June 2021 CrIS J3 TVAC MN Gas Cell ILS Tests

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Introduction

- We look at the CrIS J3 TVAC MN Plateau 22 CO_2, CH_4, and CO gas cell ILS tests, and compare measured transmittances with calculated reference truth from LBLRTM and UMBC-LBL.
- Methods and results are overall similar to the PFL and PFH tests, and rather than examine each test in detail, we summarize the PFL, PFH, and MN metrology laser residuals in tabular form.
- In the previous presentation, we saw a significant ripple in the PFH CO observed data. This was removed by using calibrated radiances for the 4-value transmittance ratio.
- We continue with the example by comparing fitting results for transmittances from calibrated radiances and from count spectra. Calibrated radiances reduce $\mathrm{RMS}(a \cdot \tau_{\mathrm{obs}} + b - \tau_{\mathrm{calc}})$, while leaving the metrology laser residuals largely unchanged.
- This increases our confidence in the tabulated results that follow, which were done with transmittances from count spectra.

TVAC PFL, PFH, and MN absolute residual summary

PFL metrology laser absolute residuals by FOV, 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

PFH metrology laser absolute residuals by FOV, ppm

Test	1	2	3	4	5	6	7	8	9
6-1 s1 d0 CO	-16.11	-19.34	-19.34	7.09	5.80	5.80	32.23	30.94	32.23
6-1 s1 d0 CH4	-18.69	-21.27	-22.56	6.45	5.16	3.22	28.36	27.72	27.07
6-2 s1 d0 CO2	-19.98	-20.63	-23.85	5.80	8.38	4.51	28.36	28.36	25.78
6-6 s2 d0 CO2	-23.18	-25.12	-25.76	2.58	4.51	0.64	24.47	25.12	21.90

MN metrology laser absolute residuals by FOV, ppm

Test	1	2	3	4	5	6	7	8	9
6-15 s2 d0 CO2	-24.51	-23.87	-25.16	0.65	4.52	2.58	21.29	23.87	23.22
6-21 s1 d0 CO2	-21.31	-21.96	-20.67	1.94	2.58	3.23	23.25	23.89	25.83
6-22 s1 d0 CH4	-21.96	-22.60	-23.25	1.29	5.81	3.23	23.89	24.54	23.25
6-22 s1 d0 CO	-18.73	-20.67	-19.37	3.87	2.58	4.52	27.12	27.77	29.71

TVAC PFL, PFH and MN relative residual summary

PFL metrology laser relative residuals by FOV, 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

PFH metrology laser relative residuals by FOV, ppm

Test	1	2	3	4	5	6	7	8	9
6-1 s1 d0 CO	-21.91	-25.14	-25.14	1.29	0.00	0.00	26.43	25.14	26.43
6-1 s1 d0 CH4	-23.85	-26.43	-27.72	1.29	0.00	-1.93	23.20	22.56	21.91
6-2 s1 d0 CO2	-28.36	-29.00	-32.23	-2.58	0.00	-3.87	19.98	19.98	17.40
6-6 s2 d0 CO2	-27.69	-29.62	-30.27	-1.93	0.00	-3.86	19.96	20.61	17.39

MN metrology laser relative residuals by FOV, ppm

Test	1	2	3	4	5	6	7	8	9
6-15 s2 d0 CO2	-29.03	-28.38	-29.67	-3.87	0.00	-1.94	16.77	19.35	18.71
6-21 s1 d0 CO2	-23.89	-24.54	-23.25	-0.65	0.00	0.65	20.67	21.31	23.25
6-22 s1 d0 CH4	-27.77	-28.42	-29.06	-4.52	0.00	-2.58	18.08	18.73	17.44
6-22 s1 d0 CO	-21.31	-23.25	-21.96	1.29	0.00	1.94	24.54	25.19	27.12

