Calibration of SNPP-CrIS for the NASA L1b Product

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AIRS STM: October 2015

Overview

- Compare using ~2200 clear ocean tropical scenes
- Calculated radiances use kCARTA (monochromatic) and ECMWF

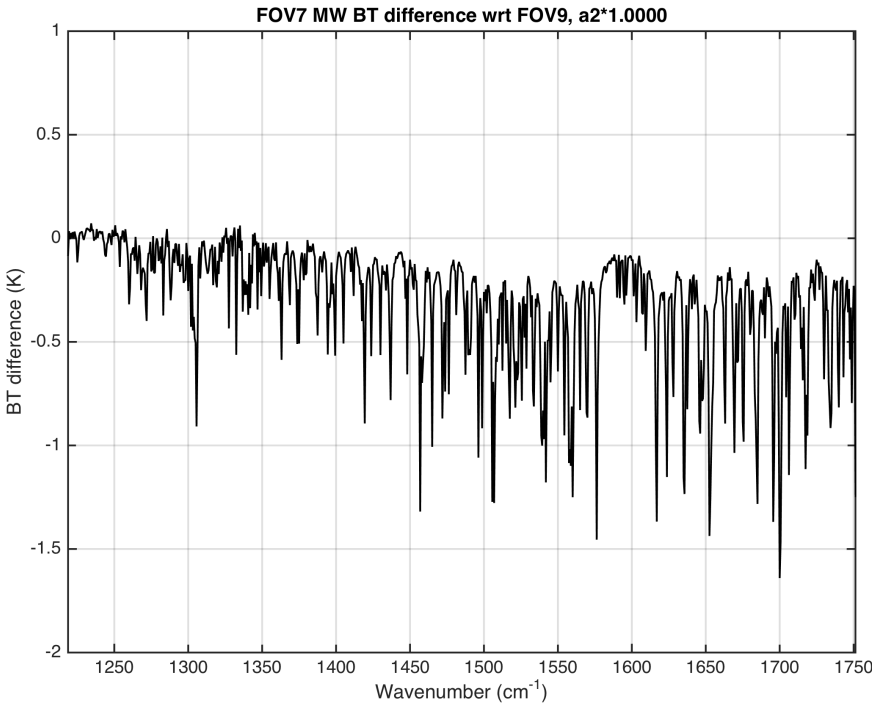
Key issues:

- C4 RTA needs instrument responsivity applied
- CCAST does not need in-band part of responsivity
- Does it matter?

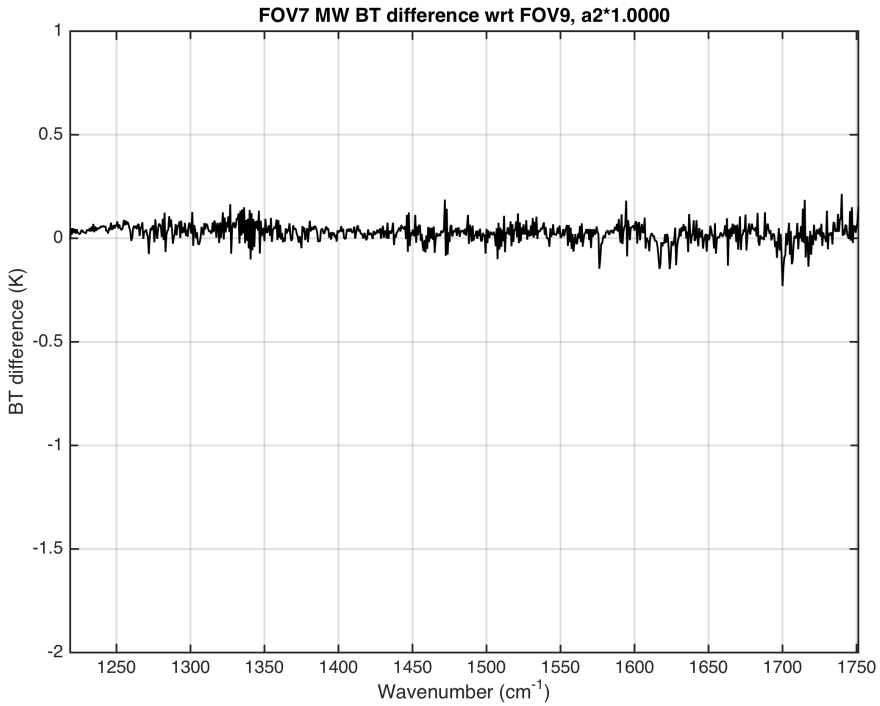
FOV7 Improvements (Dave Tobin, UW (SSEC)

FOV 7

Differences wrt FOV9 with MW7 a2 x 1:



Differences wrt FOV9 with MW7 a2 x 0.70:



Calibration Equations

CCAST now supporting many SDR approaches.

Calibration Equation Definitions

For this talk the term "UMBC" denotes the CCAST reference calibration equation while "NOAA" refers to the SDR Team equation C4.

UMBC:

$$r_{ES} = F \cdot \cdot f \cdot SA^{-1} \cdot f \cdot \frac{ES - \langle SP \rangle}{\langle ICT \rangle - \langle SP \rangle} SA^{-1} r_{ICT}$$

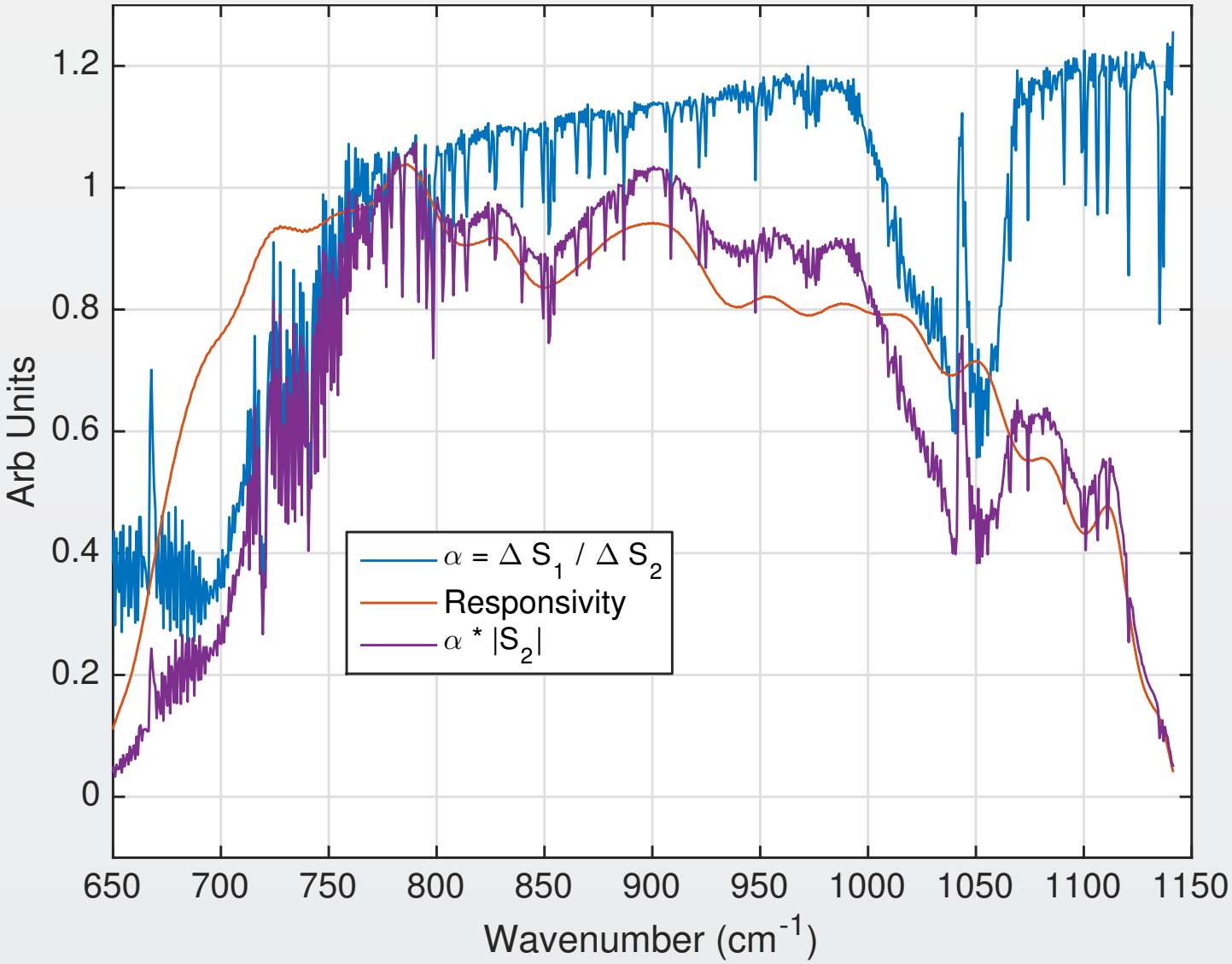
NOAA-C4:

$$r_{ES} = r_{ICT} \frac{F \cdot f \cdot SA^{-1} \cdot f \cdot \left\{ \frac{\Delta S_1}{\Delta S_2} \cdot |S_2| \right\}}{F \cdot f \cdot SA^{-1} \cdot f \cdot |\Delta S_2|}$$

