National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS Project Status

T. Pagano

April 26, 2011

Dedicated to
Mous Chahine

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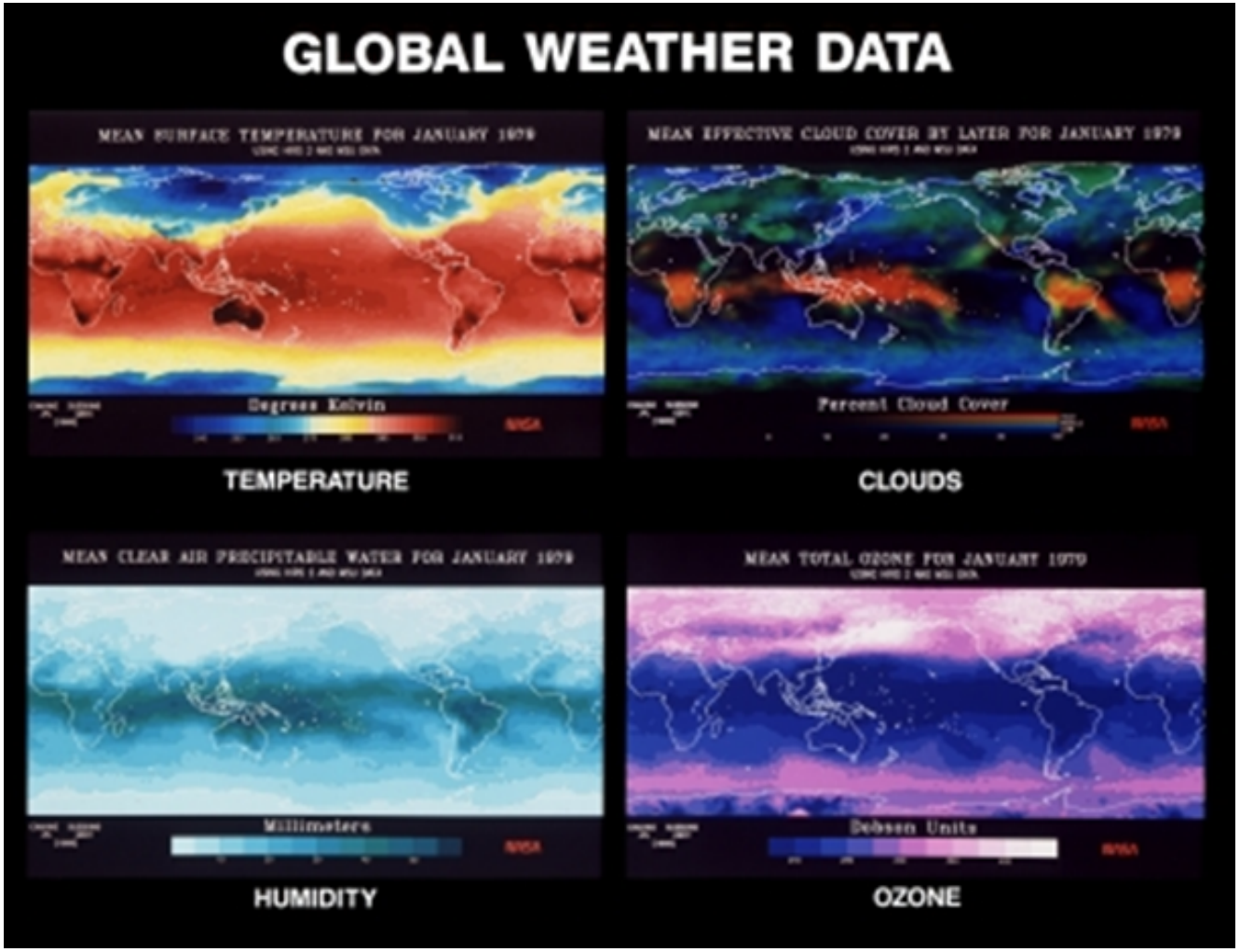
First Sounder Global Images from Dr. Chahine 1979



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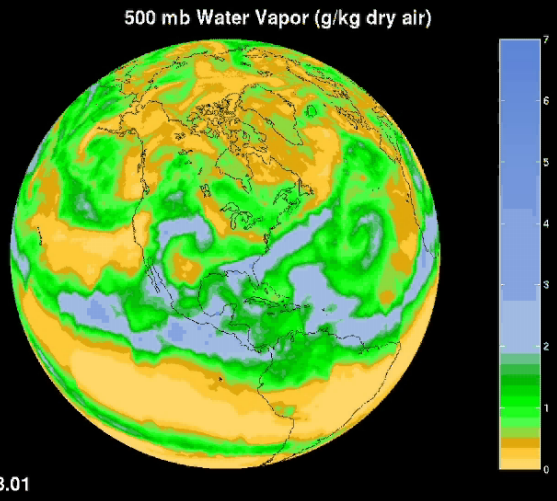
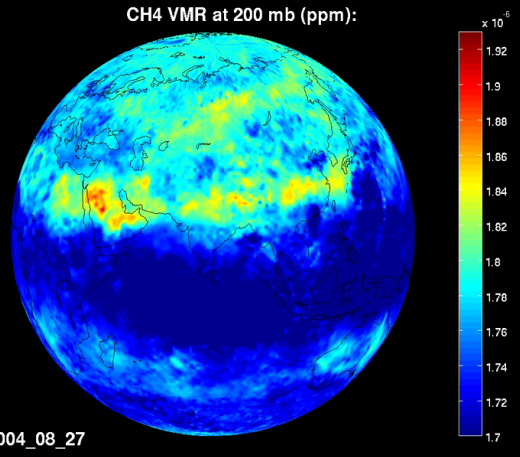
Today's Greenhouse Gases from AIRS

