National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS Ongoing Error Analysis Activities

AIRS Calibration Team:

Steve Broberg

Tom Pagano, George Aumann

Larrabee Strow

March 22, 2017

Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

GRWG: IR Sub-group
Wednesday, March 22, 2017
Madison, WI

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Brief AIRS Overview

- **AIRS is doing well, approaching its 15 year anniversary, with another 5 years operations on Aqua anticipated**
- **Grating spectrometer with 2378 IR channels**
  - ***2104 channels have redundant A & B detectors***
  - ***there have been occasional table uploads to restore/improve/optimize degraded channels***
- **Level 1B PGE (v5)**
  - ***2378 AIRS channels with individual calibration coefficients - unchanged since launch***
  - ***v5 is good to 100-200 mK, on average***
- **L1C cleans L1B irregularities and fills gaps, but is not a new calibration**

Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

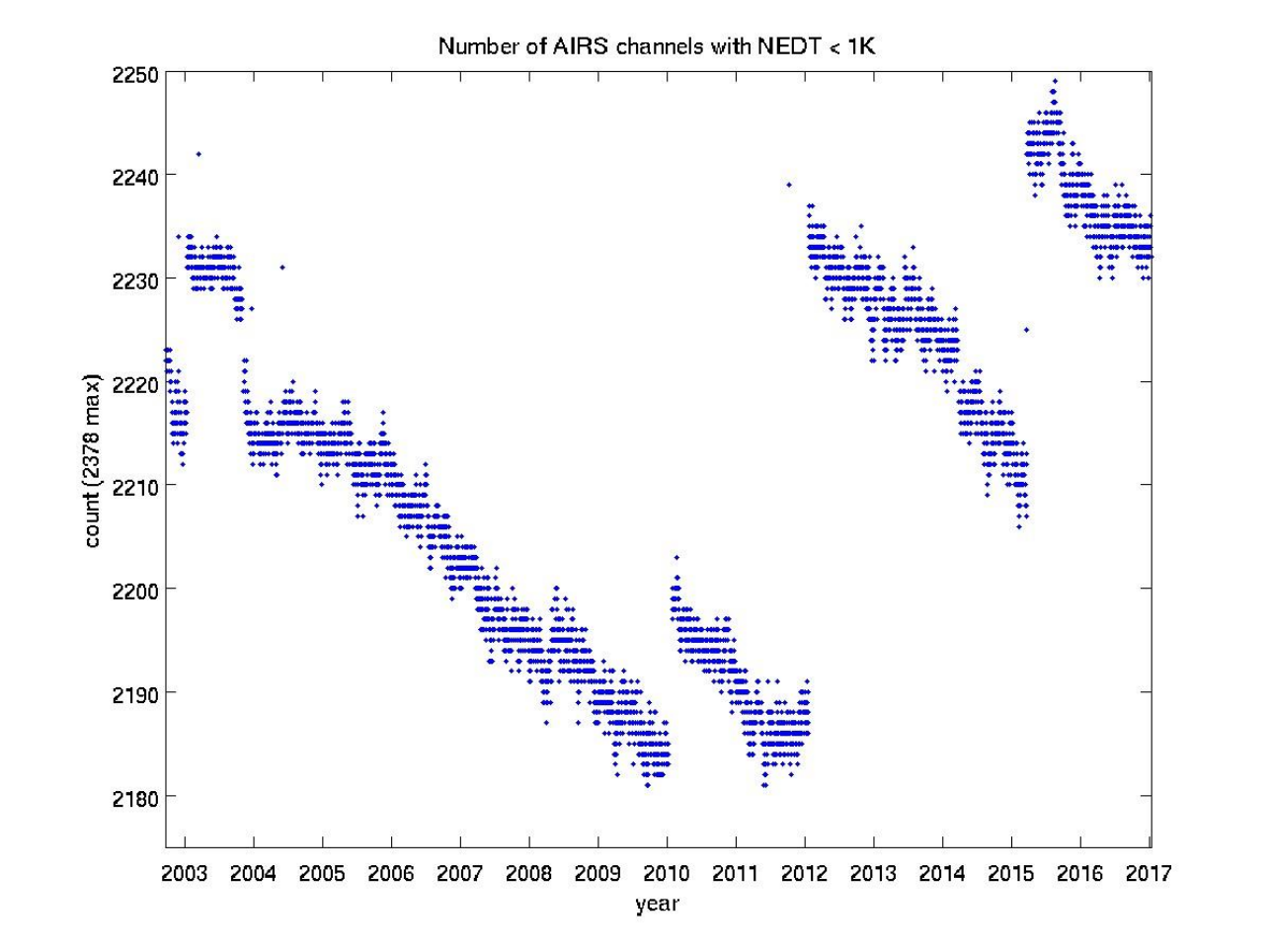
AIRS Health: Number of AIRS channels with NEΔT < 1K is greater than at-launch

