Perspectives on Building a Climate Record of AIRS+CrIS

L. Larrabee Strow, Sergio de-Souza Machado, Howard Motteler, Chris Hepplewhite, and Steven Buczkowski (UMBC)

AIRS Science Team Meeting: October 24, 2017

Introduction

Strategies for connecting AIRS and CrIS(s)

Outline

- General Approach
- Motivation and Requirements
- Sensor Differences and Mitigation

Themes of This Talk

- Sensors stable to <0.003K/year
- They provide an excellent climate monitoring platform (now 15+ years). Natural use of these data by users?
- How will we
  1. Maintain stability across instruments
  2. Provide users with error estimates based on sensor measurement accuracies

General Approach

Existing Approach

- AIRS L1b —> Retrieval —> L3 —> AIRS Climate?
- CrIS L1b —> Retrieval —> L3 —> CrIS Climate?
- Combined Time series: (AIRS Climate) + (CrIS Climate)?

AIRS/CrIS Retrieval Differences:

- Forward models (RTA). Hard to make them "identical".
- Instrument Line Shapes (width, centroids), channel sensitivities, noise, channel selection
- Spatial response (Aumann Sept. 2016 STM: 3x3 CrIS has about 8% more variability, better Cloud-clearing?)
- Radiometric offsets: in the 0.1-0.25K range

Proposed Strategy

1. AIRS L1b —> AIRS L1c —> AIRS2CrIS (AIRS w/ CrIS ILS)
2. Adjust AIRS2CrIS radiometric calibration to CrIS calibration
3. Add noise to individual scenes (will vary between CrIS and AIRS2CrIS depending on wavenumber)

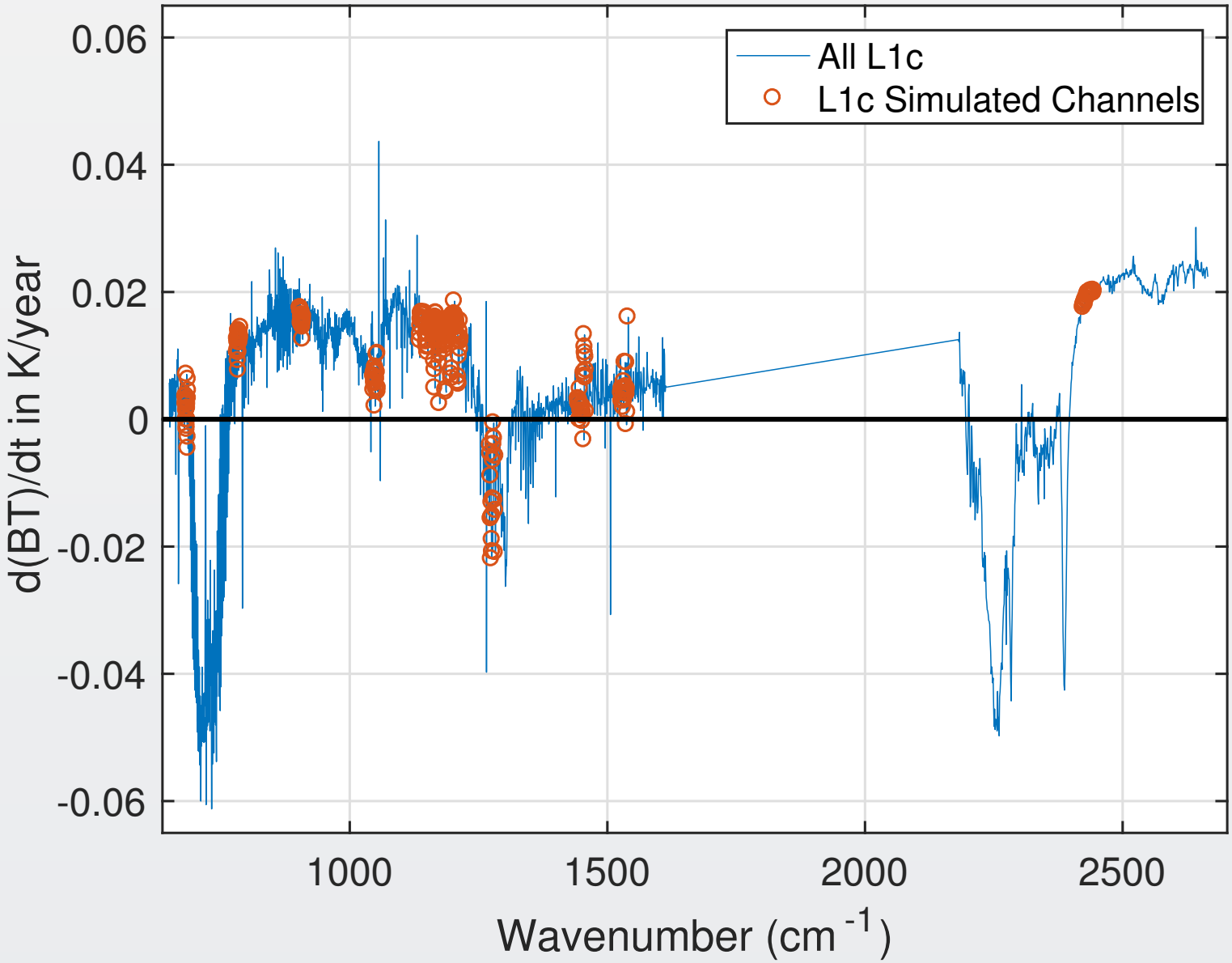
ILS conversion is very easy and very accurate. See Howard Mottelers talk: "AIRS deconvolution and the translation of AIRS to CrIS radiances" (3:20 PM Thursday)

Benefits

- A uniform radiance time series "cL1d" (c is for combined)
- Provides a radiance climatology. (Rad L3 —> Geophysical L3).
- *Allows radiance offsets to be applied on a channel-by-channel basis for L2 retrievals*. What is the alternative?
- Permits use of a single forward model, removing possible paramaterization differences in fast RTAs
- Easier system to manage, more uniformity

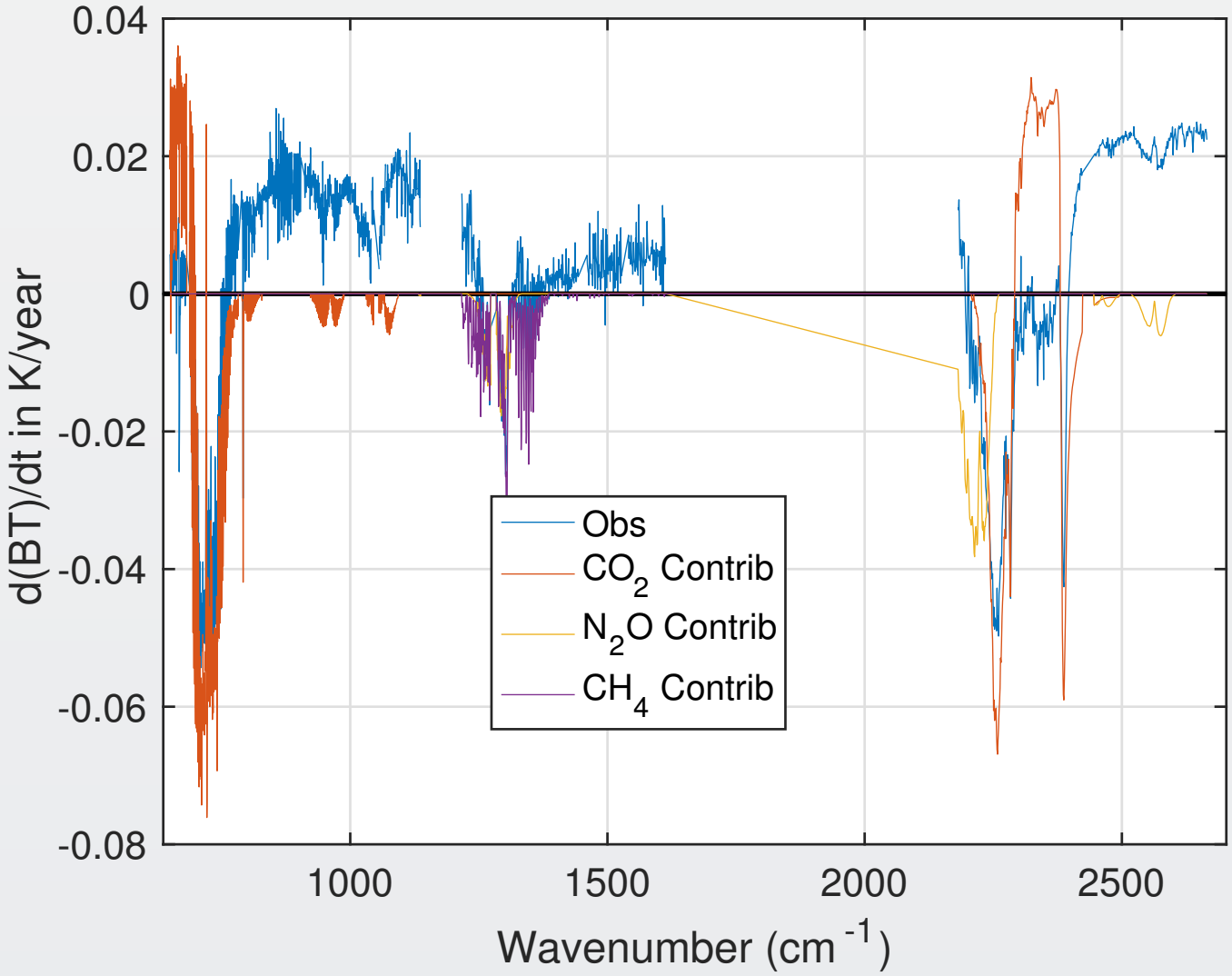
Motivation

AIRS 14-Year Global L1c BT Trends (Unc: ~ 0.003K/year)



