A Proposed AIRS+CrIS Radiance Product for Long-Term Continuity

AIRS Science Team Meeting

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Overview

Themes:

- Seamless (as possible) transition from AIRS to CrIS for sounding products
- Put new emphasis on routine/fast processing of data subsets for validation and Level 3
- Alternative products for climate research (ROSES)
- Need top-down requirements on retrieval system with priorities clearly stated.

Goals:

- Radiance data set that can support climate level trending that spans instruments (our ROSES proposal)
- Fix retrieval liens "up-front" if possible
- Create data sets that can be easily used by others
- Re-think product development in an era of declining resources.

AIRS, CrIS Differences

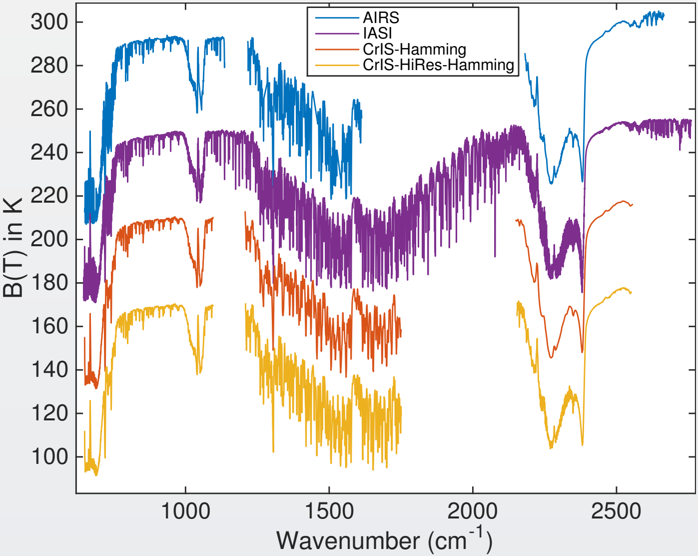
- Instrument Line Shape (ILS):
  - CrIS: sinc
  - AIRS: 2378 ILS's, about 75% in good shape
- Footprints: roughly similar, some small issues
- Orbits: sampling almost identical (later)
- Noise: nominally similar
- Calibration (later)

ILS Differences

- Large in B(T)
- Existing approach: Retrievals use different forward models
- Cannot inter-calibrate AIRS and CrIS with different ILS functions!
- A hyperspectral radiance climatology requires same ILS between instruments

Our approach: Convert AIRS to the CrIS ILS

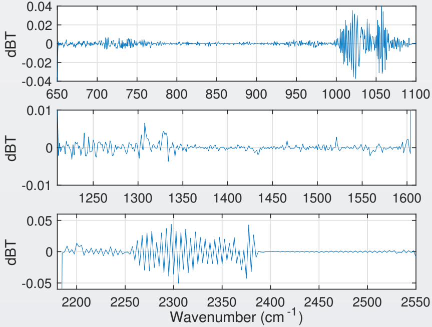
Spectral Differences Among AIRS, CrIS, IASI



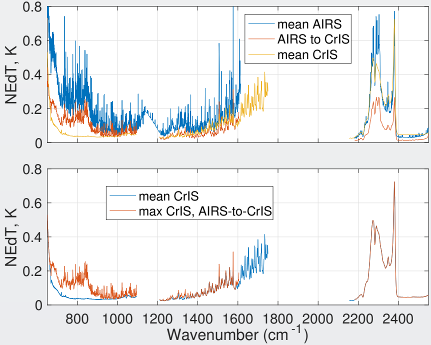
AIRS2CrIS Algorithm

- Simple deconvolution to 0.1 cm^{-1} grid
- $S_a r = r_A$, $r_o = S_a^{-1} r_A$ using Moore-Penrose pseudoinverse
- $r_{A2C} = S_c \circledast r_o$
- Small additional terms using linear regression (mostly bias)
- Errors below assume AIRS ILS functions are perfect

AIRS2CrIS Mean Error (std. similar)



