May 2021 CrIS J3 TVAC PFL Gas Cell ILS Tests

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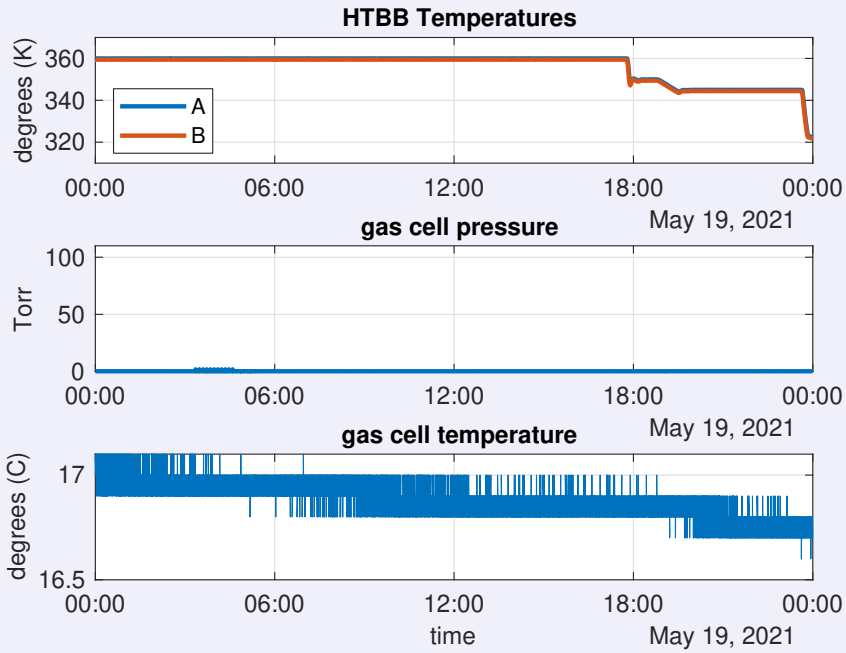
Introduction

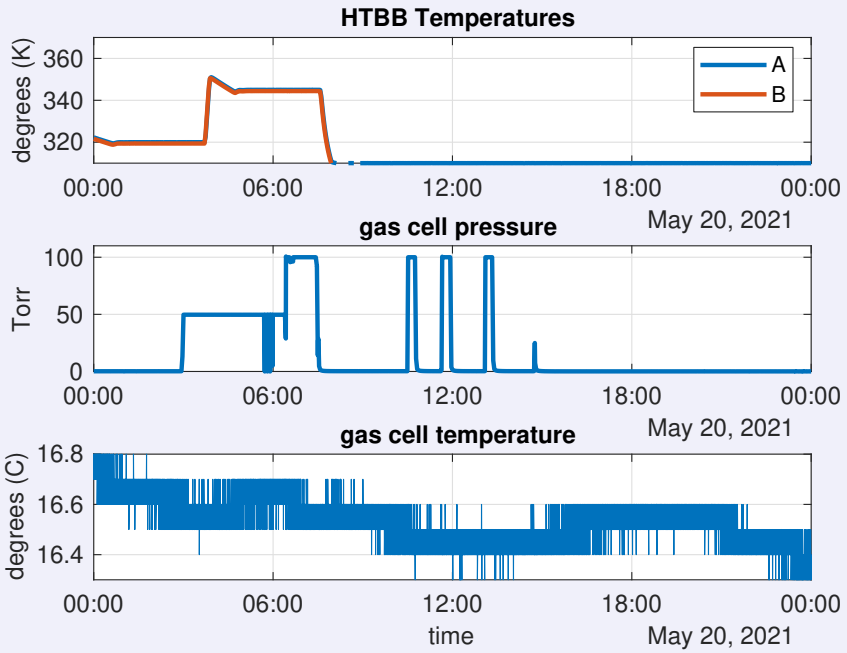
- We look at the CrIS J3 TVAC PFL Plateau 20 CO_2, CH_4, and CO gas cell ILS tests, and compare measured transmittances with calculated reference truth from LBLRTM and UMBC-LBL.
- Overall, the test results look good. Transmittance residuals are small, and the metrology laser residuals are in reasonable agreement.
- We compared sweep directions for the CO_2 side 1 and 2 tests. The met laser residuals were quite close, within 1 ppm.
- We have included examples of monitoring test logs (the CSS, CMD, and TCR files) for start and stop times for each test leg, and for plots of HTBB temperature, gas cell temperature, and gas cell pressure over time.

Methods

- For each test we partition the data into four legs, FT1, FT2, ET1, and ET2. (FT1 is cell full, HTBB temperature T1, etc.)
- For each test 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 L1b 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.

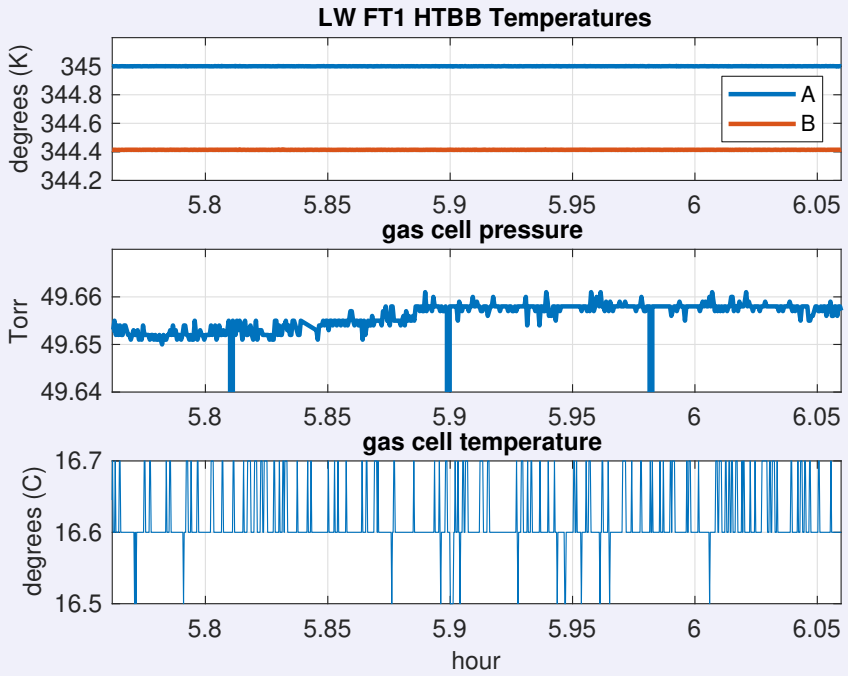
19 May 2021 TVAC PFL Side 2 Plateau 20

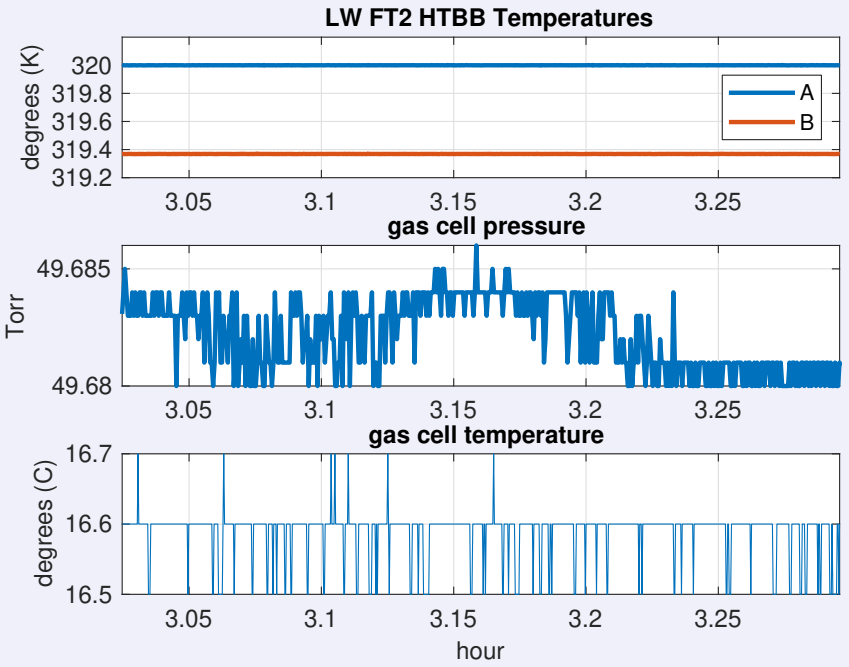




HTBB temperatures, gas cell pressure and gas cell temperature from the CCS files, for 19-20 May 2021. This data is used along with a scan of the CMD and SQL log files for an overview and to find the test stages. The ILS tests begin around 23:00 on May 19.

CO_2 PFL side 2 gas cell full test legs



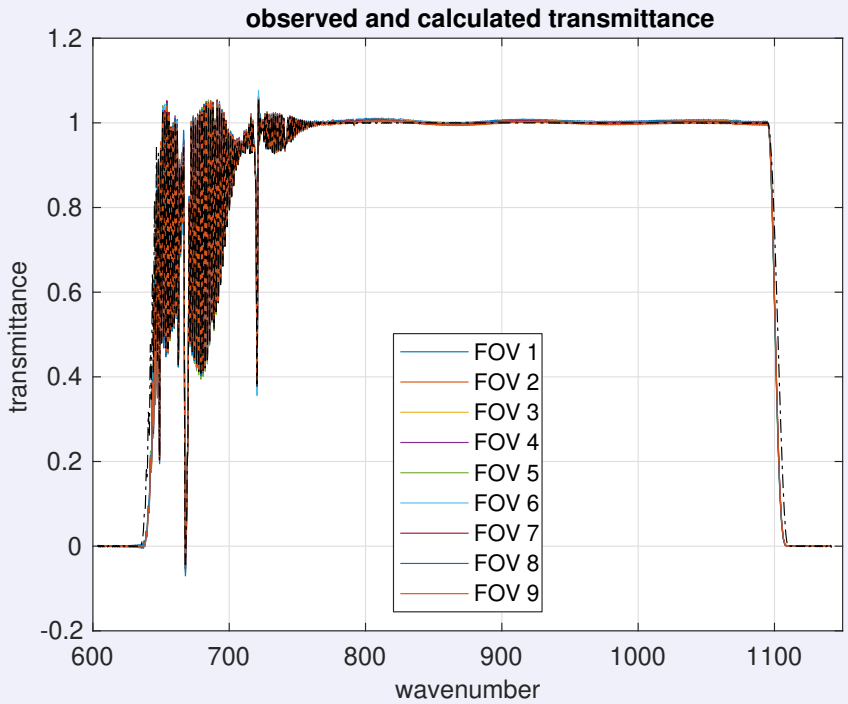


A detail from the previous plot, trimmed to the cell-full test legs, as determined by start/stop commands in the CMD files. The x axis is fractional hour of the day. We get true gas cell temperature and pressure from this data. The gas cell looks (which we see as ES data) are a subset of the time spans above, usually towards the middle. There are also ICT looks that we do not currently use.

