cris extended resolution calibration algorithm comparisons

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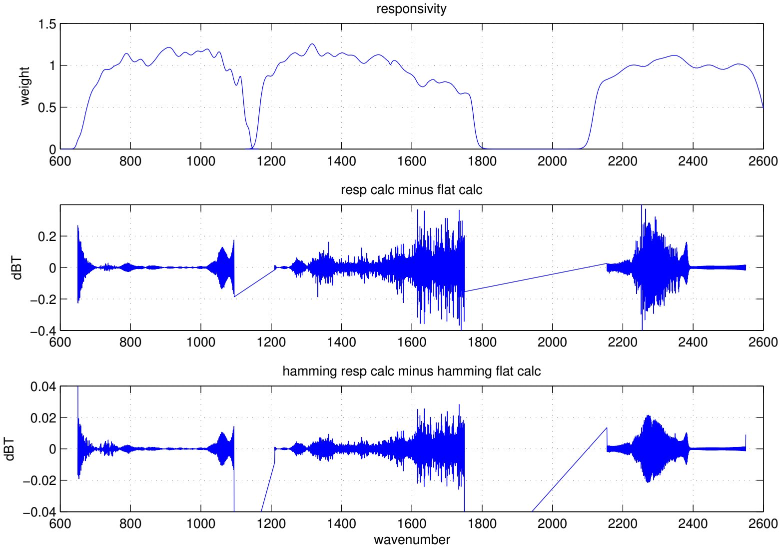
introduction

- we compare the UMBC implementations of our CCAST reference and the NOAA 4 calibration algorithms on extended resolution data
- this allows for identical ILS and processing details—the only difference in tests is the form of the calibration equation
- we show results for clear matchups, comparing the CCAST algorithm with flat reference truth and NOAA 4 with reference truth convolved with instrument responsivity
- the respective residuals are very similar

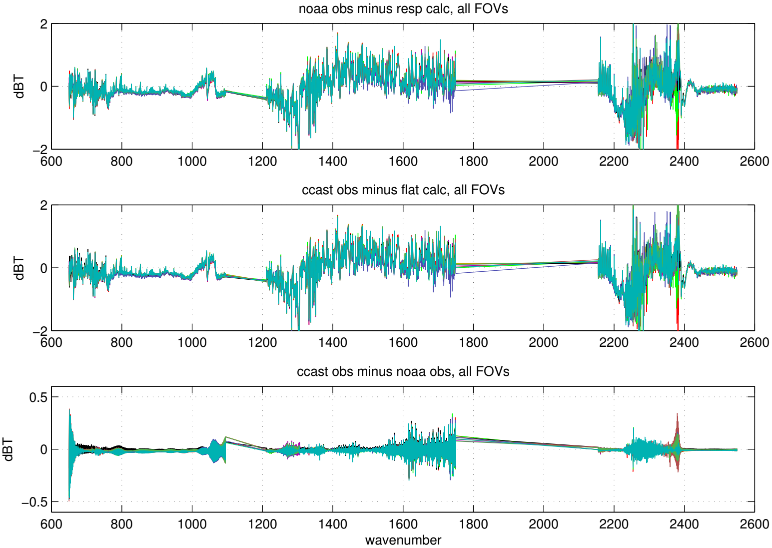
methods

- we start with 3782 clear matchups from ccast granule SDR_d20160120_t0304487 and calculate upwelling radiances with kcarta at a 0.0025 cm-1 grid
- for the “flat” tests the ccast processing filters are applied pointwise and the result is convolved to the CrIS user grid
- for the “resp” tests instrument responsivity is applied pointwise to the kcarta radiances, these are convolved to the user grid, and then divided pointwise by inverse responsivity
- all test are done with periodic sinc wrapping at the sensor grid, cosine apodization of the extended res points, the old a2 weights, and double Fourier interpolation to the user grid

