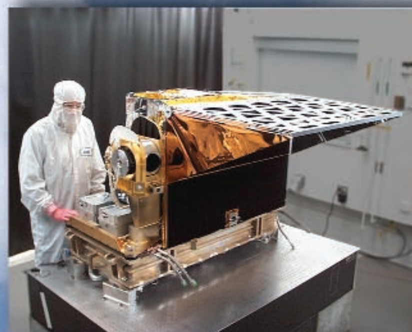
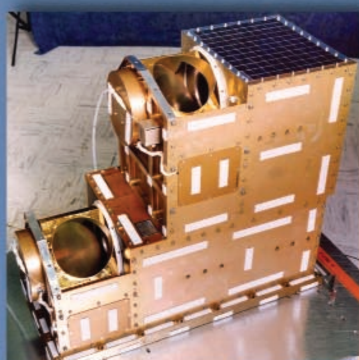


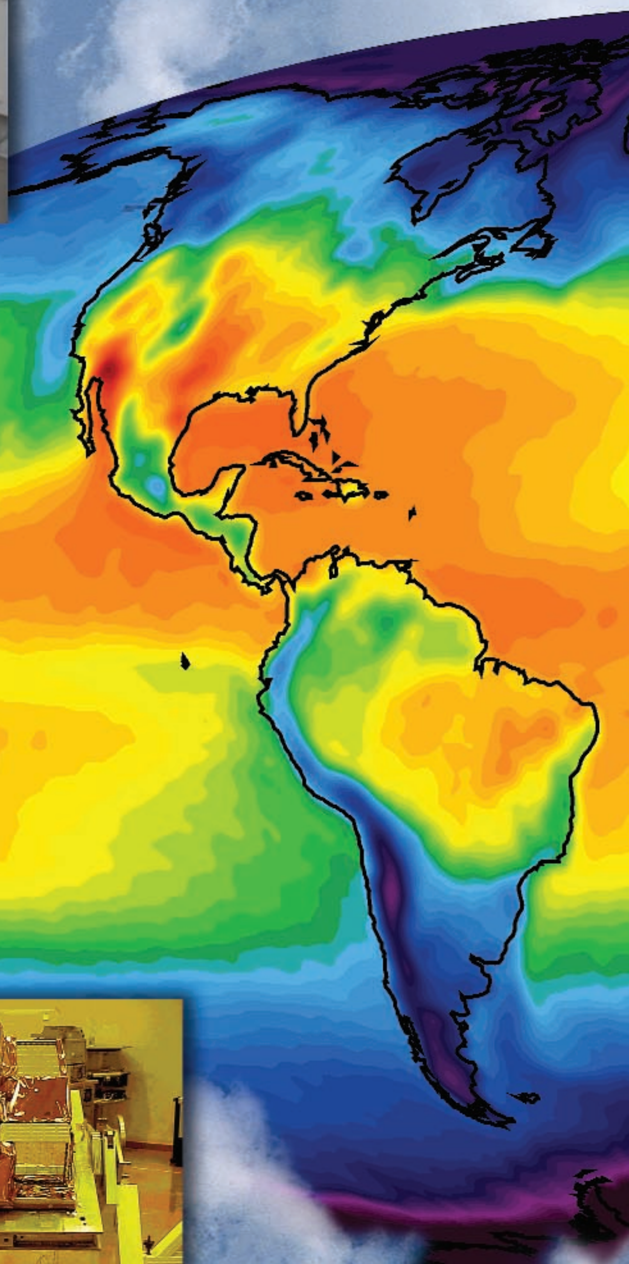
AIRS



AMSU-A1

AMSU-A2

HSB



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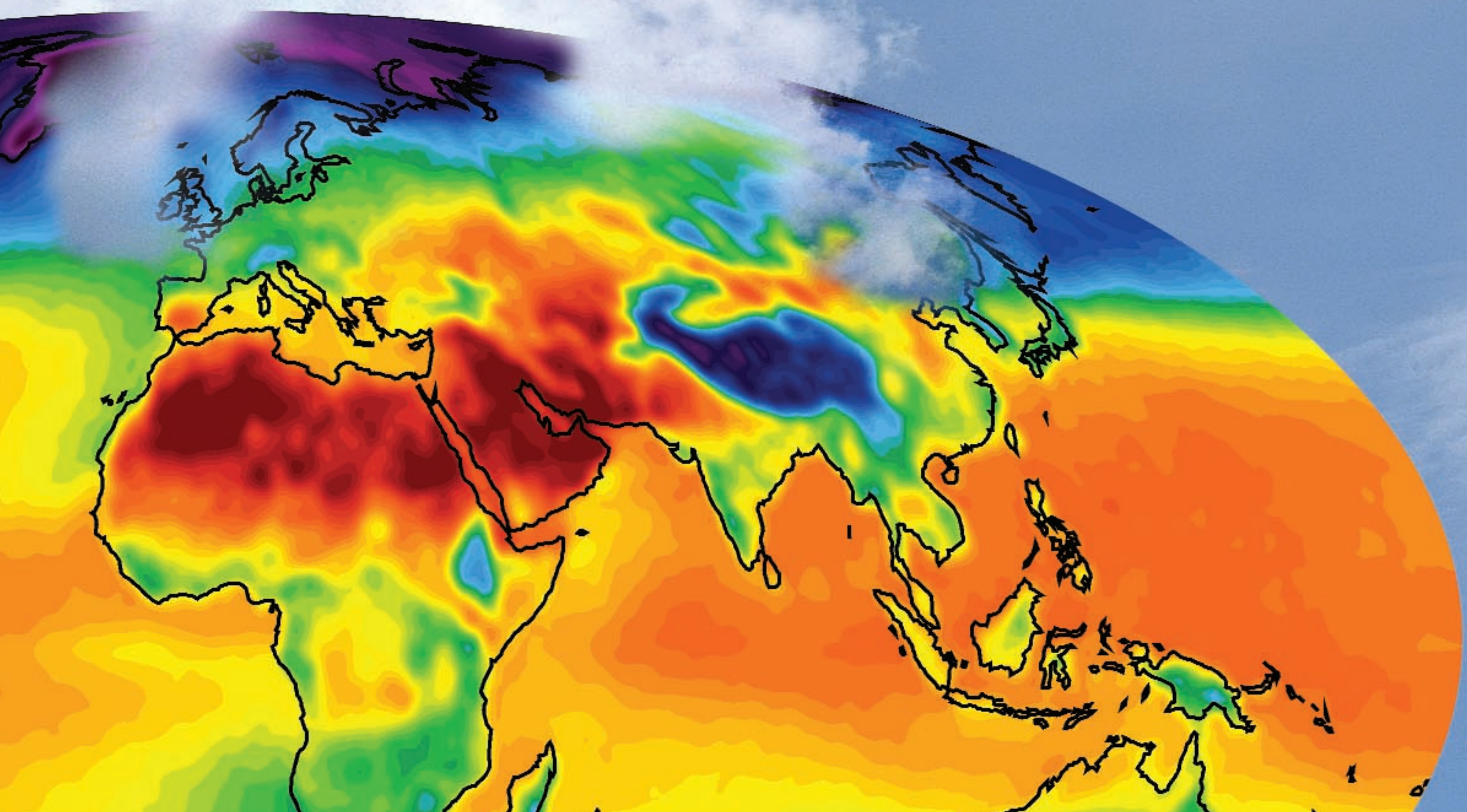
AIRS/AMSU/HSB

The Atmospheric Infrared Sounder, with its companion Advanced Microwave Sounding Unit and Humidity Sounder for Brazil



Providing New Insights into Earth's Weather and Climate

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Edited by: Moustafa Chahine, Michael Gunson, Marguerite Syvertston, and Claire Parkinson