H_2O

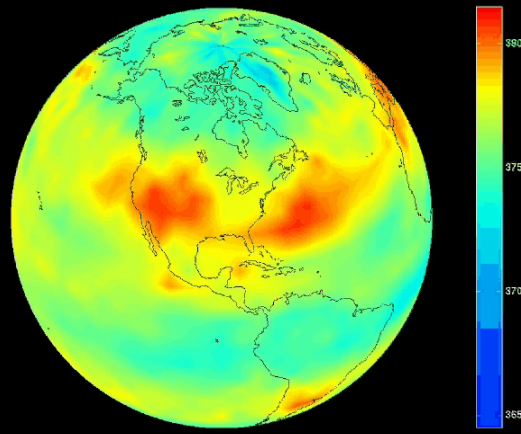


CH_4



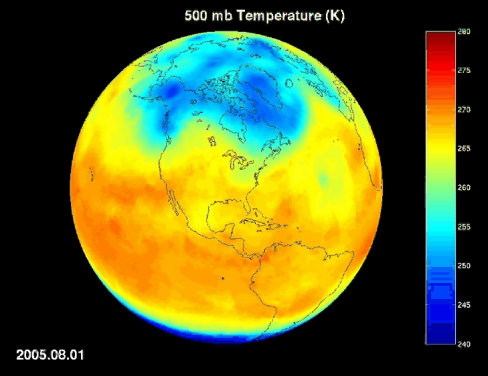
CO_2

Mid-Tropospheric CO_2 (ppm)

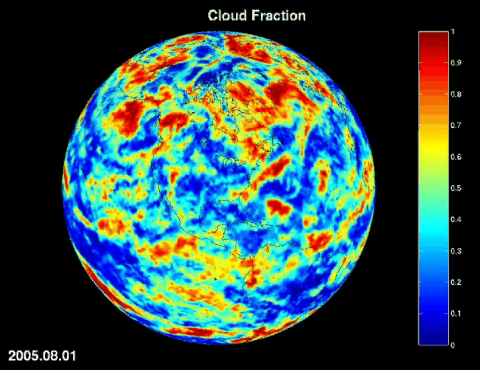


Pagano, JPL, 2009

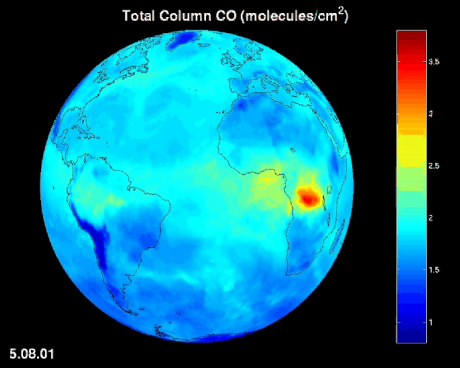
Other AIRS Atmospheric Climate Products



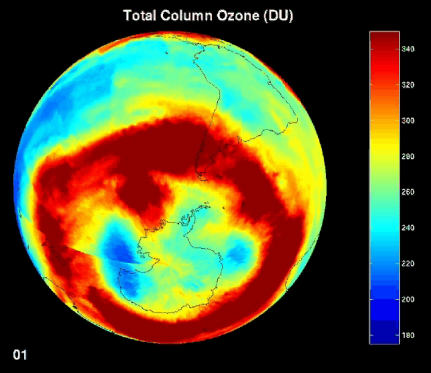
Temperature



Clouds



CO



O_3

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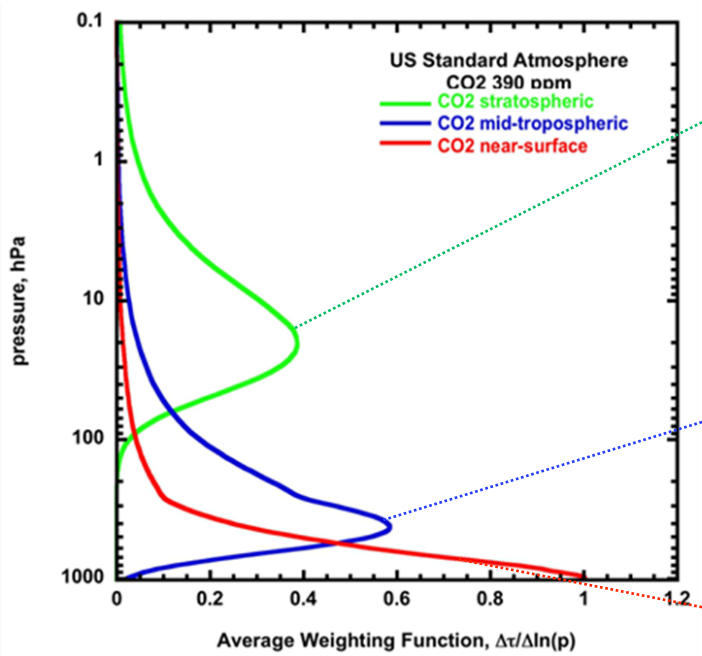
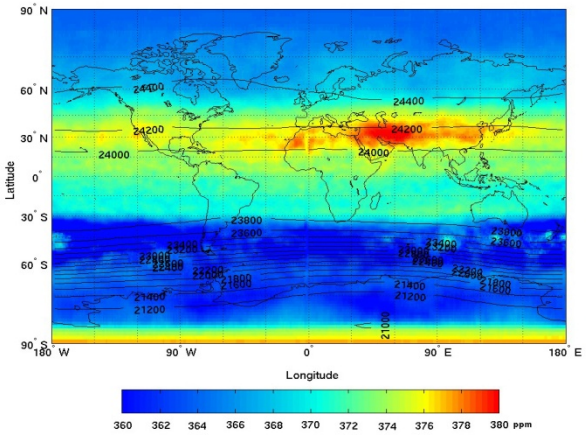
3 Layers of CO_2 Derived from AIRS by Dr. Chahine, and Colleagues, 2011 Images for July 2003