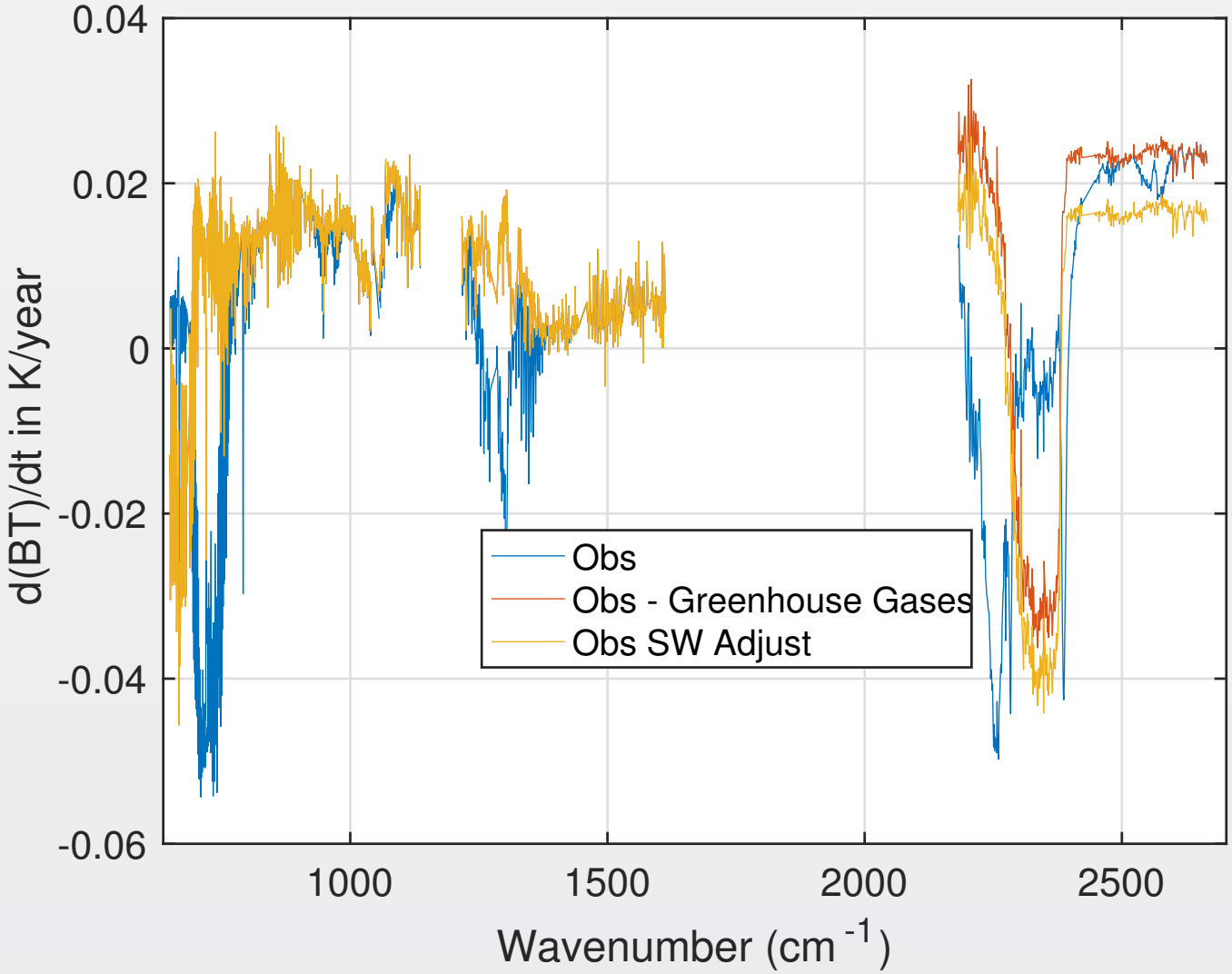
Effects of Greenhouse Gases on 14-Year Trends

Long term greenhouse gas trends can be removed using in-situ data.



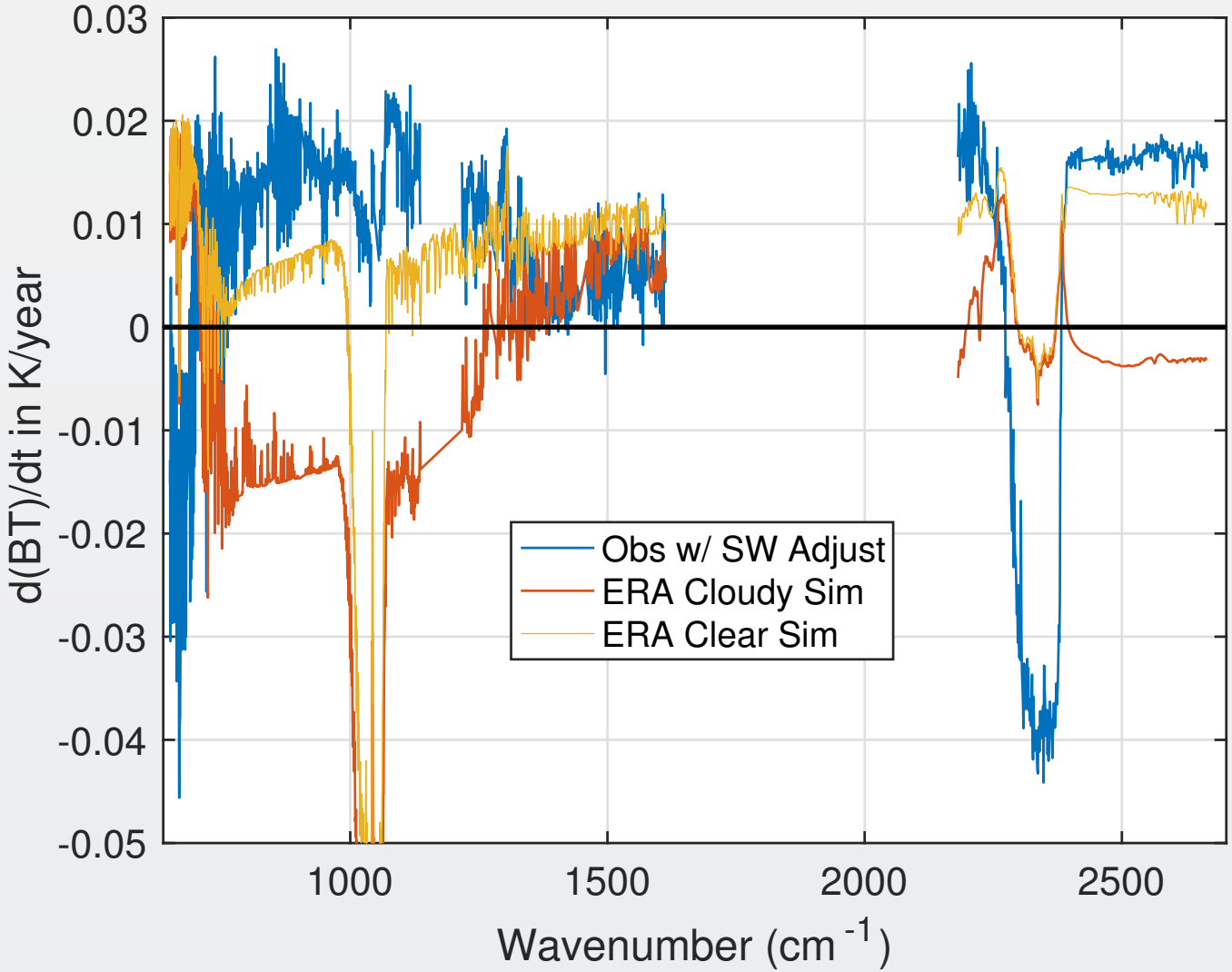
14-Year Trends after Removal of Greenhouse Gases