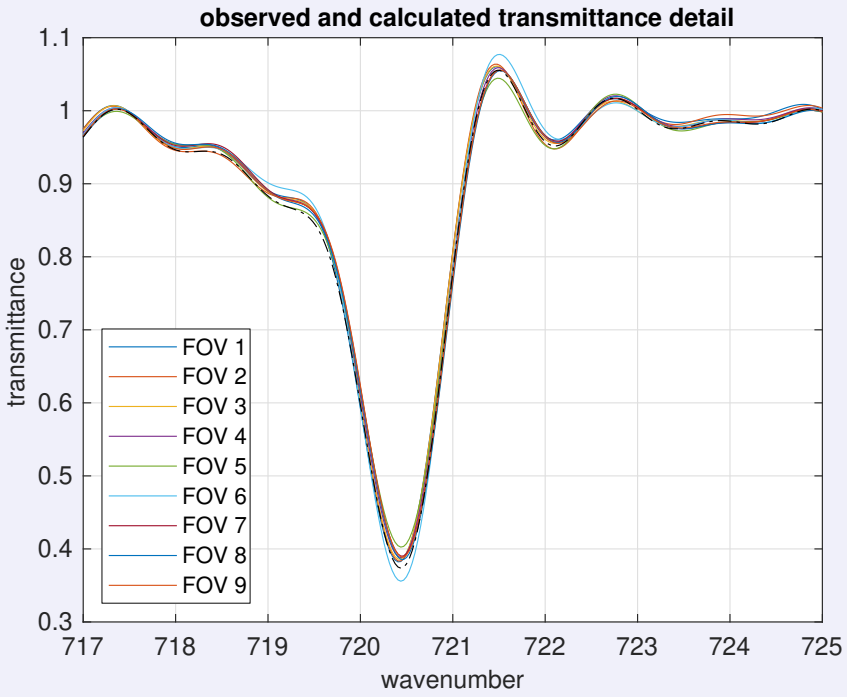
CO_2 LW PFL side 2 test parameters

- PFL Plateau 20, 19-20 May 2021
- side 2, sweep direction 0
- fitting interval 672 to 712 cm^{-1}
- metrology laser 773.94286 nm, from neon 703.44765 nm
- ATBD default focal plane
- SA correction from ILS with periodic sinc at the sensor grid
- HTBB nominal T1 345 K, T2 320 K
- gas cell pressure 49.67 Torr
- gas cell temperature 16.6 C
- gas cell length 12.59 cm

CO_2 side 2 data before fitting

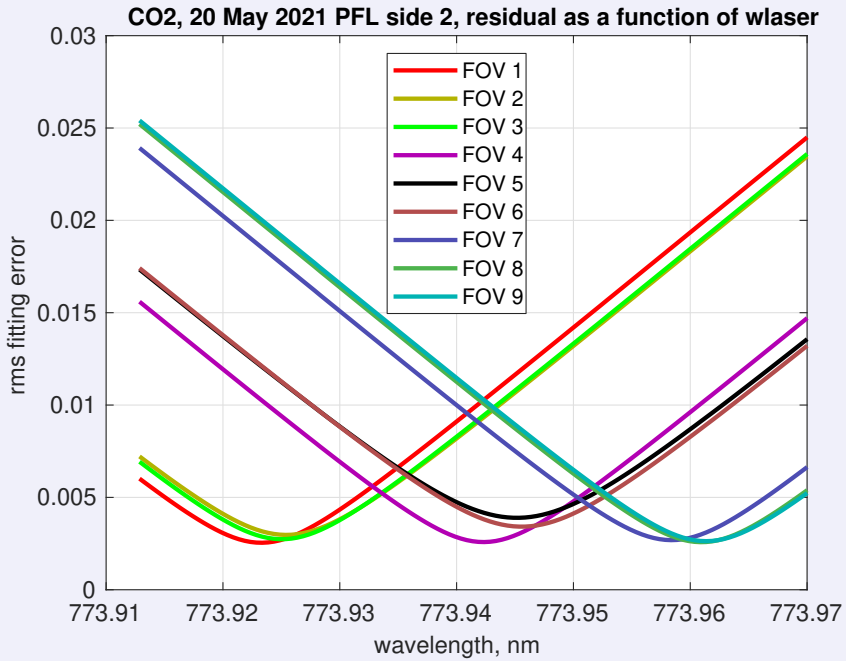


An overview of observed and calculated transmittance, after the SA correction but before any fitting.

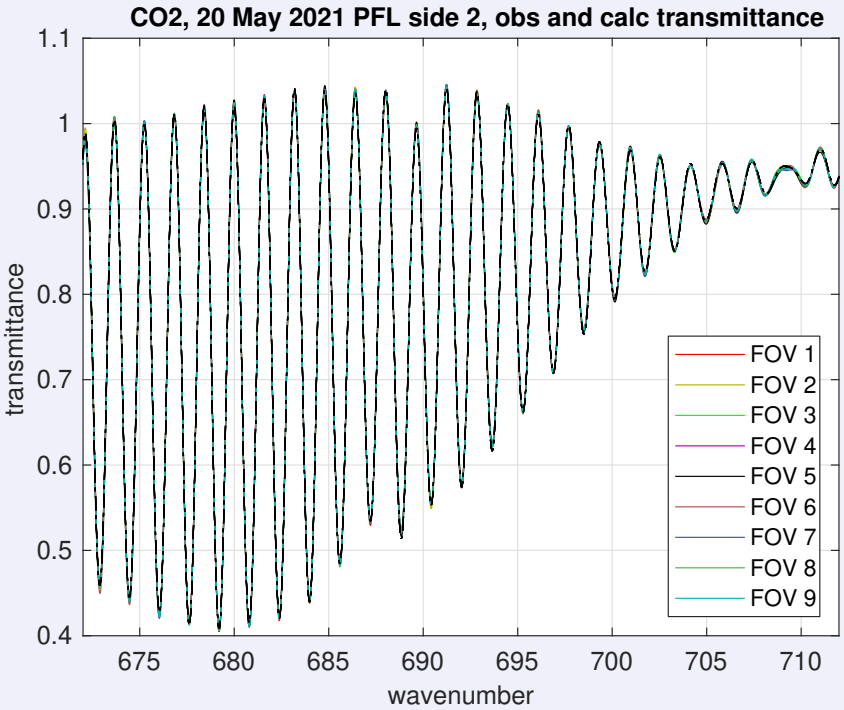


A detail from the previous plot. FOV 6 is slightly out of group, but FOV to FOV consistency and agreement with calculated transmittance is relatively good.

CO_2 side 2 fitting overview

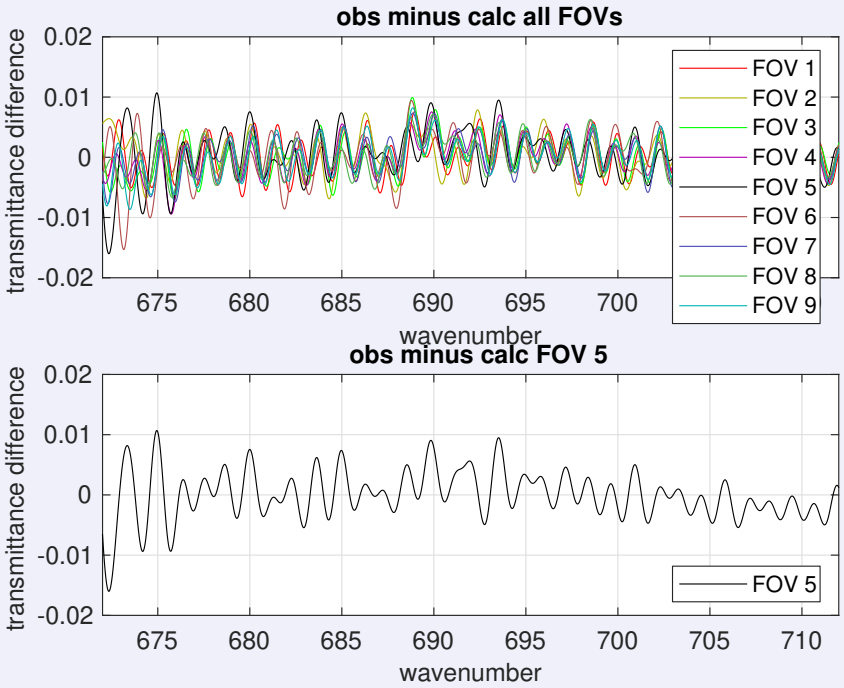


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength.