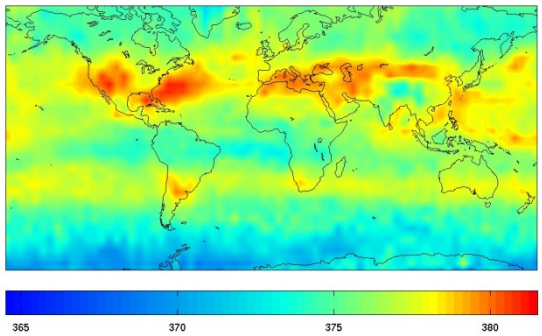
Sensitivity of AIRS Channels to CO2

Stratosphere



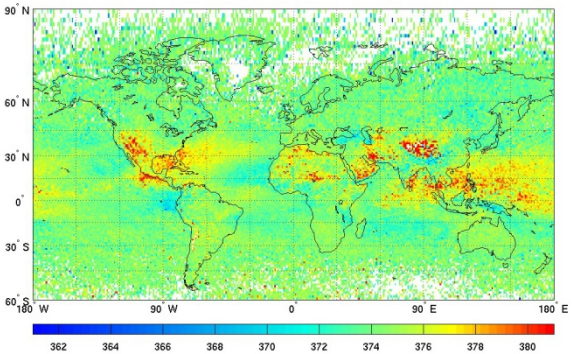
Preliminary

Mid-Troposphere



Validated
Sept 02 - Present

Lower Trop



Preliminary

M. Chahine et. al. (JPL)

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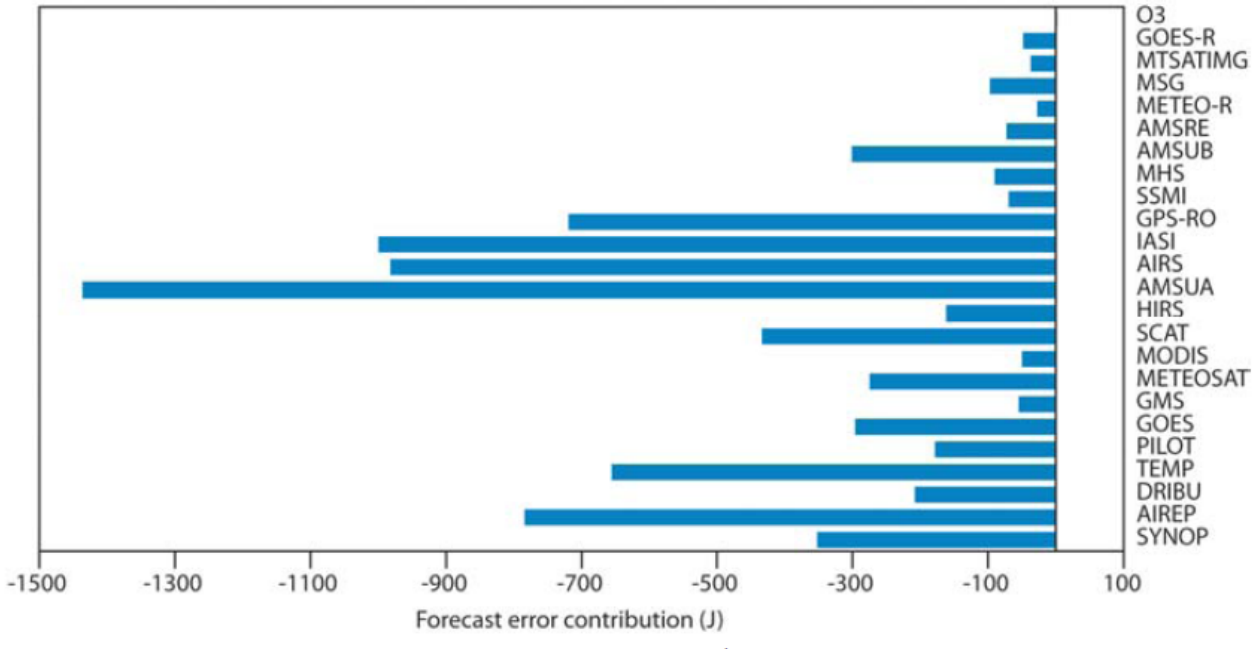
ECMWF Finds High Infrared Sounder Impact

- Microwave satellite measurements (AMSU-A) are responsible for 18% of the forecast error reduction
- Infrared measurements (AIRS and IASI) for 12% each
- 10% of error reduction is due to radio occultation



From Cardinali (ECMWF Tech. Memo. 599, 2009), See also, Cardinali, C, Monitoring the observation impact on the short-range forecast, Q. J. R. Meteorol. Soc. 135: 239–250 (2009)

