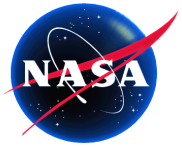

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The Atmospheric Infrared Sounder (AIRS) in Atmospheric and Climate Research

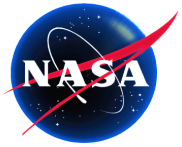
ITSC-16

16 May 2008

Thomas S. Pagano, Hartmut H. Aumann,
Moustafa T. Chahine

Jet Propulsion Laboratory

California Institute of Technology



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Outline

- AIRS Instrument on EOS Aqua Spacecraft
- AIRS Calibration and Validation
- Data Products and Validation
- Weather Forecast Improvement
- Climate
    - L2 and L3 Product
    - Climate Data Record
- Conclusions

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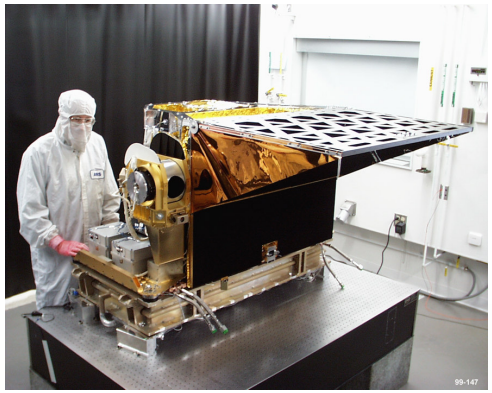
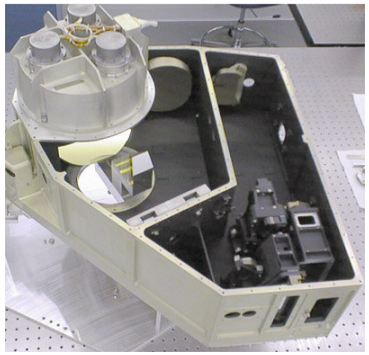
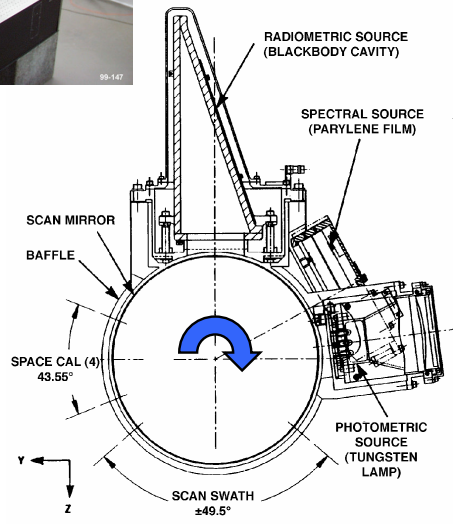
The Atmospheric Infrared Sounder on NASA's EOS Aqua Spacecraft

AIRS Characteristics

- Launched: May 4, 2002
- Orbit: 705 km, 1:30pm, Sun Synch
- IFOV : 1.1° x 0.6° (13.5 km x 7.4 km)
- Scan Range: ±49.5°
- Full Aperture OBC Blackbody, ε>0.998
- Full Aperture Space View
- Solid State Grating Spectrometer
  - IR Spectral Range:
    3.74-4.61 μm, 6.2-8.22 μm,
    8.8-15.4 μm
  - IR Spectral Resolution:
    ≈ 1200 (λ/Δλ)
  - # IR Channels: 2378 IR
- VIS Channels: 4
- Mass: 177Kg,
  Power: 256 Watts,
  Life: 5 years, 7 years goal
  (12 years current predictions)







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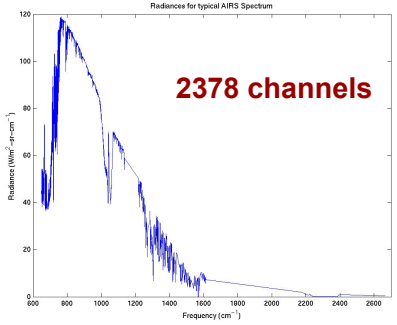
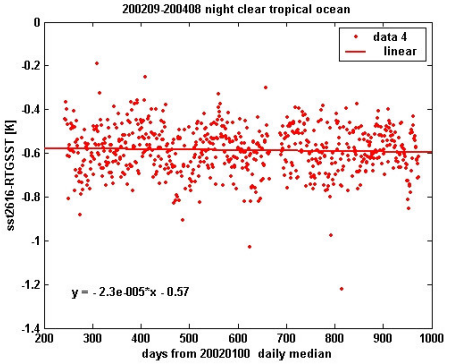
AIRS Radiometric and Spectral Accuracy and Stability Validated In Flight