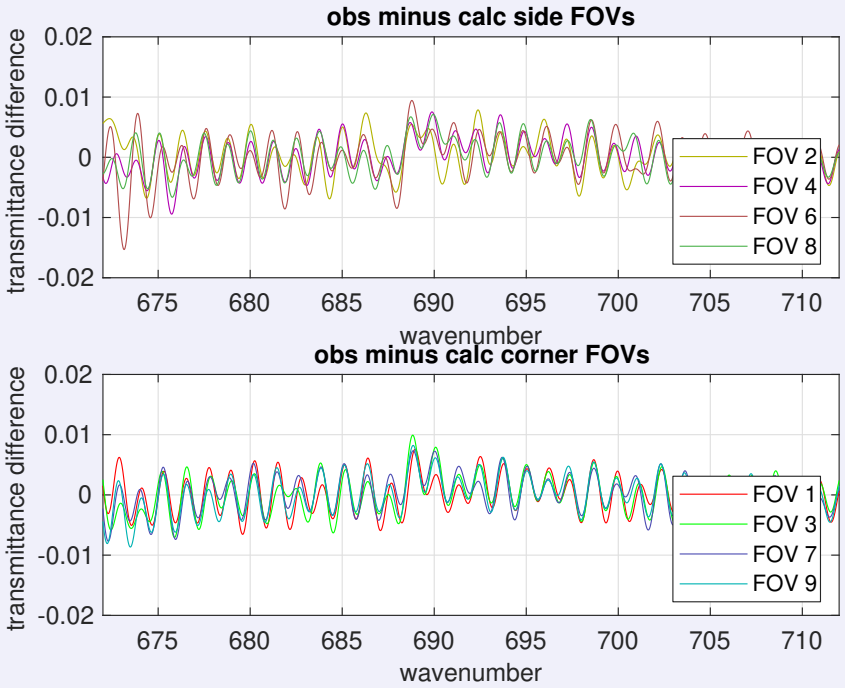


Fitted observed and calculated transmittance, over the fitting interval. At this level of detail we see all values are very close.

CO_2 side 2 obs minus calc breakouts



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



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

CO_2 side 2 tabulated residuals

metrology laser absolute residuals, ppm

20.03	-0.65	-25.20	7	4	1
23.26	3.23	-22.61	8	5	2
23.90	3.23	-23.26	9	6	3

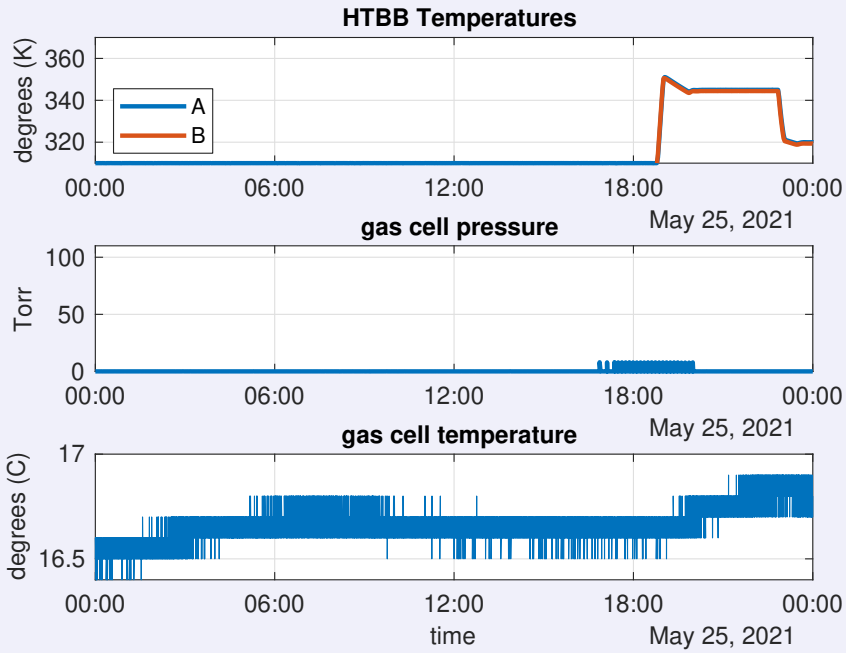
metrology laser relative residuals, ppm

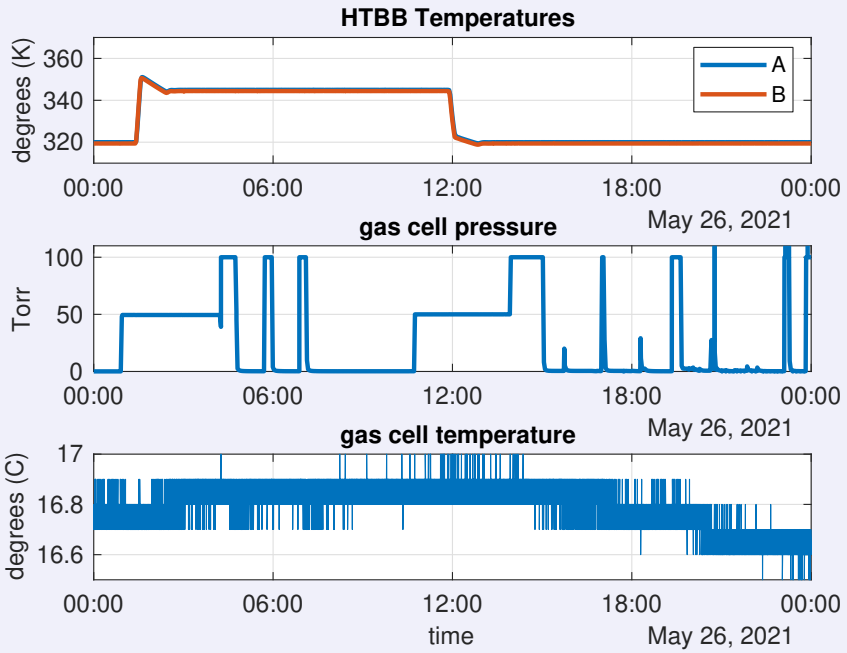
16.80	-3.88	-28.43	7	4	1
20.03	0.00	-25.84	8	5	2
20.67	0.00	-26.49	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	0.981	0.0090	0.0025	-25.20	773.9234
2	0.981	0.0104	0.0030	-22.61	773.9254
3	0.988	0.0049	0.0027	-23.26	773.9249
4	0.985	0.0067	0.0026	-0.65	773.9424
5	0.969	0.0226	0.0039	3.23	773.9454
6	0.992	0.0031	0.0034	3.23	773.9454
7	0.988	0.0045	0.0027	20.03	773.9584
8	0.985	0.0091	0.0026	23.26	773.9609
9	0.993	0.0027	0.0026	23.90	773.9614

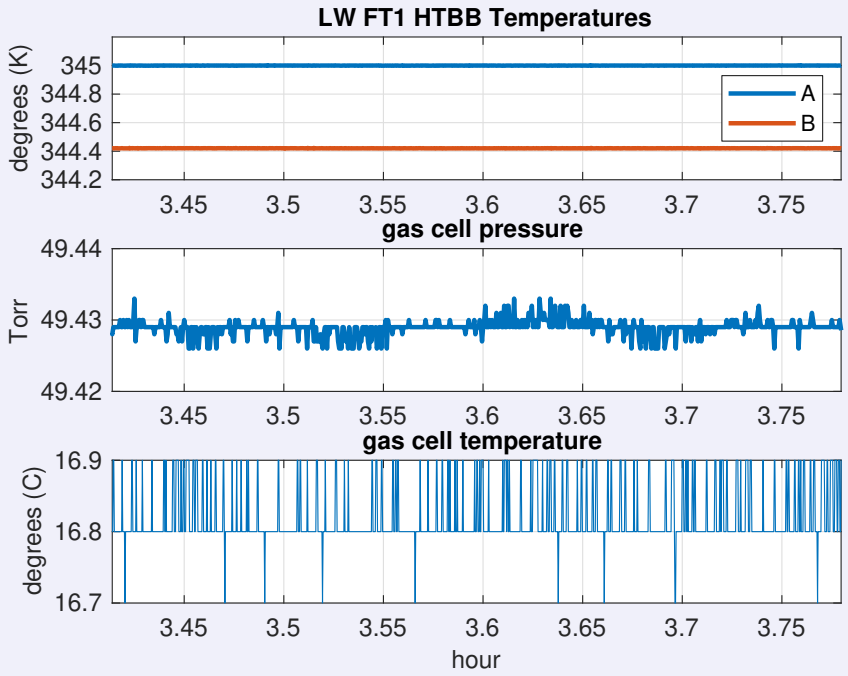
25-26 May 2021 TVAC PFL Side 1 Plateau 20

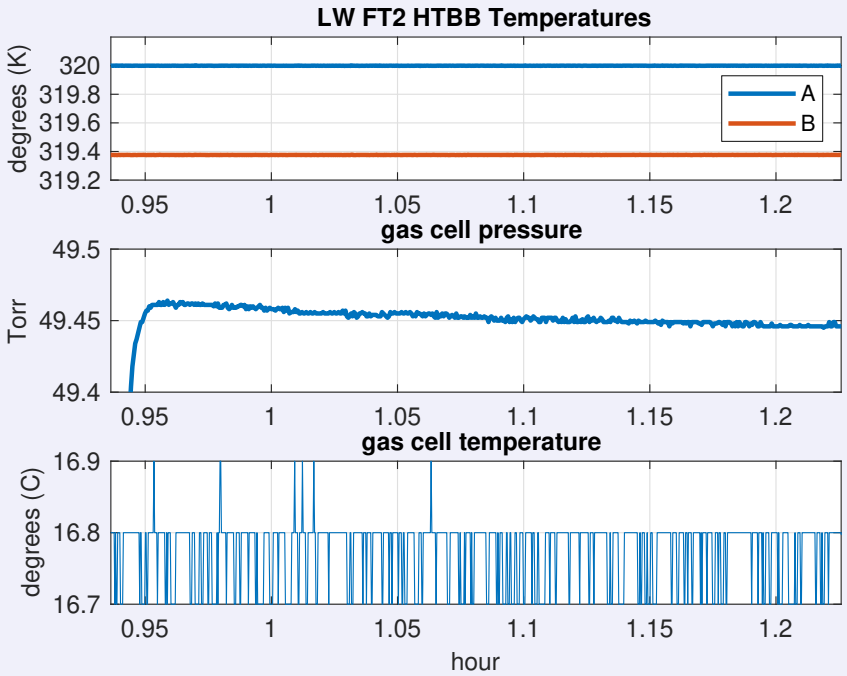




HTBB temperatures, gas cell pressure and gas cell temperature from the CCS files, for 25-26 May 2021. This data is used along with a scan of the CMD and SQL files for an overview and to find the test stages. The ILS tests begin around 22:00 on May 25.