Technical Input: Moustafa Chahine, Michael Gunson, Eric Fetzer, Mark Hofstadter, Bjorn Lambrigtsen, Ed Olsen, and George Aumann

Graphics Input: Jeff Hall

Designed by: Scott Hulme, Winnie Humberson

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The Atmospheric Infrared Sounder

Enhancing the quality of global meteorological observations can yield considerable economic benefits through more reliable climate prediction, improved weather forecasts, better understanding of the factors influencing air quality, and mitigation of the economic and human costs of natural hazards.

Terra, launched in December 1999, and Aqua, planned for launch in 2001, are two main Earth Observing System (EOS) observatories that will use multiple instruments to acquire the necessary data with the required high precision and accuracy.

The Atmospheric Infrared Sounder, set for launch aboard Aqua, will make global measurements of our atmosphere, providing new insights into Earth's weather and climate.

The Atmospheric Infrared Sounder (AIRS), together with the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder for Brazil (HSB) on the Aqua mission, represents the most advanced sounding system ever deployed in space. The system is capable of measuring the atmospheric temperature in the troposphere with radiosonde accuracies of 1 K over 1 km-thick layers under both clear and cloudy conditions, while the accuracy of the derived moisture profiles will exceed that obtained by radiosondes. Furthermore, the system will provide additional data on land and ocean surface temperature and surface emissivity, cloud fraction (see centerfold example from an earlier instrument) and cloud top height, and ozone burden of the atmosphere. This makes AIRS/AMSU/HSB the primary observing system to study the global water and energy cycles, climate variation and trends, and the response of the climate system to increased greenhouse gases.

Weather or Climate?

When we talk about the weather, we are talking about conditions at one specific place and time. If someone says "Yesterday we had an inch of rain in Los Angeles, but today is clear and dry," he is talking about weather. The weather is constantly changing.

When we talk about climate, we are describing the long-term average of weather. If someone says "Los Angeles usually gets two inches of rain in the month of November," he is talking about climate. You have to make measurements for many years to get an idea of what the true climate is.

The difference between weather and climate is like the difference between a sports team winning one game and having a winning year. Some games you win, some games you lose (which is like the weather changing day-to-day), but if at the end of the year you've won a lot more than you've lost, you'd say you've had a winning year (or a winning climate)!

Measuring the Atmosphere with Radiosondes

Currently, weather balloons are the most important source of information about Earth's atmosphere. They are usually called 'radiosondes,' sonde meaning 'sounding' in French, a reference to the ancient maritime practice of measuring the deep ocean from ships. 'Radio' refers to their method of data return. Hundreds of balloons are launched around the globe twice daily to sample the atmosphere to heights of about 15 km (10 mi). Each balloon, about the diameter of a child's wading pool, lifts temperature, humidity and pressure sensors in a milk carton-sized box. The sensors transmit information to a receiver on the ground, where it is processed and distributed to weather forecasting centers. The result is a snapshot of the atmosphere every twelve hours at a limited number of sites around the world.

