



National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS Project Status

Thomas S. Pagano

California Institute of Technology, Jet Propulsion Laboratory,
4800 Oak Grove Dr. Pasadena, CA 91109

October 13, 2009

NASA Sounder Science Team Meeting
Greenbelt, MD



National Aeronautics and
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Jet Propulsion Laboratory
California Institute of Technology
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Agenda

- AIRS/AMSU and Aqua Status
- AIRS/AMSU Data Products
- Science Highlights
- Version 6 Development Status

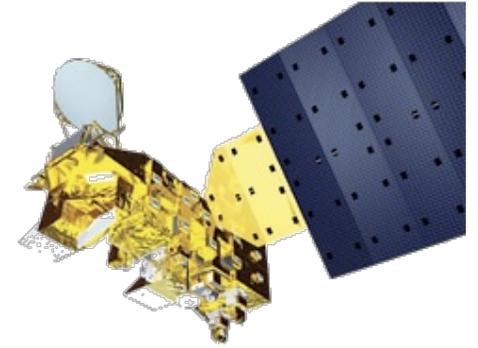


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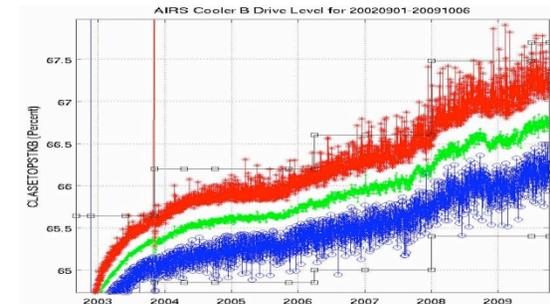
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Instrument and Spacecraft Status

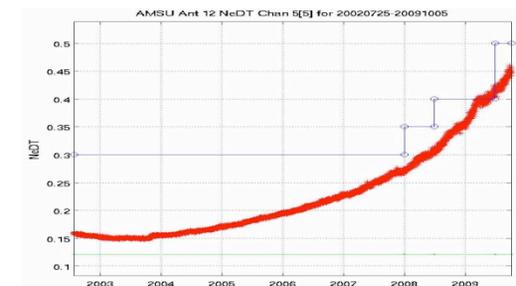
- Aqua in good health—fuel will last at least through 2017 and probably several years beyond
- AIRS is in excellent health
 - Most engineering parameters are not changing
 - A few are slowly varying
 - If their present trends continue they will be fine until well after Aqua fuel runs out
- AMSU-A is in good health except
 - Channel 4 died (late 2007)
 - Channel 5 is degrading but should be useful until sometime in 2010
 - Channel 7 has been noisy since launch



AIRS Cooler B Drive Current



AMSU Ch5 Noise



3



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AIRS Electronic Library Online

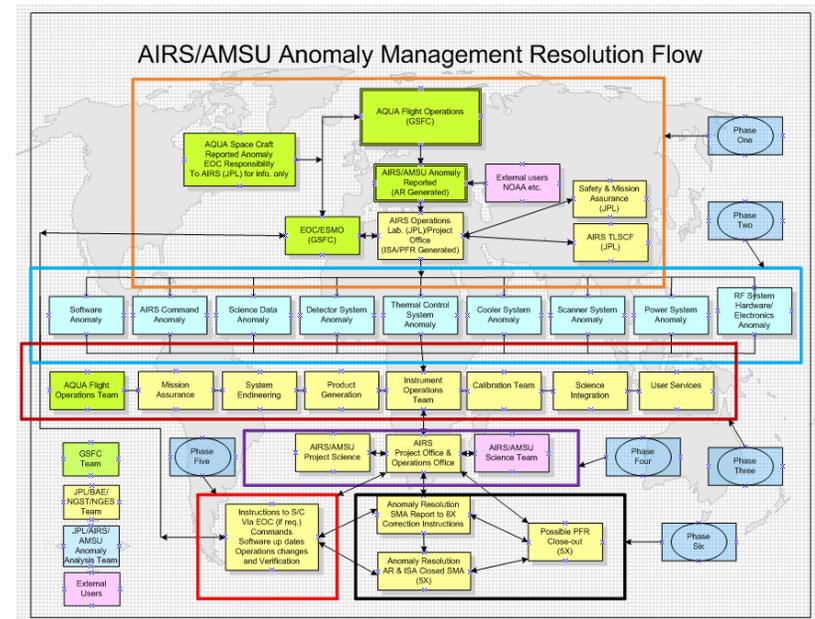
Welcome to the AIRS Electronic Library

This is the access portal to the AIRS library stored on a local hard disk for easy, rapid access to all library documents. The historical documents date back to the 1970's and other documents to the contract start in the late 1980's. The library is divided into four main folders covering the following documents types:

- 1) **Loral/Lockheed/Bae Design File Memos (called DFNs)**
- 2) **JPL AIRS Design Memos (called ADFs)**
- 3) **AIRS Document Library**
- 4) **AIRS Drawing Library**