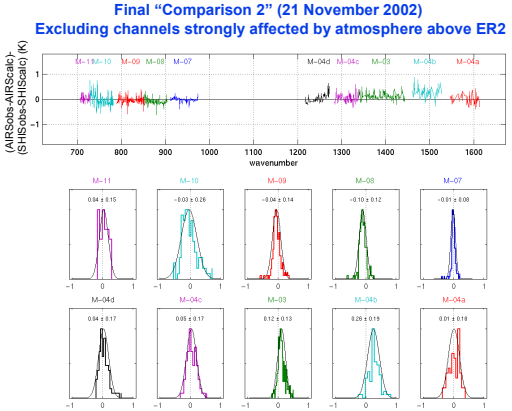
AIRS Hyperspectral Coverage Climate Data Record (CDR) over 5 Billion Spectra



AIRS Radiometric Performance: Stable to <8mK/yr – H. Aumann (JPL)

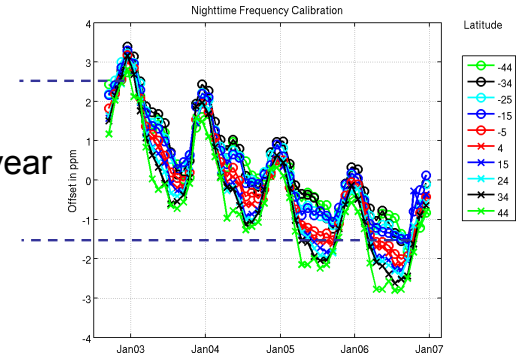


Scanning HIS Validates Rad Accy to 0.2K – H. Revercomb (UW)



AIRS Frequencies Stable Knowledge to < 1 PPM - L. Strow (UMBC)

< 1 ppm/year



L1B product

Reference: JGR, VOL. 111, April 2006

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AIRS Products and Validation Status

AIRS Product	Uncertainty Estimate (Version 5)	Val Status (Version 5)	Source
Radiances			
AIRS IR Radiance	<0.2%		Project
AIRS VIS/NIR Radiance	15-20%	Stage 1	Project
AMSU Radiance	1-3 K		Project
HSB Radiance	1-3 K		Project
Core Products			
Cloud Cleared IR Radiance	1.0 K		Project
Sea Surface Temperature	1.0 K		Project
Land Surface Temperature	2-3 K	Stage 1	Project
Temperature Profile	1 K / km		Project
Water Vapor Profile	15% / 2km		Project
Total Precipitable Water	5%		Project
Fractional Cloud Cover	20%		Project
Cloud Top Height	1 km		Project
Cloud Top Temperature	2.0 K		Project
Neccesary Products*			
Total Ozone Column	5%		Project
Ozone Profile	20%		Project
IR Dust**	0.5 K	Stage 1	Project
Research Products			
Carbon Monoxide	15%		NOAA/UMBC
Methane	2%	Stage 1	NOAA
Carbon Dioxide**	1-2 ppm	Stage 1	NASA/NOAA
OLR	5 W/m2	Stage 1	GSFC
HNO3**	0.2 DU	Stage 1	NOAA/UMBC
Sulfur Dioxide**	1 DU	Stage 1	NOAA/UMBC

>90% complete

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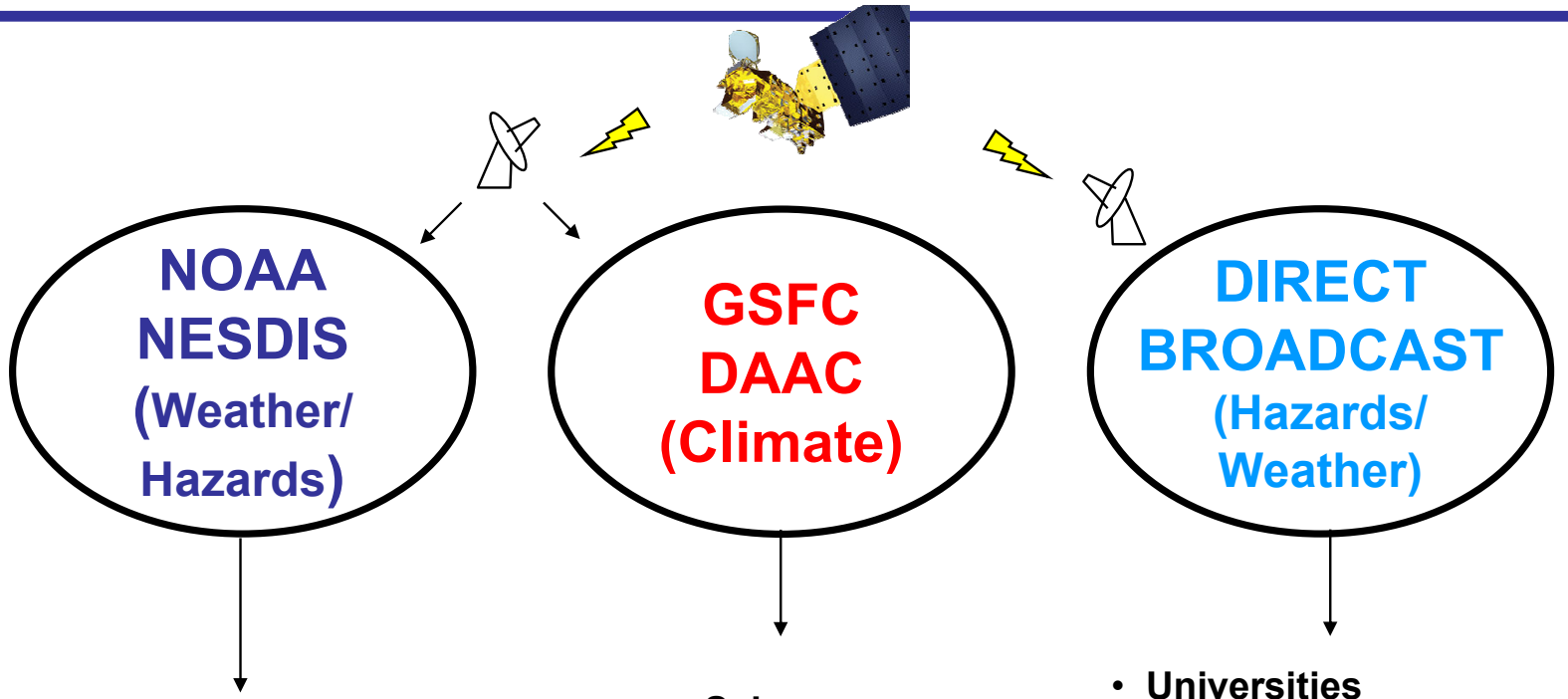
AIRS/AMSU DATA DISTRIBUTION CENTERS