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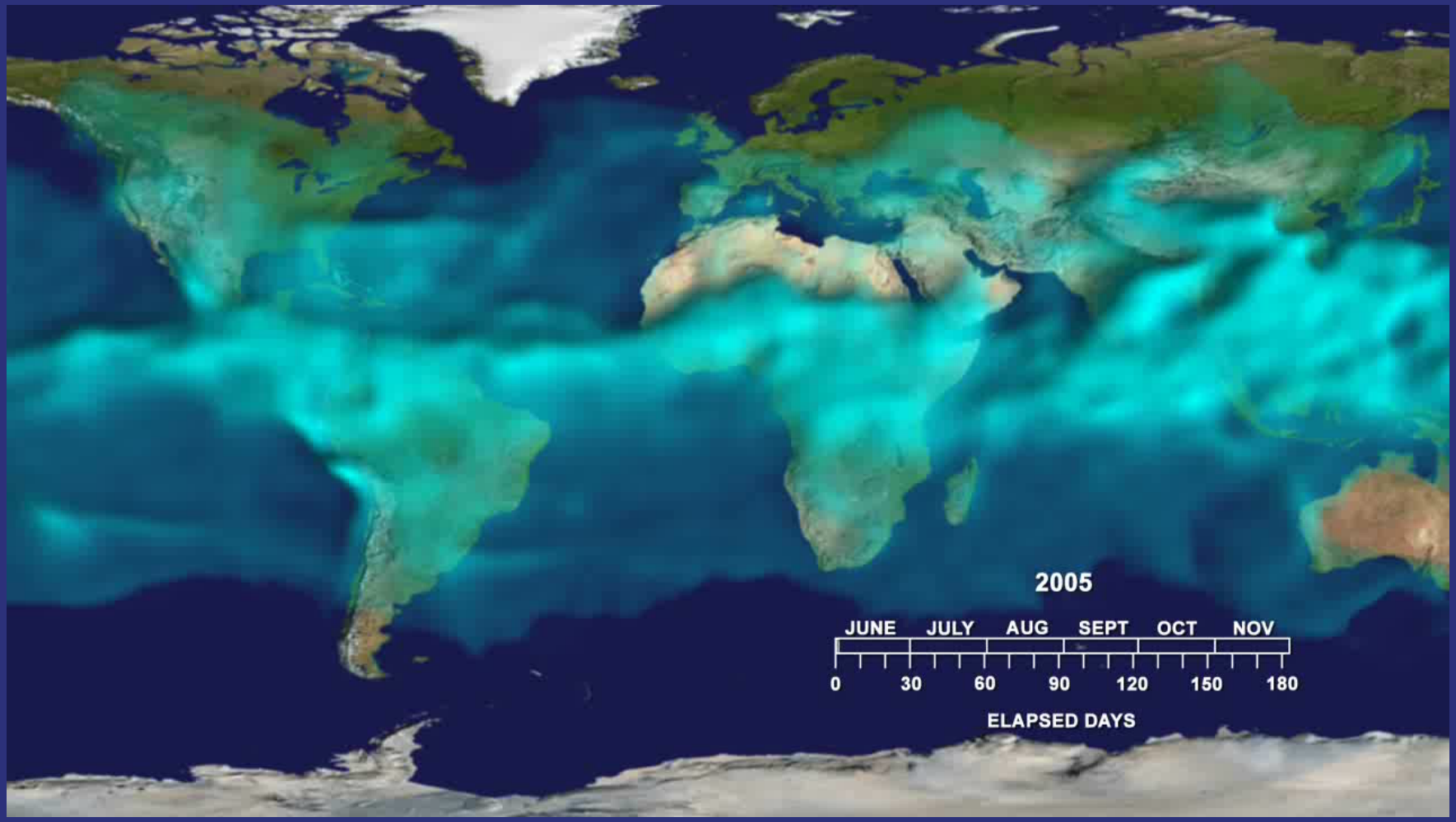
AIRS Gives First Look at Water Waves in the Atmosphere



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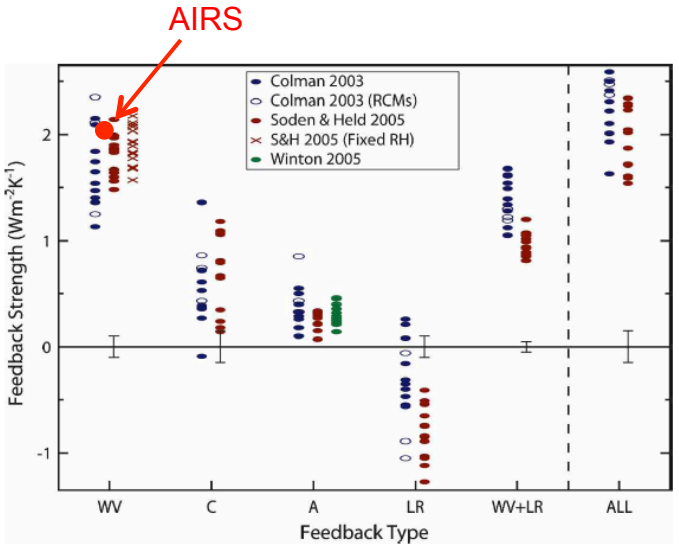
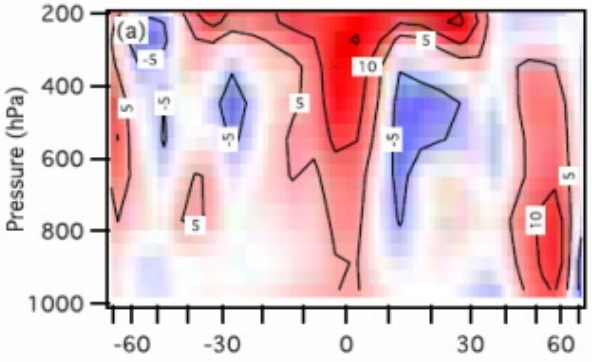
AIRS Data Used to understand Climate Feedbacks

- AIRS Water Vapor Profiles provide good sensitivity to interannual differences
- Difference between warm year and cooler years give a measure of response of water vapor to warming
- Results show a positive upper tropospheric water vapor feedback



Bony, S., et al., "How Well Do We Understand and Evaluate Climate Change Feedback Processes?", Journal of Climate, Vol 19, p 3445-3482.

Water Vapor % Difference
2007(Warmer)-2008(Cooler) (Dessler, 2008)



- 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.
- Gettelman, A., Fu, Q., "Observed and simulated upper-tropospheric water vapor feedback", Journal of Climate, 2008, 21, 13, 3282-3289