Drawing Tree
Drawings
ECOs
Specifications
Test Documents
Vendor and Sub-Contractor Drawings/ECOs

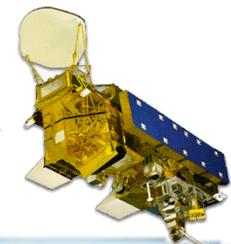
Anomaly Resolution Management Plan Complete





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AIRS Science Data Providers using code developed and distributed by the AIRS Project



DIRECT BROADCAST COMMUNITY



NOAA STAR

(bent pipe)



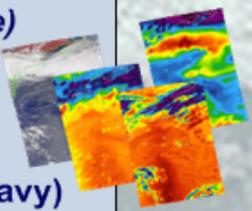
GES DISC



NWP CENTERS

(near-real-time)

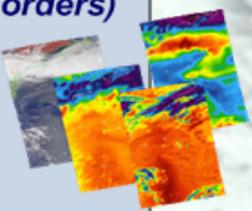
- NCEP
- CMC (Canada)
- JMA (Japan)
- FNMO (US Navy)
- BMRC (Australia)
- UK Met Office
- ECMWF (Europe)
- Meteo-France
- DWD (Germany)
- CPC



DISC Archive Users

(ad-hoc and standing orders)

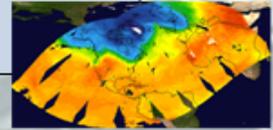
- Weather and Climate Research
- Climate Databases
- Hurricane Studies



DISC NRT Users

(near-real-time ftp access)

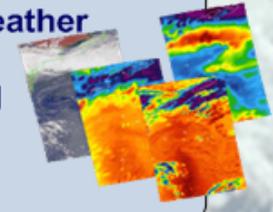
- Weather Forecast Centers
- Regional Warnings



Direct Broadcast Users

(near-real time)

- US Navy (NOCC)
- NASA SPoRT (Regional NOAA)
- Algeria – Univ of Blida
- Australia – Bureau of Meteorology
- Brazil – INPE and CTPEC
- China – CECT CHINACOMM
- Taipei – Central Weather Bureau
- UK – Fleet England
- Other International





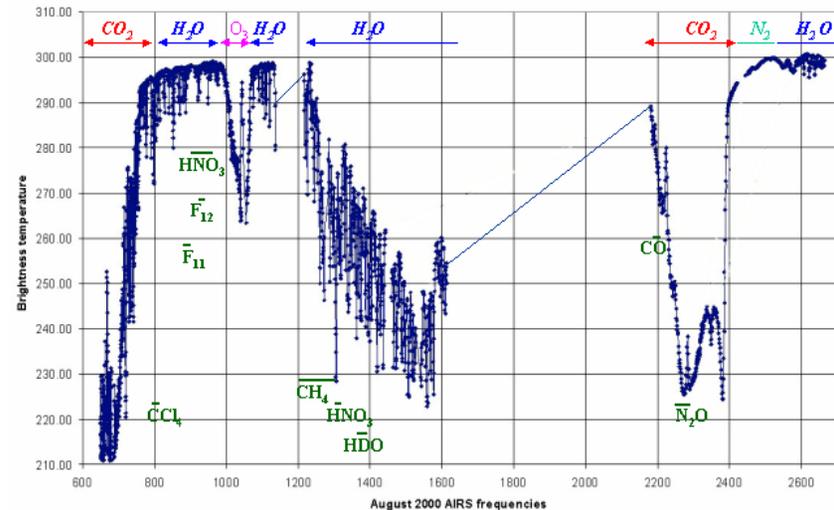
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11 Core AIRS Products Measure Atmospheric State

| AIRS Product | Product | Accuracy (V5) | Val Status (V5) |
|---------------------------|------------|---------------|-----------------|
| Core: Radiances | | | |
| AIRS IR Radiance | L1B-AIRS | <0.2K | Stage 3 |
| AIRS VIS/NIR Radiance | L1B-VIS | 15-20% | Stage 1 |
| AMSU Radiance | L1B-AMSU | 1-3 K | Stage 3 |
| HSB Radiance | L1B-HSB | 1-3 K | Stage 3 |
| Core: Geophysical | | | |
| Cloud Cleared IR Radiance | L2 | 1.0 K | Stage 2 |
| Sea Surface Temperature | L2 | 1.0 K | Stage 2 |
| Land Surface Temperature | L2 | 2-3 K | Stage 1 |
| Temperature Profile | L2 | 1 K / km | Stage 3 |
| Water Vapor Profile | L2 | 15% / 2km | Stage 3 |
| Total Precipitable Water | L2 | 5% | Stage 3 |
| Fractional Cloud Cover | L2 | 20% | Stage 2 |
| Cloud Top Height | L2 | 1 km | Stage 2 |
| Cloud Top Temperature | L2 | 2.0 K | Stage 2 |
| Carbon Monoxide | L2 | 15% | Stage 2 |
| Carbon Dioxide | Post-Proc | 1-2 ppm | Stage 1 |
| Core: Necessary* | | | |
| Total Ozone Column | L2 | 5% | Stage 2 |
| Ozone Profile | L2 | 20% | Stage 2 |
| Land Surface Emissivity | L2 | 10% | Stage 1 |
| IR Dust | L1B-Flag | 0.5 K | Stage 1 |
| Research Products | | | |
| Methane | L2 | 2% | Stage 1 |
| OLR | L2-Support | 5 W/m2 | Stage 1 |
| HNO3 | L1B-Post | 0.2 DU | Stage 1 |
| Sulfur Dioxide | L1B-Flag | 1 DU | Stage 1 |

