A first look at the 7-8 Jan 2020 CrIS TVAC PFL gas cell tests

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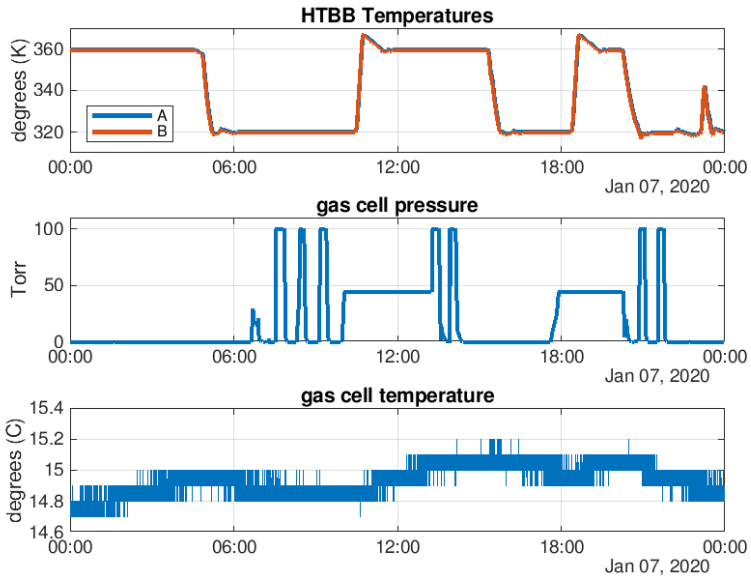
Introduction

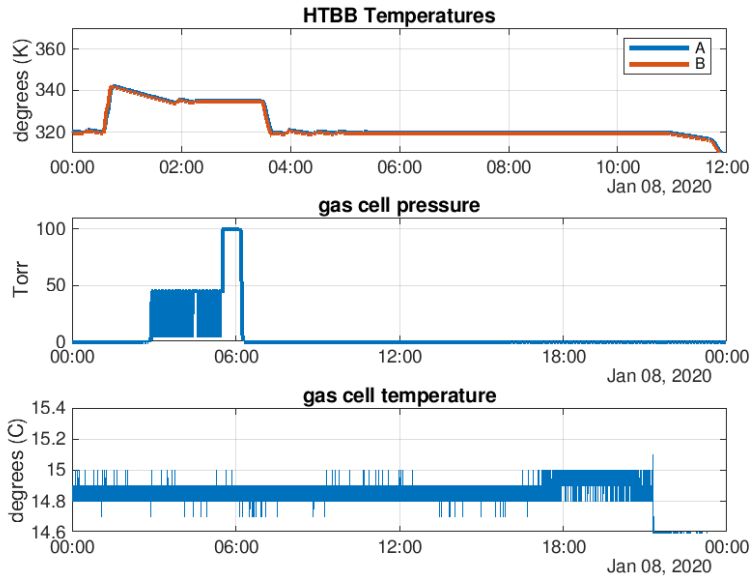
- We do a preliminary analysis of the PFL Plateau 20 CH_4, CO_2, and CO gas cell tests, and compare these with calculated reference truth.
- These initial results look fairly good, but we have taken some shortcuts, including using less than optimal test interval subsets and (for CO_2 and CO) older transmittance calcs that do not quite match the current cell parameters.
- Working from our metrology laser residuals we show focal plane fits for all three CrIS bands.
- We have included examples of monitoring the test logs (the CSS, CMD, and TCR files), in the form of plots of HTBB temperature, gas cell temperature and gas cell pressure over time.
- The J2 tests appear to have been done at the older 866/1052/799 point resolutions. This is not a problem for us, but was unexpected.

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 the SA correction, and interpolate to a finer grid for residual analysis.
- 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 by fitting obs to calcs and then 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.