Surface and LW Trop. Atmospheric Trends ~ +0.01K/year



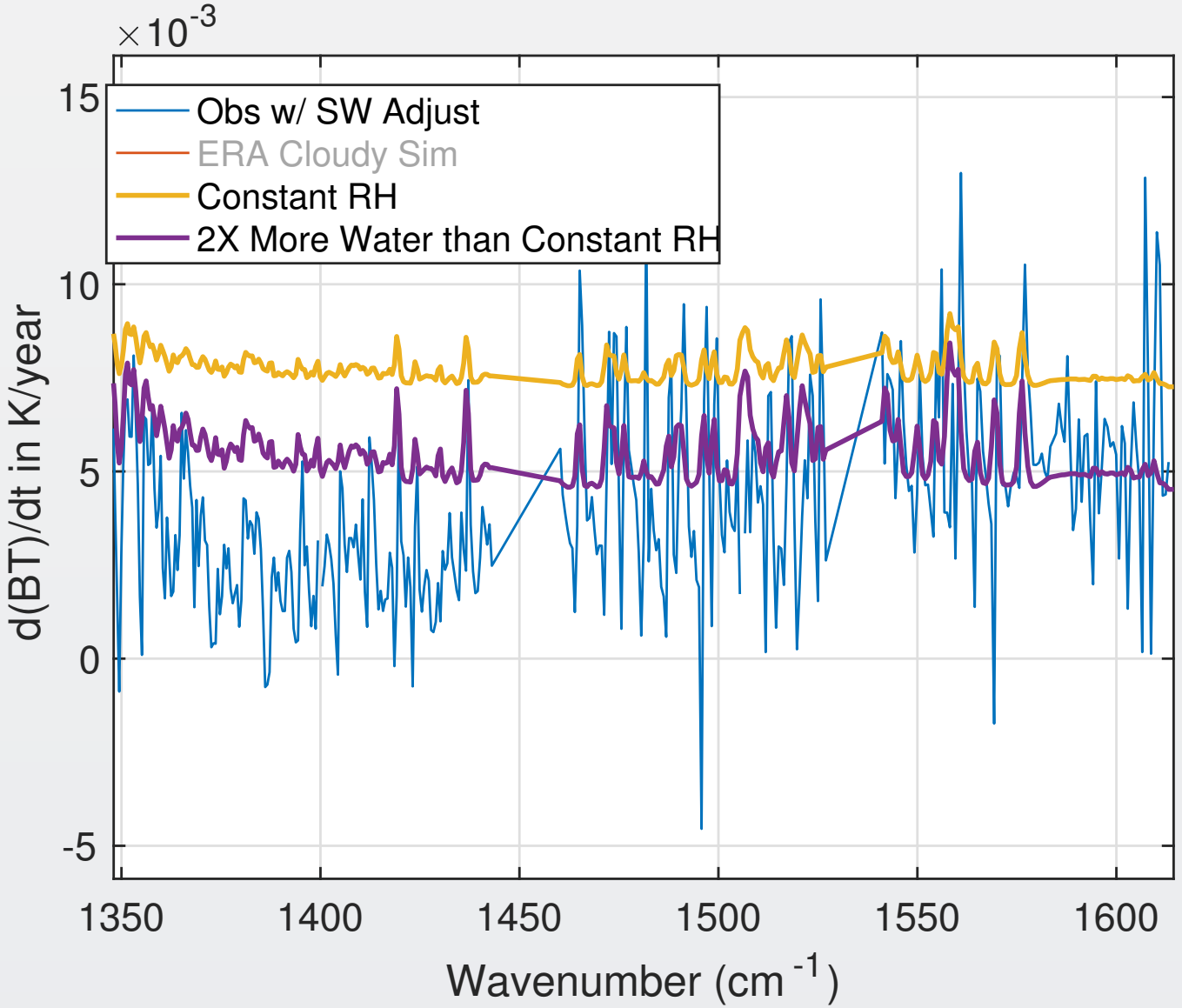
(SW adjusted using clear-scene SST comparisons.)

14-Year Trends Compared to ERA



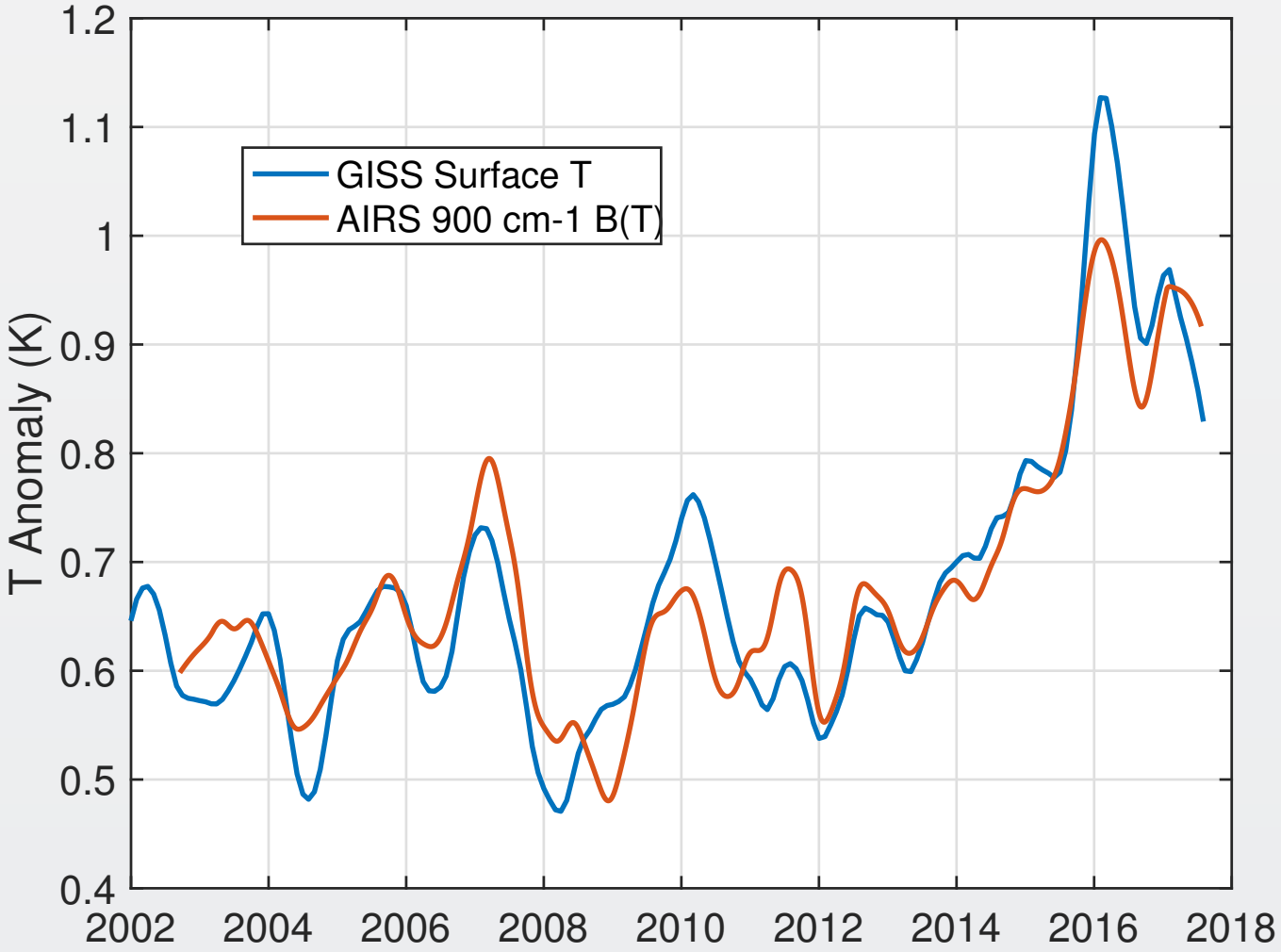
ERA cloud trends too large. ERA cannot tune upper strat for CO_2 variability?? Or, is upper strat CO_2 different?

Will Relative Humidity Change With Global Warming?



This is a key climate question suitable for AIRS + CrIS

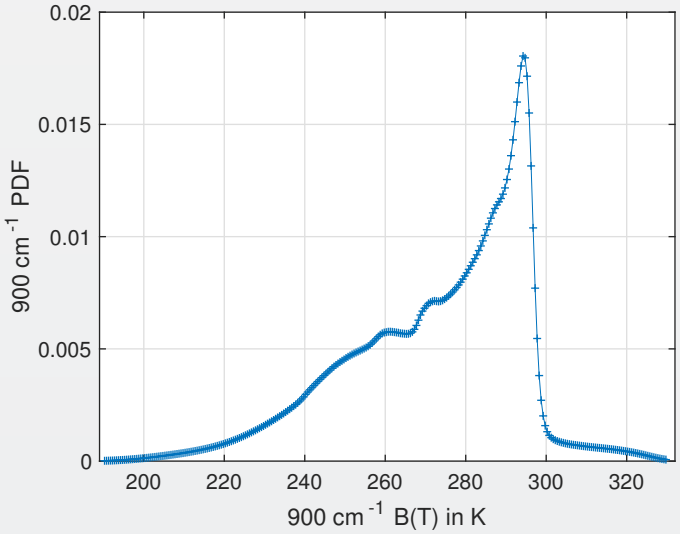
GISS vs AIRS 900 cm^{-1} B(T) Anomalies



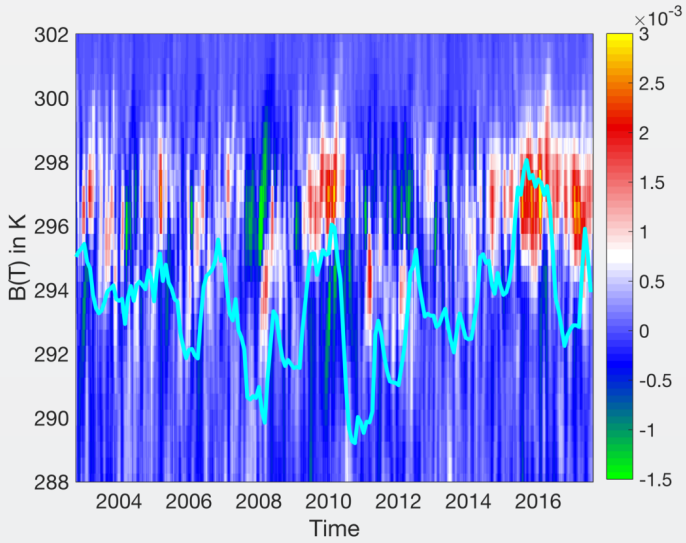
Changes in clouds are small (can be proven over ocean) so window channels track surface stations.

