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

AGU Press Conference, 12/15/2009
Atmospheric Infrared Sounder (AIRS)

AIRS Measures the Infrared Spectrum of Atmosphere With Global Daily Coverage

NASA Aqua Spacecraft
Launched May 4, 2002

CO₂  O₃  AIRS Spectrum

H₂O
CH₄
CO
AIRS Climate Products

Water Vapor

Temperature

Clouds

500 mb Water Vapor (g/kg dry air)

500 mb Temperature (K)

Cloud Fraction

Tom Pagano, Jet Propulsion Laboratory

AIRS Greenhouse Gases

- **Carbon Monoxide**
  - Total Column CO (molecules/cm^2)
  - 2005.08.01

- **Methane**
  - CH4 VMR at 200 mb (ppm):
  - 2004_06_27

- **Ozone**
  - Total Column Ozone (DU)
  - 2005.08.01
AIRS Carbon Dioxide Product Released Today

Dr. Moustafa T. Chahine, Jet Propulsion Laboratory

Carbon Dioxide in the Mid-Troposphere, July 2009

Data acquired by AIRS, the Atmospheric Infrared Sounder on NASA’s Aqua Satellite

Image credit: C. Thompson, JPL
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 CO₂ from 1958 to 2000:
Δ(CO₂) ≈ 380ppm - 310ppm = 70ppm

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

Mauna Loa Observatory

Mauna Loa vs AIRS collocated within 500 km

Trends by least-squares fit
AIRS: 2.09 ± 0.08 ppm/yr
MLO: 1.99 ± 0.14 ppm/yr

AIRS on AQUA spacecraft since May 2002

7 Years of AIRS Mid-Tropospheric CO$_2$
3-7 miles above Earth’s surface

AIRS Daily CO$_2$ Yield
$1^\circ \times 1^\circ$ Spatial Resolution
15,000 CO$_2$ Soundings
AIRS V5 CO2: Day 2003 7 15x1

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

AIRS Monthly CO$_2$ Yield
$1^\circ \times 1^\circ$ Spatial Resolution
450,000 CO$_2$ Soundings
AIRS V5 CO2: Day 2003 7 15x1
AIRS CO\textsubscript{2} with Mauna Loa CO\textsubscript{2} 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)*

2. **Complexity of the Southern Hemisphere Carbon Cycle**

   *CO₂ Belt in the SH*

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“No country is immune from the effects of increased greenhouse gases”
AIRS: A New Tool for Monitoring CO Gas Emissions from Biomass Burning

AIRS Measures Global Daily Carbon Monoxide

California “Station Fire”, August 2009

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

Moustafa Chahine, Jet Propulsion Laboratory

*Breakthroughs in Weather, Climate and Greenhouse Gases from AIRS on Aqua, AGU Press Conference, 12/15/2009*
AIRS Methane Observations
in the upper troposphere

AIRS Methane (CH4) Time Series

Comparison of Atmospheric Time Series of CO2 and CH4

www.cmdl.noaa.gov

Animated AIRS CH4 Global Map

Moustafa Chahine, Jet Propulsion Laboratory
• 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

Forcing

- e.g., CO$_2$ increase

Temperatures increase

Atmospheric humidity increases

Feedback
“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

![Graph showing calculated values of the water vapor feedback. The x-axis represents climate models, and the y-axis represents feedback strength in W/m²/K. The data points indicate variability across different models.]
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
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.
• 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

Eric Fetzer, Jet Propulsion Laboratory

AIRS Improves Typhoon Forecasts

**Control:**
No Cyclone

**With AIRS data:**
Good landfall location, Good landfall timing

**Nargis:**

**Nargis, Helene and Wilma:**
For more information, please go to the AIRS public web site at

http://airs.jpl.nasa.gov