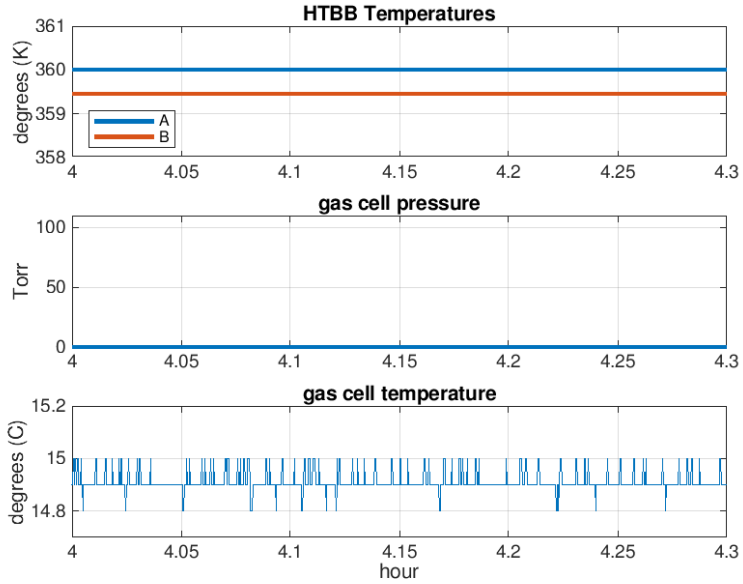
7-8 Jan 2020 TVAC PFL Plateau 20

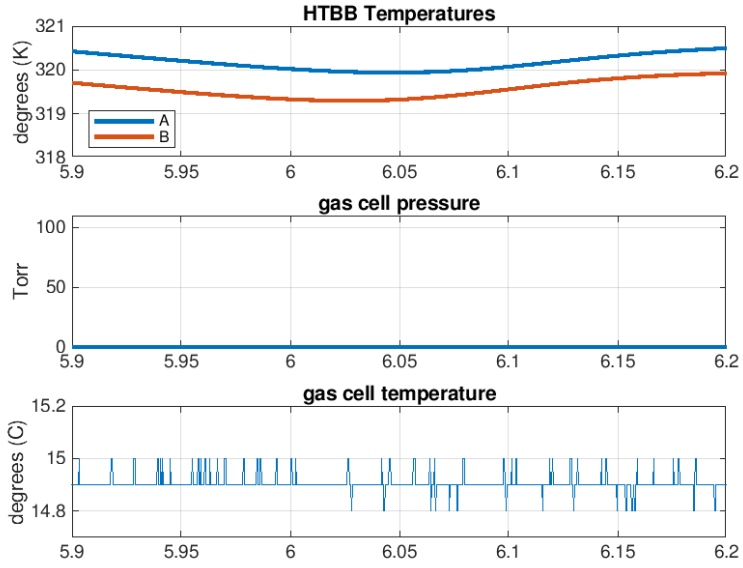




HTBB temperatures, gas cell pressure and gas cell temperature from the CCS files, for 7-8 Jan 2020. This data is used along with a scan of the CMD and SQL files to find the test stages.

7 Jan MW CH4 cell empty test legs

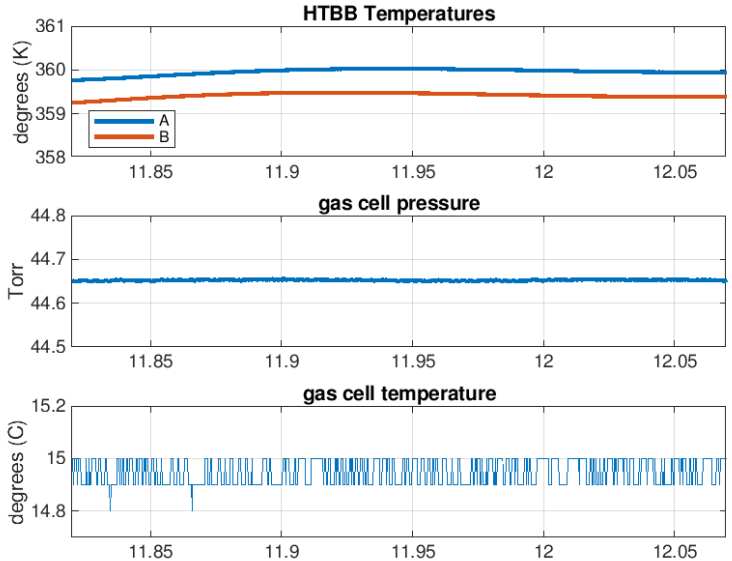




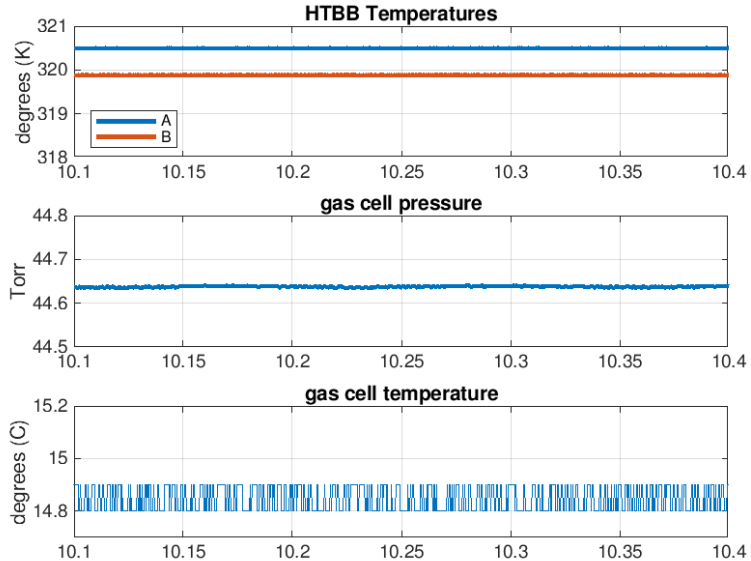
"empty high" leg of the the 7 Jan transmittance test, PFL Plateau 20. The x-axis here is hour of the day for 7 Jan. This data looks good.

"empty low" leg of the the 7 Jan transmittance test. The x-axis is again hour of the day. We see some HTBB drift.

7 Jan MW CH4 cell full test legs



"full high" leg of the the 7 Jan CH4 transmittance test. The x-axis is hour of the day. As in the empty low leg we see some HTBB drift.