Discussion of residuals

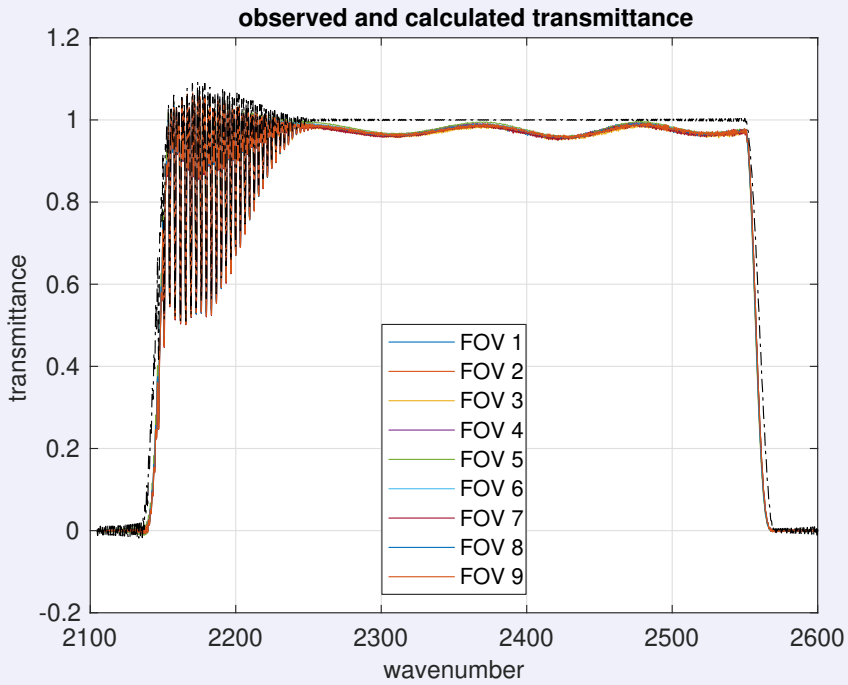
- The tabulations above were completed by 24 June, well before consent to break. The tabulated results have a discretization of approximately 0.64 ppm. This is a test parameter, a tradeoff between speed and accuracy.
- A value w_0 for the metrology laser is calculated from the Neon and eng NeonCal parameters. The metrology laser residuals are the shift in ppm from w_0 that is needed to minimize $\mathrm{RMS}(a \cdot \tau_{\mathrm{obs}} + b - \tau_{\mathrm{calc}})$.
- All tests (PFL, PFH, and MN) are done with the same value for the Neon wavelength, 703.44765 nm. In the absolute tabulation we see the FOV 5 residuals are all positive, and are within a few ppm across tests, which suggests a Neon adjustment.
- The relative residuals are quite consistent across tests, and are significant. For these initial tests we are mainy intersted in consistency. The default focal plane is a poor match for CrIS J3, but this is easily adjusted, working from the focal plane geometry and the tabulations above.

CO PFH side 1 test parameters

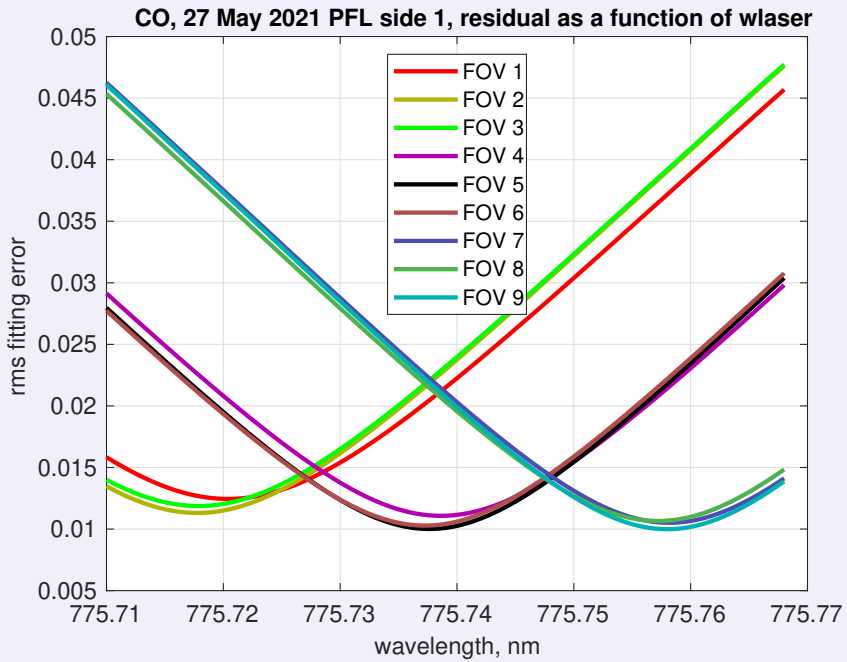
In the following, we compare transmittances calculated directly from count spectra with those calculated from calibrated radiances, for the CO SW PFH test:

