

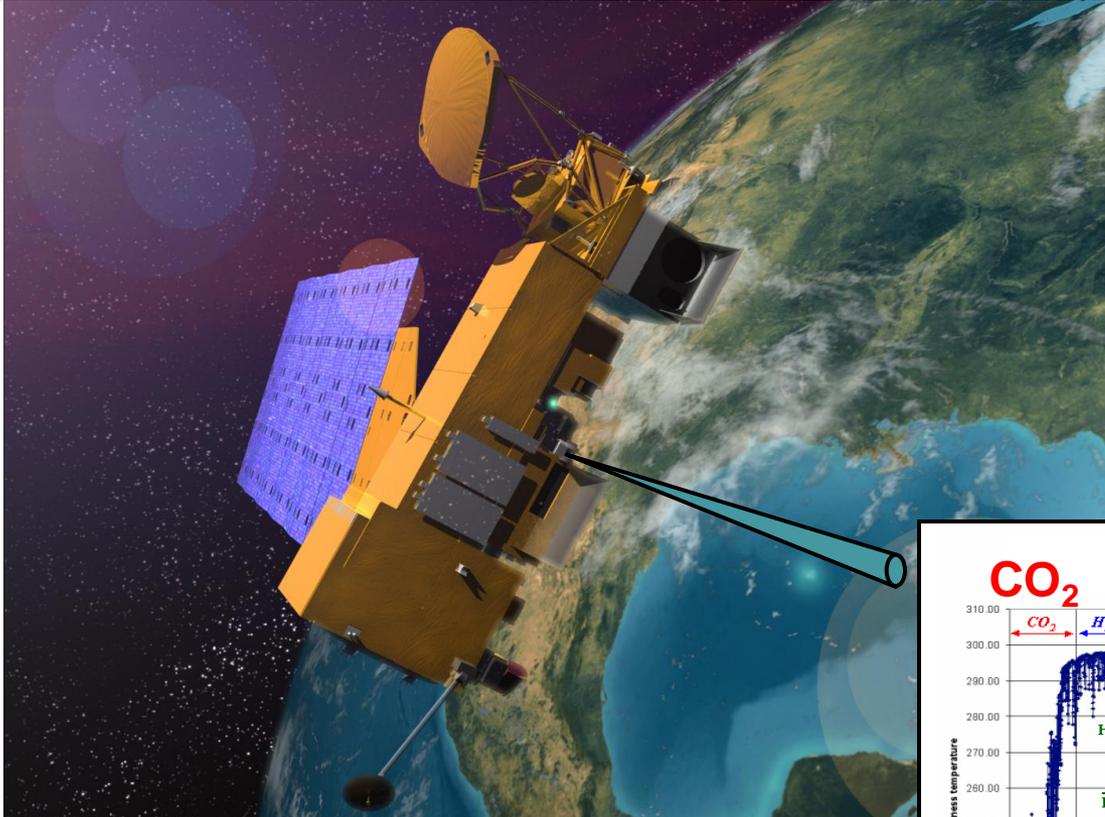


Jet Propulsion Laboratory
California Institute of Technology

Breakthroughs in Weather, Climate and Greenhouse Gases from AIRS on Aqua

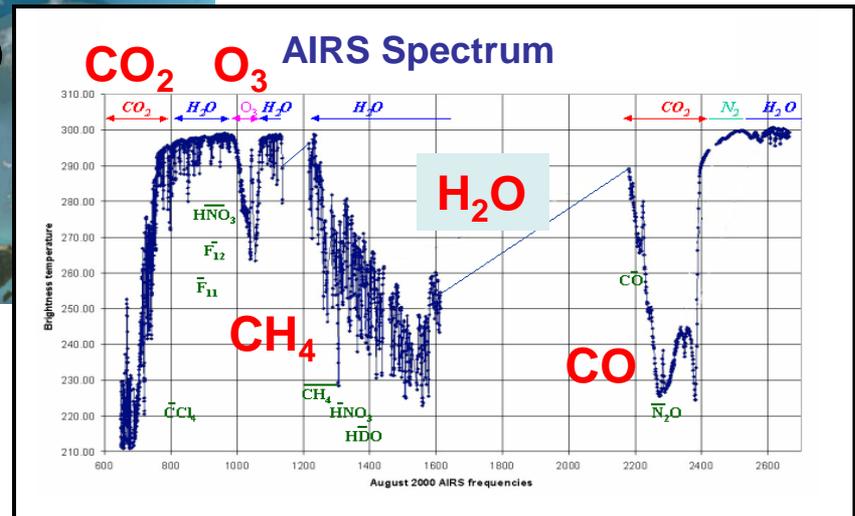
AGU Press Conference, 12/15/2009

Atmospheric Infrared Sounder (AIRS)



NASA Aqua Spacecraft
Launched May 4, 2002

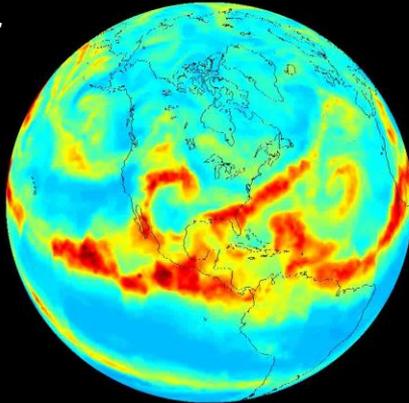
**AIRS Measures the Infrared Spectrum of
 Atmosphere With Global Daily Coverage**



AIRS Climate Products

Water Vapor

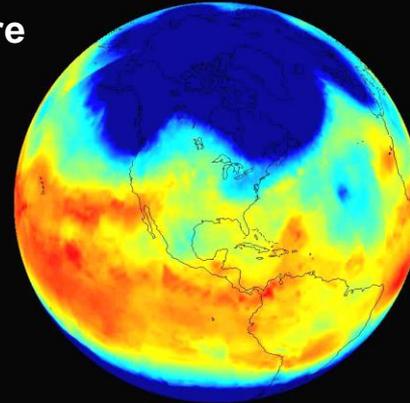
500 mb Water Vapor (g/kg dry air)



2005.08.01

Temperature

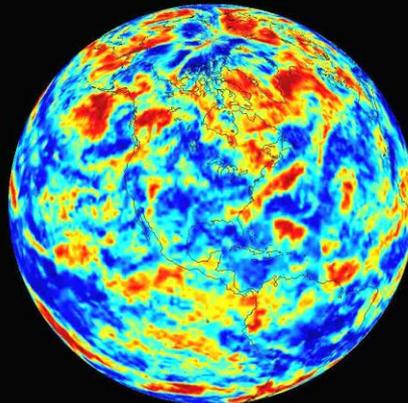
500 mb Temperature (K)



