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Atmospheric Infrared Sounder (AIRS) Project Status

Thomas S. Pagano

AIRS Project Manager
California Institute of Technology
Jet Propulsion Laboratory

March 7, 2006

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AIRS/AMSU Project Status Agenda

- Mission Overview
- Science Team
- Instrument Status
- Spacecraft Status
- Standard Data Products
- AIRS Users
- Research Products
- ROSES
- AIRS Project Activities
- Conclusion

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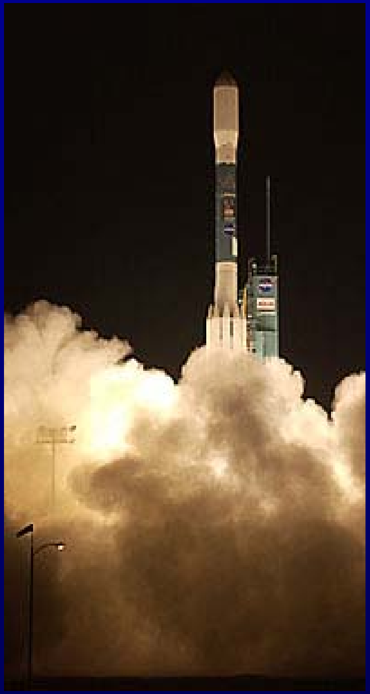
Mission Overview

- EOS Aqua Spacecraft Launched May 4, 2002
- AIRS: Atmospheric Infrared Sounder
  - 2378 Infrared Channels from 3.7-15.4 mm @ 13.5 km
  - $\lambda/\Delta\lambda > 1200$
  - 4 Vis/NIR Channels @ 2 km
- AMSU: Advanced Microwave Sounding Unit
  - 15 Microwave Channels from 23-89 GHz @ 43 km
- HSB: Humidity Sounder from Brazil
  - 4 Microwave Channels from 150-183 GHz @ 13.5 km
  - Failed February, 2003
- Objectives
  - Weather Forecasting: AIRS Already Achieved 6 hours in 6 days improvement in NH with NCEP Operational Model (JCSDA)
  - Climate Studies: Atmospheric Hydrology Cycle
  - Tropospheric Composition: O_3, CO, CO_2, CH_4, …



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AIRS Science Team

Continuing Members

Chahine, M. (TL)	JPL
Aumann, H.	JPL
Gautier, C.	UCSB
Goldberg, M	NOAA/NESDIS
Kalnay, E.	UMD
LeMarshall, J.	JCSDA
McMillin, L.	NOAA/NESDIS
Revercomb, H	U of Wisconsin
Rosenkrantz, P.	MIT
Staelin, D.	MIT
Strow, L.	UMBC
Susskind, J.	GSFC

New Members

Brewster, K.	U of Oklahoma
Barker, D.	NCAR
Icano, M.	AER
McMillan, W.	UMBC
Atlas, R.	GSFC
Lord, S.	NOAA/NCEP
Barnet, C.	NOAA/NESDIS
Knuteson, R.	U of Wisconsin
Milosevich, L..	NCAR
Tobin, D.	U of Wisconsin
Mlynczak, M	LARC

International Partners

Chedin, A. (Continuing)	CNRS
Rizzi, R. (Continuing)	U of Bologna
Calheiros, R. (Continuing)	Brazil/HSB
McNally, T.	ECMWF
Saunders, R.	UKMO

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Instrument Status: Excellent

- AIRS and AMSU Continue to Operate Normally
- Excellent Radiometric, Spatial and Spectral Stability from Both
- Small calibration changes detectable
  - 39 AIRS Channels more “noisy” than at launch due to radiation in orbit. Recoverable
  - M8 calibration at low temperatures appears slightly off
- Excellent Reliability
  - Cooler B active drive level has been <u>very slowly</u> rising for the last six months due to normal ice accumulation, and not a cause for concern
  - Chopper drive current continues a slow decline after peaking last April

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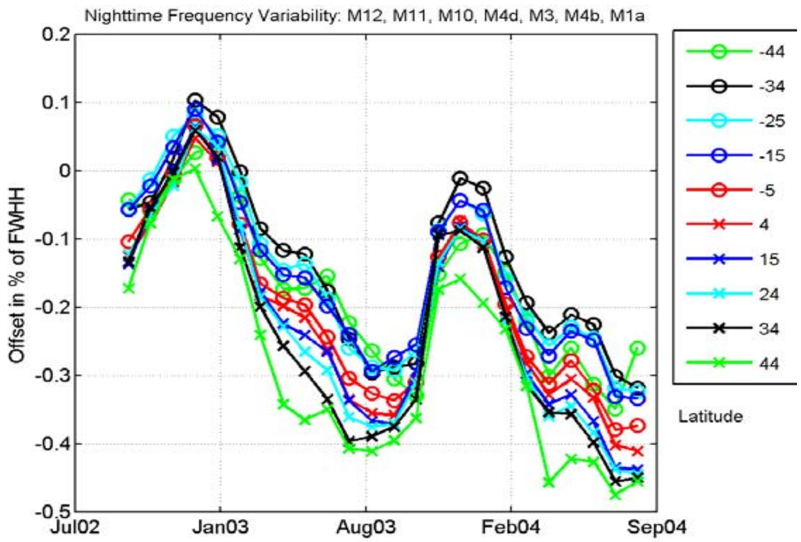
AIRS Spectral and Radiomety Extremely Stable

AIRS Frequencies Stable to <5 PPM
Knowledge to < 1 PPM
L. Strow (UMBC)

