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AIRS Spatial Calibration Status And Plans

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March 10, 2006

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Introduction (1 of 2)

- **AIRS validation requires comparison of AIRS data products with those of other instruments (for example, MODIS and HIRS)**
- **Knowledge of the AIRS spatial response for each channel is sometimes required to properly interpret differences seen between AIRS and other instruments**
- **At present, we are attempting to confirm pre-flight measurements of the AIRS spatial response. We are working on reconstructing the AIRS spatial response functions using Aqua MODIS data combined with AIRS**
  - ***MODIS and AIRS view essentially the same scenes at the same time from the same spacecraft***
  - ***MODIS spatial resolution is about a factor of 14 better than AIRS***

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Introduction (2 of 2)

- **If this work succeeds, it will demonstrate the feasibility (under some circumstances) of using in-flight data to confirm pre-flight spatial characterization**

- **If the attempt fails or works only roughly, that would re-emphasize the importance of thorough pre-flight characterization**

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Outline

- **Pre-flight measurements of the AIRS spatial response functions**
- **Processing of the measured functions to include the effects of:**
  - ***Field stop mask***
  - ***Scan mirror rotation, footprint to footprint***
  - ***Motion during a single footprint***
- **Impact on radiometry of channel-to-channel boresight offsets, as presented at the SPIE meeting in Orlando in April 2005**
- **In-flight verification of pre-flight spatial characterization**
  - ***Early results of comparisons between different AIRS channels, as presented at the SPIE meeting in San Diego in August 2005***
  - ***On-going activity using comparison of AIRS and MODIS***

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Pre-flight Measurements

- **AIRS IR spatial response functions were measured pre-flight, before the instrument was fully assembled**
- **Measurements were made:**
  - ***Without the scan mirror in place***
  - ***Before the AIRS optics were modified to add a field stop mask, which reduced the field of view in the in-scan direction***
- **The spatial collimator system (part of the AIRS Calibration and Test Facility at BAE Systems) was used to position the beam**
- **The derived response functions are valid for nadir for a motionless instrument with the originally-designed field of view**
- **All 2378 channels were measured, in a 39 x 39 grid with spacing 0.04 degrees**
- **After the field stop modification, a subset of the measurements was repeated to ensure that the apodization had the expected effect**

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Further Processing of Measured Response Functions

- The field stop mask is easily simulated—the measured response function (which we refer to as a "top hat") is just truncated in the in-scan direction
- Truncated top hat centroids were then calculated for each channel (results next slide)
- For each of the 90 AIRS footprints, the truncated top hat is then rotated by an amount equal to that footprint's nominal scan angle
- The rotated top hat is then convolved with a smearing function to mimic scanner and spacecraft motion during the footprint integration time
- Sample results are shown in subsequent slides
- The calculations have been performed and stored at each step for all 2378 IR channels

