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AIRS infrared polarization sensitivity and in-flight observations

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and
The AIRS Science Team

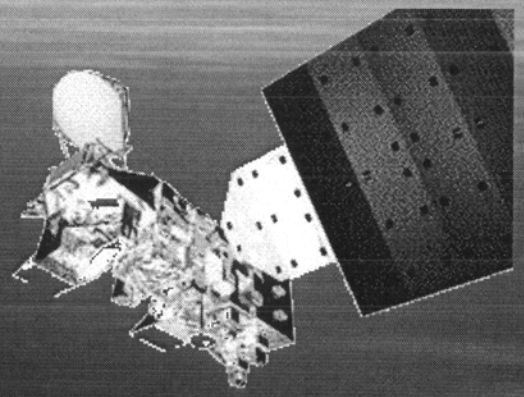
SPIE 5542-6
Denver, Colorado
August 4, 2004

Agenda

- Introduction to AIRS Project
- AIRS Standard Products
- Polarization Sensitivity
- Response to Polarized Ocean Scene

AIRS/AMSU/HSB Project Overview

Spacecraft:	**EOS Aqua**
Instruments:	**AIRS, AMSU, HSB, CERES, AMSR-E**
Launch Date:	**May 4, 2002**
Launch Vehicle:	**Boeing Delta II Intermediate ELV**
Mission Life:	**5 years**



AIRS Project Objectives

1. **Improve Weather Forecasting: AIRS data assimilated operationally by major NWP centers**
2. **Support Climate Modeling: AIRS Water Vapor Profiles**
3. **Understanding Tropospheric Chemistry: O_3, CO, CO_2, CH_4 + Others**

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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AIRS/AMSU/HSB Standard Products

Radiance Products (Level 1B)	RMS Uncertainty	Horizontal Resolution
AIRS IR Radiance	3%*	15 x 15 km
AIRS VIS/NIR Radiance	20%	2.3 x 2.3 km
AMSU Radiance	0.25-1.2 K	45 x 45 km
HSB Radiance	1.0-1.2 K	15 x 15 km
Standard Core Products (Level 2)		
Cloud Cleared IR Radiance	1.0K	45 x 45 km
Sea Surface Temperature	0.5K	45 x 45 km
Land Surface Temperature	1.0K	45 x 45 km
Temperature Profile	1K	45 x 45 km
Humidity Profile	15%	45 x 45 km
Total Precipitable Water	5%	45 x 45 km
Fractional Cloud Cover	5%	45 x 45 km
Cloud Top Height	0.5 km	45 x 45 km
Cloud Top Temperature	1.0 K	45 x 45 km

*Absolute Relative to NIST

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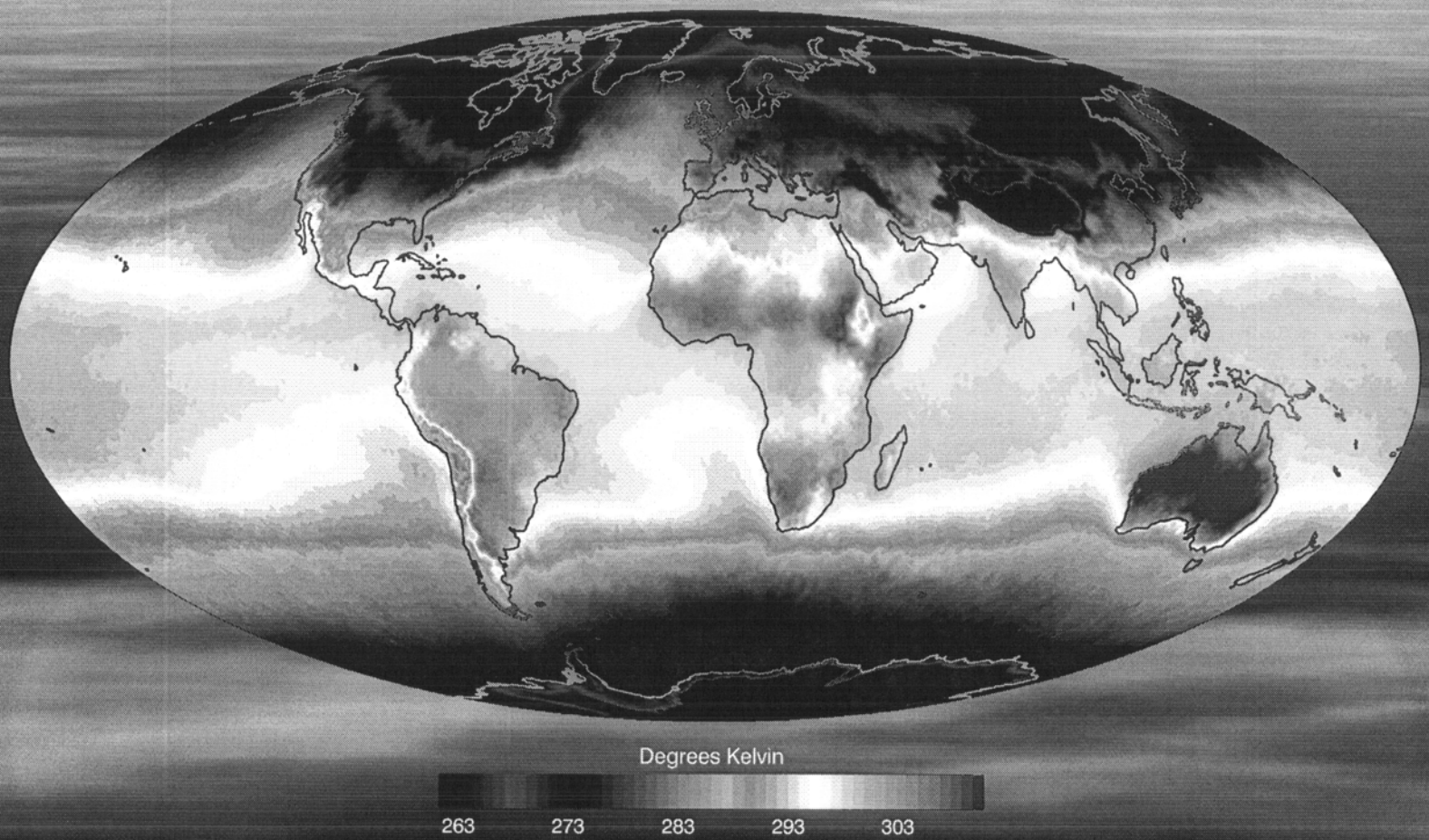
AIRS Surface Air Temperature (January 2003)



