CrIS FOV 5 Anomaly and the Nonlinearity Correction

**** DRAFT ****

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September 29, 2016

introduction

- Bob Knuteson (most recently) and others have shown FOV5 at 668.125 cm^{-1}can have an anomalously warm brightness temperature relative to the other FOVs when the 900 cm^{-1}window channel is cold
- we show a corresponding anomaly from the DC level integral of the nonlinearity correction, and for that correction, which may explain the brightness temp anomaly

methods

- the nonlinearity correction applied to FOV 5 is significantly less than the corrections applied to other FOVs
- however the correction applied to FOV 5 relative to the other FOVs is slightly greater for spectra with a cold vs a warm window region
- this is becauce the DC level integral for FOV 5 relative to the other FOVs is slightly greater for spectra with a cold vs a warm window region

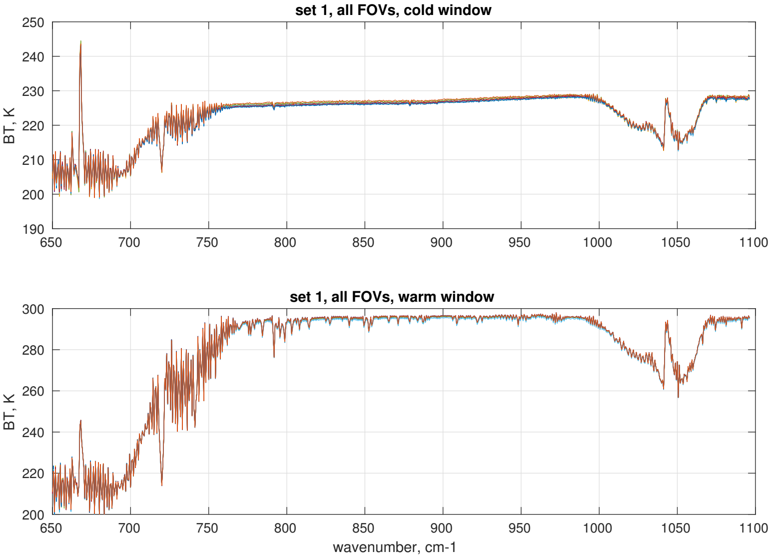
methods

- we find homogeneous scenes for two cases: warm and cold at 900 cm^{-1}, as follows
- LW brightness temperature spectra were compared for all FOVs for FOR 15 and 16 from 1–3 Jan 2016. If the max RMS difference between any pair of FOVs was less than 1K and the mean over all FOVs at 900 cm-1 was less than 230K, the FOR was saved as a "cold FOR"
- similarly, if the max RMS difference between any pair of FOVs was less than 1K and the mean over all FOVs at 900 cm-1 was greater than 270K, the FOR was saved as a "warm FOR".

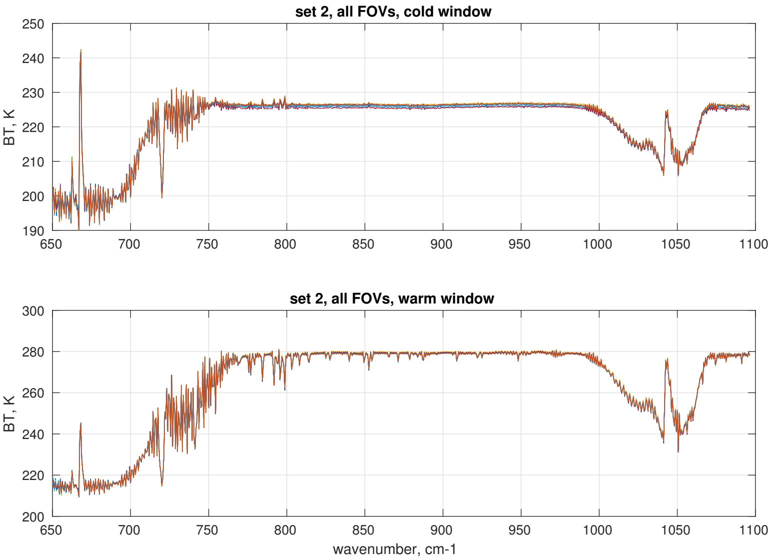
methods

- we found hundreds of warm FORs but only 7 cold FORs over the 3-day period. The cold FORs were then further ordered by their temperature at 668.125 cm^{-1}, and we took the warmest three (at 243, 242, and 241K) and paired these with warm sets with similar temperatures at 668.125 cm^{-1}