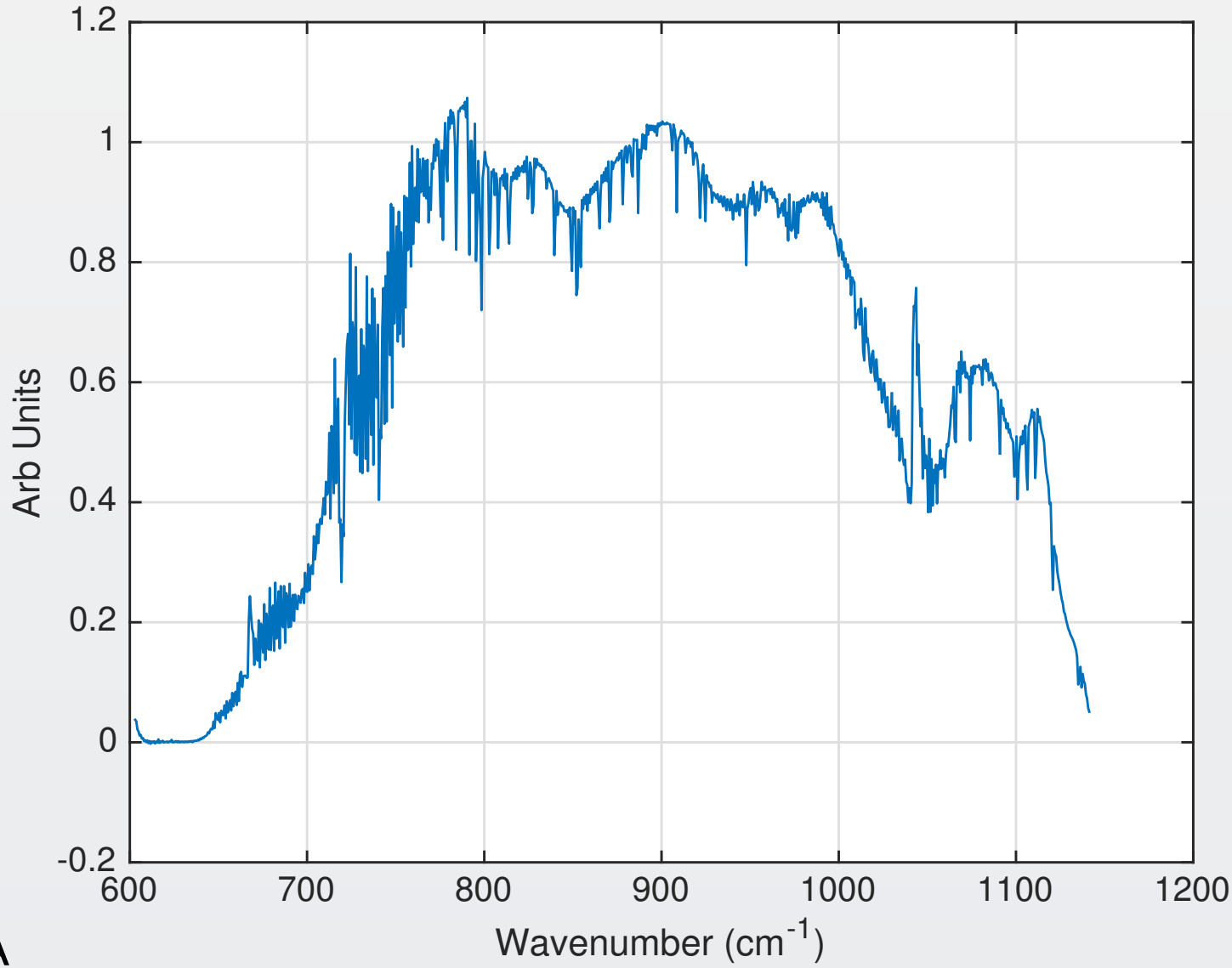
$$\Delta S_1 = FIR^{-1}(ES - \langle SP \rangle), \quad \Delta S_2 = FIR^{-1}(\langle ICT \rangle - \langle SP \rangle)$$

- r_{ES} is calibrated earth-scene radiance at the user grid
- F is resampling from sensor to user grid
- r_{ICT} is the expected ICT radiance
- f, UMBC: is a raised-cosine bandpass filter with wings at or inside the instrument responsivity, NOAA: modified ATBD filter
- SA, UMBC: Periodic sinc ILS wrapping at the sensor grid, NOAA: Periodic sinc wrapping at the undecimated sensor grid.
- Non-linearity corrections are included
- $\langle SP \rangle$ and $\langle ICT \rangle$ are averages over 9 scans