CO_2 PFL side 1 gas cell full test legs



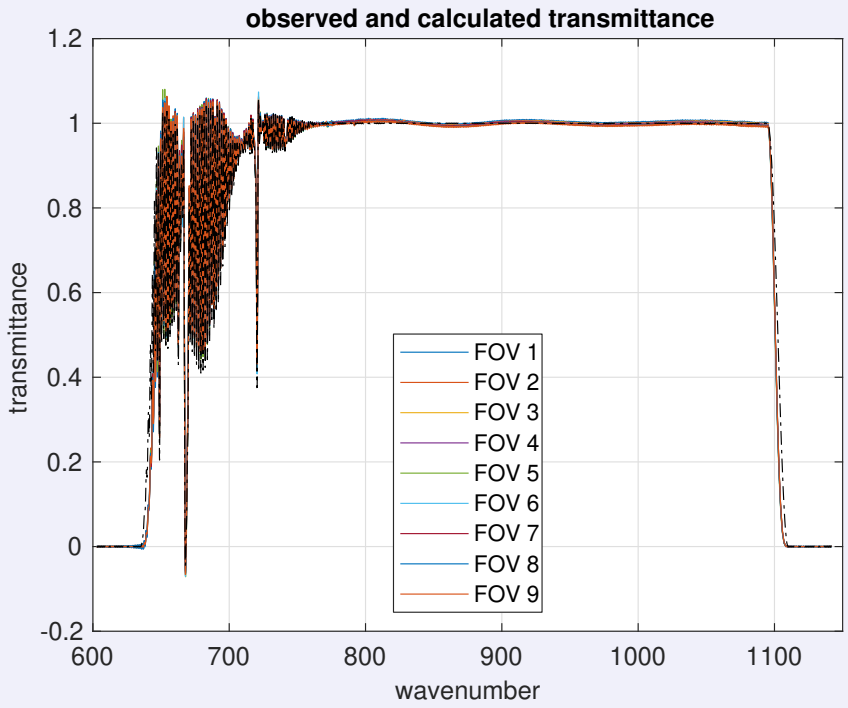


A detail from the previous plot, trimmed to the cell-full test legs, as determined by start/stop commands in the CMD files. The x axis is fractional hour of the day. We get true gas cell temperature and pressure from this data. The gas cell looks (which we see as ES data) are a subset of the time spans above, usually towards the middle. There are also ICT looks that we do not currently use.

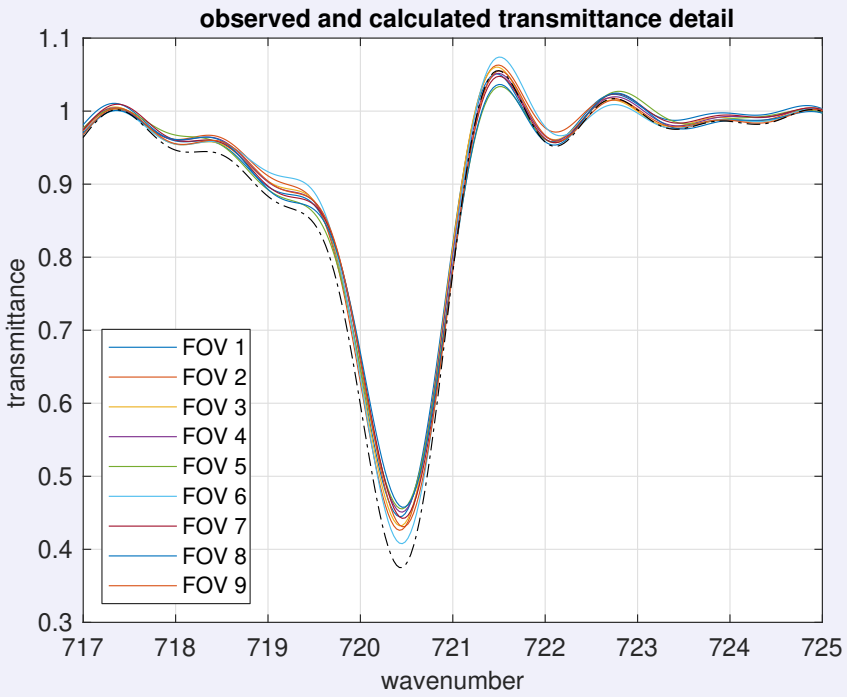
CO_2 LW PFL side 1 test parameters

- PFL Plateau 20, 25-26 May 2021
- side 1, sweep direction 0
- fitting interval 672 to 712 cm^{-1}
- metrology laser 773.13332 nm, from neon 703.44765 nm
- ATBD default focal plane
- SA correction from ILS with periodic sinc at the sensor grid
- HTBB nominal T1 345 K, T2 320 K
- gas cell pressure 49.54 Torr
- gas cell temperature 16.8 C
- gas cell length 12.59 cm

CO_2 side 1 data before fitting

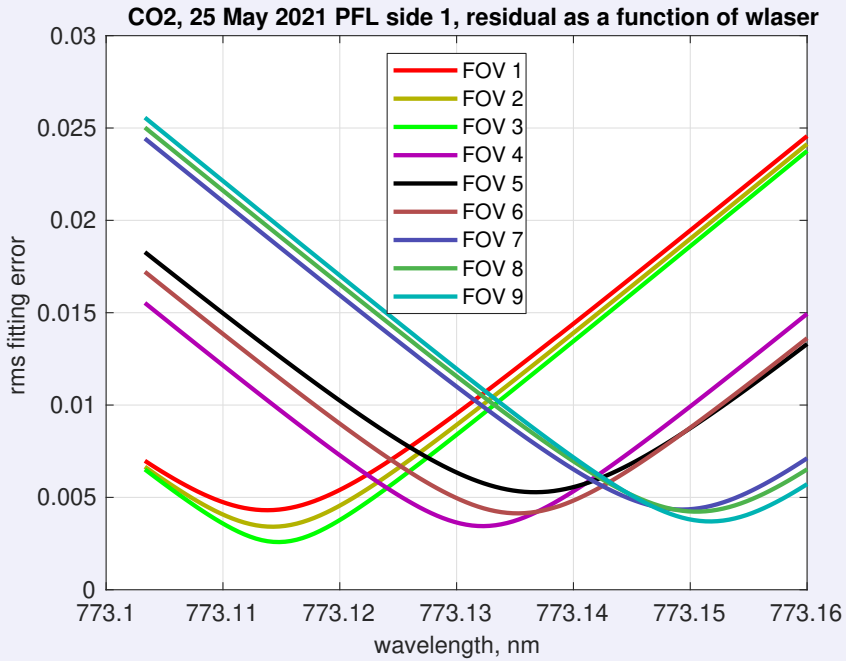


An overview of observed and calculated transmittance, after the SA correction but before any fitting.

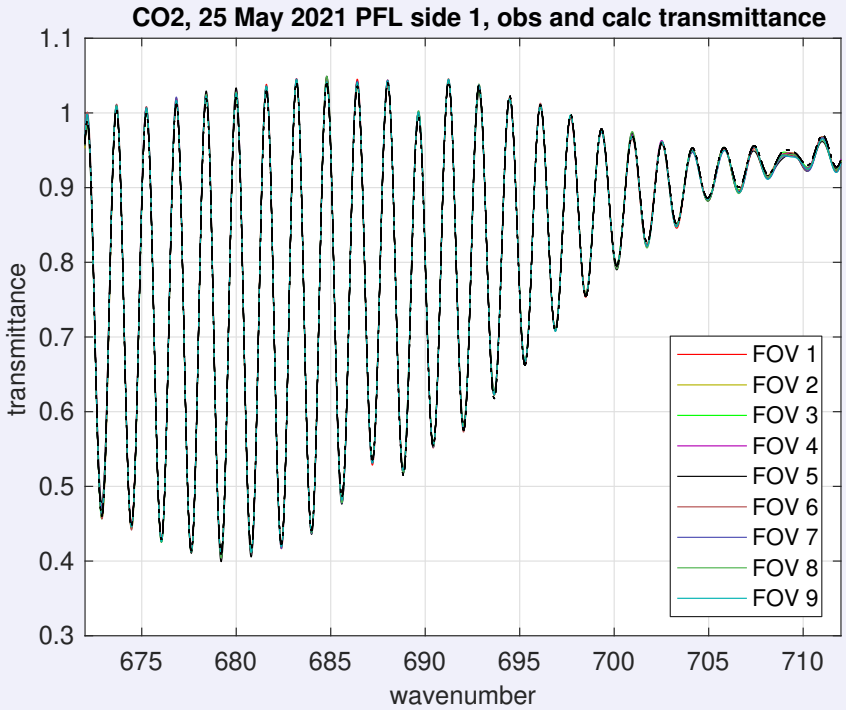


A detail from the previous plot. As with side 2, FOV 6 is slightly out of group, but now the calc (the dashed line) is further out of group. This may be due to small drifts or small differences between legs in the test procedure.

CO_2 side 1 fitting overview

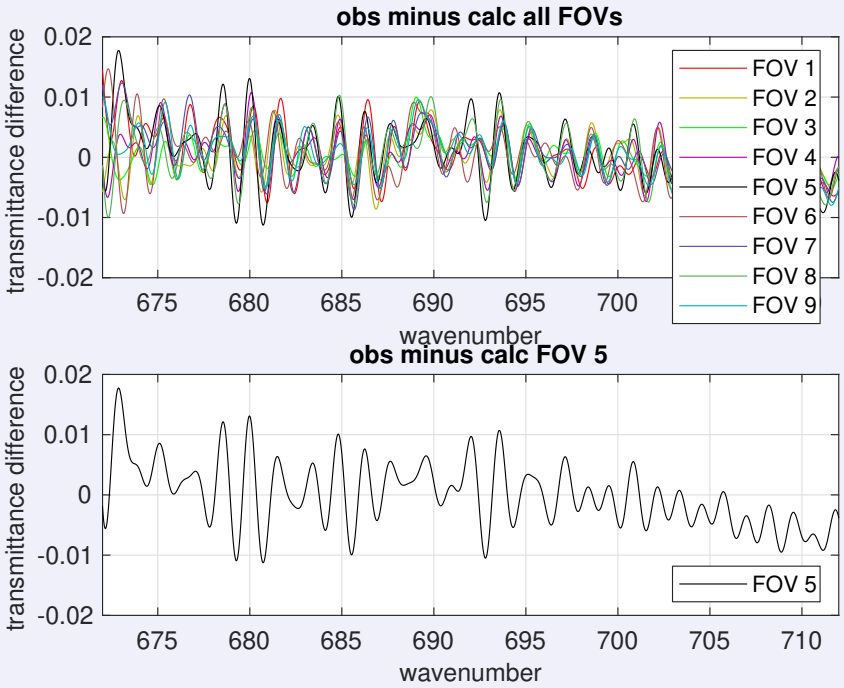


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength.