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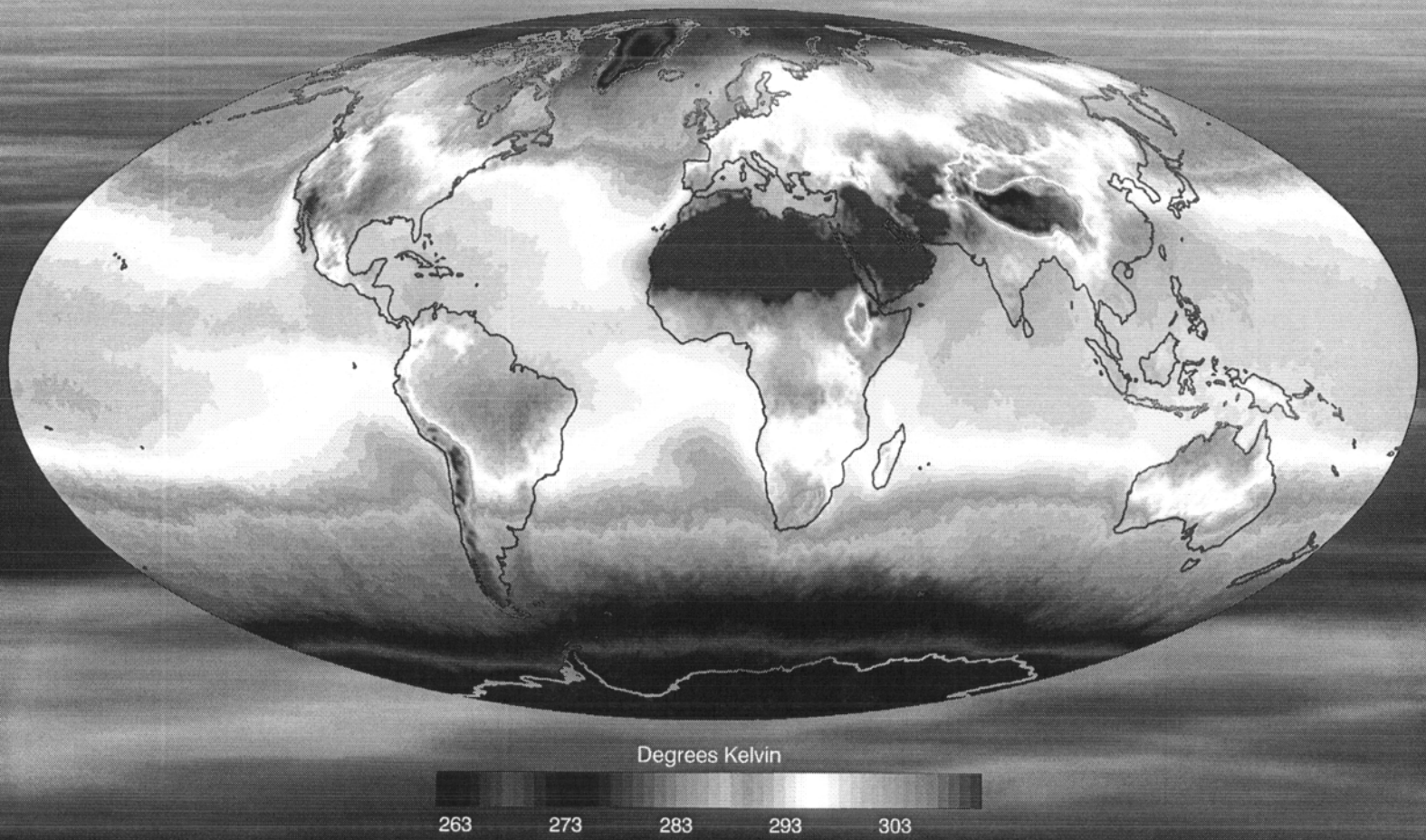
AIRS Surface Air Temperature (July 2003)



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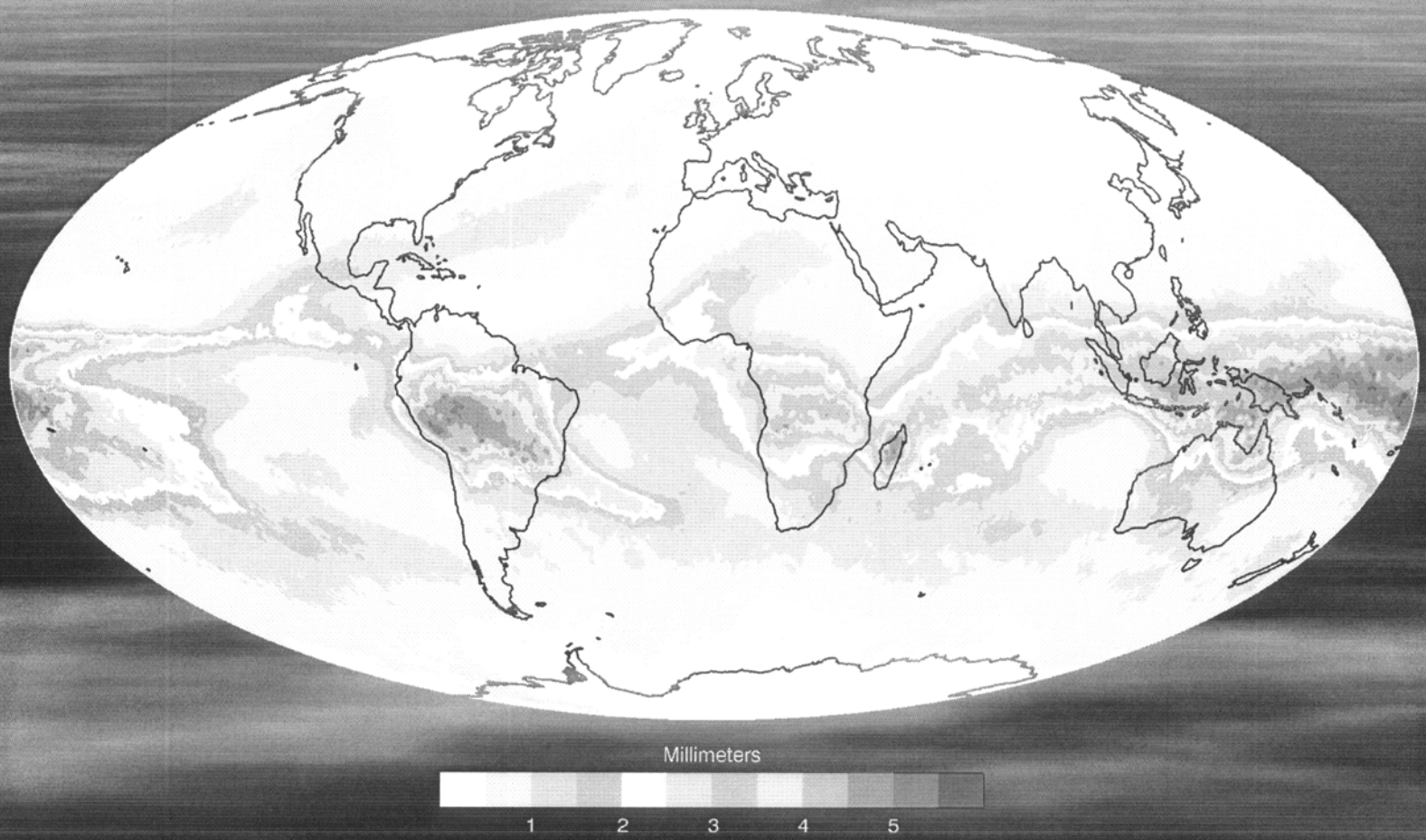
AIRS Upper Atmospheric Water Vapor (January 2003)



