

CrIS TVAC MN Side 2

Gas Cell Tests

H. E. Motteler, L. L. Strow,
S. DeSouza-Machado

UMBC Atmospheric Spectroscopy Lab
Joint Center for Earth Systems Technology

November 5, 2014

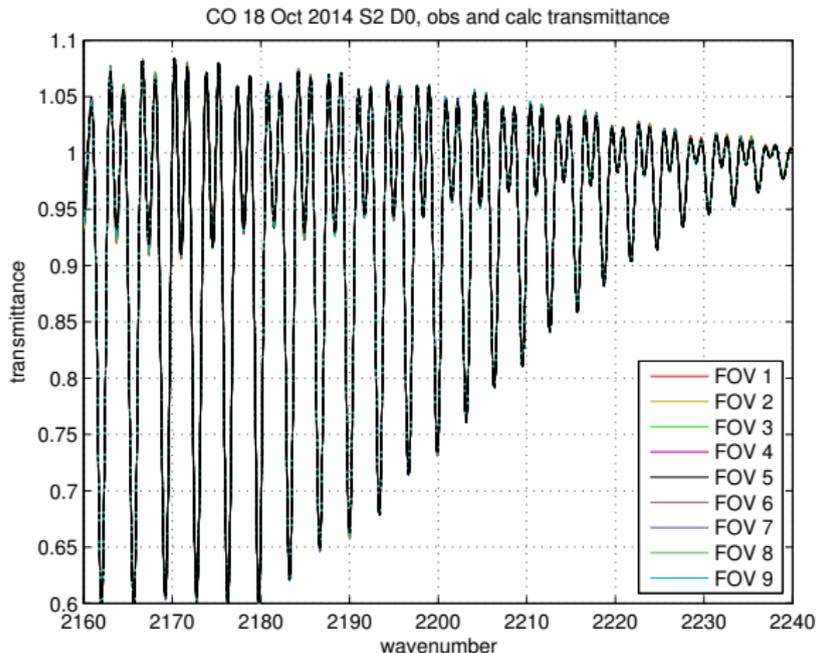
overview

- ▶ analysis of the CO, CH₄, NH₃ and CO₂ MN side 2 gas cell tests shows good agreement with calculated data and with the side 1 tests
- ▶ the metrology laser residuals are generally consistent for all three bands and both sides
- ▶ for each test, the fitting interval was chosen to include significant spectral detail
- ▶ except as noted all results shown here are for side 2

CO test parameters

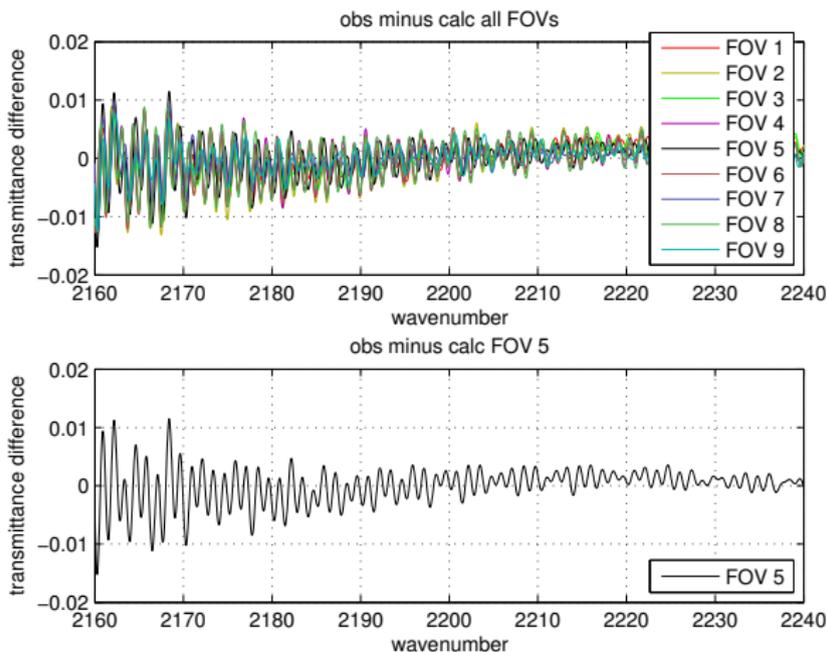
- ▶ side 2, sweep direction 0
- ▶ fitting interval 2160 to 2240 cm^{-1}
- ▶ metrology laser wavelength from neon cal
- ▶ Oct 2013 Exelis side 1 focal plane values
- ▶ ILS with periodic sinc wrap at the sensor grid
- ▶ 330 observations in each test leg
- ▶ gas cell measured pressure 41.5 torr
- ▶ gas cell observed pressure 42 torr
- ▶ gas cell temperature 16.8 C
- ▶ gas cell length 12.59 cm
- ▶ HTBB nominal T1 335 K, T2 320 K