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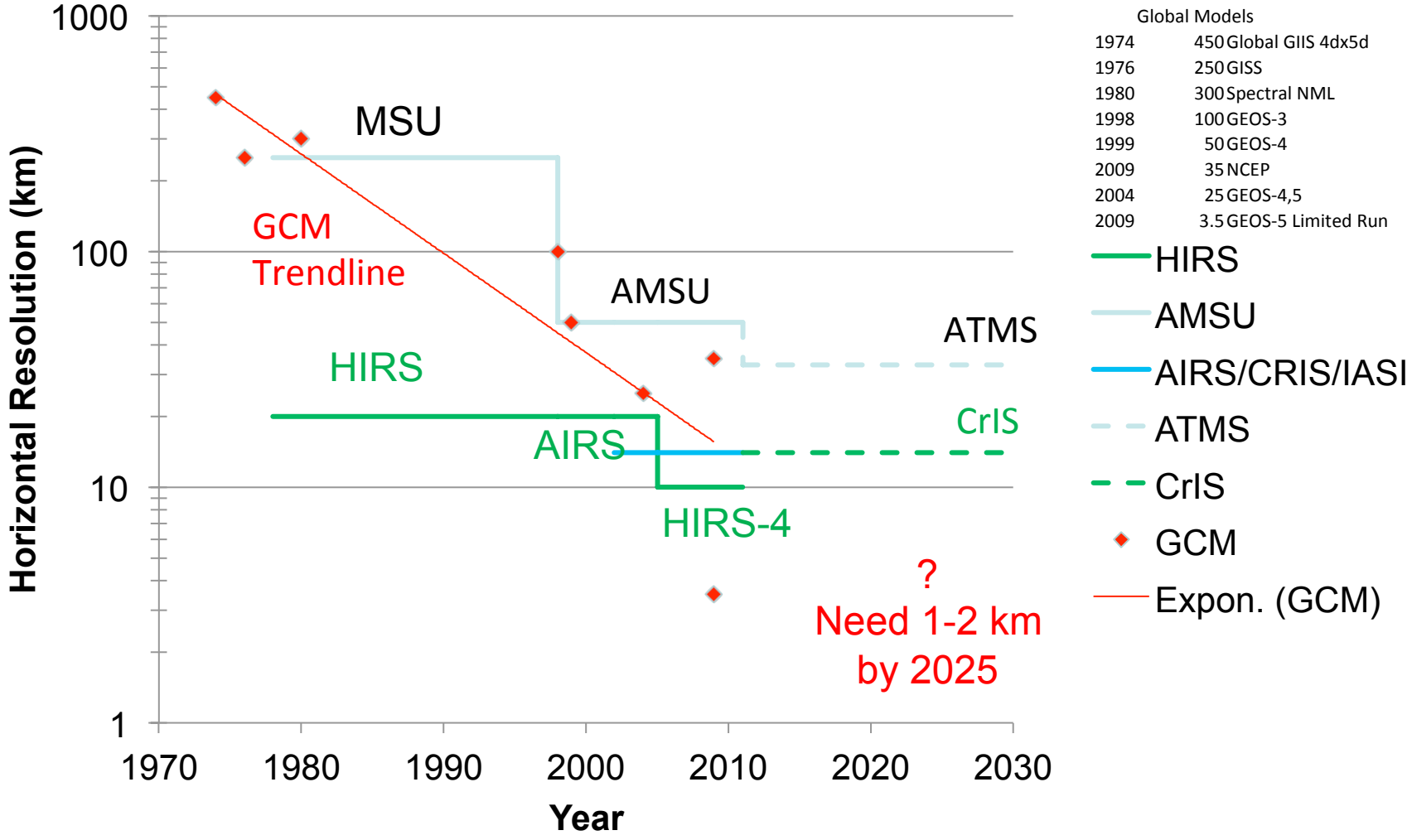
Improved Spatial Resolution from LEO Needed to Initialize & Validate GCM's



Observations of Temperature, Water Vapor, Clouds, etc. are used to initialize and validate forecast models

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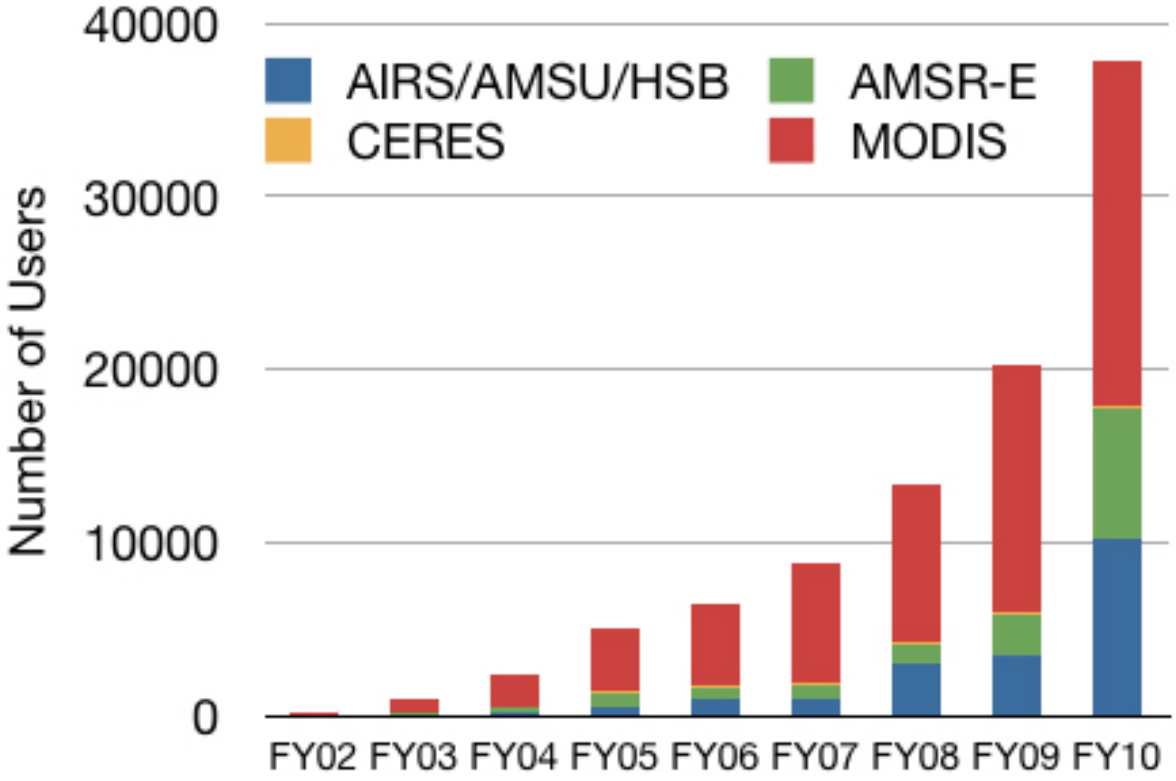
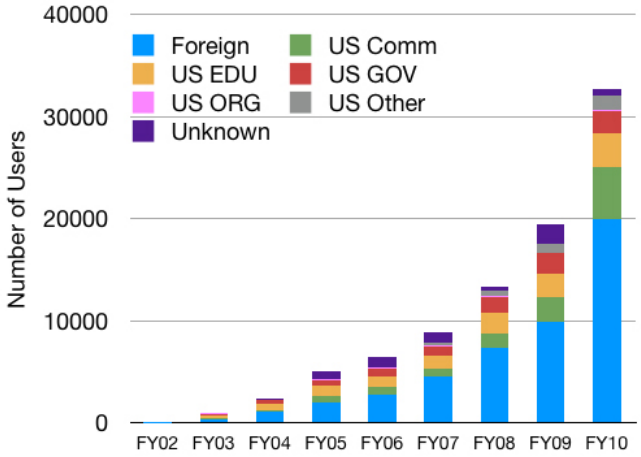
Higher Spatial Resolution Relevant to More Users: See Aqua