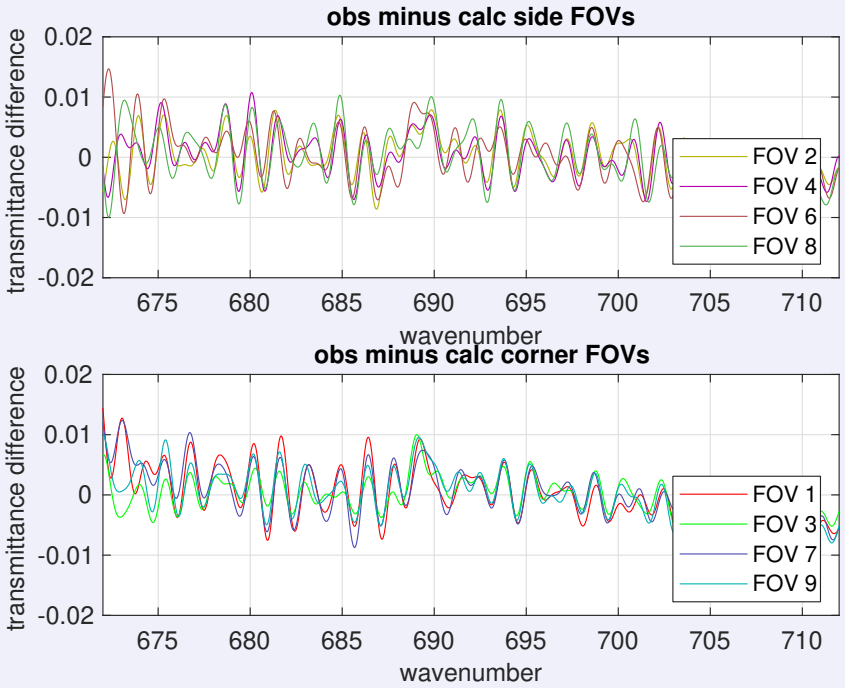


Fitted observed and calculated transmittance, over the fitting interval. At this level of detail we see all values are very close.

CO_2 side 1 obs minus calc breakouts



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



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

CO_2 side 1 tabulated residuals

metrology laser absolute residuals, ppm

20.70	-1.29	-25.22	7	4	1
21.99	4.53	-24.58	8	5	2
23.93	2.59	-23.93	9	6	3

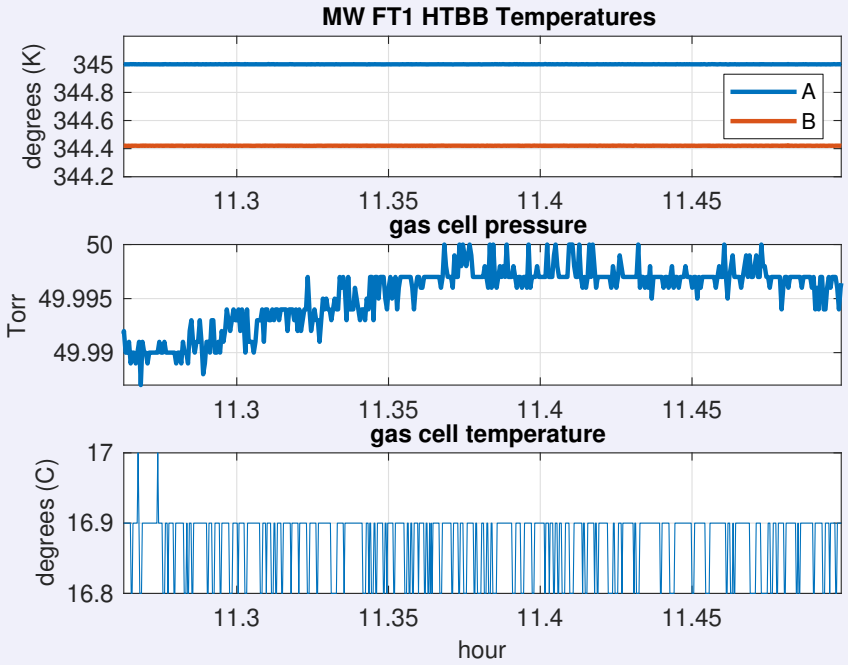
metrology laser relative residuals, ppm

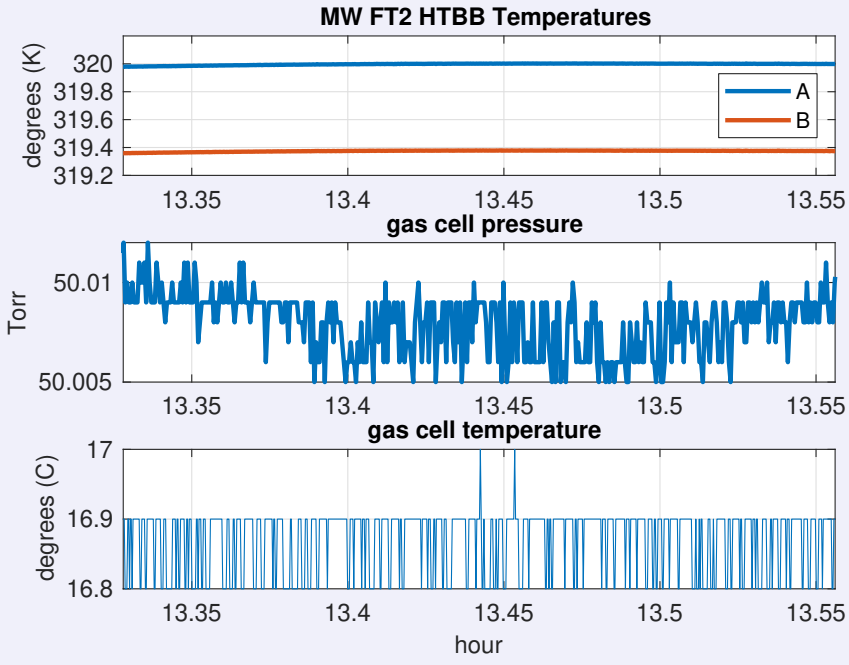
16.17	-5.82	-29.75	7	4	1
17.46	0.00	-29.10	8	5	2
19.40	-1.94	-28.46	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.058	-0.0748	0.0043	-25.22	773.1138
2	1.073	-0.0848	0.0034	-24.58	773.1143
3	1.075	-0.0853	0.0026	-23.93	773.1148
4	1.076	-0.0893	0.0034	-1.29	773.1323
5	1.054	-0.0673	0.0053	4.53	773.1368
6	1.070	-0.0800	0.0041	2.59	773.1353
7	1.061	-0.0764	0.0043	20.70	773.1493
8	1.065	-0.0761	0.0042	21.99	773.1503
9	1.067	-0.0781	0.0037	23.93	773.1518

CH_4 PFL side 1 gas cell full test legs



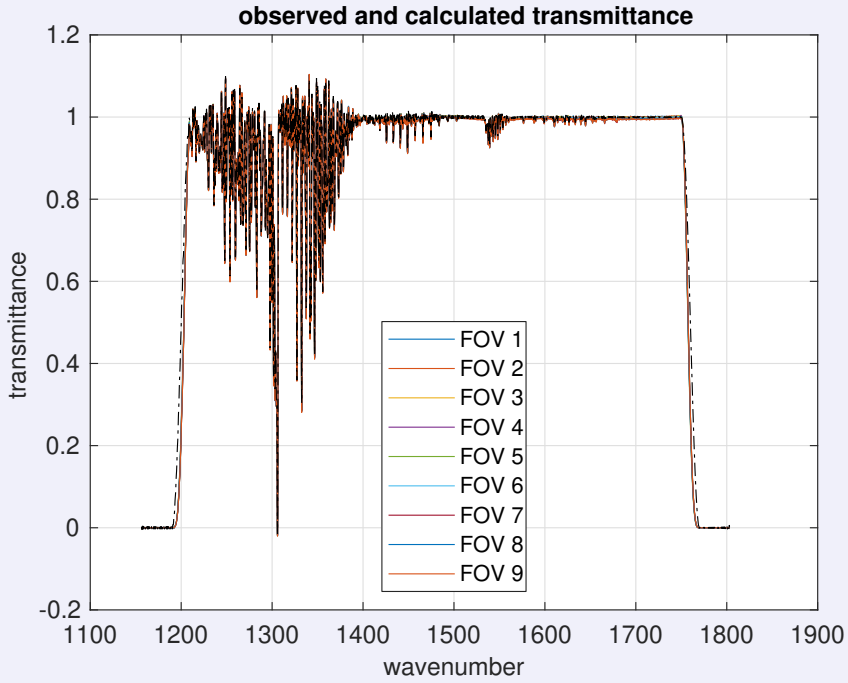


The cell-full CH_4 test legs, as determined by start/stop commands in the CMD files. The x axis is fractional hour of the day. Although the gas cell pressure may look drifty at first glance, note the very small steps in the y-axis.