CO obs and calc



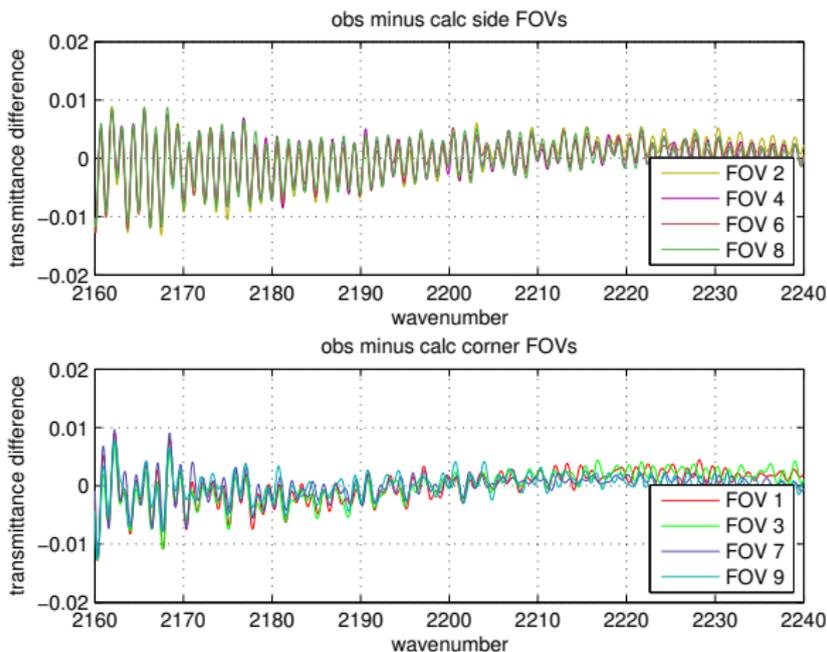
Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

CO obs minus calc



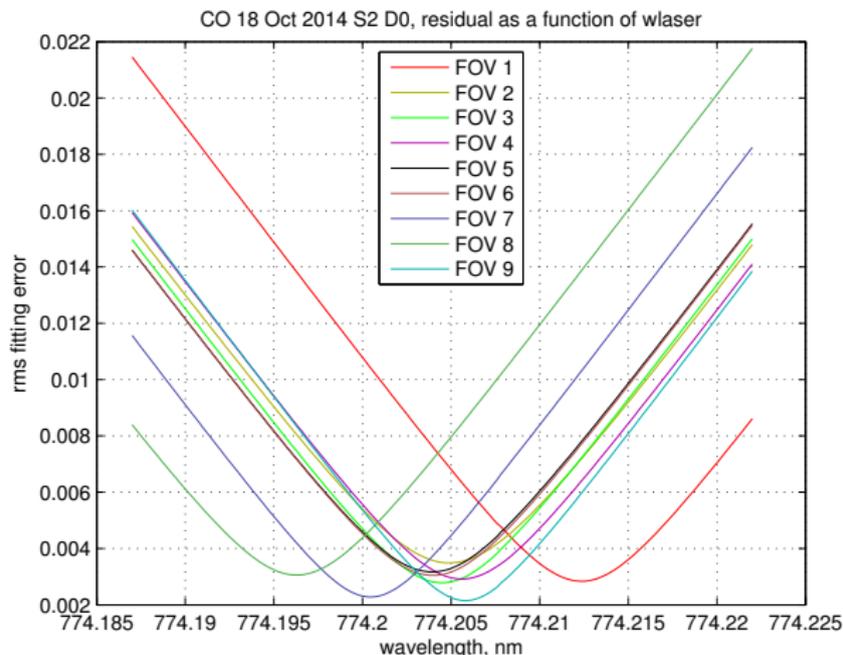
Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.

CO obs minus calc



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

CO fitting residuals



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

CO tabulated residuals

metrology laser relative residuals, ppm

-4.65	2.07	10.85	7	4	1
-10.07	0.00	1.03	8	5	2
2.33	0.26	0.52	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.002	0.0041	0.0028	13.43	774.2124
2	1.007	-0.0025	0.0035	3.62	774.2048
3	1.002	0.0008	0.0028	3.10	774.2044
4	1.006	-0.0025	0.0029	4.65	774.2056
5	0.999	0.0021	0.0032	2.58	774.2040
6	1.003	-0.0032	0.0030	2.84	774.2042
7	1.007	-0.0056	0.0023	-2.07	774.2004
8	1.011	-0.0110	0.0031	-7.49	774.1962
9	0.994	0.0026	0.0021	4.91	774.2058

residual interpretation

- ▶ we minimize $\text{RMS}(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ over the fitting interval as a function of the metrology laser wavelength
- ▶ from the previous slide, d_{min} is the value of this expression at the minima, w_{fov} the metrology laser wavelength at the minima, w_{min} the difference of w_{fov} and the value from neon calibration, and “metrology laser relative residuals” are the difference of w_{fov} and the value for FOV 5.
- ▶ a and b represent radiometric or other physical uncertainty, such as true and calculated cell pressure being different
- ▶ so for example if the calculated cell pressure is greater than the true pressure we will typically still find the correct minima, but the a weights will be greater than 1.