Components Operated on by SA^{-1}

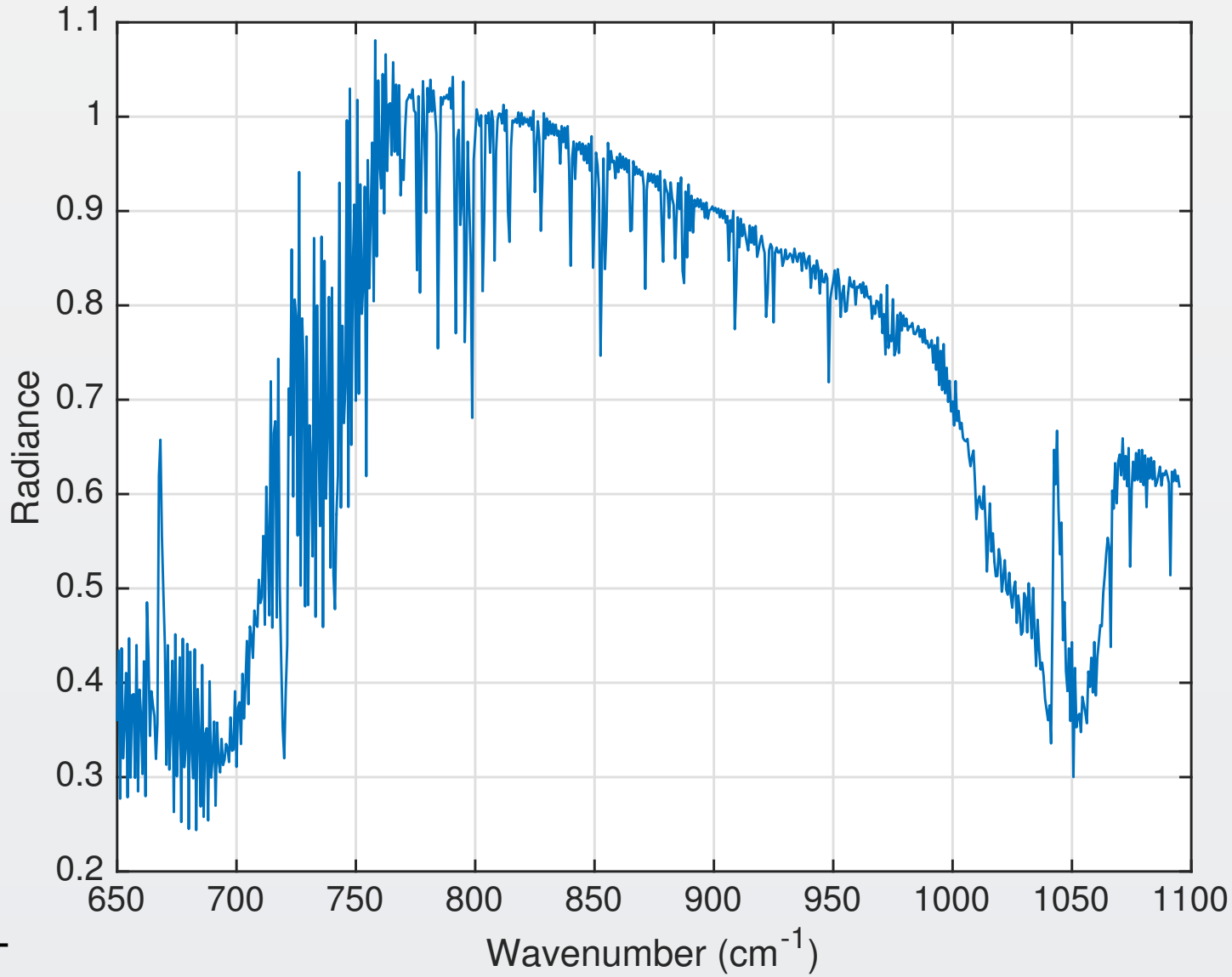


Components Operated on by SA^{-1}



NOAA

Components Operated on by SA^{-1}



CCAST

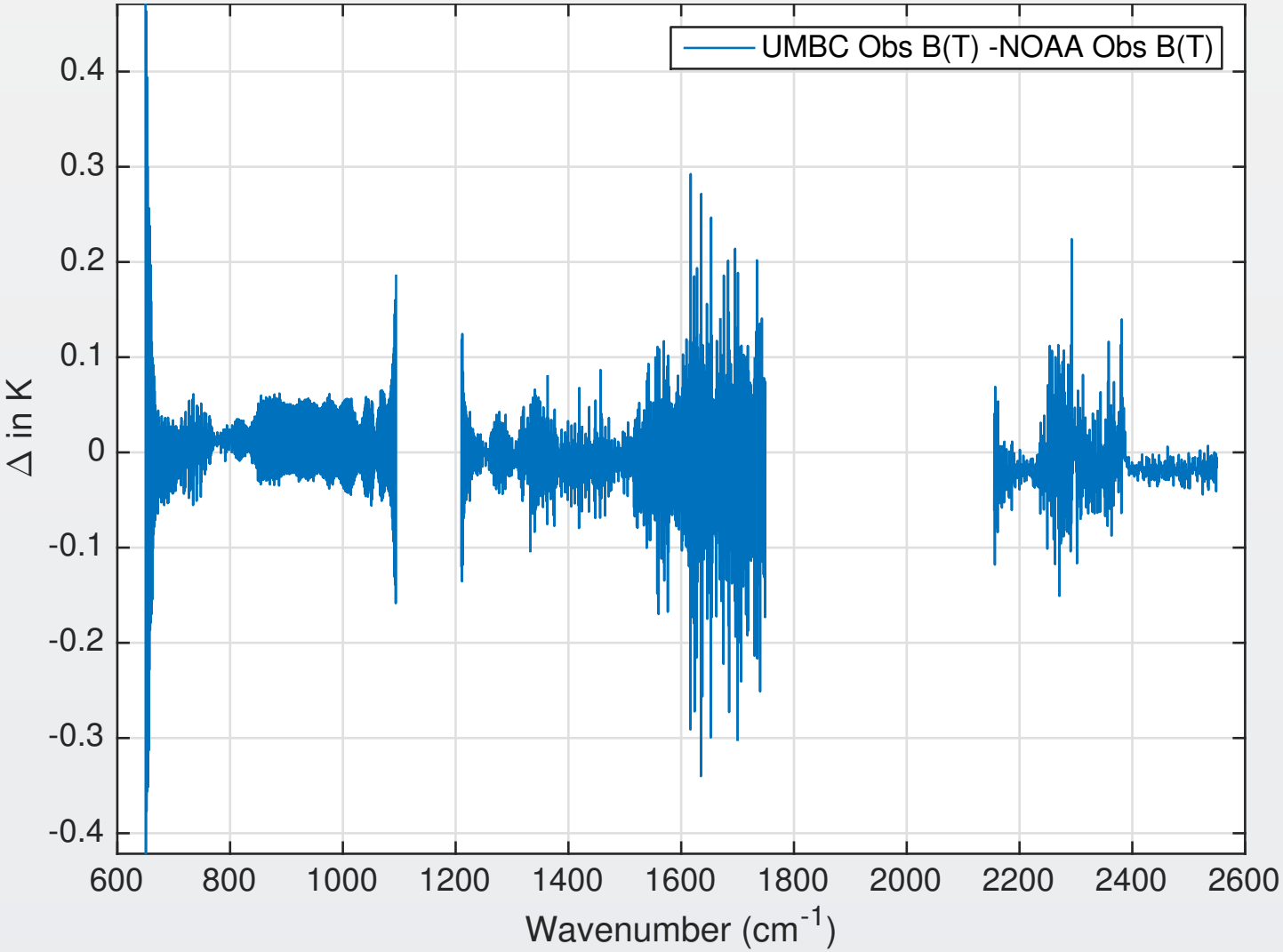
Simulations (RTA)

- RTA with NOAA approach: apply responsivity to monochromatic radiance, then divide out responsivity after the FFT.
- This implies a different forward model, RTA, for each instrument.
- The instrument response function is no longer a sinc function (some disagree with this statement). An individual channel is not the spectral space convolution with a sinc...
- If the detector filter (part of responsivity) changes (spacecraft temperature), the SDR will change and the RTA will need to change. Unlikely, but possible.
- The radiance record will be different for the next CrIS since the reponsivity will be slightly different.

Next slides: UMBC w/ FILT legend in plots means we are comparing the NOAA simulated radiance to the UMBC CCAST generated observations.

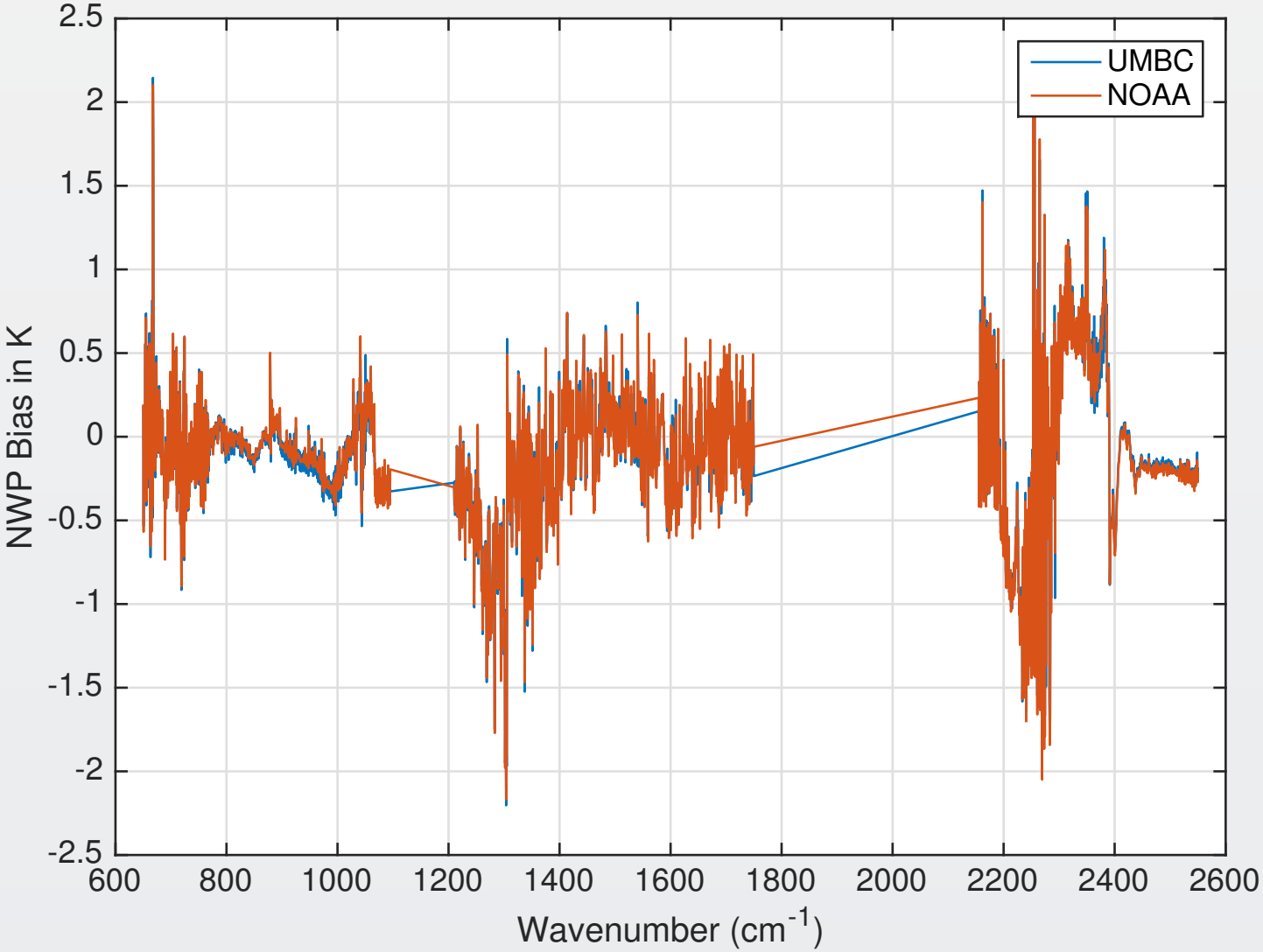
NOAA, UMBC Observations are Different

A consequence of the SDR calibration equation.