Table Loads

2003-01-10
2003-11-18
2012-01-21
2013-06-10
2015-03-23

Instrument Events

2003-10-29 Solar Flare safety shutdown
2010-01-09 28V SEU
2014-03-22 Cooler A 59K-> 68K



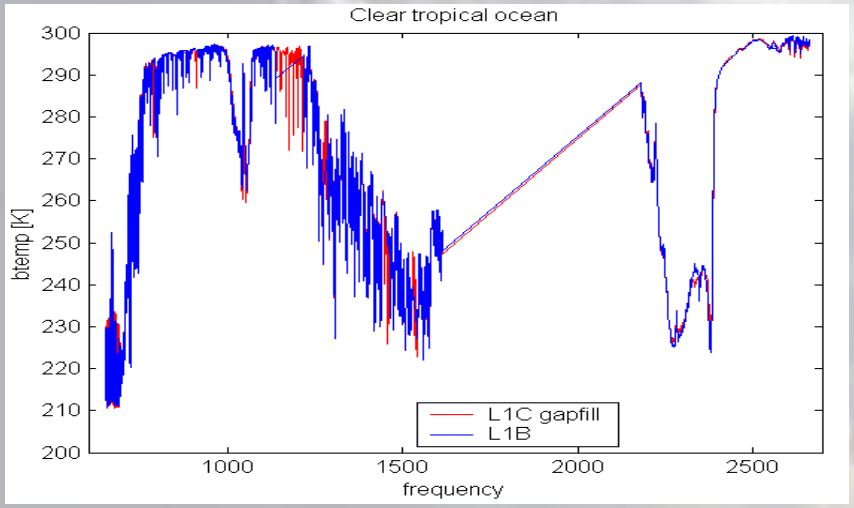
Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

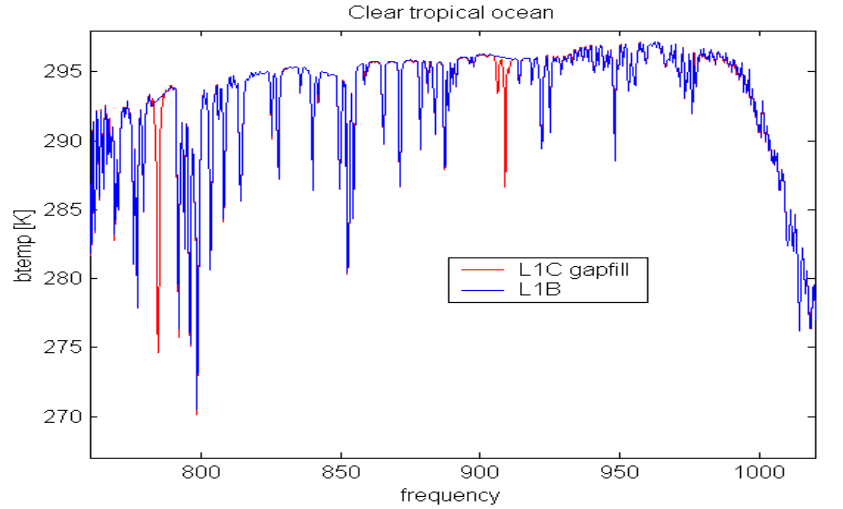
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Level 1C :Supports broad band inter-calibration efforts

- **First version is available—does cleaning and gap filling well**
  - ***~135 channels with NEDT > 1K are replaced, the ~2240 good AIRS channels are copied directly into the L1C***
  - ***The new 2645 SRF channels are monotonic increasing channel frequencies (overlap regions are removed).***
  - ***At the GES DISC they maintain a rolling 1-month of products***





Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

Ongoing AIRS calibration evaluations

- **Radiometric stability is determined daily relative to the SST**
- **Spectral calibration using spectrally resolved water lines**
- **Radiometric Coefficients**
  - ***Differences between adjacent window channels illustrate the magnitude of residual calibration errors***
  - ***Lunar roll maneuvers allow for a new time evaluation of the scan mirror polarization***
  - ***Scene dependence of temperature differences***
  - ***Optimum calibration of the A/B channels. There is currently one set of coefficients for each channel's A/B detector pair***
  - ***There are some unexplained time dependent drifts in the SW at cold scene temperatures***
- **AIRS and CrIS calibration data subsets support comparisons with CrIS, differences seen as a function of temperature and CrIS FOV**

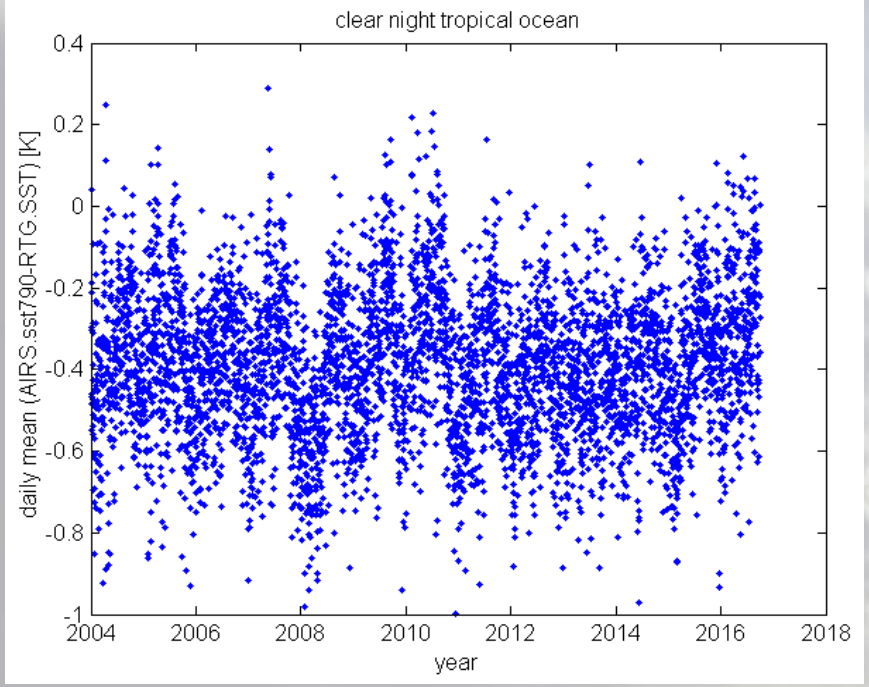
Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

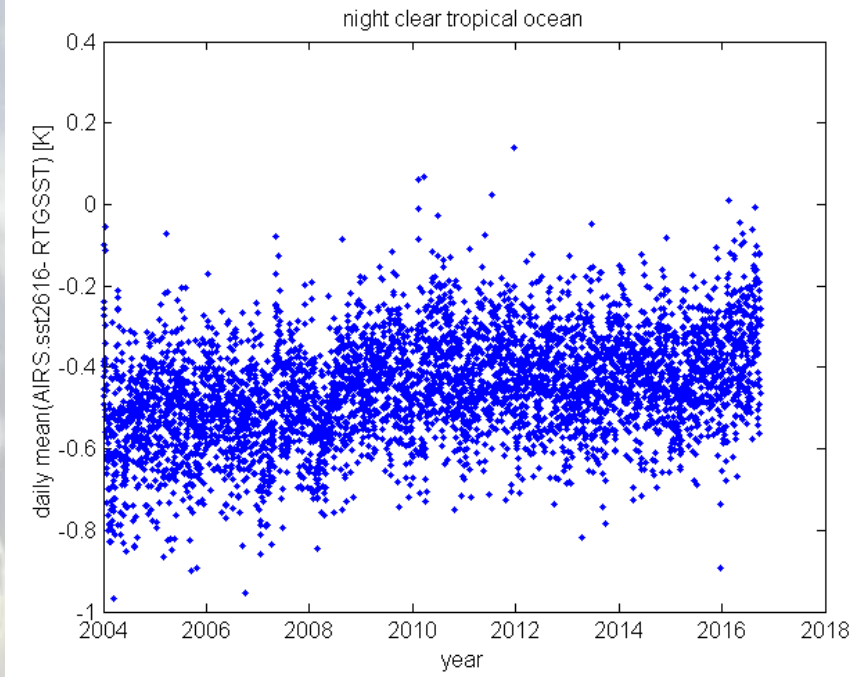
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS radiometric stability