Recent Warming Not Related to ENSO

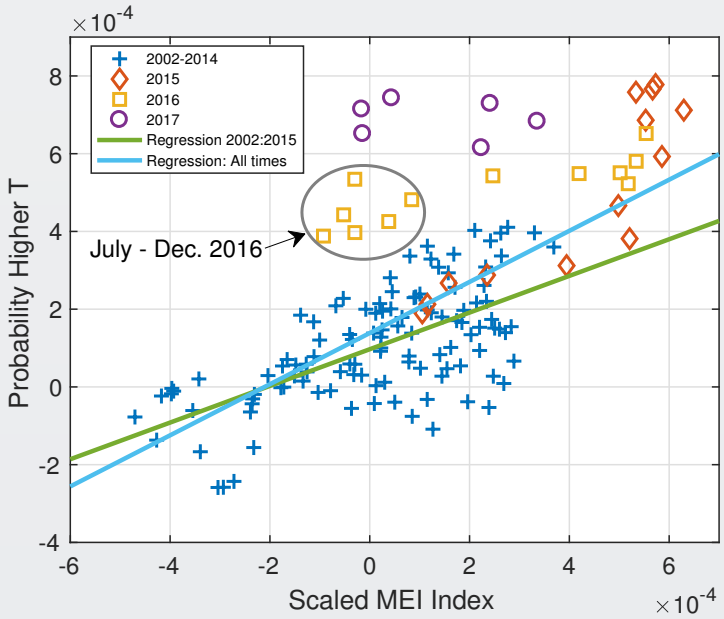
Global 900 cm^{-1} PDF



Warmer Scene PDF Anomalies



Warming vs ENSO (MEI index)



- This appoach minimizes clouds (more is possible)
- Provides simple analysis with high certainties

Differences and Similarities Between AIRS and CrIS Radiances

Intercalibration Issues

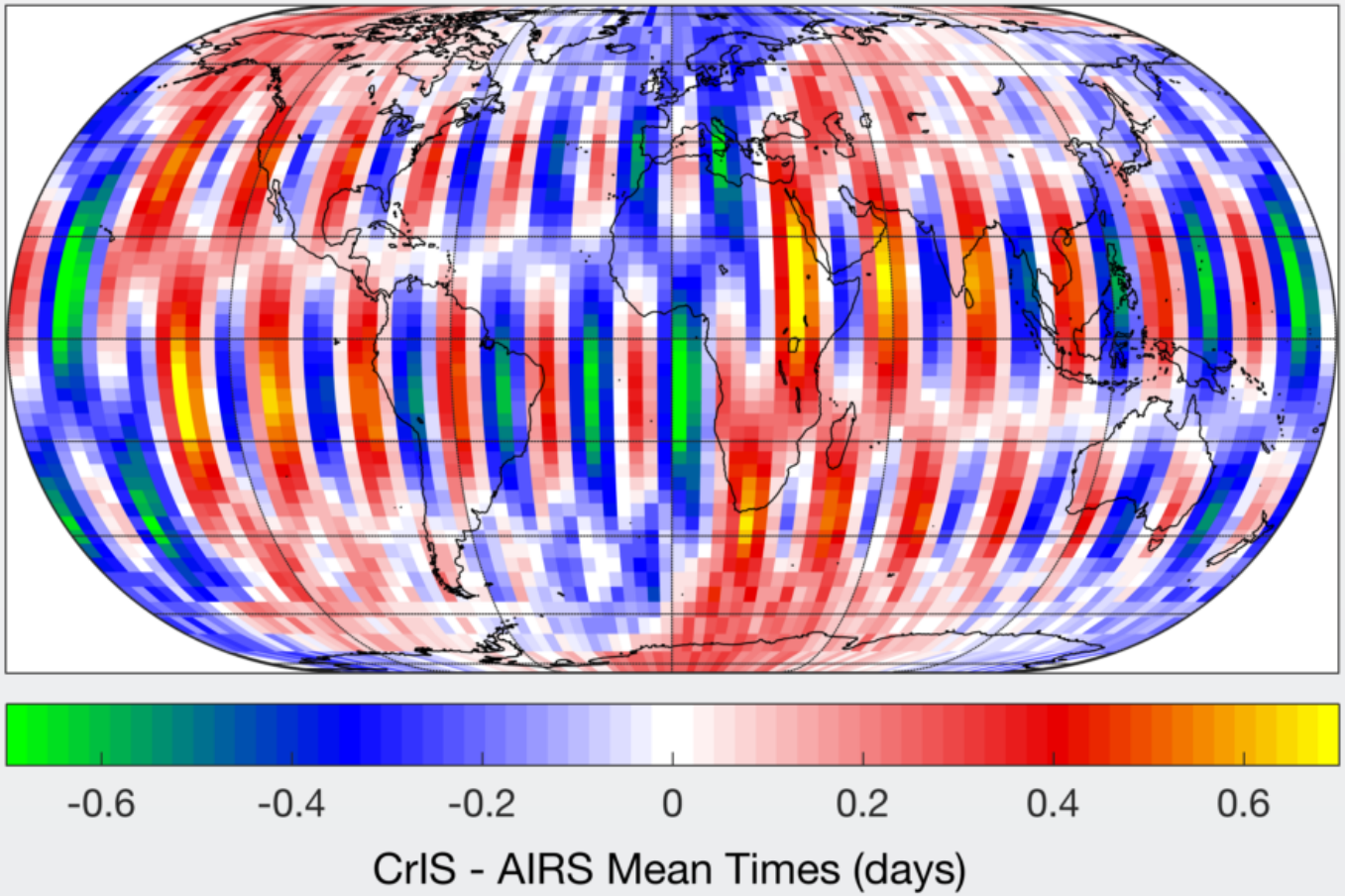
Approaches

- SNOs
- Statistical comparisons of radiances

Previous Issues

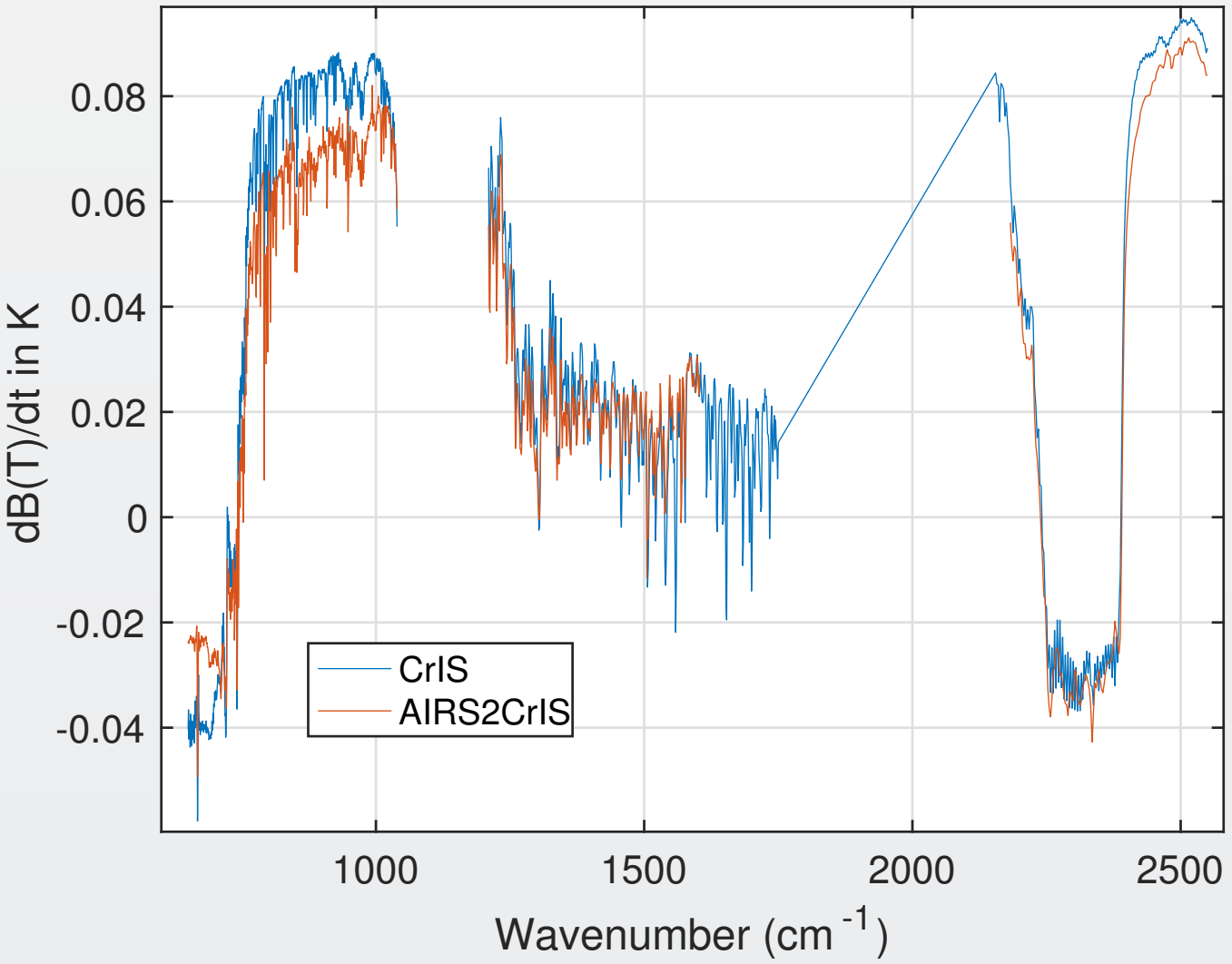
- UMBC and JPL used "AIRXBCAL" like data: random nadir subsets
- These do not provide good enough sampling for statistical intercomparisons (mostly due to time differences in scene sampling)
- *This Work:* CrIS Q/A based on imaginary radiance values too severe, we only limit min radiance (3 values for LW/MW/SW)
- *This Work:* Full all-scan sampling (every scene, yearly statistics!)