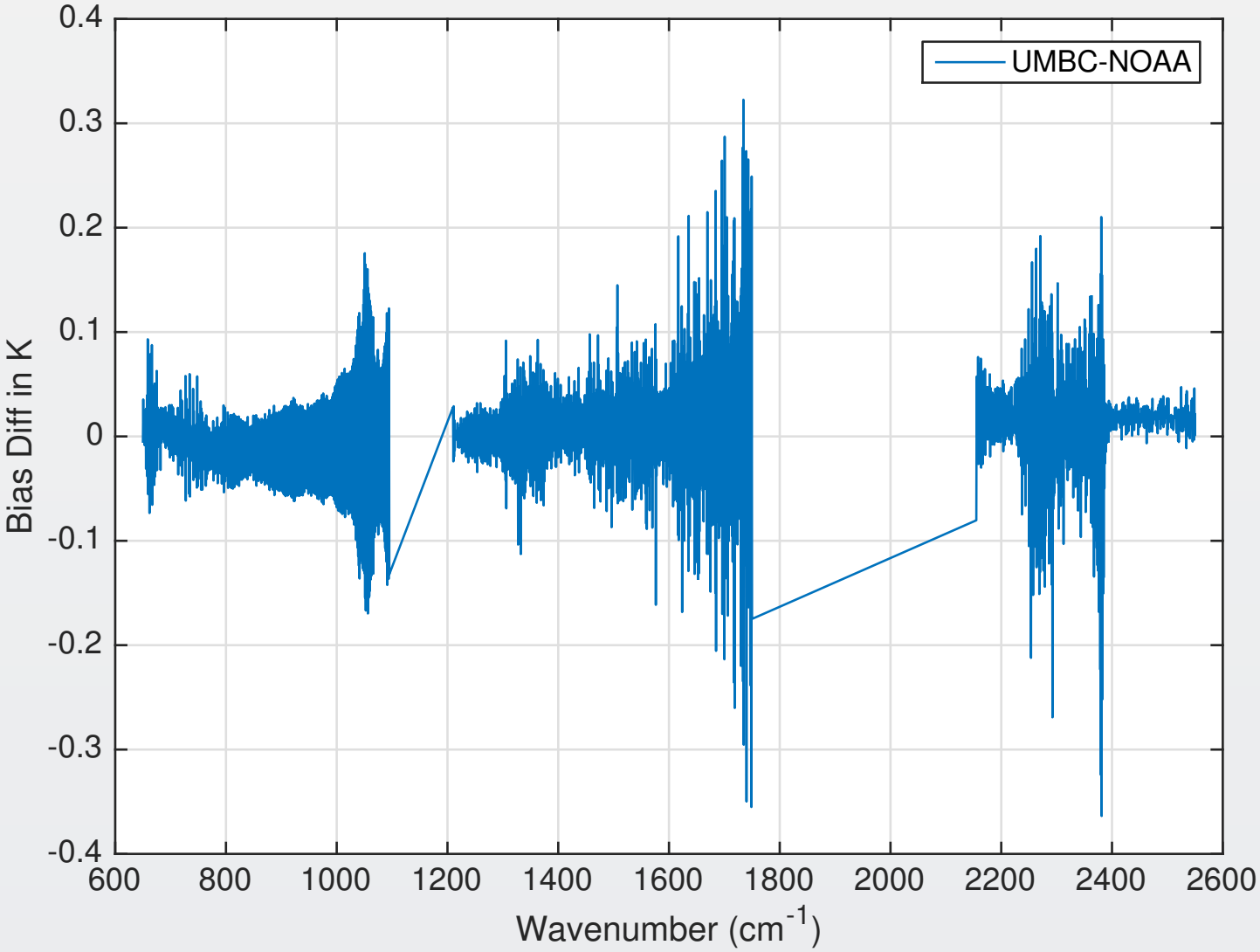
NWP Biases: All FOVs

The NOAA and UMBC biases are very similar.



NWP Bias Difference between NOAA and UMBC

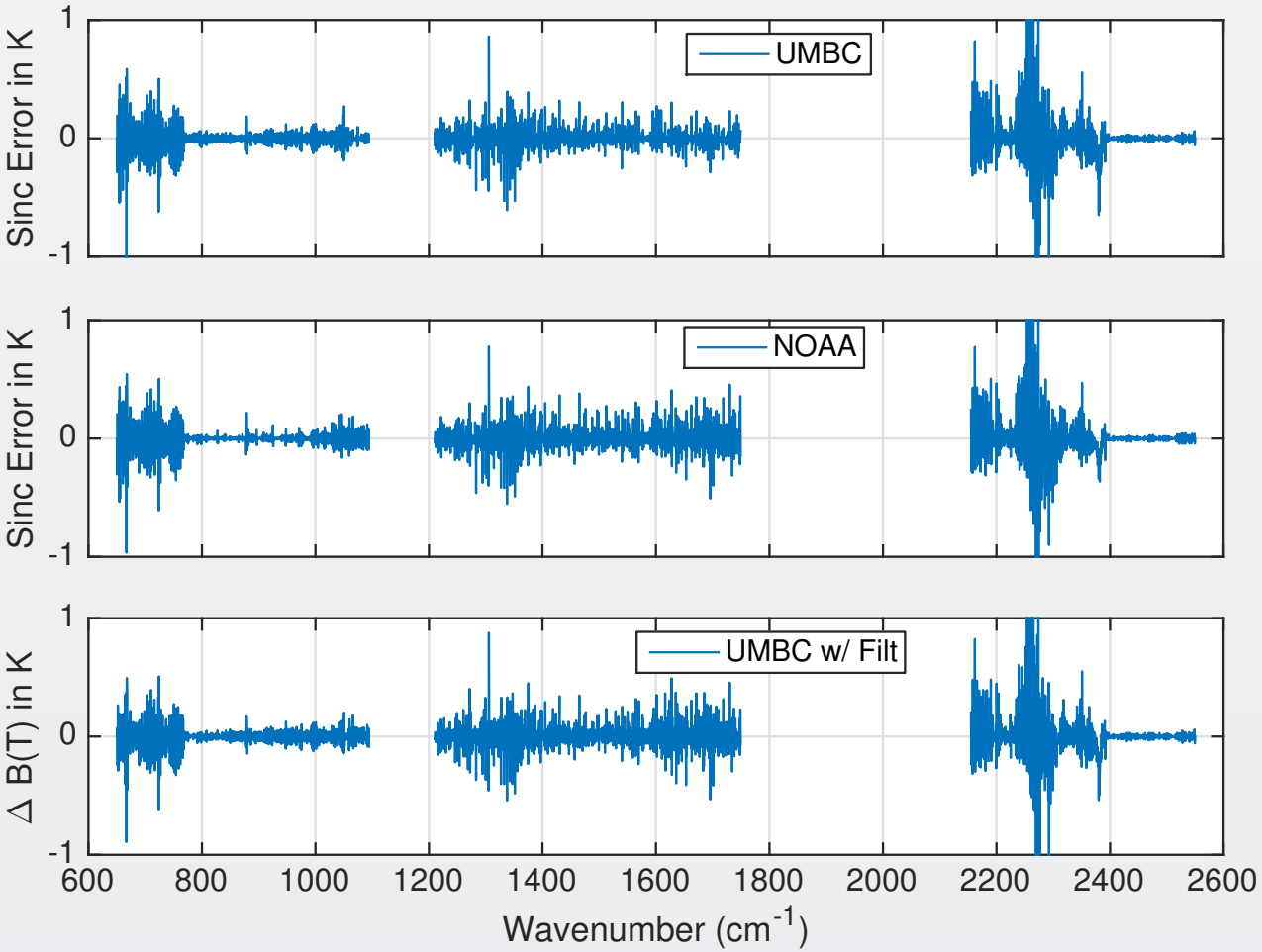
Ringing only, quite small.