- **Relative to the SST, stability in the 790, 900, 961, 1231 channels is typically smaller than 0.5 mK/year with 0.5 mK/year uncertainty.**
- **The 2508 and 2616 channels have a trend of about 15 mK/year for tropical ocean temperatures.**



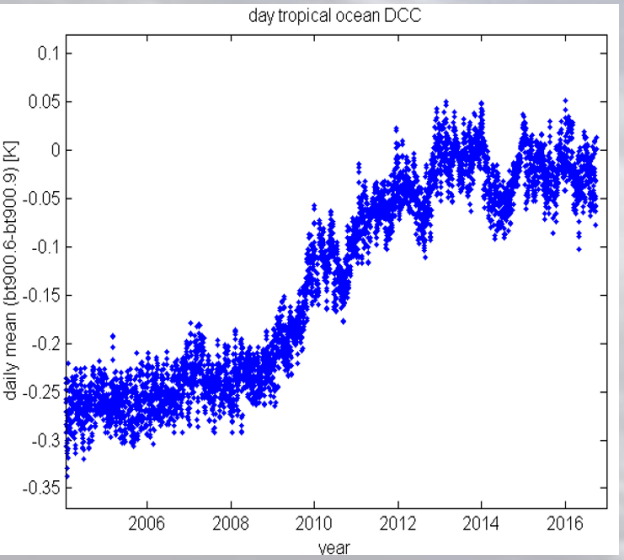


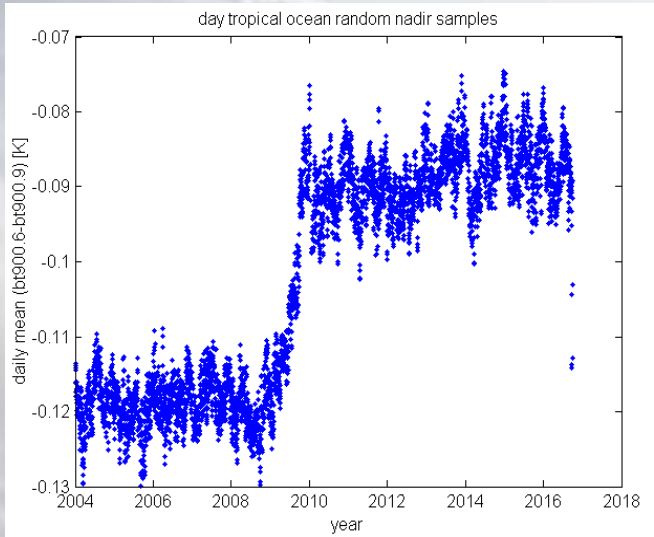
Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

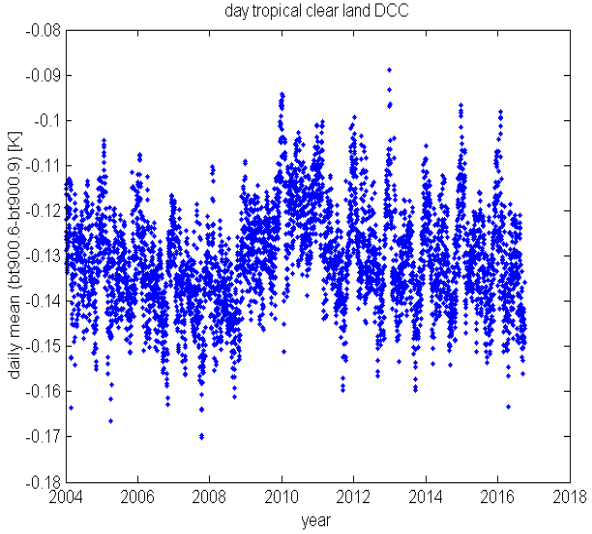
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS adjacent window channel differences illustrate unexplained changes