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

AIRS IR Frequencies Extremely Stable



AIRS IR Radiometry Extremely Stable

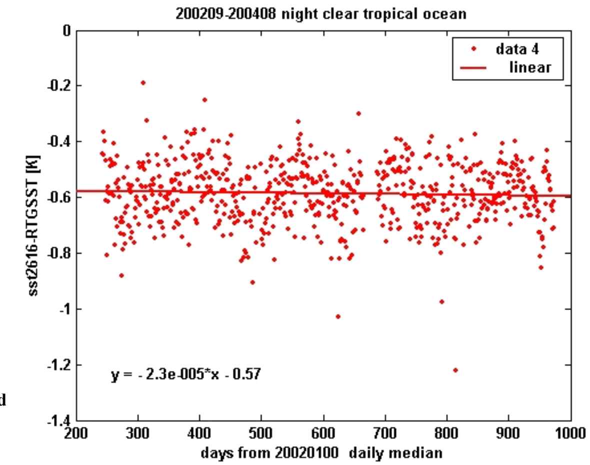
Instrument Stability
Fundamental to
Weather and Climate
Quality Observations

SST2616 compared to
RTG.SST at night
-0.57K bias observed
-0.37K bias expected

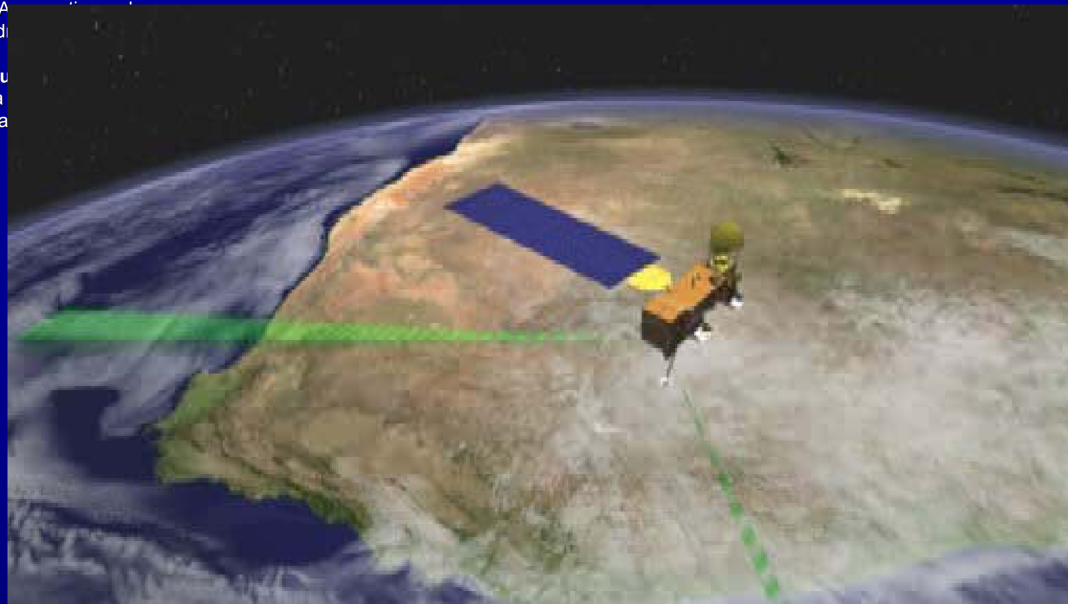
First principles using
NIST traceable
calibration

Stability better than
8 mK/Year

difference between observed
and expected bias
due to cloud contamination



Aumann et al 2004 "Evaluation of AIRS Data for Climate Applications"
SPIE 5570b Las Palmas September 2004



Aqua Spacecraft Status

- Aqua is generally healthy
- Three anomalies related to the power generation and storage systems are open, but there has been no impact on operations
- Given current trends, the primary life-limiting resource is fuel for maneuvers
  - 69 kg are available for the mission, with much more available if the re-entry reserve requirement can be relaxed
  - So far we have used about 45 kg
    - About 20 were used in post-launch orbit adjustments
    - About 15 were used in a series of inclination adjustments in fall 2004
    - About 10 have been used in all the MODIS lunar calibration roll maneuvers and drag make up burns to date
  - Another series of inclination adjustments is planned for fall 2006

AIRS Standard Products

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AIRS/AMSU/HSB Standard Products

Radiance Products (Level 1B)	RMS Requirement	Current Estimate
AIRS IR Radiance	3%*	<0.2%
AIRS VIS/NIR Radiance	20%	10-15%
AMSU Radiance	0.25-1.2 K	1-2 K
HSB Radiance	1.0-1.2 K	N/A
Standard Core Products (Level 2)		
Cloud Cleared IR Radiance	1.0 K	<1.0 K
Sea Surface Temperature	0.5 K	0.8 K
Land Surface Temperature	1.0 K	TBD (V5)
Temperature Profile	1 K / km	1K / km
Humidity Profile	15% / 2 km	15% / 2km
Total Precipitable Water	5%	5%
Fractional Cloud Cover	5%	TBD (V5)
Cloud Top Height	0.5 km	TBD (V5)
Cloud Top Temperature	1.0 K	TBD (V5)

*Absolute Relative to NIST

NOAA/NESDIS Distributes to NWP Centers

AIRS Data

NOAA NESDIS

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

- **NOAA/NESDIS**
- **Satellite Meteorology and Climatology Division**
- **Office Research and Applications**
- **Mitch Goldberg, Chris Barnet**

NWP Centers

NCEP, GLA, CMC, JMA, FNMOC, BOM, UK Met, ECMWF, Meteo Fr., DWD, GMAO, JPL

- **Joint Center for Satellite Data Assimilation (JCSDA)**
- **John Le Marshall**
  - **Director JCSDA**
  - **AIRS Science Team Member**