NWP Centers
NCEP, GLA, CMC, JMA, FNMOC,BOM, UK Met, ECMWF, Meteo Fr., DWD

- **Science Community**
- **Public**
- **JPL**

- **Universities**
- **Local Weather Stations**
- **Brazil (INPE)**
- **China**
- **Korea**
- **DoD**

http://daac.gsfc.nasa.gov

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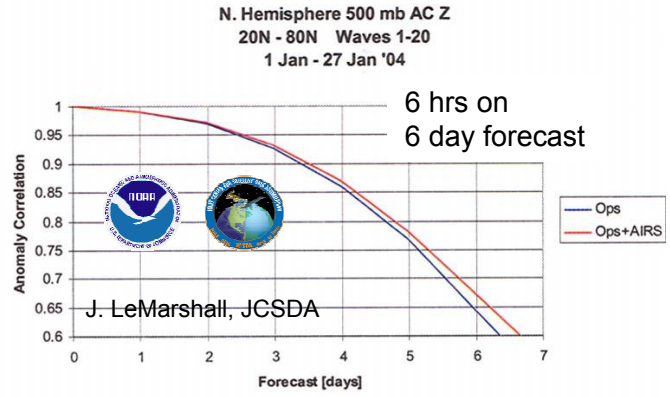
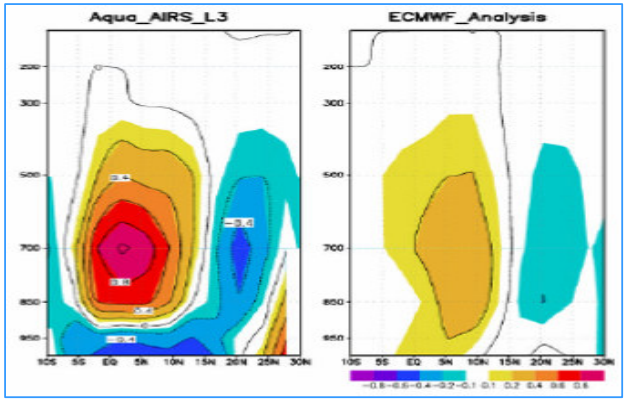
Sounders Improve Operational Weather Forecasts and Weather Research