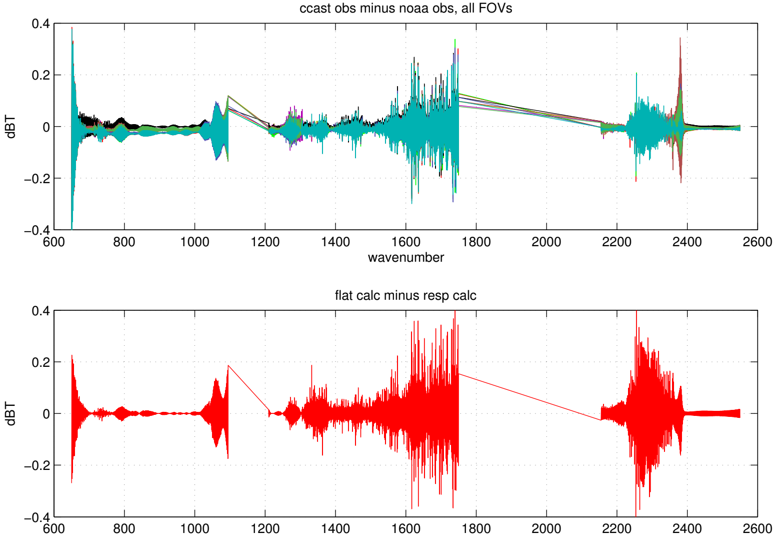
responsivity vs flat reference truth



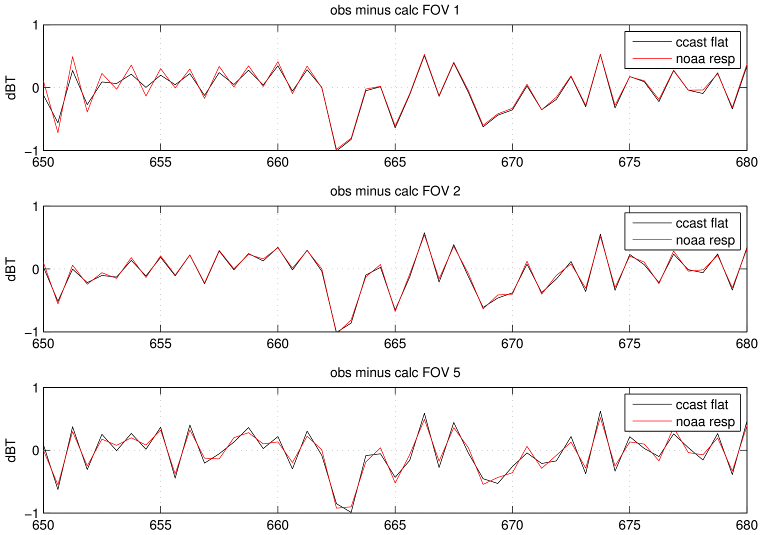
obs minus calc overview



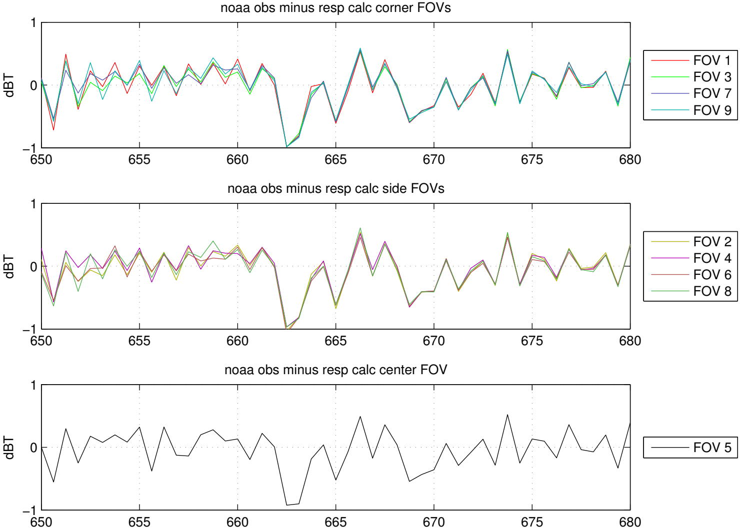
obs and calc residuals



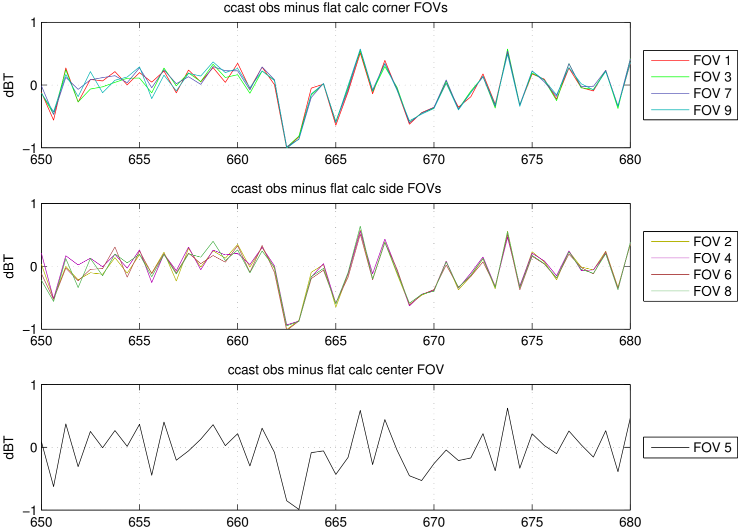
obs minus calc LW detail



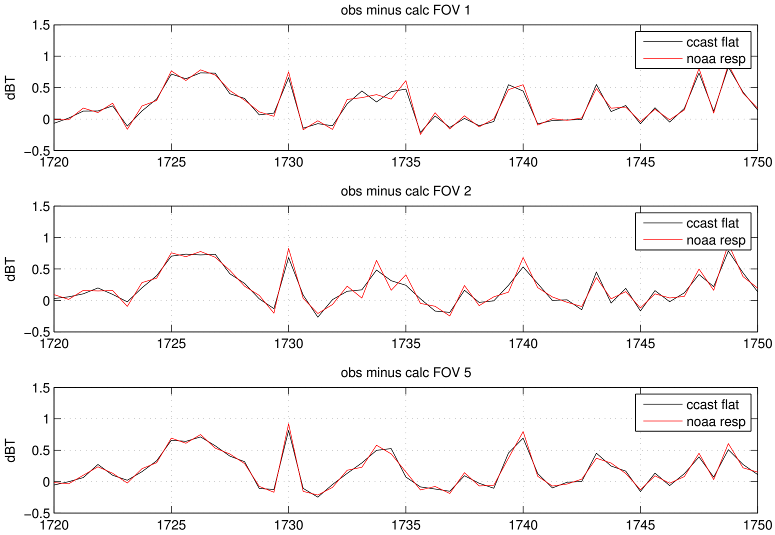
noaa all fovs LW detail



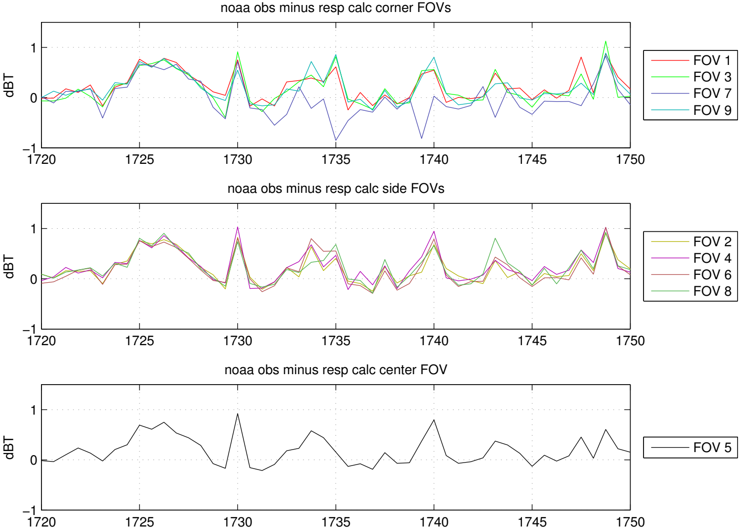