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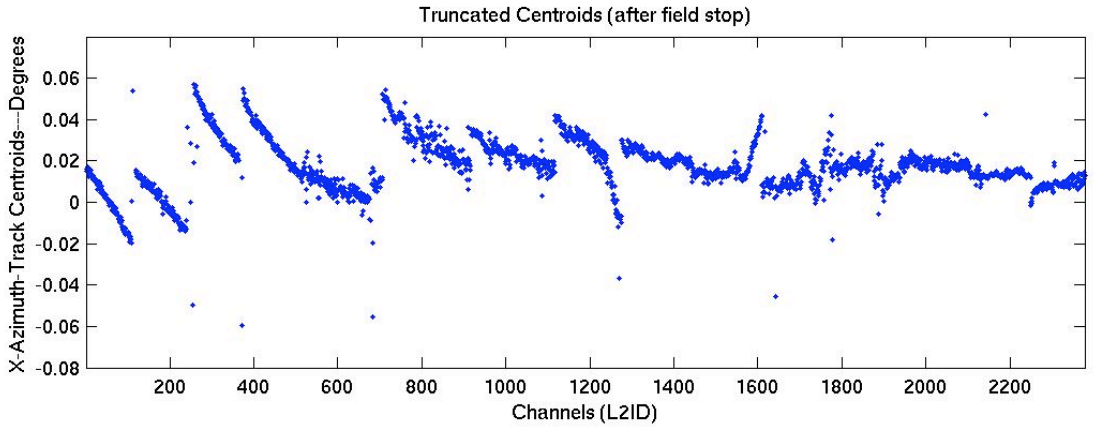
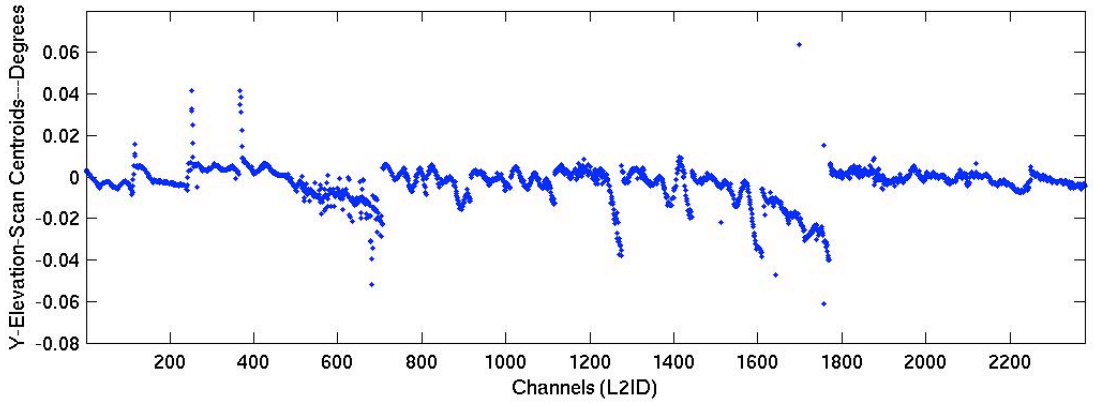
AIRS Channel Centroid Offsets

- **Standard deviations**
  - ***x ➔ 0°.031***
  - ***y ➔ 0°.016***
- **Outliers**
  - ***Noisy during prelaunch test***
  - ***Partially shadowed***
- **Systematic changes across arrays**
  - ***Pupil-imaging-unique focal plane illumination effects***





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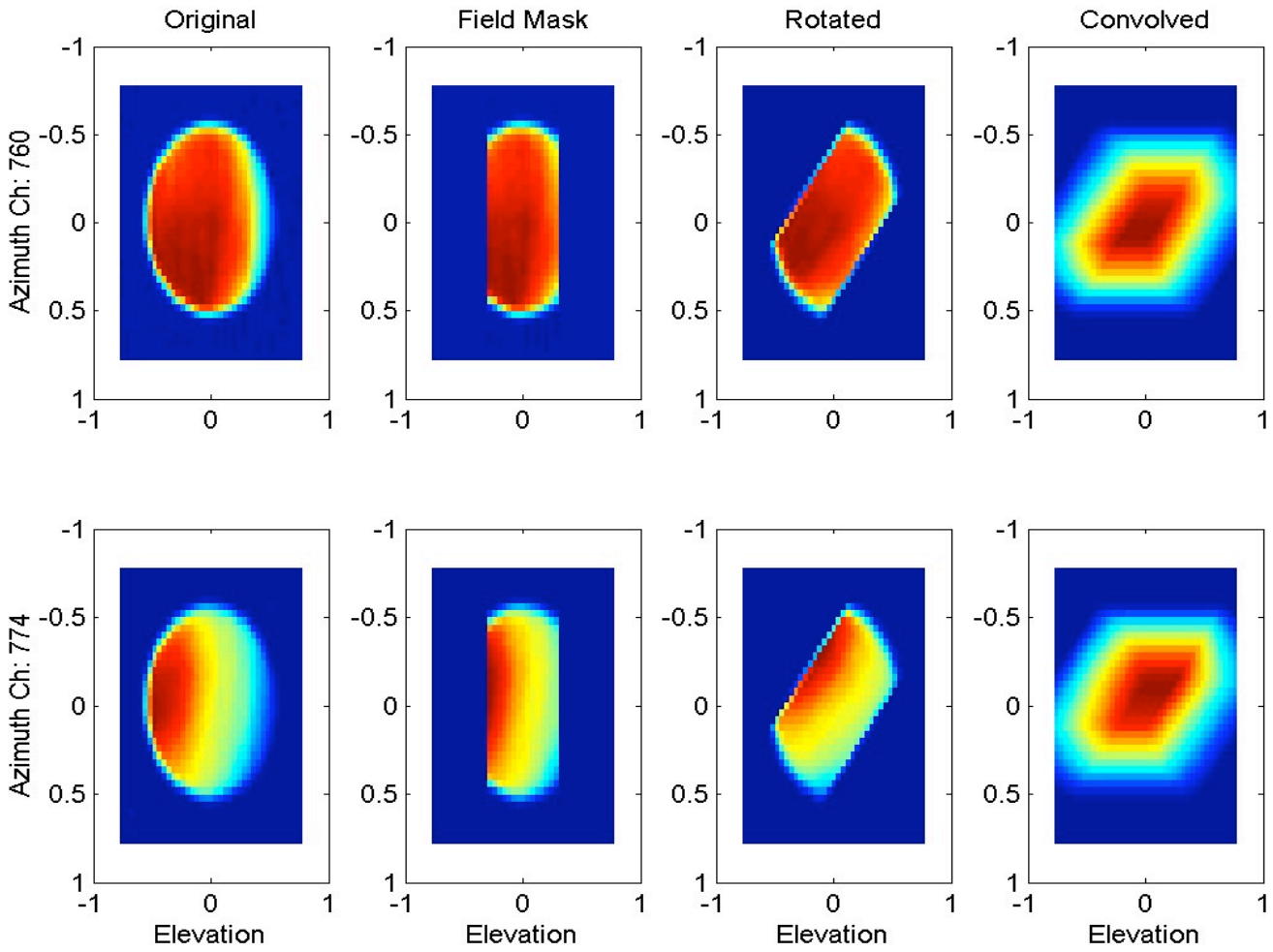
AIRS Flight Spatial Response (Convolved and Rotated) From Pre-Flight Optical Bench (Original)