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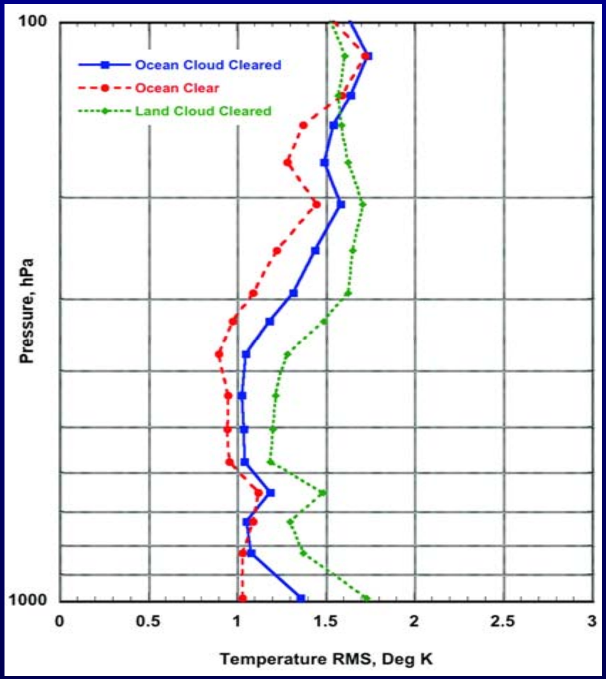
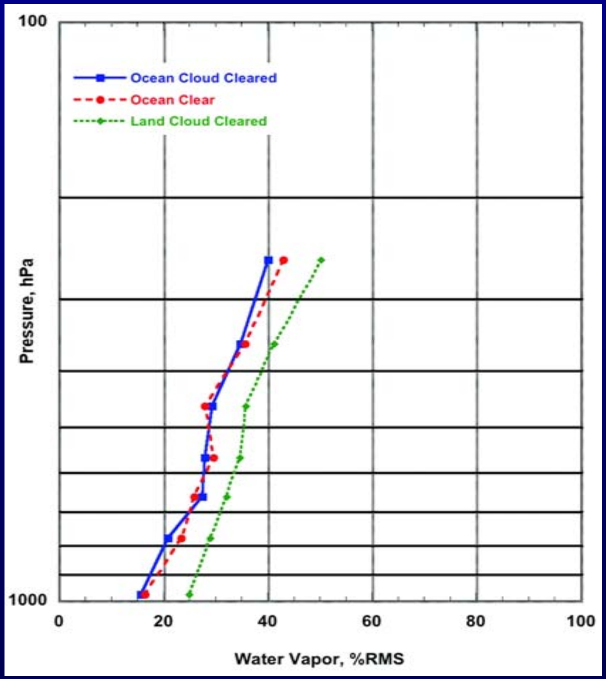
Highly Accurate Temperature and Water Vapor Profiles Can Be Achieved from Space

Temperature Profiles



Water Vapor Profiles



AIRS Validation With Collocated Radiosondes
Cloud Cleared (N= 59,433) *vs.* Clear (N=1000)
ALL Samples (Sea/Land/Coastal)

(Murty Divakarla/NOAA)