Day Tropical Ocean DCC
210 K scene
250 mK step

Day Tropical Ocean
280 K scene
Bias 100 mK
30 mK step

Day Tropical Land
310 K scene
Bias 130 mK
20 mK step

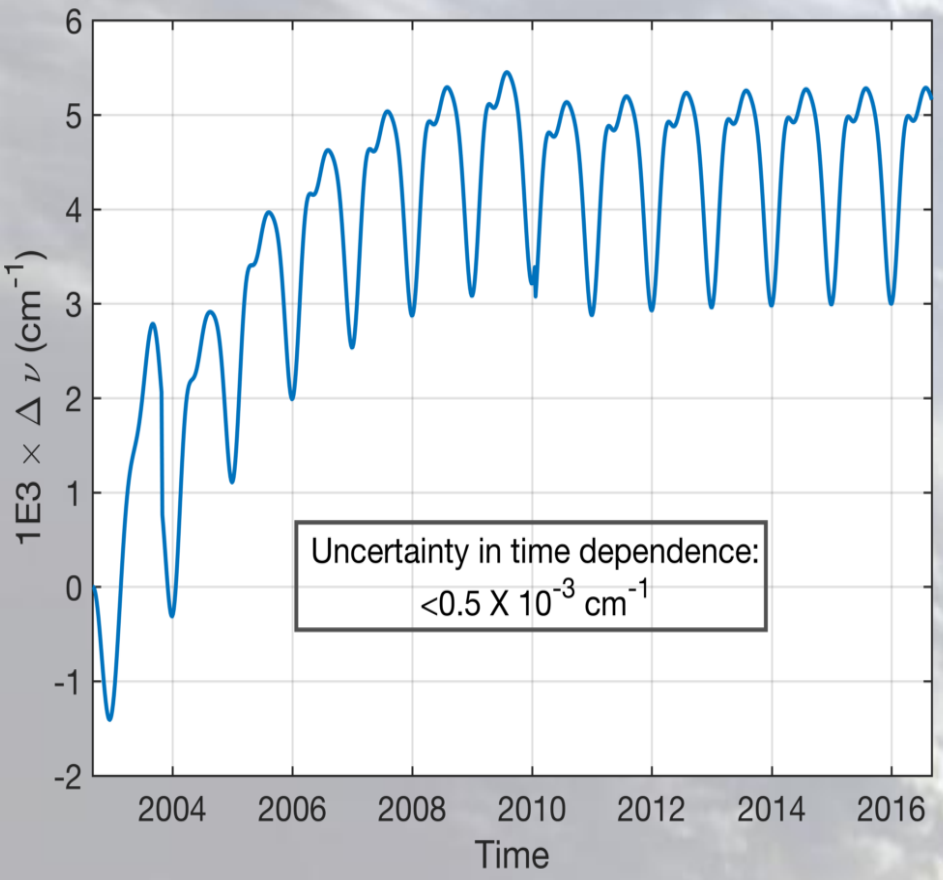
The colder the scene, the bigger the effect.

Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS frequency calibration vs. time



AIRS spectral calibration has shifted 0.4% of the SRF width, mostly in the first 5 years.

For non-window channels, the frequency shift can result in a 0.2K change over the life of the mission

L. Strow

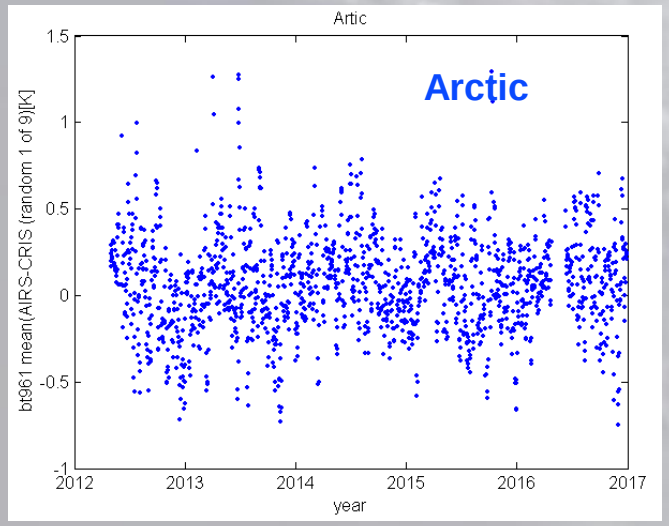
Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