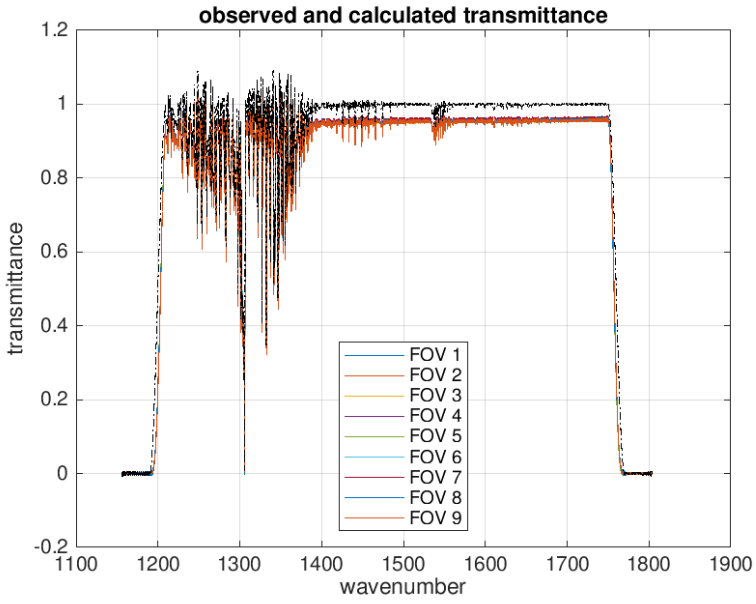


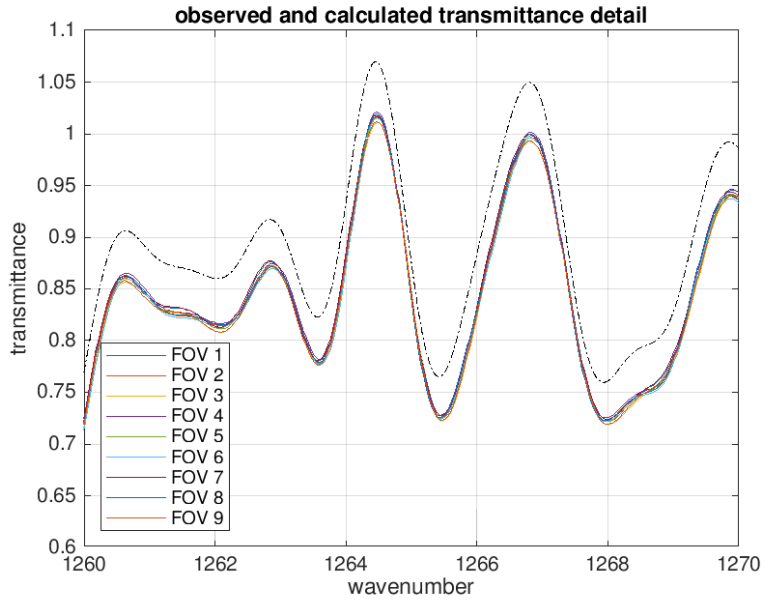
"full low" leg of the the 7 Jan CH4 transmittance test. This looks good.

CH4 MW test parameters

- PFL Plateau 20, 7-8 Jan 2019
- side 1, sweep direction 0
- fitting interval 1220 to 1380 cm^{-1}
- metrology laser 773.0764 nm, from neon 703.4476 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 14.85 C
- gas cell length 12.59 cm

CH4 data before fitting

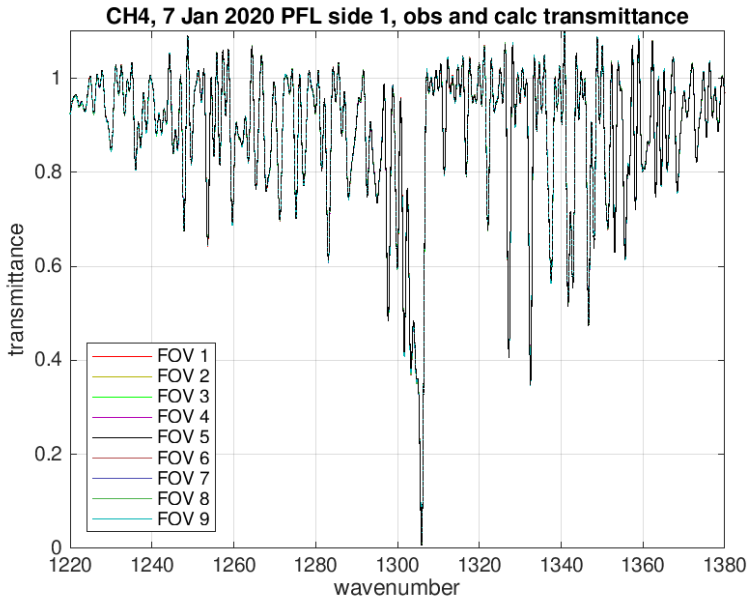


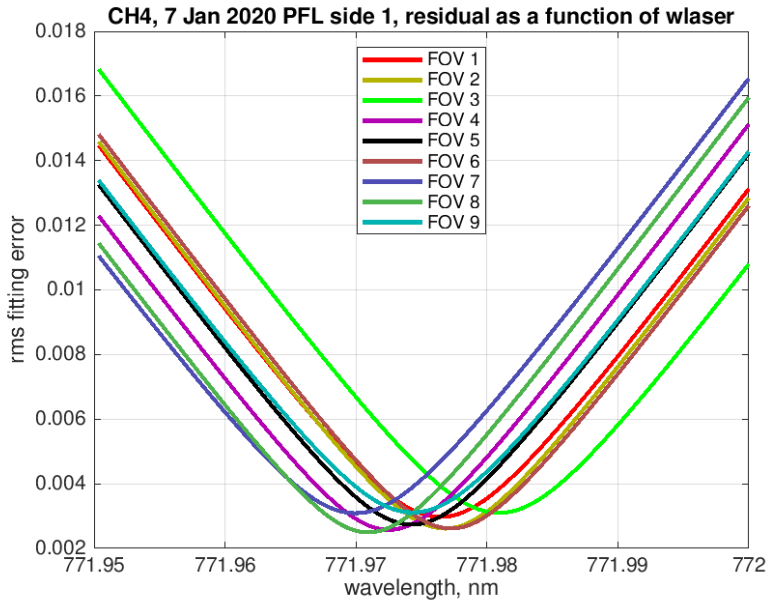


Observed and calculated transmittance after the SA correction but before fitting. We see a significant bias in the obs, possibly due to problems with the HTBB or gas cell stability. More careful subsetting of the test data would probably fix this.