Full Sampling Time Differences between AIRS and SNPP-CrIS



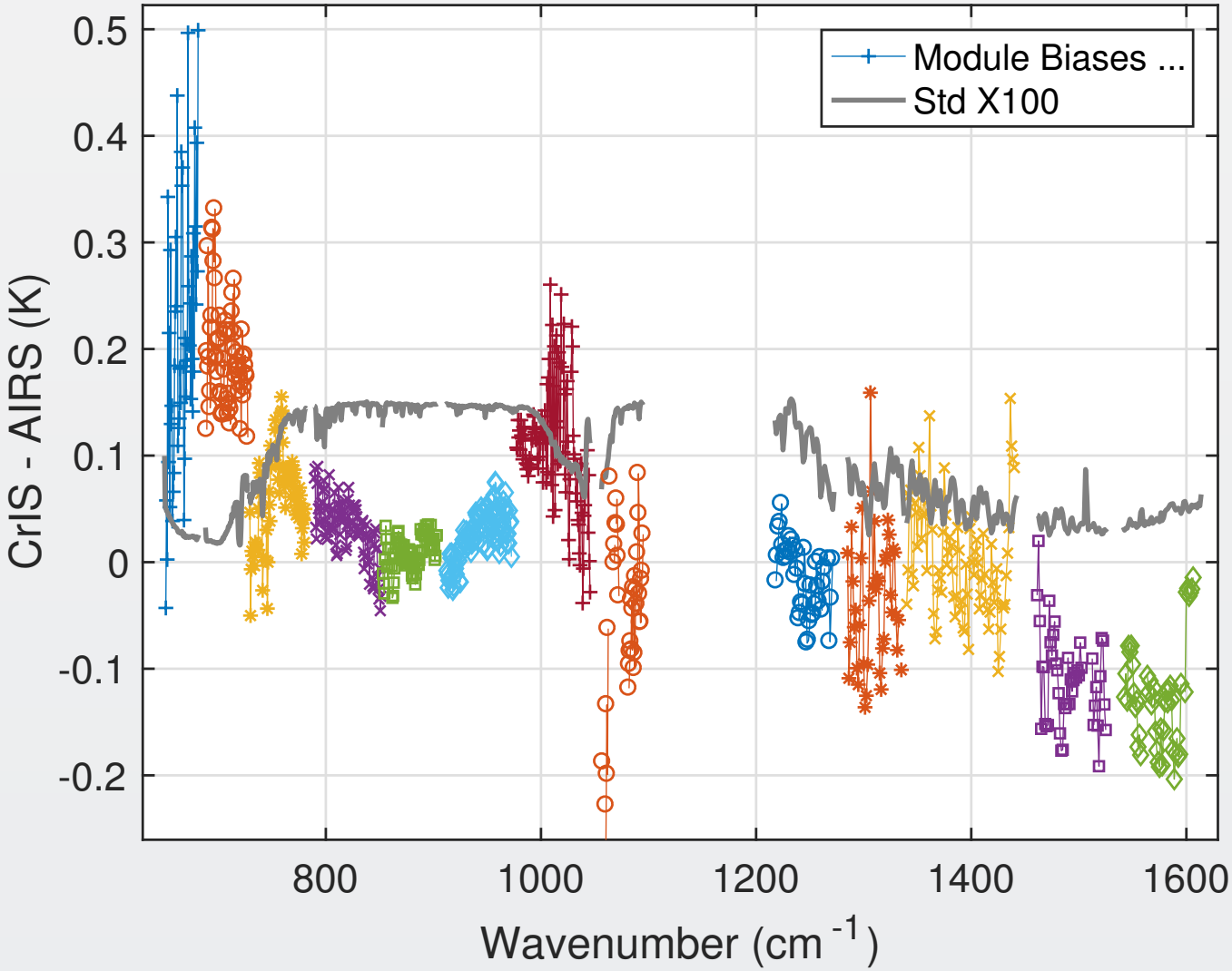
Mean global time difference is zero. Zonal averages near zero.
Importance for retrieval products is uncertain, likely small?

AIRS vs CrIS 5-year rates: Both are Stable



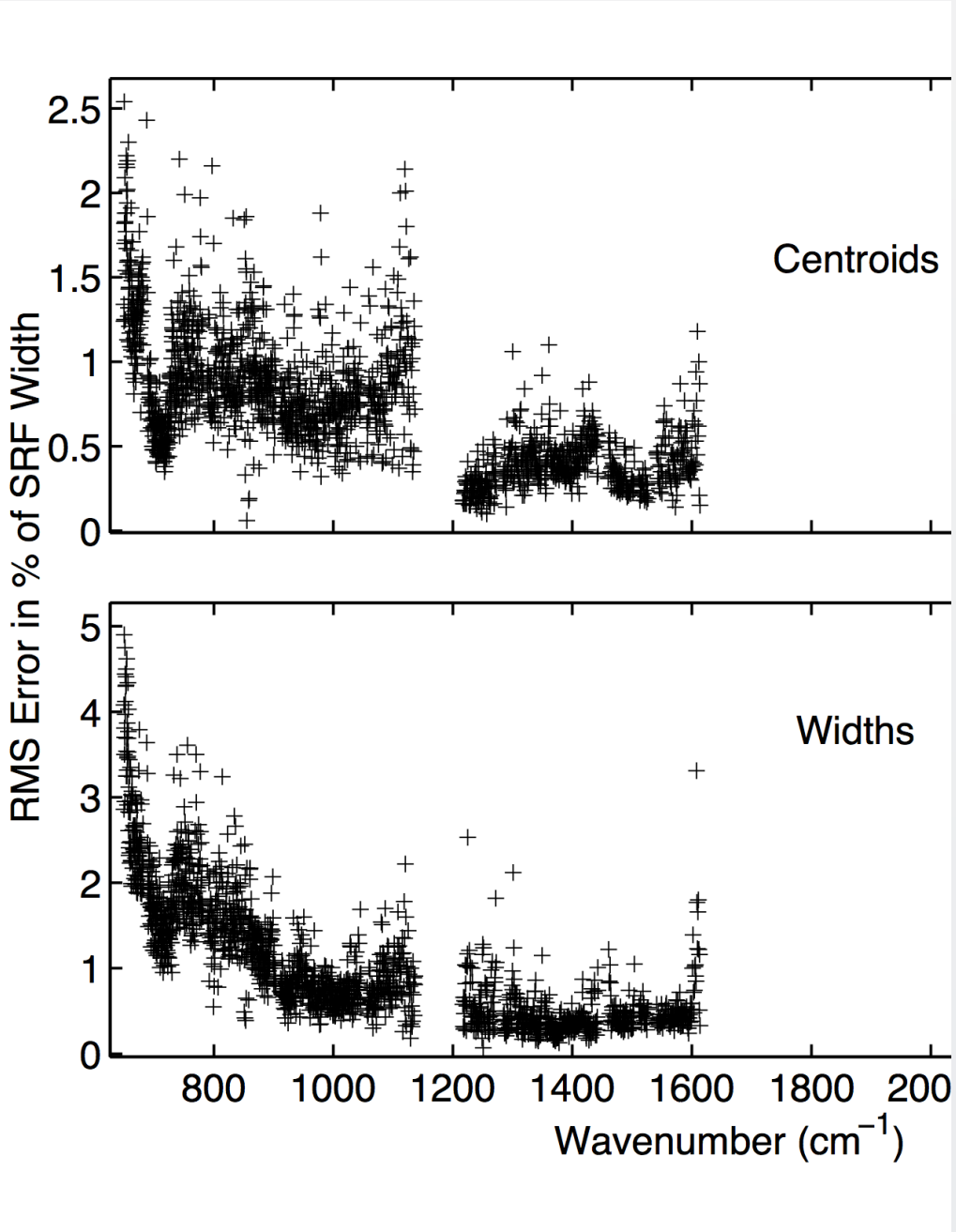
Differences are far below statistical uncertainties. Example of AIRS2CrIS.