CO residual comparison

met laser CO side 2 minus CO side 1, ppm

-1.03	0.77	0.77	7	4	1
-0.26	0.00	0.77	8	5	2
-1.81	0.26	-0.52	9	6	3

met laser CO side 2 minus CH₄ side 2, ppm

-0.26	0.00	-0.26	7	4	1
1.03	0.00	0.00	8	5	2
2.07	1.29	0.52	9	6	3

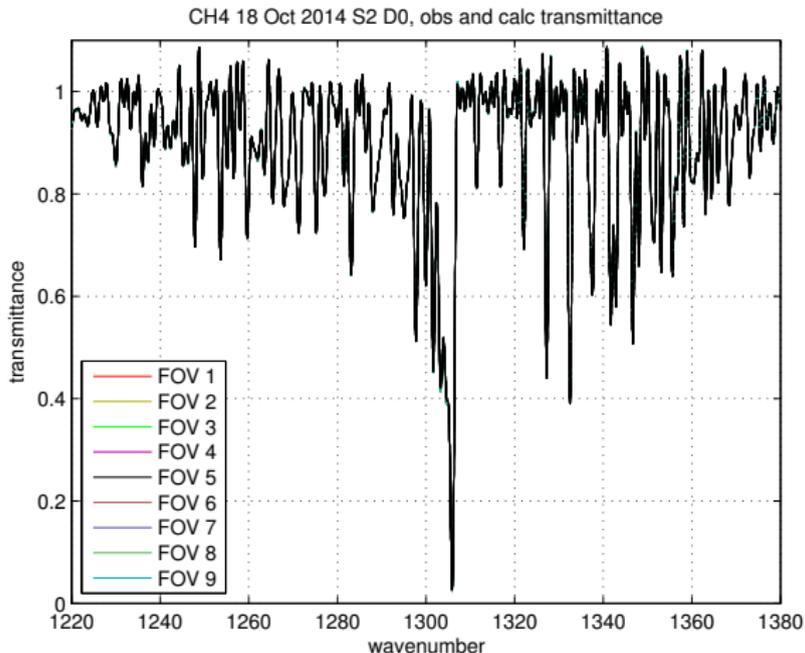
met laser CO side 2 minus NH₃ side 2, ppm

4.13	1.81	3.62	7	4	1
-0.26	0.00	1.55	8	5	2
2.84	0.26	1.03	9	6	3

CH₄ test parameters

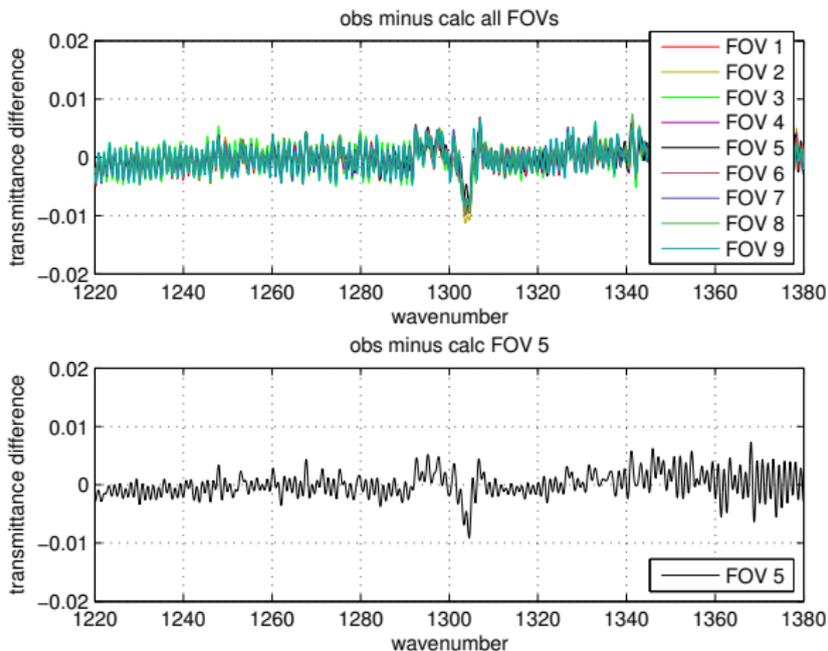
- ▶ side 2, sweep direction 0
- ▶ fitting interval 1220 to 1380 cm⁻¹
- ▶ metrology laser wavelength from neon cal
- ▶ Oct 2013 Exelis side 1 focal plane values
- ▶ ILS with periodic sinc wrap at the sensor grid
- ▶ 330 observations in each test leg
- ▶ gas cell measured pressure 41.6 torr
- ▶ gas cell observed pressure 41.5 torr
- ▶ gas cell temperature 16.8 C
- ▶ gas cell length 12.59 cm
- ▶ HTBB nominal T1 360 K, T2 320 K

