36	7	4	1
1.68	4.40	8.81	8	5	2
6.22	7.77	12.18	9	6	3

metrology laser relative residuals, ppm

-2.46	0.00	5.96	7	4	1
-2.72	0.00	4.40	8	5	2
1.81	3.37	7.77	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	0.972	0.0128	0.0029	10.36	771.9785
2	0.976	0.0088	0.0041	8.81	771.9773
3	0.973	0.0116	0.0030	12.18	771.9799
4	0.980	0.0044	0.0040	4.40	771.9739
5	0.973	0.0107	0.0023	4.40	771.9739
6	0.979	0.0056	0.0041	7.77	771.9765
7	0.978	0.0059	0.0031	1.94	771.9720
8	0.981	0.0027	0.0040	1.68	771.9718
9	0.972	0.0118	0.0032	6.22	771.9753

Conclusions

- We have done a preliminary analysis of the PFL Plateau 20 CH_4, CO_2, and CO gas cell tests, and compared these with calculated reference truth. Overall, the results look quite good.
- The HTBB drift seen in many of the test legs is significant but managable with our approach to regression fitting. The effect of the drifts could be reduced with more careful subsetting, if needed.
- Metrology laser relative residuals are in reasonable agreement, and can be reduced further with focal plane adjustments. Metrology laser absolute residuals could be reduced with a more judicious choice of neon wavelengh, or possibly by simply using the eng neon value.