2005.08.01

Clouds

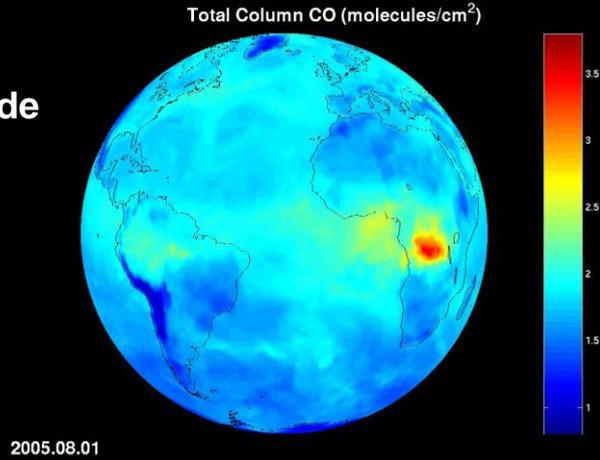
Cloud Fraction



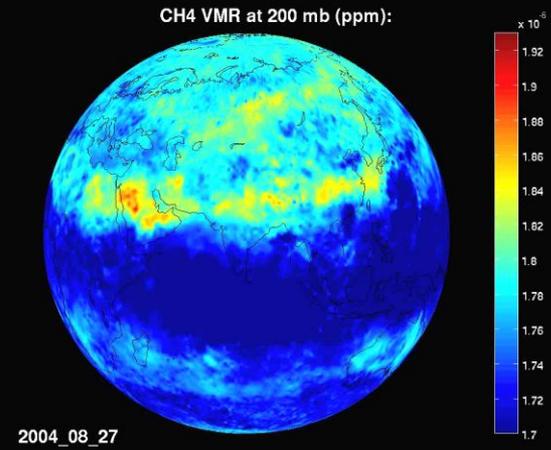
2005.08.01

AIRS Greenhouse Gases

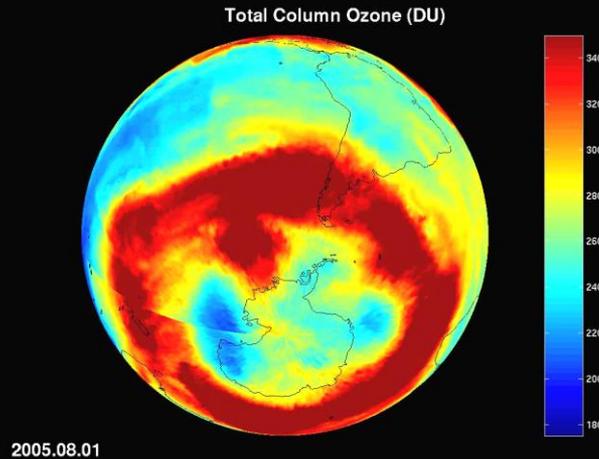
Carbon Monoxide



Methane

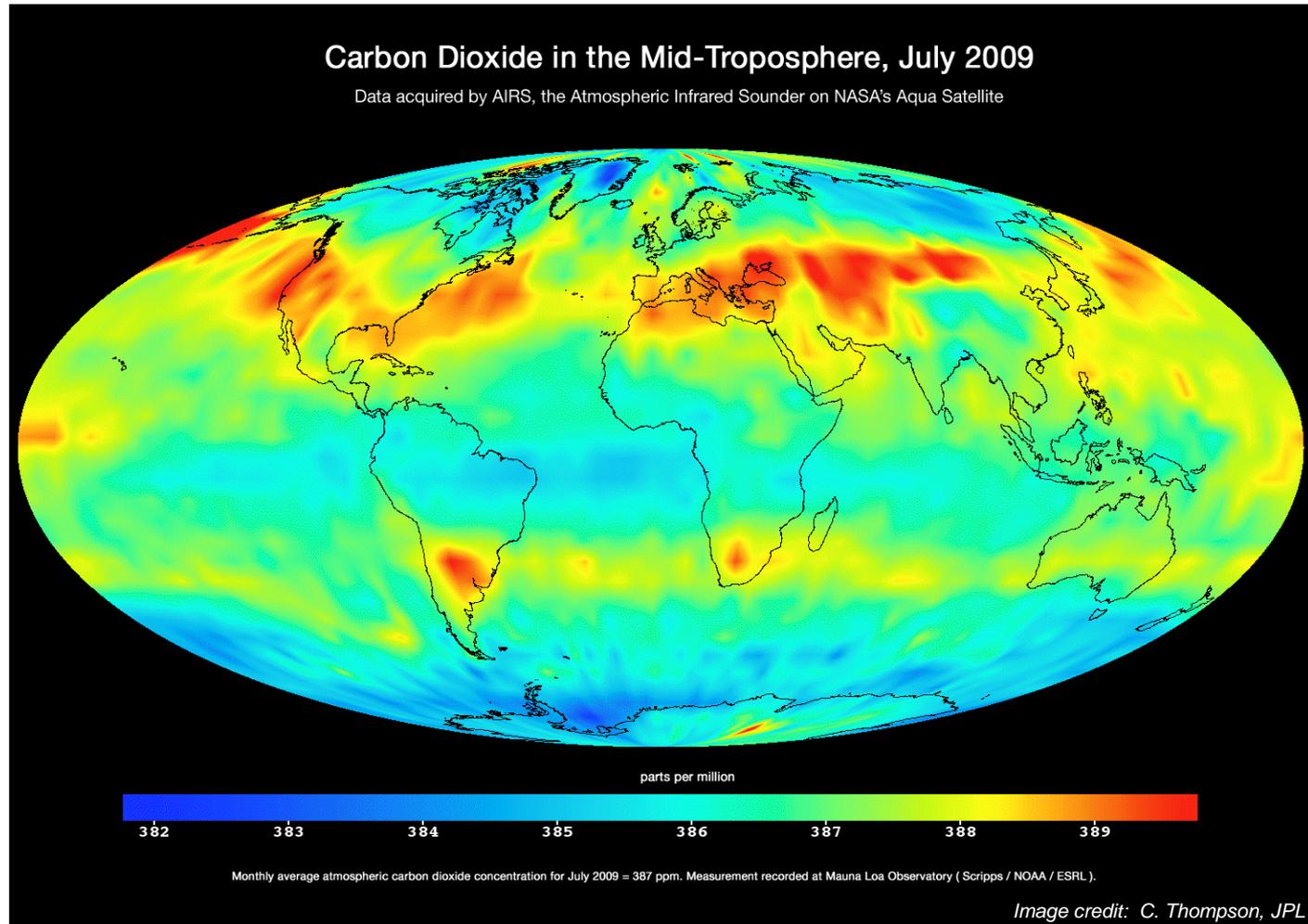


Ozone



AIRS Carbon Dioxide Product Released Today

Dr. Moustafa T. Chahine, Jet Propulsion Laboratory



AIRS 3D Water Vapor Validates Strong Water Vapor Feedback

Dr. Andrew Dessler, Texas A&M

