# CRIS PERFORMANCE CHARACTERISTICS RELATIVE TO AIRS AND IASI FOR NWP/NUCAPS

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# Outline

- CrIS versus IASI Noise Error Correlations
- CrIS long-term stability (vs IASI and AIRS)
- CrIS scene characteristics versus AIRS

**Why Comparisons**

- Many NWP lessons-learned used only AIRS and IASI
- CrIS has some non-trivial differences
- Radiometric accuracy is only part of the story

# Noise Correlations

# Assimilation and Retrieval Cost Function

Minimize cost function

$$J = (x - x_b)^T B_x^{-1} (x - x_b) + (y - K(x))^T (E + F)^{-1} (y - K(x))$$

- $x - x_b$ State increment
- $K$ RTA
- $y$ Measurement
- $E$ Instrument "noise" covariance matrix (and non-linearity)
- $F$ Representativeness, RTA error covariances

Form $E + F$ using ECMWF 3-hour forecast. Assume $F$ is the same for each instrument, so difference in correlation matrices only $E$ is left, the instrument correlation matrix.

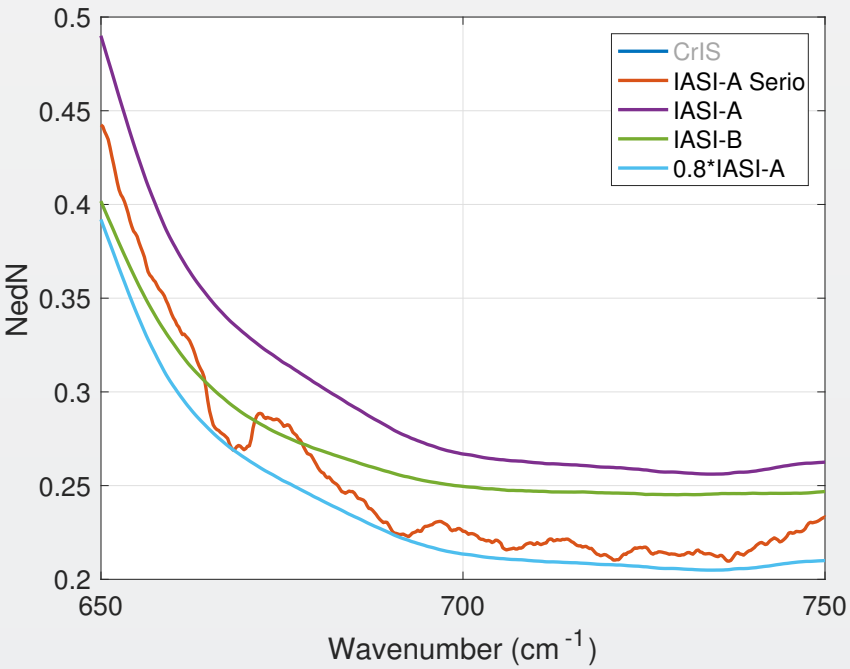
# Start with CrIS and IASI ECMWF Bias Correlations

- Use SNO pairs so CrIS and IASI observing the same state (1 year's worth)
- Clear ocean scenes, tropical so RTA is pretty accurate
- Convert IASI to CrIS ILS "IASI->CrIS"
- Modify CrIS to have "IASI->CrIS" noise
- Concentrate on 650-750 $cm^{-1}$ because:
- $F$ correlations nearly unity when surface, water vapor dominate

Do this for both IASI-A and IASI-B.

The problem: Getting IASI noise right.

# IASI Noise Values




Unlabelled IASI noise is from CNES

IASI-A from Carmine Serio, via retrieval studies

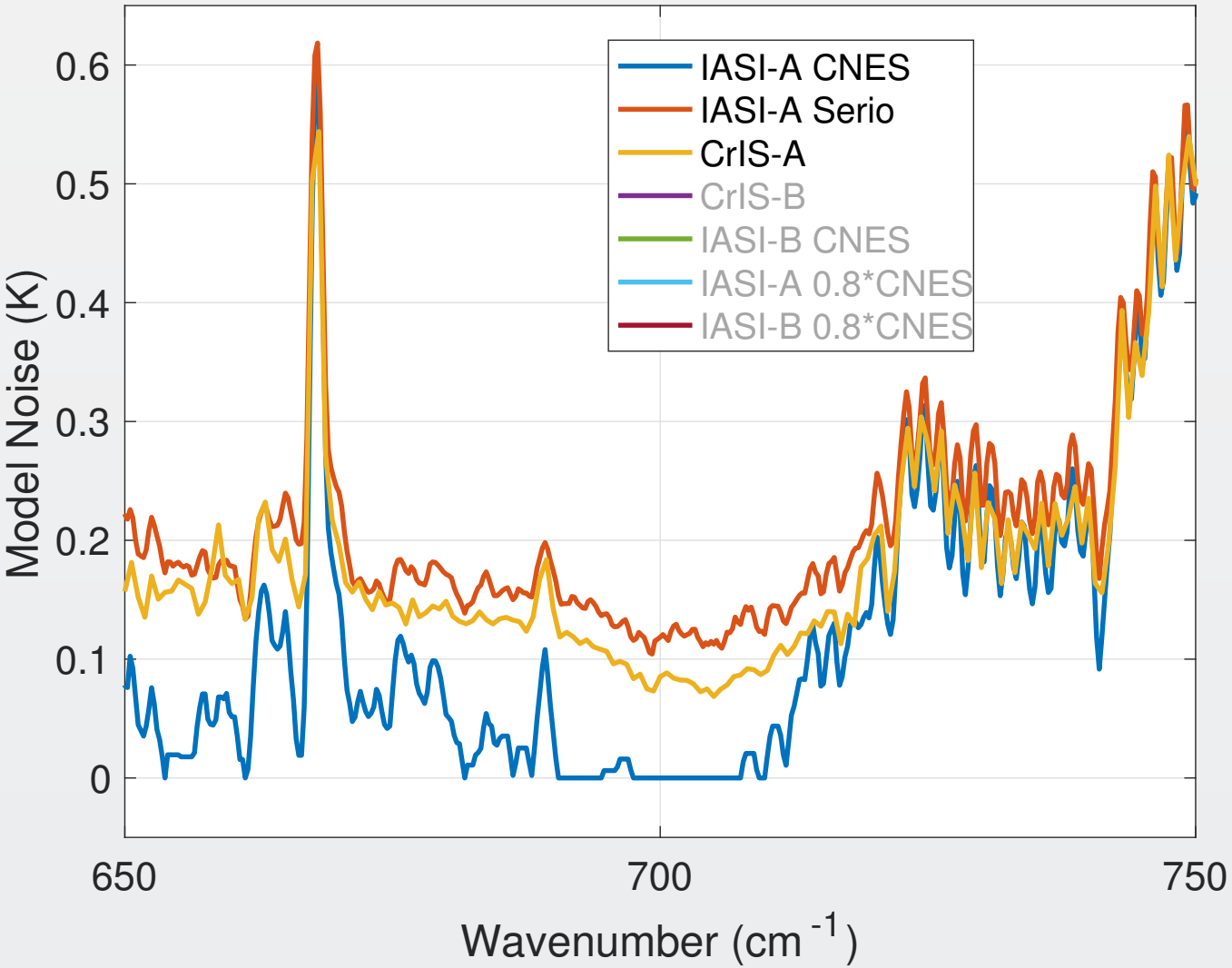
0.8*IASI-A is our (UMBC) rough estimate of IASI-A noise

Must have IASI noise right when intercomparing with CrIS noise covariances/correlations.