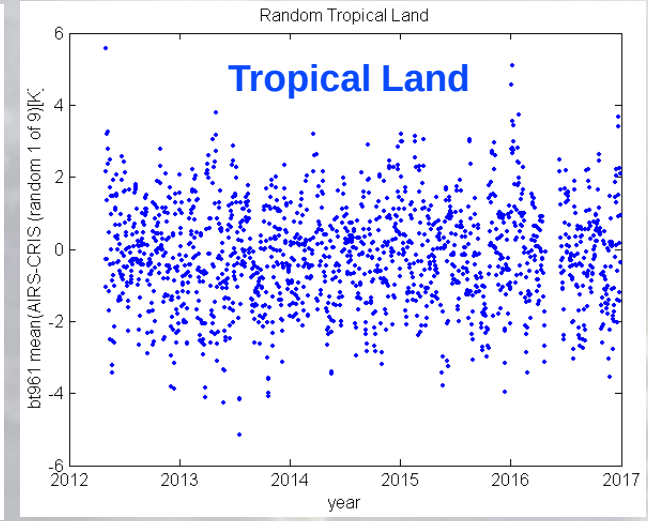
National Aeronautics and
Space Administration

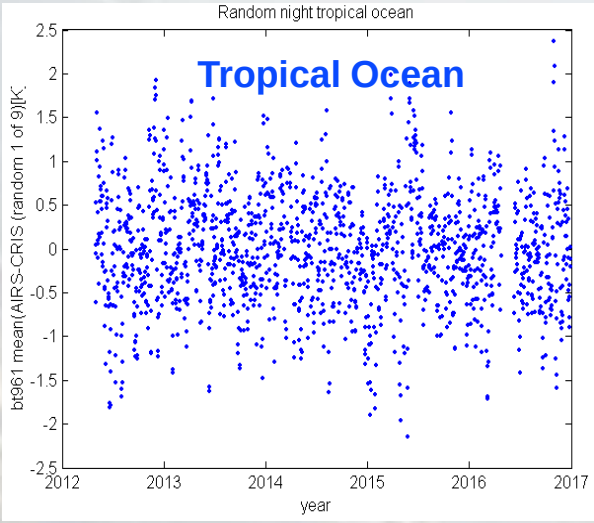
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS-CrIS 4 year differences are a function of scene temperature and CrIS FOV

- **Random arctic, the average difference is +58 mK**
  - ***-50 mK to +165mK dependinding on the CrIS FOV***
- **Random day tropical land, the average difference is -180 mK**
  - ***-43 mK to -380 mK depending on the CrIS FOV)***
- **Random night tropical ocean, the average difference is +30 mK**
  - ***-7 mK to +123 mK depending on the CrIS FOV***







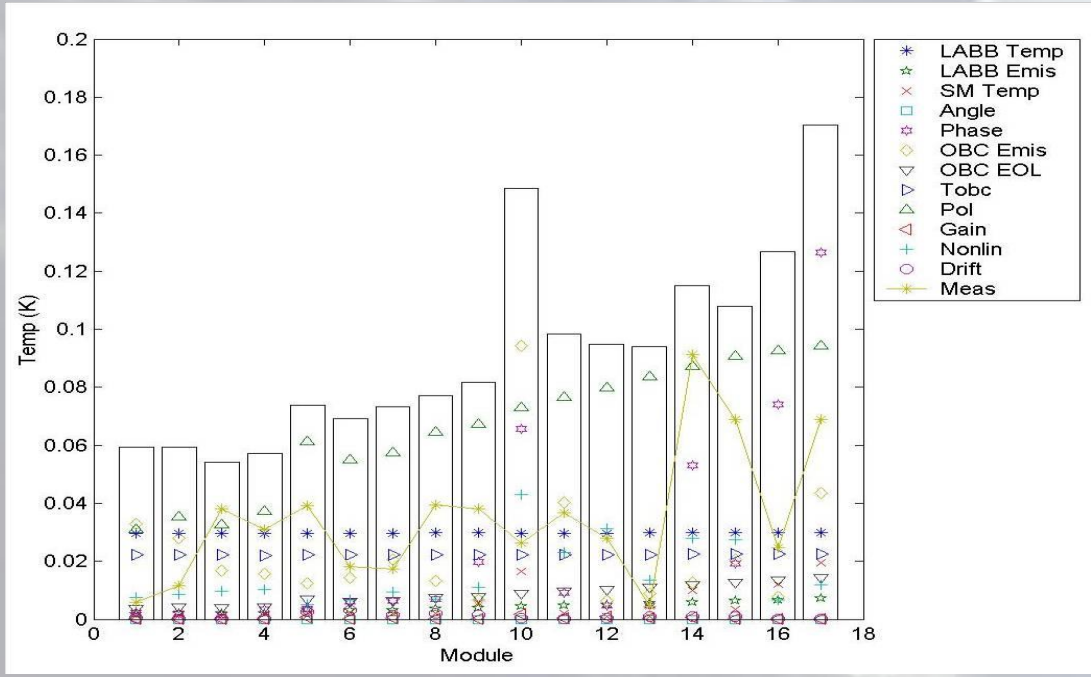
Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