NCEP Operational Improvement

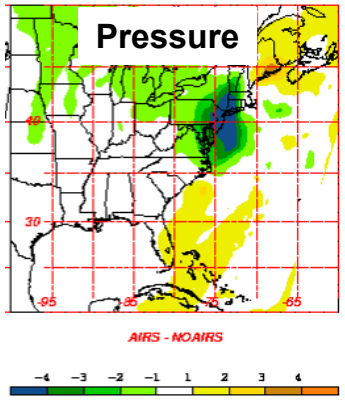


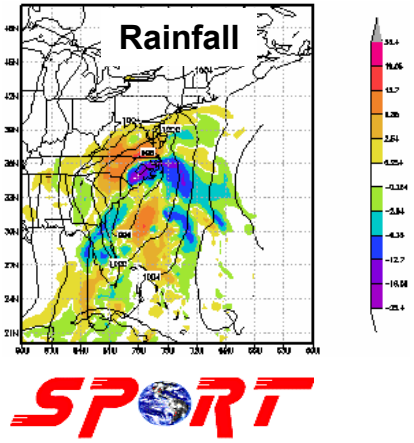
AIRS Research Validates Models



J. Fu, U of Hawaii

Regional Forecast Improvement

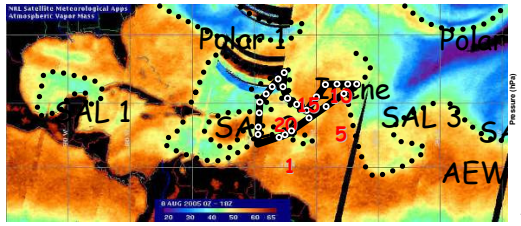


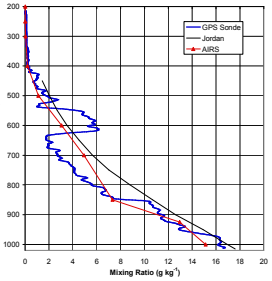


B. Zavodsky, NASA SPoRT

NOAA Hurricane Center

Saharan Air Layer Hurricane Supression





J. Dunion, NOAA

Climate Research with AIRS

1. Use AIRS L2 and L3 data products
2. Climate Record Validation

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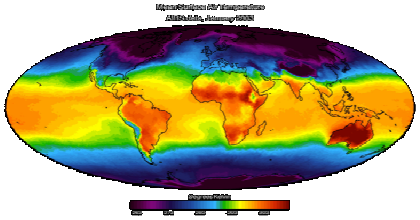
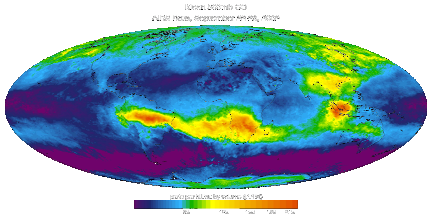
AIRS Climate Data Products
9/2002--Present