AIRS Channels for Tropical Atmosphere with T_{surf} T=301K
Full Spectrum



*Necessary Products are required to retrieve accurate temperature profiles (1K/km) in all conditions

Validation Status Definitions (Common to all Aqua Instruments)

Stage 1: Validation Product accuracy has been estimated using a small number of independent measurements obtained from selected locations and time periods and ground-truth/field program effort.

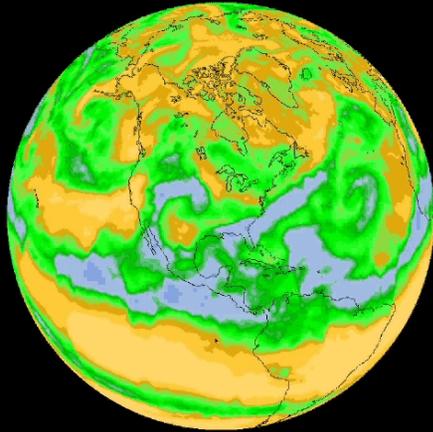
Stage 2: Validation Product accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.

Stage 3: Validation Product accuracy has been assessed, and the uncertainties in the product well-established via independent measurements made in a systematic and statistically robust way that represents global conditions.

AIRS Greenhouse Gases

H₂O

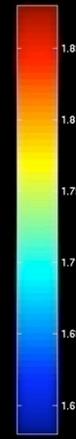
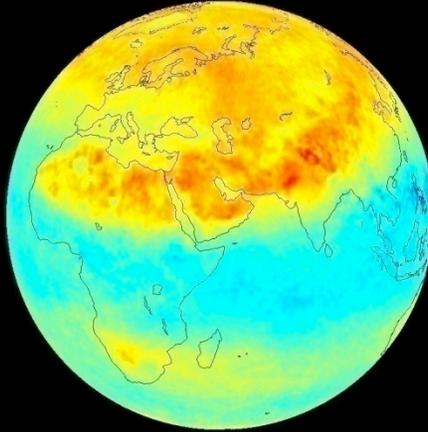
500 mb Water Vapor (g/kg dry air)



2005.08.01

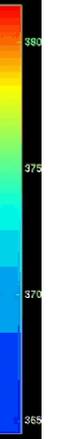
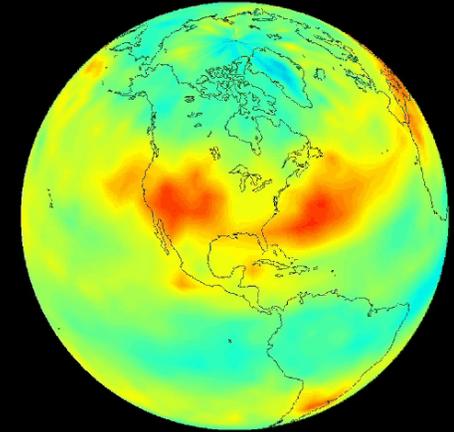
CH₄

CH₄ Volume Mixing Ratio, 210 mb



.08.08

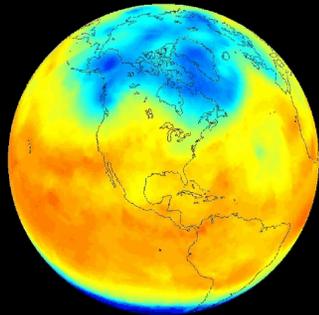
CO₂



Pagano, JPL, 2009

Other AIRS Atmospheric Climate Products

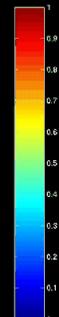
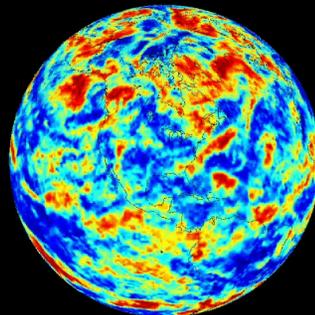
500 mb Temperature (K)