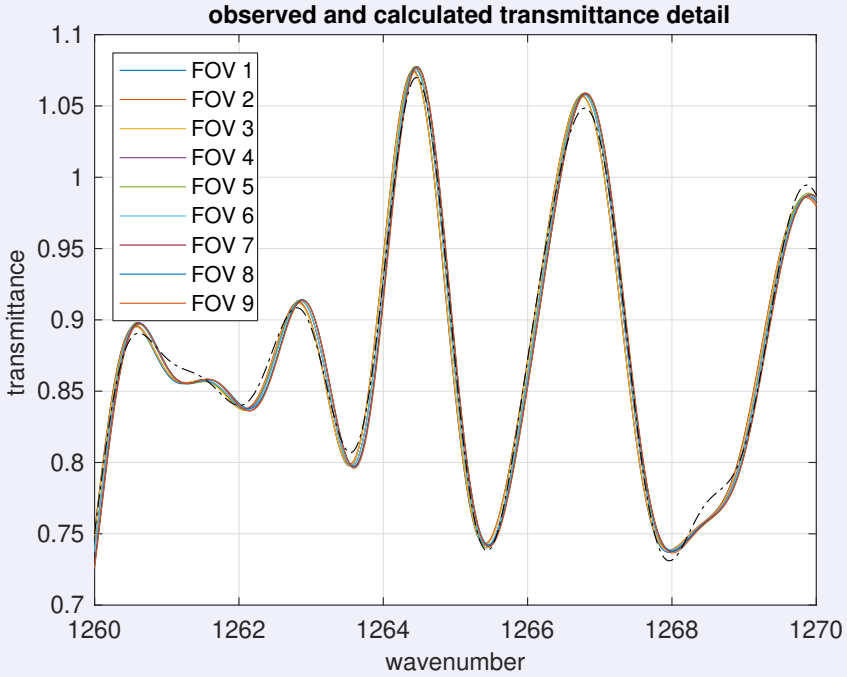
CH_4 MW PFL side 1 test parameters

- PFL Plateau 20, 26-27 May 2021
- side 1, sweep direction 0
- fitting interval 1220 to 1380 cm^{-1}
- metrology laser 773.13338 nm, from neon 703.44765 nm
- ATBD default focal plane
- SA correction from ILS with periodic sinc at the sensor grid
- HTBB nominal T1 345 K, T2 320 K
- gas cell pressure 50.00 Torr
- gas cell temperature 16.9 C
- gas cell length 12.59 cm

CH_4 side 1 data before fitting

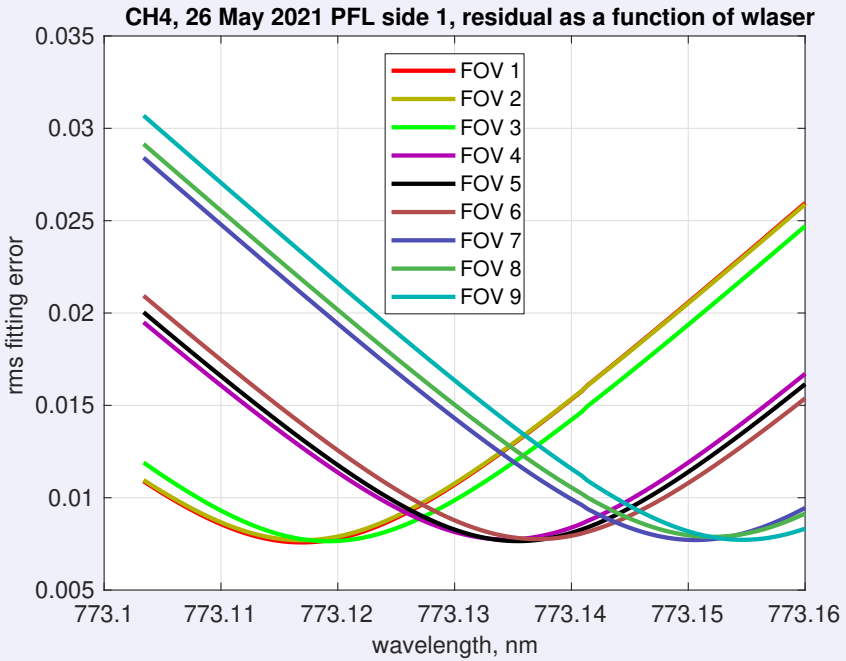


An overview of observed and calculated transmittance, after the SA correction but before any fitting.

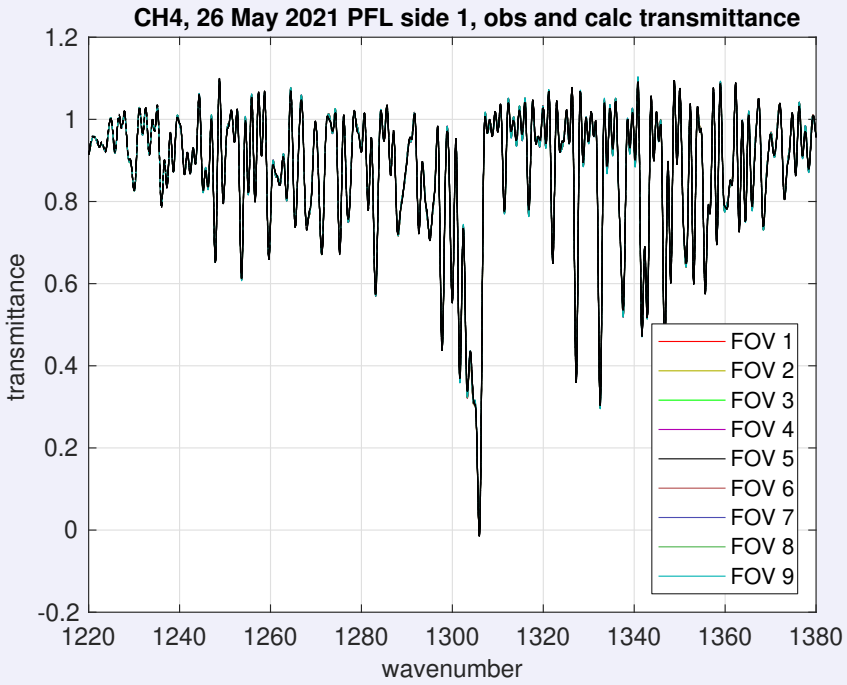


A detail from the previous plot. Agreement among the FOVs is quite good, but the calculated transmittance is out of group at some points.

CH_4 side 1 fitting overview

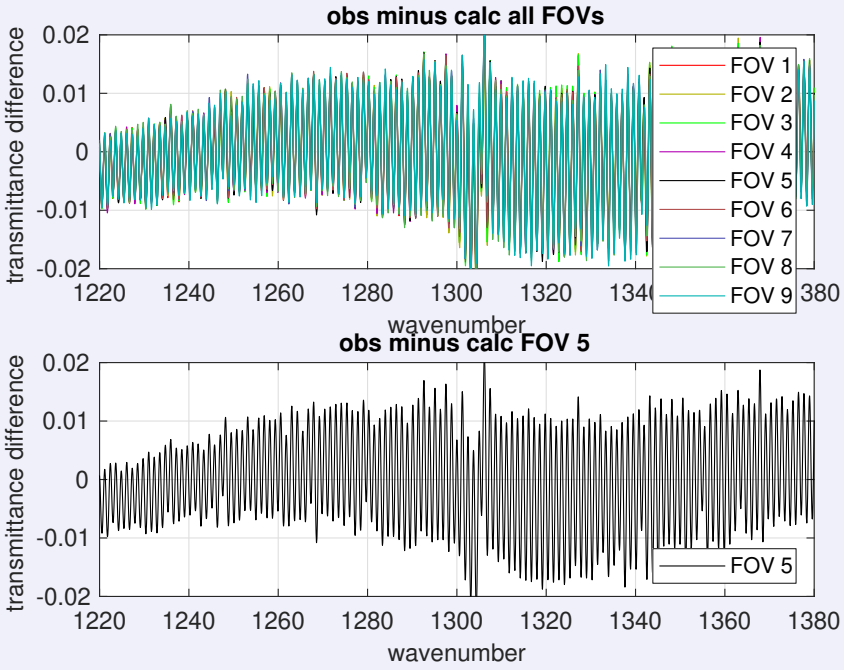


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength.

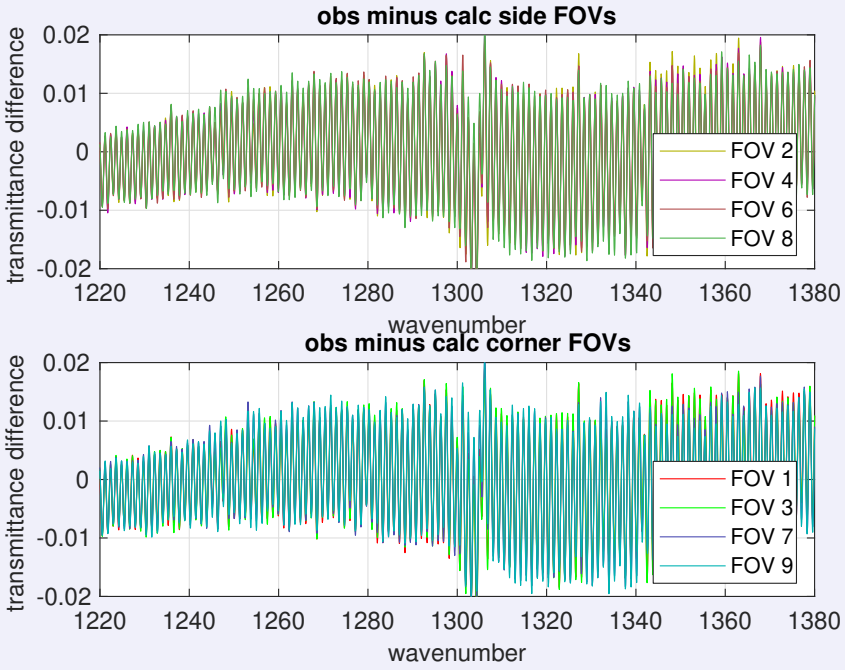


Fitted observed and calculated transmittance, over the fitting interval. At this level of detail we see all values are very close.