SNO differences by AIRS Module (1-Year of SNOs)

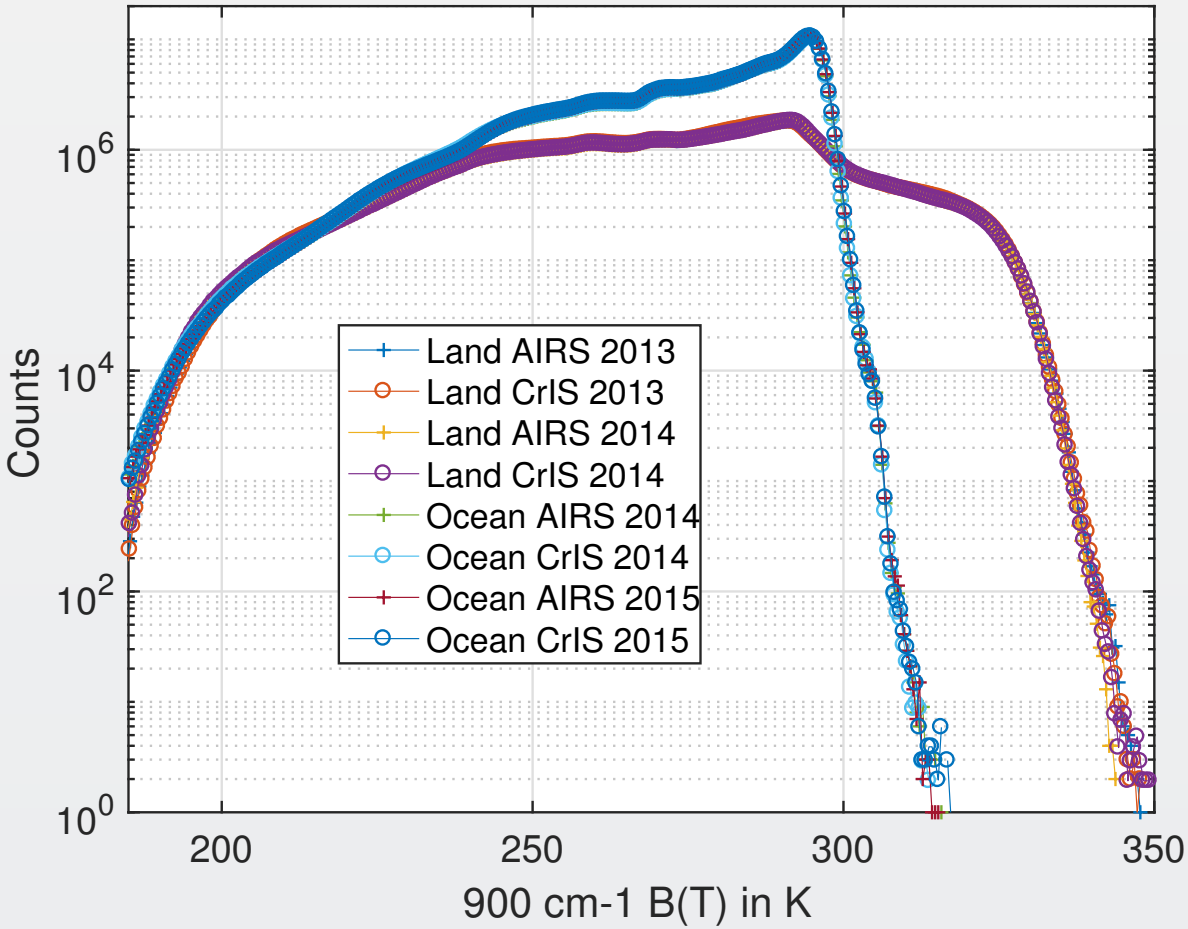


AIRS2CrIS shown. Statistical errors very small. Small scale variability likely AIRS ILS uncertainties!

Use SNOs to Improve AIRS Longwave ILS?

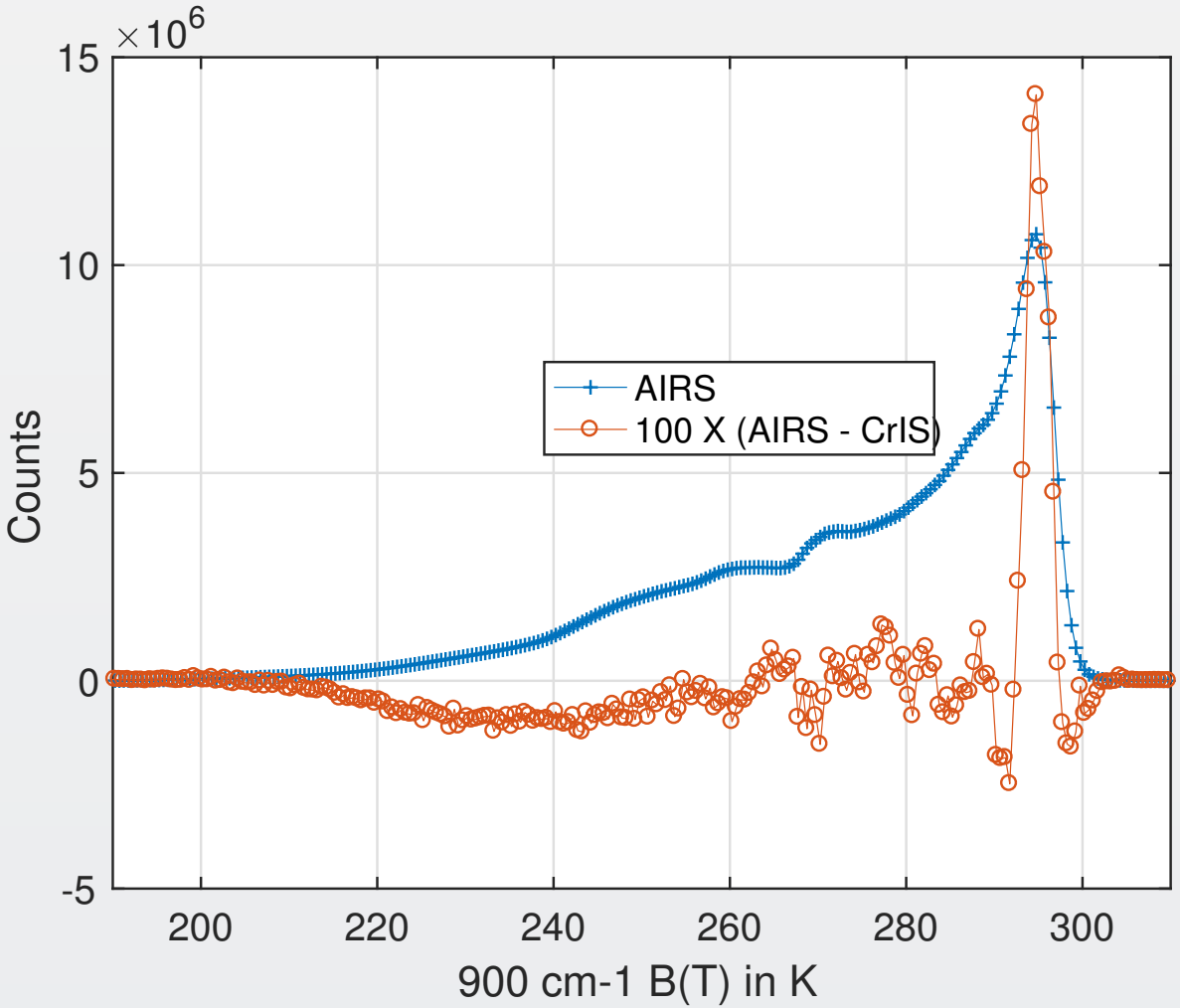


Longwave Count Histograms (700 Million per Year)