2005.08.01

Temperature

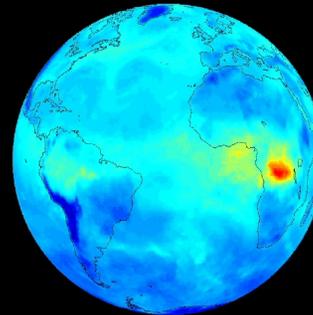
Cloud Fraction



2005.08.01

Clouds

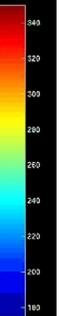
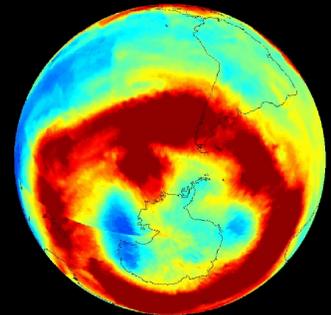
Total Column CO (molecules/cm²)



2005.08.01

CO

Total Column Ozone (DU)



01

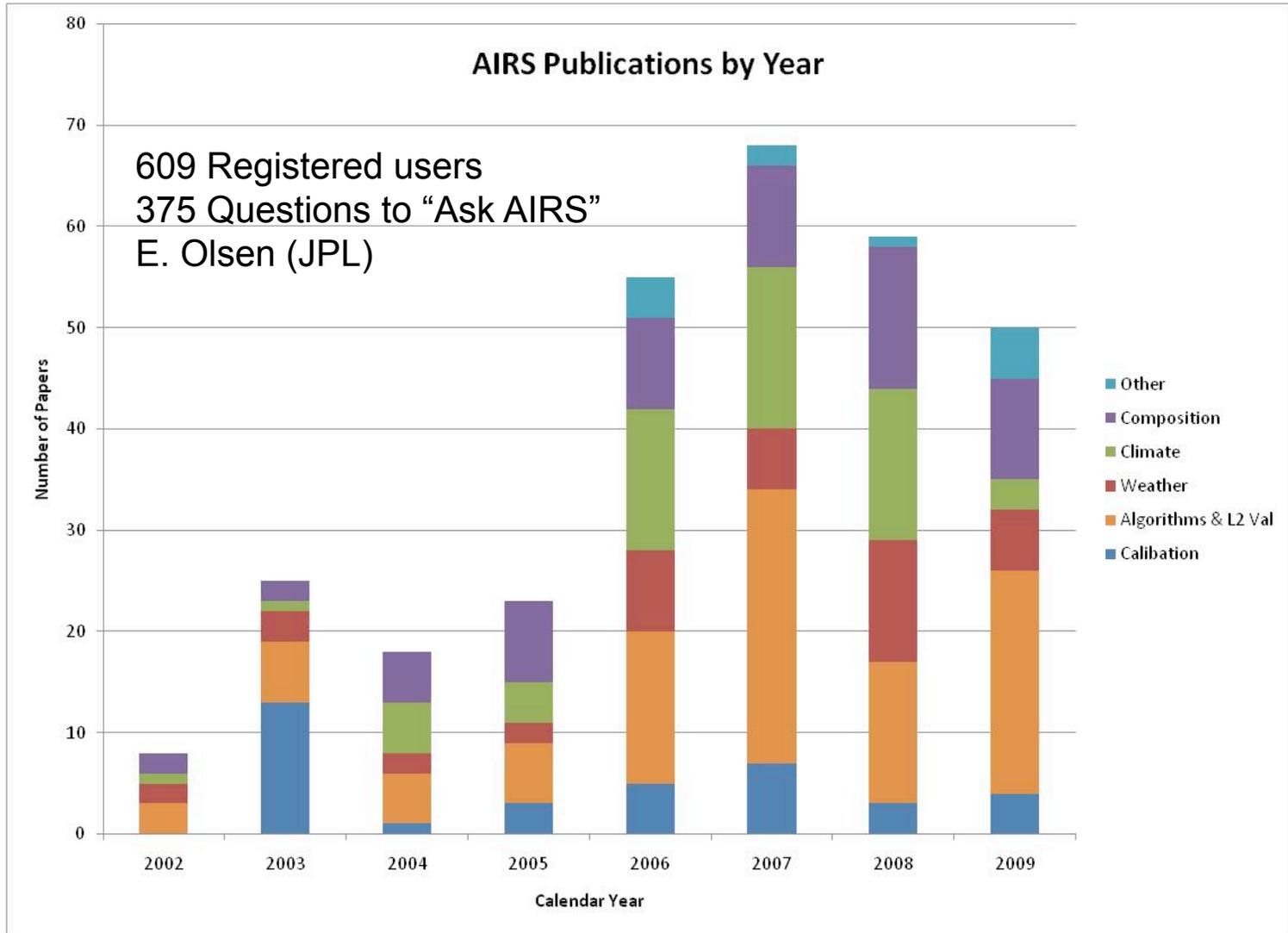
O₃



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AIRS Peer-Reviewed Science Publications Through October 2009; 306 Total





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AIRS Improving Weather Forecasts

- AIRS Operational at NCEP**

- 6Hrs Improvement on 6 Day Forecast (LeMarshall 2005)

