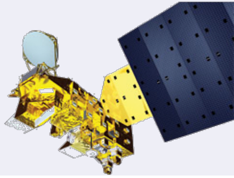

Evaluation of the AIRS and CrIS relative radiometric calibration under cloudy conditions

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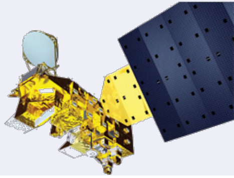
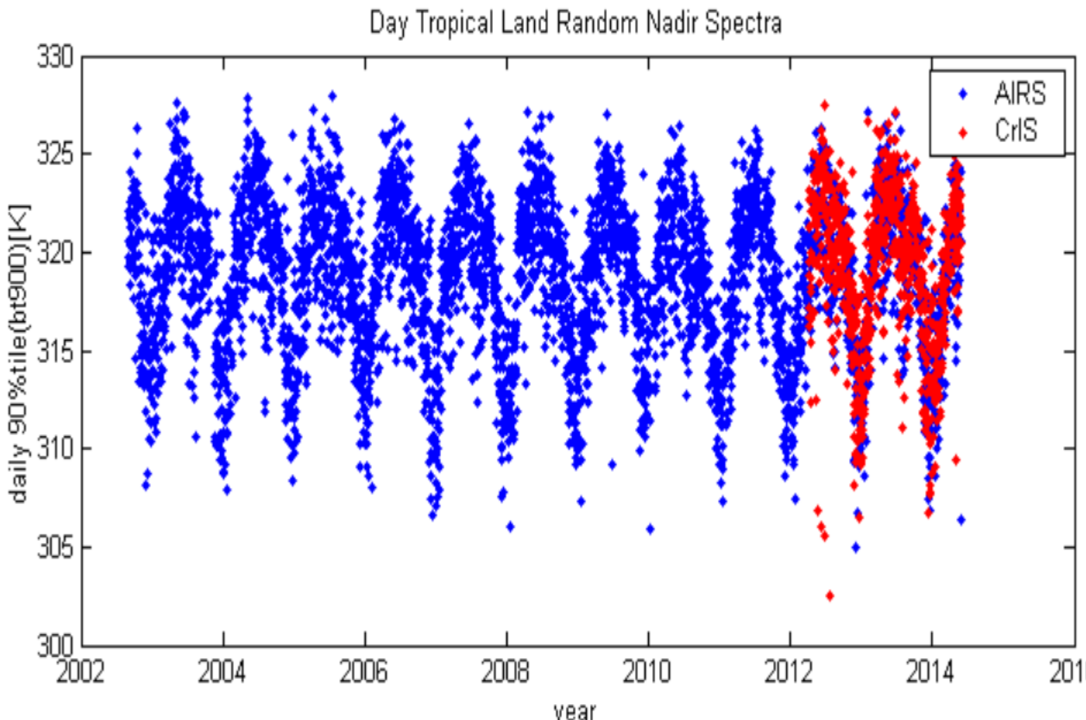


Outline

- Motivation
- Method
- Results
- Discussion
- Conclusions

Motivation

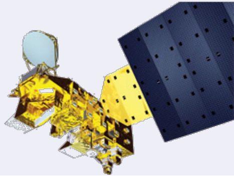
- Climate change is expected to create changes at the 100 mK/decade level.
- The data from many instruments have to be concatenated to form global and regional time series.
- If AIRS were to stop working today, CrIS is expected to continue the climate data record from AIRS.
- How accurately would this record be continued?



How good is the radiometric alignment of the CRIS data (red) with the AIRS data for the two year overlap period?

Note the strong seasonal variability of the AIRS measurements, continued with CrIS.

Challenges



There are several practical problems with making comparisons at the 100 mK level using calibrated radiances.

The comparison has to be carried out for conditions which are representative of the data and the intended subdivision of the data.

Day and night radiometric performance are not assured to be identical (note the GOES midnight sun problem)

The response to scene inhomogeneity (cloudy data) may not be the same as the response under spatially uniform (cloud free) conditions

AIRS and CrIS are in 1:30 PM ascending node obits, with the same footprint size, but:

1) The spectral resolution and spectral sampling are different
2) The data are not spatially or time aligned.