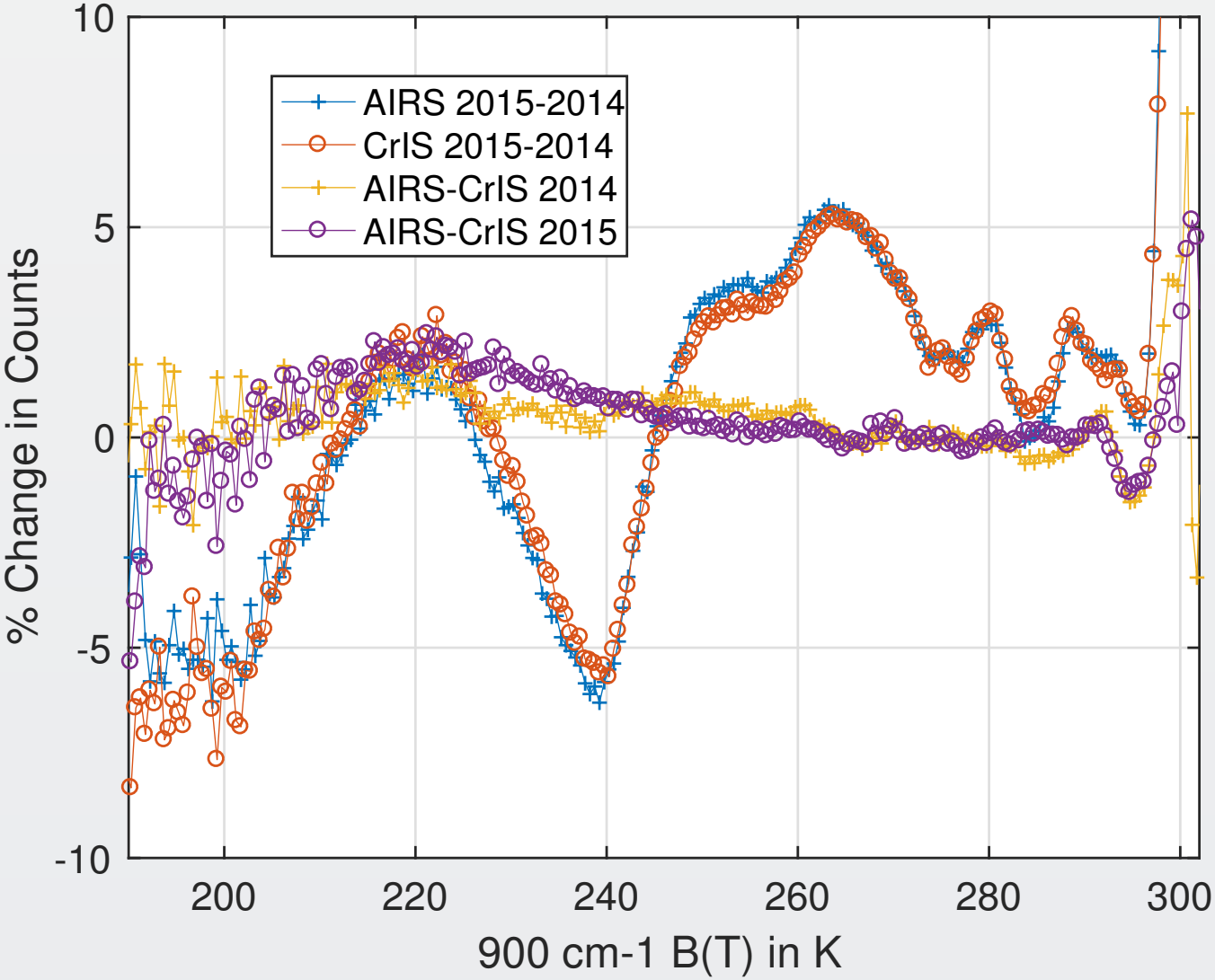
Not land counts only agree with change in CrIS Q/C

Longwave Ocean Count Differences (due to spatial diffs?)

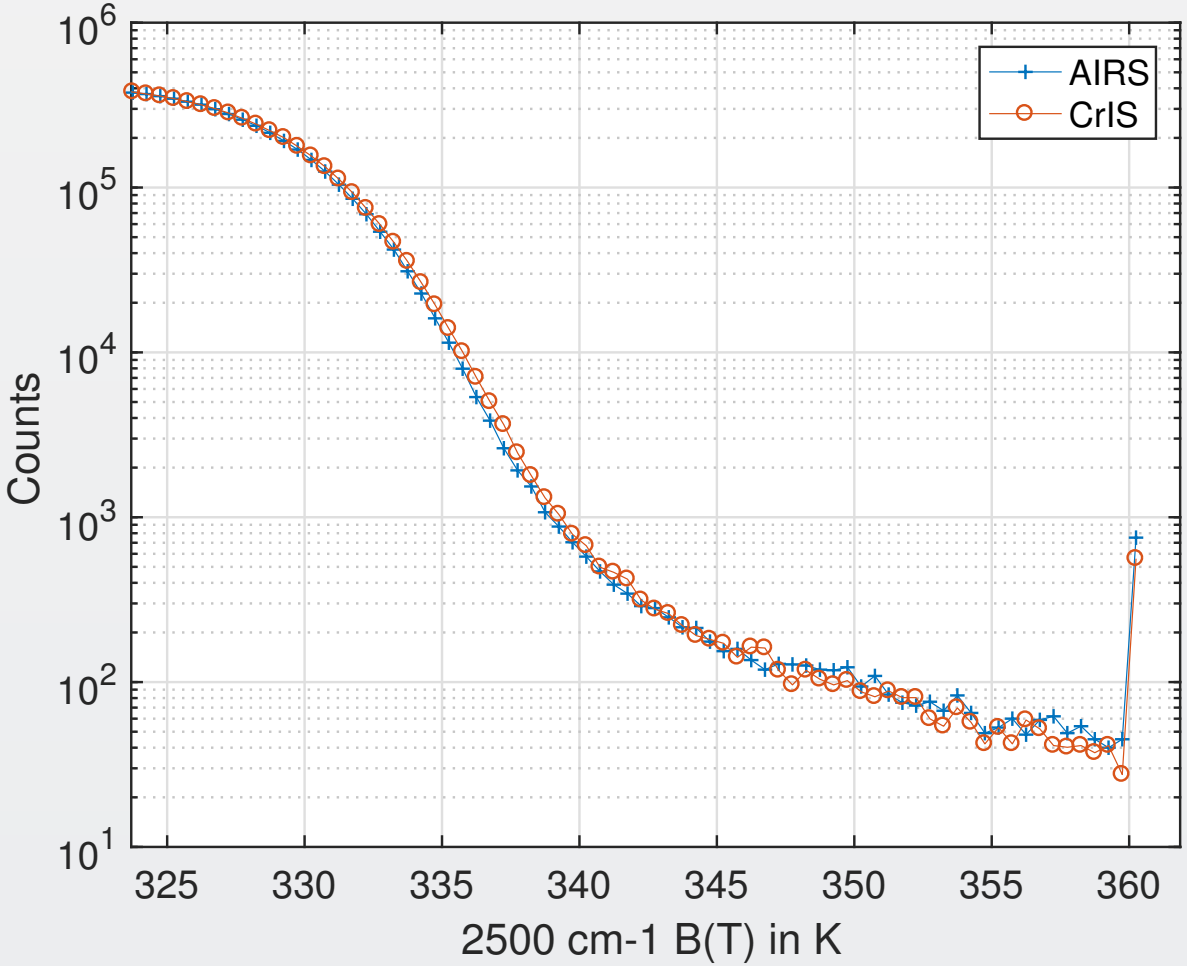


AIRS FOV is slightly smeared relative to the CrIS FOV.

Longwave Counts Vary More with Year than Between Instruments



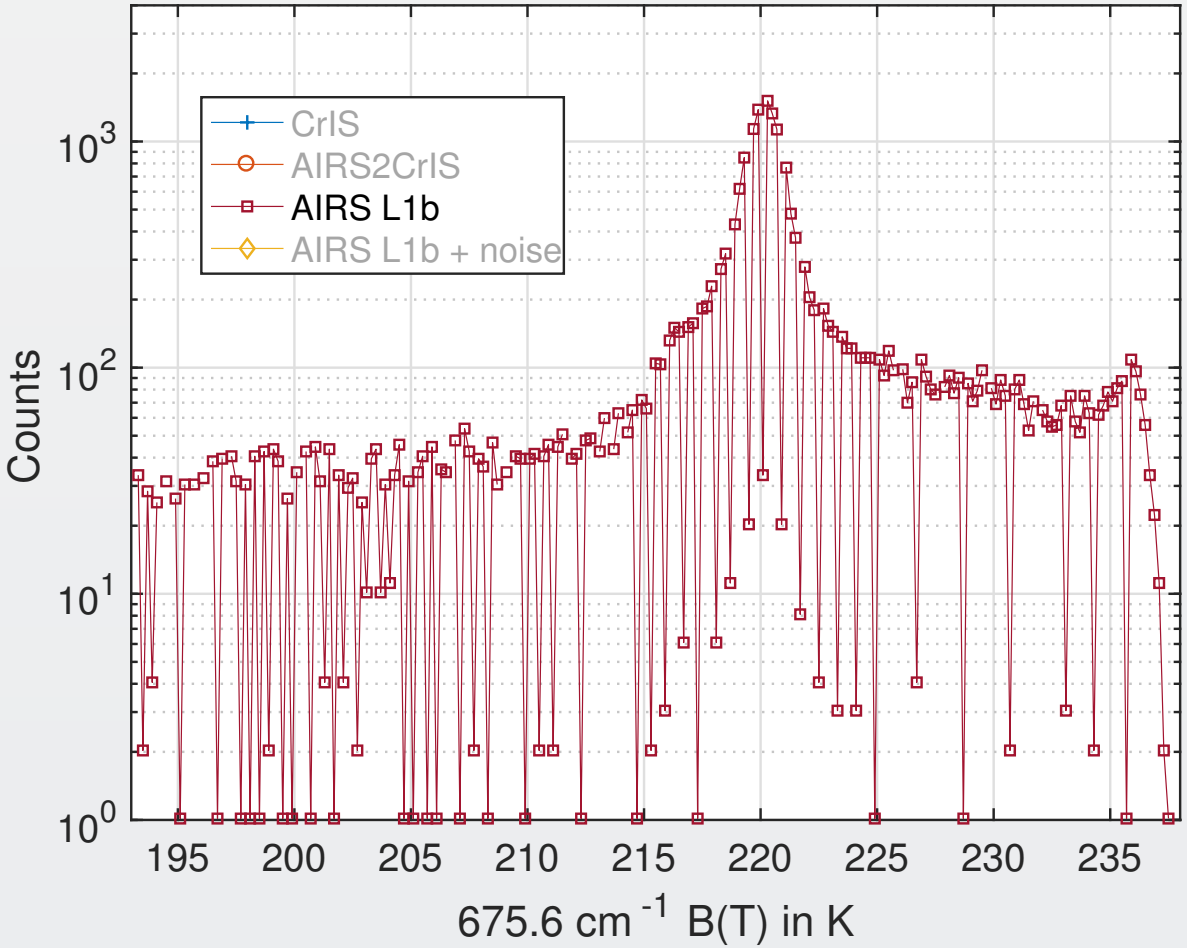
Hot Scene Shortwave Histograms (solar reflection off clouds)