Global: Day & Night, Pole to Pole, Land & Oceans, Cloudy & Clear, Daily

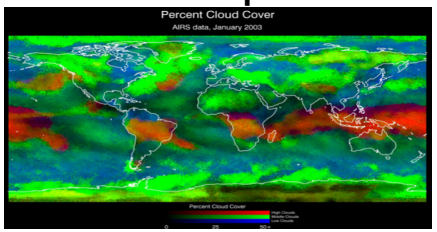
Atmospheric Temperature



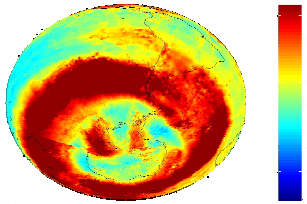
CO



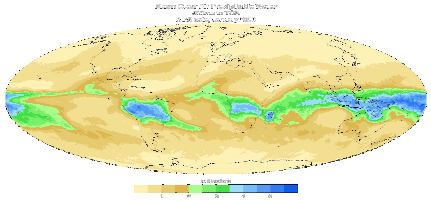
Cloud Properties



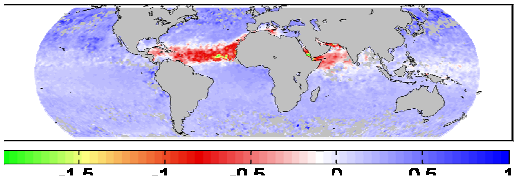
Ozone



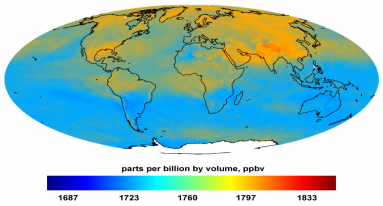
Atmospheric Water Vapor



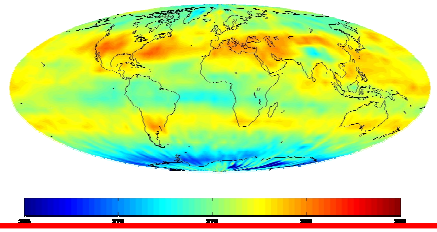
Dust



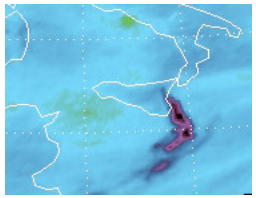
Methane



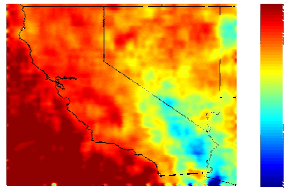
CO2



SO2



Emissivity



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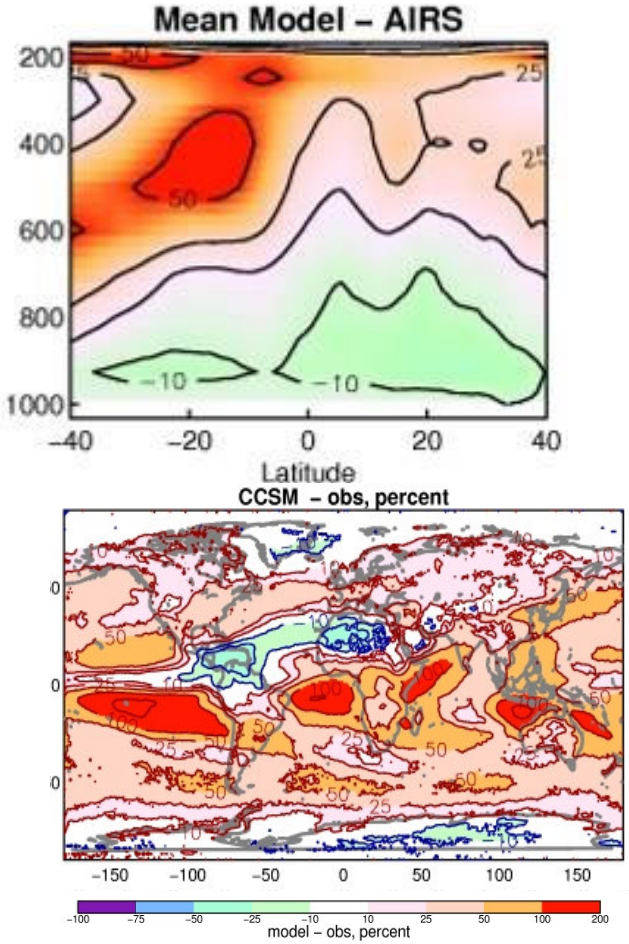
Disagreement between AIRS Water Vapor and Climate Models

- Mapped Products (L3)
  - The models are drier than AIRS observations by 10%-25% in the tropics below 800 hPa.
  - The models are more moist by 25%-100% between 300 and 600 hPa, especially in the extra-tropics.

** David W. Pierce, Tim P. Barnett, Eric J. Fetzer, Peter J. Gleckler, Three-dimensional tropospheric water vapor in coupled climate models compared with observations from the AIRS satellite system, GRL, VOL. 33, L21701, doi:10.1029/2006GL027060, 2006*



2003-2005 400 hPa water

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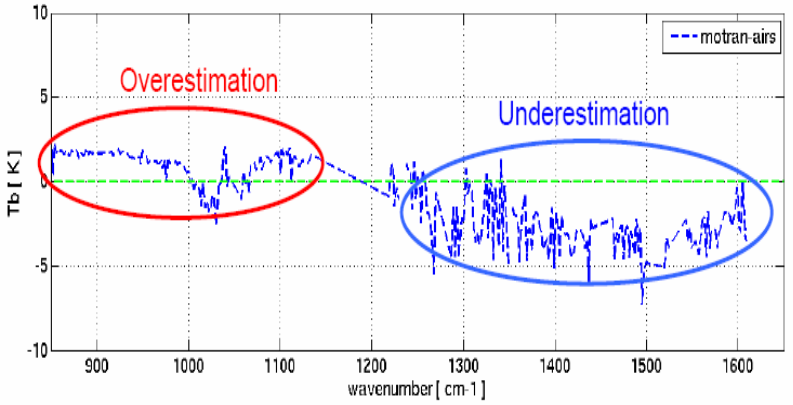
Disagreement between AIRS Water Vapor and Climate Models

- Radiances (L1b)
  - Model agrees with OLR but....
  - Compensating Errors

    Models dry in lower troposphere compensated by higher surface flux

    ** Huang et al. 2007.*

Unit: W m^{-2}	OLR		Window band	
	Total sky	Clear sky	Total sky	Clear sky
CERES	**241.73**	**275.87**	**66.94**	**83.28**
AM2	**240.63**	**263.43**	**73.99**	**87.56**
AM2-CERES	-1.10	**-12.44**	7.05	**4.28**



Climate Research with AIRS

1. Use AIRS L2 and L3 data products
2. Climate Record Validation

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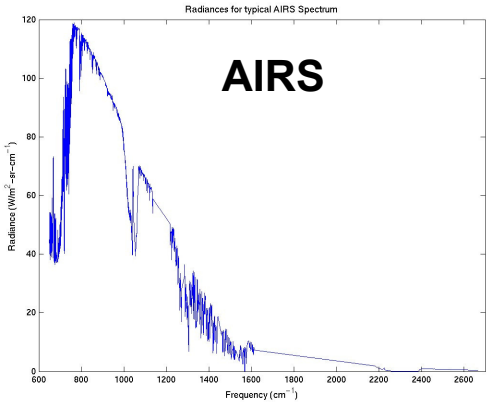
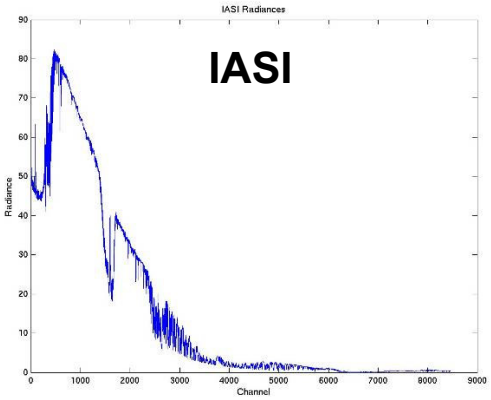
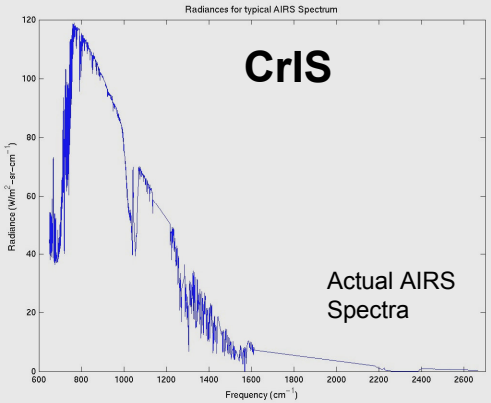
AIRS Started Series of Operational Hyperspectral Sounders