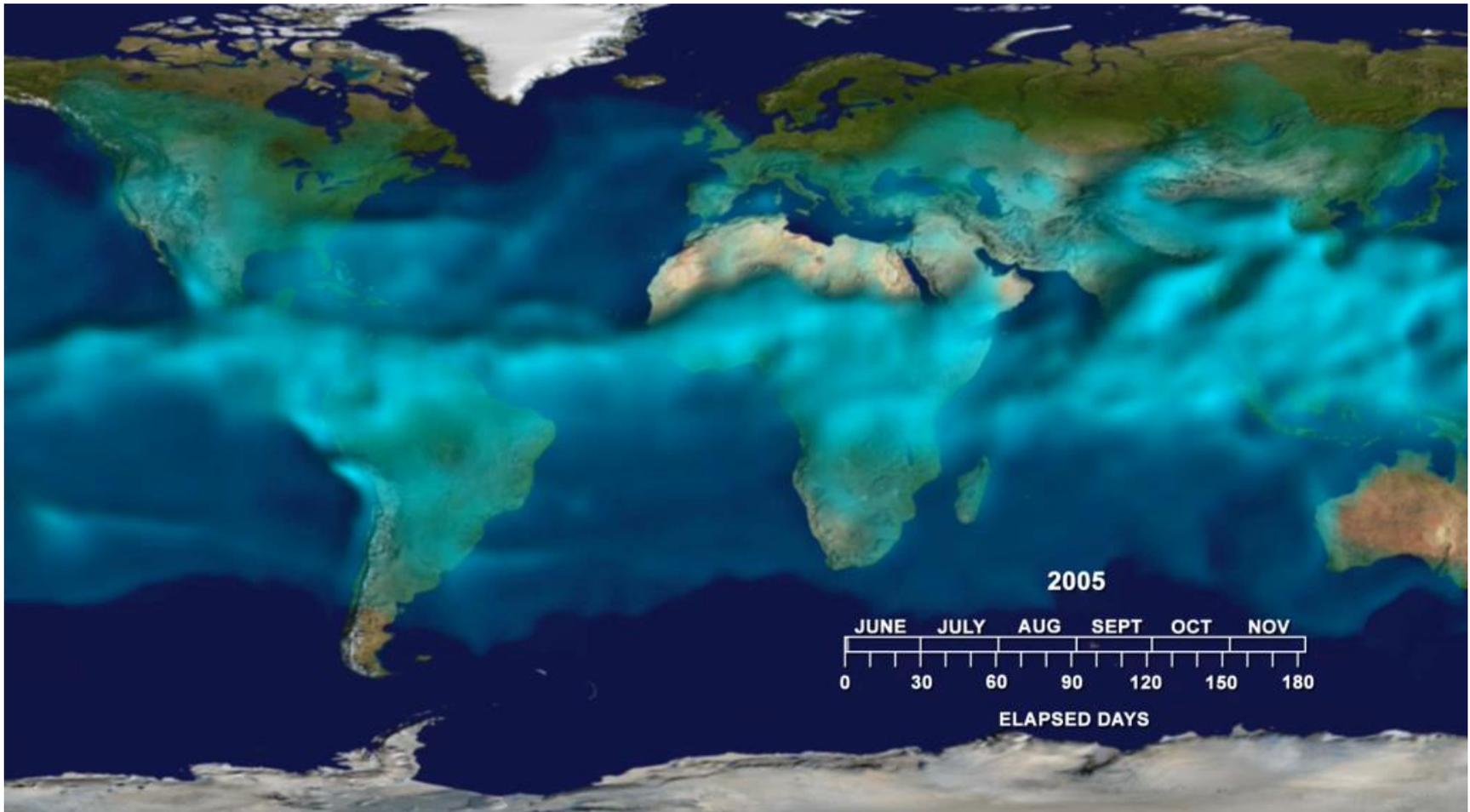
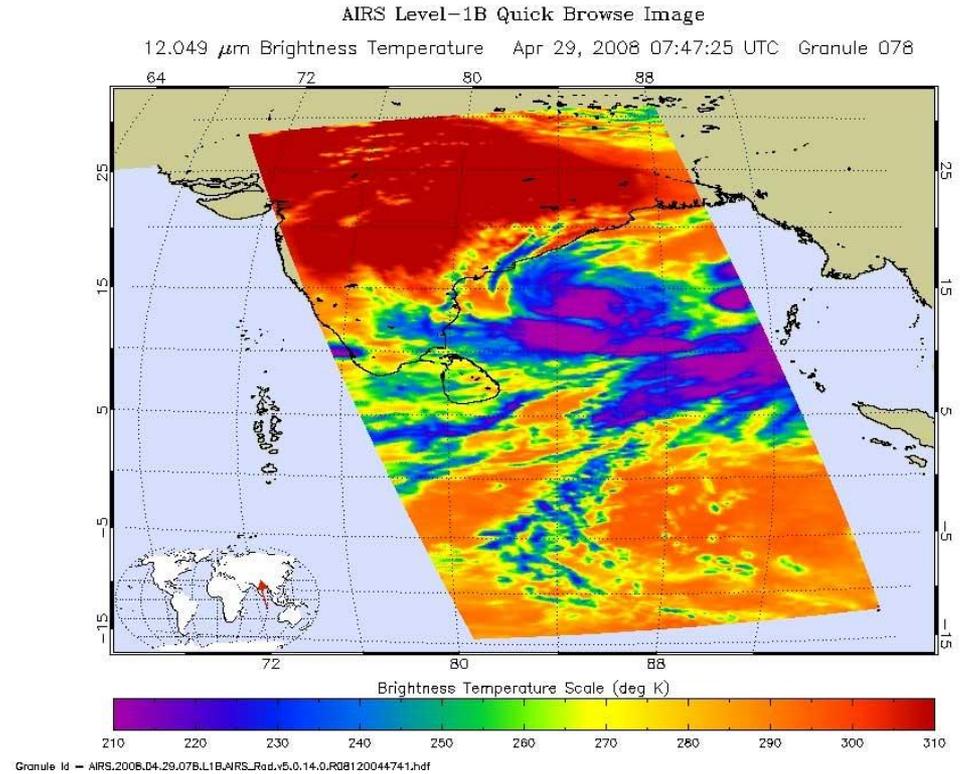
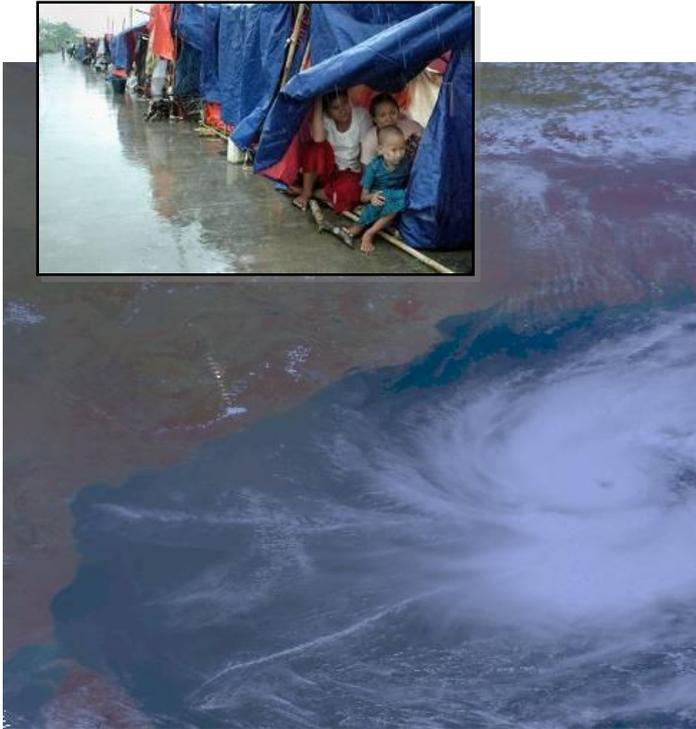


Image credit: V. Realmuto, JPL

AIRS Improves Weather Forecast

Dr. Eric Fetzer, Jet Propulsion Laboratory



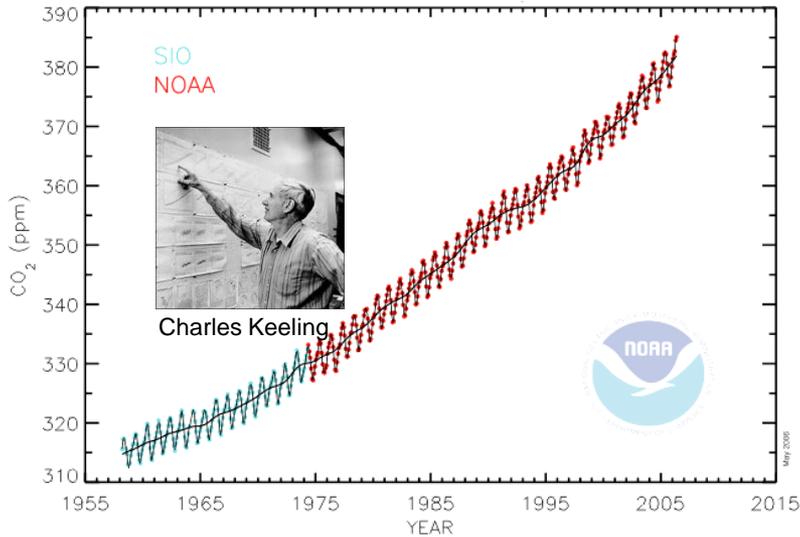
AIRS Visible Image x 3 Frequencies

AIRS Infrared Image x 2,378 Frequencies

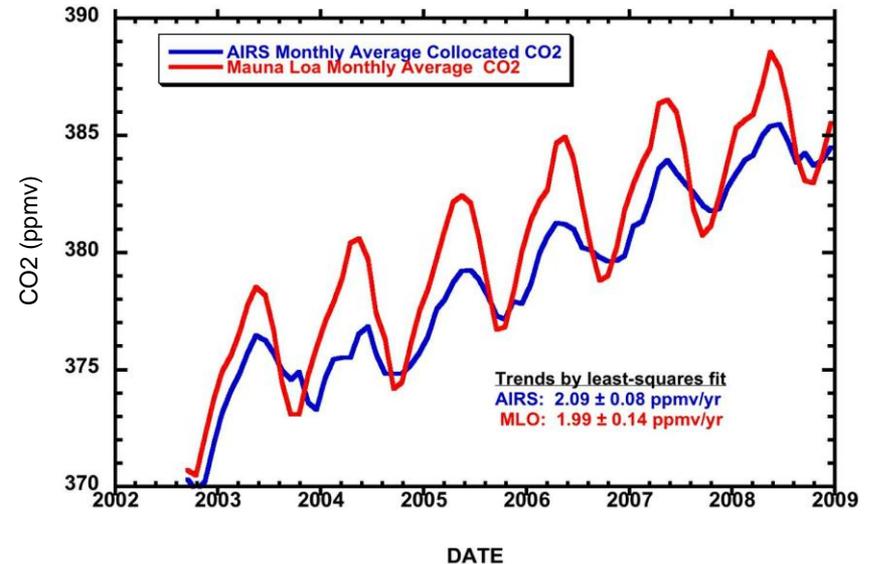
Tropical Cyclone Nargis, Myanmar (Burma) May 2008