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Impact Of Channel Misalignments On AIRS Radiometry

- In early 2005 George Aumann analyzed the effects on radiometry of channel boresight misalignments
- Three pairs of AIRS channels were used
  - *Within each pair, channels had essentially the same weighting function*
  - *One pair had well-aligned boresights (within 0.004 degrees)*
  - *One pair was moderately misaligned (0.023 degrees)*
  - *One pair was significantly misaligned (0.036 degrees)*
- Conclusions
  - *Even in high-contrast scenes, the mean brightness temperatures were unaffected by misalignment*
  - *The standard deviation of difference images and their gradients showed a linear dependence on the amount of misalignment*

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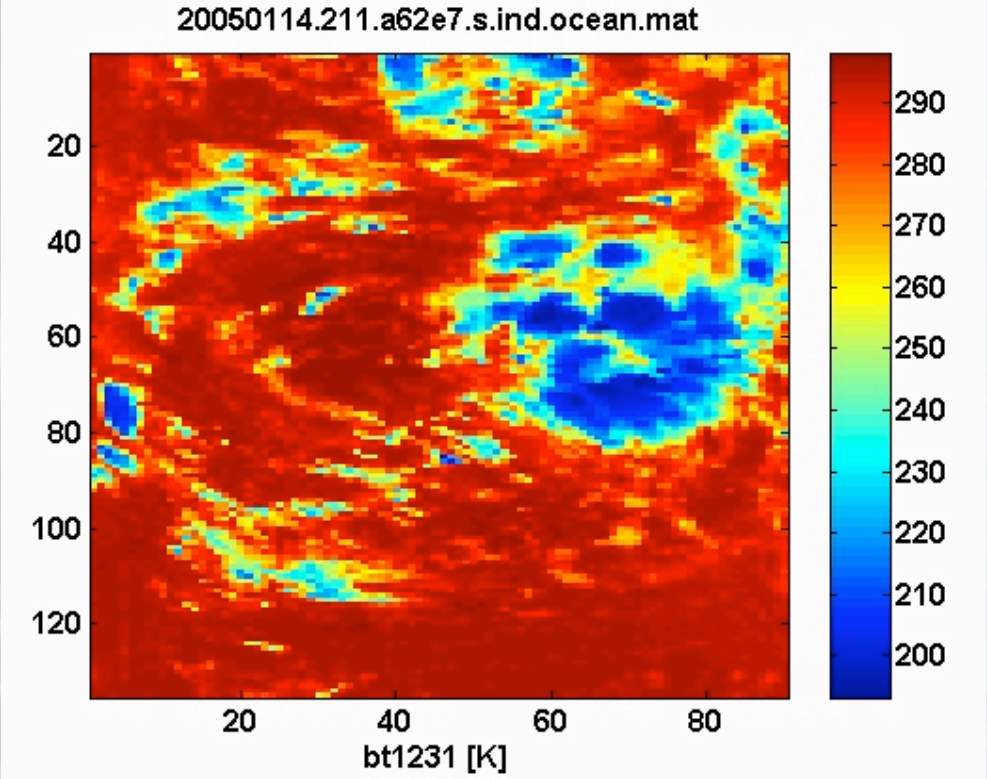
Indian Ocean Scene (Night)