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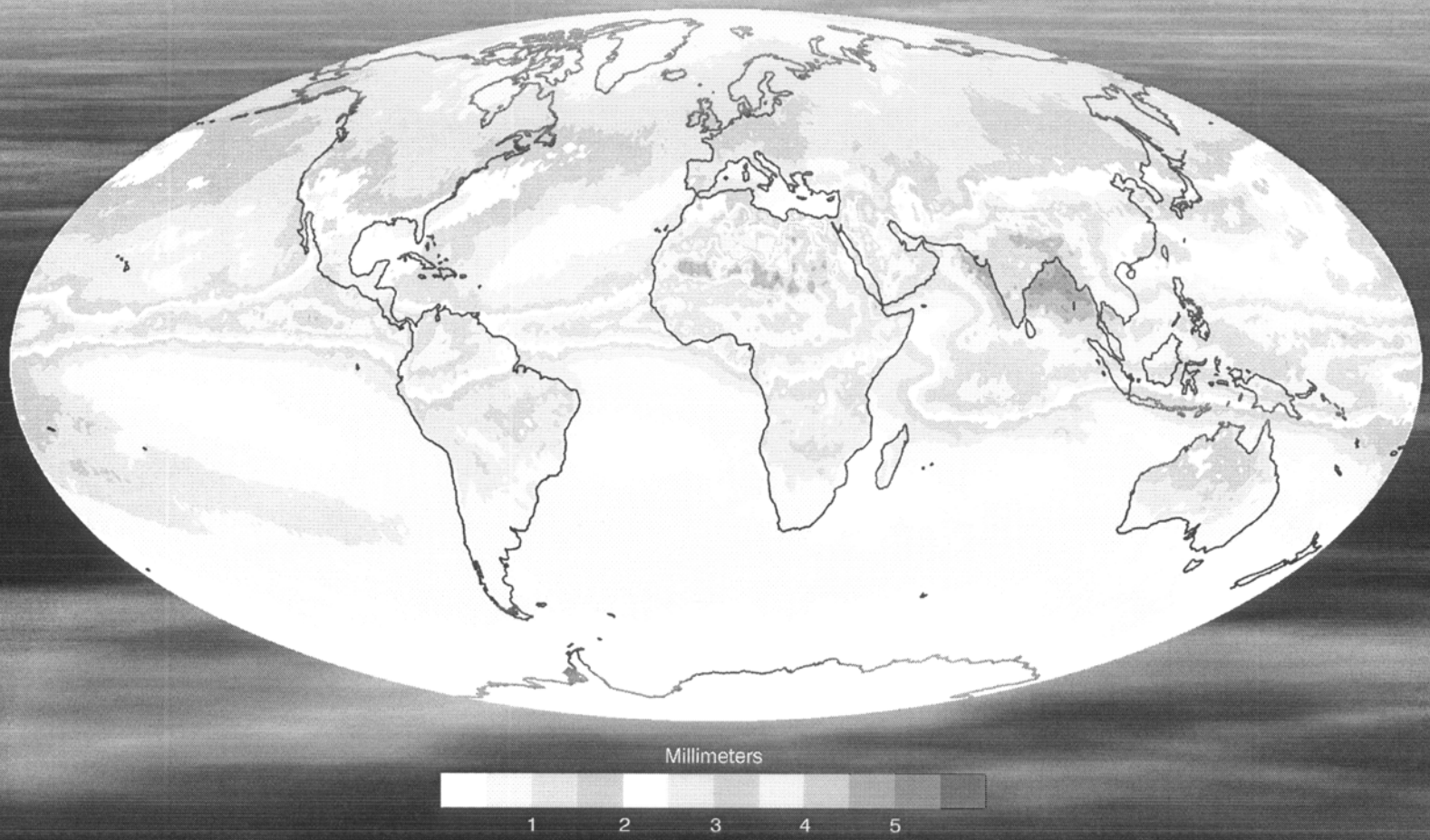
AIRS Upper Atmospheric Water Vapor (July 2003)



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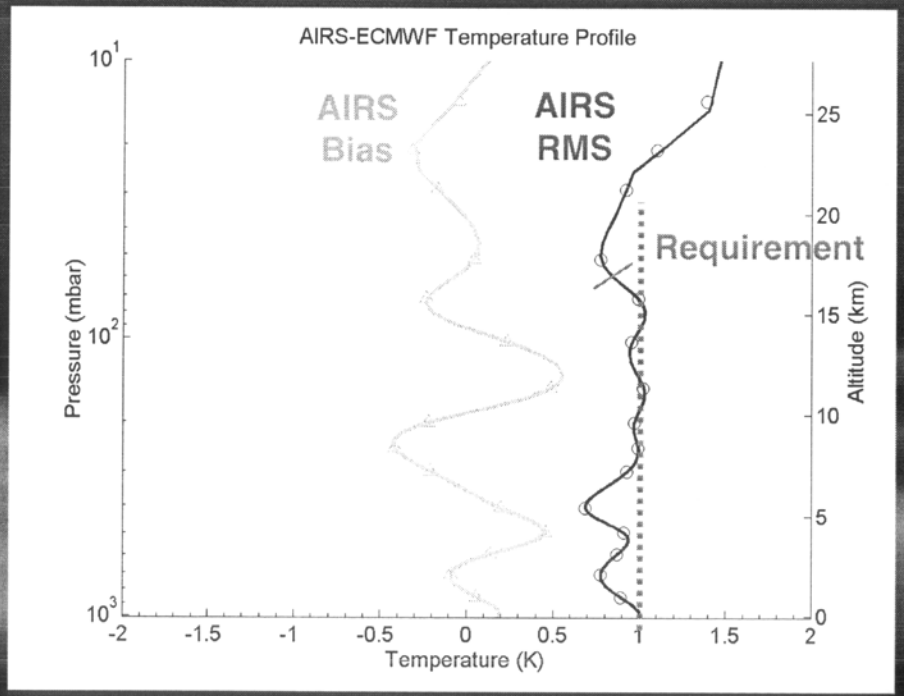
AIRS Shows High Vertical Accuracy and Horizontal Resolution of Temperatures