AIRS Space Observations Continue Historic CO₂ Monitoring

Mauna Loa Monthly Mean Carbon Dioxide
NOAA ESRL GMD Carbon Cycle



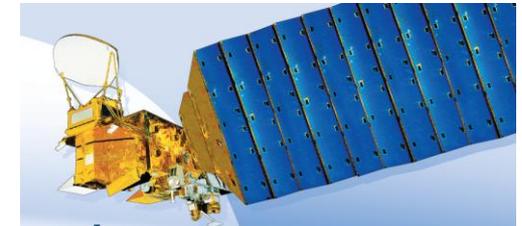
Mauna Loa vs AIRS collocated within 500 km



Mauna Loa Observatory

Mauna Loa CO₂ from 1958 to 2000:
 $\Delta(\text{CO}_2) \approx 380\text{ppm} - 310\text{ppm} = 70\text{ppm}$

Mean = 1.7 ppm/yr. Recent = 2 ppm/yr



AIRS on AQUA spacecraft
since May 2002

Public Release: Monday, Dec. 14, 2009

7 Years of AIRS Mid-Tropospheric CO₂

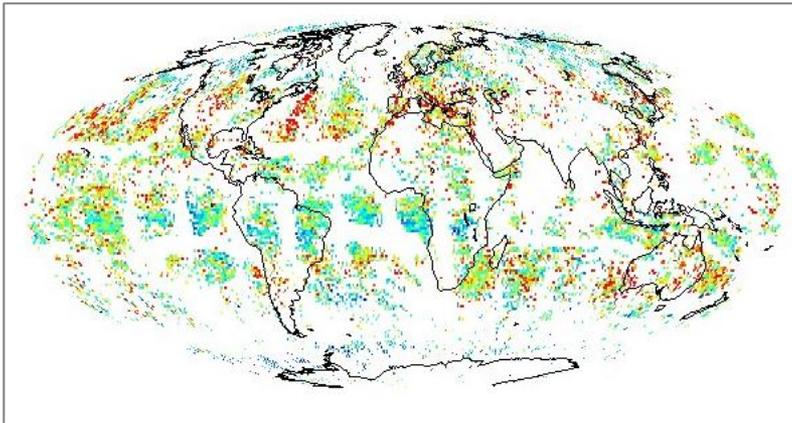
3-7 miles above Earth's surface

AIRS Daily CO₂ Yield

1°x1° Spatial Resolution

15,000 CO₂ Soundings

AIRS V5 CO₂: Day 2003 7 15x1

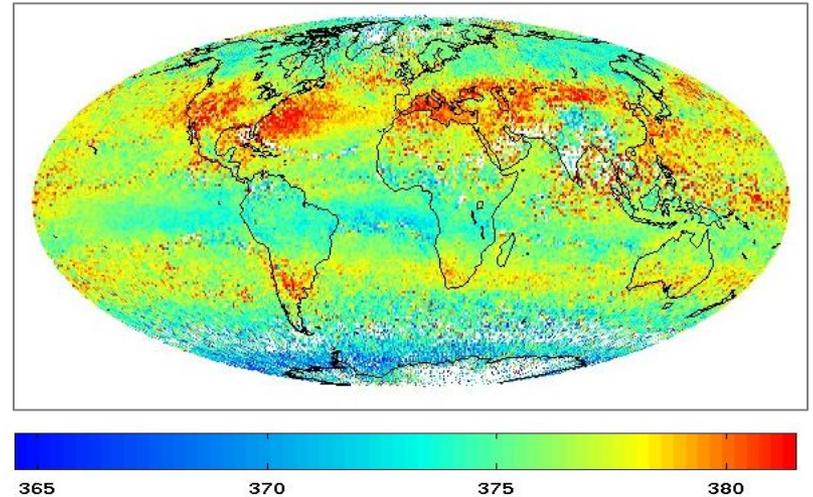


AIRS Monthly CO₂ Yield