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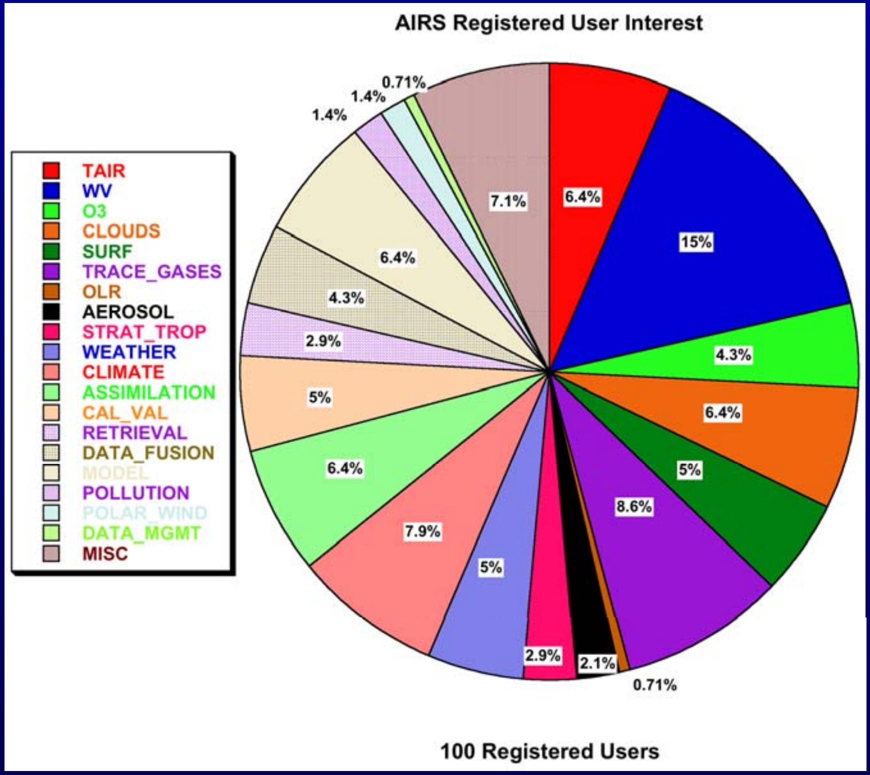
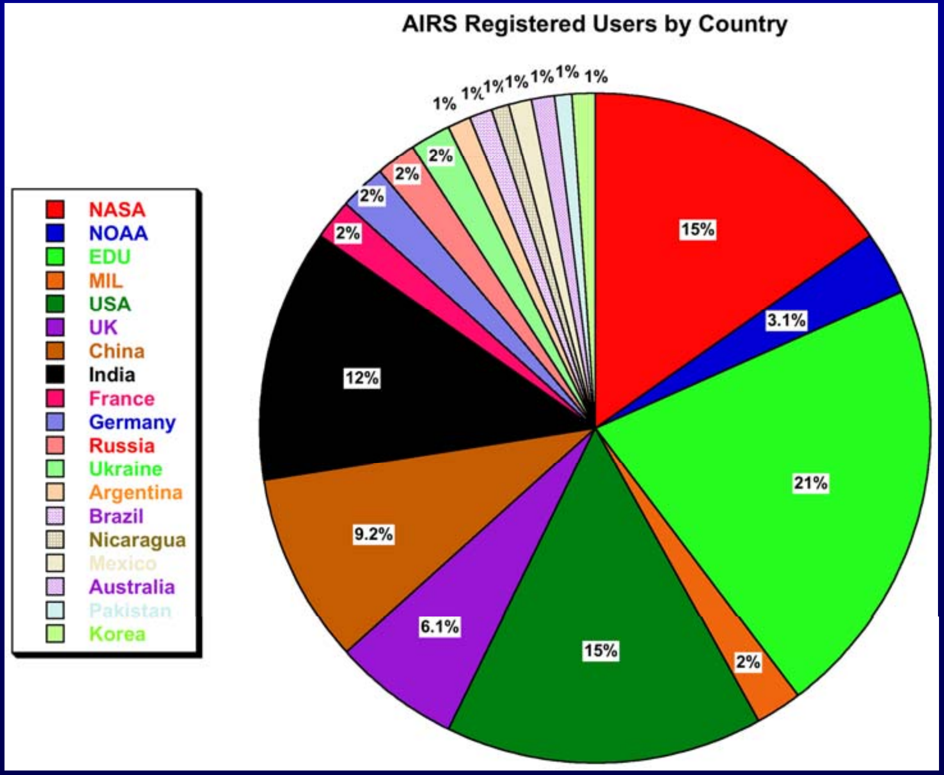
AIRS Has Diverse International User Set Request from DAAC (Not NOAA)

Most users interested in T(p), q(p)



Most users from Universities



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Standard Product Activation / Validation Timeline

Version	3.0	4.0	5.0	6.0
Activation Date	9/03	4/05	9/06	10/07
Radiance Products (L1)	Ocean	Land	Polar	Global
AIRS Radiance	Prov	Val2	Val3	Val4
VIS/NIR Radiance	Prov	Val2	Val3	Val4
AMSU Radiance	Beta	Prov	Val2	Val3
HSB Radiance	Beta	N/A	N/A	N/A
Standard Products (L2)				
Cloud-Cleared IR Radiance	Beta	Val2	Val3	Val4
Surface Temperature	Beta	Val1	Val2	Val4
Temperature Profile	Val1	Val2	Val3	Val4
Humidity Products	Beta	Val1	Val2	Val3
Cloud Cover Products	N/A	Val1	Val2	Val3

Beta = Not suitable for scientific investigations.

Prov = Provisionally validated. Useable for scientific investigations with caution. Validated for non-polar, night, ocean only.

Val1 = non-polar, day/night, ocean.
Val2 = Val1 + land.
Val3 = Val2 + polar
Val4 = Global All Cases

AIRS Research Products

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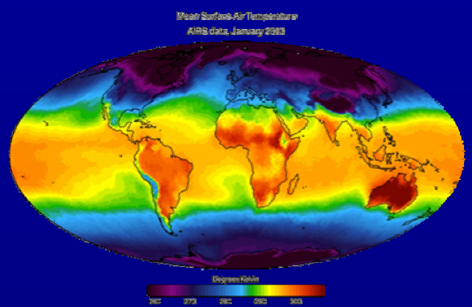
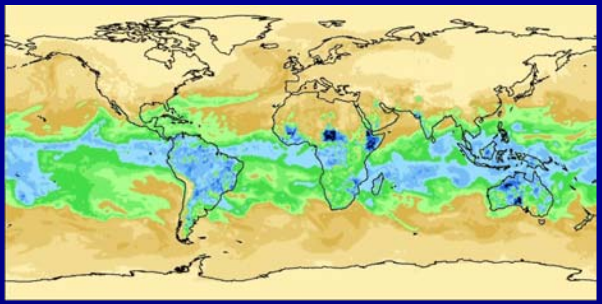
AIRS Research Products