Examine Model Noise $= \sqrt{(}$Bias Std$^2$ $-$ Inst. Noise.$^2$)

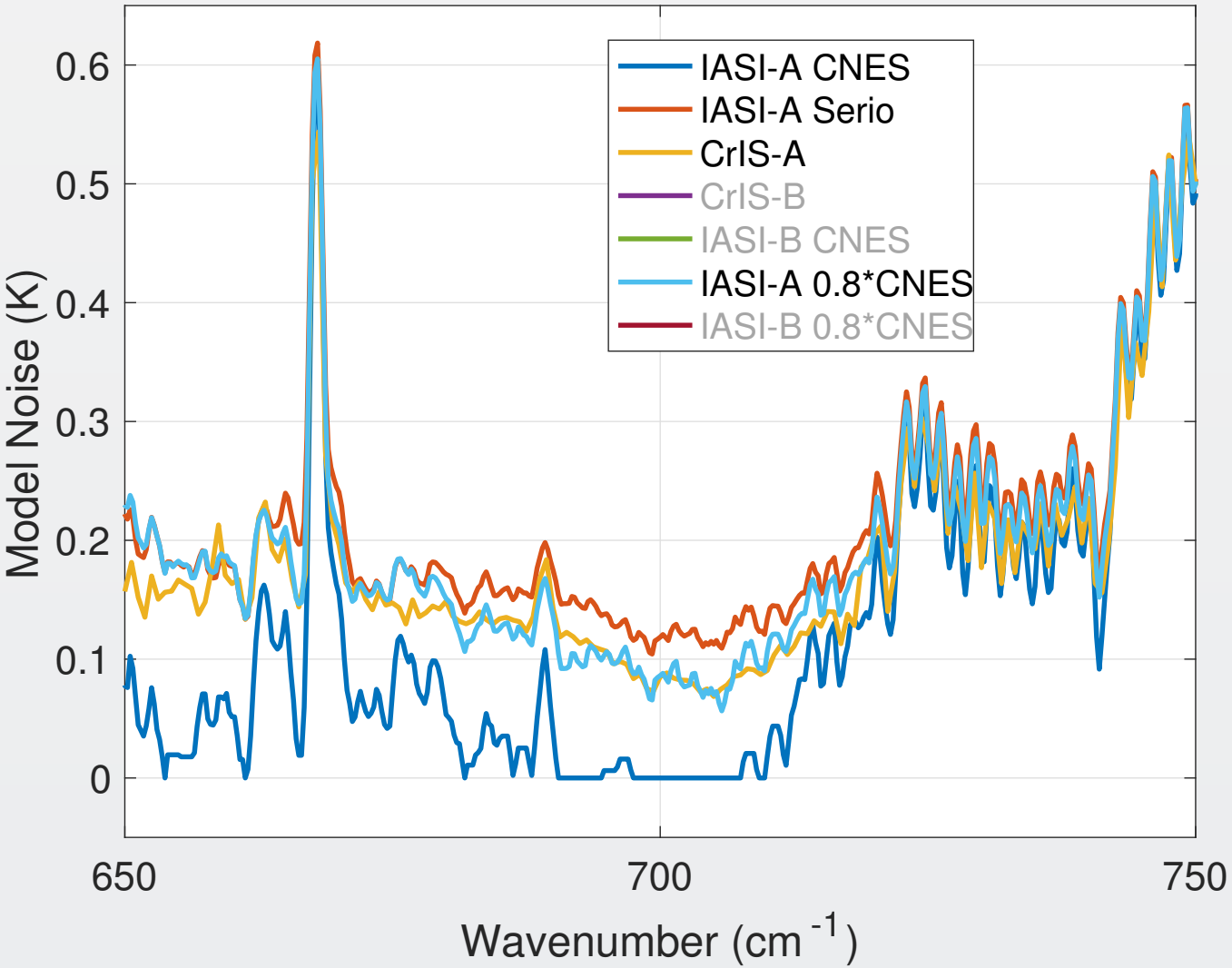
Std and Inst. Noise should be uncorrelated.