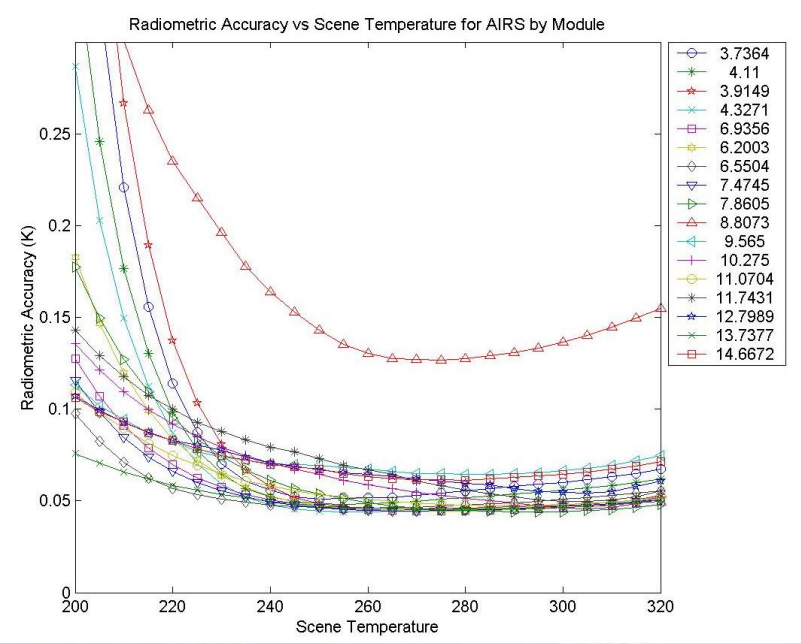
AIRS Radiometric Uncertainy Estimated in 2008 to be better than 0.2K at 265K

Module Dependent Errors at 265K by Contributor



AIRS cal team revisiting uncertainty estimates based on new data available.

Modeled Module Dependent Errors vs. Temperature



Pagano, T. S., H. Aumann, R. Schindler, D. Elliott, S. Broberg , K. Overoye, M. Weiler, "Absolute Radiometric Calibration Accuracy of the Atmospheric Infrared Sounder", Proc SPIE, 7081-46, San Diego, Ca, August 2008

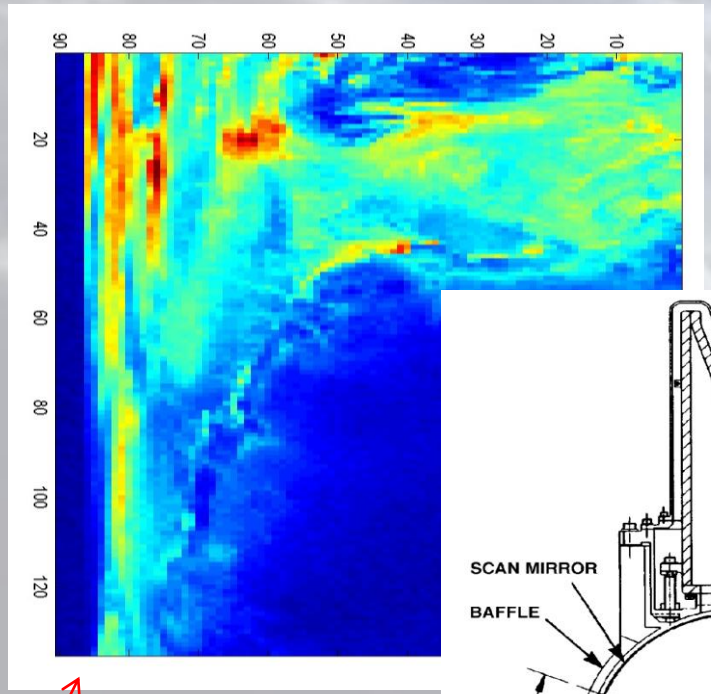
Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