- Key Publications in 2008/2009**

- Le Marshall, J., Jung, J., Goldberg, M., Barnet, C., Wolf, W. Derber, J., Treadon, R., Lord, S., Using Cloudy AIRS Fields of View in Numerical Weather Prediction, Australian Meteorological Magazine, 2008, 57, 3, 249-254
- Reale, O., W. K. Lau, J. Susskind, E. Brin, E. Liu, L. P. Riishojgaard, M. Fuentes, and R. Rosenberg (2009), AIRS impact on the analysis and forecast track of tropical cyclone Nargis in a global data assimilation and forecasting system, Geophys. Res. Lett., 36, L06812, doi:10.1029/2008GL037122

- AIRS Data Used by NASA SPoRT in Real Time**

- McCarty, W., G. Jedlovec, and T. L. Miller (2009), Impact of the assimilation of Atmospheric Infrared Sounder radiance measurements on short-term weather forecasts, J. Geophys. Res., 114, D18122, doi:10.1029/2008JD011626

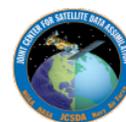
- AIRS Imagery Used by NASA Hurricane Center**

- http://www.nasa.gov/mission_pages/hurricanes/main/index.html

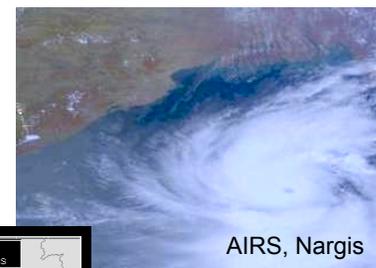
| <u>Storm</u> | <u>Basin</u> | <u>Dates</u> |
|--------------|--------------|------------------------------------|
| Parma | W. Pacific | 0/01/09, 10/05/09 |
| Melor | W. Pacific | 09/30/09, 10/01,02/09, 10/05,06/09 |
| AL08 | Atlantic | 09/28/09 |
| Grace | Atlantic | 10/05/09, 10/06/09 |
| Olaf | E. Pacific | 10/01/09, 10/05/09 |



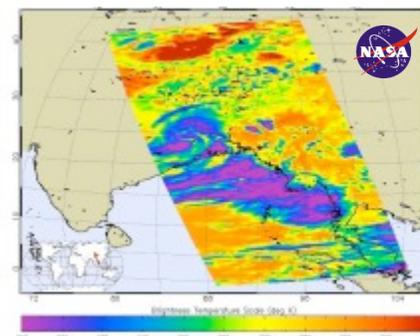
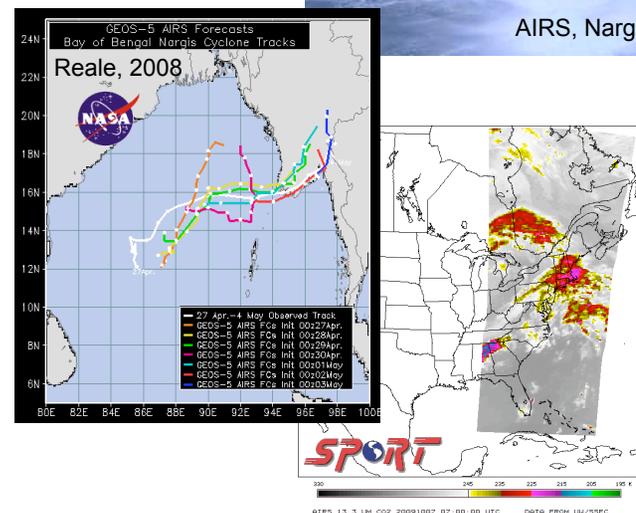
NOAA
NESDIS/NCEP



JCSA



AIRS, Nargis



AIRS, Tropical Cyclone 03B, 9/10/2009



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AIRS Improving Climate Prediction 2009 Highlights