- PFH Plateau 21, 1 June 2021
- side 1, sweep direction 0
- fitting interval 2160 to 2240 cm^{-1}
- metrology laser 775.73301 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 49.0 Torr
- gas cell temperature 18.5 C
- gas cell length 12.59 cm

CO PFH side 1 with transmittance from count spectra

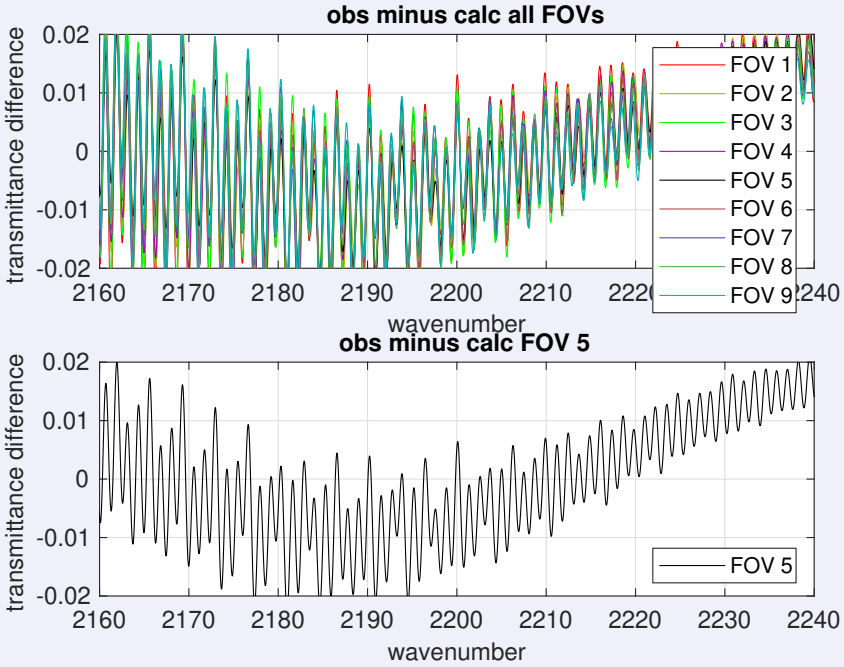


Observed and calculated transmittance, after the SA correction but before any fitting, with transmittance calculated directly from count spectra. We see a significant ripple in the observed data.