CH₄ obs and calc



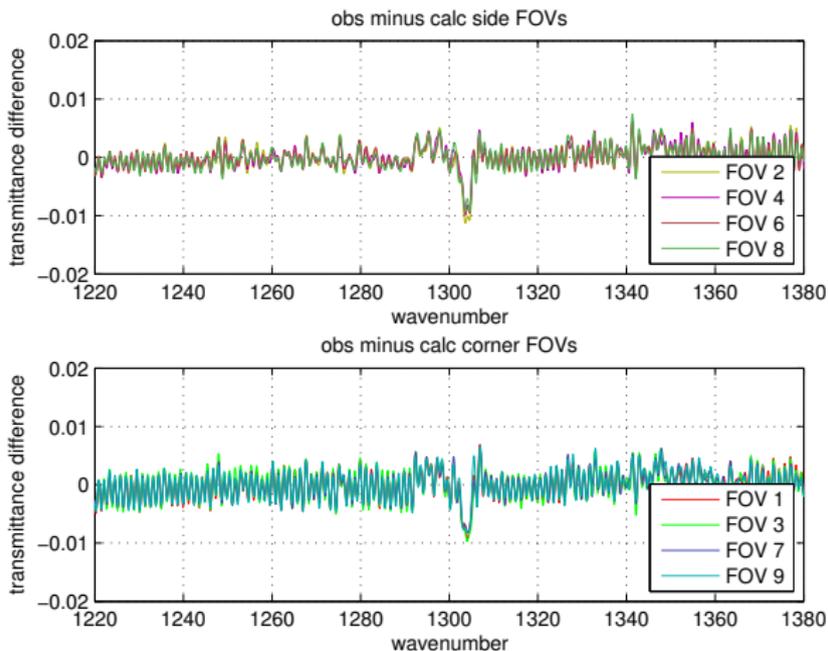
Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are very close.

CH₄ obs minus calc



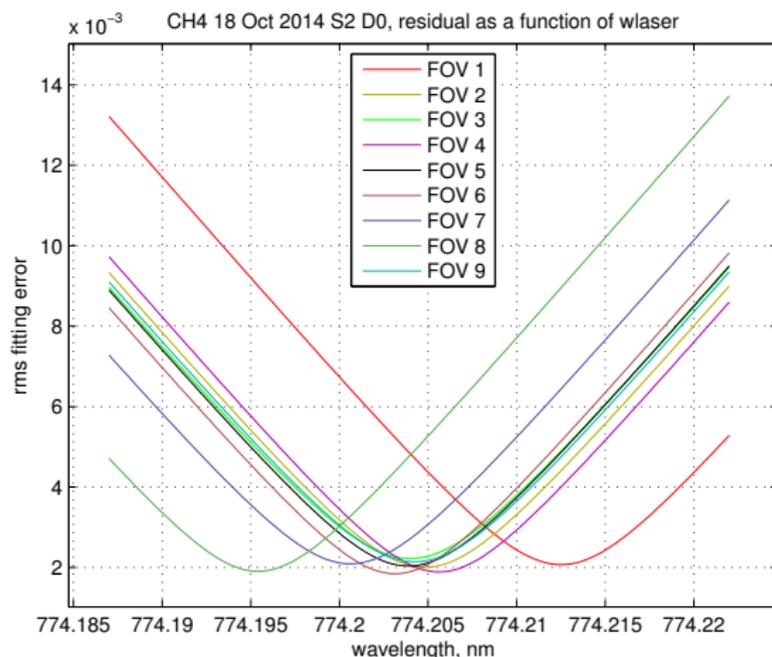
Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.

CH₄ obs minus calc



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

CH₄ fitting residuals



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

CH₄ tabulated residuals

metrology laser relative residuals, ppm

-4.39	2.07	11.11	7	4	1
-11.11	0.00	1.03	8	5	2
0.26	-1.03	0.00	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.000	0.0002	0.0021	13.69	774.2126
2	1.002	-0.0019	0.0020	3.62	774.2048
3	1.002	-0.0015	0.0022	2.58	774.2040
4	1.002	-0.0018	0.0019	4.65	774.2056
5	1.000	0.0005	0.0020	2.58	774.2040
6	1.006	-0.0054	0.0018	1.55	774.2032
7	1.004	-0.0027	0.0021	-1.81	774.2006
8	1.007	-0.0046	0.0019	-8.52	774.1954
9	0.984	0.0143	0.0021	2.84	774.2042