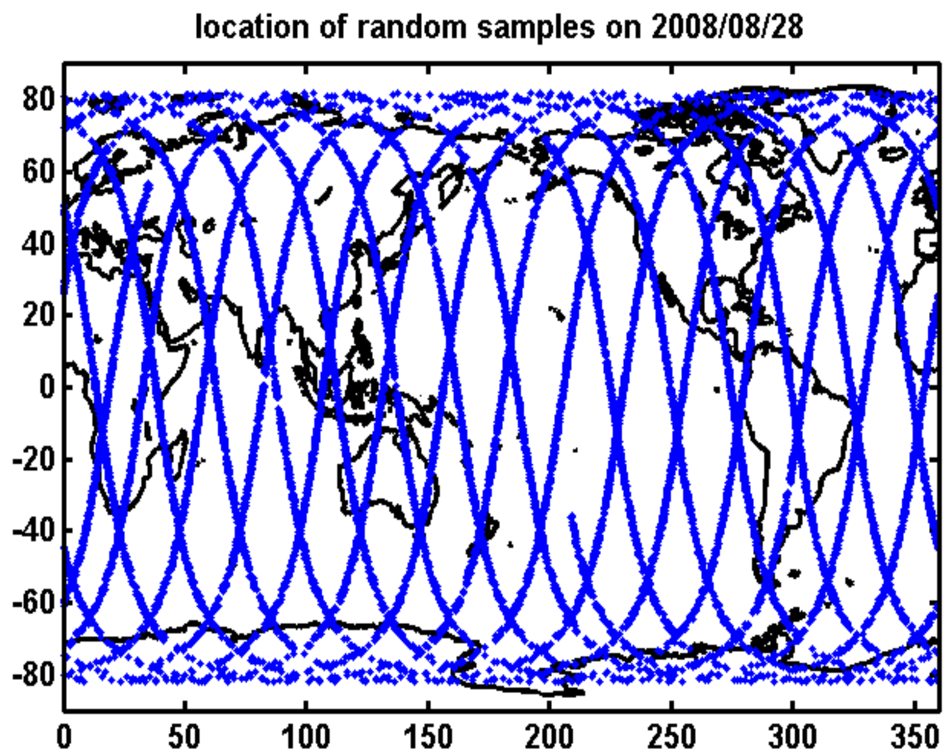
Random nadir sampling of spectra

We use 22,000 pseudo Random Nadir Samples (RNS) each day from AIRS and CrIS.

The RNS are select to be area representative, i.e. the mean of all data is an unbiased global mean.

The RNS are representative of the local cloud cover. With one month of data each spot on the globe is covered multiple times.

Using RNS assumes that the calibration is scan angle independent. This is not totally assured (note the AMSU and ATMS problems).