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

CH4 fitting overview

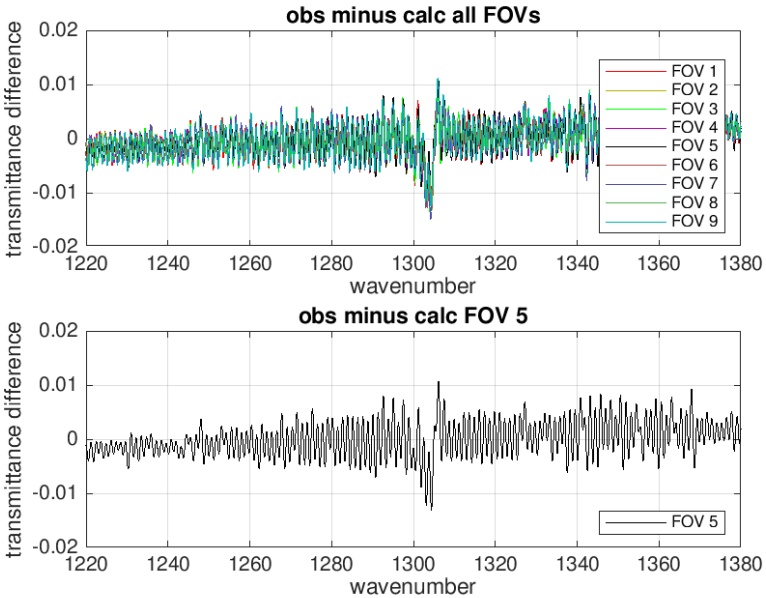




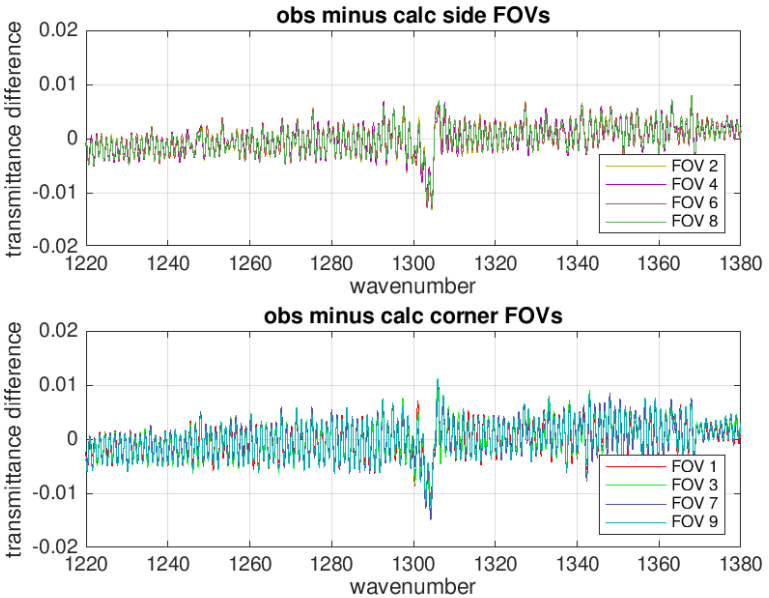
Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

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.

CH4 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.

CH4 tabulated residuals

metrology laser absolute residuals, ppm

-0.65	2.59	7.77	7	4	1
0.65	5.18	8.42	8	5	2
5.18	9.07	13.60	9	6	3

metrology laser relative residuals, ppm

-5.83	-2.59	2.59	7	4	1
-4.53	0.00	3.24	8	5	2
0.00	3.89	8.42	9	6	3

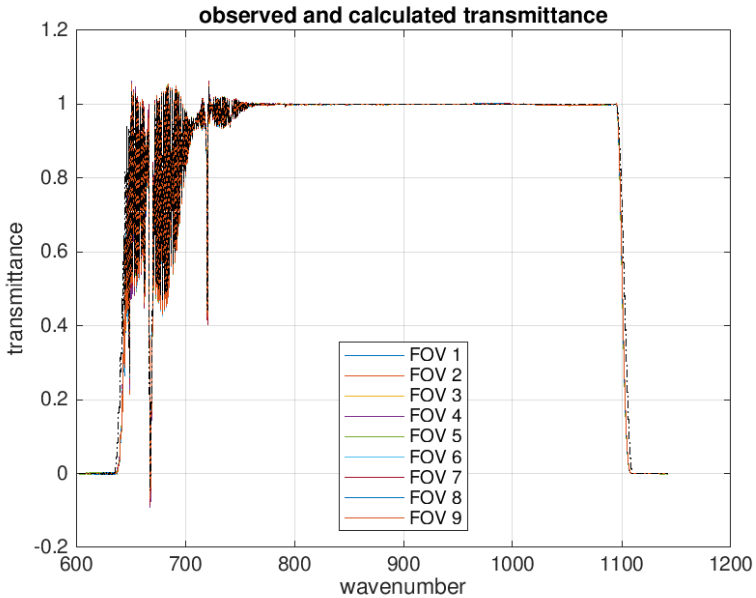
regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.035	0.0135	0.0030	7.77	771.9764
2	1.040	0.0115	0.0026	8.42	771.9769
3	1.041	0.0130	0.0031	13.60	771.9809
4	1.036	0.0115	0.0026	2.59	771.9724
5	1.038	0.0127	0.0027	5.18	771.9744
6	1.043	0.0107	0.0026	9.07	771.9774
7	1.035	0.0119	0.0031	-0.65	771.9699
8	1.038	0.0128	0.0025	0.65	771.9709
9	1.041	0.0118	0.0031	5.18	771.9744