Aqua Registered Users at GES/DISC Since Launch



Courtesy of GES/DISC

Truly Global User Base



LEO Imagers and Sounders are Essential to Earth Science Investigations and Must be Priority for Future Upgrades.

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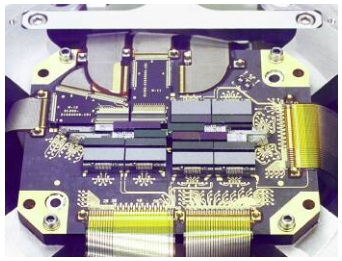
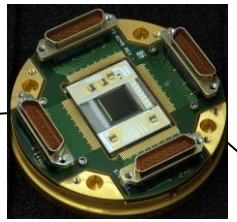
AIRS/MODIS Technology Has Evolved Since the 1990's

AIRS
BAE Systems
PV/PC HgCdte
17 modules
2 x ~180
100 x 50 um

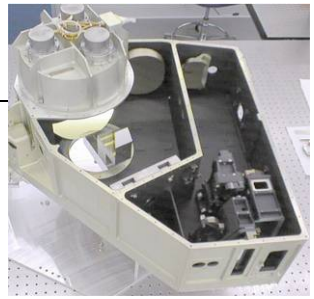


BAE Systems
HgCdTe
15 μm Cutoff
512 x 512

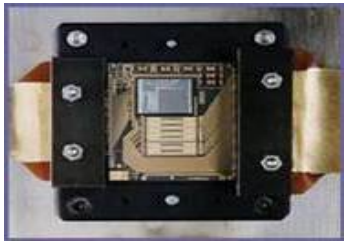


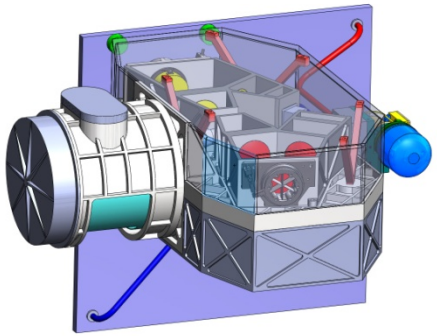
SIRAS IIP1
Refractive 16°
Grating Spectr

AIRS
Reflective 1.1°
Grating Spectr



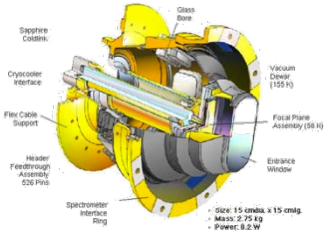
MODIS
Raytheon Vision Systems
PV/PC HgCdTe
4 FPAs
10 x ~10
400 x 400 um



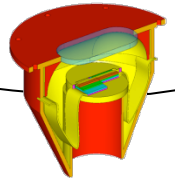


Atmospheric Remote-sensing Imaging Emission Sounder (ARIES)

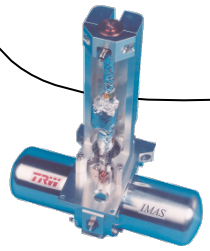
AIRS
Large Dewar



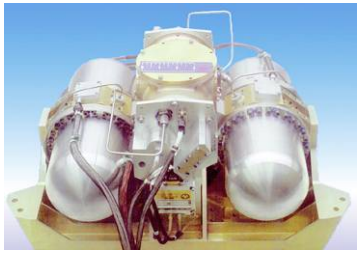
High Efficiency
Mini Dewars



NGST
Small Single
Pulse Tube
Cooler



AIRS
Large Dual Pulse
Tube Coolers



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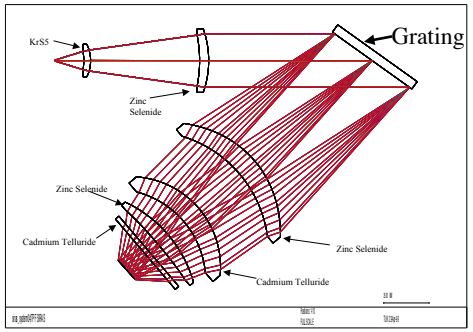
Wide Field Optics Improve Spatial Resolution and/or Coverage