Temperature Profiles Accurate to 1K/km to 30 mb

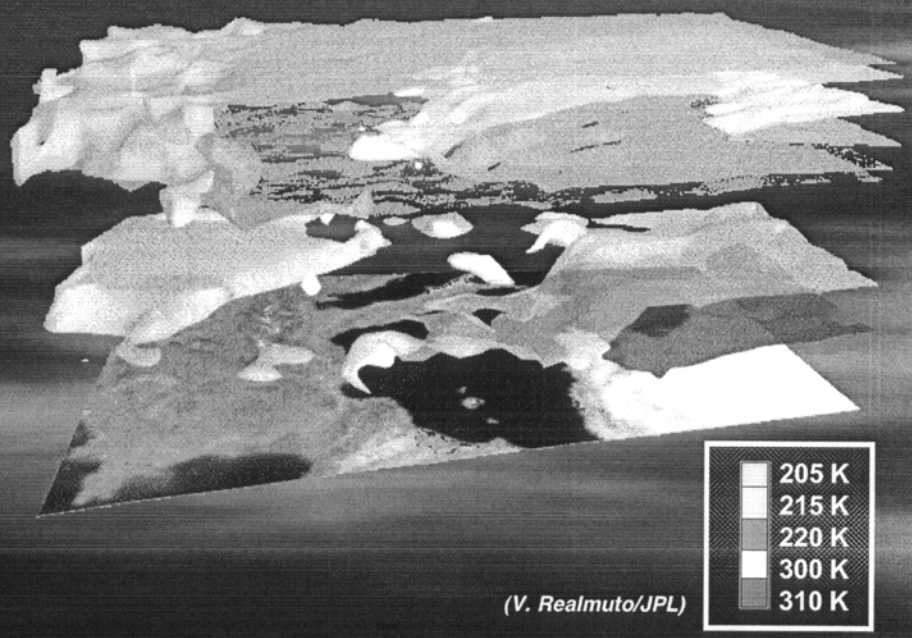
Ocean, Mid Latitude vs ECMWF



(T. Hearty/JPL)

Isotherms Show Good Horizontal Resolution

September 8, 2003



(V. Realmuto/JPL)

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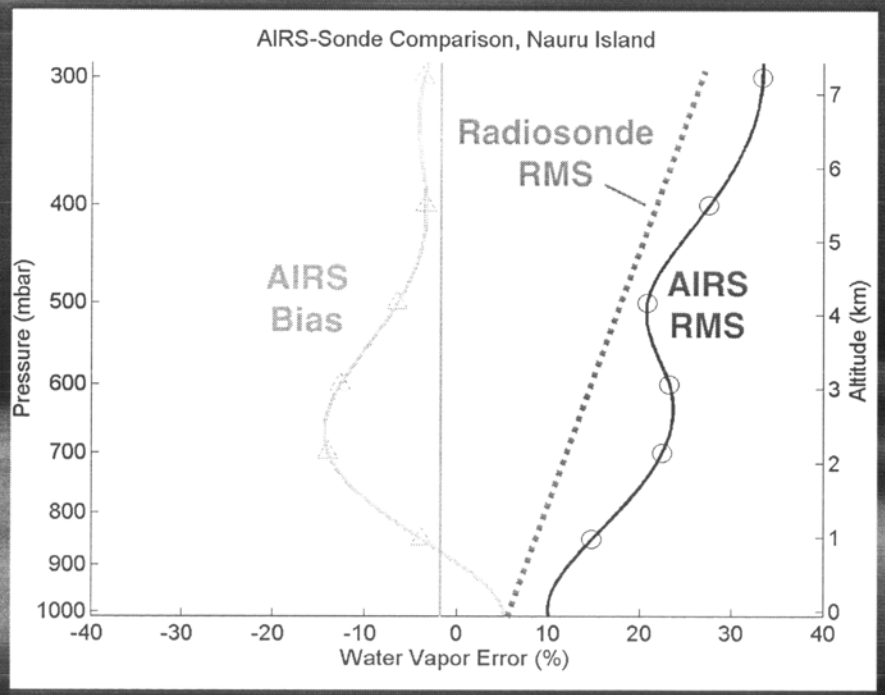
AIRS Shows High Accuracy and Horizontal Resolution of Water Vapor

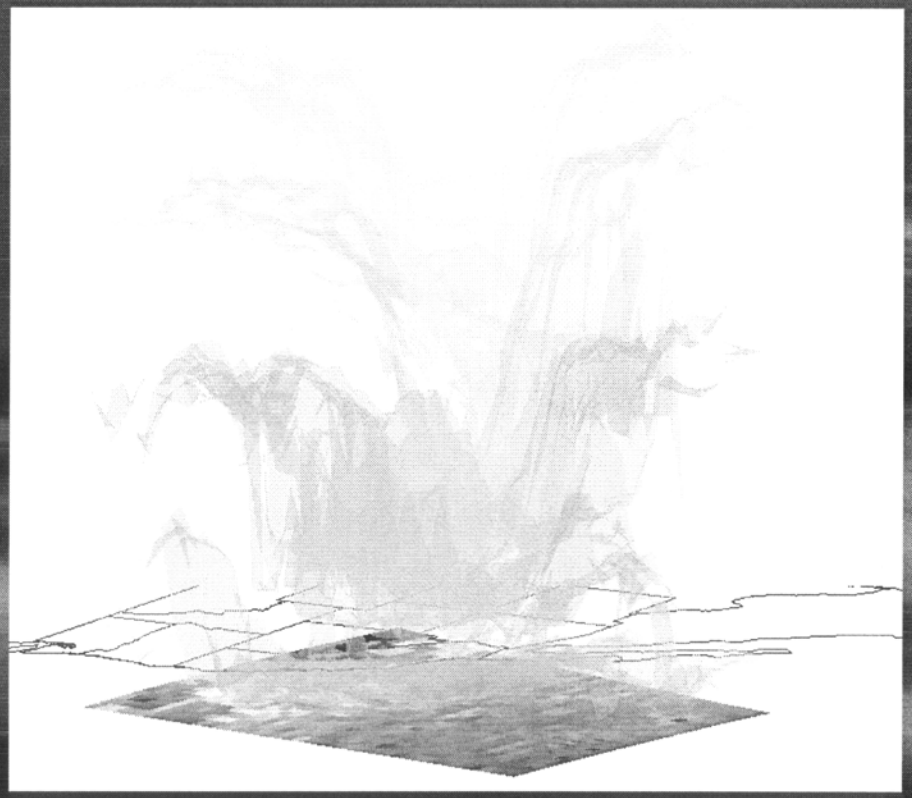
Water Vapor Profiles Match Radiosondes

Nauru Island Radiosondes



(E. Fetzer/JPL)