- This is a typical AIRS nighttime scene over ocean
- This is a brightness temperature image measured in a single AIRS channel at 1231 cm^{-1}
- Note the cold (high) cloud formation
- Note also some fainter circular cloud features
- Part of the scene is clear and we are seeing to the ocean surface



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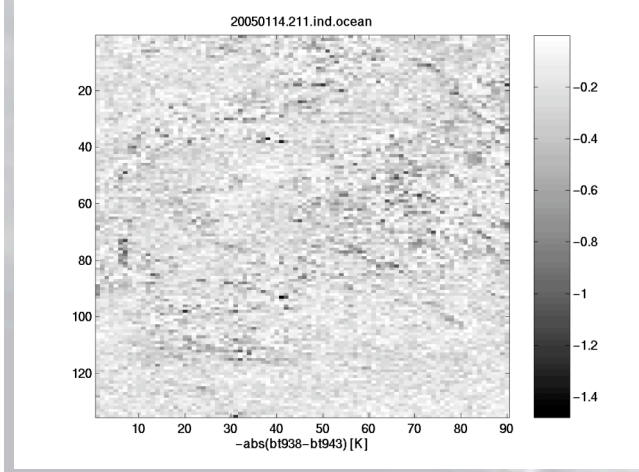
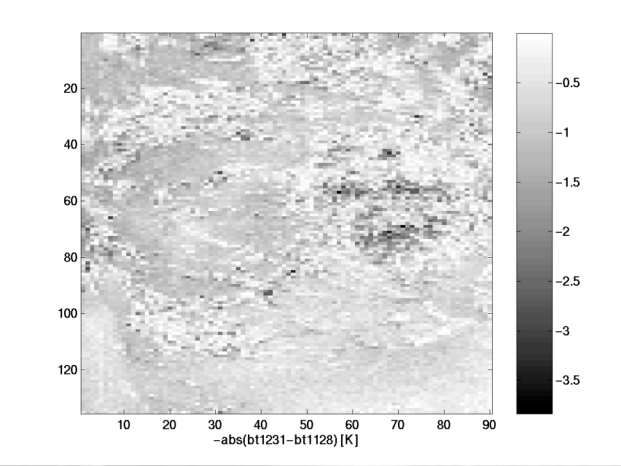
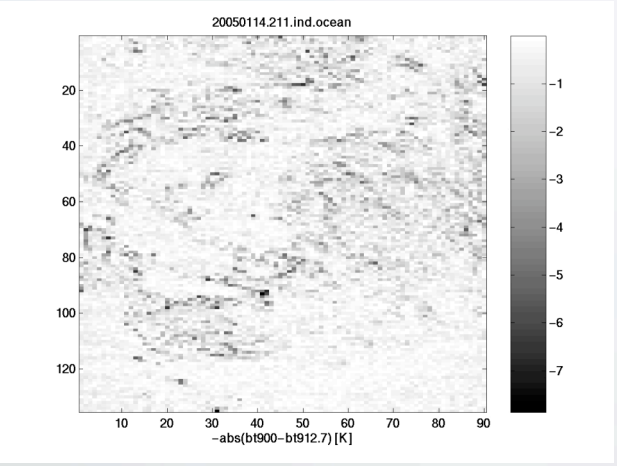
Indian Ocean Difference Images







- Well aligned (.004)
- - |bt938 - bt943|
- Very little image bleed through
- Total range ≈ 1.6K

- Aligned to within .023
- - |bt1231 - b1128|
- Moderate image bleed through
- Total range ≈ 4.0K

- Aligned to within .036
- - |bt901 - b913|
- Considerable image bleed through
- Total range ≈ 8.0K