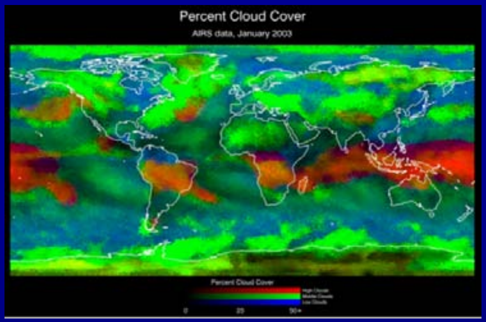
Near Surface Temperature



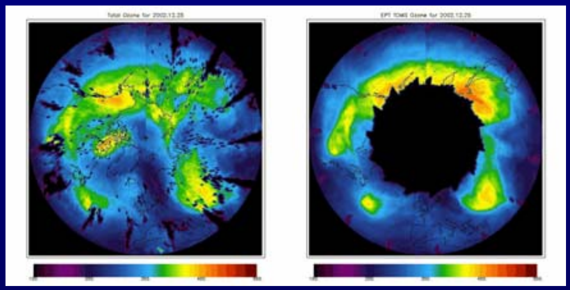
Daily 500 mb H2O



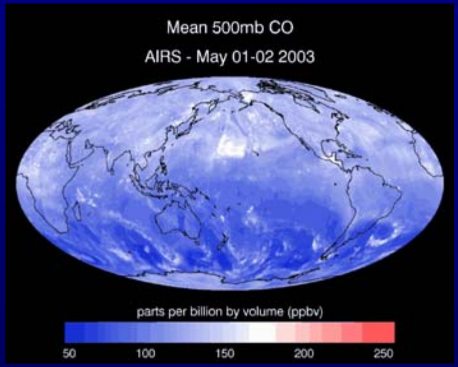
Clouds



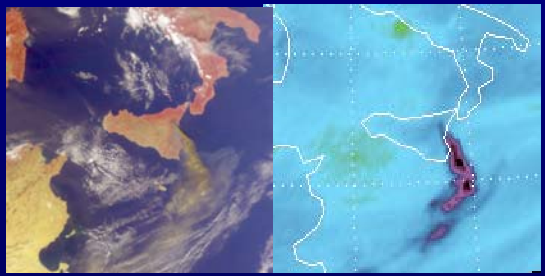
Ozone



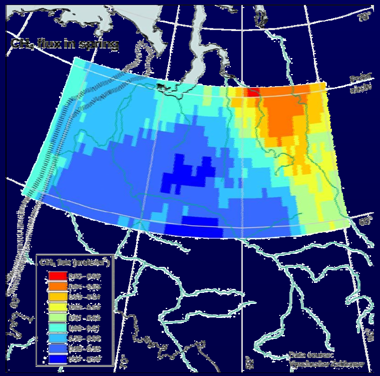
CO



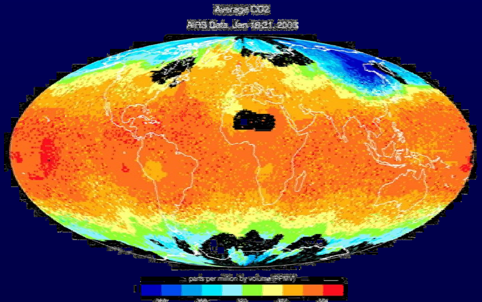
SO_2



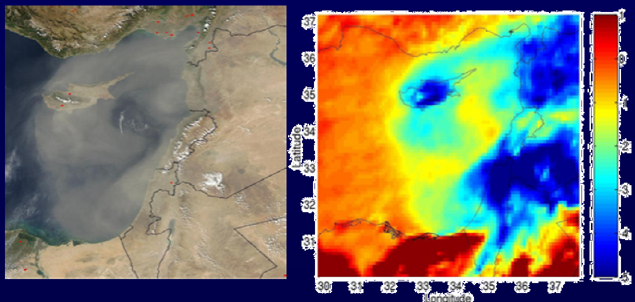
CH_4



CO_2



Aerosols



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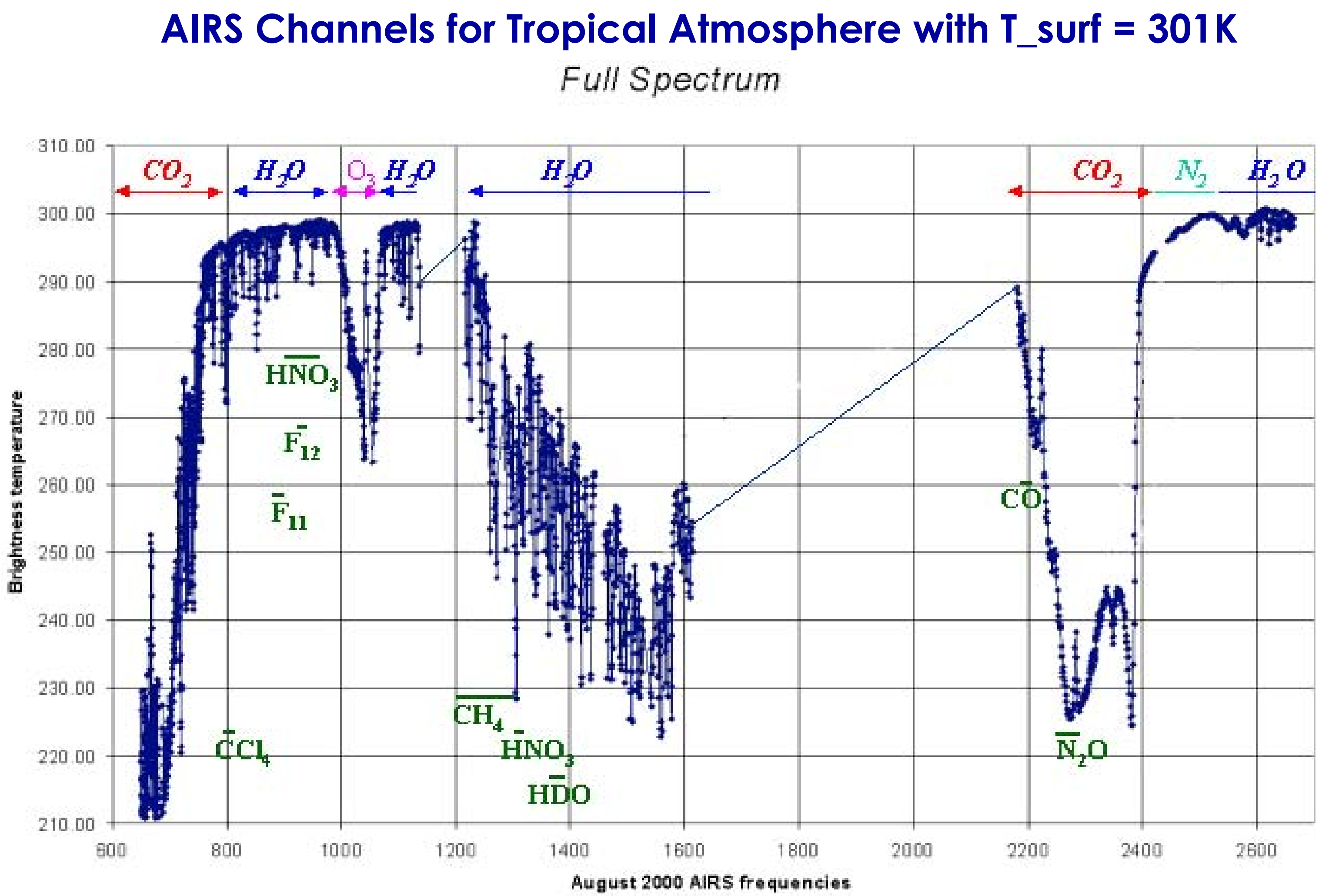
Infrared Spectrum Rich with Information about The Atmosphere