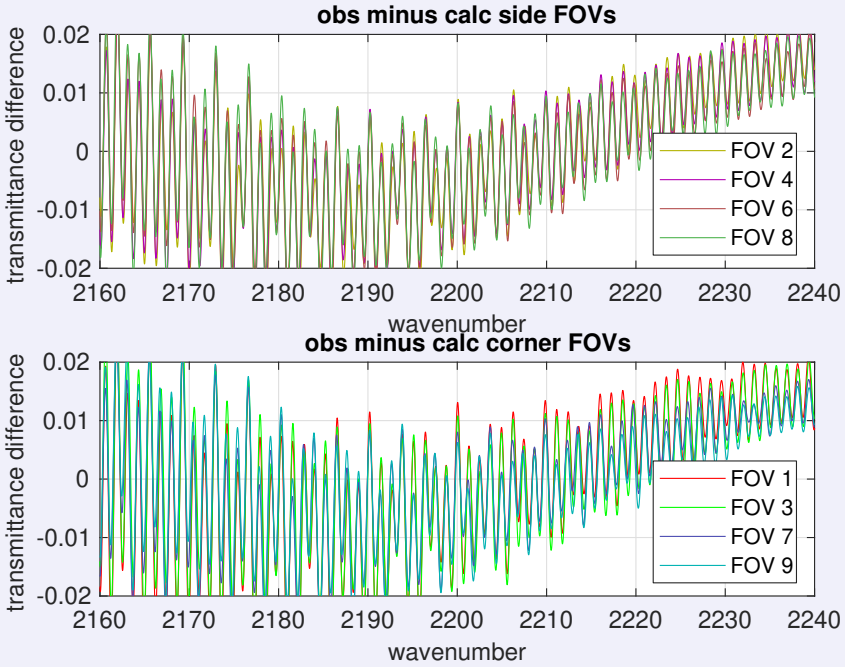


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength. Despite the ripple, we have convergence to well-defined minima.

CO PFH side 1 obs minus calc breakouts (from count spectra)



Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval. We see the ripple in the residuals.



Observed minus calculated transmittance for side and corner FOVs, over the fitting interval. We see the ripple in the residuals.

CO PFH side 1 tabulated residuals (from count spectra)