CH_4 side 1 obs minus calc breakouts



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



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

CH_4 side 1 tabulated residuals

metrology laser absolute residuals, ppm

21.99	1.29	-21.34	7	4	1
23.93	2.59	-21.34	8	5	2
27.81	4.53	-18.11	9	6	3

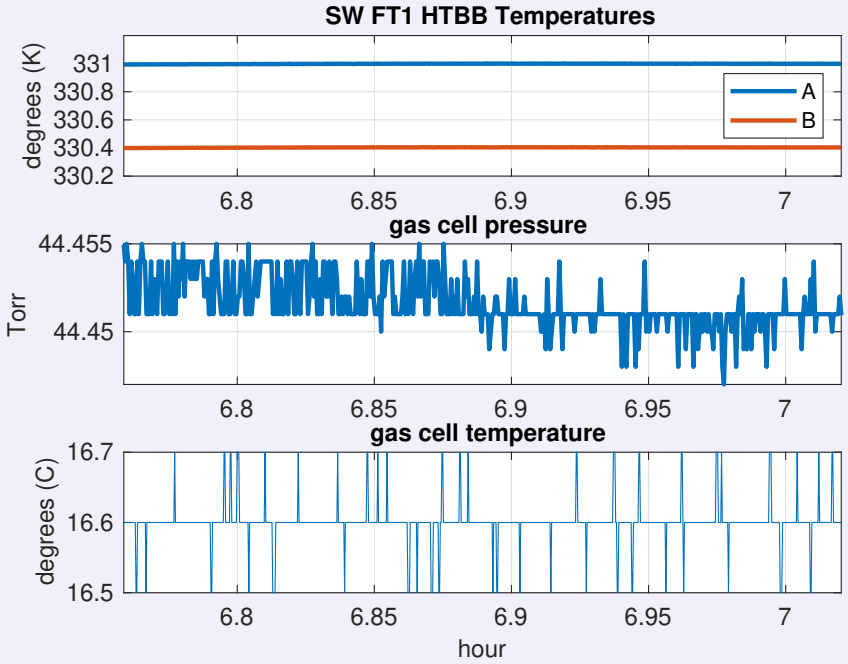
metrology laser relative residuals, ppm

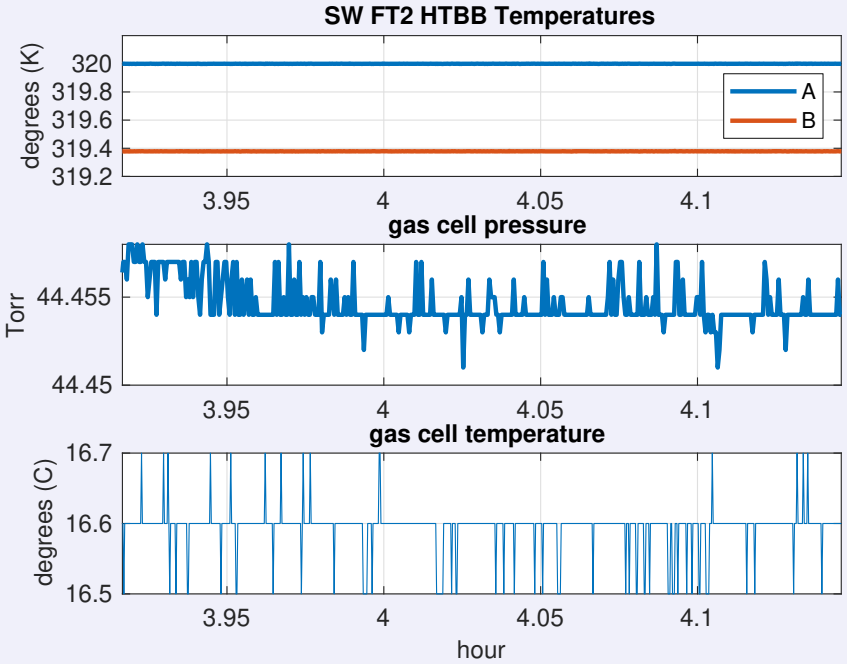
19.40	-1.29	-23.93	7	4	1
21.34	0.00	-23.93	8	5	2
25.22	1.94	-20.70	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	0.988	0.0139	0.0076	-21.34	773.1169
2	0.990	0.0123	0.0077	-21.34	773.1169
3	0.989	0.0134	0.0076	-18.11	773.1194
4	0.985	0.0163	0.0077	1.29	773.1344
5	0.984	0.0168	0.0077	2.59	773.1354
6	0.988	0.0141	0.0078	4.53	773.1369
7	0.984	0.0170	0.0077	21.99	773.1504
8	0.984	0.0172	0.0079	23.93	773.1519
9	0.982	0.0194	0.0077	27.81	773.1549

CO PFL side 1 gas cell full test legs



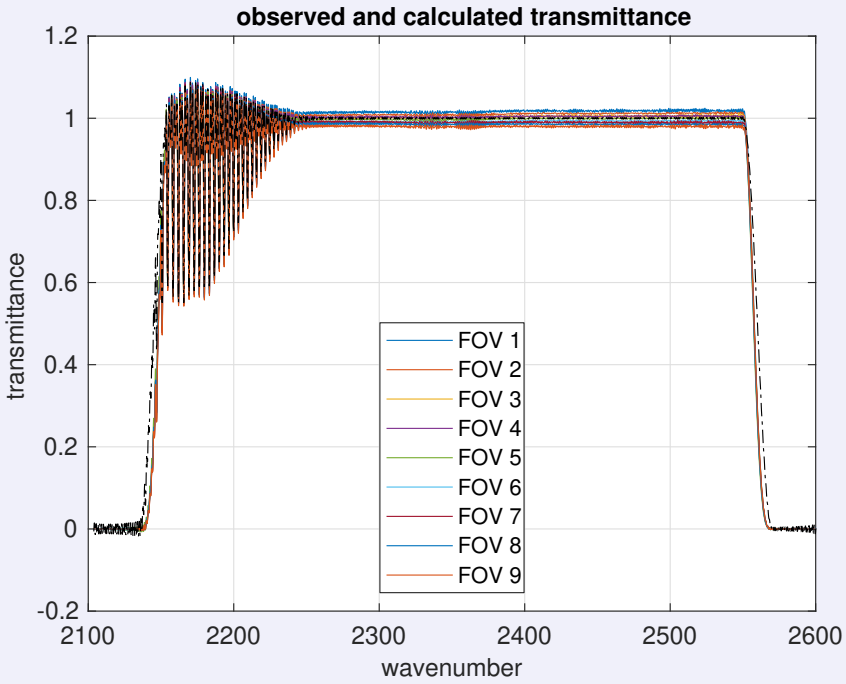


The cell-full CO test legs, as determined by start/stop commands in the CMD files. The x axis is fractional hour of the day. Although the gas cell pressure may look drifty at first glance, note the very small steps in the y-axis.

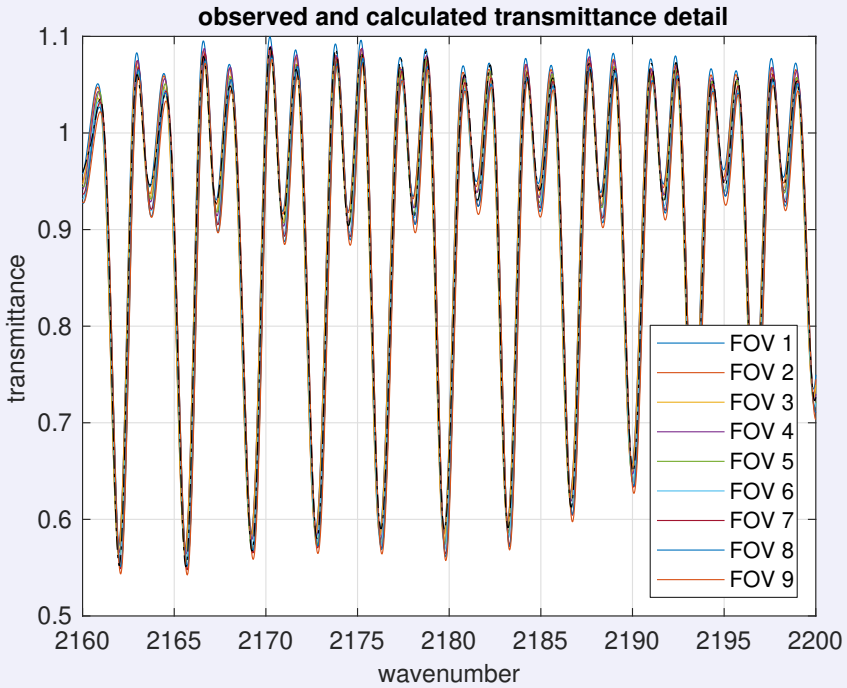
CO SW PFL side 1 test parameters

- PFL Plateau 20, 27 May 2021
- side 1, sweep direction 0
- fitting interval 2160 to 2240 cm^{-1}
- metrology laser 773.13342 nm, from neon 703.44765 nm
- ATBD default focal plane
- SA correction from ILS with periodic sinc at the sensor grid
- HTBB nominal T1 330 K, T2 320 K
- gas cell pressure 44.53 Torr
- gas cell temperature 16.6 C
- gas cell length 12.59 cm

CO side 1 data before fitting

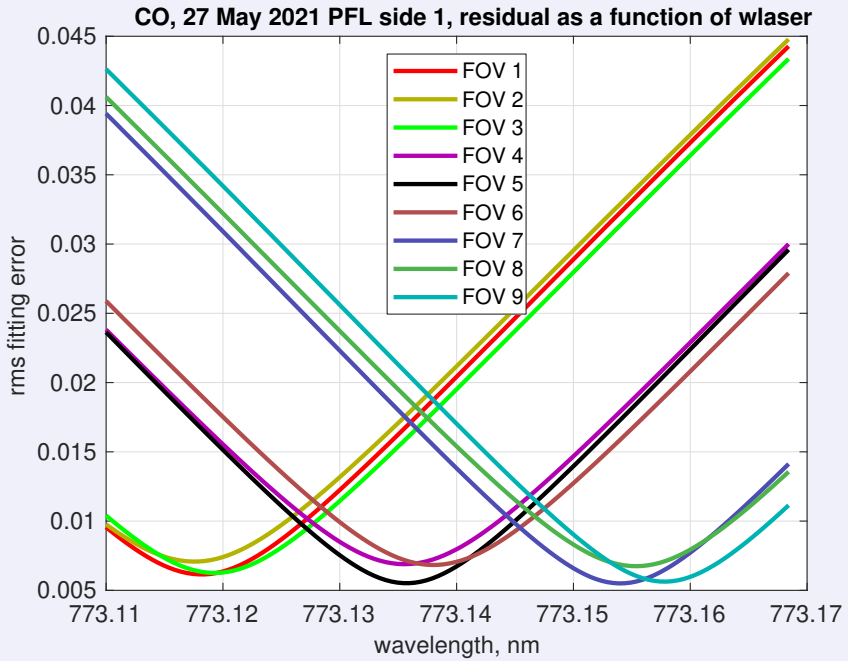


An overview of observed and calculated transmittance, after the SA correction but before any fitting.