Mike Gunson (JPL)

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Next NASA Funding Opportunity through ROSES

- ROSES: Research Opportunities in Space and Earth Science 2006
- Appendix A1: Earth Science Focus Area
  - $87.5M / Year
  - Fewer Investigations than last year
- A.15 - Earth System Science Research using Data and Products from the Terra, Aqua, and ACRIMSAT Satellites
  - Notice of Intent: May 1, 2006
  - Proposals Due: July 7, 2006
  - **Includes: AIRS Science Team, NASA NPP Science Team**
- Many other Programs to consider
  - A.14 (Proposals Due 4/6/06) Interdisciplinary Research
  - A.9 (Proposals Due 5/4/06) Atmospheric Composition
  - A.16(Proposals Due 4/20/06): International Polar Year
- NSPIRES: http://nspires.nasaprs.com

AIRS Project Activities

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Current AIRS Project Activities

- Instrument Operations
  - Maintain health and safety of AIRS and AMSU. Trend Telemetry
- Level 1 Products
  - Improve calibration and characterization using in-situ observations and re-analysis of pre-flight data. Includes Spectral, Spatial and Radiometric
- Level 2 and 3 Products
  - Product Development
    - Integrate Science Team Algorithms for Version 5
    - Investigate AIRS-Only Retrievals, Spectral Emissivity
    - Subsystem and System test of V5 modules
  - Product Generation: Software to DAAC and NOAA
  - Validation of Version 4 and 5 data products
  - Product Documentation: User Guides, ATBD, Data Readers
- Research Products Development
  - Trace Gas Retrieval Algorithms. PRM, VPD, OE
  - Climate Modeling Support. Facilitate use of AIRS data.
- User Services, Website, Press Releases
- Monthly Reports; Program Reviews

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AIRS/AMSU Project working with other NASA instrument Teams. One NASA

- AMSR-E: Cross validation of water vapor. JPL wins NEWS proposal to combine A-Train water vapor products (Fetzer/JPL)
- GPS: GPS receivers used to validate AIRS water vapor in polar regions (Manucci/JPL)
- TES: Cross validation of AIRS Ozone in an effort to improve AIRS trace gas retrieval algorithms (Irion/JPL)
- MLS: Cross comparison of cloud/ice products with AIRS and assessment of temperature biases
- MISR: Cross validation of AIRS Aerosol Products (Diner/JPL)
- MODIS: Cross-calibration, SST validation, Cloud Clearing (Tobin/UW, Aumann/JPL)

- **AIRS has become a calibration standard by which other sensors gauge their radiometric accuracy**