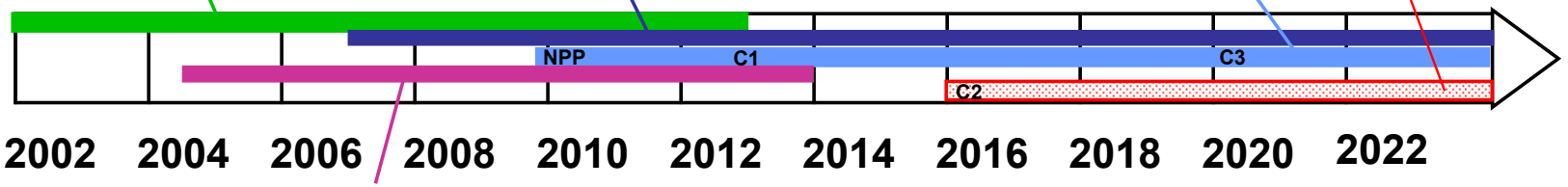


AIRS on Aqua
1:30 PM Orbit
14 km GSD
±49.5° Swath
0.1-0.2K Absolute
10mK/year Stability

IASI on MetOp
10:30 AM Orbit
12 km GSD
±49° Swath

CrIS on NPOESS
1:30 PM Orbit
14 km GSD
±48.3° Swath
C1: 2013
C3: 2020

NPOESS
5:30 AM
C2: 2016
CrIS De-Manifested



2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022

TES on Aura
1:30 PM Orbit

Climate Research with AIRS

1. Use AIRS L2 and L3 data products

→ 2. Climate Record Validation

If AIRS and CRIS radiances are concatenated, how radiomentically consistent is the resulting data record ?

Use AIRS and IASI data for the evaluation

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Any disagreement between AIRS and IASI is not a climate signal

- Diurnal coverage differences
- Spectral resolution differences
- Footprint size difference

Agreement has to be achieved under climatogically representative conditions

- Global
- cloudy

Validation under clear tropical ocean conditions is realtively easy

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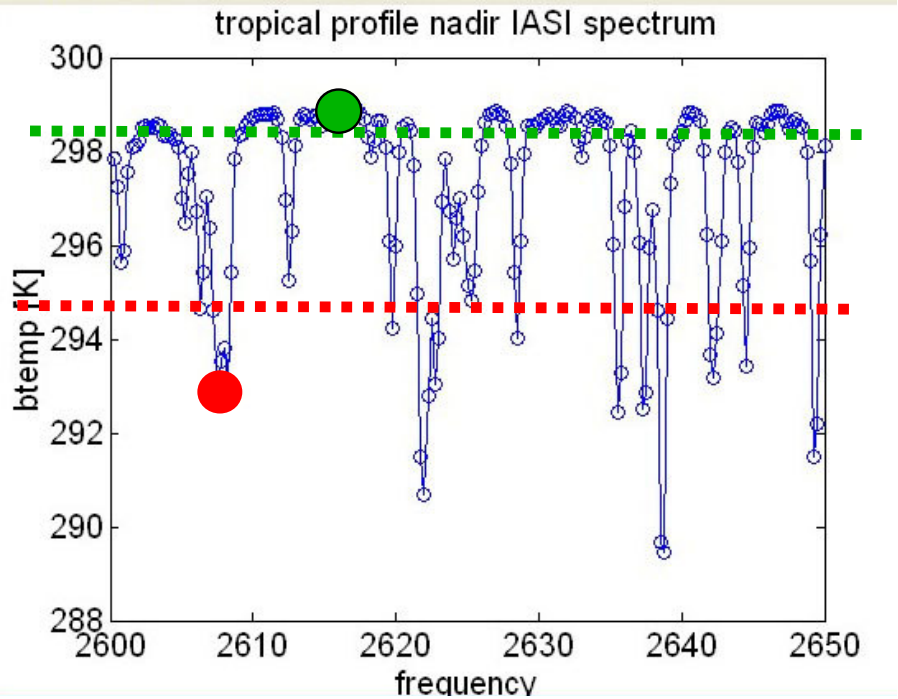
IASI Calibration Montoring using (obs-calc) at 2616 cm-1 for tropical ocean

- Band 3 (Shortwave)
  - uses the synthesized 2616 cm^{-1} and 2607^{-1} channels to decrease the effect of noise
  - 2616 synthesized by average of 93 window channels