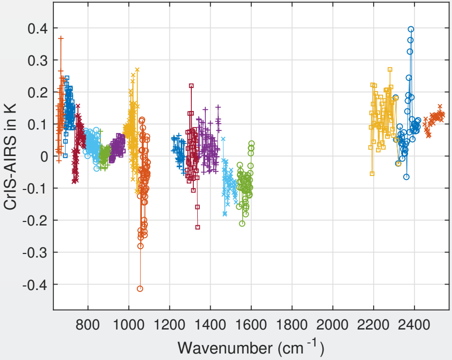
AIRS2CrIS Noise



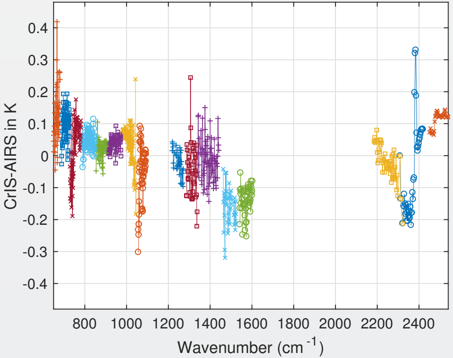
Shortwave sounding region max noise dominated by CrIS

SNPP versus AIRS

2016 SNOs



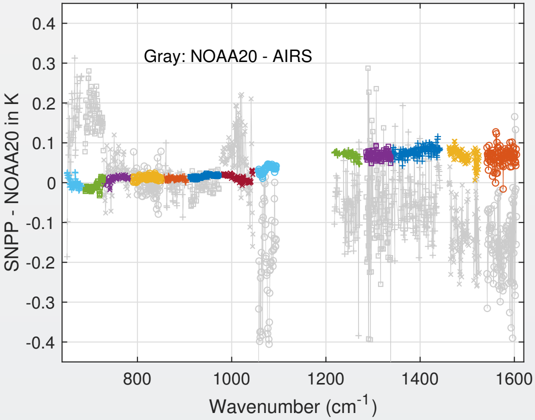
2016 Random Comparisons



Sources for Differences

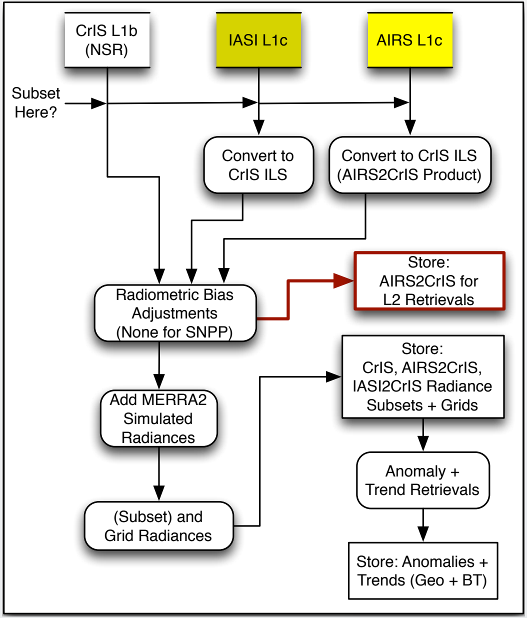
- Differential calibration AIRS modules
- AIRS SRFs (widths and centroids)
- Non-linearity: CrIS, AIRS?
- etc.

SNPP vs NOAA20 CrIS (via AIRS Snos)



- *Preliminary*, NOAA20 CrIS non-linearity will be updated in July 2018
- Connecting CrIS instruments together will be easier!
- So far spatial, spectral, and sampling among CrIS instruments will be identical

Data Processing Flow



Anomaly and Trend Approach

Linear solution for trends with a-priori state = 0 given by,

$$\frac{dx}{dt} = \left(K^T S_\epsilon^{-1} K + R^{-1}\right)^{-1} \left(K^T S_\epsilon^{-1} \frac{dBT}{dt}\right)$$