1°x1° Spatial Resolution

450,000 CO₂ Soundings

AIRS V5 CO₂: Day 2003 7 15x1



Day/Night, Pole-to-Pole, Land/Ocean/Ice, Cloudy/Clear

AIRS CO₂ with Mauna Loa CO₂ Overlaid

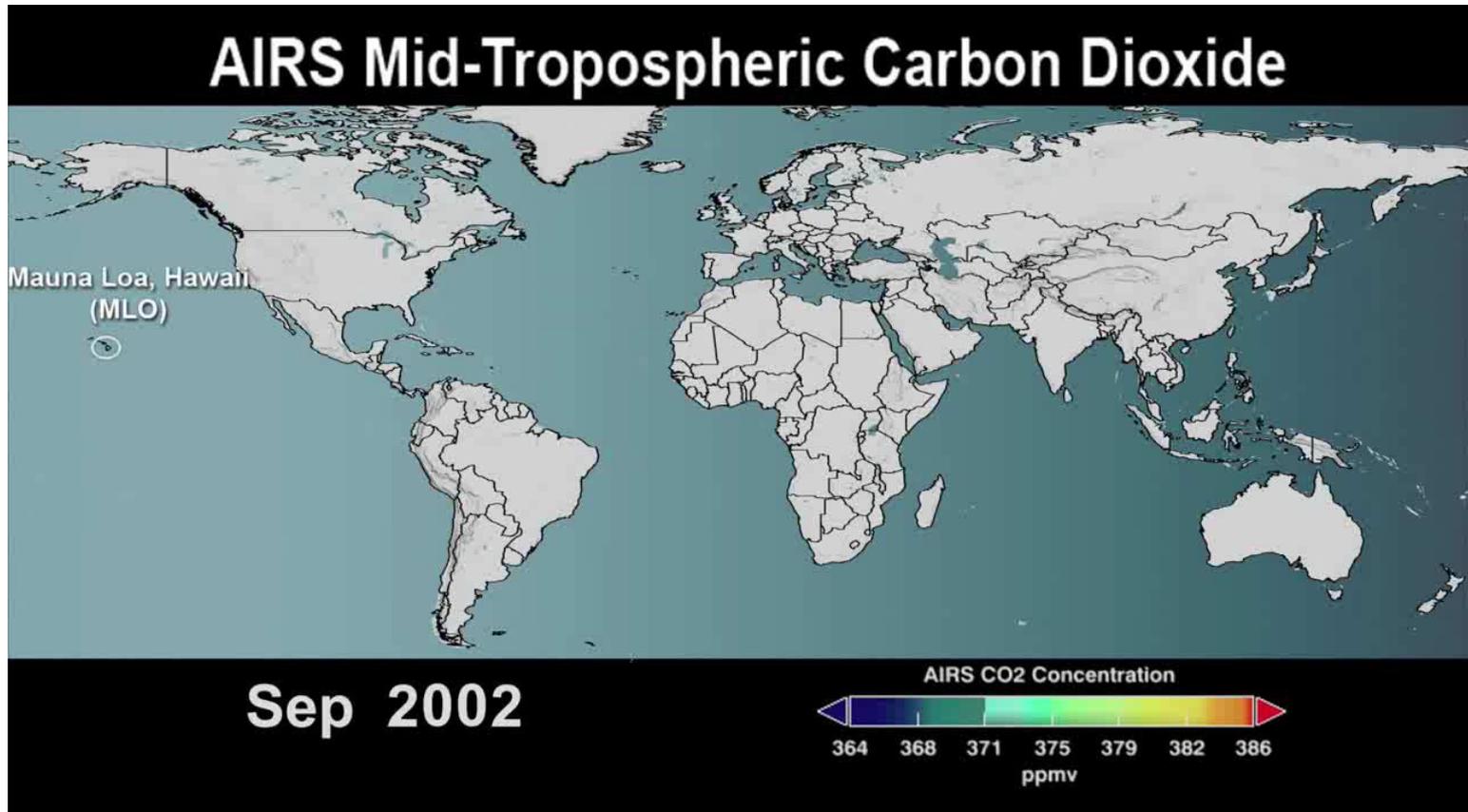


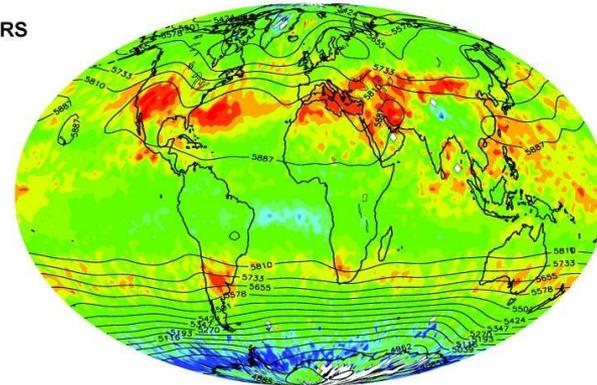
Image credit: L.. Perkins, GSFC/SVS

What We Have Observed/Learned

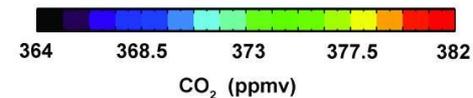
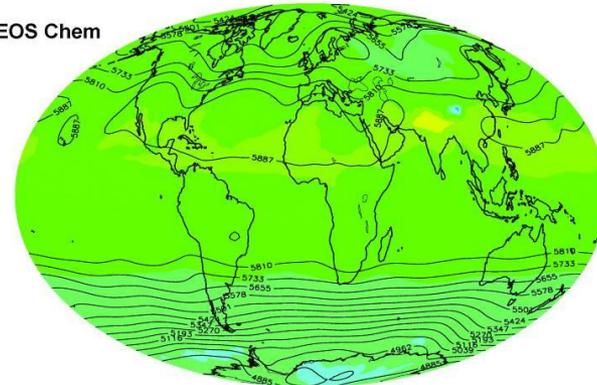
1. CO₂ is NOT Well Mixed in the Troposphere

Driven by Weather Patterns (Jet Stream)

AIRS



GEOS Chem

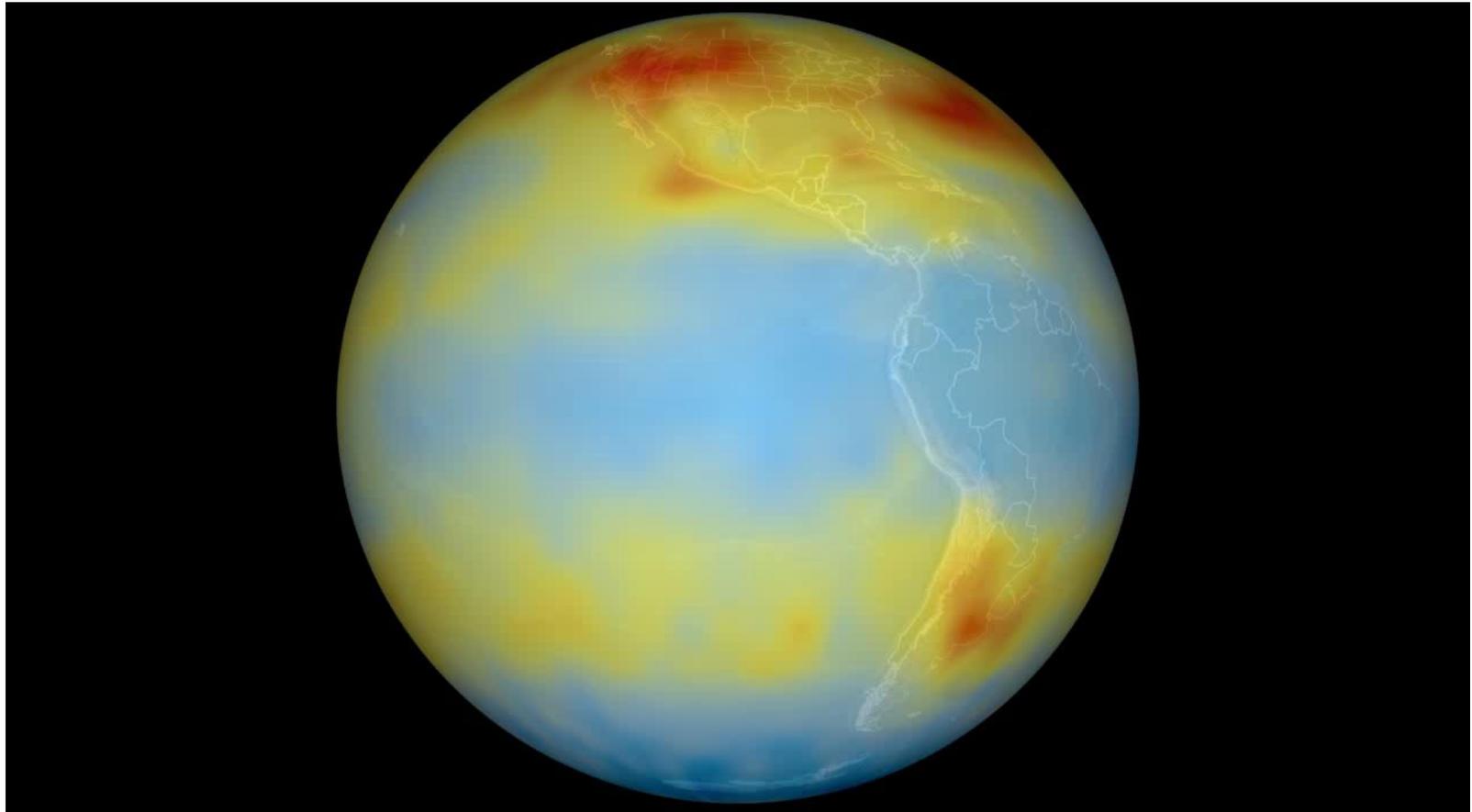


2. Complexity of the Southern Hemisphere Carbon Cycle

CO₂ Belt in the SH

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.

“No country is immune from the effects of increased greenhouse gases”



