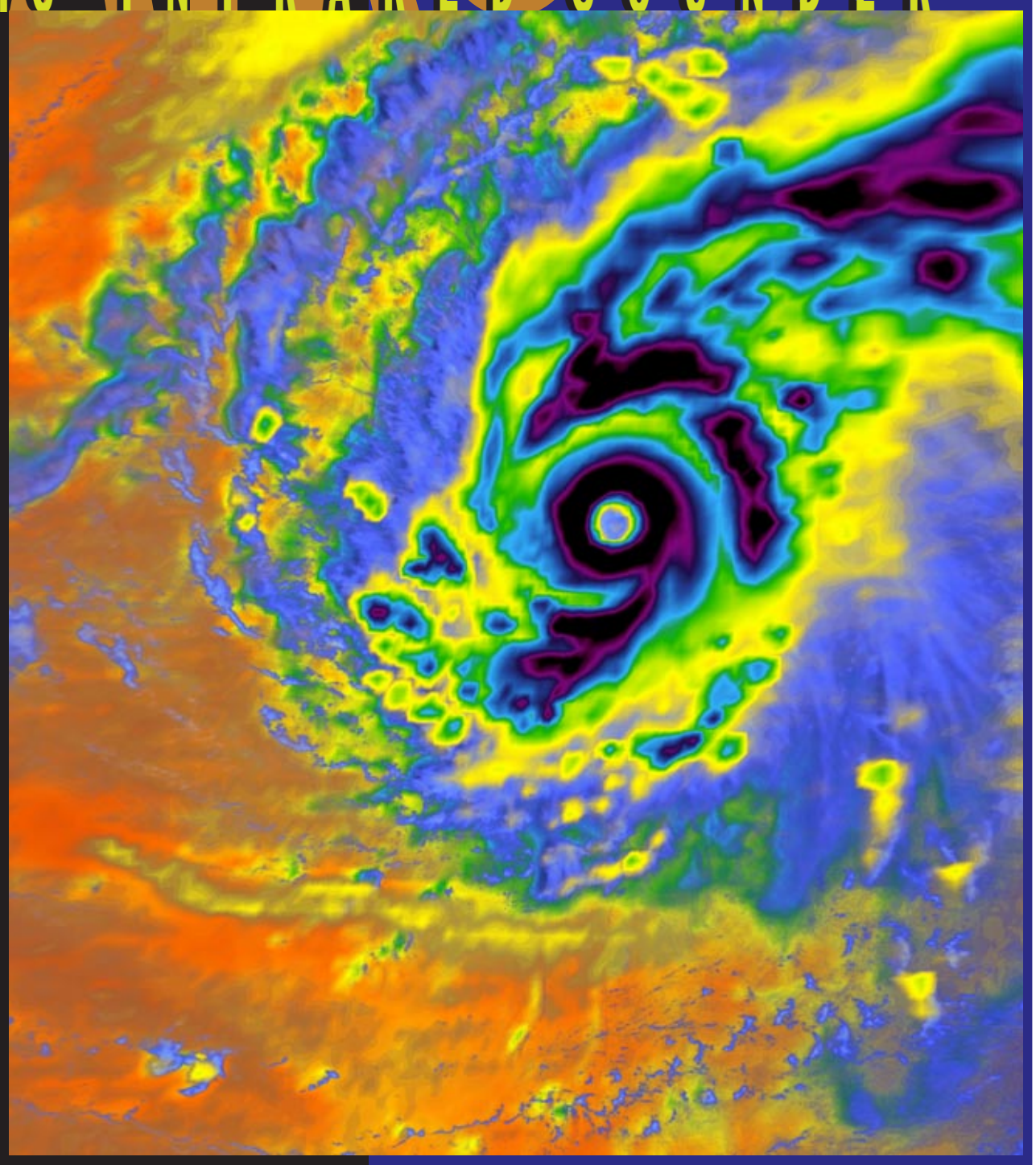
AIRS

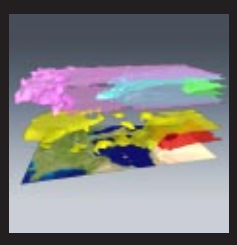
ATMOSPHERIC INFRARED SOUNDER

The Atmospheric Infrared Sounder (AIRS) brings new capability to weather forecasting by providing high-spectral-resolution infrared measurements of Earth's atmosphere. AIRS and its companion microwave instruments aboard NASA's Aqua satellite measure Earth's atmospheric water vapor and temperature profiles on a global scale. The instruments scan in a synchronized manner, providing multispectral views of the continually changing atmosphere.