# Model Noise from ECMWF Bias Std.



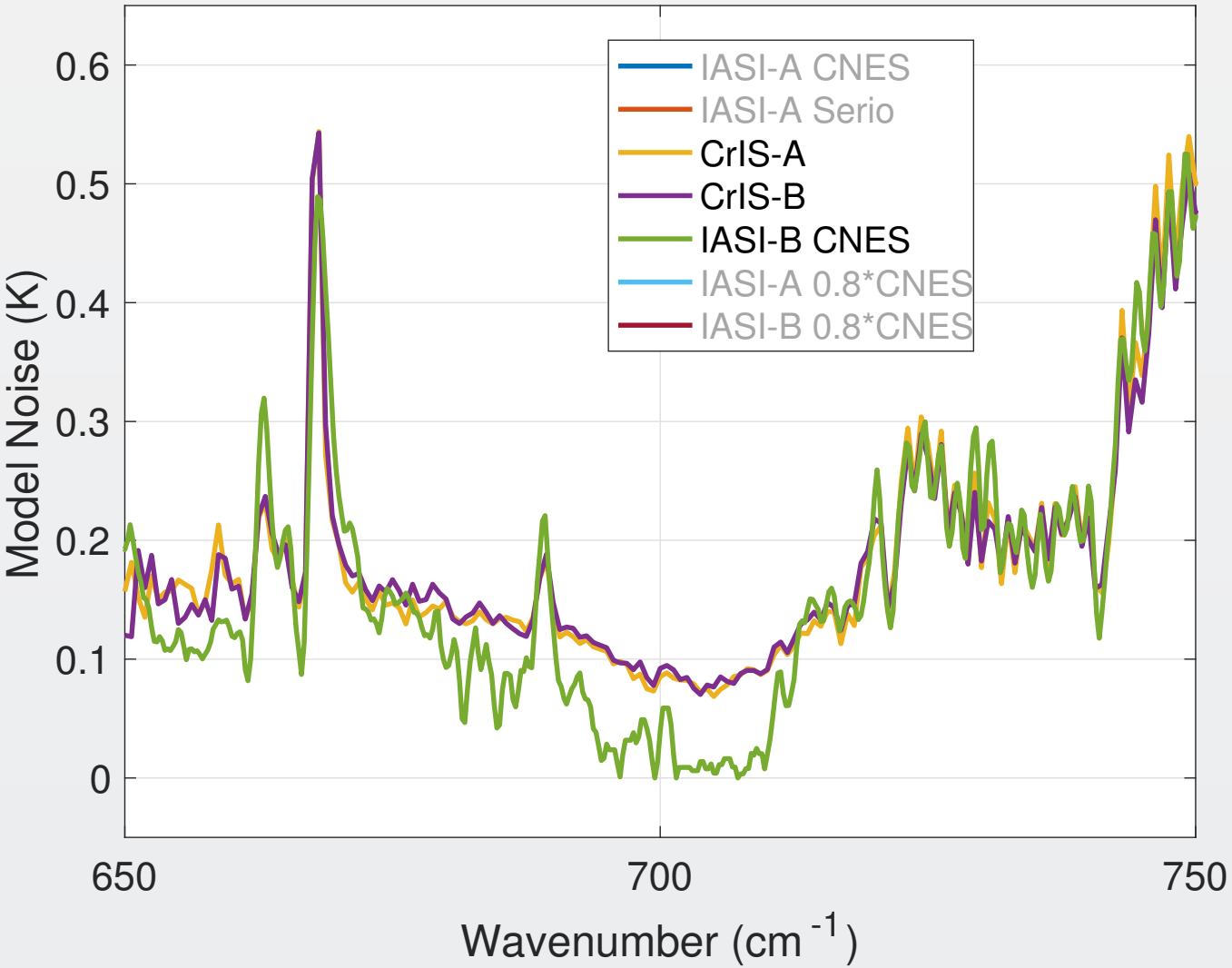

IASI-A and CrIS

# Model Noise from ECMWF Bias Std.



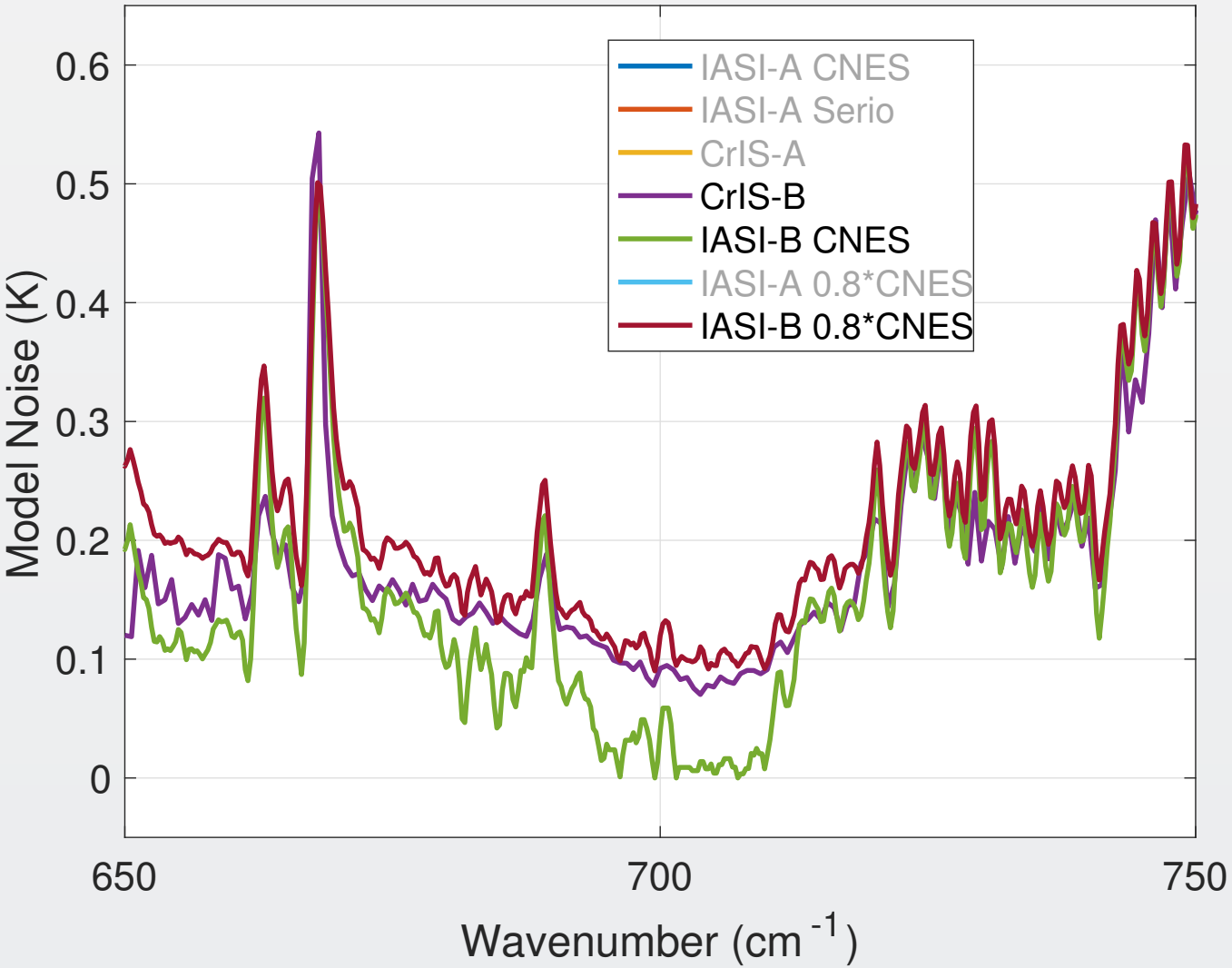

IASI-A Modified and CrIS

# Model Noise from ECMWF Bias Std.




IASI-B and CrIS

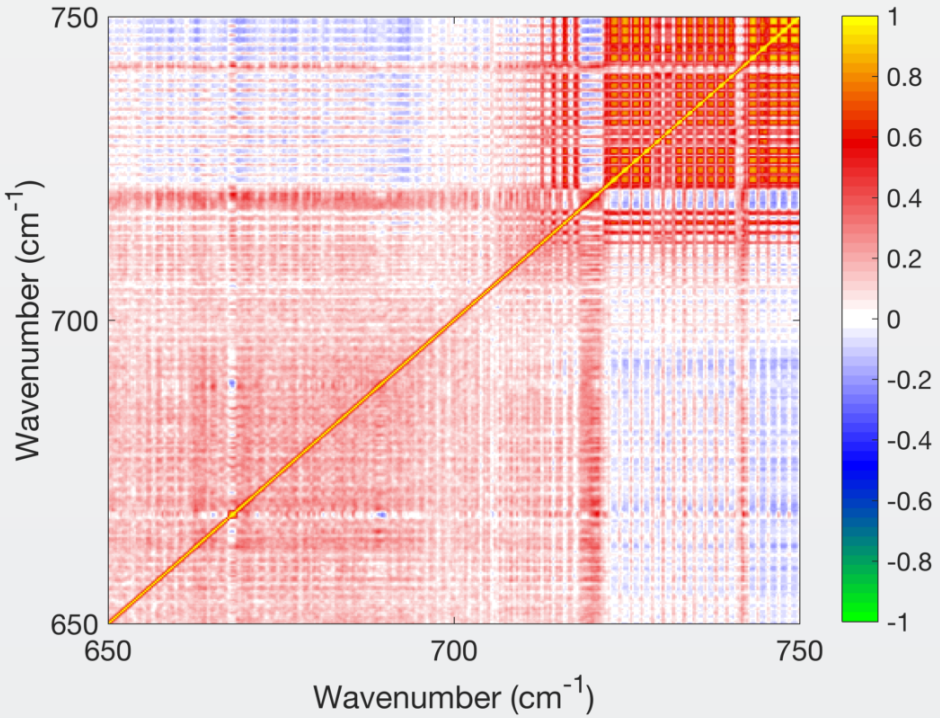
# Model Noise from ECMWF Bias Std.