Isohyets Show Good Horizontal Resolution



T. Pagano (JPL))

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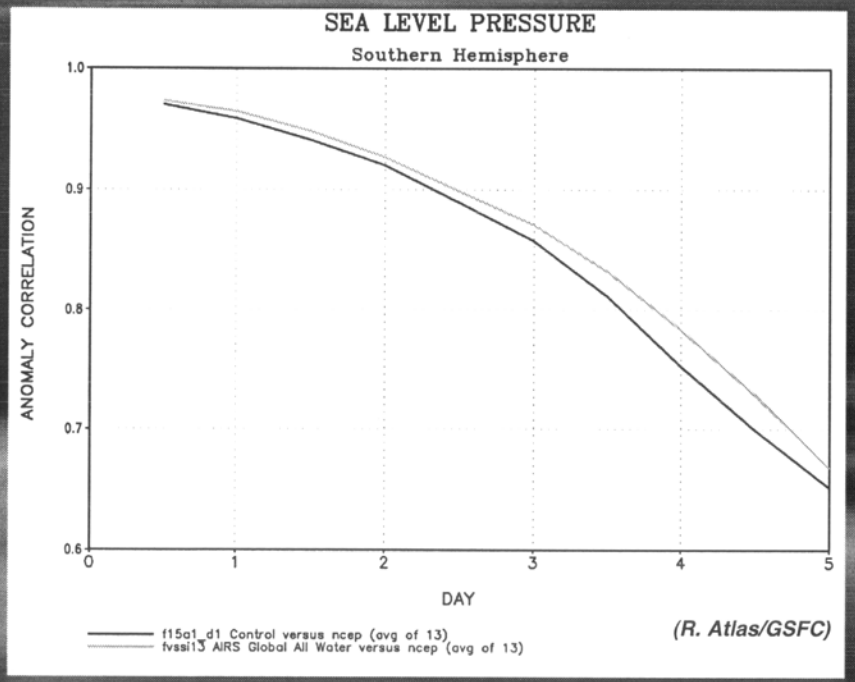
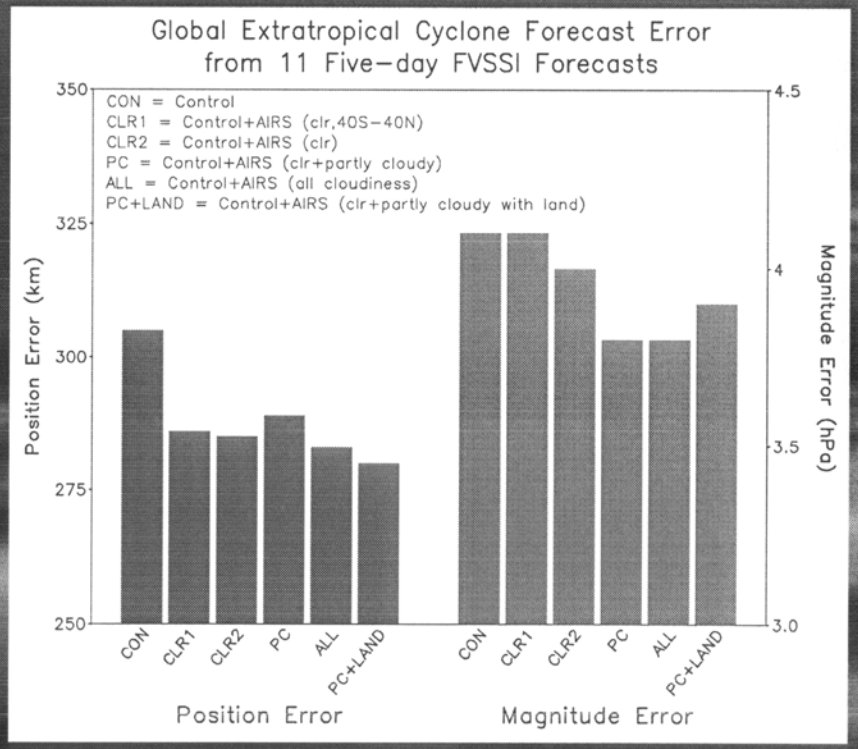
Weather: Forecasts Impact

AIRS Improves 5 Day Forecast Score by 5-8 hours in SH



(R. Atlas/GSFC)

AIRS Reduces Cyclone Position and Magnitude Error Globally



(R. Atlas/GSFC)

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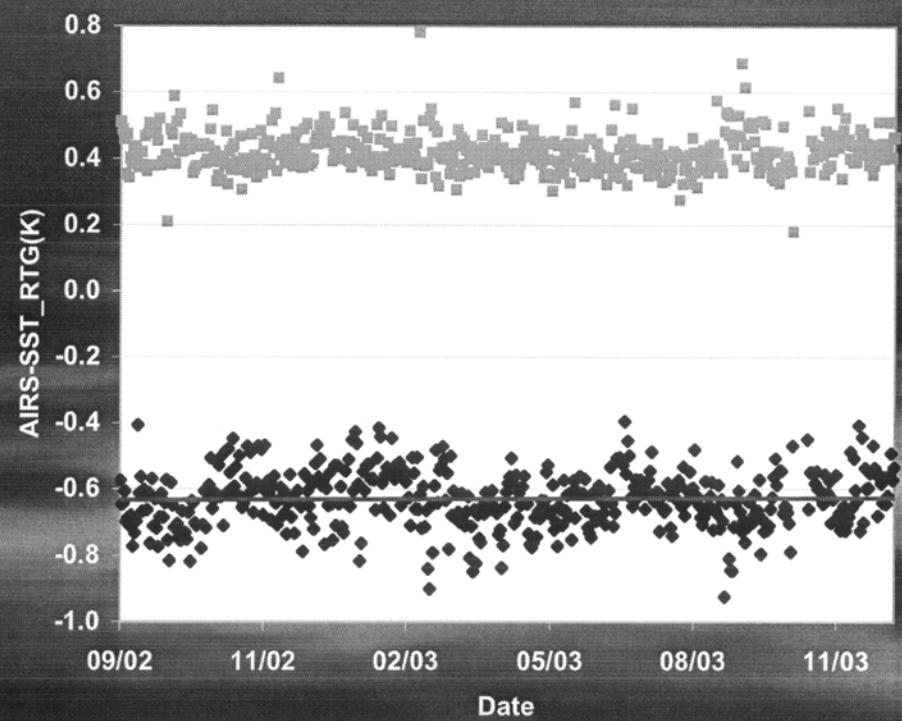
Instrument Stability Allows Polarization to be Observable

- AIRS Stability Demonstrated using SST
  - (Aumann, SPIE 2004)
  - < 5 mK/Year Bias Drift
  - RMS Constant at 0.4K
- Same Observations Used for Overlap Channel Polarization
- Observations Considered
  - Clear Ocean Scenes
  - Day and Night Separately
  - One Month, 2003