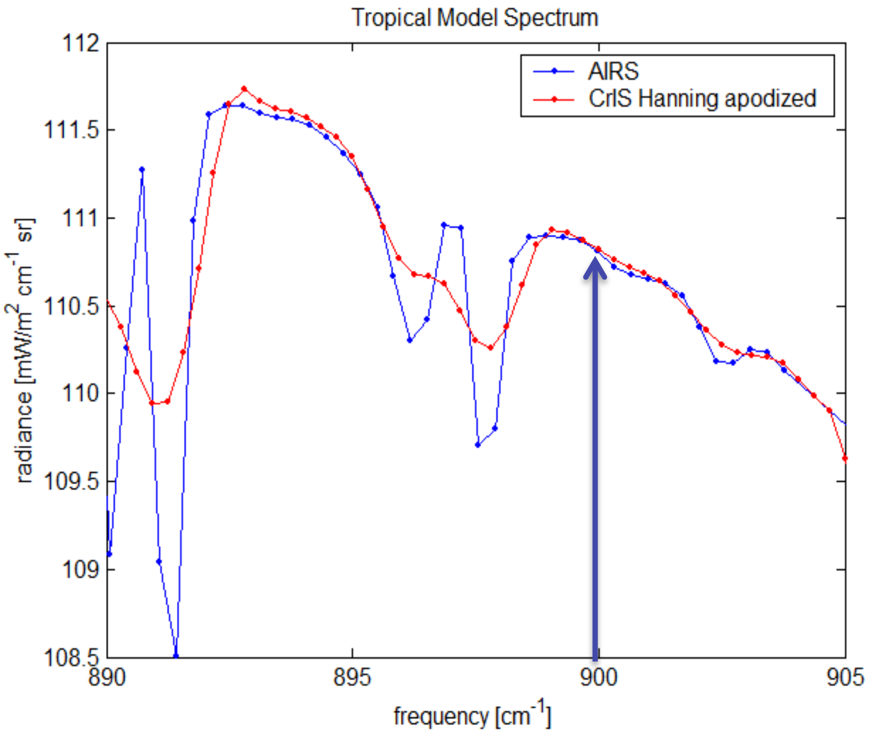
22,000 AIRS RNS from 2008/08/28

Alignment of the spectral sampling

In order to compare the data and expect agreement at the better than 100 mK level, the data have to be normalized to the same spectral resolution and sampled on the same spectral grid.

The AIRS and CrIS Spectral Response Function (SRF) are very different. This is a problem in the vicinity of atmospheric absorption features.

This problem has not been resolved for any arbitrary channel at the 100 mK level.



We bypass the SRF normalization and resampling problem by analyzing one channel in the broad atmospheric window region near 900 cm^{-1}. The difference here is less than 50 mK.

PDF analysis

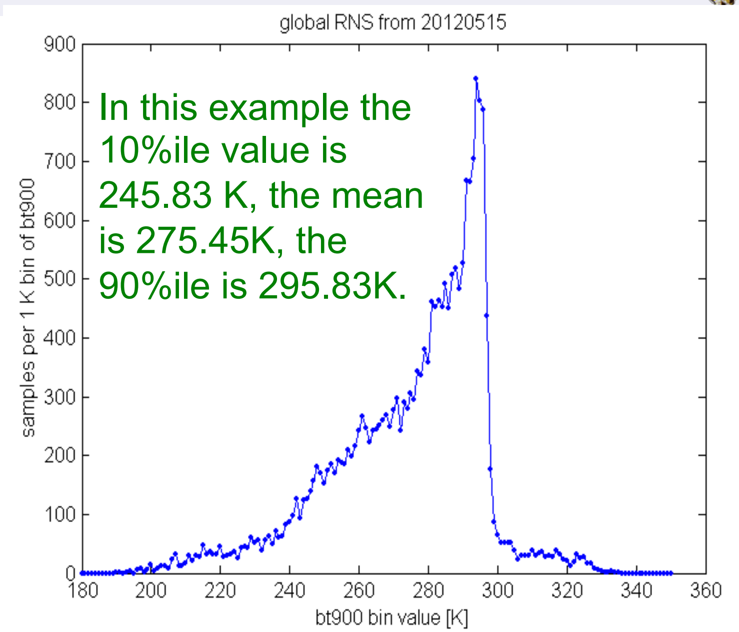
For each day we have 22,000 RNS from AIRS and from CrIS (quality filtered IDPS processing).

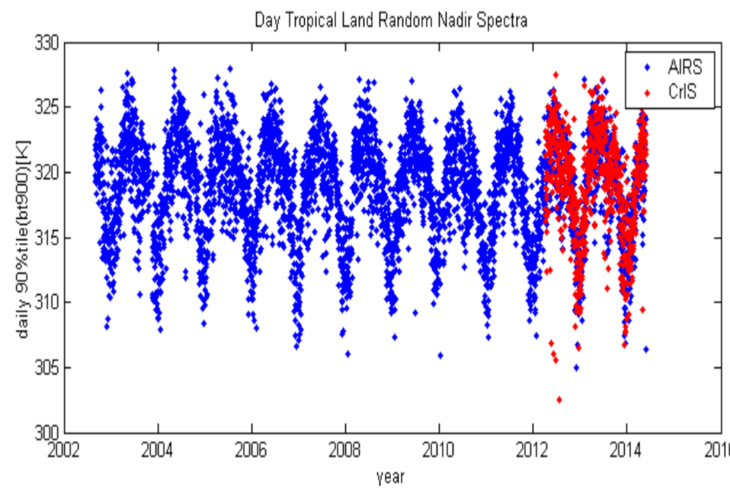
On the right is an example of AIRS global data for 2012-05-15.