    2607.9 synthesized by averaging 45 water channels between 2600 cm^{-1} and 2650 cm^{-1}
- Use very tight spatial coherence test for extremely clear footprints

  Yield is 1% of the night tropical ocean footprints, typically 1500 matchups per day, same % as AIRS clear



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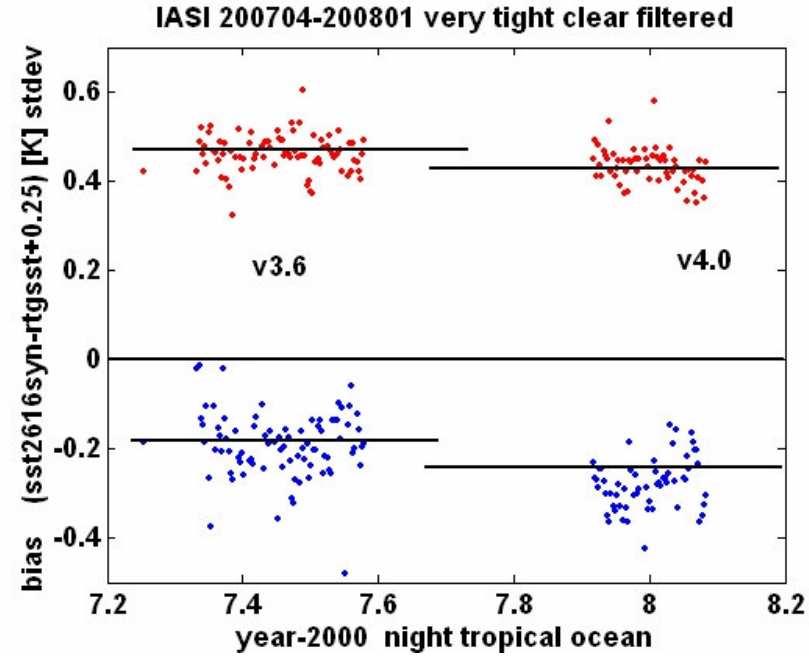
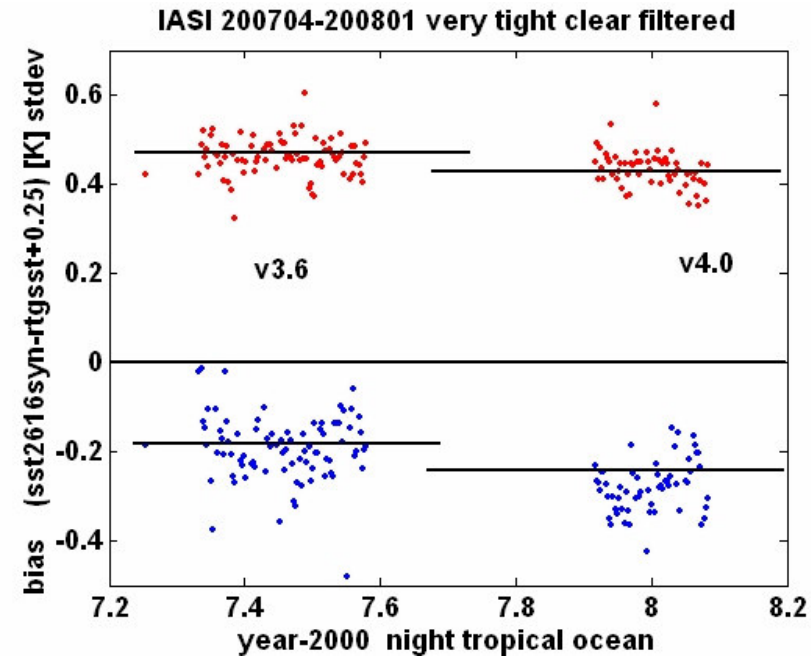
IASI.2616syns (obs-calc)



mean=-0.19 K mean = -0.28
stdev= 0.46 K stdev = 0.43

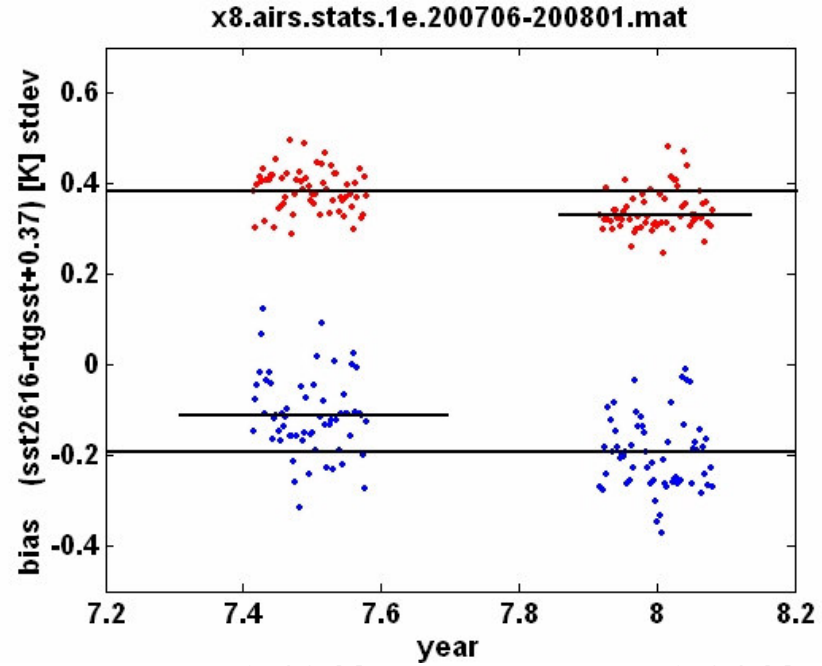
The IASI – AIRS double difference shows excellent radiometric accuracy under clear 300 K conditions