• Model Validation

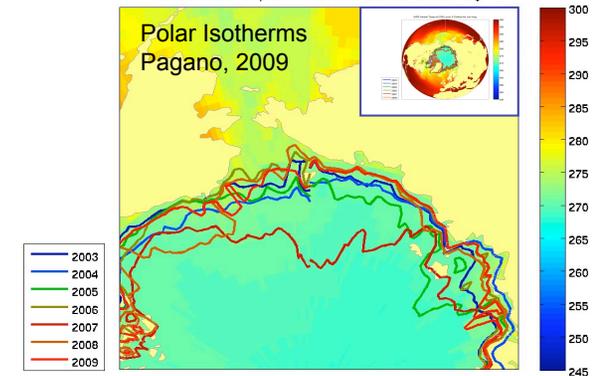
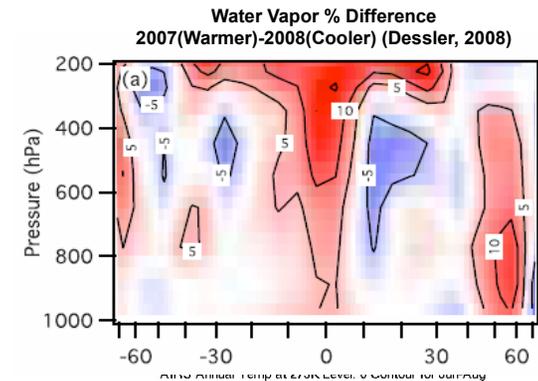
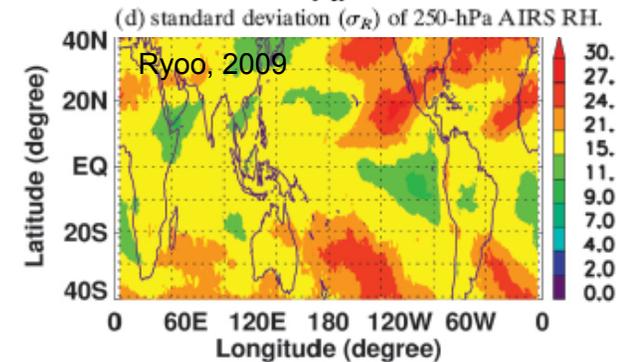
- Ryoo, Ju-Mee; Igusa, Takeru; Waugh, Darryn W., PDFs of Tropical Tropospheric Humidity: Measurements and Theory, J.Clim., 2009, 22, 12, 3357-3373,
- Casey, Sean P.F., Dessler, A.E., Schumacher, Five Year Climatology of Midtropospheric Dry Air Layers in Warm Tropical Ocean Regions as Viewed by AIRS/Aqua, C., Journal of Applied Meteorology and Climatology, 2009, 48, 9, 1831-1842

• Process Studies

- Dessler, A. E., Z. Zhang, and P. Yang (2008), Water-vapor climate feedback inferred from climate fluctuations, 2003-2008, Geophys. Res. Lett., 35, L20704, doi:10.1029/2008GL035333.
- Zelinka, Mark D., Hartmann, Dennis L., Response of Humidity and Clouds to Tropical Deep Convection, J.Clim., 2009, 22, 9, 2389-2404
- Savtchenko, A., Deep convection and upper-tropospheric humidity: A look from the A-Train, Geophys. Res. Lett., 36, L06814, doi:10.1029/2009GL037508, 2009
- Wright, J. S., Fu, R., and Heymsfield, A. J., A statistical analysis of the influence of deep convection on water vapor variability in the tropical upper troposphere, Atmos. Chem. Phys. Discuss., 9, 4035-4079, 2009

• Clouds

- Kahn, B. H., A. Gettelman, E. J. Fetzer, A. Eldering, and C. K. Liang (2009), Cloudy and clear-sky relative humidity in the upper troposphere observed by the A-train, J. Geophys. Res., 114, D00H02, doi:10.1029/2009JD011738





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AIRS Composition Highlights

• CH₄

- Xiong, X., Houweling, S., Wei, J., Maddy, E., Sun, F., and Barnett, C.: Methane plume over south Asia during the monsoon season: satellite observation and model simulation, *Atmos. Chem. Phys.*, 9, 783-794, 2009
- Xiong, X., Barnett, C., Wei, J., Maddy, E., Information-based mid-upper tropospheric methane derived from Atmospheric Infrared Sounder (AIRS) and its validation, *Atmospheric Chemistry and Physics Discussions*, Volume 9, Issue 4, 2009, pp.16331-16360

• SO₂

- S. A. Carn, J.S. Pallister, L. Lara, J.W. Ewert, S. Watt, A.J. Prata, R.J. Thomas, G. Villarosa, The Unexpected Awakening of Chaitan Volcano, Chile, *EOS, transactions, American Geophysical Union*, vol 90, No. 24, 16 June 2009, p. 205

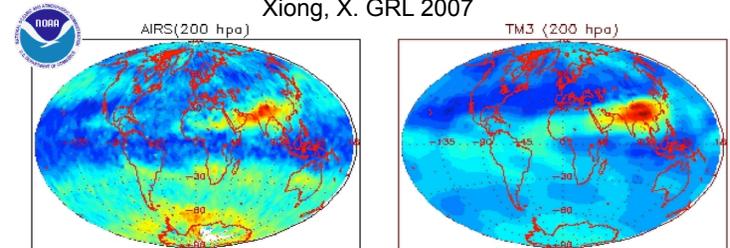
• CO

- Tanimoto, H., K. Sato, T. Butler, M.G. Lawrence, J.A. Fisher, M. Kopacz, R.M. Yantosca, Y. Kanaya, S. Kato, T. Okuda, S. Tanaka, J. Zeng, Exploring CO pollution episodes observed at Rishiri Island by chemical weather simulations and AIRS satellite measurements: Long-range transport of burning plumes and implications for emissions inventories, *Tellus B*, 61B, 394-407, 2009.
- Yurganov, L. N., W. W. McMillan, A. V. Dzhola, E. I. Grechko, N. B. Jones, and G. R. van der Werf (2008), Global AIRS and MOPITT CO measurements: Validation, comparison, and links to biomass burning variations and carbon cycle, *J. Geophys. Res.*, 113, D09301, doi: 10.1029/2007JD009229.