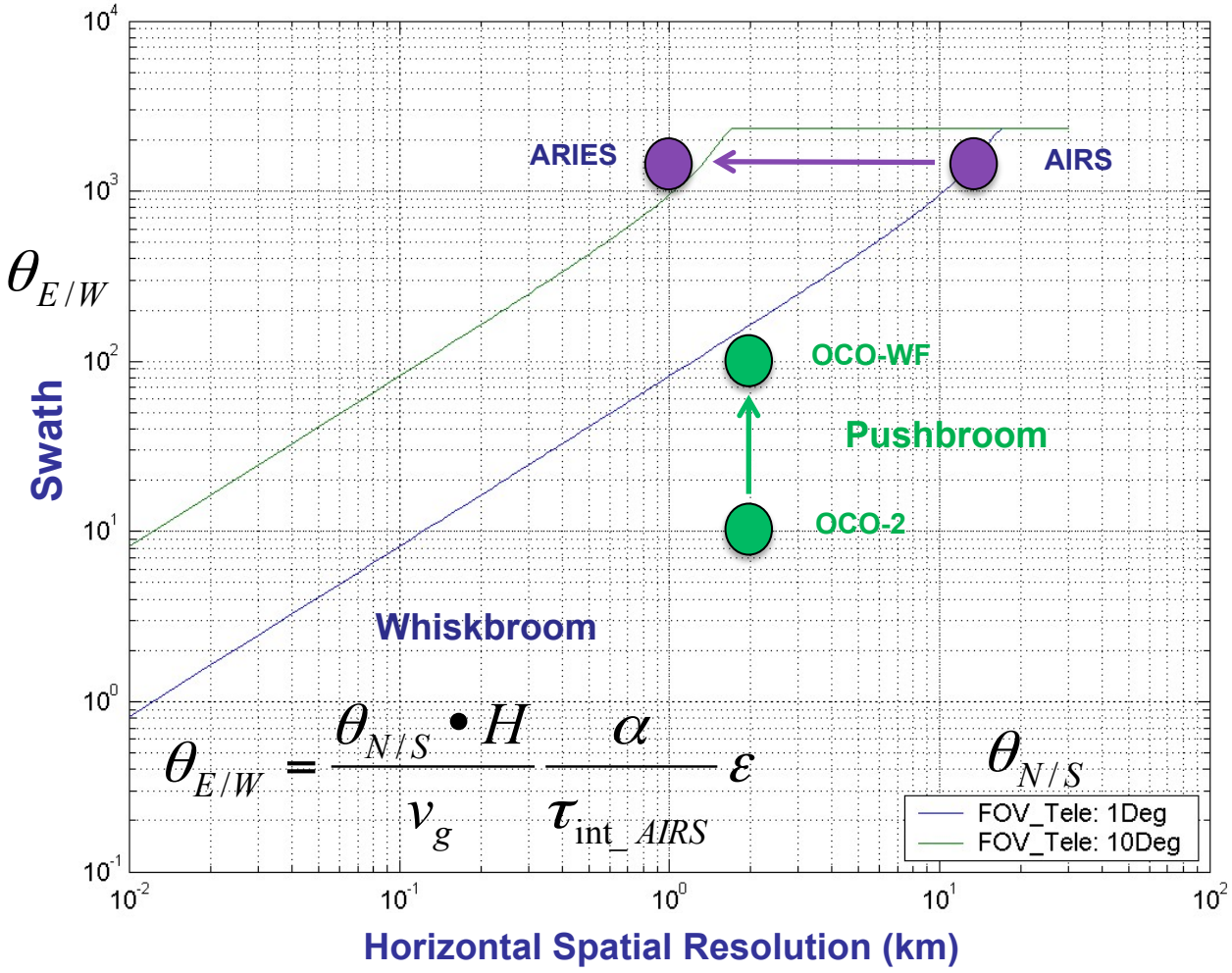
Wide Field Grating Spectrometer Demonstrated on IIP 2001



- **Whiskbroom: Wide field slows scan, enabling higher spatial resolution**

- **Pushbroom: Wide field directly extends E/W Swath**

Full Swath vs Spatial Resolution for AIRS-Like Sounder



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High Spatial Resolution (1km) AIRS / Hyperspectral MODIS Now Possible

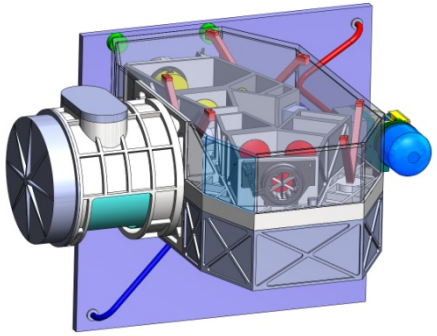
AIRS

AIRS on Aqua
14 km GSD, ±49.5°
2378 Channels
0.4-15.4 μm
177 kg, 256 W
0.9 m^3, 1.3 Mbps

For example:

ARIES (IR, JPL)

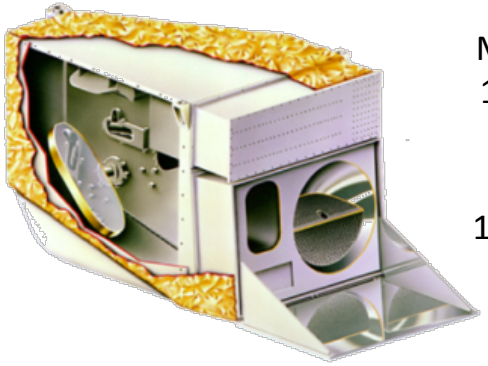
Atmospheric Remote-sensing Imaging Emission Sounder



1 km GSD. ±55°
4096 Channels
3.3-15.4 μm
100 kg, 150 W
0.5 m^3, 60 Mbps

Unplanned

MODIS

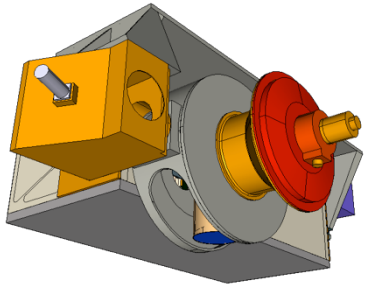


MODIS on Aqua
1 km GSD, ±55°
0.4-14.4 μm
220 kg, 160 W
1.5 m^3, 11 Mbps

For example:

ORCA (Solar Reflective, GSFC)

Ocean Radiometer for Carbon Assessment



1 km GSD. ±58°
108 Channels
0.24-2.14 μm
140 kg, 130 W
0.5 m^3, 13 Mbps

NASA Planned (For PACE)