Ringing Diagnostics

Showing Bias$_{Hamming}$-Bias$_{Sinc}$

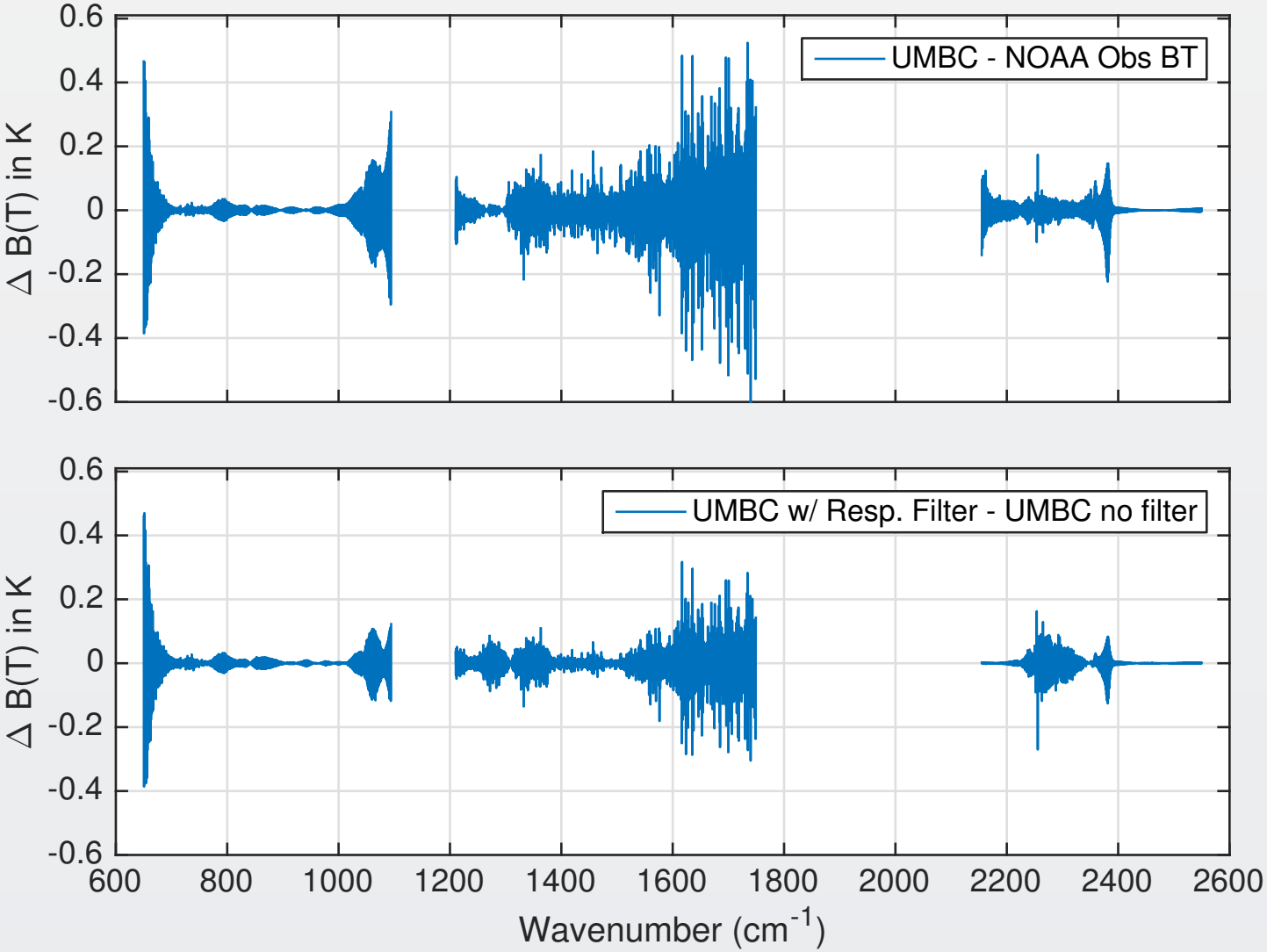
UMBC w/ Filt: Bt$_{calc}$ with Responsivity applied before doing the FFT.



Mid-wave worse with UMBC w/ Filt.

NOAA and UMBC Differences: Responsivity Filter

NOAA C5 numerator embeds responsivity info into the SDR



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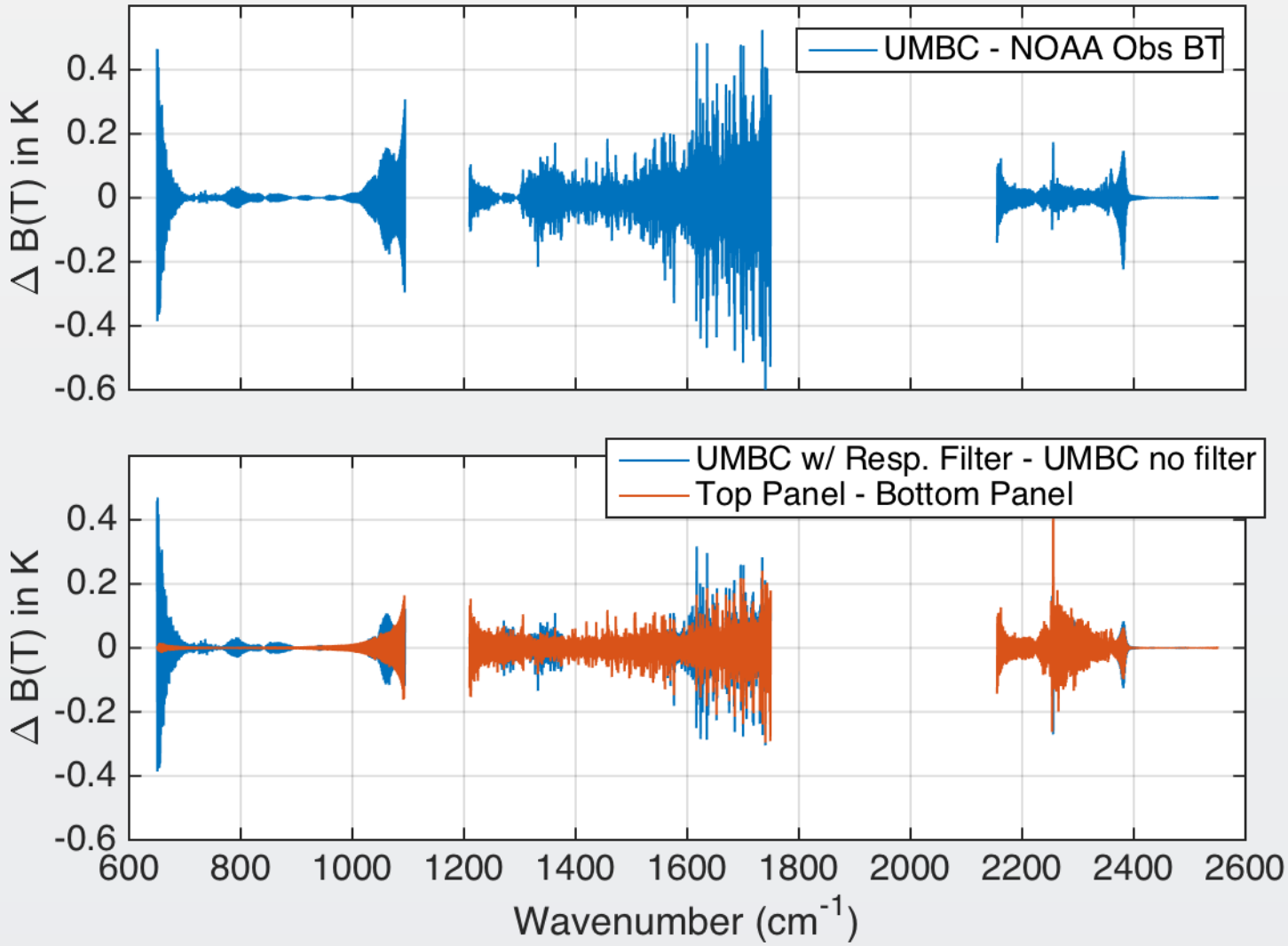
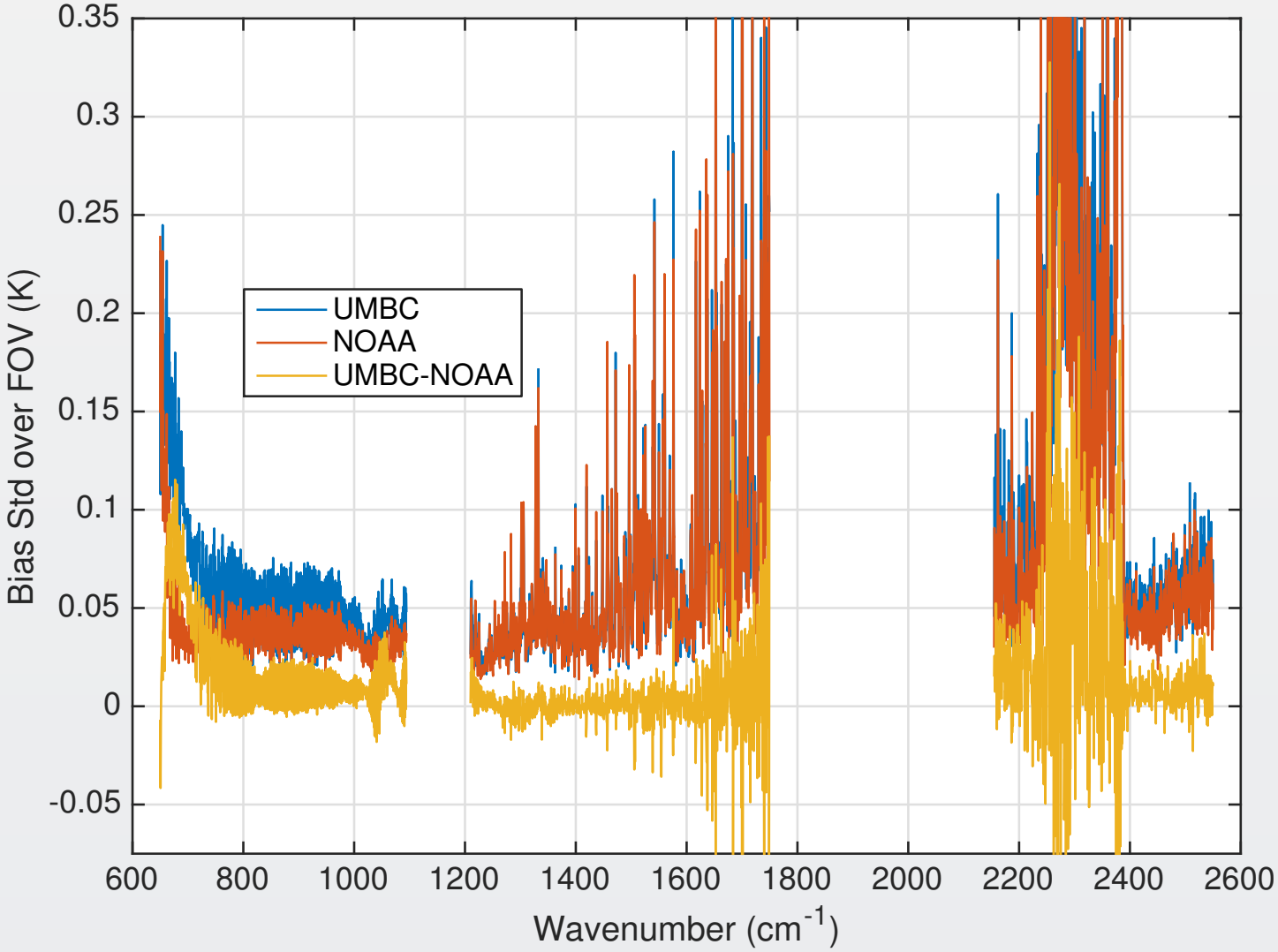