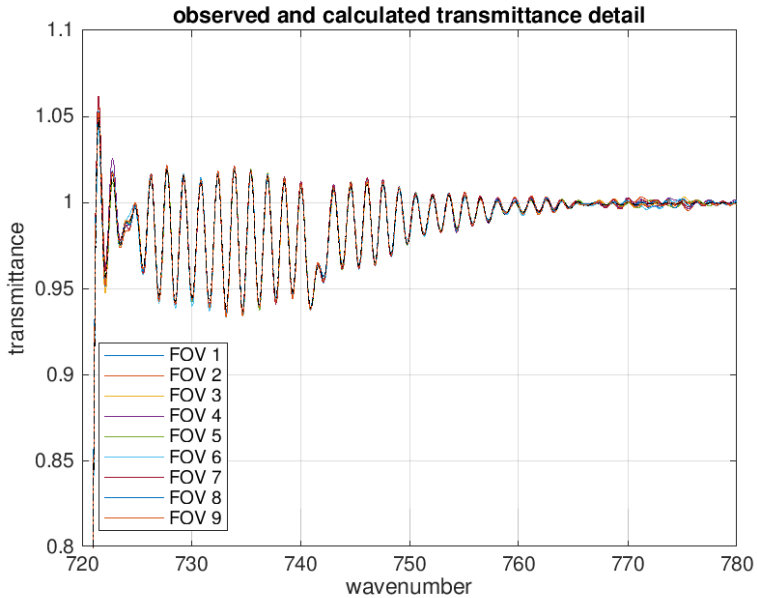
CO2 LW test parameters

- PFL Plateau 20, 7-8 Jan 2019
- side 1, sweep direction 0
- fitting interval 672 to 712 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 45.05 torr
- gas cell temperature 15.0 C
- gas cell length 12.59 cm

CO2 data before fitting

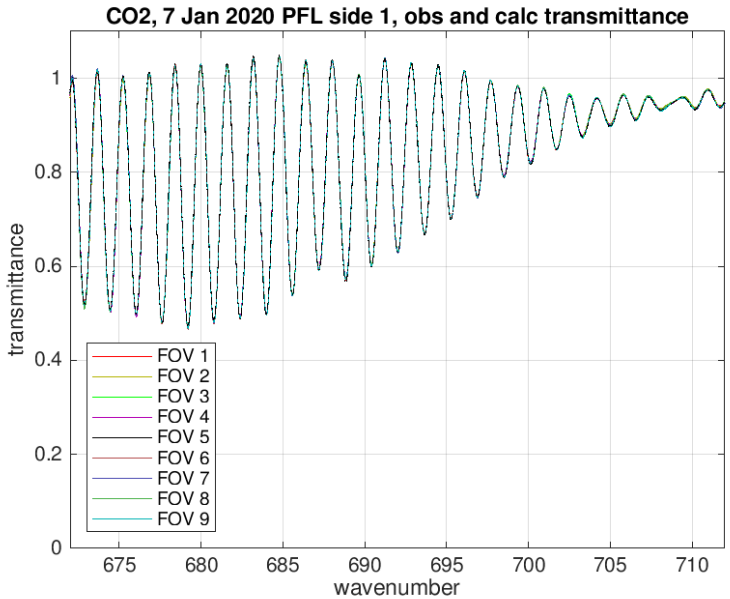


Observed and calculated transmittance after the SA correction but before any fitting. This looks fairy good, despite some mismatch in the calculated and actual gas cell parameters.

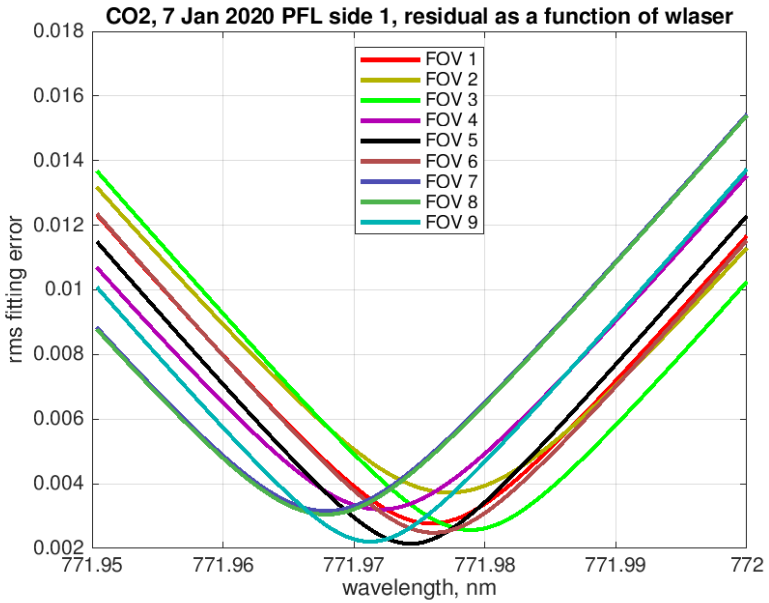


A detail from the previous plot. The FOV to FOV consistency and agreement with calculated transmittance is fairly good.