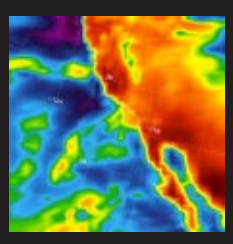


Supertyphoon Pongsona over Guam, December 8, 2002. The image is a composite made by overlaying data from the infrared, microwave, and visible/near infrared sensors that make up the AIRS sounding system. High cold clouds appear blue; lower, warmer clouds are green through orange. Earth's surface is warmest and appears red.

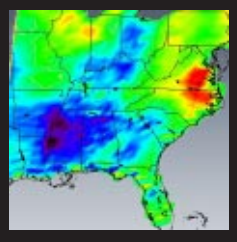
Weather and Climate Modeling for the 21st Century



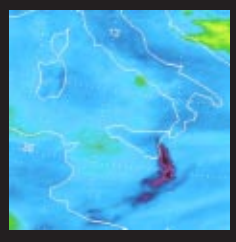
Penetration of cold air mass (blue) into prevailing layer (pink) in the upper atmosphere over the western Mediterranean Sea, September 8, 2002.



Details of a storm front approaching the southwest coast of the U.S., February 11, 2003.



Flooding in south-east U.S. due to Hurricane Isidore, September 28, 2002.



Sulfur dioxide plume injected into the atmosphere during eruption of Mount Etna, October 28, 2002.

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL 400-1137 3/04

AIRS

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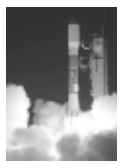
The Atmospheric Infrared Sounder (AIRS) brings a new capability to weather forecasting by providing high-spectral-resolution infrared measurements of Earth's atmosphere. When combined with microwave instruments, AIRS improves the accuracy of measurements of atmospheric humidity, temperature, cloud properties, and the amounts of greenhouse gases. AIRS also measures land and sea surface temperatures.

AIRS and its companion microwave instruments aboard NASA's Earth Observing System (EOS) Aqua satellite measure Earth's atmospheric water vapor and temperature profiles on a global scale. The instrument sounding suite is composed of a hyperspectral infrared instrument (AIRS) and two multichannel microwave instruments, the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder for Brazil (HSB). The sounding suite also includes a visible/near-infrared (Vis/NIR) instrument to provide diagnostic support. The instruments were launched on Aqua on May 4, 2002.

The Jet Propulsion Laboratory, California Institute of Technology, manages the AIRS instrument suite for the National Aeronautics and Space Administration.



AIRS will:

- **Improve weather forecasting**
- **Establish the connection between severe weather and climate change**
- **Determine if the global water cycle is accelerating**
- **Detect the effects of greenhouse gases**

AIRS Data Products

The data collected by AIRS and its companion microwave sounders are being used by scientists around the world to better understand weather and climate, and by the United States National Weather Service and other international forecasting agencies to improve weather prediction.

The data products provided by AIRS, AMSU, and HSB include Level 1B, Level 2, Level 3, and Browse Products. The table below gives product resolution and accuracies for Level 1 and Level 2 products.

Level 1B Products

Level 1B products include the calibrated and geolocated radiances from the four instruments — AIRS, AMSU, HSB, and Vis/NIR. A separate file is provided for each of the products.

Level 2 Products

The Level 2 product accuracies and resolutions for AIRS, AMSU, and HSB include cloud-cleared infrared radiances, sea and land surface temperatures, temperature and humidity profiles, total precipitable water, and various cloud products. All Level 2 products are contained in three files: Level 2 standard products, Level 2 cloud-cleared radiances, and Level 2 support products.

Uncertainty and Resolution of AIRS, AMSU, and HSB Radiance and Standard Products

	RMS Uncertainty*	Vertical Resolution	Horizontal Resolution
Radiance Products (Level 1B)			
AIRS IR Radiance	0.1–0.5K	N/A	15 × 15 km
AIRS Vis/NIR Radiance	20%	N/A	2.3 × 2.3 km
AMSU Radiance	0.25–1.2 K	N/A	45 × 45 km
HSB Radiance	1.0–1.2 K	N/A	15 × 15 km
Standard Core Products (Level 2)			
Cloud-Clear IR Radiance	1.0 K	N/A	45 × 45 km
Sea Surface Temperature	0.5 K	N/A	45 × 45 km
Land Surface Temperature	1.0 K	N/A	45 × 45 km
Temperature Profile	1 K	1 km below 700 mb, 2 km 700–30 mb	45 × 45 km
Humidity Profile	15%	2 km in troposphere	45 × 45 km
Total Precipitable Water	5%	N/A	45 × 45 km
Fractional Cloud Cover	5%	N/A	45 × 45 km
Cloud-Top Height	0.5 km	N/A	45 × 45 km
Cloud-Top Temperature	1.0 K	N/A	45 x 45 km

**Radiance error defined as temperature error of Planck blackbody at 250 K.*

Level 3 Products

AIRS Level 3 products are composed of Level 2 geophysical data that have been spatially and/or temporally re-sampled to a uniform spatial grid. Level 3 data sets are substantially smaller than the lower level source products from which they are derived due to re-sampling and selecting a reduced set of reporting parameters. Level 3 products provide a global view of AIRS data in a size that is manageable for long-term or large-scale studies. The uniformity of Level 3 products allows comparisons of data sets from different sources. AIRS Level 3 product development is driven by the need for global analysis of AIRS data for weather and climate studies and to provide an easy-to-use, quantitive gridded data set for interdisciplinary studies. A partial list of Level 3 products includes temperature and water vapor profiles, surface skin temperature, surface air temperature, column ozone, and column liquid water.