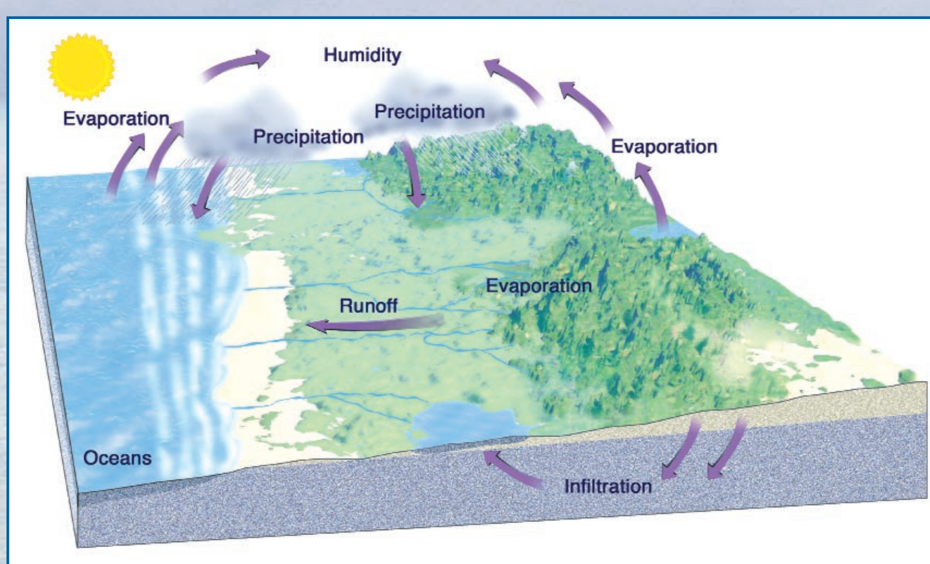
This picture is not complete. Most radiosondes are launched over land, so that the 75% of the world covered by ocean is not sampled. Furthermore, economic differences between countries further influence coverage. Europe and North America have excellent coverage, while much of Africa, Asia and South America are sparsely sampled.

Improving the world weather observing system is also an essential objective of Earth system science and applications, because the phenomena that govern long term climate are the same as those that manifest themselves in transient weather perturbations. AIRS/AMSU/HSB observations are, therefore, equally applicable to both climate and weather studies and will be provided to the US National Centers for Environmental Prediction (NCEP) and the European Centre for Medium-Range Weather Forecasts (ECMWF) for assimilation into the operational forecast General Circulation Models. Through such assimilation, the AIRS/AMSU/HSB observations will lead to substantial increases in the mid- and long-range weather forecast skill.

Is the Global Water Cycle Accelerating?

Water is indispensable to all living species, and fresh water is an essential ingredient of life on land. Water also plays a unique and almost irreplaceable role for innumerable industrial processes and domestic applications. For these reasons, fresh water is an immensely valuable resource on which our existence depends. Evaporation, precipitation, and the long-range transport of water vapor by winds are the processes that constantly recycle water and renew fresh water resources - a feature unique to our planet, at least as far as we know. As civilization has evolved, we have been making ever-increasing demands on water resources and by now, any substantial change in the global water cycle would entail serious consequences in many regions of the world where water resources are already strained.

The amount of water vapor carried by the atmosphere increases dramatically with temperature, because warm air has a much larger water holding capacity than cold air. As our global climate becomes warmer, models predict an acceleration of the global water cycle, increased evaporation and increased global precipitation. Increased evaporation entails faster depletion of ground water resources, although more abundant rainfall means more frequent and generally larger flooding events. The report from the Intergovernmental Panel on Climate Change (1996) states that "Warmer temperatures will lead to a more vigorous hydrological cycle; this translates into prospects for more severe droughts and/or floods in some places .... Several models



indicate an increase in precipitation intensity, suggesting a possibility for more extreme rainfall events.” Thus, accurate characterization of the rate of recycling of water in the atmosphere may be a sensitive index of the multiple roles of hydrology in the climate system.

One general indicator of the strength of the global water cycle is the mean residence time of water in the atmosphere. The equivalent of the entire water content of the atmosphere is recycled 33 times each year. (This is obtained by dividing the average global yearly precipitation of 95 cm/year by the total atmospheric content of precipitable water vapor of 2.9 cm). This gives water a mean global residence time in the atmosphere of about 11 days (Chahine, *Nature* 1992). Variations in the residence time, or its equivalent the recycling rate, can be obtained from space observations with an accuracy that permits determination of how it is changing on a monthly basis.

The results from current space data are not very accurate but nevertheless show a small trend toward acceleration of the recycling rate of 0.4 ± 0.5% per year. If this trend persists, it may lead to an intensification of the global hydrological cycle, having major impacts on regional water resources and the possibility of changes in the magnitude and timing of runoff and the intensity of floods and droughts.