AIRS Radiances Extremely Stable Validated using RTG SST



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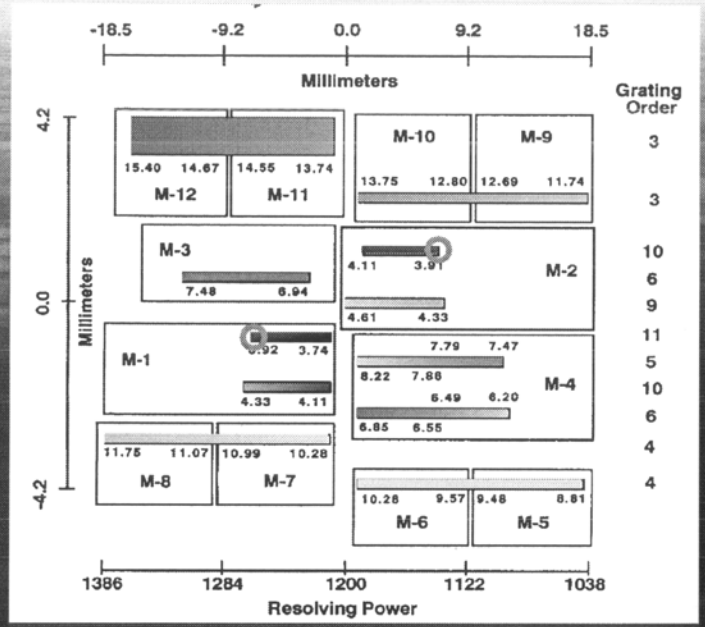
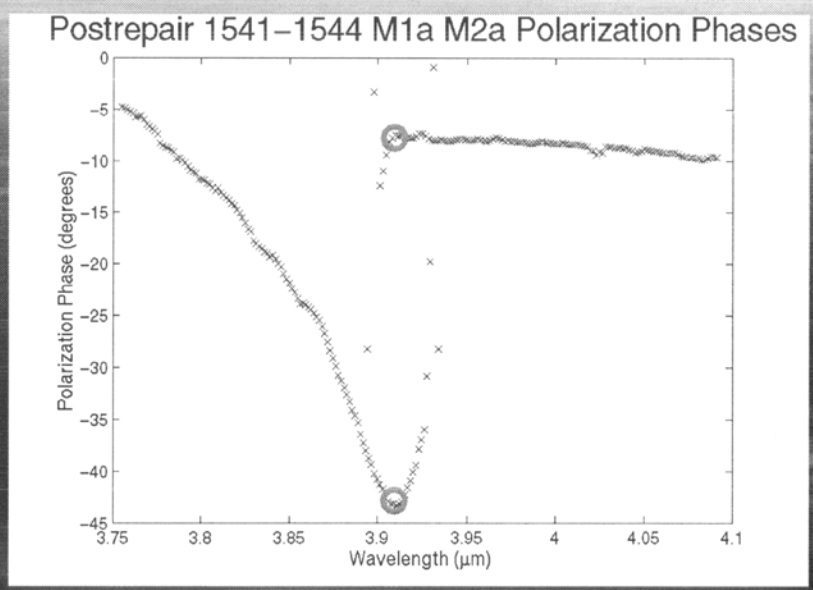
AIRS Overlap Channels Have Different Polarization





Channel	2252	2280
Wavelength (microns)	3.9051	3.9045
Wavenumber (cm^{-1})	2560.8	2561.1
Scan Mirror Polarization	0.0031	0.0031
AIRS Polarization	0.1398	0.0200
AIRS Phase (deg)	-7.76	-43.2

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Expect Signal Difference in Overlap Channels if Scene Polarized

$$S = Msp\ Nsc$$

$$M_{sp} = \frac{1}{2}\begin{bmatrix} q+r & (q-r)\cos 2\delta & (q-r)\sin 2\delta & 0 \\ (q-r)\cos 2\delta & (q+r)\cos^2 2\delta + 2\sqrt{(qr)}\sin^2 2\delta & \left(q+r-2\sqrt{(qr)}\sin 2\delta \cos 2\delta\right) & 0 \\ (q-r)\sin 2\delta & \left(q+r-2\sqrt{(qr)}\right)\sin 2\delta \cos 2\delta & (q+r)\sin^2 2\delta + 2\sqrt{(qr)}\cos^2 2\delta & 0 \\ 0 & 0 & 0 & 2\sqrt{(qr)} \end{bmatrix}$$

$$N_{sc} = \frac{1}{2}P_{sc}\begin{bmatrix} \varepsilon_s(\theta) + \varepsilon_p(\theta) \\ \left[\varepsilon_s(\theta) - \varepsilon_p(\theta)\right]\cos 2\theta \\ \left[\varepsilon_s(\theta) + \varepsilon_p(\theta)\right]\sin 2\theta \\ 0 \end{bmatrix}$$

$$\boxed{S_o = S_{sc} - S_{sv} = N_{sc}K\tau\{1 + p_K p_t \cos 2(\theta - \delta)\}}$$

$$p_K = \frac{\varepsilon_s - \varepsilon_p}{\varepsilon_s + \varepsilon_p} \qquad p_t = \frac{q-r}{q+r} \qquad K = \frac{\varepsilon_s + \varepsilon_p}{2} \qquad \tau = \frac{q+r}{2} = 1$$

$$\boxed{T_{err} = \frac{S_1 - S_2}{\partial N_{sc} / \partial T}}$$

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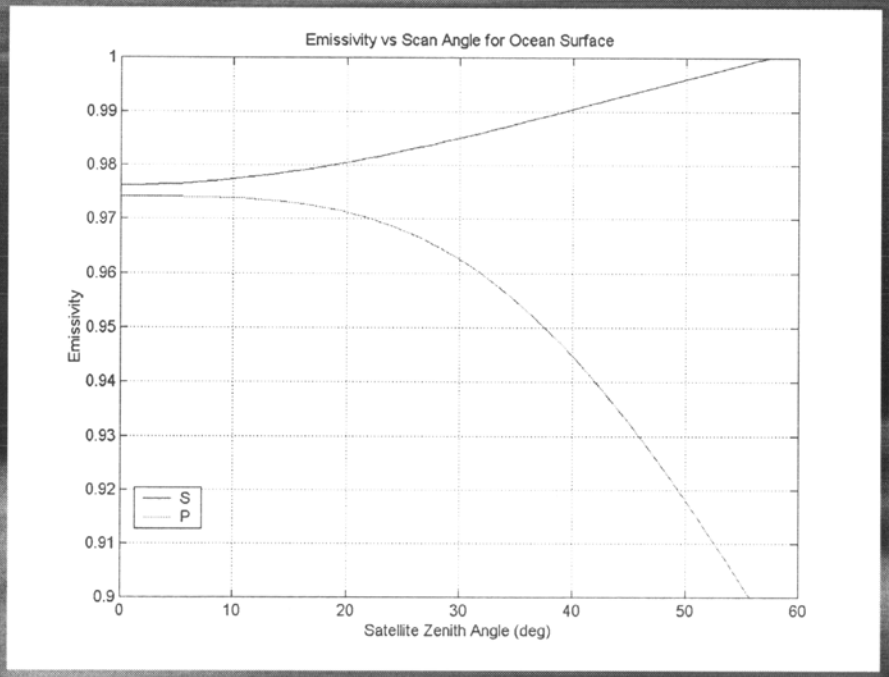
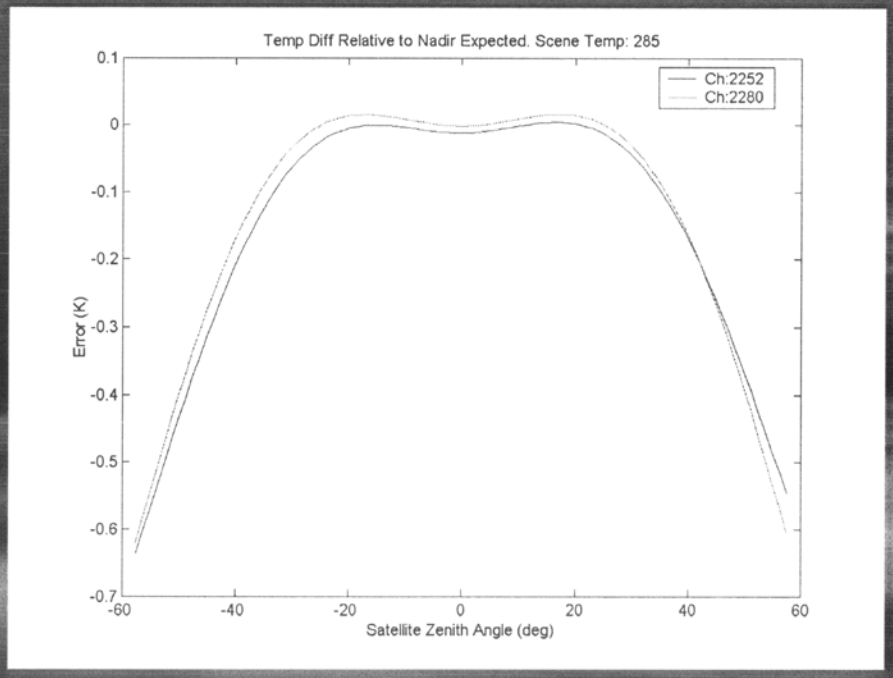
Overlap Channels Respond Differently to Scene Polarization