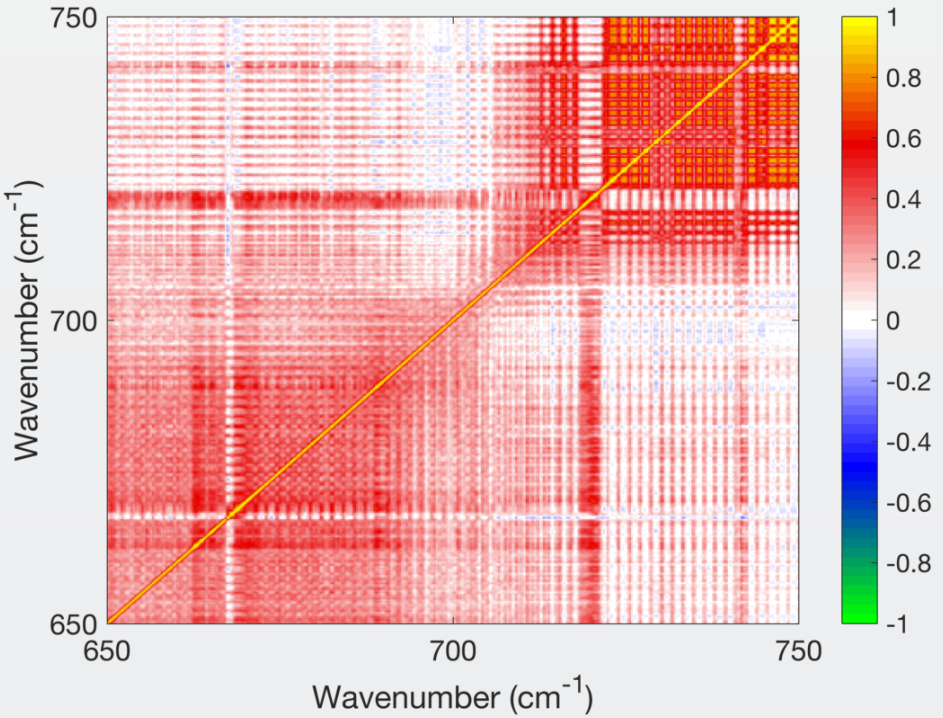

IASI-B modified and CrIS

# IASI-A vs IASI-B Bias Correlations

## IASI-A



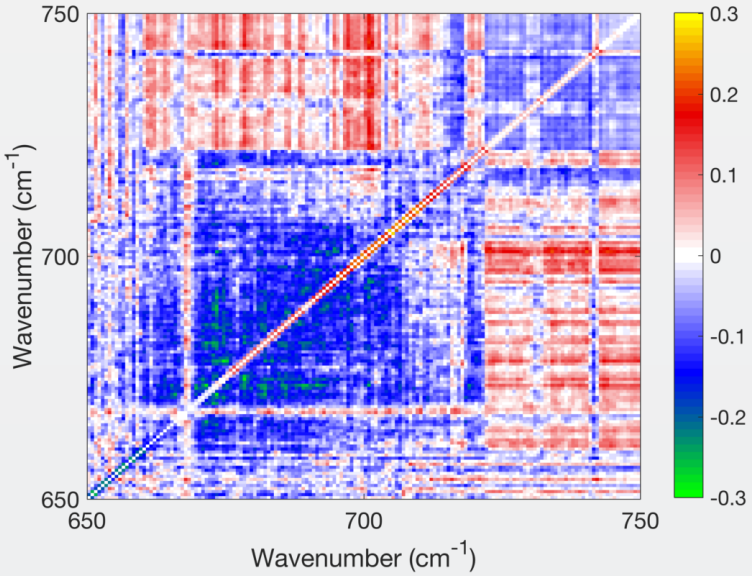

## IASI-B



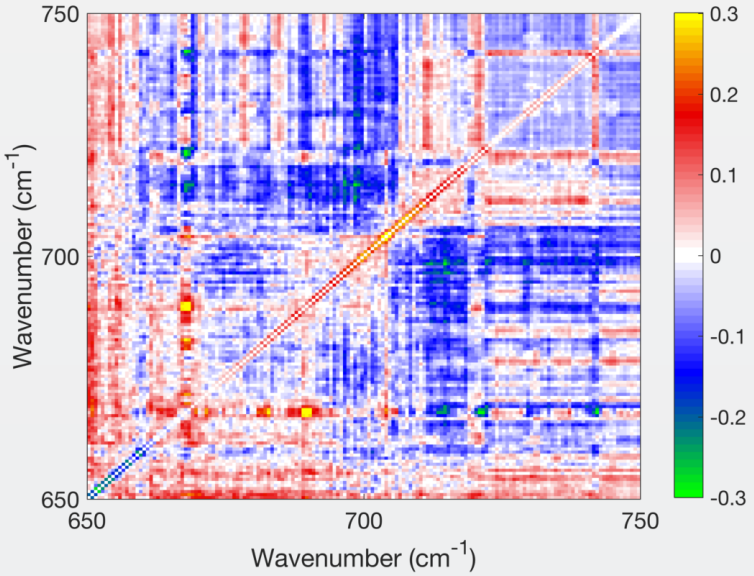

IASI-B bias correlations higher, presumably due to increased non-linearity in IASI-B

# IASI-A and IASI-B minus CrIS Correlations

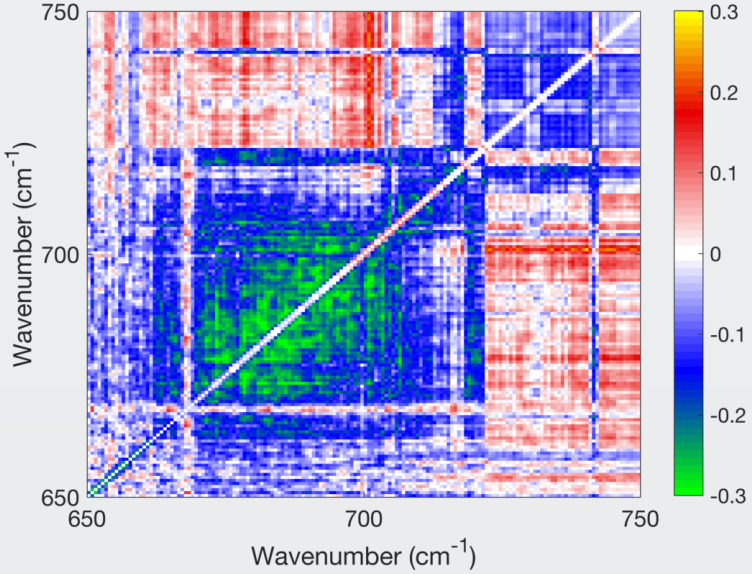
## IASI-A: CNES Noise




## IASI-B: CNES Noise




## IASI-A: 0.8*CNES Noise




So? CrIS looks more like IASI-B? Why?

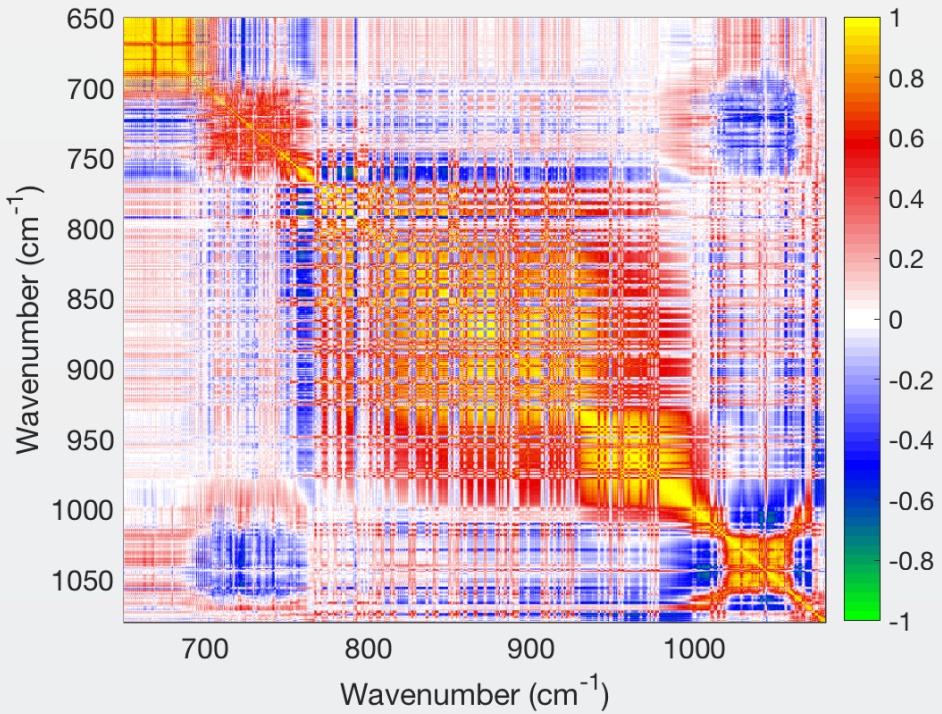
Non-linearity?

Now I know why it took NWP a long time to implement noise covariance matrices! It's hard.

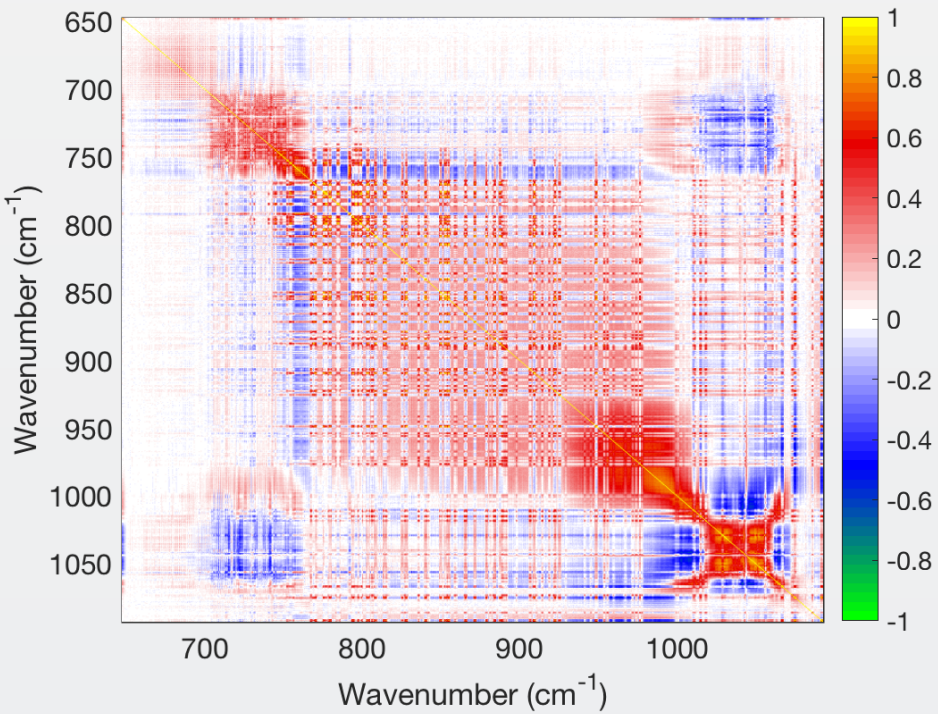
Possible to do with CrIS-A/B? No SNOs?