January 2003

Image credit: L.. Perkins, GSFC/SVS

AIRS: A New Tool for Monitoring CO Gas Emissions from Biomass Burning

AIRS Measures Global Daily Carbon Monoxide

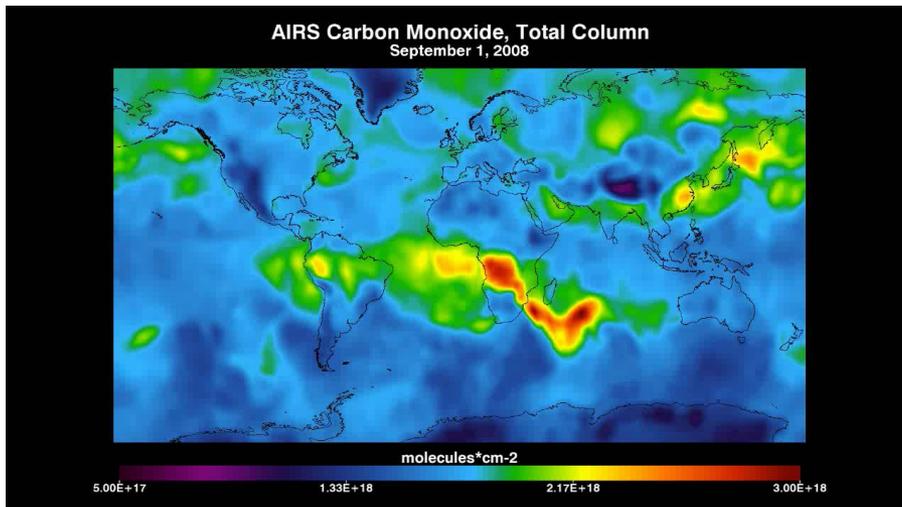


Image credit: C. Thompson, JPL

California "Station Fire", August 2009

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

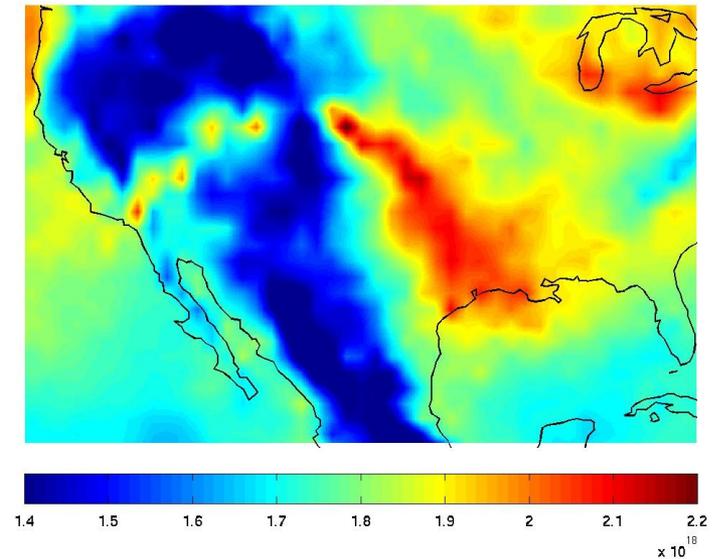
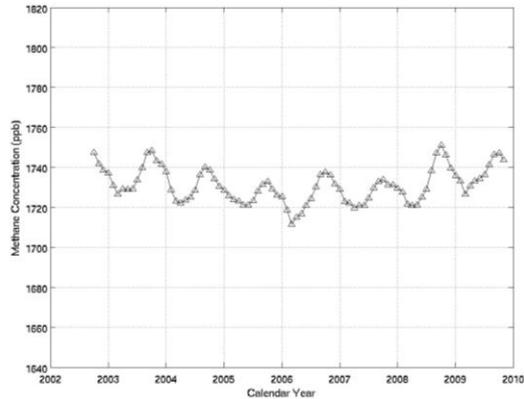


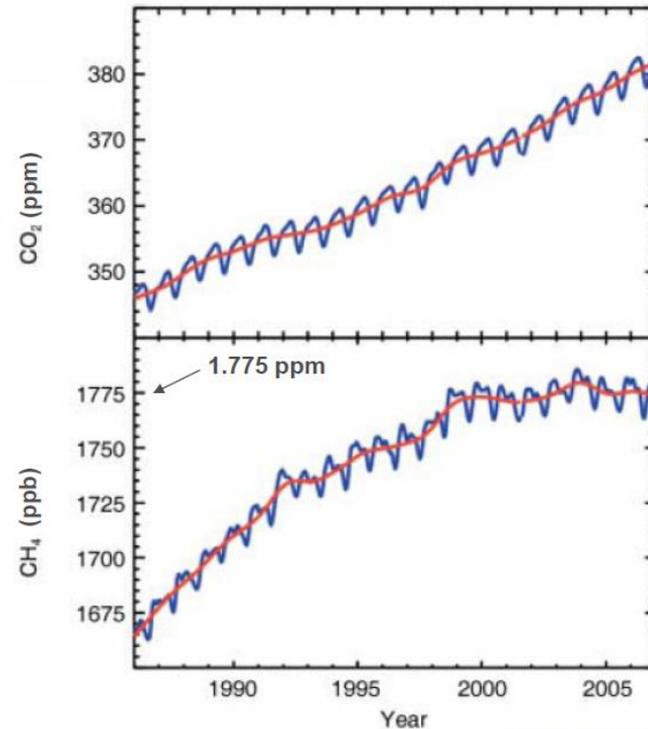
Image credit: T. Pagano, JPL

AIRS Methane Observations in the upper troposphere

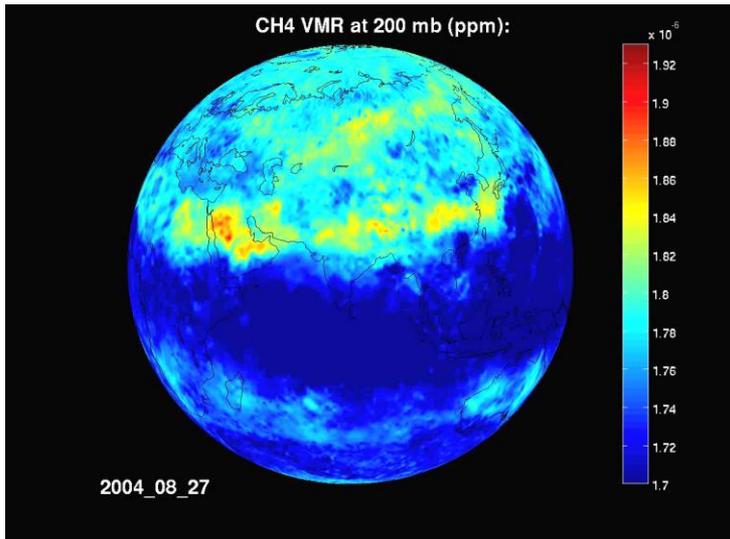
AIRS Methane (CH₄) Time Series



Comparison of Atmospheric Time Series of CO₂ and CH₄



Evans, *New Phytologist*, 2007.
www.cmdl.noaa.gov



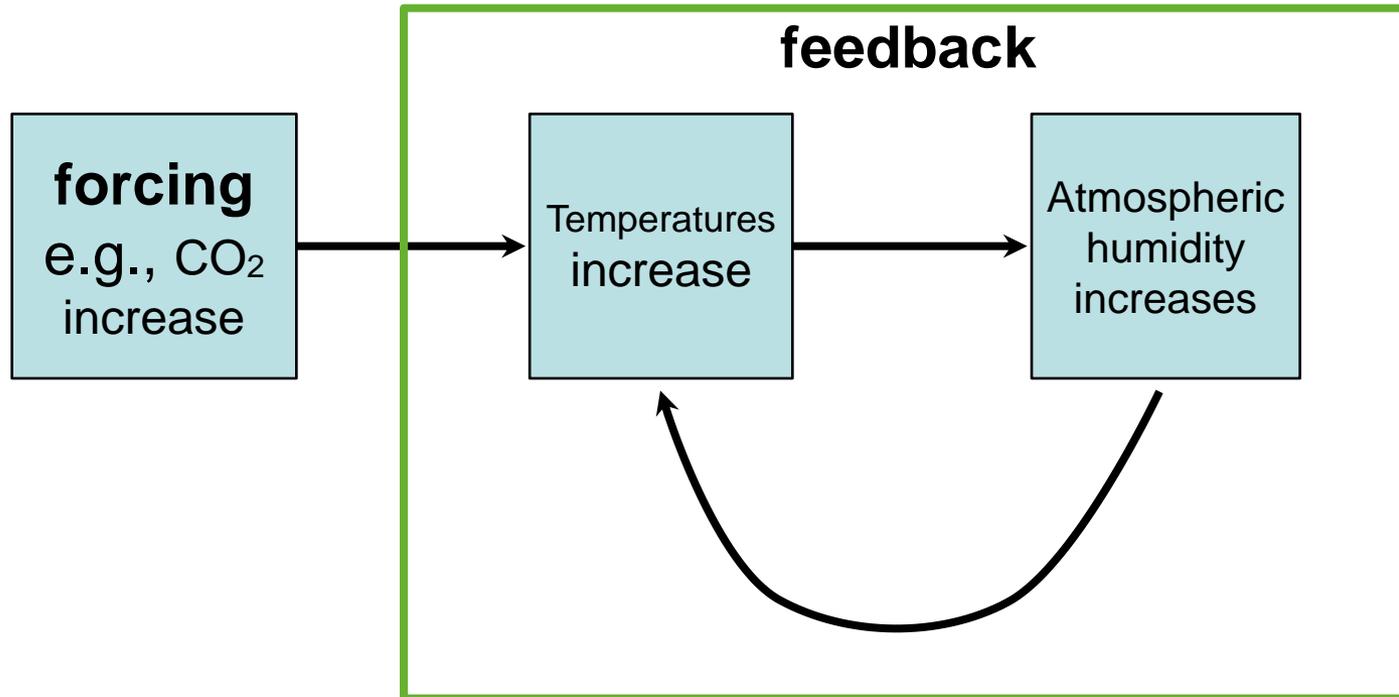
Animated AIRS CH₄ Global Map

Water Vapor Feedback

- AIRS provides a unique view of the water vapor distribution and the water vapor feedback
- Water vapor feedback is a strong amplifier of the warming due to carbon dioxide
- Warming over the next century of a few degrees Celsius is essentially guaranteed — unless there exists a presently unknown offsetting negative feedback (e.g., clouds)