metrology laser absolute residuals, ppm

32.23	7.09	-16.11	7	4	1
30.94	5.80	-19.34	8	5	2
32.23	5.80	-19.34	9	6	3

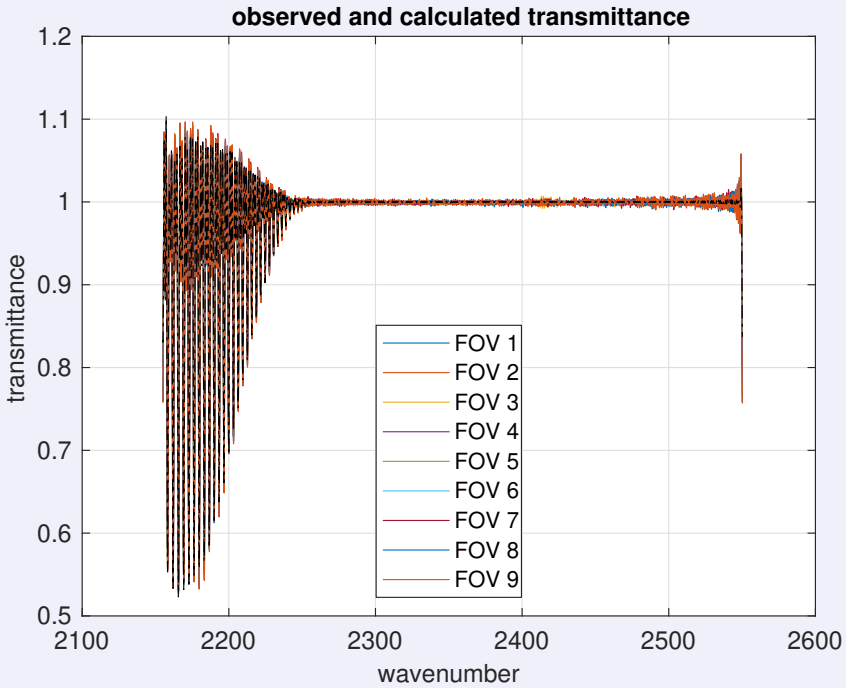
metrology laser relative residuals, ppm

26.43	1.29	-21.91	7	4	1
25.14	0.00	-25.14	8	5	2
26.43	0.00	-25.14	9	6	3

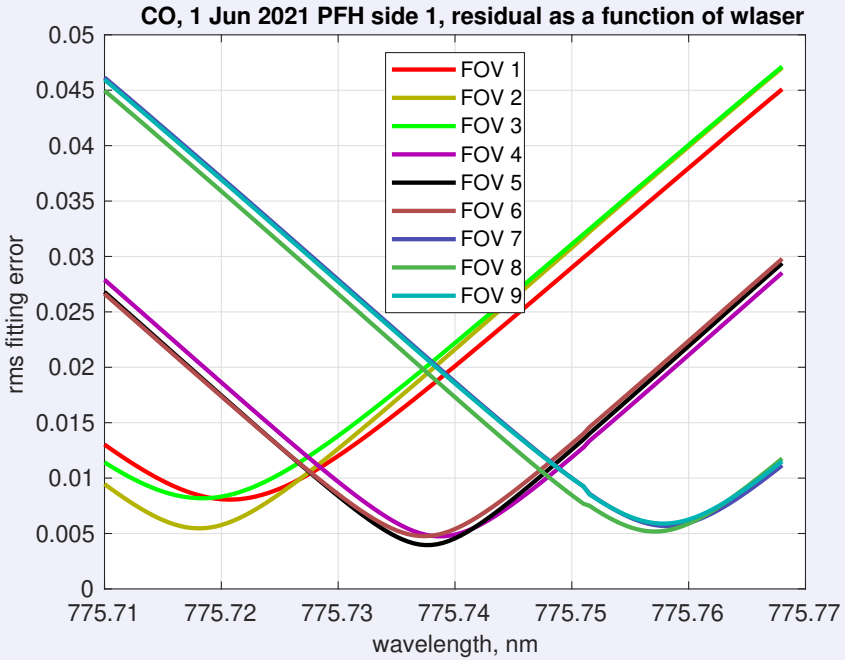
regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.027	0.0025	0.0124	-16.11	775.7205
2	1.034	-0.0033	0.0113	-19.34	775.7180
3	1.040	-0.0051	0.0119	-19.34	775.7180
4	1.011	0.0146	0.0111	7.09	775.7385
5	1.006	0.0175	0.0100	5.80	775.7375
6	1.017	0.0095	0.0103	5.80	775.7375
7	1.000	0.0294	0.0105	32.23	775.7580
8	1.005	0.0240	0.0107	30.94	775.7570
9	0.998	0.0287	0.0100	32.23	775.7580

CO PFH side 1 with transmittance from calibrated radiances

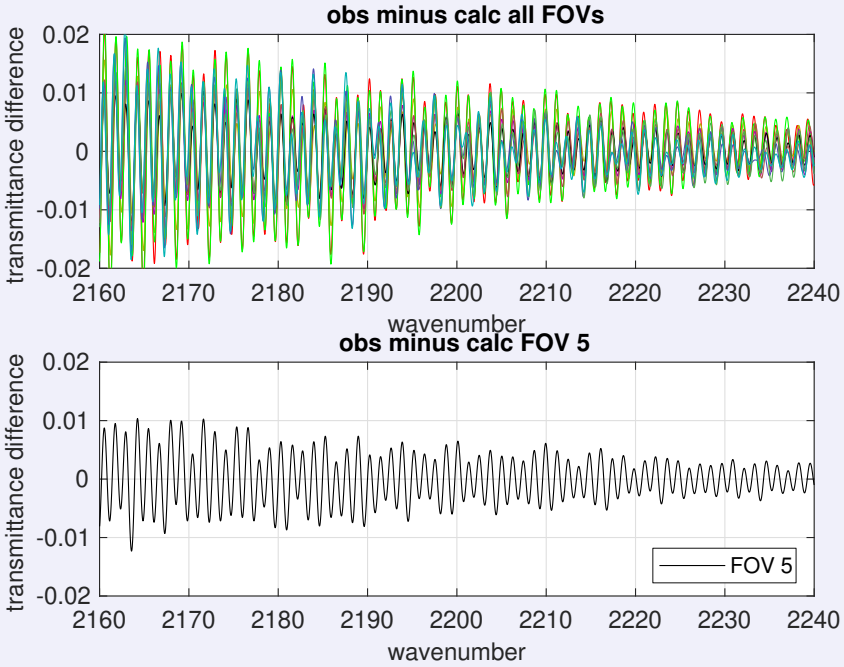


Observed and calculated transmittance, after the SA correction but before any fitting, with transmittance calculated from calibrated radiances. The ripple is gone.

