AIRS/CrIS Radiance Inter-Calibration: Tests of Trends Using Time Series Combining Both Sensors

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Overview

- A Hyperspectral IR climate record depends on sensor continuity
- Spectral : AIRS, CrIS, IASI SRFs/ILS Very Different
- Radiometric : Differences in the 0.3K or less range, great starting point.
- Spatial : AIRS footprint slightly smeared relative to CrIS, slight impact on extrema.
- Sampling : AIRS/CrIS sample the globe at slightly different times and atmospheric paths. Strategies to mitigate exist.
- We examine radiometric differences between AIRS and SNPP/NOAA20 CrIS, using both SNOs and statistical sampling.
Spectral Considerations

- Convert AIRS to the CrIS ILS/SRF. Presently using NSR, will switch in future to something close to 0.8/0.6/0.4 OPD “CrIS Hybrid”, or “CHIRP”
- Need AIRS L1c (at the DAAC) for production of AIRS2CrIS products.
- Conversion of IASI2CrIS is essentially trivial since IASI L1c gaussian apodization is far from zero at 0.8 cm path difference, so conversion to 0.8 sinc ILS is robust.
Radiometric Considerations

- AIRS CrIS SNO’s global, but heavily weighted to high latitudes
- At minimum, we want best statistical match between sensors. We use equal-area weighted set (1% of 2016 scenes) sampled over all scan angles.
- All scan angle required to keep AIRS and CrIS mean sampling times as close as possible.
- AIRS and CrIS have slightly different mean scan (secant) angles. Easy to correct AIRS to CrIS mean secant, magnitude \( \sim 0.2K \)
- We get very good agreement between SNOs and statistical comparisons, giving us some confidence that the instrument differences are not too scene dependent.
Example of One Month of AIRS:CrIS SNOs: Maps

- **Delay AIRS-CrIS mins**
  - Color bar: -100 to 100
  - X-axis: Longitude [deg] from -100 to 100
  - Y-axis: Latitude [deg] from -50 to 50

- **Separation deg**
  - Color bar: 0 to 0.06
  - X-axis: Longitude [deg] from -100 to 100
  - Y-axis: Latitude [deg] from -5 to 5

- **CrIS BT (K)**
  - Color bar: 200 to 320
  - X-axis: Longitude [deg] from -100 to 100
  - Y-axis: Latitude [deg] from -50 to 50

- **SNO Bias AIRS minus CrIS (K)**
  - Color bar: 900 cm⁻¹ dBT (K)
  - X-axis: Longitude [deg] from -100 to 100
  - Y-axis: Latitude [deg] from -5 to 5
  - Color bar: 0 to 10

Example of One Month of AIRS:CrIS SNOs: Bias

- CrIS minus AIRS (K)
- CclS minus AIRS
- dBT (K)

Wavenumber cm$^{-1}$

C minus A rel. FOV 5
- AIRS is used as a cross-calibration transfer standard since no SNOs between SNPP and NOAA20
- CrIS and AIRS calibrations still being worked by respective teams
NPP.CrIS and N20.CrIS Differences by FOV (via AIRS)

Bad AIRS channels past 1500 wavenumbers not masked out...
NPP.CrIS and N20.CrIS Differences by FOV (via IASI)

Very similar to differences using AIRS (previous slide)
SNOs and random comparisons are in good agreement.
Statistical comparisons are corrected larger mean secant viewing angle of CrIS
Multi-year Mission Overlap Permits Bias Trending

**CrIS vs AIRS**

- Time series of BT (K) with overlapping data points for 2013 to 2018.
- Difference in BT (K) (dBT) shown below the BT data.

**CrIS vs IASI**

- Similar data series as CrIS vs AIRS, showing BT (K) and dBT (K) over the same time period.
A "CHIRP" Time Series Test

- Need to connect AIRS to CrIS for long-term hyperspectral sounder time series
- We are proposing “CHIRP”, where AIRS is converted to some form of the CrIS ILS (0.8/0.6/0.4 OPD).
- Here we do a simple first test: (using CrIS NSR ILS)
  - Create a 10-year time series with AIRS (converted to CrIS ILS: AIRS2CrIS)
  - Create a 5-year time series with CrIS
  - Radiometrically adjust (bias) AIRS2CrIS to CrIS using a single static global bias offset (see earlier slides)
  - Merge 1st 5-years of AIRS2CrIS with the CrIS 5-year time series to create a CHIRP test time series
  - Intercompare trends from these two time series
- Final time series: AIRS2CrIS is 2007-2012, CrIS is 2012-2017
AIRS/CrIS Hybrid Time Series Trends

![Graph showing AIRS/CrIS Hybrid Time Series Trends](image)

- **AIRS Only 10-years**
- **AIRS 5-years then CrIS 5-years, static BT adjust**
- **AIRS 5-years then CrIS 5-years, no BT adjust**
- **Std of Diff over Lat with static BT Adjust**
- **Mean of Diff over Lat with static BT Adjust**
- **Linear rate uncertainty (interannual variability)**
AIRS/CrIS Hybrid Time Series Trends: Without Adjust

![Graph showing time series trends with various lines indicating different conditions and adjusting methods. The x-axis represents wavenumber in cm⁻¹, and the y-axis represents dB(T)/dt in K/Year. The legend differentiates between AIRS Only 10-years, AIRS 5-years then CrIS 5-years, static BT adjust, AIRS 5-years then CrIS 5-years, no BT adjust, Std of Diff over Lat with static BT Adjust, Mean of Diff over Lat with static BT Adjust, and Linear rate uncertainty (interannual variability).]
AIRS/CrIS Hybrid Time Series Trends: Std/Means over Latitude

![Graph showing dB(T)/dt in K/Year as a function of Wavenumber (cm⁻¹)].

- AIRS Only 10-years
- AIRS 5-years then CrIS 5-years, static BT adjust
- AIRS 5-years then CrIS 5-years, no BT adjust
- Std of Diff over Lat with static BT Adjust
- Mean of Diff over Lat with static BT Adjust
- Linear rate uncertainty (interannual variability)
AIRS/CrIS Hybrid Time Series Trends: Add Interannual-Variability

![Graph showing dB(T)/dt in K/Year vs. Wavenumber (cm⁻¹)]

- AIRS Only 10-years
- AIRS 5-years then CrIS 5-years, static BT adjust
- AIRS 5-years then CrIS 5-years, no BT adjust
- Std of Diff over Lat with static BT Adjust
- Mean of Diff over Lat with static BT Adjust
- Linear rate uncertainty (interannual variability)
Latitude Dependent Trends of 902 cm\(^{-1}\) Window Channel

Note issue in Arctic. Maybe too low sampling (due to equal area?).
Summary

- Radiometric differences are small between all instruments, but large at the climate level.
- We use SNOs and large random (equal area weighted) statistical samples to inter-calibrate (radiometry).
- Instruments all appear very stable, so these differences can be accounted for.
- (If) we have enough overlap (true so far) the uncertainty in instrument differences is /very/ small, maybe <0.03K?
- Over 5-years that is <0.01K.
- Early hybrid ("CHIRP") time series tests are encouraging.