Forcing and Feedback



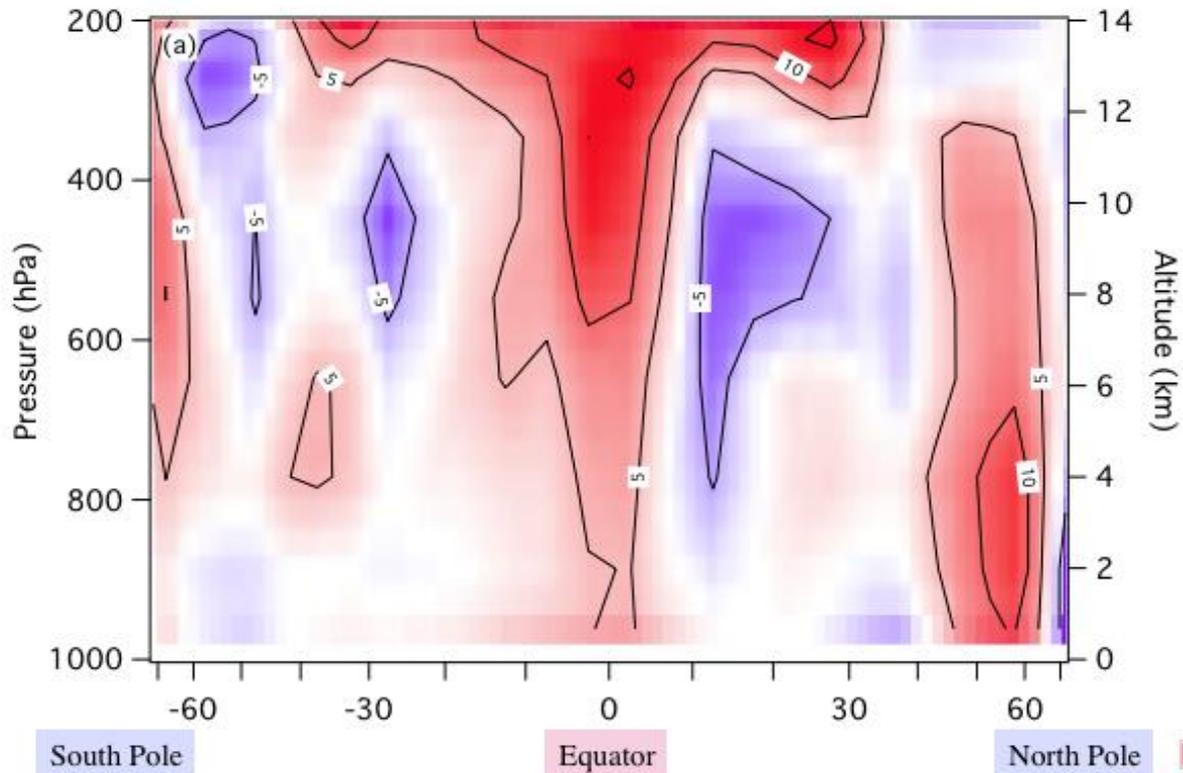
Water Vapor and Climate Models

“Because carbon dioxide is not the major greenhouse gas. The major greenhouse gas is water vapor.” But current climate models “do not know how to handle water vapor and various types of clouds. That is the elephant in the corner of this room. I hope we’ll have good numbers on water vapor by 2020 or thereabouts.”

- Lowell Wood,
quoted in *Superfreakonomics*, 2009

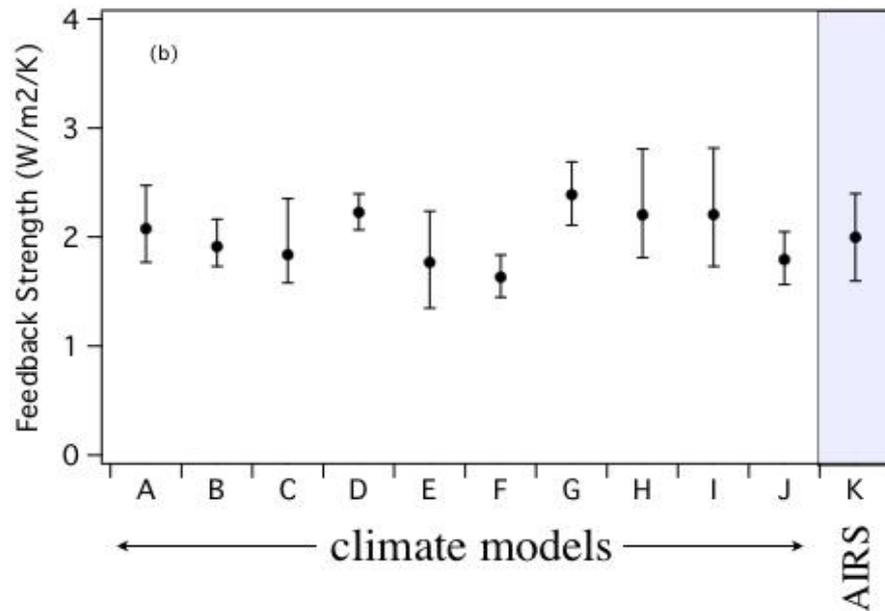
Percent Change in Specific Humidity Between El Nino and La Nina

Change in surface temperature = 0.6 degrees Celsius



Comparing Climate Models and AIRS

Calculated values of the water vapor feedback



AIRS Measurements of Water Vapor

- AIRS allows us to observe the fine structure of the water vapor feedback with unprecedented resolution
- We have confirmed that the water vapor feedback is strong and positive, and it doubles the direct warming from greenhouse gases
- Models do a good job of simulating this
- Large future warmings are essentially guaranteed — unless there exists a presently unknown offsetting negative feedback

Destruction from Tropical Cyclones

Tropical cyclones in the Bay of Bengal are the most destructive weather on the planet

- Individual storms can kill as many as 500,000 people.
 - Many storms kill thousands.
- Low-lying regions around the Bay of Bengal are particularly vulnerable.
 - High population densities.
 - Developing economies (transportation and communication infrastructure often insufficient).
- Forecasting storms in this area is difficult.