# RTA (SARTA) Parameterization Error Correlations

**Raw: No Noise**



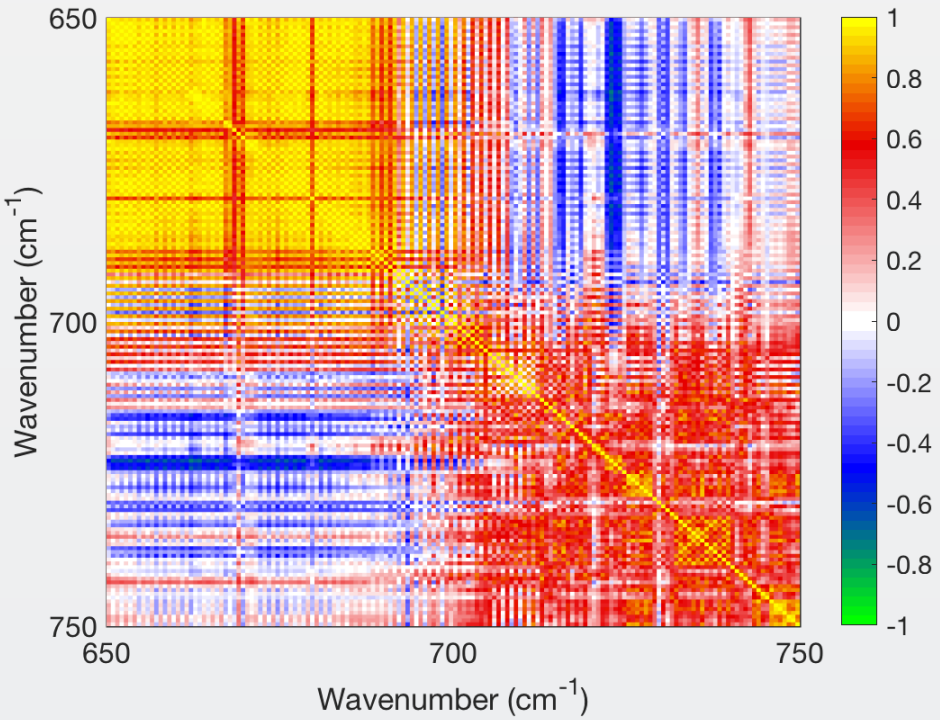

**With CrIS Noise**



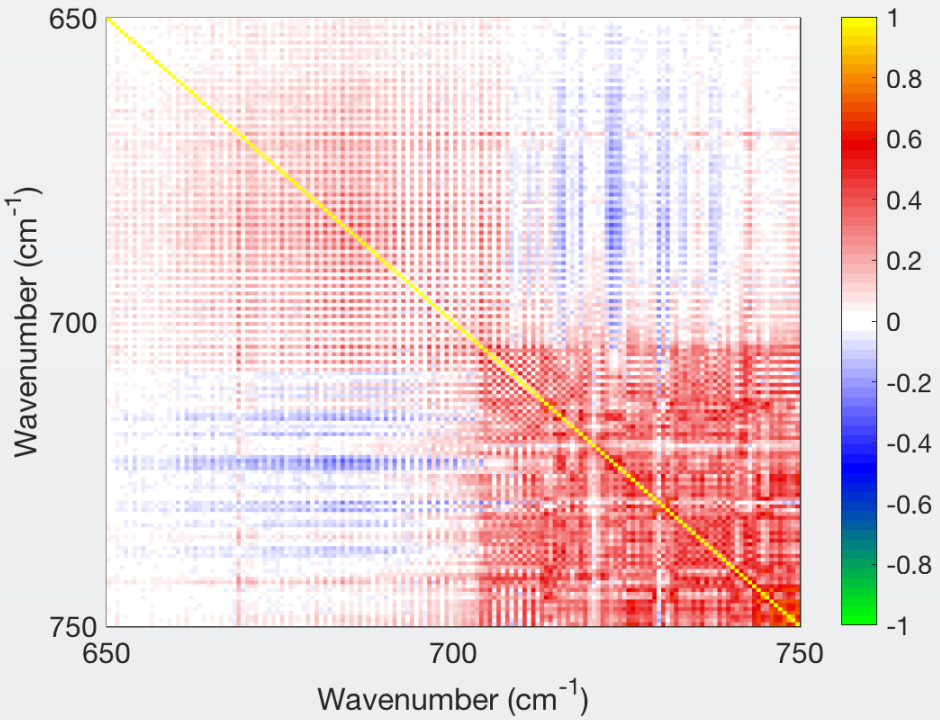

- 705 global profiles
- Computed covariances between LBL (kCARTA) and fast RTA (SARTA)
- Same kCARTA used to create SARTA parameterizations

# RTA (SARTA) Parameterization Error Correlations: LW Zoom

**Raw: No Noise**




**With CrIS Noise**




- Compare to CrIS ERA correlations
- A significant fraction of “instrument” error correlation could be the RTA
- This is only parameterization error, not line-by-line errors

# Degrees of Freedom Analysis

- Using Rodger's OEM methodology.
- 2K temperature, 40% water vapor a-priori covariances
- Concentrate on relative differences, absolute DOFs highly uncertain (depend on a-priori, etc.)
- 1X, 2x, 4X represent native noise multipliers
- ECMWF, UKMO using ~ 2X for CrIS
- Others? use fixed obs uncertainty, 0.5K temperature channels, ? water channel (if used)

| | 1X | 2X | 4X |
|---|---|---|---|
| Using ECMWF 117 channel set | | | |
| IASI | 6.2 | 4.2 | 2.6 |
| CrIS | 10.8 | 8.3 | 5.9 |
| | | | |
| Using all channels | | | |
| IASI | 21.2 | 17 | 13.3 |
| CrIS | 22.6 | 18 | 14.7 |

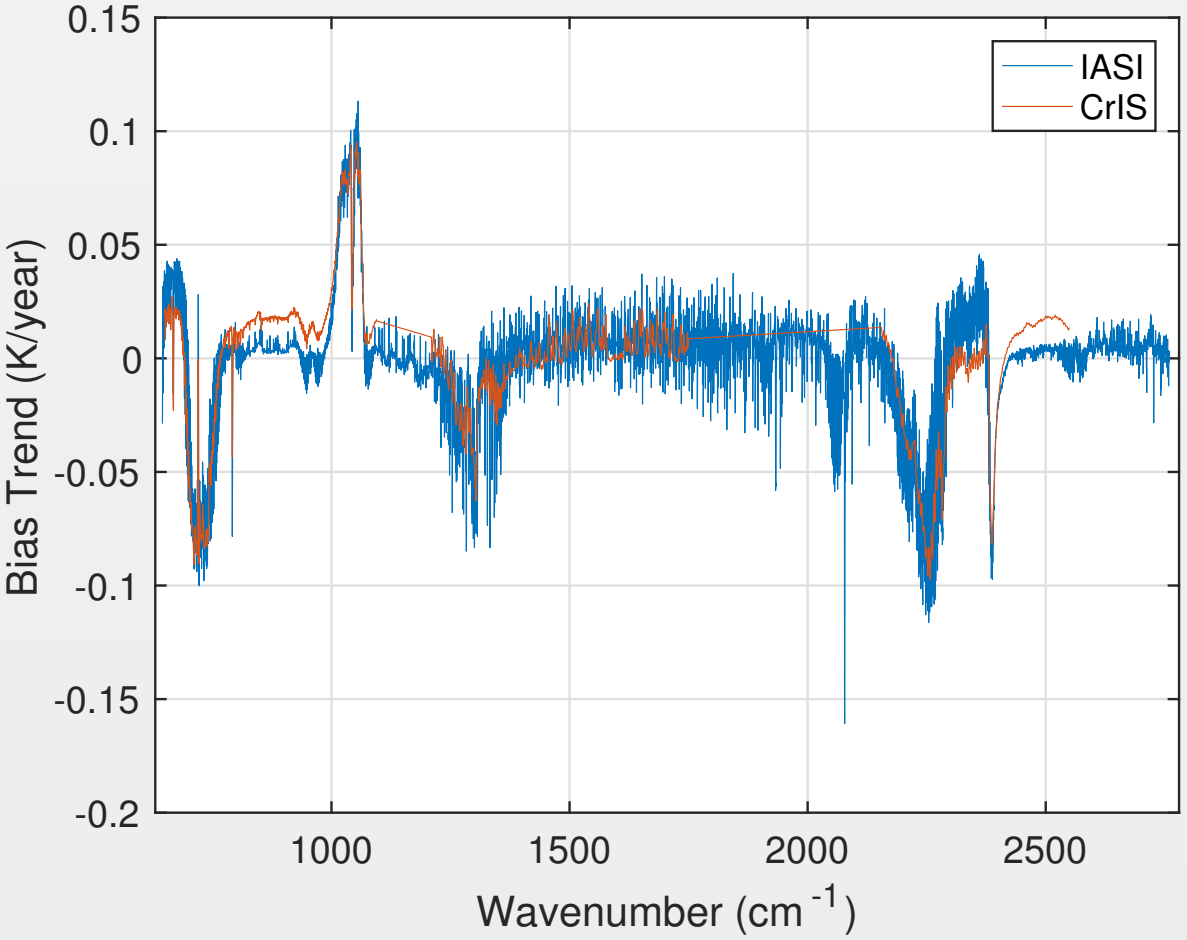
CrIS improvements larger for small channel set, even with increased noise