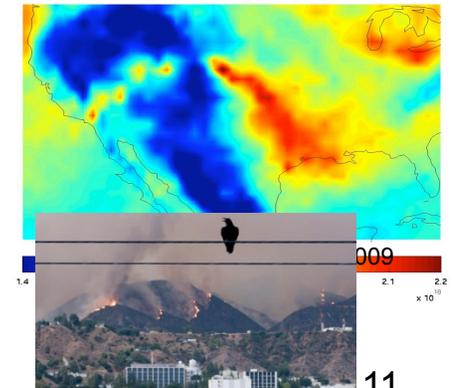
• Dust

- Peyridieu, S., Chédin, A., Tanré, D., Capelle, V., Pierangelo, C., Lamquin, N., and Armante, R.: Saharan dust infrared optical depth and altitude retrieved from AIRS: a focus over North Atlantic – comparison to MODIS and CALIPSO, *Atmos. Chem. Phys. Discuss.*, 9, 21199-21235, 2009

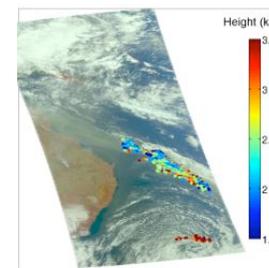
September minus May 2004 **Methane** difference
Xiong, X. GRL 2007



CO Total Column (mol/cm²): Aug 30-Sep 02, 2009 2009.09.02



AIRS Dust Score
DeSouza-Machado (UMBC)



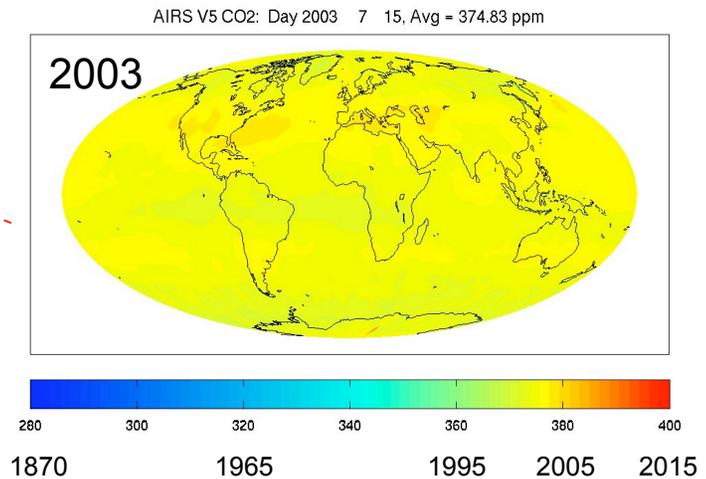
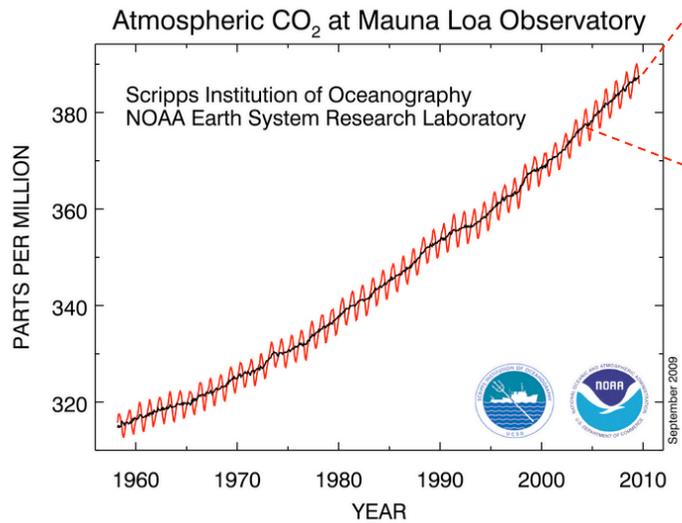
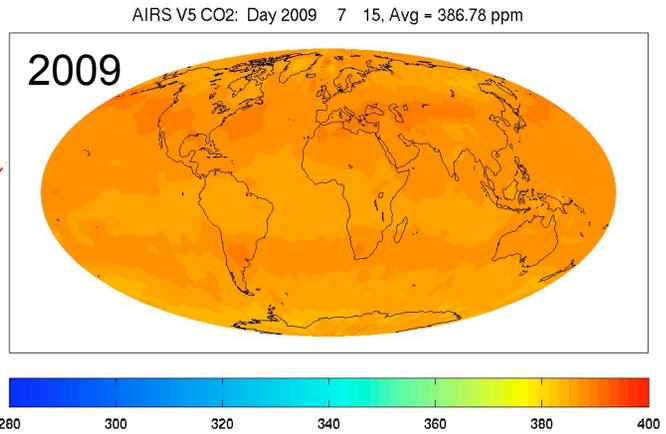
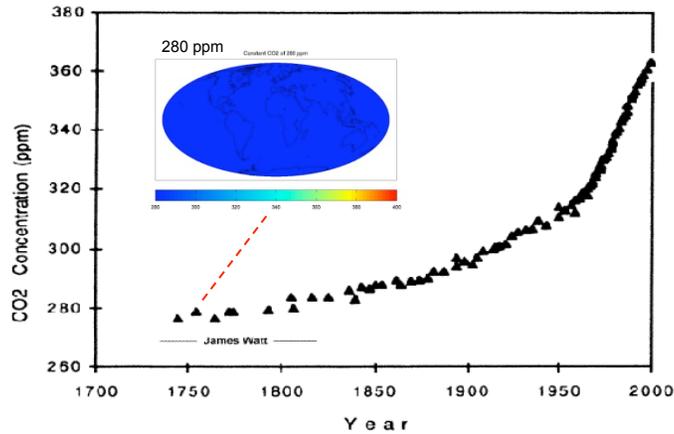