We characterize the PDF by its value at the 10%ile, the mean and the 90%ile value.

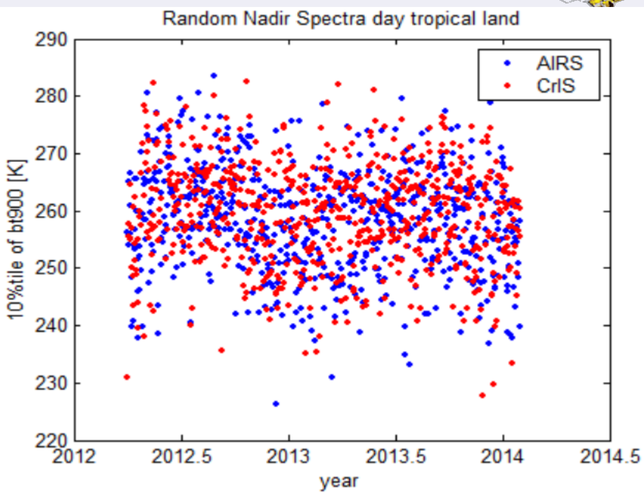
The PDF analysis makes use of the mean value theorem: If data from the same region are randomly sampled frequently enough using two instruments, the PDFs derived from the two data sets will be statistically indistinguishable.

We then create the time series of the these values and compare AIRS and CrIS for the days where there are measurements from both instruments.



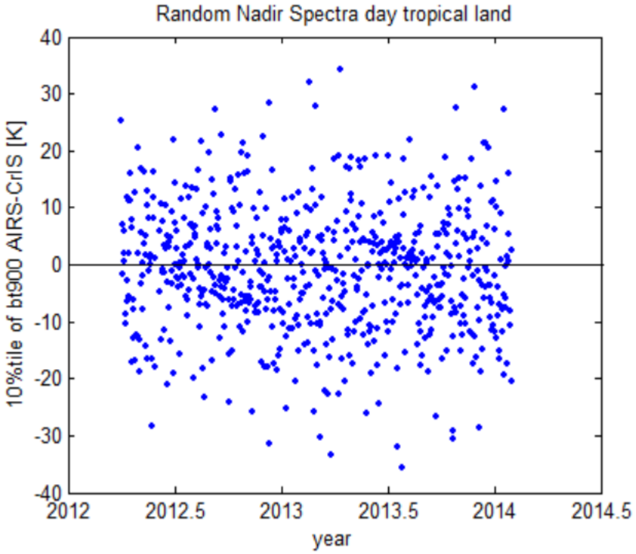


PDF analysis (continued)



The time series of the 10% values for tropical land from 705 days between May 2012 and April 2014 is shown on the upper right. Each point represents the daily mean of 1200 tropical land RNS from the 1:30 PM (day) overpasses.

The mean brightness temperature is about 258 K. Since this is tropical land, the data are partly cloudy.



The daily values from AIRS and CrIS are highly correlated. The difference between AIRS and CrIS daily 10%ile values (shown on the right) is Gaussian distributed.

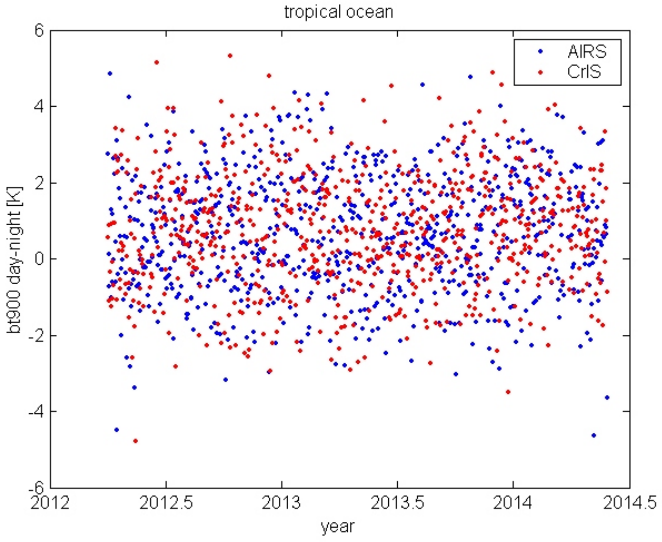
The mean AIRS-CrIS is -1.05 K with a 1 sigma probable error in the mean of 0.43K