NWP fixed obs uncertainy implies different instrument noise multipliers!

RTA errors may start to dominate is true 2X noise used for CrIS!

# CrIS Stability

# CrIS Stability: Clear Ocean Bias Trends vs ECMWF

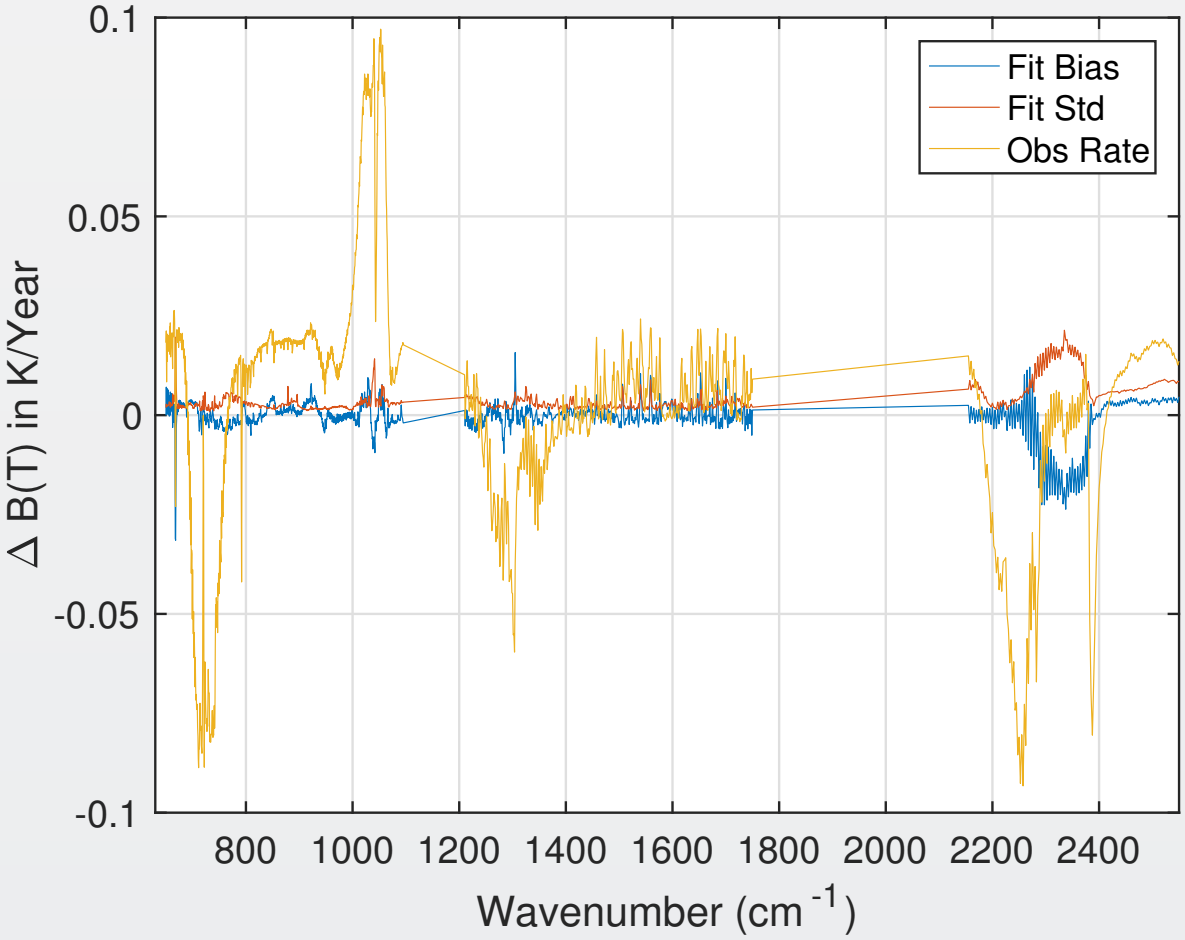



MLO: 2.49 ppm/year (last 5 years)

CriS Tropics: 2.56 ppm/year (last 5 years)

Difference = 0.0035K/year in possible drift!

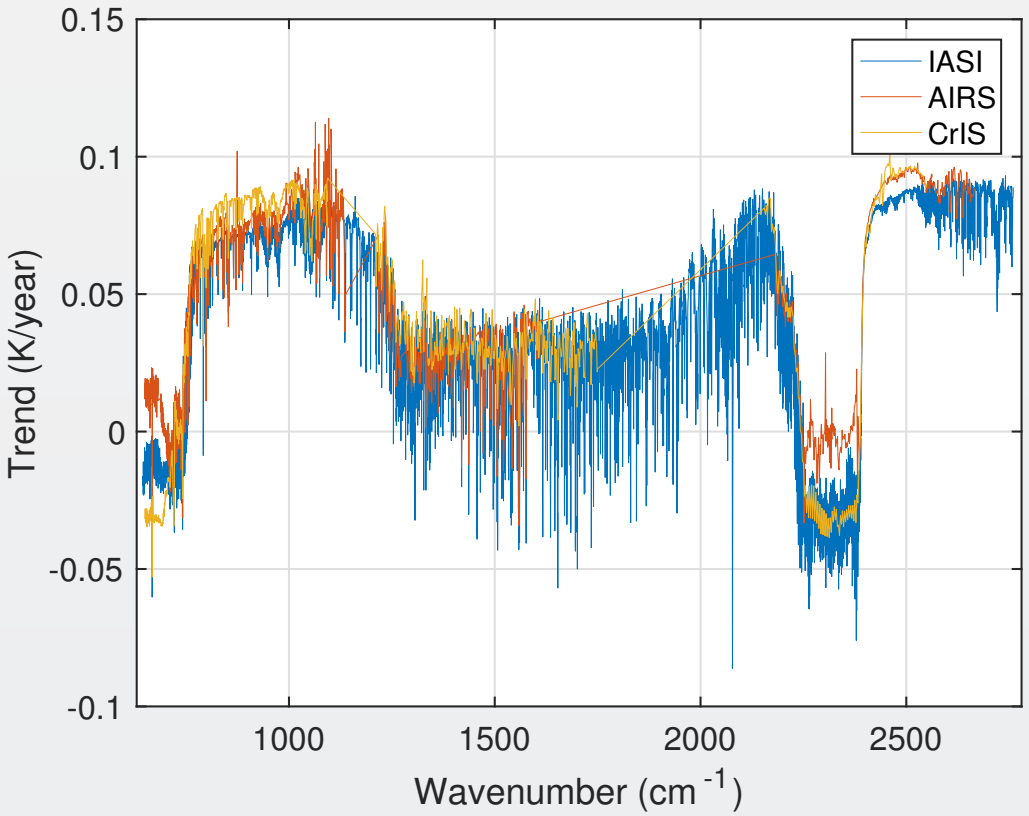
# CrIS Stability: OE Fits to Bias Rate




SST vs ERA (ghrsst): 0.0035K/year in BT units

$CH_4$ vs MLO: ~0.01K/year (MLO: 8.6 ppb/year, CrIS: 8.1 ppb/year)

# CrIS All-Sky Trends




**For 900 cm$^{-1}$ channels:**

**CrIS:** 0.085 K/year

**AIRS:** 0.076 K/year

**IASI:** 0.072 K/year

Latitude variability high: $\pm$0.2-0.3K/year BUT within 2$\sigma$ estimated uncertainties

This is a short time period. 14-year AIRS trend is $\sim$0.015K $\pm$0.01K.