IASI.2616syns (obs-calc)



mean=-0.19 K mean = -0.28
stdev= 0.46 K stdev = 0.43

AIRS.2616 (obs-calc)



mean=-0.12 K mean = -0.21 K
stdev= 0.38 K stdev = 0.33 K

Validation under clear tropical ocean conditions at the 0.1K level is a necessary condition, but not sufficient for climate quality

Validation under cloudy and cold conditions is critical for climate applications

The mean Earth brighness temperature in a 10 micron window channel is 275 K, much colder in water channels.

Validation at the 0.1K level is very difficult.

- Massive averages
- AIRS/IASI difference at orbit crossings

None have reached the 0.1 K level

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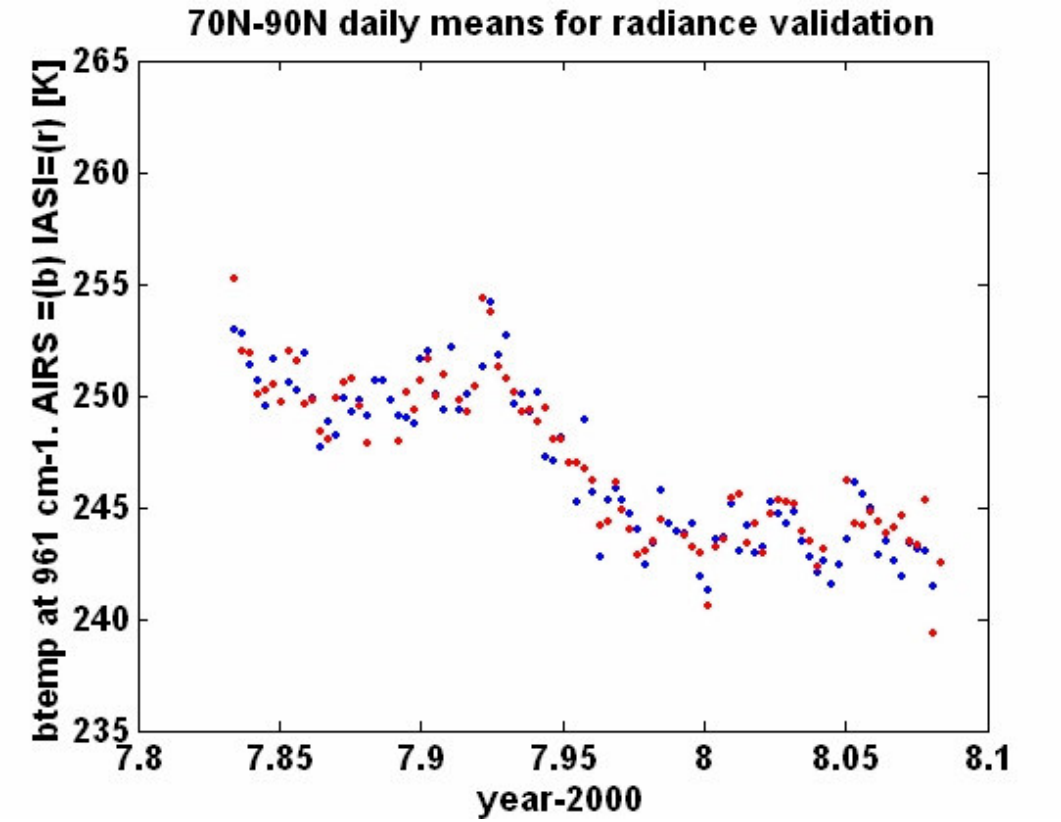
Polar night minimizes diurnal effects due to different orbits



each dot is the daily mean 70-90N btemp at 961 cm-1

IASI-AIRS daily mean difference = 0.23 ± 0.19 K
(stdev=1.82 K for 91 days)

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Summary and Conclusions

- The AIRS on Aqua measures hyperspectral infrared with high accuracy and stability
- AIRS Products support model validation and process studies
  - Disagreements with climate models in water vapor
  - validation and accurate spot error estimation are difficult
- AIRS-IASI comparions show climate quality under clear tropical ocean conditions at the 0.1 K level.

  - comparison under cloudy and cold conditions are in progress. Very difficult at the 0.1 K level.
- For more information on AIRS see
  - http://airs.jpl.nasa.gov