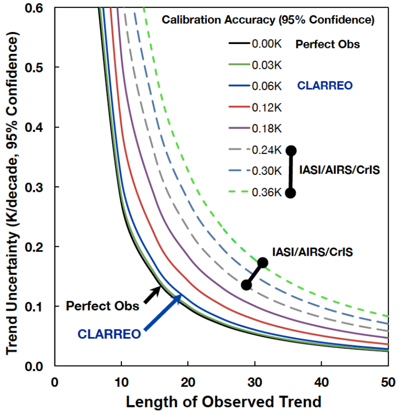
- x is the atmospheric state
- K are the B(T) Jacobians
- S_ϵ is the observation error covariance matrix.
- R combines empirical regularization (Tikonov L1-type) and the *a-priori* covariance-based terms

S_ϵ covariances represent inter-annual variability and instrument stability. Provides signficiant constraints compared to L3 time derivatives.

Jacobian state from standard all-sky retrievals or from re-analysis; high accuracy not needed.

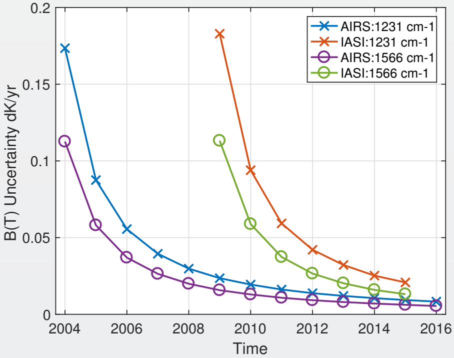
Time Series Length Nearing Climate Scales

CLARREO Schematic: Our Uncertainty?



AIRS, CrIS, IASI are *all* very stable

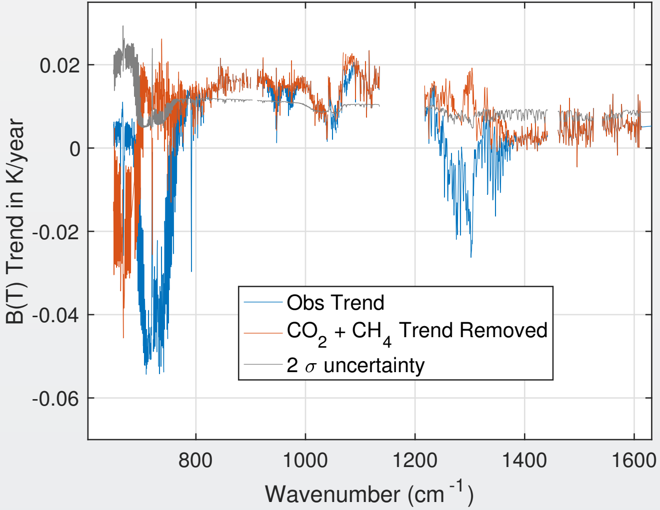
AIRS 14-Year global trends



These are 2-σ B(T) statistical uncertainties due to inter-annual variability.

Some channels, some latitudes not gaussian (strat sudden warmings, QBO, etc.)

Global B(T) Trend (hardest case)



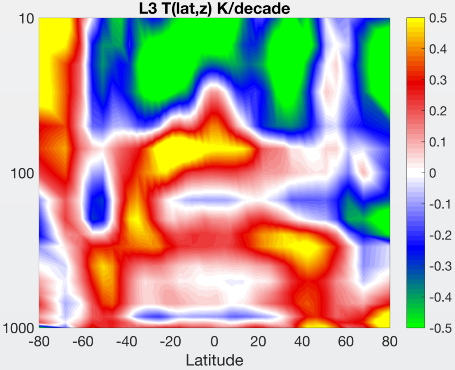
Uncertain on fit vs specify CO_2, CH_4 etc. trends. We have done both.

Specifying OK for long-term trends.

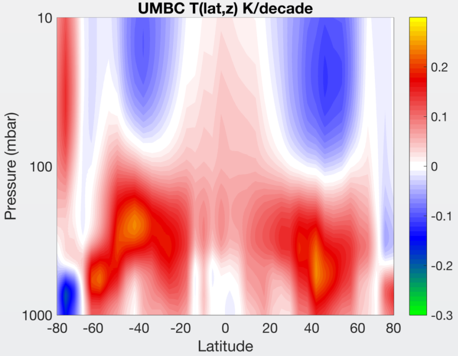
Example: 14-Year Zonal Temperature Trends

NOTE larger color scale on left.