S and P Emissivity of Water (Shaw, 2000)



Response of Each Overlap Channel



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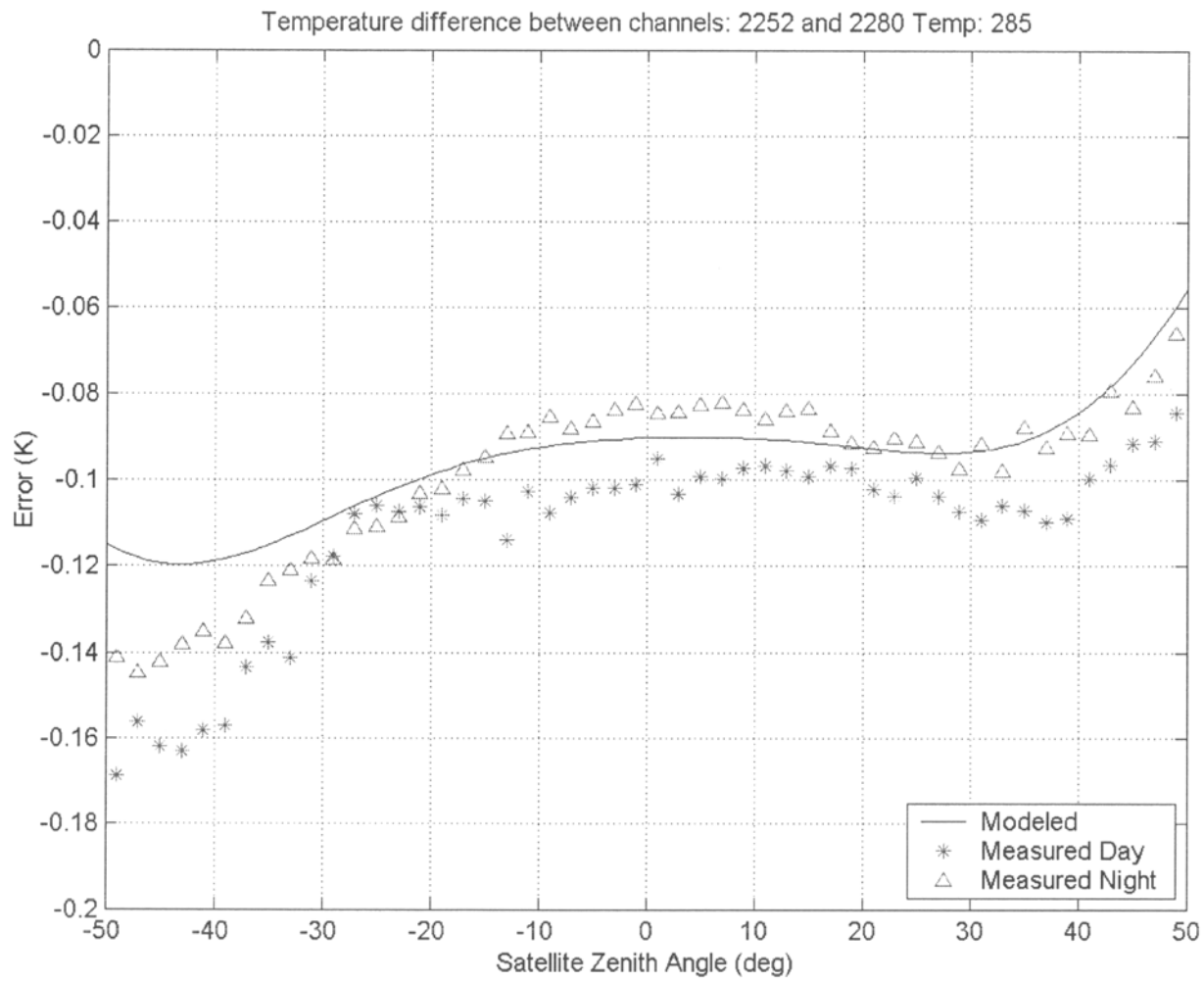
Modeled Response to Ocean Polarized Radiance Matches Observations



Summary and Conclusions

- Key AIRS Products Meet Requirements
- Stability Excellent
- Instrument Sensitive to IR Scene Polarization
- Response to Ocean Surface Polarization Observed
- Compares well with expectations
- Negligible Impact to Radiometry
- For more information…