test set 1

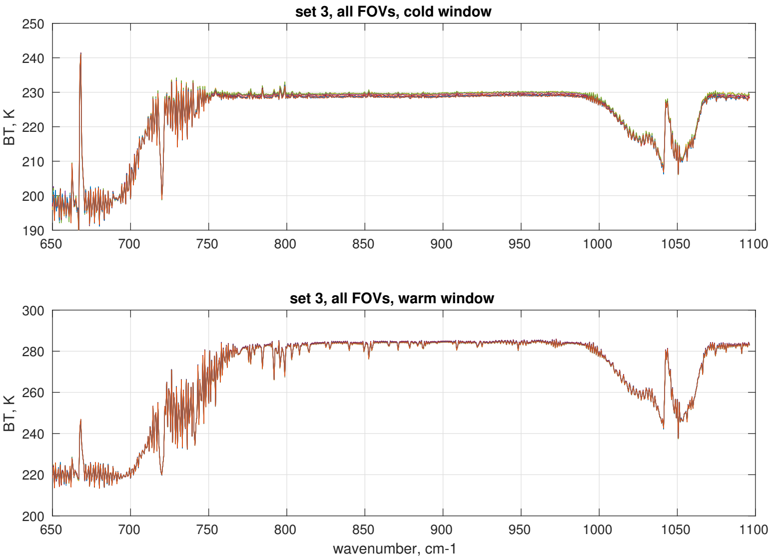

set 1, all FOVs, cold window
BT, K
250
240
230
220
210
200
190
650
700
750
800
850
900
950
1000
1050
1100
set 1, all FOVs, warm window
BT, K
300
280
260
240
220
200
650
700
750
800
850
900
950
1000
1050
1100
wavenumber, cm-1

test set 2

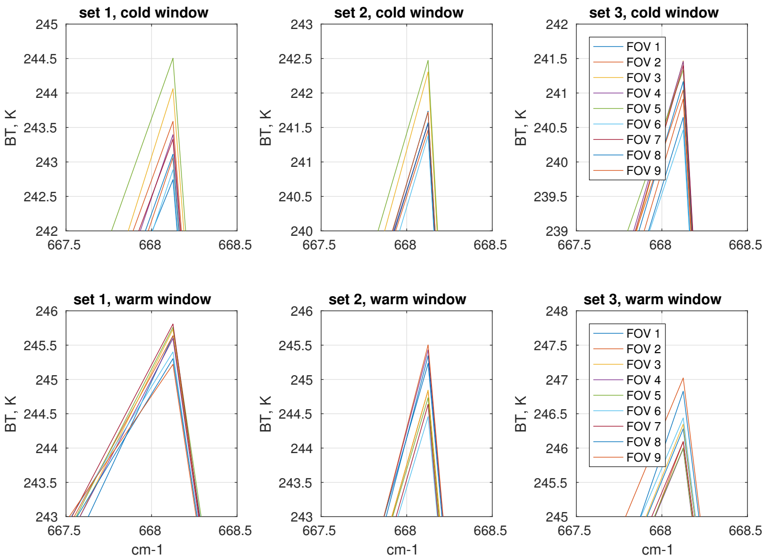


set 2, all FOVs, cold window
BT, K
250
240
230
220
210
200
190
650
700
750
800
850
900
950
1000
1050
1100
set 2, all FOVs, warm window
BT, K
300
280
260
240
220
200
650
700
750
800
850
900
950
1000
1050
1100
wavenumber, cm-1

test set 3


set 3, all FOVs, cold window
BT, K
250
240
230
220
210
200
190
650
700
750
800
850
900
950
1000
1050
1100
set 3, all FOVs, warm window
BT, K
300
280
260
240
220
200
650
700
750
800
850
900
950
1000
1050
1100
wavenumber, cm-1