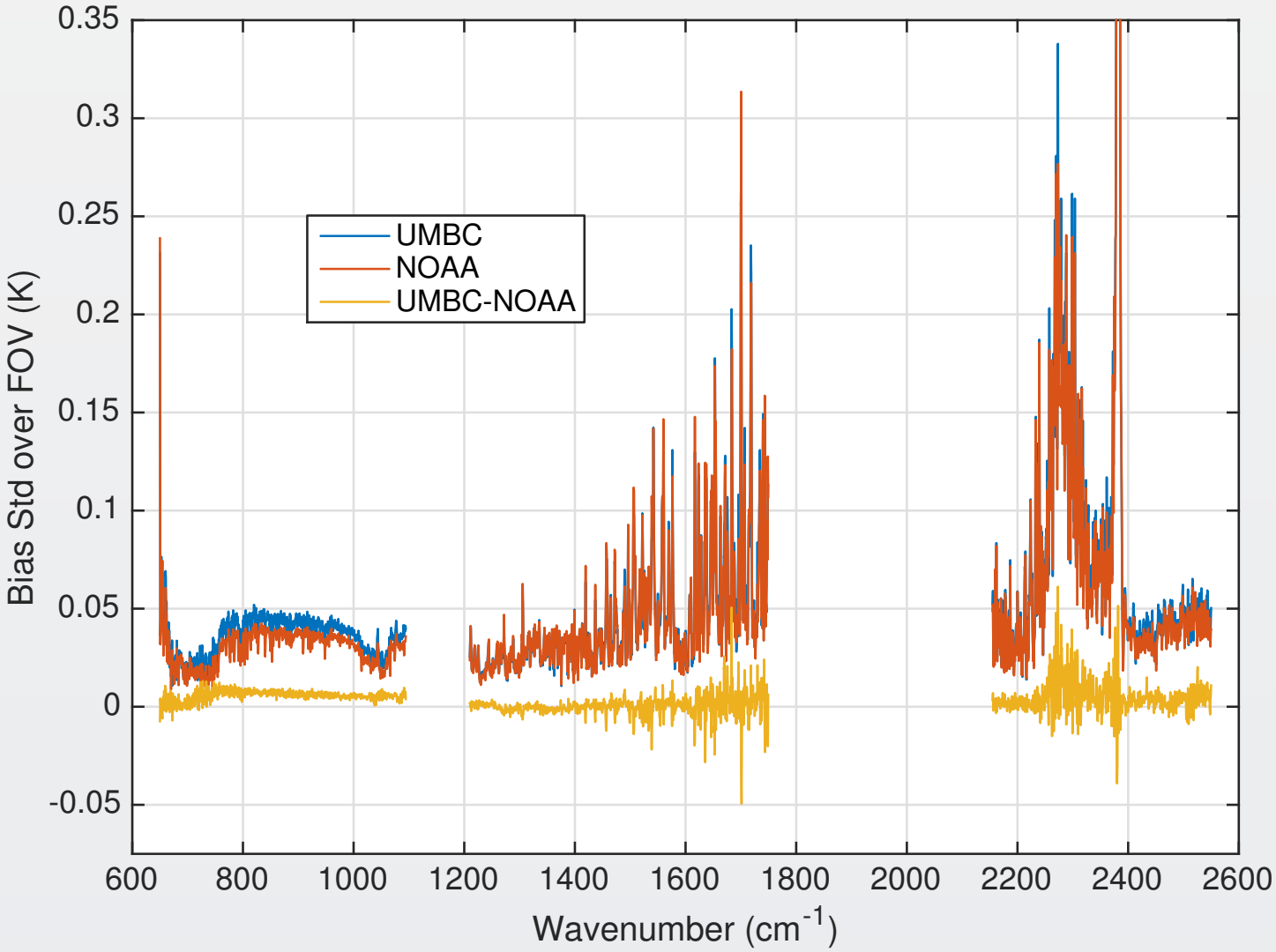
SDR Variability over FOV ID: Sinc ILS

NOAA has smaller variability over FOV, esp. in long-wave



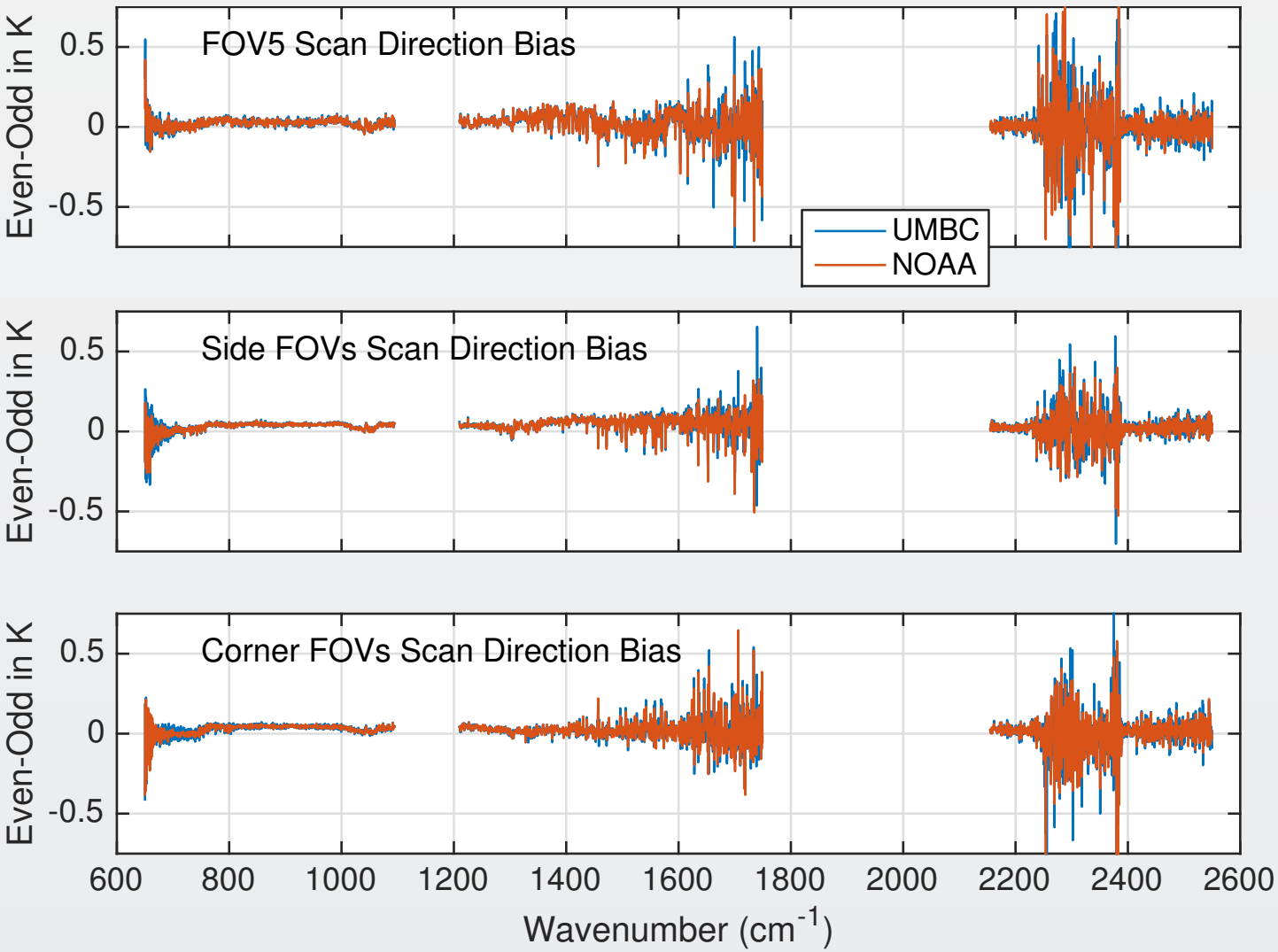
SDR Variability over FOV ID: Hamming ILS

With Hamming ILS, larger UMBC is gone.