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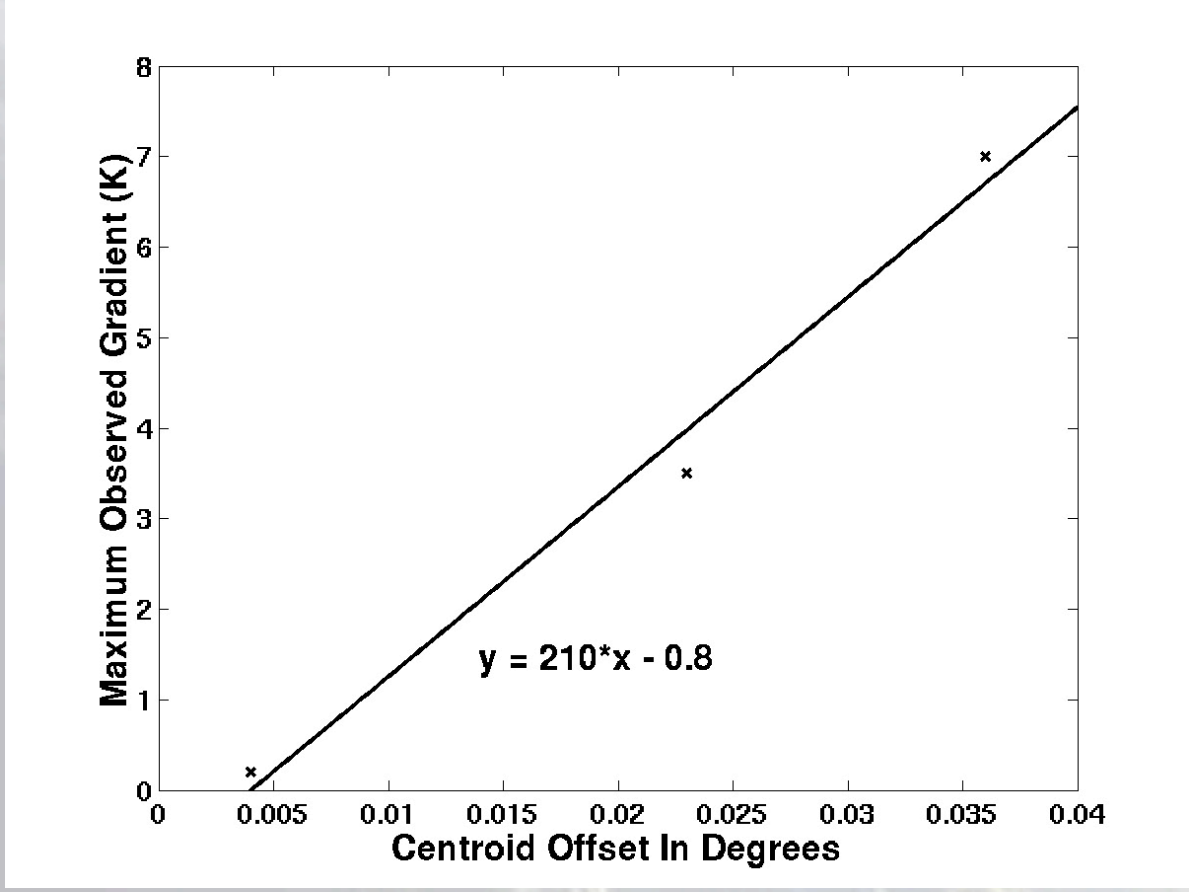
Maximum Gradients Versus Boresight Offset



- **The maximum gradients seen in the differences are proportional to the boresight offset**

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Initial Post-Launch Check Of Pre-Flight Spatial Characterization (1 of 2)

- Channels 760 and 774, near 11 microns, were analyzed by Tom Pagano last year
- These channels observe essentially the same part of the atmosphere, but have significantly different top hat centroids determined pre-flight
- He performed a regression analysis to find the best set of nine coefficients, assuming that a given pixel in one channel equals the weighted sum of its nearest neighbors (3x3 grid) for the other channel
- He also took an entire granule image in each of the two channels, resampled them to a lat/lon grid, and (using trial and error) minimized their difference image subject to differing spatial offset amounts

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Initial Post-Launch Check Of Pre-Flight Spatial Characterization (2 of 2)

- **The results from both methods did not confirm the centroid values calculated from the pre-flight data**
  - ***The two regression analyses agreed more closely with each other than with offsets predicted from the pre-flight measurements***
  - ***The observed flight-data offsets were somewhat larger than the pre-flight values***
- **For that reason, we have chosen to hold off making the top hat functions at each step available to the public**
  - ***We want to understand the apparent discrepancy between the pre-flight measurements and analysis of in-flight data***