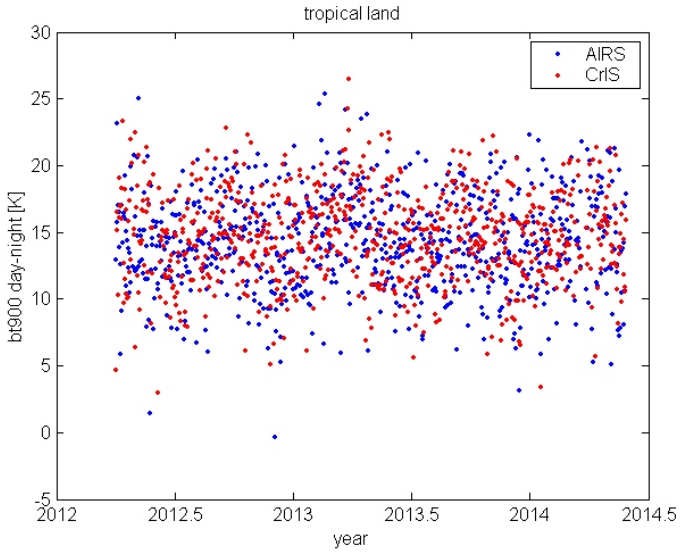
PDF analysis (continued)

The time series of the day-night difference for tropical zone for 783 days between May 2012 and June 2014 is shown on the right for ocean (top) and land(bottom).

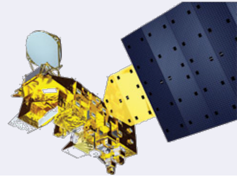
For the tropical ocean the daily day-night from AIRS (+0.63K) and CrIS (+0.72K) are nearly Gaussian distributed with no significant seasonal signature.

For the tropical land the daily day-night from AIRS (+14.24±0.12K) and CrIS (+14.65±0.12K) show a significant systematic difference.





Results of PDF analysis of two years of random sample AIRS and CrIS spectra at 900 cm^{-1}



	Daily count	10%ile (AIRS-CrIS)	Mean (AIRS-CrIS)	90%ile (AIRS-CrIS)
Global day	11,000	+0.167±0.066 (247K)	+0.192±0.034 (276 K)	+0.041±0.027 (298K)
Global night	11,000	+0.587±0.217 (240K)	+0.170±0.031 (271 K)	+0.028±0.114 (294K)
Trop ocean day	4,000	+0.120±0.285 (256K)	-0.041±0.063 (294 K)	-0.083±0.013 (297K)
Trop ocean night	4,000	+0.454±0.212 (260K)	+0.032±0.056 (283 K)	-0.083±0.011 (296K)
Trop land day	1,200	-1.051±0.430 (258K)	-0.351±0.147 (292 K)	-0.053±0.124 (319K)
Trop land night	1,200	+0.483±0.348 (252K)	+0.029±0.117 (278 K)	-0.183±0.041 (294K)
Arctic	1,100	+0.056±0.044 (244K)	+0.032±0.025 (256 K)	+0.090±0.049 (267K)
Antarctic	1,100	+0.011±0.048 (219K)	-0.025±0.032 (234 K)	-0.045±0.048 (255K)

Remarkable cases where the difference exceed 2 sigma confidence are highlighted in yellow.

The Arctic is defined as latitudes above 68N.

The Antarctic is defined as latitudes below 68S.

Discussion

For the Arctic and Antarctic AIRS and CrIS agree at the better than 100 mK level in the 10%ile, the mean and the 90%ile values. The result for the mean agrees with the Simultaneous Nadir Overpass (SNO) results published by Tobin 2013. The average SNO locations for CrIS and AIRS are almost exclusively in the Arctic or Antarctic.