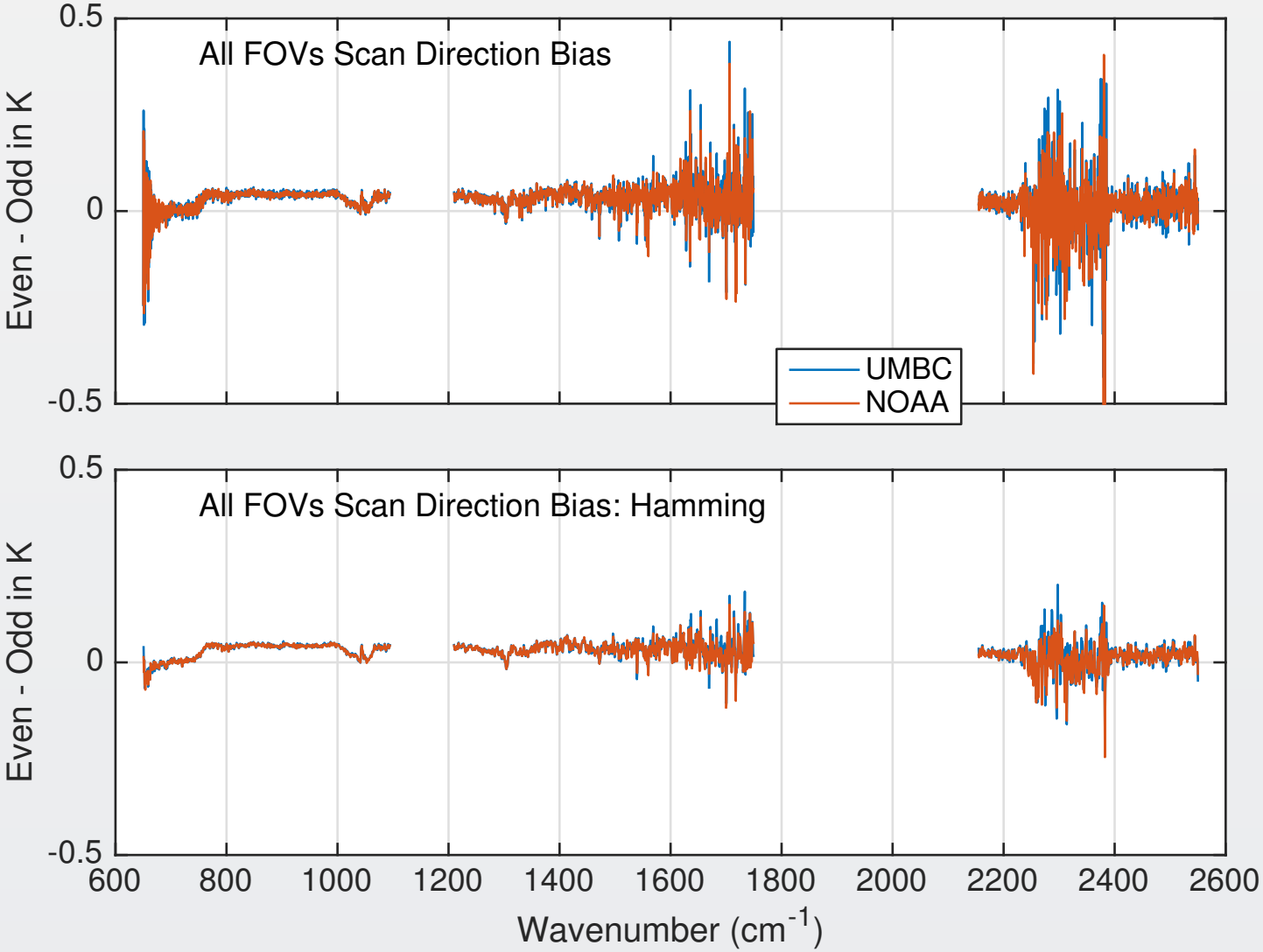
Bias with Scan Direction: Sinc ILS

NOAA and UMBC very similar.



Bias with Scan Direction: Hamming ILS

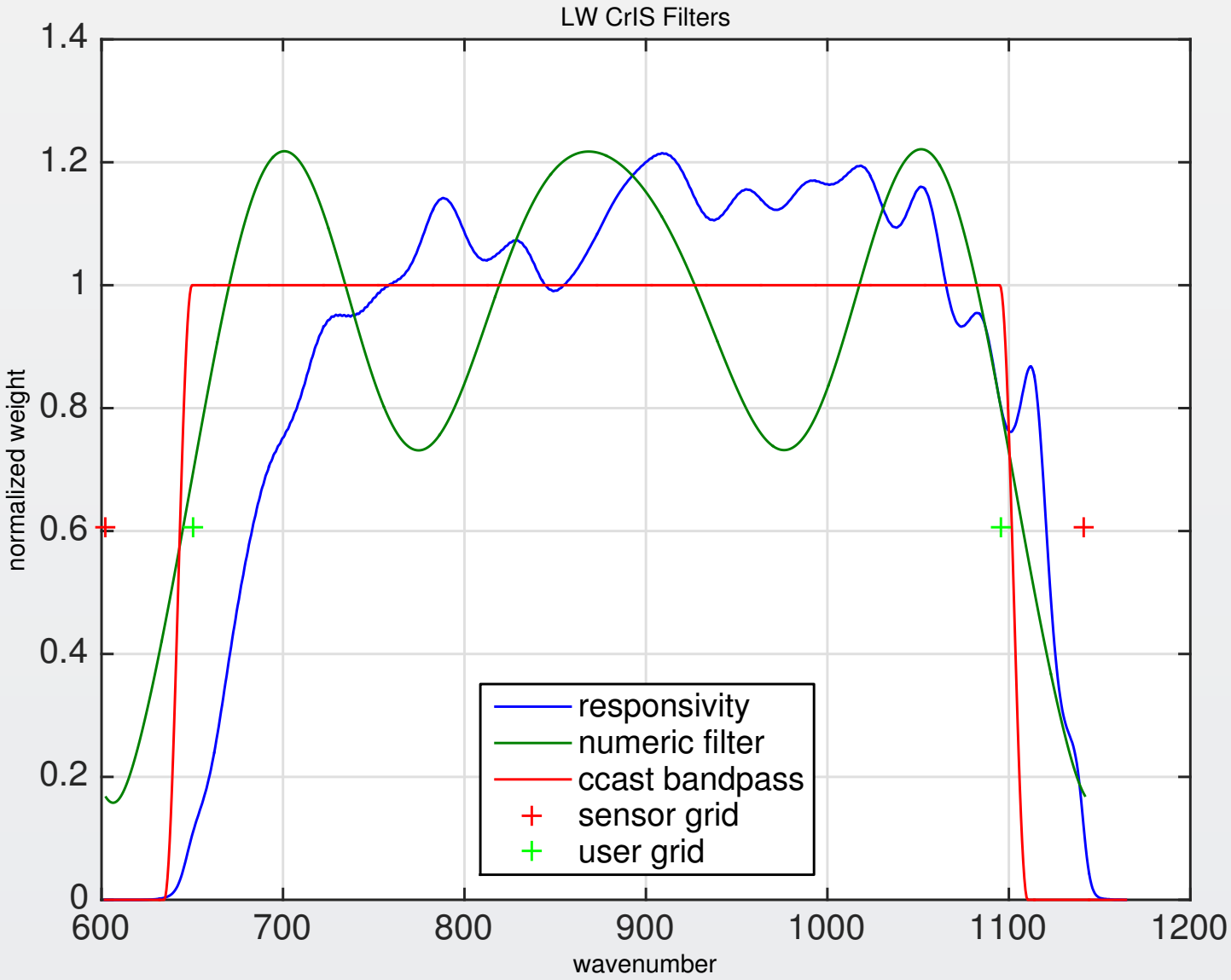
Very small, DC offsets may be scene differences?