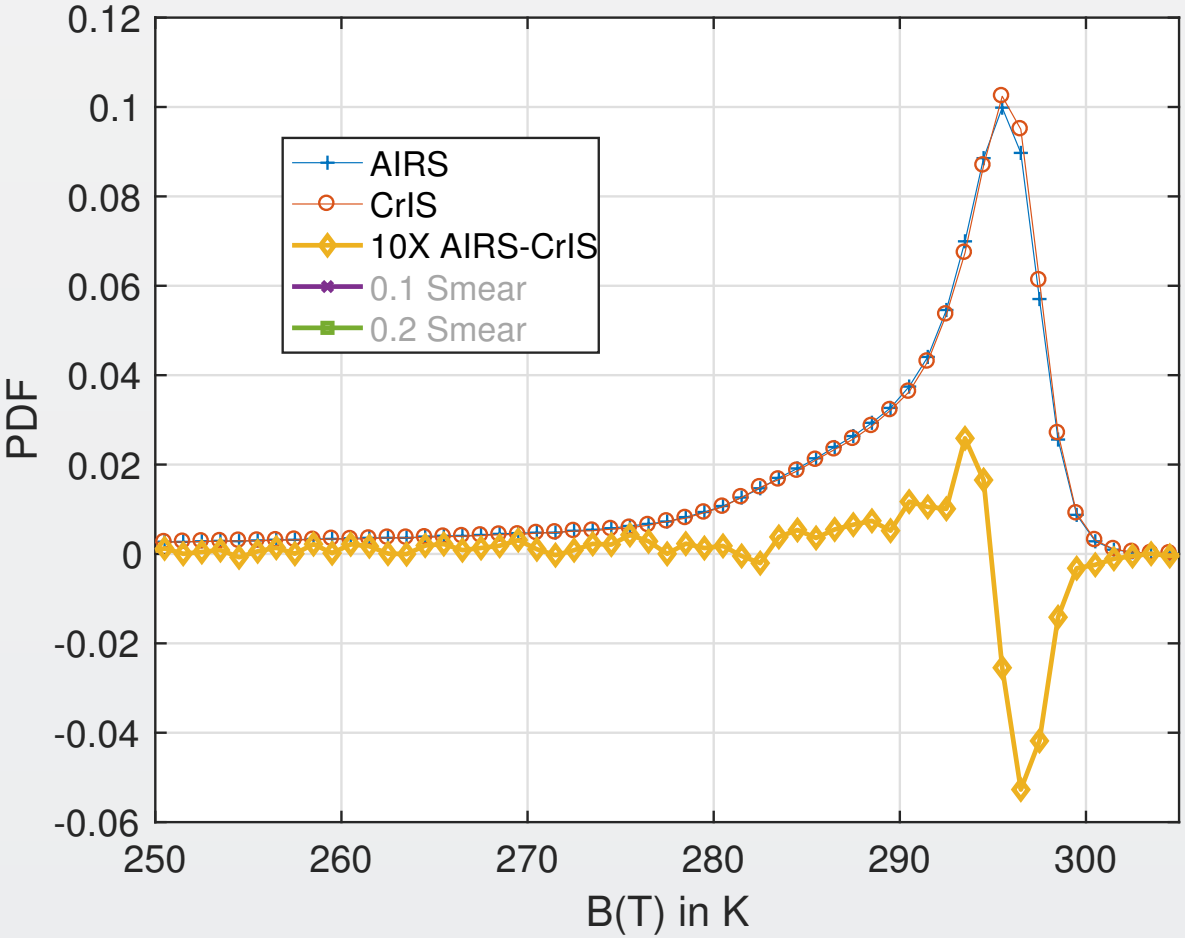
# AIRS versus CrIS PDFs: Spatial Differences

# Examine PDF Differences between AIRS and CrIS

- CrIS and AIRS have slightly different effective fields-of-view
- Both are nominally ~14 km, but AIRS is slightly smeared
- AIRS instantaneous footprint is less than 14 km, but scan mirror moves during data collection
- Second issue: the orbits are different, and the times of observation are different
- This may produce different “effective” radiometric differences

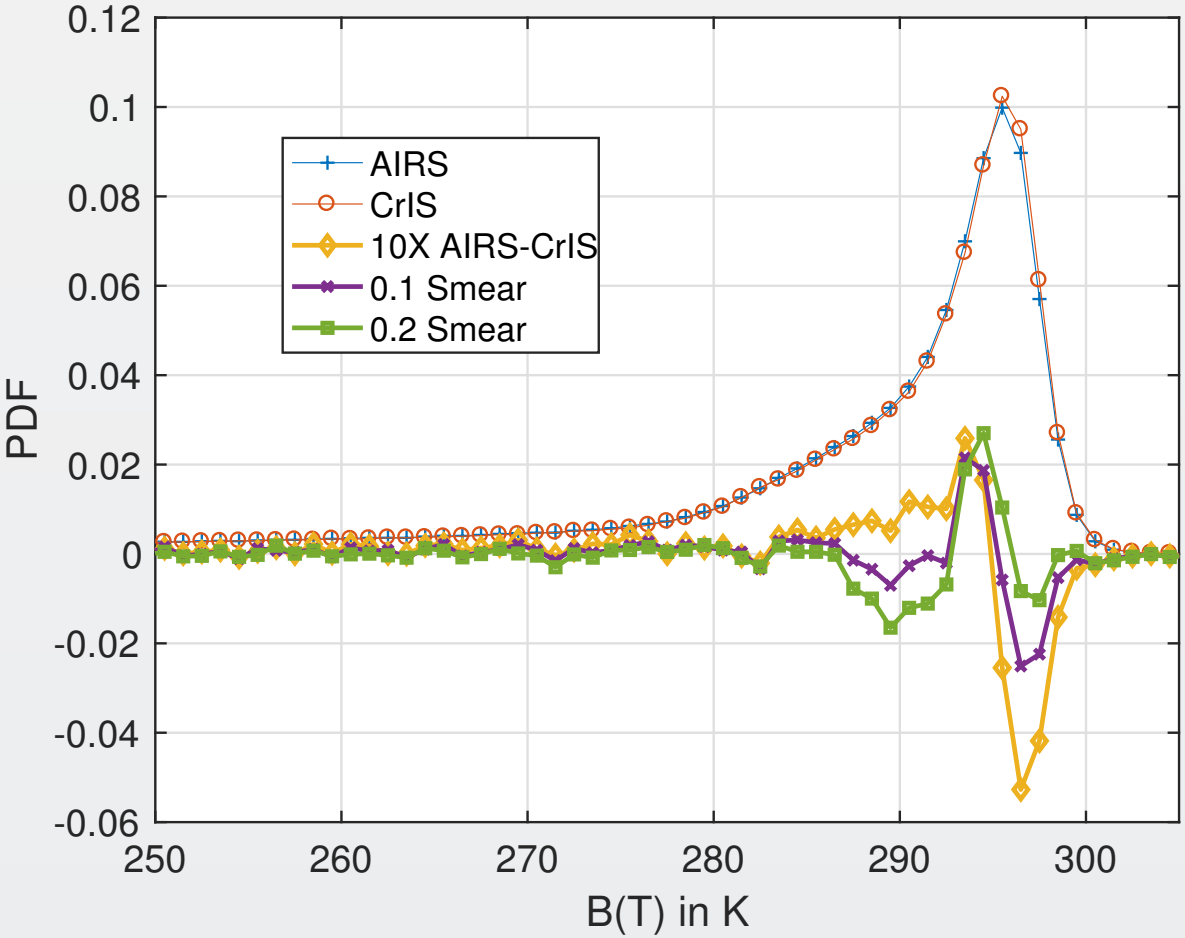
This is all relatively preliminary.