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Regression Technique and Trial and Error Show Greater Offsets than Pre-Flight Data

- **Channel pair 760 (M8) / 774 (M7)**
  - ***Pre-flight relative offset 0.035***
  - ***In-flight regression relative offset 0.103***

Channel	Frequency	Pre-Mask Centroid Pre-Flight		Post-Mask Centroid Pre-Flight		Regression Centroid In-Flight		Trial and Error In-Flight	
		Az	**El**	**Az**	**El**	**Az**	**El**	**Az**	**El**
	(cm-1)	**(deg)**	**(deg)**	**(deg)**	**(deg)**	**(deg)**	**(deg)**	**(deg)**	**(deg)**
760	**900.655**	**-0.010**	**-0.053**	**-0.009**	**-0.011**	**N/A**	**N/A**	**N/A**	**N/A**
774	**912.656**	**-0.035**	**-0.102**	**-0.036**	**-0.034**	**N/A**	**N/A**	**N/A**	**N/A**
Difference	12.001	-0.025	-0.049	-0.027	-0.023	0.103	0.003	0.080	0.000
606	**851.607**	**-0.007**	**0.018**	**-0.006**	**0.006**	**N/A**	**N/A**	**N/A**	**N/A**
610	**851.797**	**-0.027**	**-0.103**	**-0.033**	**-0.039**	**N/A**	**N/A**	**N/A**	**N/A**
Difference	0.190	-0.020	-0.122	-0.027	-0.045	0.210	0.018	0.140	0.000

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AIRS/MODIS Comparison Technique (1 of 2)

- We are now trying a slightly different technique to attempt to verify the pre-flight top hat data and to test the feasibility of post-launch spatial characterization
- We are using AIRS channel 1489 (M3; 7.4 microns) and MODIS band 28
- Channel 1489 is one of a small minority of AIRS channels which has a highly asymmetric top hat function as measured pre-flight (see plots on next slide)
- AIRS and MODIS granule images have been resampled to eliminate differing effects between the instruments of spacecraft and scanner motion during each scan line (see following slides)

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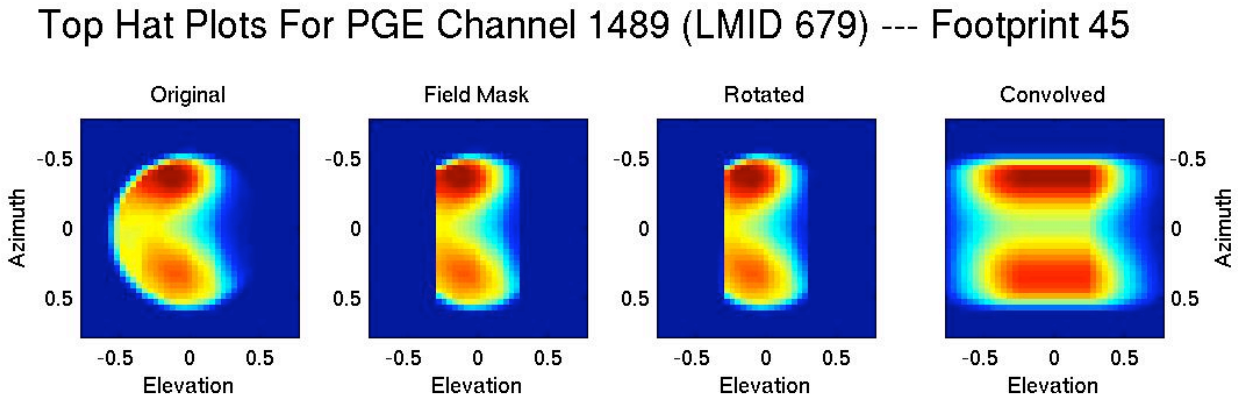
AIRS Channel 1489 Top Hats (Nadir)



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AIRS/MODIS Comparison Technique (2 of 2)

- **We then assume each AIRS nadir pixel is equal to the weighted sum of a 15 x 15 neighborhood of MODIS pixels**
  - ***Because of the resampling, the analysis technique is not limited to nadir, but that is all that has been tried so far***
- **Data from 14 overlapping scenes in 12 granules from the focus day on September 6, 2002 were combined and a least-squares fit was performed to calculate the 225 weights**
  - ***These weights should look similar to the pre-flight top hat for detector 1489***
- **We do not yet have a satisfactory fit**