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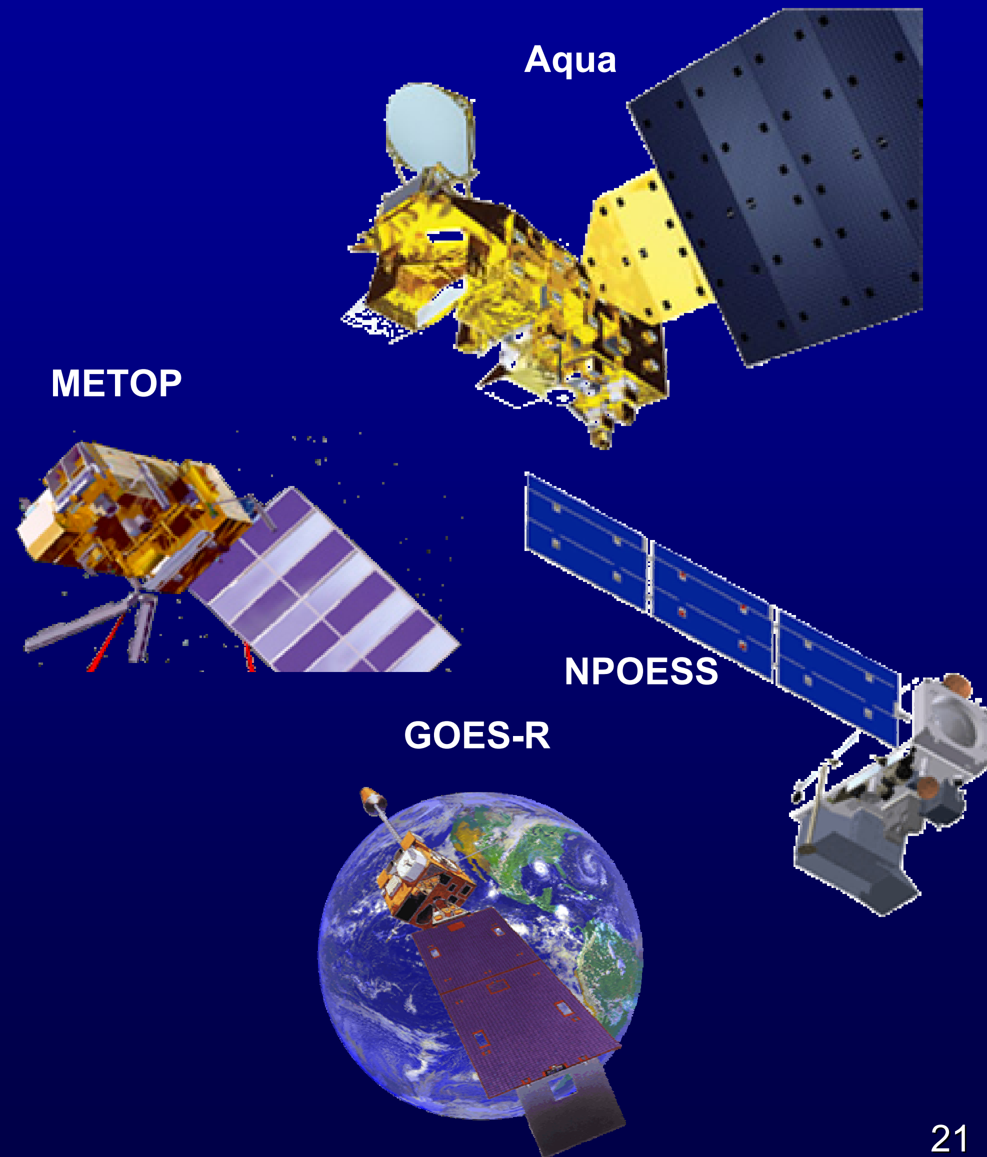
AIRS Paving the Way for Planned Sounders

- **Current IR Sounder**
  - AIRS on Aqua
    - 2002 Launch
    - LEO
    - 3.7-15.4 μm
    - 13.5 km IFOV
- **Planned IR Sounders**
  - IASI on METOP
    - 6/30/2006 Launch
    - LEO
    - 3.6-15.4 μm
    - 12 km IFOV (25 km GSD)
  - CrIS on NPP/NPOESS
    - 2009 1st Launch
    - LEO
    - 3.9-15.4 μm
    - 14 km IFOV
  - HES on GOES-R
    - 2012 Launch
    - GEO
    - 4.4 – 15.4 μm
    - 4 km IFOV



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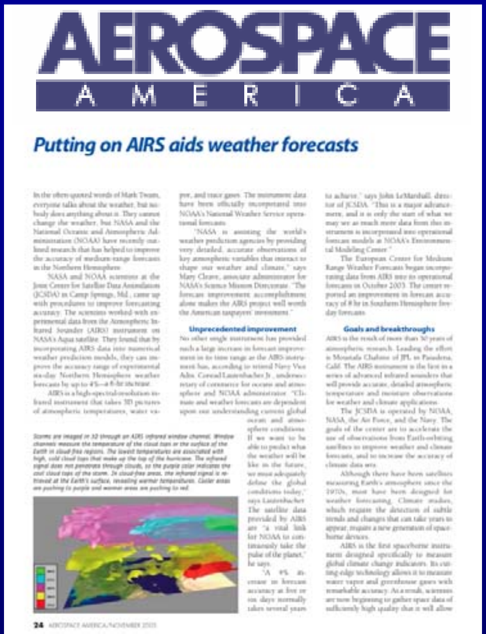
AIRS in the NEWS



AEROSPACE AMERICA

Putting on AIRS aids weather forecasts

- Aerospace America magazine - The article “Putting on AIRS aids weather forecasts” can be found in the November 2005 issue of this AIAA publication.
  - Writer Edward Flinn details AIRS' improvements to forecasting and gives an overview of the instrument and mission goals. Finn also discusses how AIRS goes about it's weather improvement business, and it's use in climate change research.

AVIATION WEEK & SPACE TECHNOLOGY

STORM SERENDIPITY

- Aviation Week covers satellites in weather forecasting
  - The article “Storm Serendipity” tells how satellites have improved the ability to forecast storms. AIRS is pointed out as having improved forecast accuracy by 6 hours.

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JCSDA Forecast Impact Published in EOS

Joint Center for Satellite Data Assimilation (JCSDA)
NCEP Operational Model

"A several hour increase in forecast range at five or six days normally takes several years to achieve at operational weather centers"

"This magnitude of improvement is quite significant when compared with the rate of general forecast improvement over the last decade".