From Level 3



From Radiance Derivatives

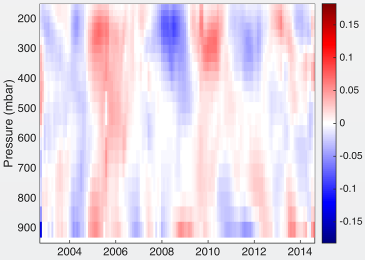


Interannual variability (observation covariance) regularizes OE solution.

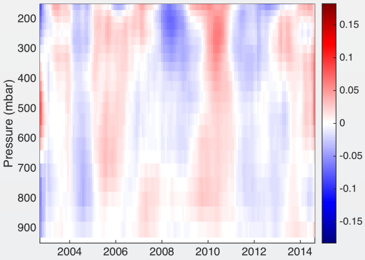
Need to work on off-diagonal obs covariances to get uncertainties right.

Anomaly Example: Water Vapor (27N to 30N Latitude Zonal)

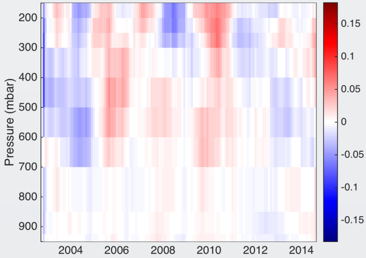
From radiance anomaly



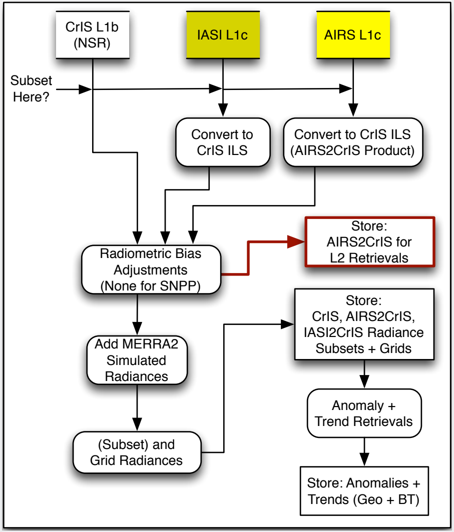
ERA × Avg Kernel



AIRS Level 3



Flow (implementation issues)



- Need L1c at the DAAC!
- How supply IASI L1c?
- AIRS2CrIS: 3 hours/day, all scenes; store or on-the-fly?
- Assume MERRA2 at the DAAC
- Start with zonal
- Then move to gridded products
- TBD
    - Zonal, grid sizes (fill from subset or full mission?)
    - Subset sizes
- Red Box: Use AIRS2CrIS for Level 2 record?

AIRS2CrIS for Level 2 Retrievals? (Summary)

- Continuity requires adjusting for satellite differences
  - Spectral (about 1000 channels remain)
  - Radiometric
  - Algorithm (RTA)
  - Sampling
- Most can be addressed with AIRS2CrIS
  - Sampling a problem for cloud-clearing (CC)
  - CrIS tighter FOV results in higher CC yield, effect?
  - DOFs not that different with CrIS NSR vs FSR
  - Single RTA, almost identical retrieval algorithm! Less work!
- Problems
  - De-emphasize the short wave due to drifts, CrIS/IASI noise
  - Note Saunders EUMETSAT slide (Joao's talk). CrIS NSR placing slightly higher than AIRS at UKMO.
  - Some minor gases better with native resolution (different processing?)
  - New and different
- Approach
  - Initial testing with C. Barnet
  - *Start with subsets for quick full-mission processing and L3 creation*
    - Need to reprocess often to understand climate-level behavior of the system
  - Differential CC yield goes away with single-footprint retrieval
  - I hope we have a new set of users in the next 10 years looking at climate, we need to new approaches to be ready?

AIRS2CrIS for Level 2 Retrievals? Issues

Continuity requires adjusting for satellite differences

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AIRS2CrIS for Level 2 Retrievals? Approach

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