Browse Products

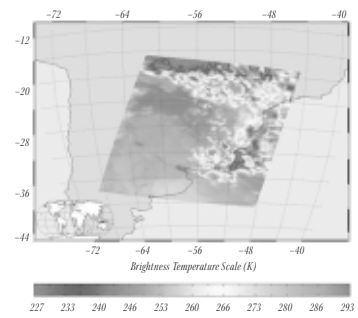
The AIRS browse products are a set of daily, global, 2-D, 8-bit raster images separated by ascending and descending orbits. The browse products are a subset of the larger Level 2 and Level 1B data sets and are used as an on-line aid to ordering of science data product granules at the Distributed Active Archive Center (see "How to Obtain AIRS Data" below). AIRS produces five browse packages, each of which contains multiple raster images of various AIRS parameters. The following browse packages are available:

- AMSU-A daily summary browse
- AIRS daily summary browse
- Level 2 retrieval daily browse package
- L2 cloud-cleared radiance daily summary browse
- L2 retrieval summary browse data

How to Obtain AIRS Data

AIRS data can be accessed from the following sources:

- Earth Observing System Data Gateway: data search and order tool at http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/
- Web Hierarchical Ordering Mechanism (WHOM): data search and order at the Goddard Space Flight Center (GSFC) Distributed Active Archive Center (DAAC) at http://daac.gsfc.nasa.gov/data/dataset/AIRS/
- Data Pool: On-line access to most recent AIRS data from Goddard Space Flight Center Distributed Active Archive Center at http://daac.gsfc.nasa.gov/data/datapool/AIRS_DP/



A representative image depicting the type of preview data available to AIRS data users.

AIRS Early Accomplishments

- Near-flawless activation of instruments completed at launch + 3 months, as planned.
- In-flight calibration and validation shows high accuracy and stability of AIRS radiances (Level 1), exceeding requirements.
- Instruments became "operational" in October 2002, providing near-real-time data to weather centers worldwide.
- Level 2 geophysical products show accuracies approaching the required levels.
- Validation results confirm that AIRS achieves temperature profiles globally with radiosonde accuracy and water vapor profiles with an accuracy far exceeding that obtained by weather balloons.

The Instrument Suite: AIRS, AMSU, and HSB

The AIRS Infrared Instrument

The AIRS instrument obtains highly accurate temperature profiles within the atmosphere, plus a variety of additional Earth/atmosphere products. It is the first high-spectral-resolution infrared sounder developed by NASA in support of operational weather forecasting by the National Oceanic and Atmospheric Administration (NOAA). The AIRS instrument incorporates numerous advances in infrared sensing technology to achieve a high level of measurement sensitivity, precision, and accuracy. The heart of the instrument is a cooled (155 K) array grating spectrometer operating over the range of 3.7 to 15.4 μm at a spectral resolution ($\lambda/\Delta\lambda$) of 1200. The spectrometer design uses a grating to disperse infrared energy across arrays of high-sensitivity detectors. The concept requires no moving parts for spectral encoding and provides 2378 spectral samples, all measured simultaneously in time and space.

The AMSU-A Microwave Instruments

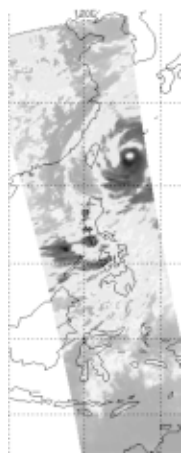
The Advanced Microwave Sounding Unit (AMSU-A) consists of two physically separate units, AMSU-A1 and AMSU-A2. Together they have 15 channels, measuring radiation in the frequency span of 23 GHz to 90 GHz. AMSU-A is designed primarily to obtain temperature profiles in the upper atmosphere (especially the stratosphere) and to provide a cloud filtering capability to the AIRS 2378 infrared channels for accurate tropospheric temperature observations.