John Le Marshall in EOS,
March 15 2005, Vol 86, No 11

EOS

IN THIS ISSUE: Preparedness and Mitigation Systems for Asian Tsunami-Type Hazards, Pg. 111
Linking the Scales of Observation, Process, and Modeling of Dust Emissions, Pg. 113
Outstanding Student Paper Awards, Pg. 115

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION VOLUME 86 NUMBER 11 15 MARCH 2005

Landslide Surveillance: New Tools for an Old Problem

Impact of Atmospheric Infrared Sounder Observations on Weather Forecasts

Advanced Sounder (AIRS) & HIRS/2

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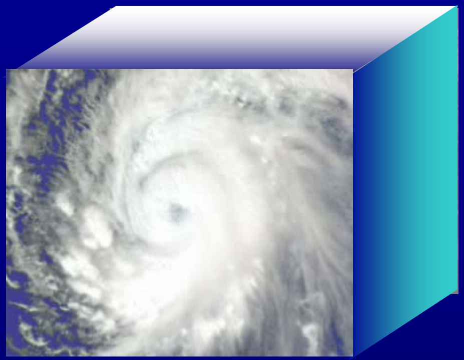
Global High Spectral and High Spatial Resolution Observations Needed

Improved:
- Water Vapor
- Surface Emissivity
- Retrievals over Land

AIRS High Spectral



AIRS
- 13.5 km IR IFOV
- 3.7-15.4 μm IR
- 2378 IR Channels
- $\lambda/\Delta\lambda$ = 1200
- NEdT = 0.05 - 0.3 K
- ± 50° FOV

High Spatial / High Spectral

ARIES
- 1 km IR IFOV
  0.25 km VIS, 0.5 km SW
- 0.4-15.4 μm
- >2000 IR Channels
- $\lambda/\Delta\lambda$ > 1000 (IR)
- NEdT = 0.1 - 0.3 K
- ± 55° FOV

MODIS High Spatial

MODIS
- 1 km IR IFOV
  0.25-0.5 km VNIR/SW
- 0.4-14.2 μm IR
- 20 RSB, 16 IR Channels
- $\lambda/\Delta\lambda$ = 20-50
- NEdT = 0.05 - 0.3 K
- ± 55° FOV

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Advanced Remote-sensing Emission and Imaging Spectrometer (ARIES)

- ARIES is an instrument concept to enhance AIRS observations from low earth orbit using higher spatial resolution
- ARIES offers Hyperspectral Visible through Infrared at Moderate Spatial Resolution (0.25 km Vis/NIR, 0.5 km SW, 1km IR)
- Full Earth Coverage. Select regions and bands desired (to reduce data rate)
- Improves observational accuracy of water vapor
  - ARIES will do for water vapor what AIRS did for temperature
- Higher resolution temperature sounding for improved weather forecasting
- Improved surface emissivity determination
- Technology development in progress since 1997. TRL 6 achieved
- Mission ready. JPL pursuing opportunities.

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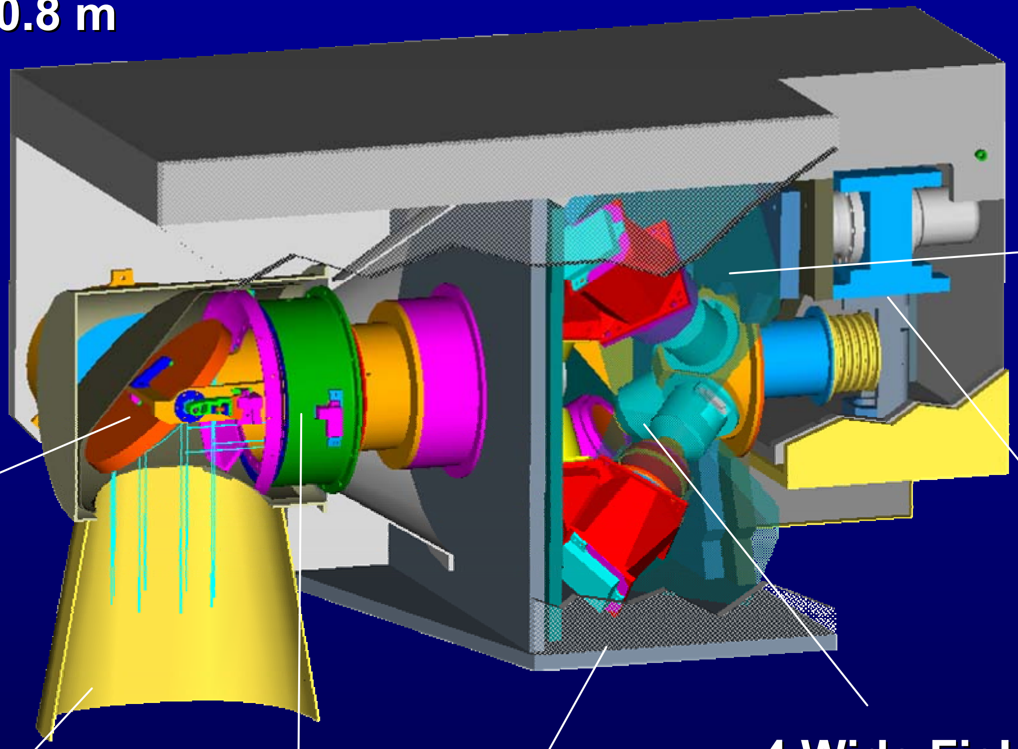
ARIES Instrument Concept

Size: 0.4 x 0.4 x 0.8 m
Mass: 70 kg
Power: 100 W



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Summary and Conclusions

- AIRS Instrument and spacecraft healthy
- AIRS Instrument stability makes products useful for climate
- Standard Data Products of excellent quality
- Version 5 to have new products and improved quality
- Research Products of great interest to NASA
- ROSES is good opportunity for new research using AIRS data
- AIRS Algorithms paving the way for future sounders
- Your publications needed to promote observational strategy
- AIRS technology development offers higher spatial resolution AIRS-like observations in the future (ARIES)
- AIRS Project here to support your needs
- AIRS Website undergoing improvement
- http://airs.jpl.nasa.gov