CH₄ residual comparison

met laser CH₄ side 2 minus CH₄ side 1, ppm

0.00	-0.26	1.55	7	4	1
-1.03	0.00	0.26	8	5	2
-0.78	-0.52	1.29	9	6	3

met laser CH₄ side 2 minus CO side 2, ppm

0.26	0.00	0.26	7	4	1
-1.03	0.00	0.00	8	5	2
-2.07	-1.29	-0.52	9	6	3

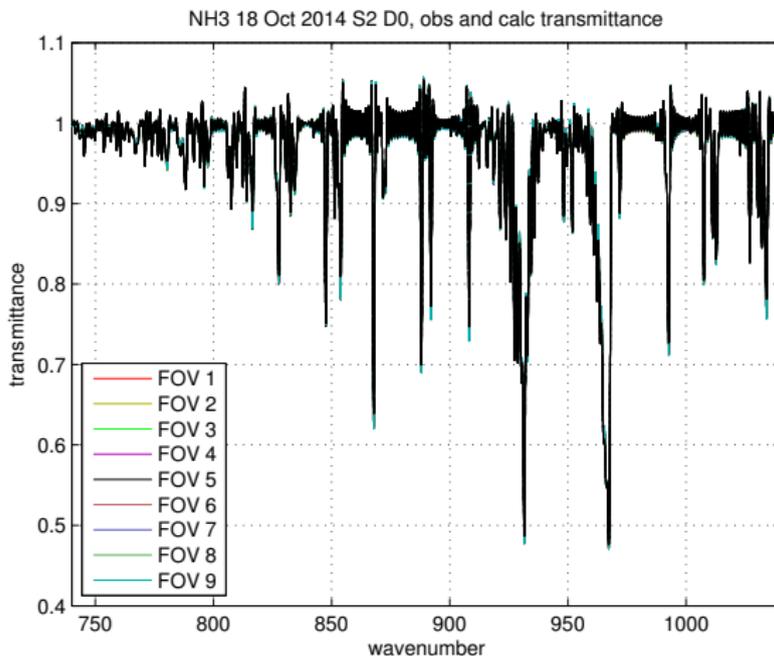
met laser CH₄ side 2 minus NH₃ side 2, ppm

4.39	1.81	3.87	7	4	1
-1.29	0.00	1.55	8	5	2
0.78	-1.03	0.52	9	6	3

NH₃ test parameters

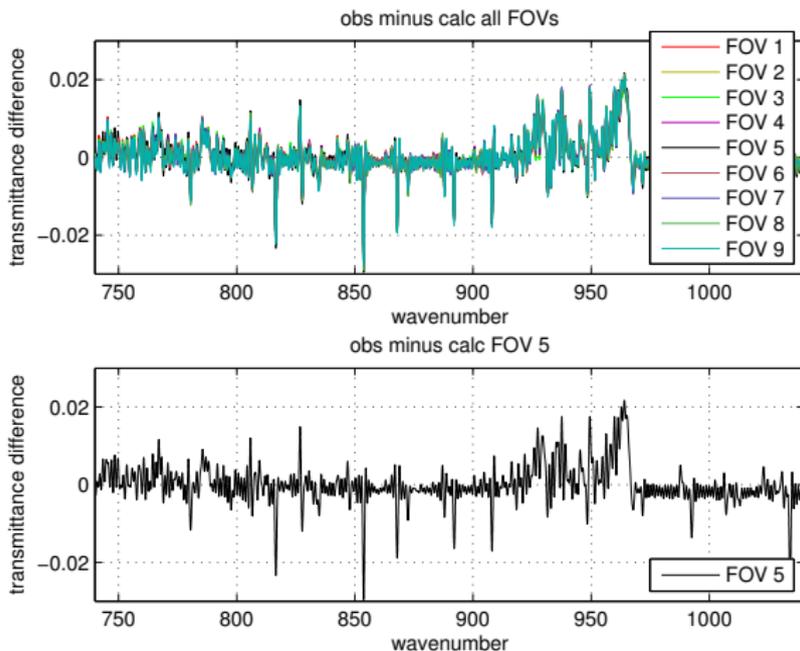
- ▶ side 2, sweep direction 0
- ▶ fitting interval 740 to 1040 cm⁻¹
- ▶ metrology laser wavelength from neon cal
- ▶ Oct 2013 Exelis side 1 focal plane values
- ▶ ILS with periodic sinc wrap at the sensor grid
- ▶ 330 observations in each test leg
- ▶ gas cell measured pressure 40.4 torr
- ▶ gas cell observed pressure 6.3 torr
- ▶ gas cell temperature 16.8 C
- ▶ gas cell length 12.59 cm
- ▶ HTBB nominal T1 360 K, T2 320 K

NH₃ obs and calc



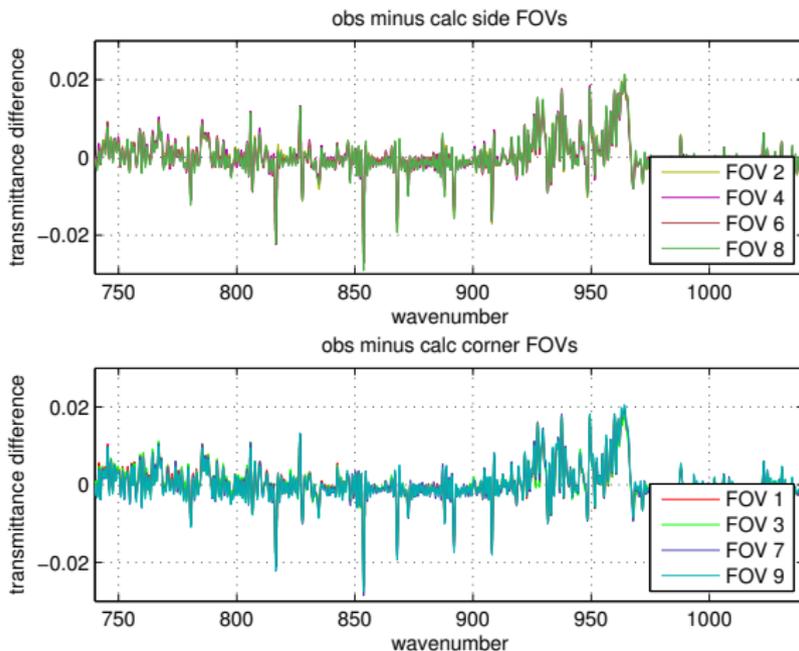
Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are close.