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Growth in CO₂ visible in AIRS Data

7 Years Available to Public in Dec '09



Chahine, M. T., L. Chen, P. Dimotakis, X. Jiang, Q. Li, E. T. Olsen, T. Pagano, J. Randerson, and Y. L. Yung (2008), Satellite remote sounding of mid-tropospheric CO₂, *Geophys. Res. Lett.*, 35, L17807, doi:10.1029/2008GL035022.



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AIRS Project Status at JPL

- Instrument Operations: Instruments Status Looks Good, Trending critical performance parameters
- Calibration and Level 1 Status
 - Level 1B radiances unchanged since launch. No Change to V6
 - New product: Level 1C
 - New calibration coefficients: spectral and radiometric
 - Resampled to common spectral scale
 - Missing channel interpolation
 - AIRS/IASI Comparisons Completed
- Level 2
 - Algorithm Development: Retrieval Initialization, Cloud Products, CO2 Products
 - Product Development: Version 5.4.1 Code Integration and CO2 PGE Developed
 - Data Production at DAAC: Version 5 and CO2 processed for entire mission
 - Product Validation: Water Vapor and Temperature, Operational Sonde Database Implemented, Surface Temperature, Clouds
 - Science and Validation Papers: 8 of 50 Publications by JPL in 2008



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Version 6 Algorithm Development Goals

From 10/07 SciTeam Meeting

- Susskind (GSFC)
 - Surface Parameters (T, e)
 - Boundary Layer T, q
 - Trend Evaluations/Recommendations
 - Improved Error Estimates and QC
 - Cloud/Dust Product Improvement
 - 1 x 3 Retrievals
- Strow (UMBC)
 - L1C Algorithm
 - RTA Scattering Algorithm
 - Additional RTA Tasks
 - Dust
 - Cirrus
 - OLR
- Blackwell (MIT)
 - SCC/NN Investigation
- Barnett (NOAA)
 - Bias Trends Removal
 - Cloud Clearing vs Warmest FOV
 - CO₂
 - SO₂, CH₄, HNO₃, N₂O, O₃
 - CAPE, LI + Convective Products
 - 1x3 (NOAA Interest, SPORT, Forecasters, etc.)
- Goldberg (NOAA)
 - Initialization State (Regression Coefficients)
 - Maintain RT System
- Rosenkranz (MIT)
 - Updated MW RTA
- JPL Science Team Algorithms
 - CO₂ (Chahine)
 - Clouds (B. Kahn)
 - L1C (H. Aumann)

*Not all Goals Achieved in V6.
Friday Discussion on Status.*



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Summary

- Instrument and Aqua Spacecraft Expected to Last Beyond 2017
- AIRS continues to improve forecast. More impact to come
- AIRS Major tool for Climate Model Validation and Process Studies
 - See AIRS Publications Database
- Sounding community has high interest in atmospheric composition
 - CO, CO₂, O₃, CH₄, SO₂
- Version 6 development underway. Need resolution on several items
- Future sounders to continue AIRS observations
 - IASI on MetOp, and CrIS on NPOESS



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Way to the future...

- NASA Aqua Sr. Review (September 2009)

“The proposed mission [Aqua] continuation will likely continue to produce new discoveries and provide high quality science services to the global community. These services are not likely to be matched by the NPP and NPOESS follow-on missions, so NASA should undertake any and all efforts necessary to sustain this irreplaceable mission”.

- What do we do for the near future?

- How do we continue AIRS science quality data products with CrIS and IASI?
 - Data Production, Validation, Cross-Comparisons, Answer Science Questions

- What do we do beyond NPOESS?

- What are requirements for operational forecasting?
- What are the requirements for science research?
- Special session on Thursday morning to discuss community needs
- We suggest NASA and NOAA engage in dialogue with the community on a larger scale (e.g. AGU, AMS, etc.)