ccast all fovs LW detail



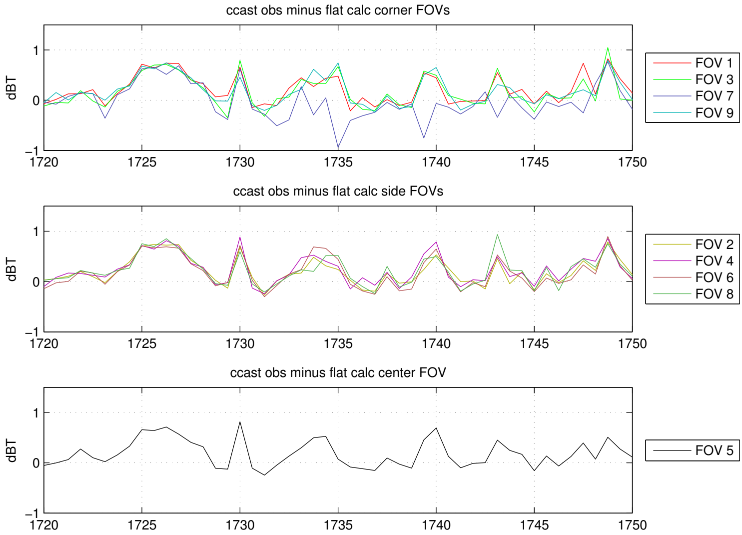
obs minus calc MW detail



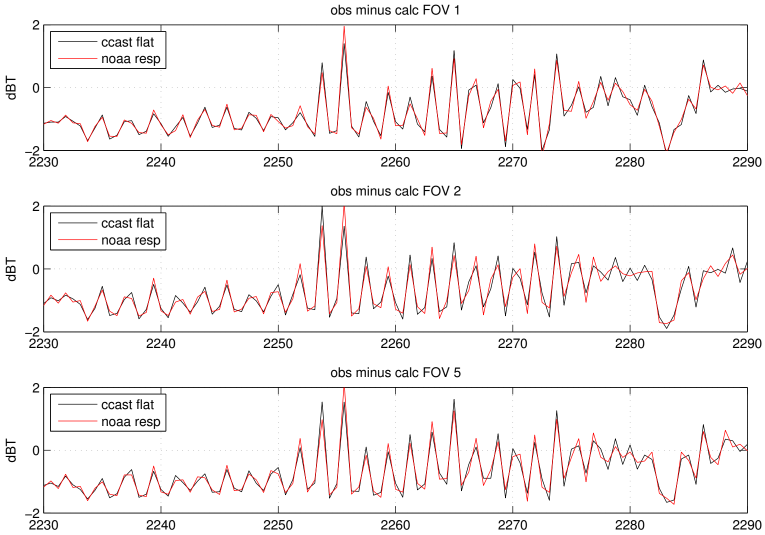
noaa all fovs MW detail



ccast all fovs MW detail



obs minus calc SW detail



obs minus calc notes

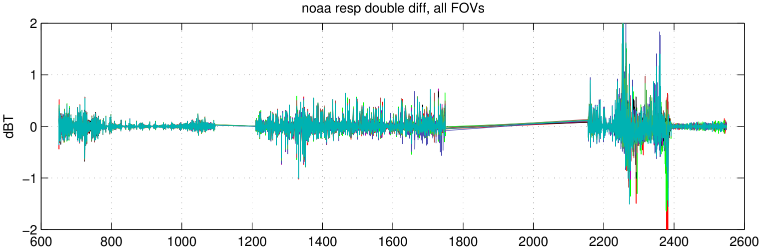
- CCAST minus flat and NOAA minus resp residuals are similar, significantly more so than for earlier comparisons
- CCAST minus NOAA is similar to the responsivity residual
- below 680 cm^{-1} we see CCAST does slightly better for the side and corner FOVS, while NOAA is slightly better for FOV 5. The CCAST residuals are more consistent across FOVs
- in the MW detail we see CCAST does slightly better for all FOVs. These results are with the old a2 weights; the new UMBC a2 weights give a significant further reduction in the MW residuals