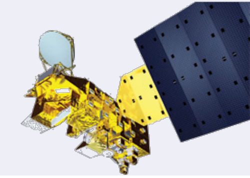
The bias between ARS and CrIS has a complicated zonal distribution. For day tropical land the CrIS mean is 350mK, the 10%ile is 1K warmer than AIRS. This difference is dominated by a large day-night difference between AIRS and CrIS.

The presence of zonal calibration artifacts in the CrIS data from the tropical zone has been alluded to in the "NPP Sounding Group Evaluation Report" April 10, 2013.

The cause for these discrepancies is currently under evaluation.

A number of variants of the CrIS L1b calibration, including an improved set of CrIS linearity coefficients, are under evaluation.

Discussion (continued)



We speculate that the reason for the discrepancy is scene contrast.

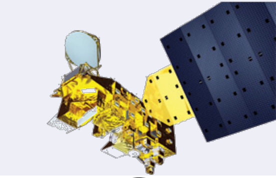
The 90%ile corresponds to scenes which are essentially free of clouds in all zones, and there the AIRS-CrIS differences are small.

For the 10%ile (cold tails) of the PDF we measure a combination of cold clouds and clear surface in the 13 km FOV, which is spatially not resolved.

Scene inhomogeneity in the CrIS field of view due to the presence of clouds was expect to create additional noise, but a bias is unexpected.

The scene contrast inside the field of view could be inferred from VIIRS data (future work), but it can be inferred directly from measurements.

Discussion (continued)



The spatial coherence, cx900, is the difference between the brightest and the coldest of the 8 footprints surrounding each sample footprint.

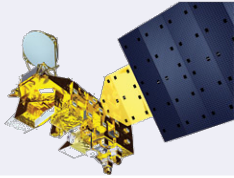
cx900 is typically 5 K in the polar zones, where the agreement between AIRS and CrIS is the best.

cx900 is 9 K in the other zones, where the agreement between AIRS and CrIS is acceptable.

cx900 is 13 K for day tropical land. This is where we see the largest difference between AIRS and CrIS for the mean and the 10%ile.

	Daily count	10%ile (AIRS-CrIS)	Mean (AIRS-CrIS)	90%ile (AIRS-CrIS)	Spatial coherence
Global day	11,000	+0.167±0.066 (247K)	+0.192±0.034 (276 K)	+0.041±0.027 (298K)	9.6K
Global night	11,000	+0.587±0.217 (240K)	+0.170±0.031 (271 K)	+0.028±0.114 (294K)	9.2K
Trop ocean day	4,000	+0.120±0.285 (256K)	-0.041±0.063 (294 K)	-0.083±0.013 (297K)	8.6K
Trop ocean night	4,000	+0.454±0.212 (260K)	+0.032±0.056 (283 K)	-0.083±0.011 (296K)	9.1K
Trop land day	1,200	-1.051±0.430 (258K)	-0.351±0.147 (292 K)	-0.053±0.124 (319K)	13.5K
Trop land night	1,200	+0.483±0.348 (252K)	+0.029±0.117 (278 K)	-0.183±0.041 (294K)	9.5K
Arctic	1,100	+0.056±0.044 (244K)	+0.032±0.025 (256 K)	+0.090±0.049 (267K)	5.9K
Antarctic	1,100	+0.011±0.048 (219K)	-0.025±0.032 (234 K)	-0.045±0.048 (255K)	4.5K

Conclusions



PDF analysis of Random Nadir Sampled data is a powerful tool for the evaluation of radiometric fidelity for a wide range of scene conditions.

The analysis reveals a very small bias between AIRS and CrIS under polar scene conditions, consistent with previous SNO analysis.

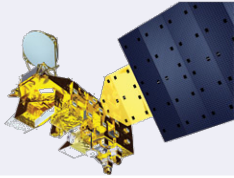
The analysis reveals a bias considerably larger than 100 mK between AIRS and CrIS for other zones, particularly for day tropical land.

Future work:

Continue evaluation funded under NPP ROSES

Look for related differences in other applications of AIRS and CrIS data (cloud properties?, data assimilation?)

Repeat the analysis with the data downloaded from UW (results shown were IDPS).



Questions?