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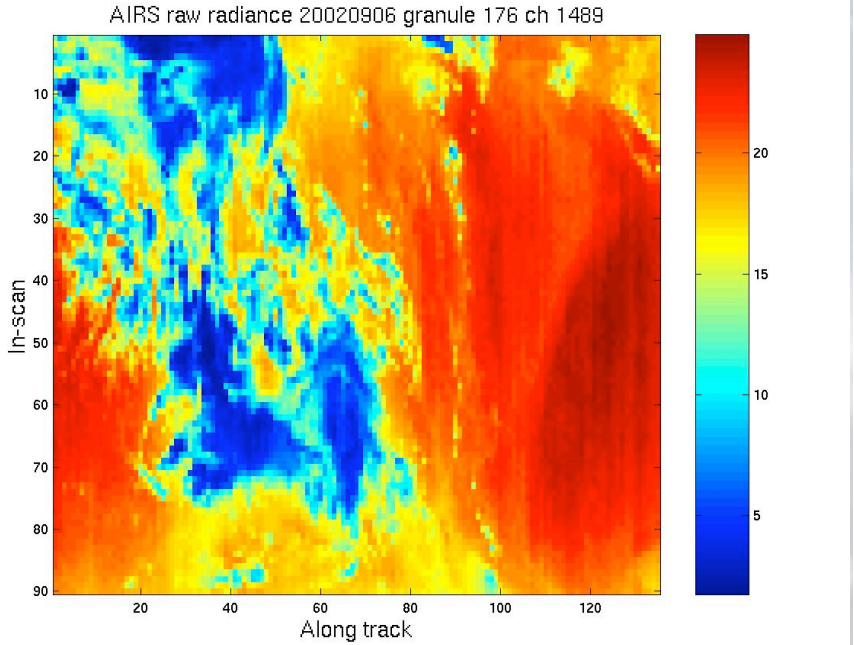
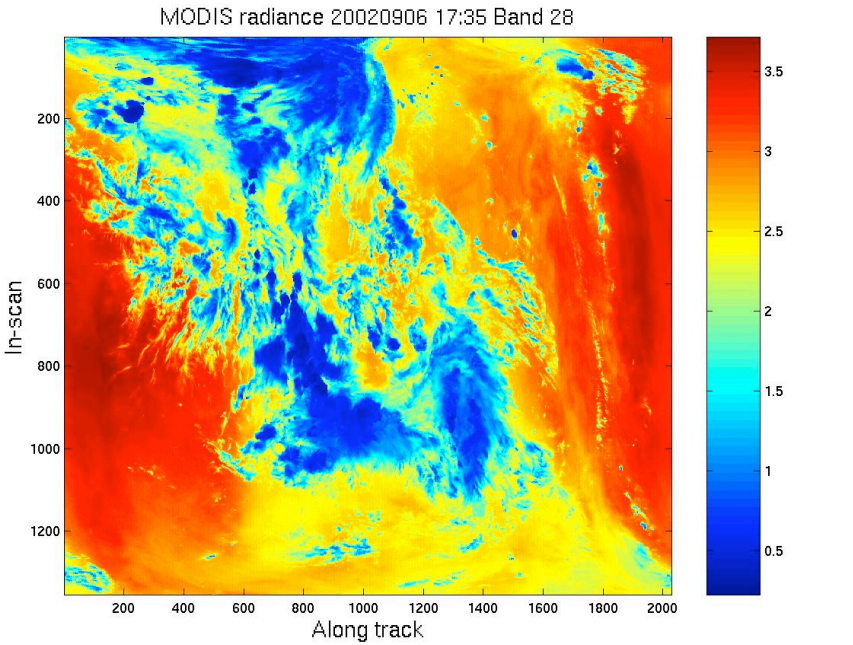
AIRS/MODIS Pair (spatially raw)