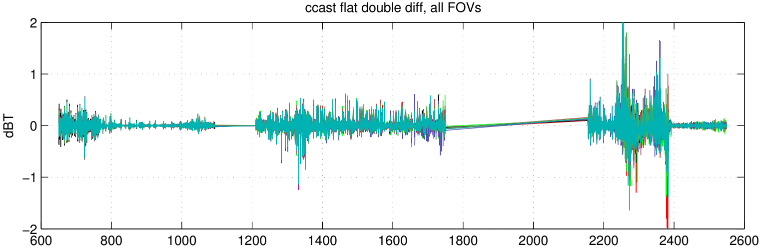
double differences

- the double difference subtracts a smoothed bias, leaving the high frequency components of the residual.

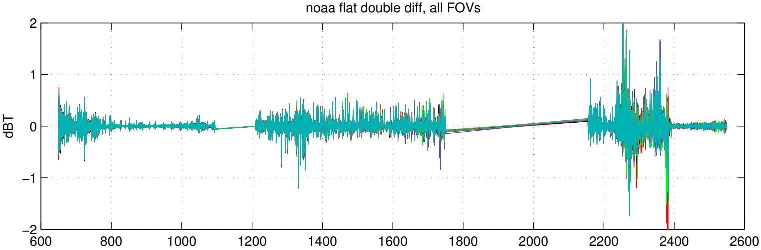
- noaa default test, with responsivity
  (noaa obs − resp calc) − (hamming noaa obs − hamming resp calc)
- ccast default test, with flat passband
  (ccast obs − flat calc) − (hamming ccast obs − hamming flat calc)
- noaa alternate test, with flat passband
  (noaa obs − flat calc) − (hamming noaa obs − hamming flat calc)
- ccast alternate test, with responsivity
  (ccast obs − resp calc) − (hamming ccast obs − hamming resp calc)