CO2 fitting overview

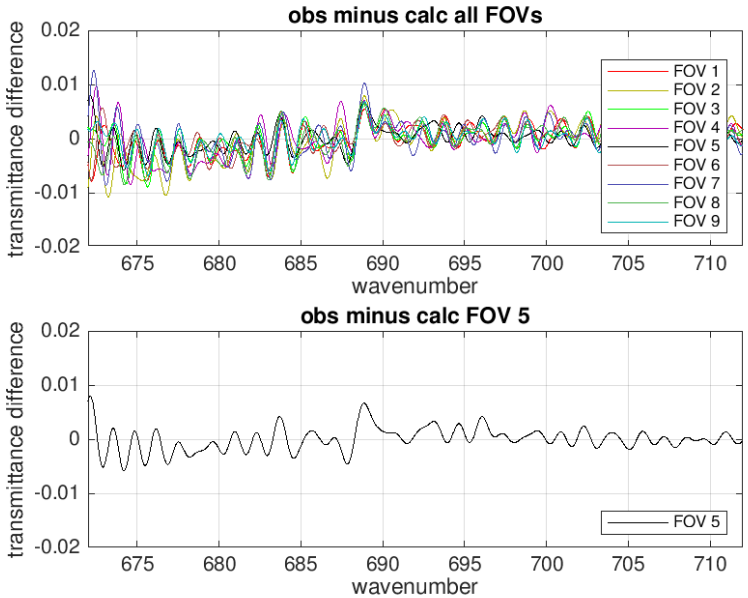


Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

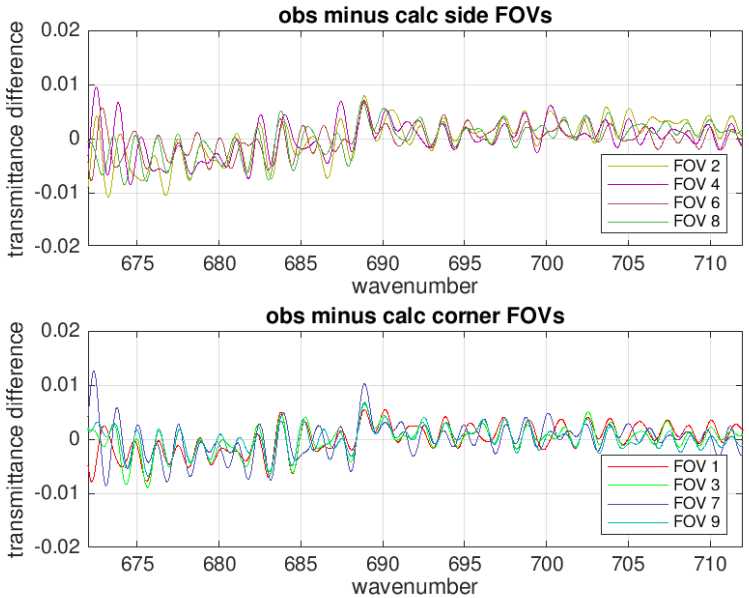


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength, for each FOV.

CO2 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.

CO2 tabulated residuals

metrology laser absolute residuals, ppm

-3.24	1.94	7.12	7	4	1
-3.24	5.18	9.07	8	5	2
1.30	7.12	11.01	9	6	3

metrology laser relative residuals, ppm

-8.42	-3.24	1.94	7	4	1
-8.42	0.00	3.89	8	5	2
-3.89	1.94	5.83	9	6	3

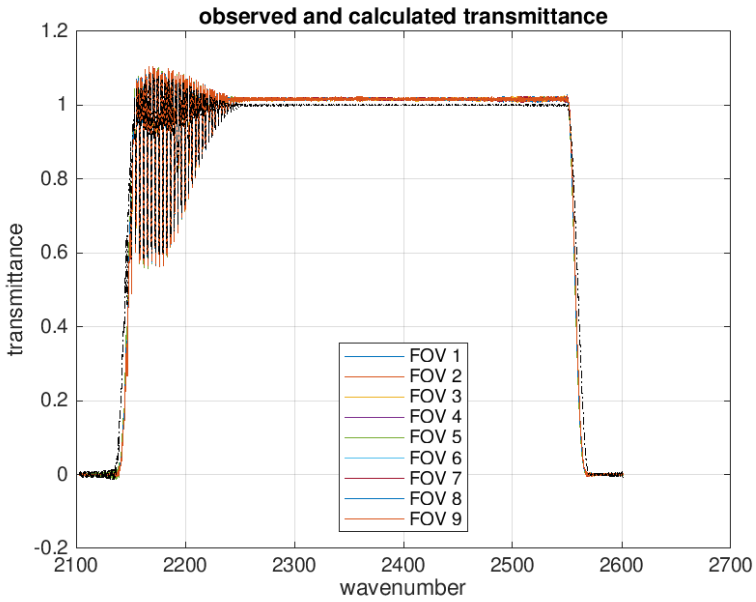
regression fitting weights and residuals