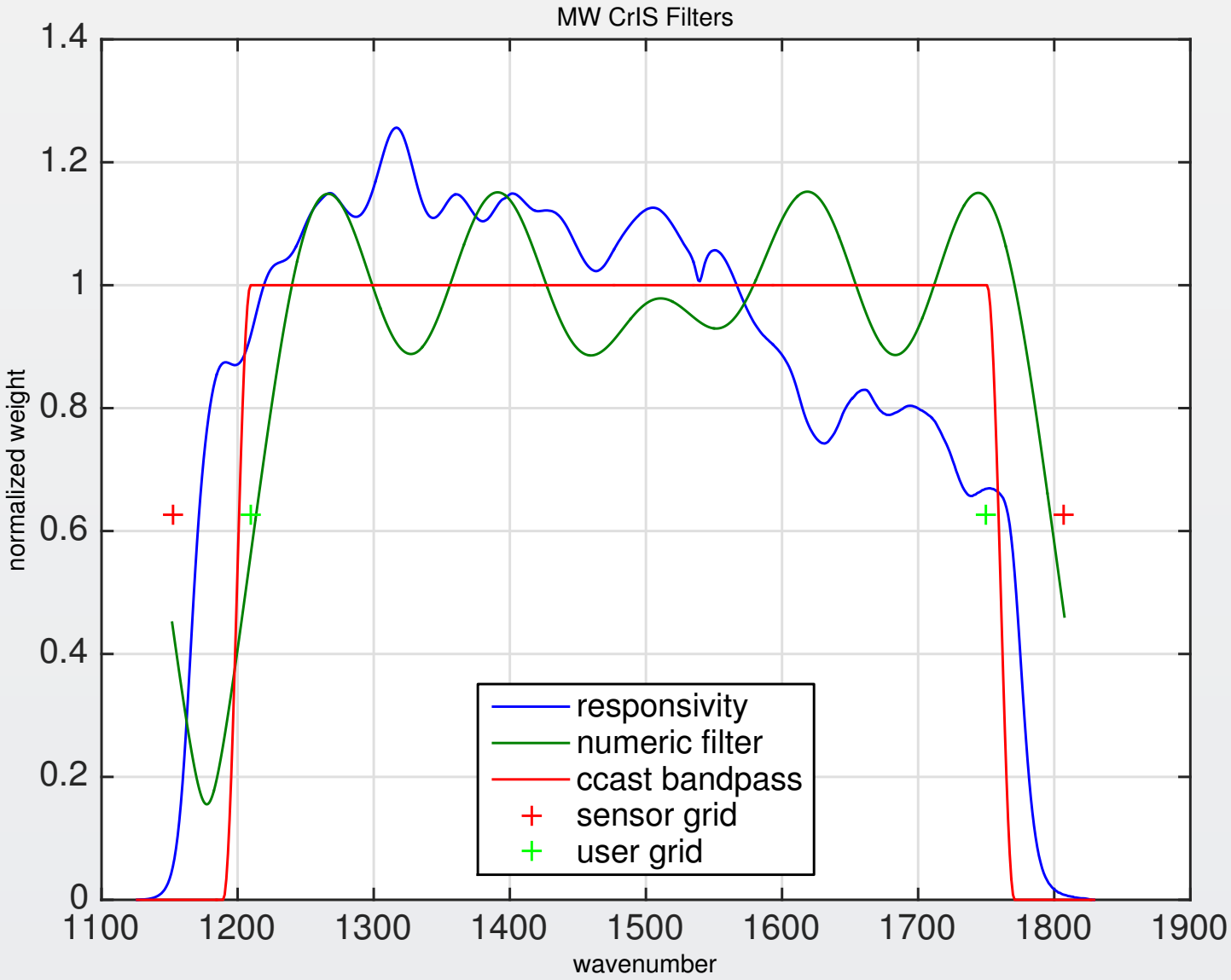
Conclusions

- Two reasons for CCAST approach:
  - CrIS RTA does not need complicated in-band responsivity filter for reference truth (good for external users).
  - Differences in CrIS radiance response among different instruments minimized using CCAST approach.
- Remaining Work
  - UMBC performance almost identical to C5 in the low end of the long-wave band, where the UMBC f cutoff matches the responsivity cutoff, hence the out-of-band is handled properly in simulation.
  - Improve? CCAST by modifying the other f filter cutoffs to more closely match the responsivity cutoffs.
  - These out-of-band contributions are quite small, and can possibly be ignored for even climate applications.
  - Examine sensitivity of these proposed calibration equations to changes in CrIS bands for J2+. Want to keep instrument inter-calibration to the climate level if possible.

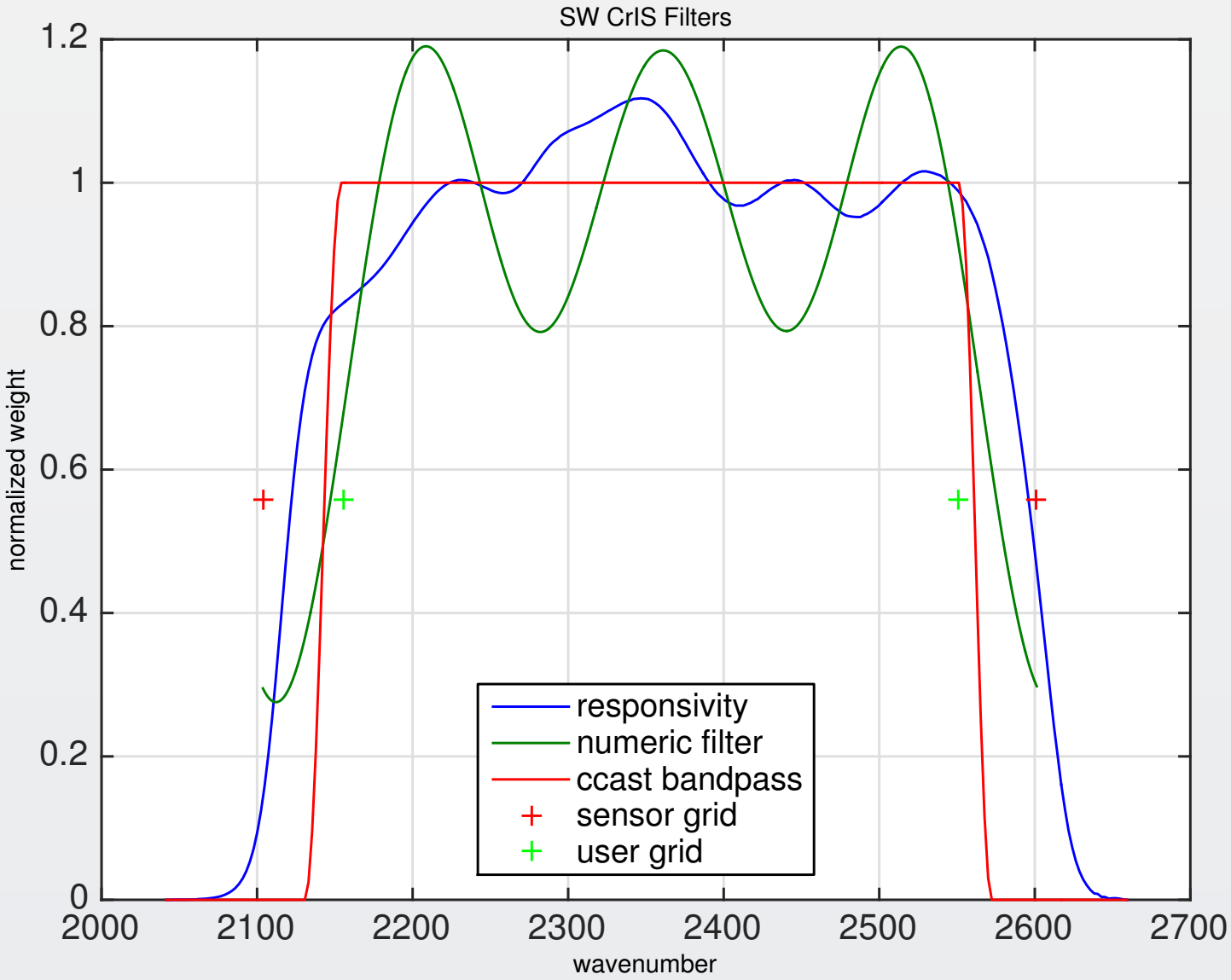
LW Filters


LW CrIS Filters
normalized weight
wavenumber
1.4
1.2
1
0.8
0.6
0.4
0.2
0
600
700
800
900
1000
1100
1200
responsivity
numeric filter
ccast bandpass
sensor grid
user grid

MW Filters


MW CrIS Filters
normalized weight
wavenumber
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1100
1200
1300
1400
1500
1600
1700
1800
1900
responsivity
numeric filter
ccast bandpass
sensor grid
user grid

SW Filters


SW CrIS Filters
normalized weight
wavenumber
1.2
1
0.8
0.6
0.4
0.2
0
2000
2100
2200
2300
2400
2500
2600
2700
responsivity
numeric filter
ccast bandpass
sensor grid
user grid