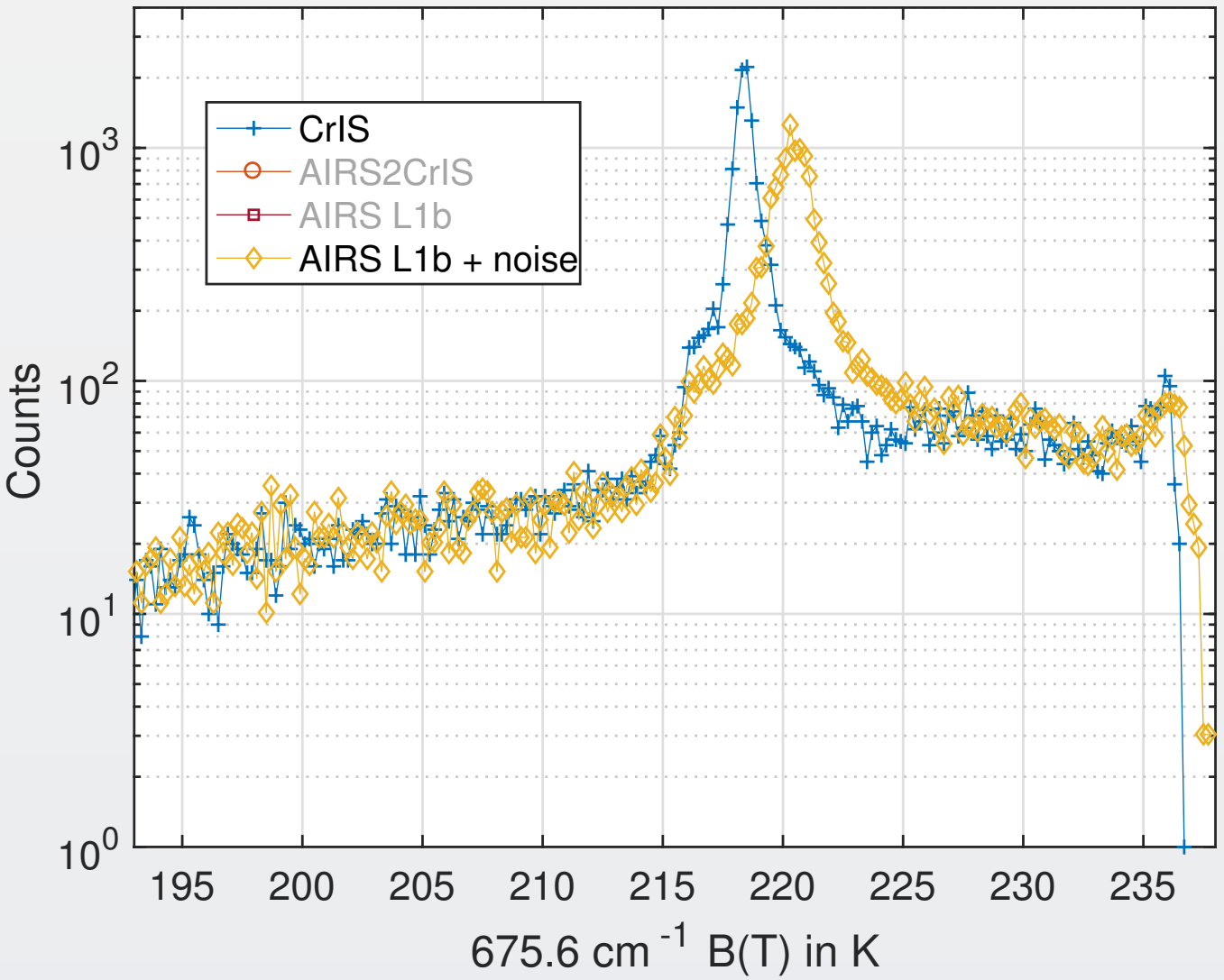
CrIS stopped far below max before change in CrIS Q/C. This is a remarkable result!

Do AIRS2CrIS and CrIS Have Simiar Count Spectra?

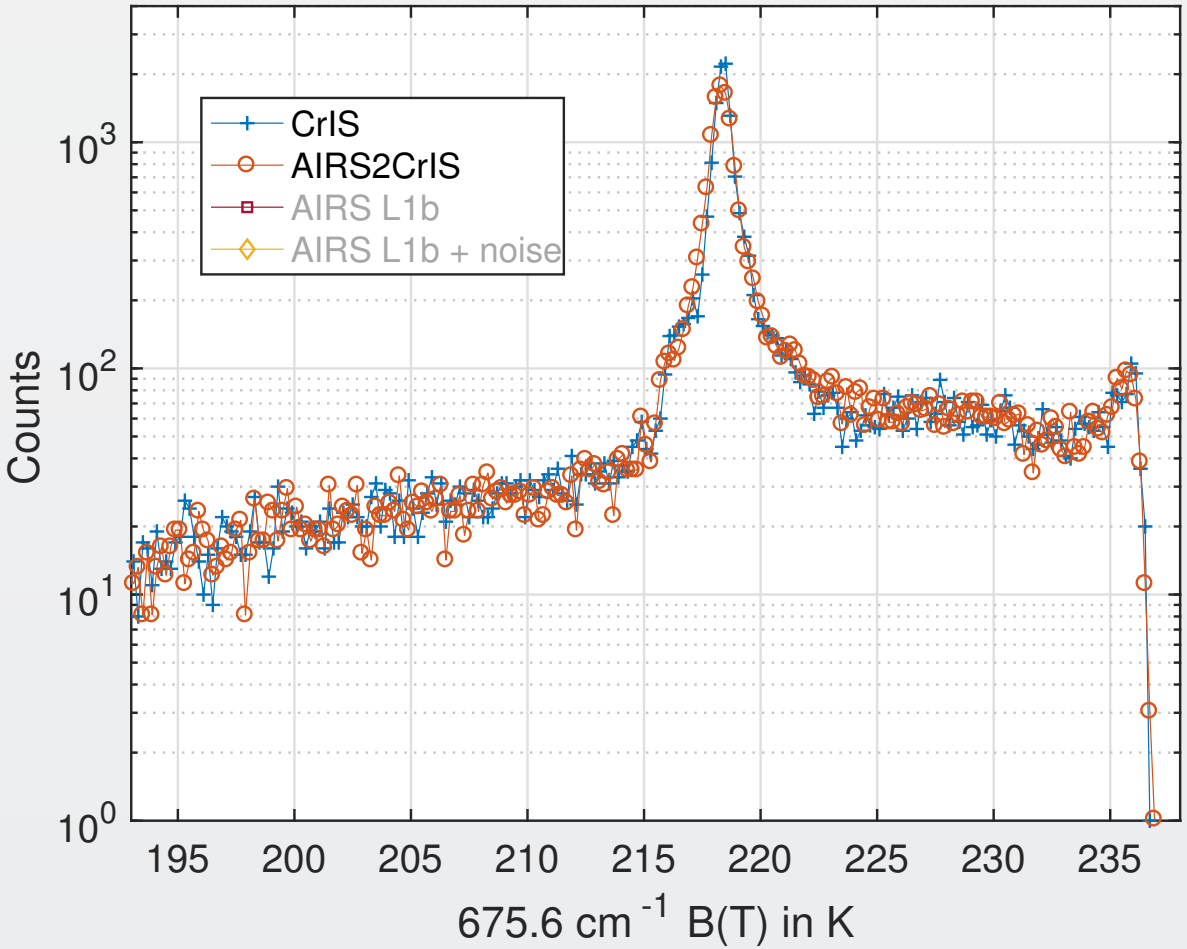
Random Sampled AIRS L1c and AIRS2CrIS for 1 Day



Add Noise to AIRS (L1b/c radiances are rounded)



Now Compare CrIS counts to AIRS2CrIS



Very similar, note how sharp drop in AIRS hot wing now agrees with CrIS.

Conclusions

UMBC: Next Steps

- Test climate level trends and anomalies between AIRS and AIRS2CrIS
  - Create 10-year AIRS T/Q trends based on radiance trends
  - Create 5-year AIRS + 5-Year CrIS radiance product and then compare T/Q trends from this product to the AIRS-only product
- Spectral calibration of AIRS L1c so variable ν RTA is not needed

Sounder SIPS and Science Team

- Consider using AIRS2CrIS?
- Should simplify retrieval system, not unimportant in time of diminishing funds
- Will allow us to produce a combined, homogenous radiance record for future research
- AIRS2CrIS is the only way I know to easily remove radiometric calibration differences between AIRS and CrIS. We should not just "eat" this difference and plow ahead.