The HSB Microwave Instrument

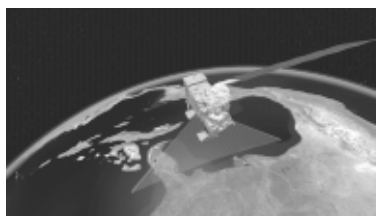
The Humidity Sounder for Brazil (HSB) is a 4-channel microwave sounder provided by the Brazilian Space Agency and is designed to obtain humidity profiles under cloudy conditions. The HSB instrument also detects heavy precipitation in the AMSU fields-of-view, which would prevent the use of AMSU-A for cloud filtering of the AIRS infrared channels.

The AIRS Optical Sensor

AIRS also makes use of an optical sensor. The Vis/NIR photometer uses optical filters to define four spectral bands in the 400 to 1000 nm region. The primary function of the AIRS Vis/NIR channels is to provide diagnostic support to the temperature and moisture retrievals, setting flags that warn of the presence of low clouds or highly variable surface features within the infrared field of view.



Typhoon Ramasun as seen by the AIRS infrared instrument, July 3, 2002.



The AIRS instruments are carefully aligned with each other and scan the atmosphere in a synchronized way, giving us simultaneous multispectral views of a highly variable target.

Looking Into the Future

The wealth of knowledge that can be gleaned from AIRS data is only just beginning to be realized. The AIRS project continues to look for ways to maximize the information that can be gained from this rich data set. Future plans include:

- Support National Weather Prediction Center to demonstrate improved weather forecast
- Enhance core product accuracy
- Validate data products over greater spatial and temporal extent
- Maintain and upgrade direct broadcast software
- Develop Level 3 and decimated products
- Facilitate climate data record development

Research Products

In addition to using the AIRS/AMSU/HSB data to generate relatively well-established "core products," i.e., temperature and moisture vertical profiles, surface temperature, and total column ozone, members of the AIRS science team are also working on a number of products where feasibility, achievable accuracy, precision, and spatial and temporal coverage are not fully established. Research products under development include:

- Carbon dioxide total column
- Carbon monoxide total column
- Methane distribution
- Ozone vertical distribution
- Other trace gases (SO_2, etc.)
- Longwave outgoing radiation (spectrally resolved)
- Precipitation index
- Detection and characterization of cirrus clouds

Climate Data Records

Climate data records are remote and in situ observations that enable the detection and attribution of causes of global change. Climate data records will be produced by future NASA missions to further the understanding of Earth's climate system. AIRS data will contribute to climate data records by providing the following:

- Global mapping in three dimensions of atmospheric and surface temperatures
- Global water vapor field in three dimensions

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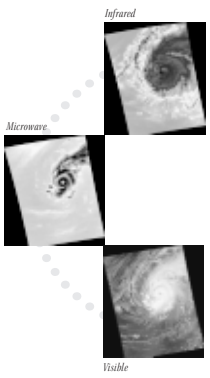
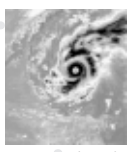
About the Cover Image

The composite color image of Supertyphoon Pongsona over Guam was made from data collected on December 8, 2002. Packing gusts of 296 kilometers (184 miles) per hour and sustained winds of 241 kilometers (150 miles) per hour, supertyphoon Pongsona struck the U.S. island of Guam on Sunday, December 8. The storm cut off electricity over the entire island along with telephone and water service, and President George W. Bush declared the U.S. territory a federal disaster area. The image was made from data acquired by the AIRS instrument suite aboard NASA's Aqua spacecraft just as the eye of the storm was about to pass over Guam.

This composite image of the supertyphoon was made by overlaying data from the infrared, microwave, and visible/near-infrared sensors that make up the AIRS sounding system. The infrared data show how the typhoon looks through an AIRS infrared "window" channel, which measures the temperature of the nearest impenetrable surface. Where the sky is clear, this window channel shows the surface of Earth; otherwise, it will show cloud tops. High cold clouds appear blue, while lower warmer clouds are green through orange. The surface of Earth, where it can be seen between the clouds, is warmest and appears red. Although the storm has a clearly defined eye, it is not cloud free and therefore shows up as yellow in the infrared image.

Overlaid onto the infrared image is the visible/near-infrared image, in which the fine details of the cloud structure can be seen in medium blue. It confirms that the eye was not cloud free at the time the data were acquired, and pinpoints towering thunderheads rising up in several areas of the typhoon's spiral arms. The microwave data see through much of the cloud cover and reveal some of the inner structure of the storm. Here the eye is more clearly defined than in the infrared image and appears to be very large, perhaps 81 kilometers (50 miles) across. Rain areas appear as blue patches, and a very intense rain cell can be seen right over Guam itself. This cell is in the leading wall of the eye and is probably associated with the highest wind speeds. It is likely that much of the damage in Guam was caused by this particular part of the storm.





Composite image of supertyphoon Pongsona made from infrared, microwave, and visible data.

For more information about the AIRS mission, visit http://www.jpl.nasa.gov/airs