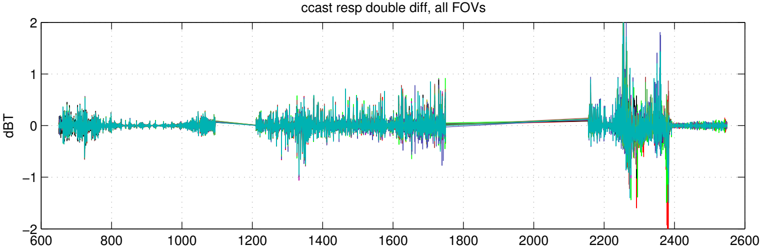
noaa resp and ccast flat double diffs



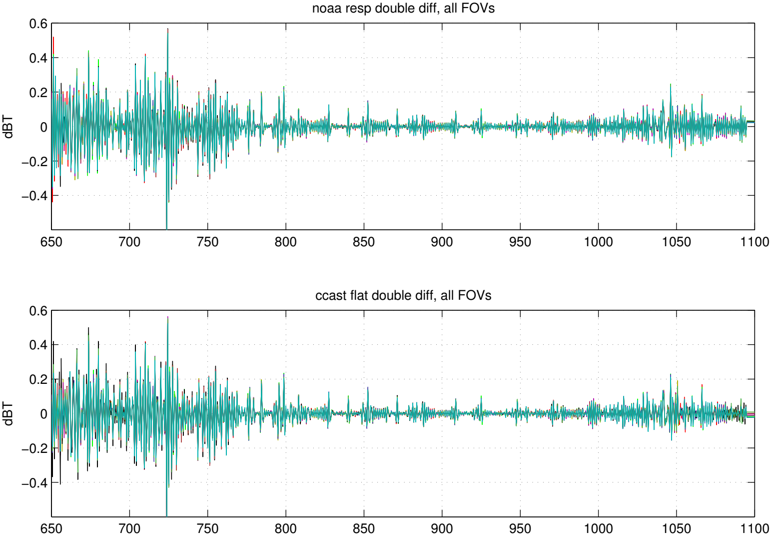


noaa flat and ccast resp double diffs

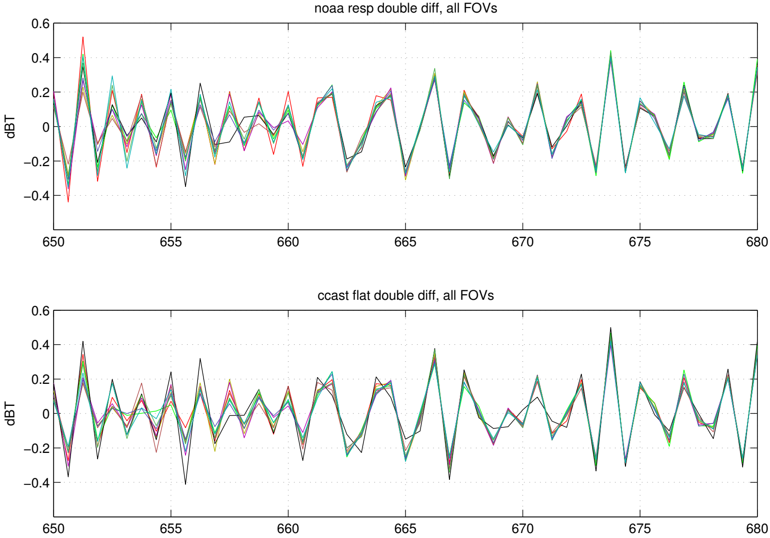




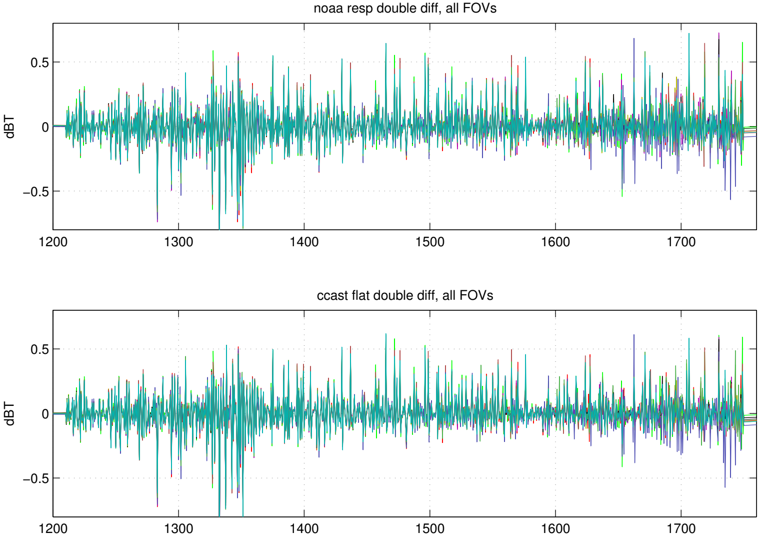
noaa resp and ccast flat LW band



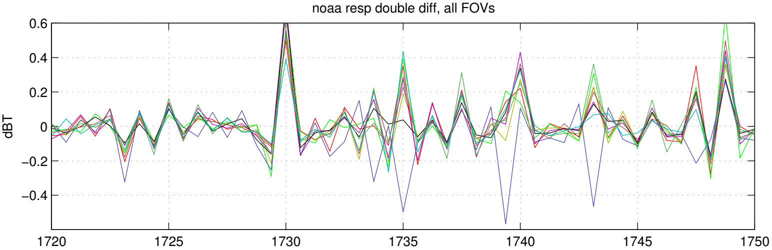
noaa resp and ccast flat LW zoom

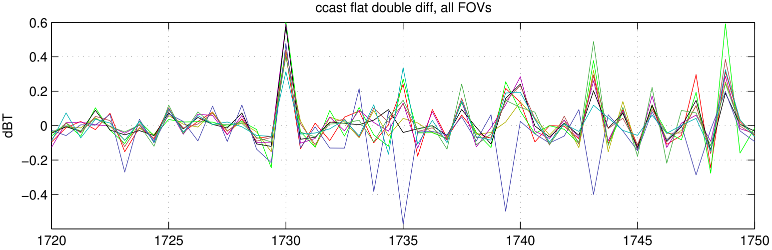


noaa resp and ccast flat MW band



noaa resp and ccast flat MW zoom





double difference notes

- double differences do not show a significant difference between the algorithms compared with their respective reference truths
- LW residuals are quite similar for both the full band and the selected zoom
- MW residuals are also quite similar, with CCAST maybe slightly better above around 1600 cm-1.
- swapping reference truth—comparing NOAA with flat reference truth and CCAST with responsivity, we see both do slightly worse overall than when compared with their default reference truths

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

ccast calibration equations

CCAST reference equation

$$r^{\text{user}}_{\text{ES}} = F \cdot r^{\text{sensor}}_{\text{ICT}} \cdot f_{\text{cos}} \cdot \text{SA}^{-1} \cdot f_{\text{cos}} \cdot \frac{\Delta\text{ES}}{\Delta\text{IT}} \tag{1}$$

$$r^{\text{user}}_{\text{ES}} = F \cdot f_{\text{cos}} \cdot \text{SA}^{-1} \cdot f_{\text{cos}} \cdot r^{\text{fov}}_{\text{ICT}} \cdot \frac{\Delta\text{ES}}{\Delta\text{IT}} \tag{2}$$