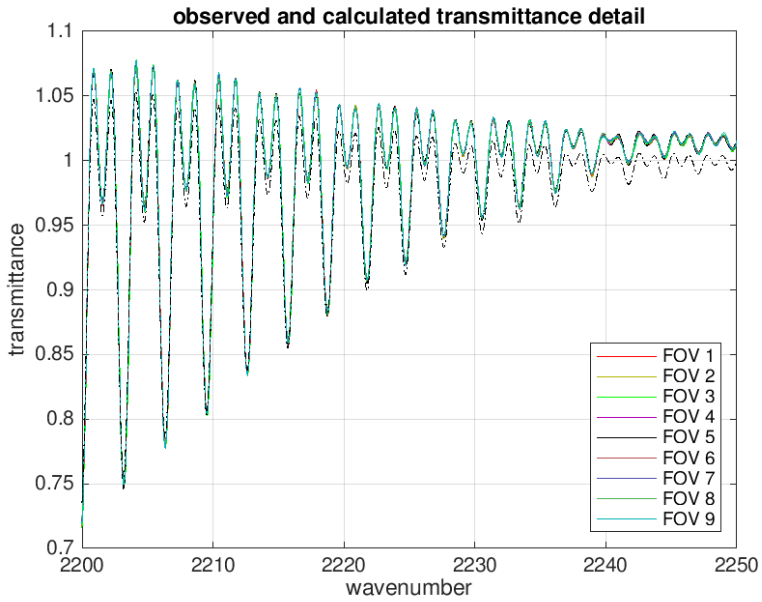
FOV	"a"	"b"	dmin	wmin	wfov
1	0.937	0.0626	0.0028	7.12	771.9759
2	0.946	0.0552	0.0037	9.07	771.9774
3	0.930	0.0687	0.0026	11.01	771.9789
4	0.936	0.0622	0.0032	1.94	771.9719
5	0.926	0.0722	0.0021	5.18	771.9744
6	0.930	0.0689	0.0025	7.12	771.9759
7	0.935	0.0625	0.0032	-3.24	771.9679
8	0.944	0.0564	0.0030	-3.24	771.9679
9	0.930	0.0679	0.0022	1.30	771.9714

CO SW test parameters

- PFL Plateau 20, 8 Jan 2019
- side 1, sweep direction 0
- fitting interval 2160 to 2240 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 335 K, T2 320 K
- gas cell pressure 45.9 torr
- gas cell temperature 14.85 C
- gas cell length 12.59 cm

CO data before fitting

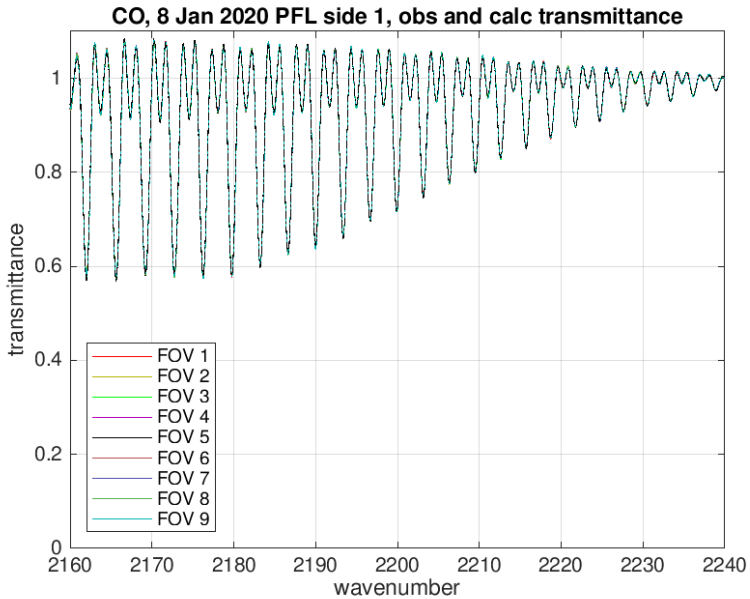




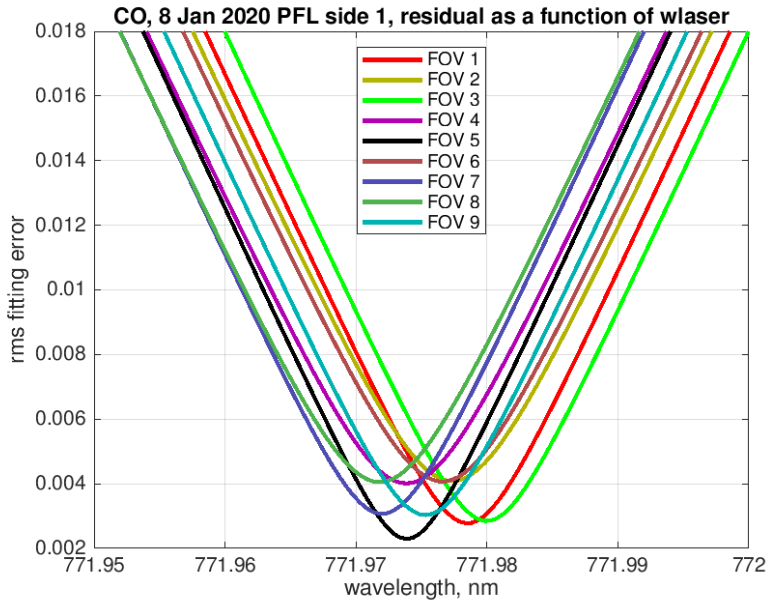
Observed and calculated transmittance after the SA correction but before fitting. We see some bias in the obs, though not as much as for CH4. As in that case, more careful subsetting would probably improve this.

A detail from the previous plot. The FOV to FOV consistency is relatively good. Note that we are using an older 41 torr calc here, so some differences are to be expected.