# CrIS vs AIRS Tropical Ocean Scene PDFs



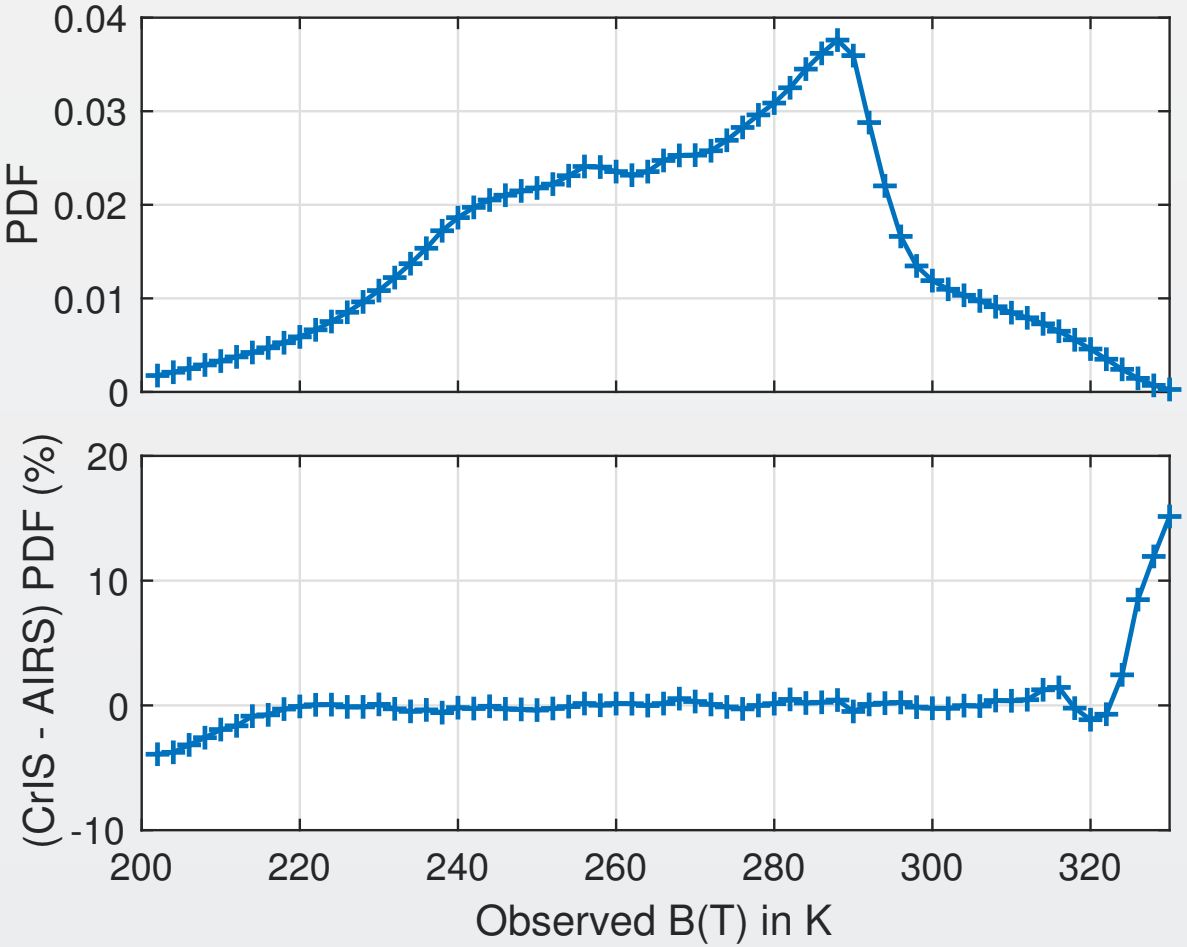

Conclusion: CrIS sees slightly more clear scenes

# CrIS vs AIRS Tropical Ocean Scene PDFs



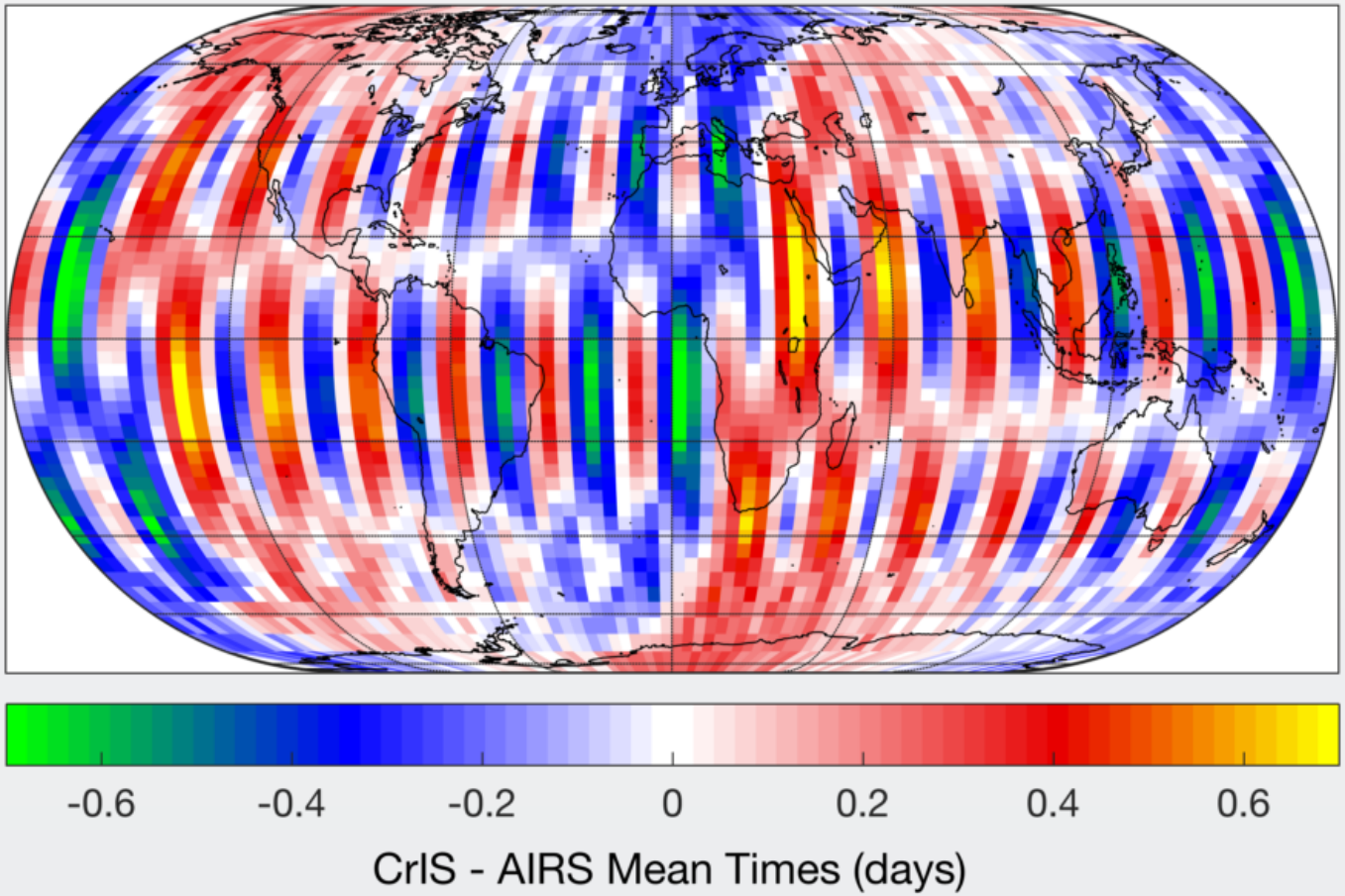

Smearing is 0.1 of adjacent CrIS cross-track footprints

# CrIS vs AIRS Global Land PDFs




These are 1-year, all scan angle PDFS, a massive amount of data.

# Mean Observing Time Differences AIRS-CrIS




Something to keep in mind when comparing data sets!