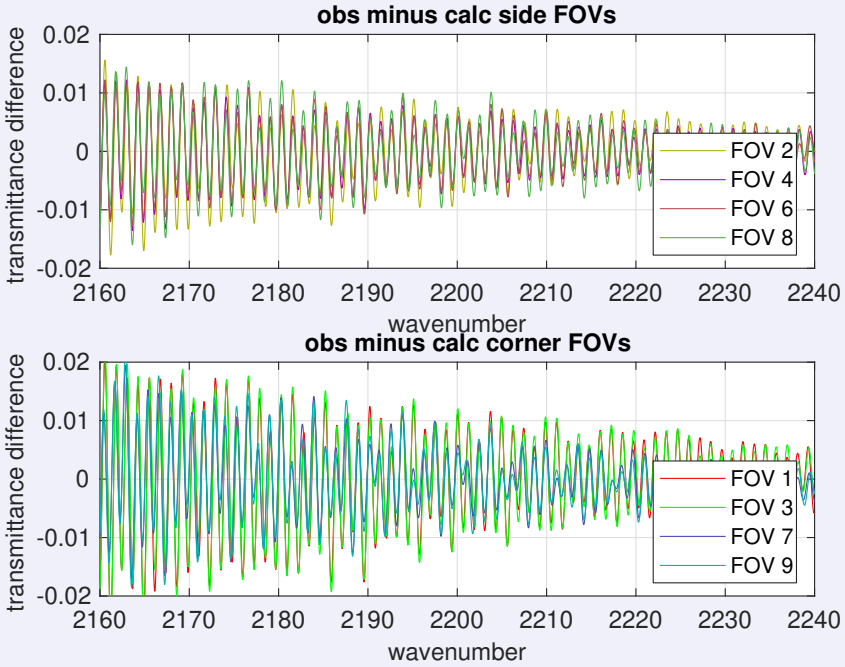


Residuals RMS$(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of metrology laser wavelength. The minima are reduced by around half.

CO PFH side 1 obs minus calc breakouts (from calibrated radiances)



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



Observed minus calculated transmittance for side and corner FOVs, over the fitting interval. The ripple is gone.

CO PFH side 1 tabulated residuals (from calibrated radiances)

metrology laser absolute residuals, ppm

32.23	7.09	-16.11	7	4	1
30.94	5.80	-19.34	8	5	2
32.23	5.80	-18.69	9	6	3

metrology laser relative residuals, ppm

26.43	1.29	-21.91	7	4	1
25.14	0.00	-25.14	8	5	2
26.43	0.00	-24.49	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.007	-0.0047	0.0081	-16.11	775.7205
2	1.014	-0.0113	0.0055	-19.34	775.7180
3	1.012	-0.0092	0.0082	-18.69	775.7185
4	0.994	0.0059	0.0047	7.09	775.7385
5	0.991	0.0094	0.0040	5.80	775.7375
6	0.997	0.0041	0.0048	5.80	775.7375
7	0.975	0.0236	0.0057	32.23	775.7580
8	0.981	0.0179	0.0052	30.94	775.7570
9	0.972	0.0260	0.0059	32.23	775.7580

Conclusions

- Comparing tests with and without calibrated radiances, with calibrated radiances obs minus calc is reduced while the metrology laser residuals remain within one discretization step, 0.64 ppm.
- Since we are mainly interested in the metrology laser residuals, this increases our confidence in the tabulated results, presented at the start, which were done with transmittances calculated directly from count spectra.
- To summarize, we have done a preliminary analysis of the PFL, PFH, and MN CH_4, CO_2, and CO gas cell ILS tests, and compared these with calculated reference truth, and with each other.
- The metrology laser relative residuals are consistent across tests, and significant. For these initial tests we are mainy intersted in consistency. The default focal plane is a poor match for CrIS J3, but this is easily adjusted, working from the focal plane geometry and the tabulations above.

Future Work

- The next step is to use the metrology laser residuals and some basic assumptions about focal plane geometry to get an improved focal plane model, and to rerun some of the tests, probably all of MN, as a check.
- Although the results we have gotten using count spectra appear to be valid, the reduced RMS($a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}}$) working from calibrated radiances makes a strong case for switching to the latter, to increase confidence in the results.