CO fitting overview

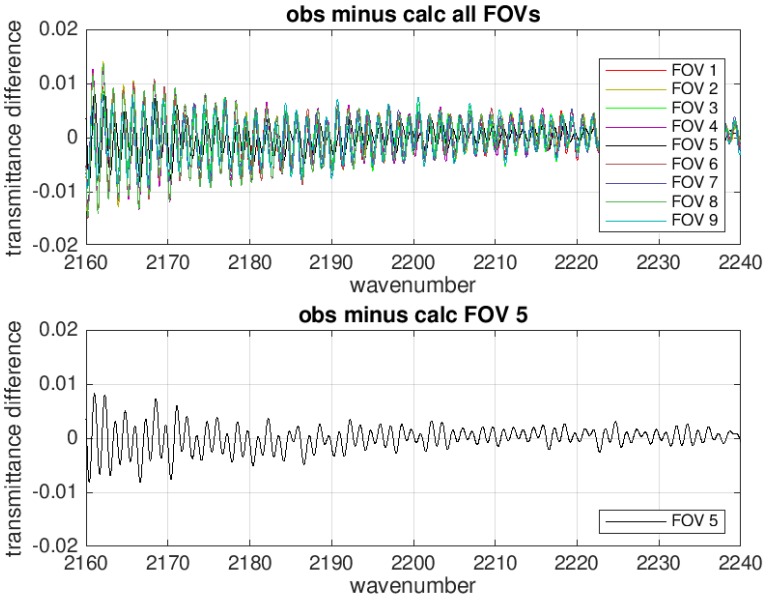


Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

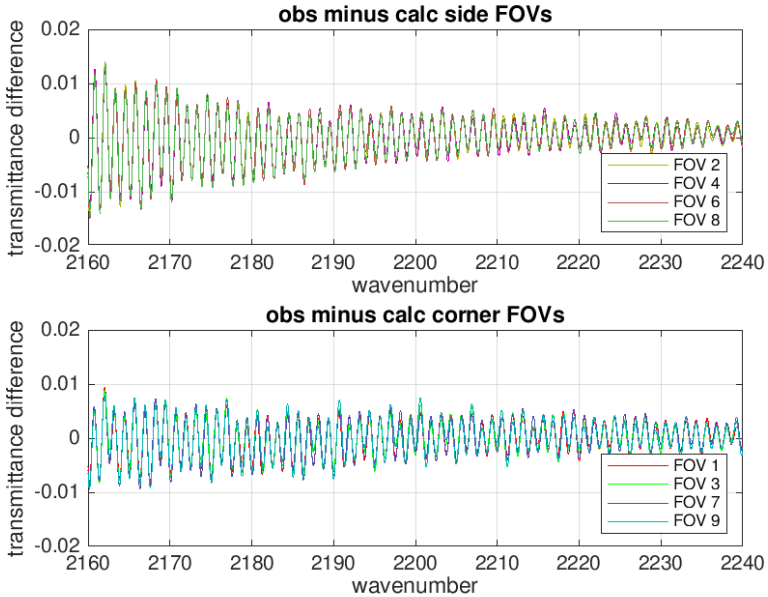


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength, for each FOV.

CO 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 tabulated residuals

metrology laser absolute residuals, ppm

1.94	4.53	10.36	7	4	1
1.94	4.53	9.07	8	5	2
6.48	8.42	12.31	9	6	3

metrology laser relative residuals, ppm

-2.59	0.00	5.83	7	4	1
-2.59	0.00	4.53	8	5	2
1.94	3.89	7.77	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	0.938	0.0469	0.0028	10.36	771.9784
2	0.943	0.0429	0.0041	9.07	771.9774
3	0.940	0.0456	0.0028	12.31	771.9799
4	0.946	0.0387	0.0040	4.53	771.9739
5	0.940	0.0447	0.0023	4.53	771.9739
6	0.945	0.0399	0.0041	8.42	771.9769
7	0.945	0.0402	0.0031	1.94	771.9719
8	0.948	0.0372	0.0041	1.94	771.9719
9	0.939	0.0459	0.0030	6.48	771.9754

Focal Plane Fits to CH_4 PPM Shifts

- Neon already increased from Engr. Pkt by 16.7 ppm
- Metrology laser offsets from gas cell spectra (ppm)

-0.65	2.59	7.77
0.65	5.18	8.42
5.18	9.07	13.60

- Optimum focal plane offsets, radial magnification

dx	dy	rdr
-158	+214	~32
unc dx	unc dy	unc rdr
38	38	~25

- Metrology laser residuals from (relative) ppm fit

-0.24	0.08	-0.49
0.95	0	1.37
-0.05	-0.37	-0.23

Focal Plane Fits to CO_2 PPM Shifts

- Metrology laser offsets from gas cell spectra (ppm)

-3.24	1.94	7.12
-3.24	5.18	9.07
1.30	7.12	11.01

- Optimum focal plane offsets, radial magnification

dx	dy	rdr
-118	+280	~44
unc dx	unc dy	unc rdr
58	58	~44

- Metrology laser residuals from (relative) ppm fit

-0.72	0.21	-0.31
2.30	0	0.76
-0.75	-0.44	0.37

Focal Plane Fits to CO PPM Shifts

- Metrology laser offsets from gas cell spectra (ppm)

1.94	4.53	10.36
1.94	4.53	9.07
6.48	8.42	12.31

- Optimum focal plane offsets, radial magnification

dx	dy	rdr
-90	+186	~103
unc dx	**unc dy**	**unc rdr**
36	36	~24

- Metrology laser residuals from (relative) ppm fit

0.49	-0.15	-0.82
0.62	0	0.60
-0.61	-0.59	0.71

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. Initial results are promising, but could be improved with better test interval subsetting and transmittance calcs.
- It's not clear how much of this analysis can be automated. At a minimum it seems like a good idea to browse the data stream over time, as we have been doing, before chosing test subsets.
- These tests should probably be run at whatever operational resolution is chosen. We do not truncate the interferograms for any resolution mode, as discussed in past presentations, and there are small differences.