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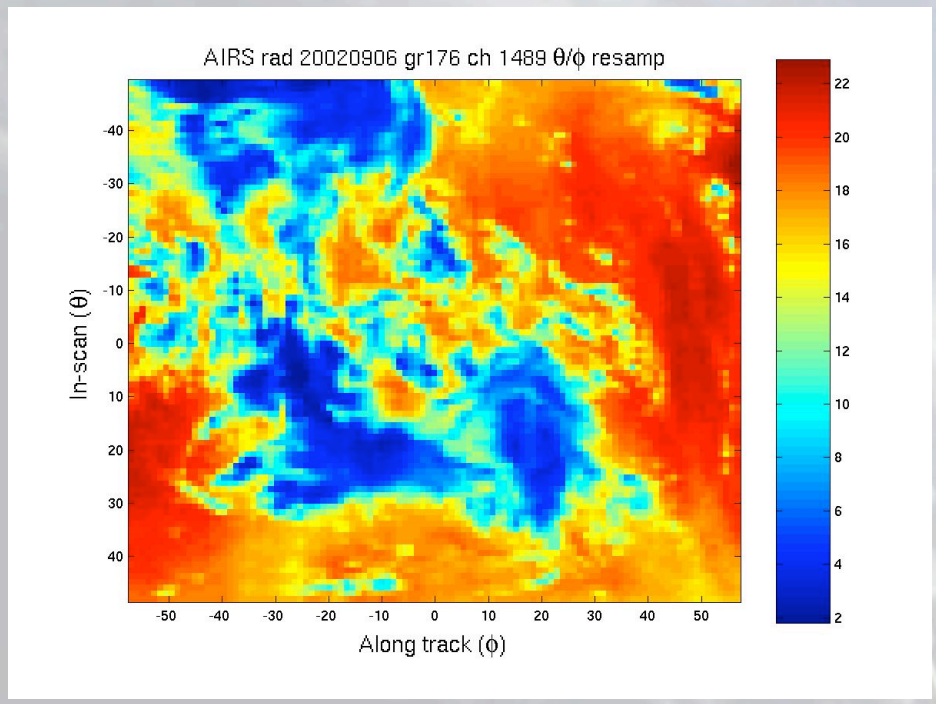
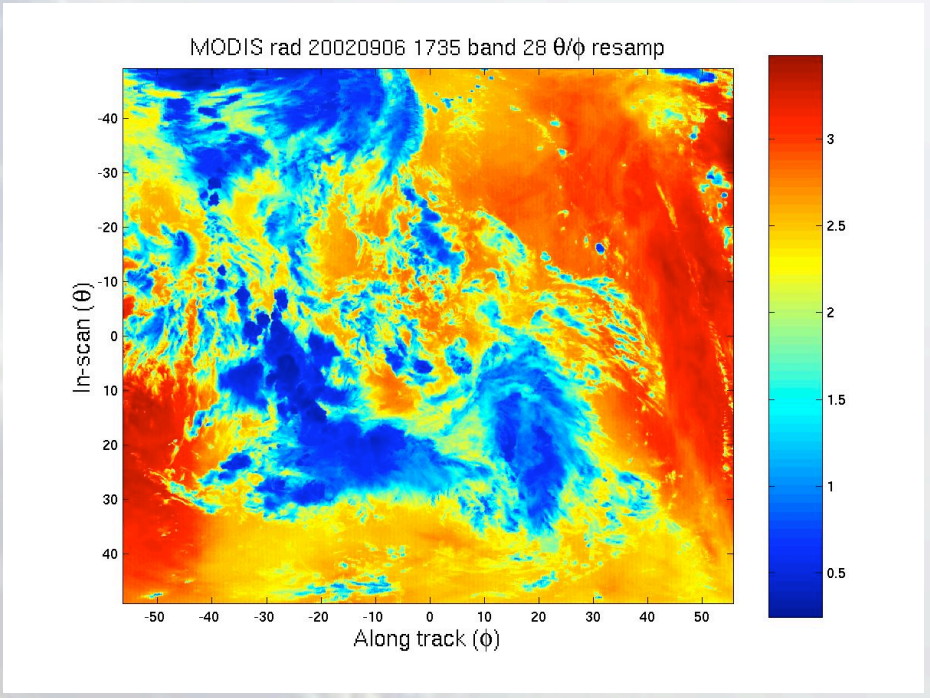
AIRS/MODIS Pair—Resampled, Overlap Area Only





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Summary

- **In order to properly validate an instrument and to enable inter-instrument comparisons, the spatial response needs to be fully characterized**
- **A complete set of ground-based AIRS spatial response functions exists**
  - ***Although most channels are well aligned, a few show significant misalignments***
  - ***The effects of misalignments have been studied and shown not to affect mean radiometry***
- **AIRS and MODIS Aqua provide an opportunity to test the feasibility of confirming spatial characterization in flight**
- **Attempts to verify the pre-launch AIRS measurements using flight data have been inconclusive so far, but the problem is being actively worked**