NH₃ obs minus calc



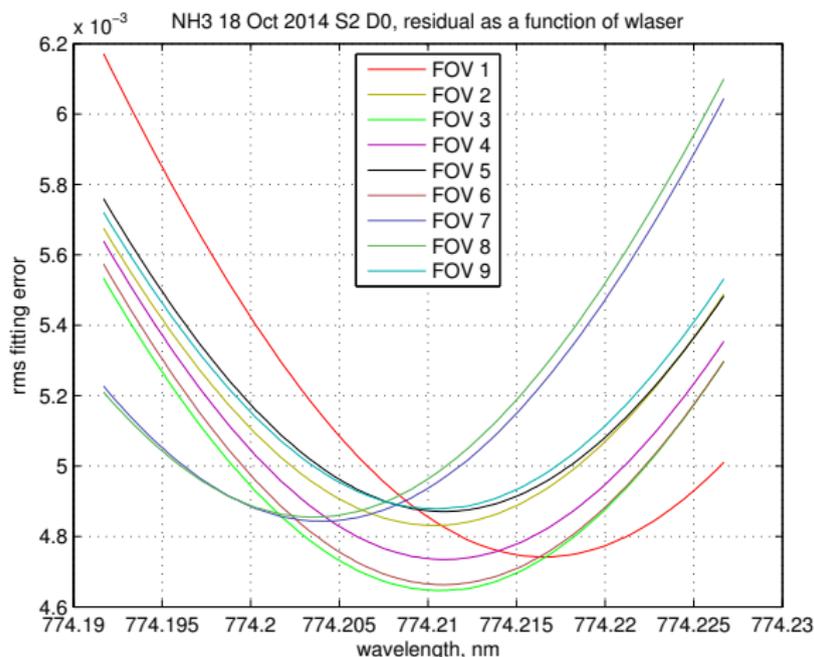
Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.

NH₃ obs minus calc



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

NH₃ fitting residuals



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

NH₃ tabulated residuals

metrology laser relative residuals, ppm

-8.78	0.26	7.23	7	4	1
-9.82	0.00	-0.52	8	5	2
-0.52	0.00	-0.52	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.005	-0.0026	0.0047	19.12	774.2165
2	1.001	0.0010	0.0048	11.37	774.2105
3	1.007	-0.0056	0.0046	11.37	774.2105
4	1.006	-0.0047	0.0047	12.14	774.2111
5	0.986	0.0121	0.0049	11.88	774.2109
6	1.008	-0.0080	0.0047	11.88	774.2109
7	1.005	-0.0052	0.0048	3.10	774.2041
8	1.001	-0.0024	0.0049	2.07	774.2033
9	1.004	-0.0055	0.0049	11.37	774.2105

NH₃ residual comparison

met laser NH₃ side 2 minus NH₃ side 1, ppm

-0.77	0.26	1.55	7	4	1
-0.52	0.00	1.29	8	5	2
-0.78	0.00	1.03	9	6	3

met laser NH₃ side 2 minus CO side 2, ppm

-4.13	-1.81	-3.62	7	4	1
0.26	0.00	-1.55	8	5	2
-2.84	-0.26	-1.03	9	6	3

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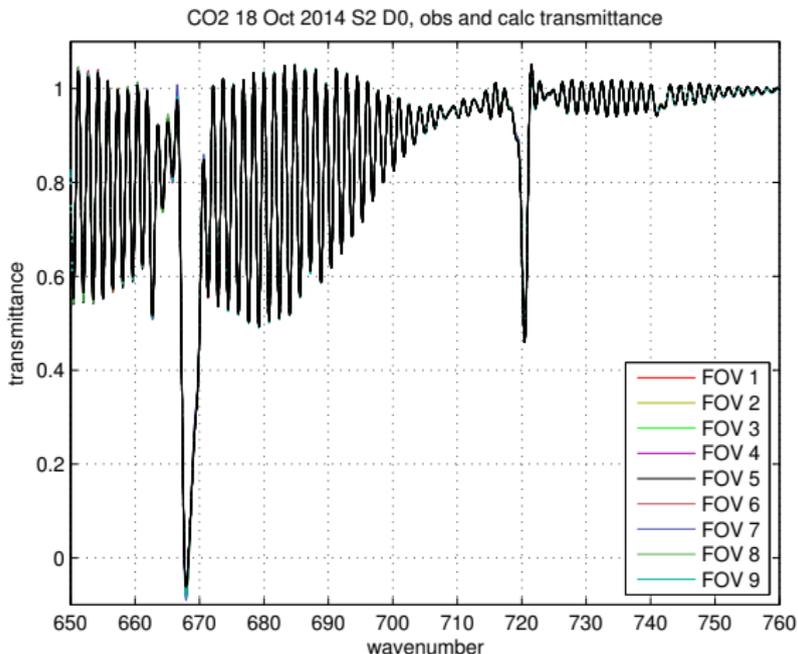
met laser NH₃ side 2 minus CH₄ side 2, ppm