668 cm-1 zoom


set 1, cold window
set 2, cold window
set 3, cold window
set 1, warm window
set 2, warm window
set 3, warm window
BT, K
cm-1
FOV 1
FOV 2
FOV 3
FOV 4
FOV 5
FOV 6
FOV 7
FOV 8
FOV 9
667.5
668
668.5

nonlinearity correction

- let $/$ be pointwise division, and

$$r_{\text{in}}^{\text{s}} = r_{\text{in}} / f_{\text{N}}$$

$$r_{\text{sp}}^{\text{s}} = r_{\text{sp}} / f_{\text{N}}$$

- the DC level is given by

$$v_{\text{dc}} = v_{\text{inst}} + \frac{2 \cdot \sum_{i=1}^{n} \left| r_{\text{in}}^{\text{s}} - r_{\text{sp}}^{\text{s}} \right|}{c_{\text{m}} \cdot c_{\text{a}} \cdot c_{\text{p}} \cdot d \cdot n}$$

- the corrected radiances (scaled by f_{N}) are

$$r_{\text{out}}^{\text{s}} = r_{\text{in}}^{\text{s}} \cdot (1 + 2 \cdot a_2 \cdot v_{\text{dc}})$$

parameters

- r_{in} is scene count spectra
- r_{sp} is space-look count spectra
- n is the number of decimated points
- d is the decimation factor
- c_{m} is modulation efficiency
- c_{p} is PGA gain
- c_{a} is A/D gain
- v_{inst} instrument contribution to DC level
- v_{dc} is estimated DC level
- f_{N} is the numeric filter at the sensor grid
- a_2 are the correction parameters

DC Level Integral

Values from the DC level integral

	set 1		set 2		set 3	
FOV	cold	warm	cold	warm	cold	warm
1	0.1190	0.3988	0.1157	0.3047	0.1231	0.3323
2	0.1269	0.4202	0.1233	0.3233	0.1314	0.3476
3	0.1188	0.3965	0.1173	0.3062	0.1251	0.3276
4	0.1258	0.4171	0.1232	0.3192	0.1313	0.3476
5	0.1353	0.4447	0.1312	0.3407	0.1409	0.3683
6	0.1296	0.4250	0.1266	0.3291	0.1337	0.3552
7	0.1343	0.4476	0.1292	0.3420	0.1387	0.3711
8	0.1244	0.4188	0.1223	0.3196	0.1286	0.3458
9	0.1155	0.3801	0.1117	0.2899	0.1170	0.3139

correction factor

correction factor

FOV	set 1 cold	set 1 warm	set 2 cold	set 2 warm	set 3 cold	set 3 warm
1	1.0576	1.0684	1.0575	1.0648	1.0577	1.0659
2	1.0443	1.0527	1.0442	1.0500	1.0445	1.0507
3	1.0498	1.0588	1.0498	1.0558	1.0500	1.0565
4	1.0677	1.0804	1.0676	1.0761	1.0679	1.0774
5	1.0392	1.0475	1.0391	1.0447	1.0394	1.0455
6	1.0523	1.0620	1.0522	1.0589	1.0525	1.0597
7	1.0469	1.0560	1.0467	1.0530	1.0470	1.0538
8	1.0529	1.0631	1.0528	1.0597	1.0530	1.0606
9	1.0912	1.1073	1.0909	1.1018	1.0913	1.1033

conclusions

- with the switch to extended res, we have seen a significant convergence in calibration algorithm performance
- the NOAA "SA-1 first" algorithm does slightly better when compared with reference truth convolved with responsivity, while the CCAST "ratio first" algorithm does slightly better when compared with reference truth convolved with a flat passband
- this may be because responsivity cancels out more completely in the ratio-first method
- because reference truth convolved with a flat passband is a more conventional and non instrument-specific standard, the ccast algorithm, or some similar ratio-first method, may be preferable