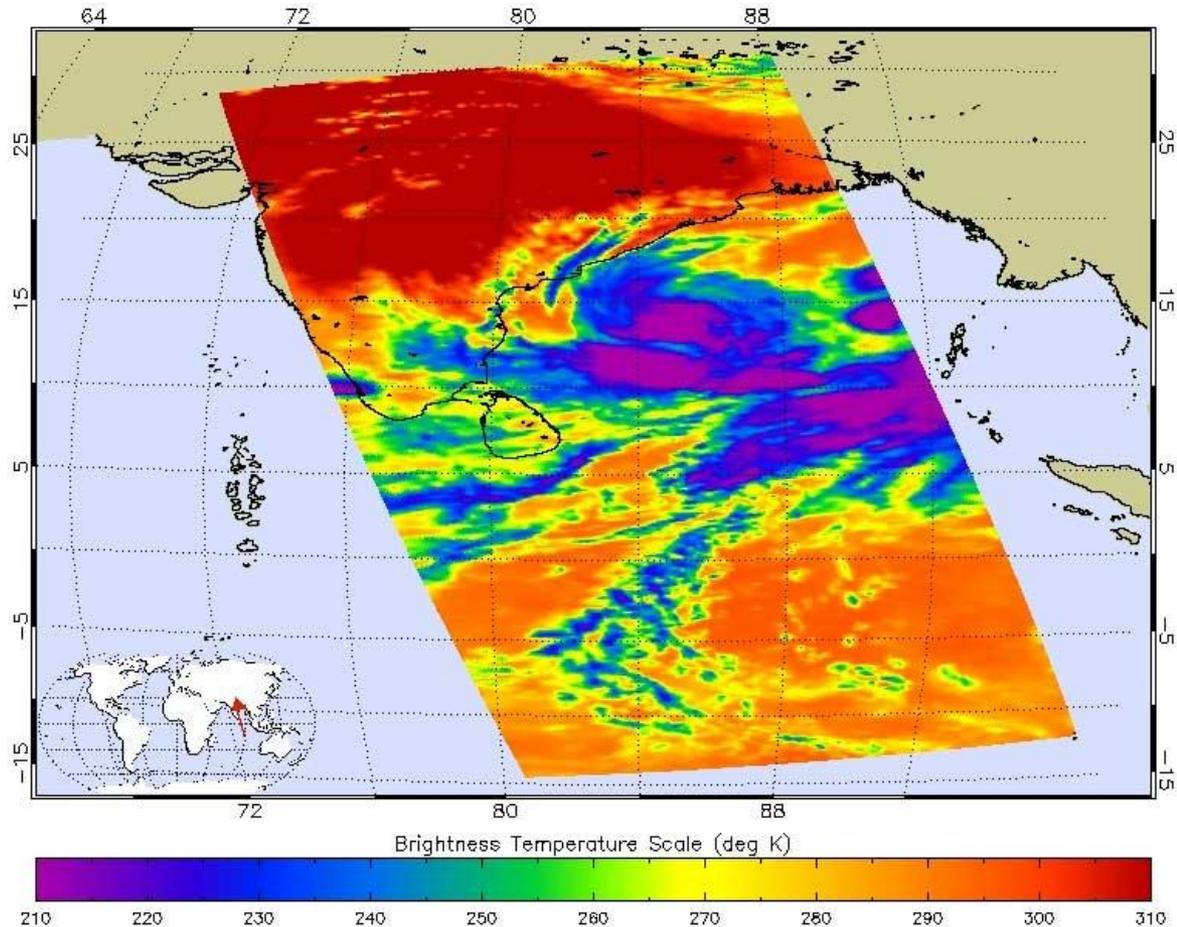
AIRS Data and Forecast Improvement

- The global forecast missed Tropical Cyclone Nargis storm track by several hundred miles.
- Inclusion of AIRS temperatures in the upper troposphere (about 10 miles above the surface) significantly improved a hindcast of Nargis.
- Inclusion of AIRS temperatures would have improved Nargis forecast.

AIRS Infrared Image – Cyclone Nargis

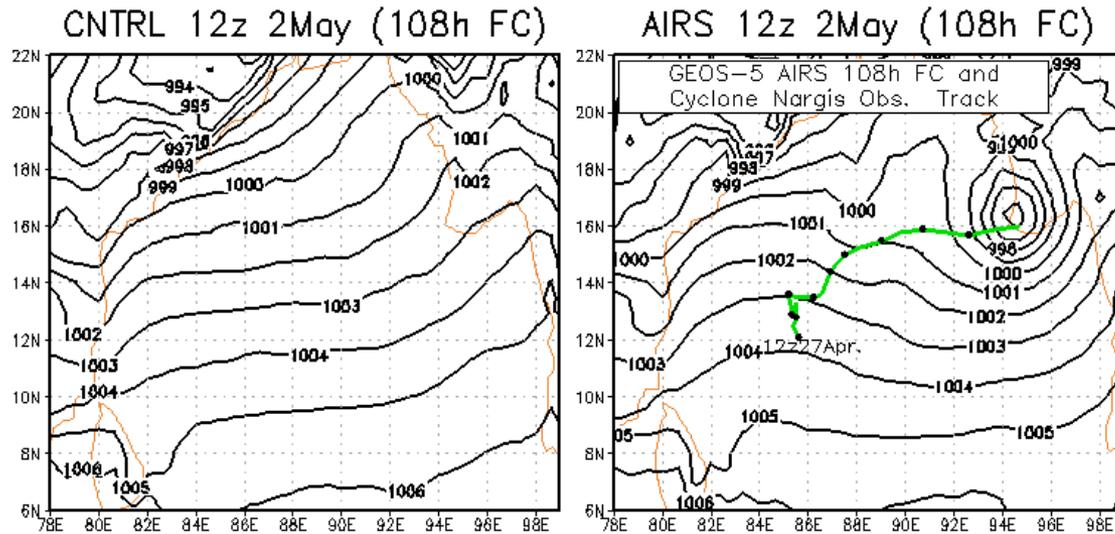
AIRS Level-1B Quick Browse Image

12.049 μm Brightness Temperature Apr 29, 2008 07:47:25 UTC Granule 078



Granule Id = AIRS.2008.04.29.078.L1B.AIRS_Rad.v5.0.14.0.R08120044741.hdf

AIRS Improves Typhoon Forecasts



Control:
No Cyclone

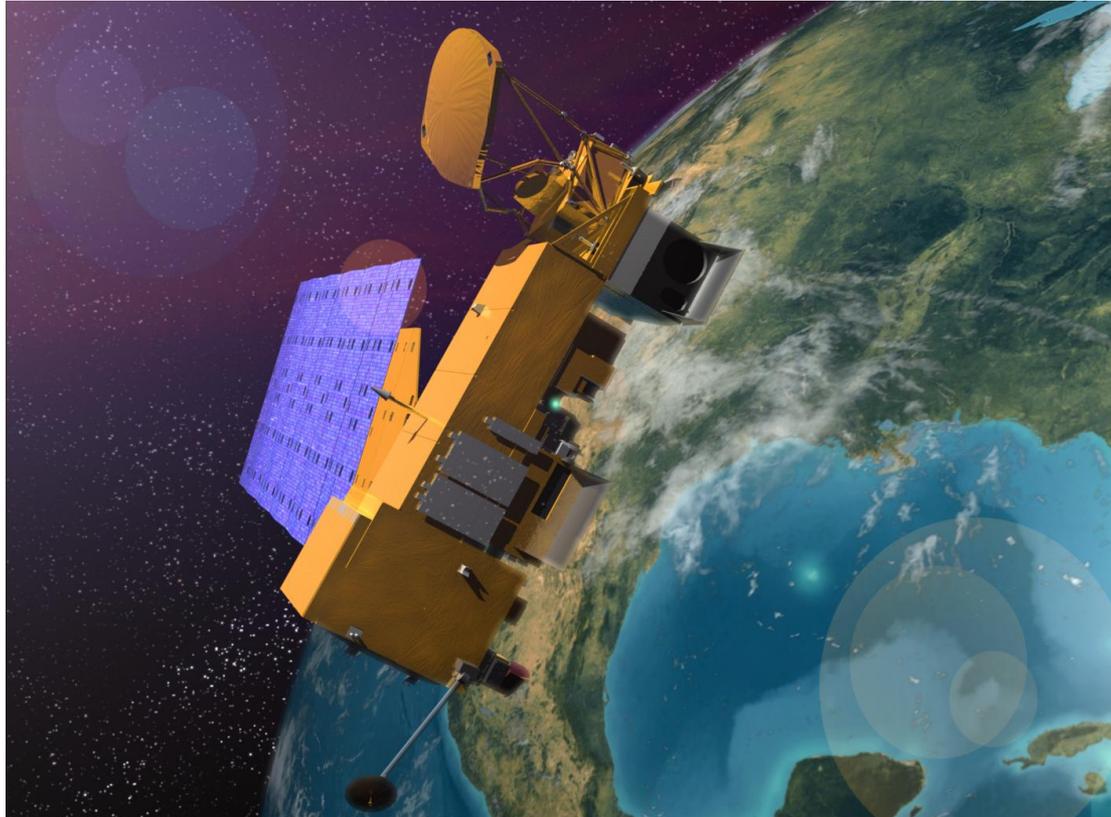
With AIRS data:
Good landfall location,
Good landfall timing

Nargis:

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.

Nargis, Helene and Wilma:

Zhou, Y. P., K.-M. Lau, O. Reale and R. Rosenberg (2009), *AIRS impact on precipitation analysis and forecast of Tropical Cyclones in a global data assimilation and forecast system*, Geophys. Res. Lett., accepted.



For more information, please go to the AIRS public web site at

<http://airs.jpl.nasa.gov>