-4.39	-1.81	-3.87	7	4	1
1.29	0.00	-1.55	8	5	2
-0.78	1.03	-0.52	9	6	3

CO₂ test parameters

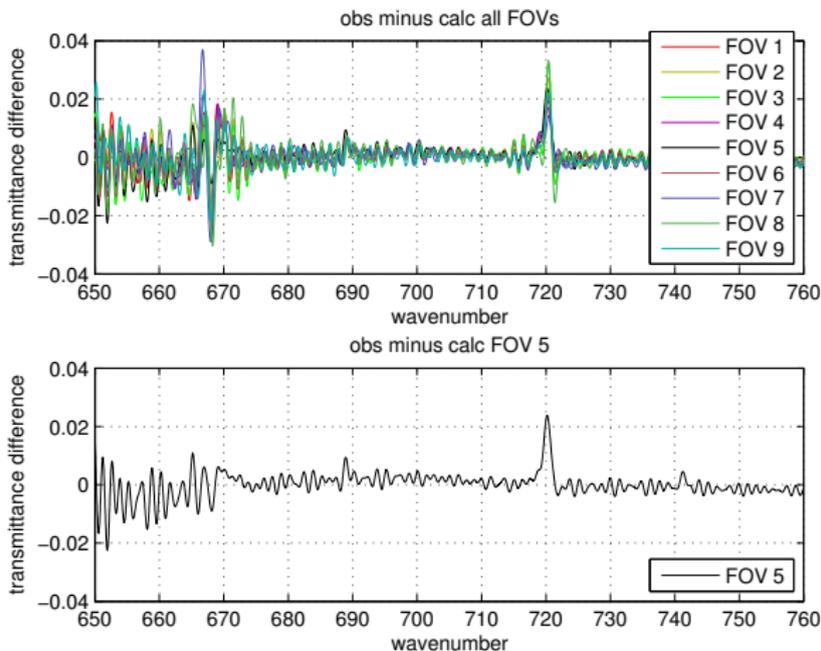
- ▶ side 2, sweep direction 0
- ▶ fitting interval 650 to 760 cm⁻¹
- ▶ metrology laser wavelength from neon cal
- ▶ Oct 2013 Exelis side 1 focal plane values
- ▶ ILS with periodic sinc wrap at the sensor grid
- ▶ 330 observations in each test leg
- ▶ gas cell measured pressure 40.5 torr
- ▶ gas cell observed pressure 40.5 torr
- ▶ gas cell temperature 16.8 C
- ▶ gas cell length 12.59 cm
- ▶ HTBB nominal T1 360 K, T2 320 K

CO₂ obs and calc



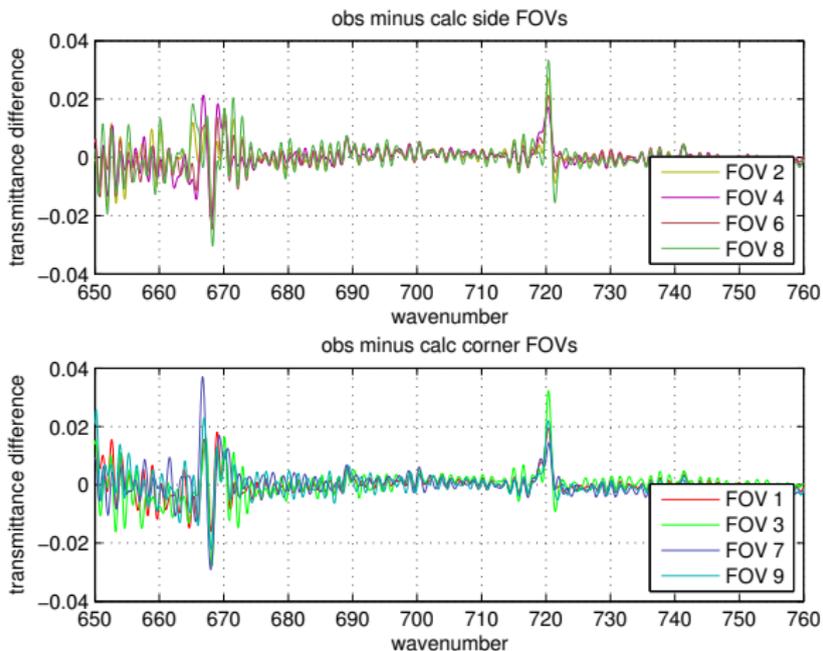
Observed and calculated transmittance for all FOVs, over the fitting interval. At this level of detail we see all values are close.