NOAA algorithm 4

$$r^{\text{user}}_{\text{ES}} = r^{\text{user}}_{\text{ICT}} \cdot \frac{F \cdot f_{\text{ATBD}} \cdot \text{SA}^{-1} \cdot f_{\text{ATBD}} \cdot (\frac{\Delta\text{ES}}{\Delta\text{IT}}) \cdot |\Delta\text{IT}|}{F \cdot f_{\text{ATBD}} \cdot \text{SA}^{-1} \cdot f_{\text{ATBD}} \cdot |\Delta\text{IT}|} \tag{3}$$

$$\Delta\text{ES} = \text{ES} - \langle \text{SP} \rangle, \quad \Delta\text{IT} = \langle \text{IT} \rangle - \langle \text{SP} \rangle$$

calibration equation parameters

$$\mathsf{ES} = \mathsf{NLC}(\mathsf{FIR}^{-1}(\mathsf{ES}_0))$$
$$\langle \mathsf{IT} \rangle = \mathsf{NLC}(\mathsf{FIR}^{-1}(\langle \mathsf{IT}_0 \rangle))$$
$$\langle \mathsf{SP} \rangle = \mathsf{NLC}(\mathsf{FIR}^{-1}(\langle \mathsf{SP}_0 \rangle))$$

NLC is the ATBD non-linearity correction and ES_0, IT_0, and SP_0 are uncorrected earth-scene, ICT, and space spectra. $\langle \mathsf{IT}_0 \rangle$ and $\langle \mathsf{SP}_0 \rangle$ are moving averages, by default over 9 scans. FIR^{-1} is pointwise division by the spectral form of the numeric filter

- $r_{\mathrm{ICT}}^{\mathsf{user}}$ is expected ICT radiance at the user grid
- $r_{\mathrm{ICT}}^{\mathsf{sensor}}$ is expected ICT radiance at the sensor grid
- $r_{\mathrm{ICT}}^{\mathsf{fov}} = \mathsf{SA} \cdot r_{\mathrm{ICT}}^{\mathsf{sensor}}$, expected uncorrected ICT radiance