- ***ARIES and ORCA Meet all Requirements of AIRS and MODIS + More!!!***

T.S. Pagano, C.R. McClain, "Evolution of Satellite Imagers and Sounders for Low Earth Orbit and Technology Directions at NASA', Proc. SPIE, 7807-20, San Diego, California, August 2010

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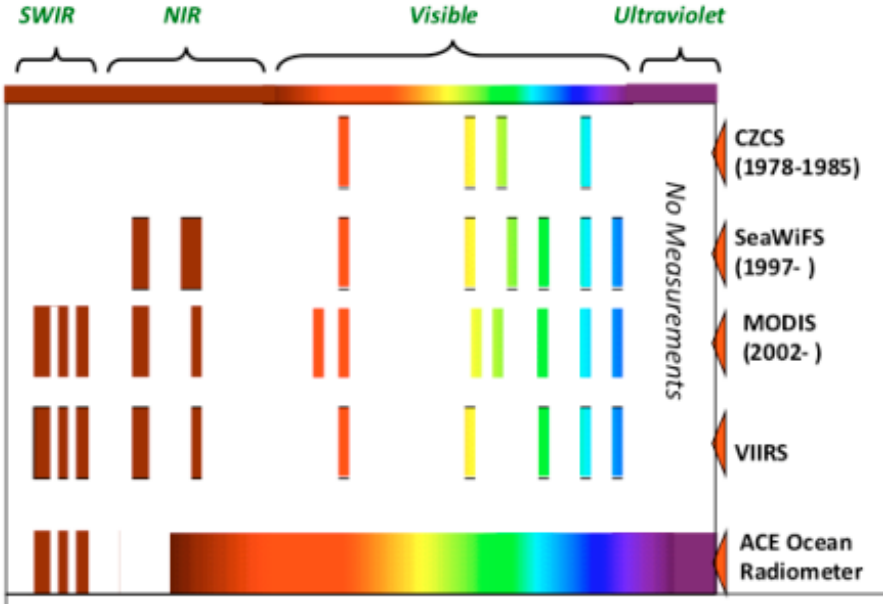
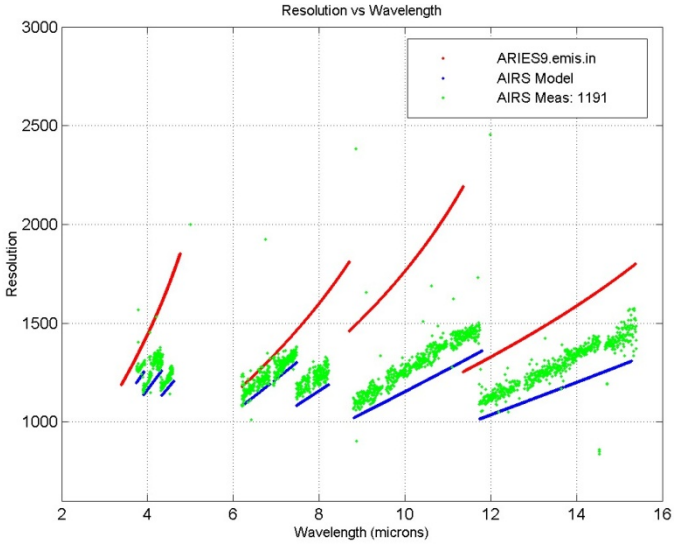
Next Gen Imaging Sounders Give Hyperspectral UV through LWIR

ORCA
108 UV/Vis/NIR Ch.
345-885 nm, $\Delta\lambda$ = 5 nm
3 SWIR Channels



ARIES
4096 Channels
~2x Better than AIRS



Band	Spectral Range	Spectral Resolution	No. Channels
MW1	2100 - 2950 cm^{-1}	1.6 cm^{-1}	1024
MW2	1150 - 1613 cm^{-1}	1.0 cm^{-1}	1024
LW1	880 - 1150 cm^{-1}	0.6 cm^{-1}	1024
LW2	650 - 880 cm^{-1}	0.5 cm^{-1}	1024

T.S. Pagano, C.R. McClain, "Evolution of Satellite Imagers and Sounders for Low Earth Orbit and Technology Directions at NASA', Proc. SPIE, 7807-20, San Diego, California, August 2010

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AIRS Project Status Summary

- **Instrument Operations**: AIRS Working Well. AMSU Ch 5 Concern
- **Instrument Calibration**: Excellent. New lead on overlap channel biases
- **Level 1B Validation**: Can't wait for CrIS. We see 50 mK errors.
- **Software Integration and Production**: V6 Near Completion
- **Data Processing Operations**: Testing Data Sets Processed
- **L2 Algorithm Assessment and Integration**: V6 Testing Begun
- **L2 Product Validation**: Many improvements in V6 performance
- **Project Science**: New Products: L1C, CAPE, LI, Clouds, CO2
- **Climate Data Records Development**: CMIP5/IPCC
- **User Services**: Over 788 Registered on AIRS site alone
- **EPO**: Captures best of the AIRS Project. **http://airs.jpl.nasa.gov**
- **Project Management**: On Budget – Behind Schedule,
  2010 NASA Science Community Workshop Draft Report Released,
  Sr. Review Proposal Submitted, Keep Making Progress!!!

Presentations by all Element Leads Today

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Mous Chahine's legendary phrases we will never forget…

- **AIRS Inception**: "1K/km"
- **AIRS Development**: "Always Make Progress"
- **AIRS Validation**: "We do it Day, Night, Land, Ocean, and in the Presence of Clouds"
- **CO_2 Retrieval Development**: "Every millikelvin counts"
- **To the public**: "This is what CO_2 would look like if you could see it"
- **For the future**: "AIRS at 1km, ARIES"

- Thank You Mous!

A Brilliant Scientist
A Great Visionary
A Caring Mentor
A Good Friend

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Special Thanks to Mous Chahine