CO₂ obs minus calc



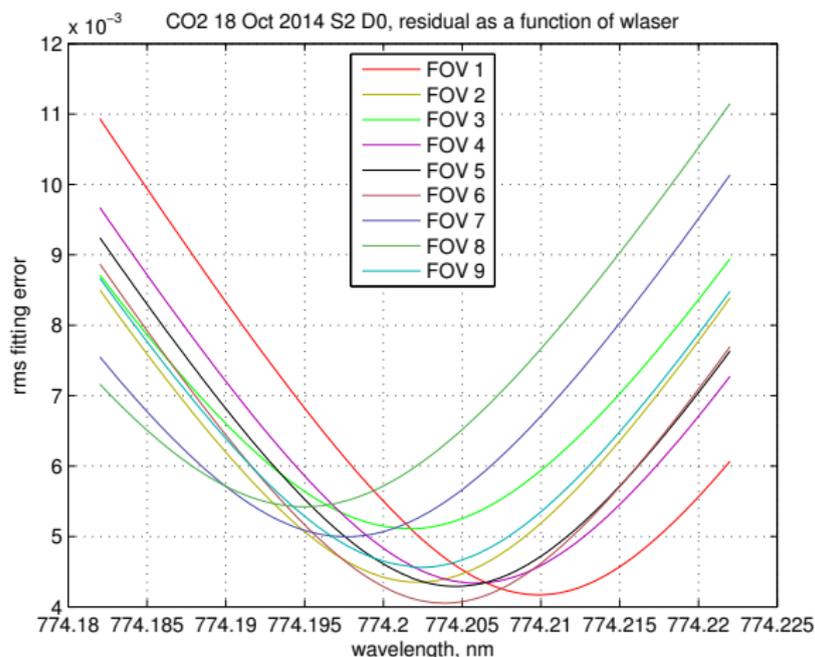
Observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.

CO₂ obs minus calc



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

CO₂ fitting residuals



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

CO₂ tabulated residuals

metrology laser relative residuals, PPM

-9.04	1.55	6.97	7	4	1
-12.66	0.00	-3.10	8	5	2
-3.10	-1.03	-3.88	9	6	3

regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	1.008	-0.0081	0.0094	14.98	774.2136
2	0.995	0.0045	0.0094	4.91	774.2058
3	1.014	-0.0126	0.0099	4.13	774.2052
4	1.003	-0.0040	0.0098	9.56	774.2094
5	0.956	0.0424	0.0089	8.01	774.2082
6	1.011	-0.0107	0.0093	6.97	774.2074
7	1.004	-0.0055	0.0108	-1.03	774.2012
8	0.998	0.0004	0.0097	-4.65	774.1984
9	1.013	-0.0138	0.0100	4.91	774.2058

CO₂ residual comparison

met laser CO₂ side 2 minus NH₃ side 2, ppm

-0.26	1.29	-0.26	7	4	1
-2.84	0.00	-2.58	8	5	2
-2.58	-1.03	-3.36	9	6	3

met laser CO₂ side 2 minus CO side 2, ppm

-4.39	-0.52	-3.88	7	4	1
-2.58	0.00	-4.13	8	5	2
-5.43	-1.29	-4.39	9	6	3

met laser CO₂ side 2 minus CH₄ side 2, ppm

-4.65	-0.52	-4.13	7	4	1
-1.55	0.00	-4.13	8	5	2
-3.36	0.00	-3.88	9	6	3

misc. notes

- ▶ the CO, CH₄, NH₃ and CO₂ MN side 2 gas cell tests are in good agreement with calculated data and the side 1 tests
- ▶ we saw a similar difference between observed and directly measured cell pressure for the 27 Oct NH₃ side 1 retest, where gas cell measured pressure was 21 torr while observed pressure was 4 torr.
- ▶ the breakouts show the residuals for the CO tests are very similar for the side and corner FOVs. This is significant for the high res SW band, where we have the strongest SA correction, and suggests that our ILS, SA correction matrix, and form of the calibration equation are all working well

test methods

- ▶ the test places a gas cell between the instrument and a black body. Four measurements are made—cell full with BB at T_1 , cell full with BB at T_2 , cell empty with BB at T_1 , and cell empty with BB at T_2 .
- ▶ let FT_1 , FT_2 , ET_1 and ET_2 be the corresponding on-axis count spectra. Then

$$\tau = \frac{FT_2 - FT_1}{ET_2 - ET_1}$$

gives a good approximation of the gas cell transmittance.

- ▶ τ is then compared with calculated transmittance, to verify instrument calibration

test methods

The main steps in analyzing the test data are

- ▶ read the CCSDS data packets
- ▶ take interferograms to count spectra
- ▶ take the mean of spectra over stable test intervals
- ▶ find $\tau_{\text{obs}} = f \circ SA^{-1} \circ f((FT_2 - FT_1)/(ET_2 - ET_1))$
- ▶ compare observed and calculated transmittance spectra at the sensor grid

This process is embedded in a search where we minimize $\text{RMS}(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$ as a function of metrology laser wavelength. From this we get both a conventional residual and the difference of wavelength at the minima from the neon calibration value.

test methods

- ▶ note the close parallel between our expression for transmittance

$$\tau_{\text{obs}} = f \cdot SA^{-1} \cdot f \cdot \frac{FT_2 - FT_1}{ET_2 - ET_1}$$

and our default CrIS calibration equation

$$r_{\text{obs}} = F \cdot r_{\text{ICT}} \cdot f \cdot SA^{-1} \cdot f \cdot \frac{ES - SP}{IT - SP}$$

- ▶ here f is a raised-cosine bandpass filter, SA^{-1} the inverse of the ILS matrix, r_{ICT} is expected ICT radiance at the sensor grid, and F is Fourier interpolation from sensor to user grid.
- ▶ the same f is applied to the line-by-line transmittances before convolution to the CrIS sensor grid