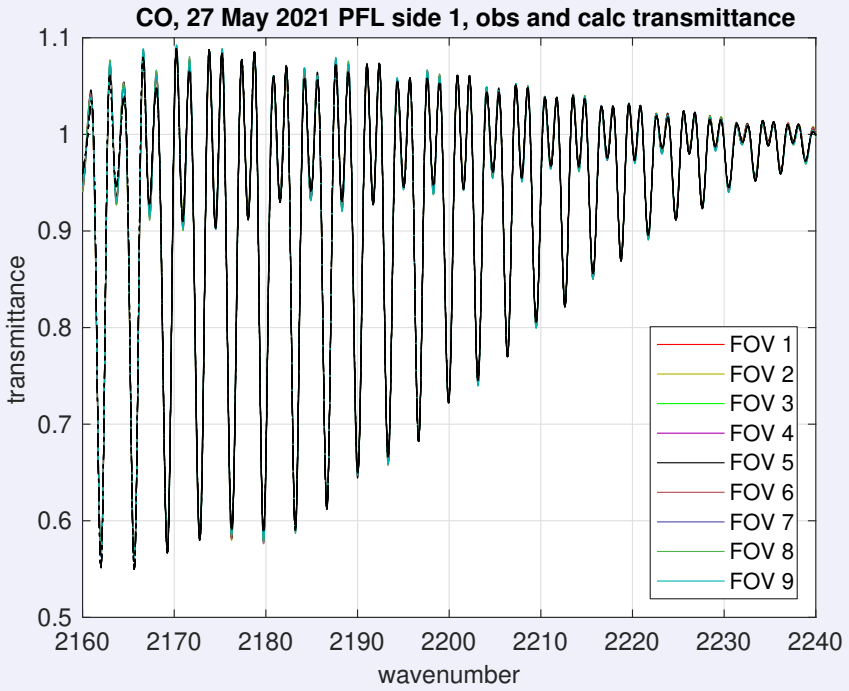


A detail from the previous plot. At this level of detail, observed and calculated data are in good agreement.

CO side 1 fitting overview

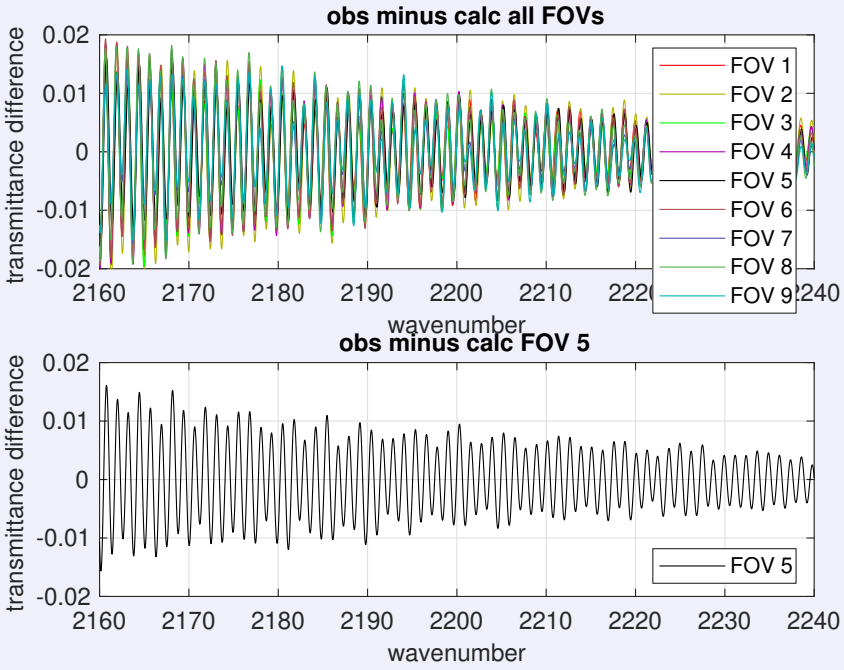


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength.

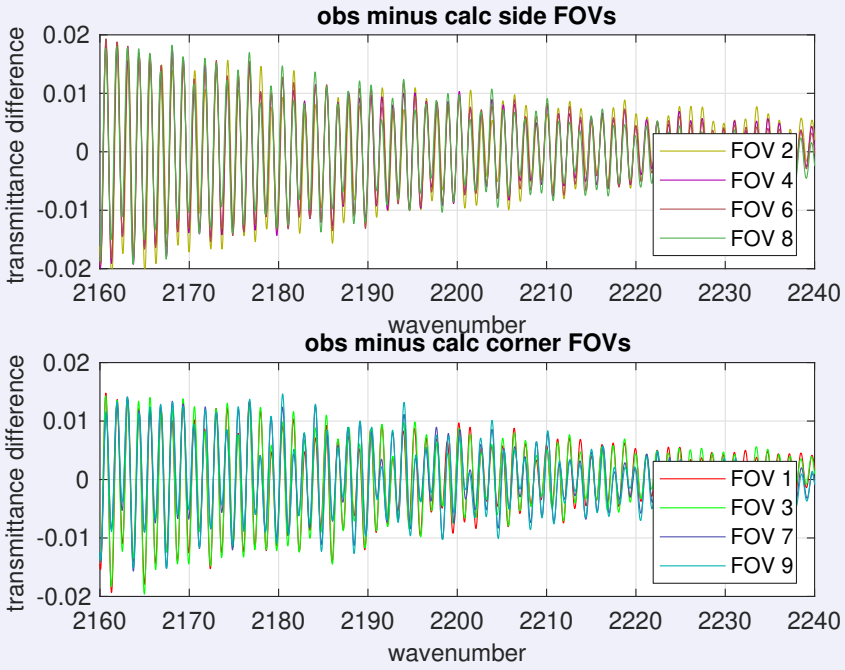


Fitted observed and calculated transmittance, over the fitting interval. At this level of detail we see all values are very close.

CO side 1 obs minus calc breakouts



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



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

CO side 1 tabulated residuals

metrology laser absolute residuals, ppm

26.52	2.59	-19.40	7	4	1
28.46	3.23	-20.70	8	5	2
31.69	5.82	-18.11	9	6	3

metrology laser relative residuals, ppm

23.28	-0.65	-22.64	7	4	1
25.22	0.00	-23.93	8	5	2
28.46	2.59	-21.34	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	0.989	-0.0008	0.0061	-19.40	773.1184
2	1.001	-0.0061	0.0071	-20.70	773.1174
3	1.005	-0.0038	0.0063	-18.11	773.1194
4	0.990	0.0078	0.0069	2.59	773.1354
5	0.993	0.0104	0.0055	3.23	773.1359
6	1.003	0.0062	0.0068	5.82	773.1379
7	0.984	0.0240	0.0055	26.52	773.1539
8	0.993	0.0190	0.0067	28.46	773.1554
9	0.992	0.0255	0.0056	31.69	773.1579

TVAC PFL ILS residual summary

metrology laser absolute residuals by FOV, in ppm

Test	1	2	3	4	5	6	7	8	9
5-19 s2 d0 CO2	-25.20	-22.61	-23.26	-0.65	3.23	3.23	20.03	23.26	23.90
5-19 s2 d1 CO2	-25.20	-23.26	-23.26	-0.65	3.23	3.23	19.38	23.26	23.26
5-25 s1 d0 CO2	-25.22	-24.58	-23.93	-1.29	4.53	2.59	20.70	21.99	23.93
5-25 s1 d1 CO2	-25.22	-23.93	-23.93	-1.94	3.88	1.94	20.05	21.34	23.28
5-26 s1 d0 CH4	-21.34	-21.34	-18.11	1.29	2.59	4.53	21.99	23.93	27.81
5-27 s1 d0 CO	-19.40	-20.70	-18.11	2.59	3.23	5.82	26.52	28.46	31.69

metrology laser relative residuals by FOV, in ppm

Test	1	2	3	4	5	6	7	8	9
5-19 s2 d0 CO2	-28.43	-25.84	-26.49	-3.88	0.00	0.00	16.80	20.03	20.67
5-19 s2 d1 CO2	-28.43	-26.49	-26.49	-3.88	0.00	0.00	16.15	20.03	20.03
5-25 s1 d0 CO2	-29.75	-29.10	-28.46	-5.82	0.00	-1.94	16.17	17.46	19.40
5-25 s1 d1 CO2	-29.10	-27.81	-27.81	-5.82	0.00	-1.94	16.17	17.46	19.40
5-26 s1 d0 CH4	-23.93	-23.93	-20.70	-1.29	0.00	1.94	19.40	21.34	25.22
5-27 s1 d0 CO	-22.64	-23.93	-21.34	-0.65	0.00	2.59	23.28	25.22	28.46

Conclusions

- We have done a preliminary analysis of the PFL Plateau 20 CH_4, CO_2, and CO gas cell ILS tests, and compared these with calculated reference truth. Overall, the results look quite good.
- The summary includes residuals for CO_2 for both sides and both sweep directions. For both side 1 and side 2, the metrology laser residuals are within 1 ppm for the two sweep directions.
- The default focal plane is clearly a poor match for CrIS J3. The next step is to fit for a better model.