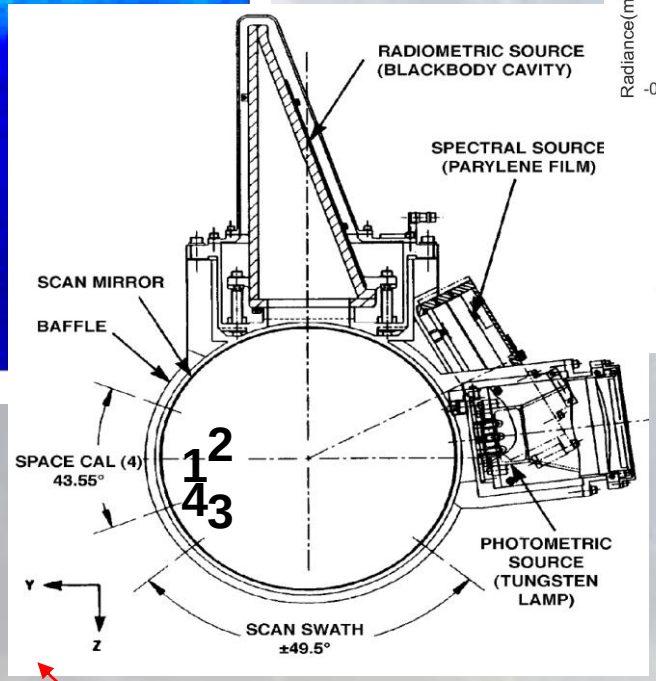
Lunar Roll Views Space off Limb Assist in Mirror Polarization Characterization

Crosstrack Footprint

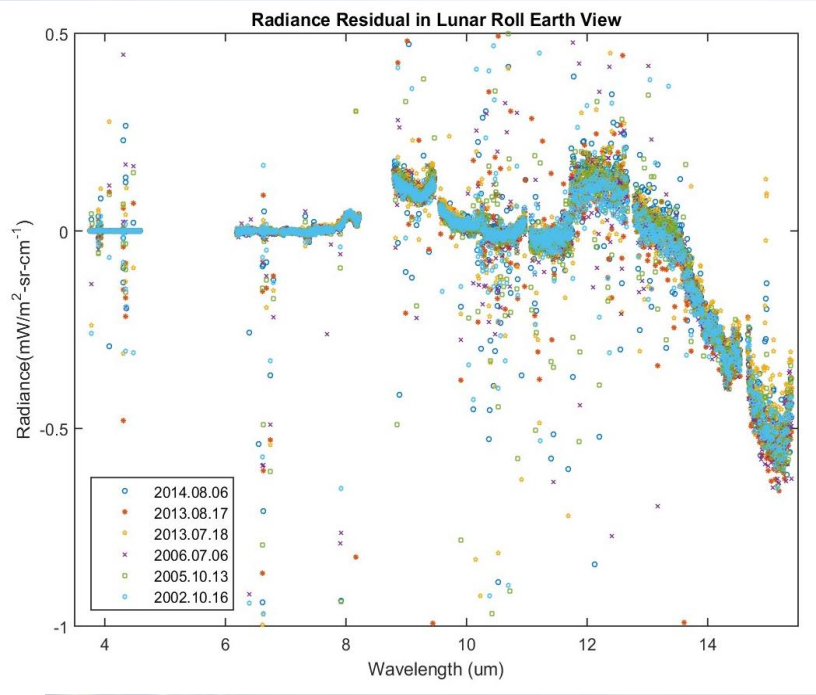


Scan number

Space



Roll Direction



Radiance Residiual – Difference between Views of Space from edge of Earth View port and Space View ports.

Copyright 2017
California Institute of Technology
Government sponsorship acknowledged

GRWG: IR Sub-group
Wednesday, March 22, 2017
Madison, WI

AIRS Radiometric Uncertainty Status

- **Revisiting uncertainty based on pre-flight testing**
  - ***Nadir and 40 Degree Tests***
  - ***Polarization, offset, emissivity and nonlinearity***
- **Using Lunar Roll data to improve estimate of polarization and phase**
- **Estimate uncertainties associated with multiple space views**
- **Use in-flight cal data to estimate changes in coefficients over time, from launch to present**
- **Use pre-flight and in-flight data to update error covariance matrix**
- **Test new coefficients over mission life for stability and accuracy**
- **Incorporate new coefficients into new L1B PGE**
- **Update ATBD, user guide and Accuracy Estimates**

Copyright 2017
California Institute of Technology
Government sponsorship acknowledged