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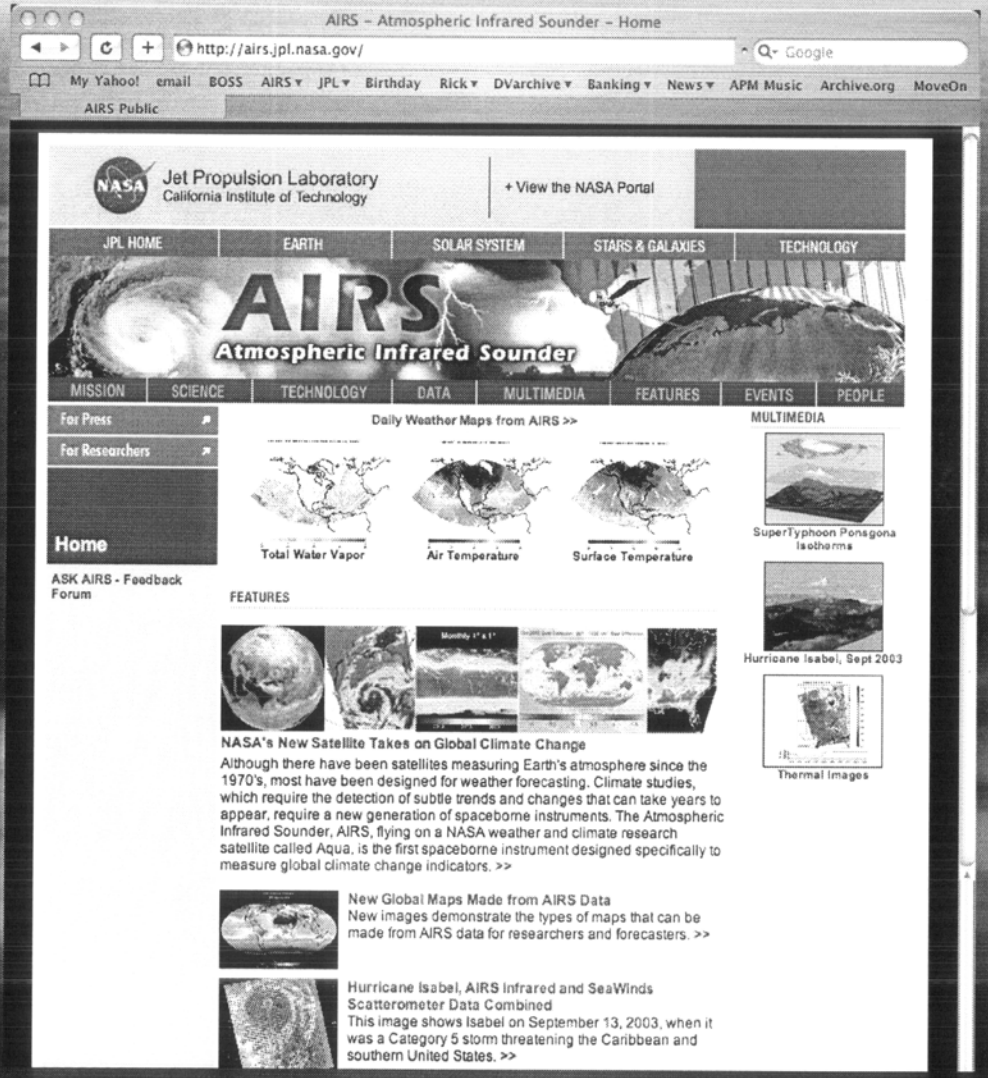
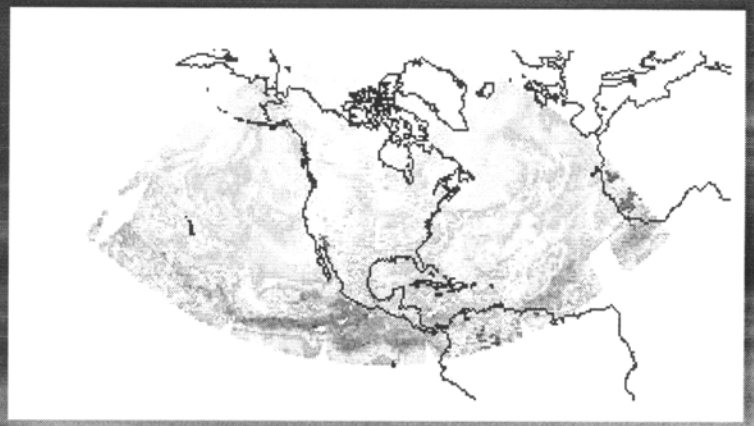
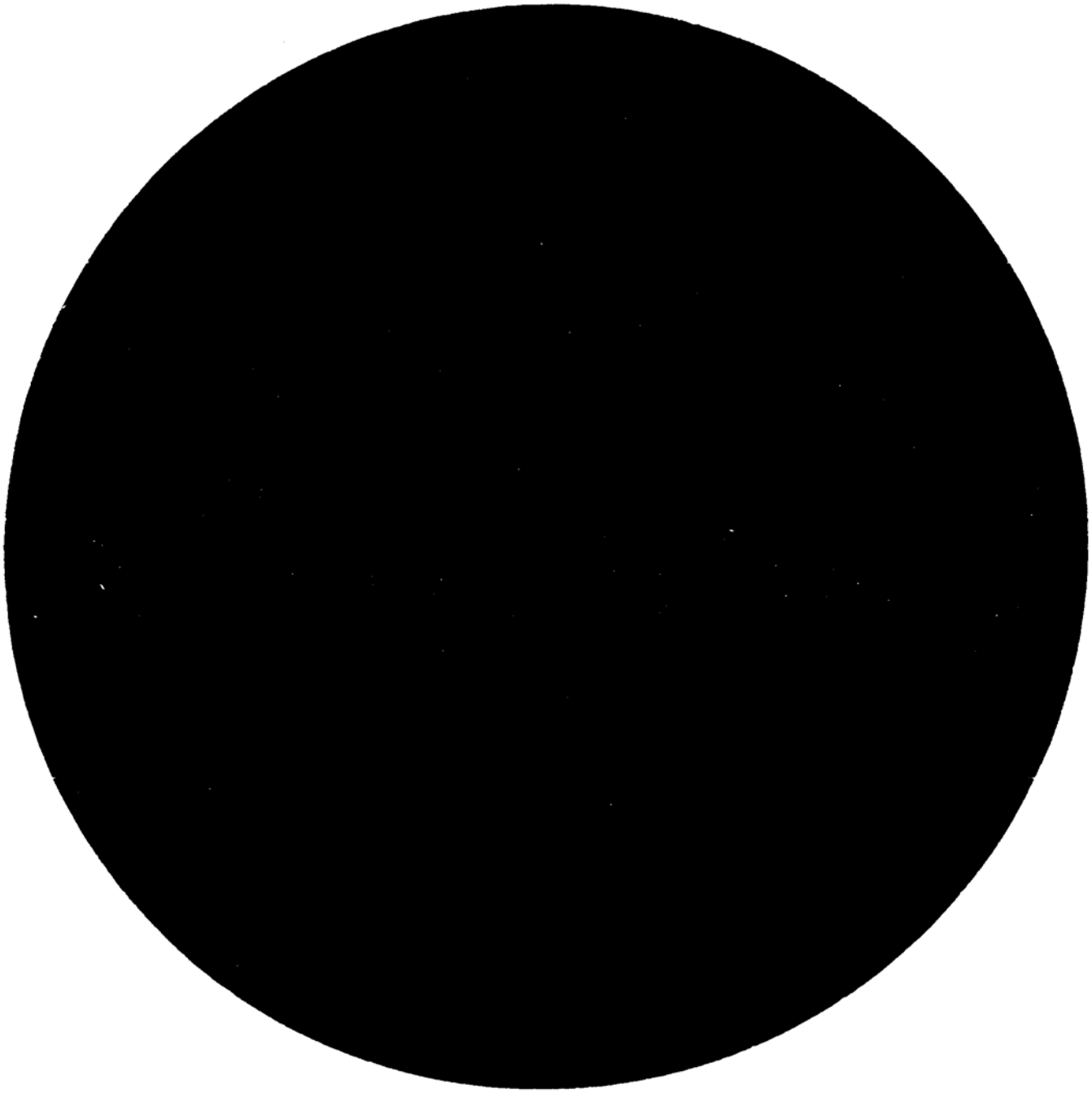
http://airs.jpl.nasa.gov



Maps of Total Water Vapor Over ConUS Provided Next Day after Acquisition
http://airs.jpl.nasa.gov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