Thus we have a direct and compelling interest in learning about any significant change in the global water cycle. The most precise way to identify such a trend is by measurement of changes in the precipitable water load carried by the atmosphere. The AIRS/AMSU/HSB suite of instruments will provide the most accurate information ever obtained about the total atmospheric water content. From this we can deduce whether, and at what rate, the Earth’s water cycle may be accelerating.

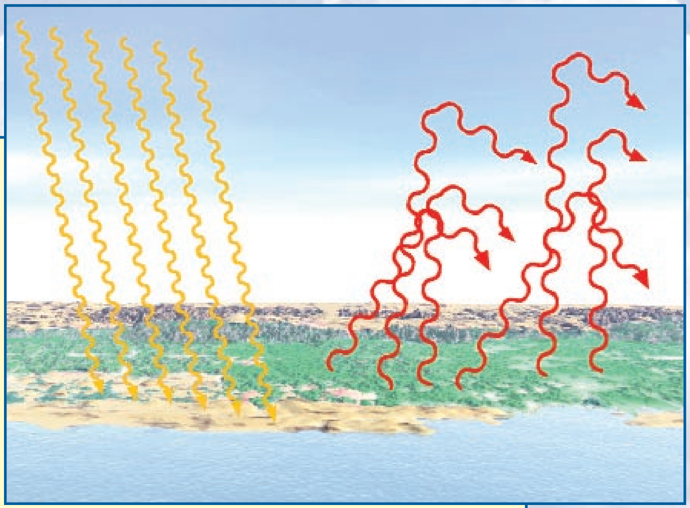
Water Vapor: Earth's Primary Greenhouse Gas

Water vapor is the dominant greenhouse gas in the Earth's atmosphere. It accounts for about 60% of the greenhouse effect of the global atmosphere, and most of its sensitivity to temperature, far exceeding the total combined effects of carbon dioxide, methane, ozone and other greenhouse gases.

From time immemorial, humans have been engaged in activities that alter the environment, first by clearing forests and using the land for their own purposes, and now by burning fossil fuels at a rate that results in a major increase in the amount of carbon dioxide and other absorbing greenhouse gases present in the atmosphere. As a result, the atmospheric concentration of carbon dioxide has already reached a level 30% higher than at any time during the past 300,000 years, despite drastic changes in the Earth's climate and successive ice ages. Methane concentration has more than doubled, while unknown amounts of "aerosol" haze have been introduced in the atmosphere. In these examples, the primary impact of human activities is well understood, yet the long-term consequences cannot be readily predicted. The reason is that the primary impacts or "forcing" of the Earth's climate may be enormously amplified by further re-adjustments in the Earth's atmosphere, land and oceans.

Water vapor in the atmosphere strongly absorbs infrared radiation emitted by the Earth's surface and therefore acts as a blanket that insulates us from the cold radiation sink of deep space. This atmospheric blanket is thickest in the tropics, where nighttime air temperature remains close to daytime values. It is thin over deserts, high mountains, and plateaus, where, partly as a consequence, temperatures drop precipitously at night. Because of the presence of variable amounts of water vapor in the air above us, the surface warming associated with an increase of energy absorbed by the planet is twice as much as it would be with a totally dry atmosphere. This is a major effect and also a source of considerable uncertainty about future climate change.

While relatively thin, water vapor in the upper troposphere is particularly effective at absorbing infrared radiation emitted by the Earth's surface. Water is brought to this level by tall storm clouds that rise high in the troposphere. However, we are not sure how clouds interact with water vapor in this critical region and whether more active convection, as anticipated with warmer conditions at the Earth's surface, would add moisture to the upper troposphere or, to the contrary, dry the air. Accurate measurements of atmospheric humidity profiles will resolve this uncertainty.

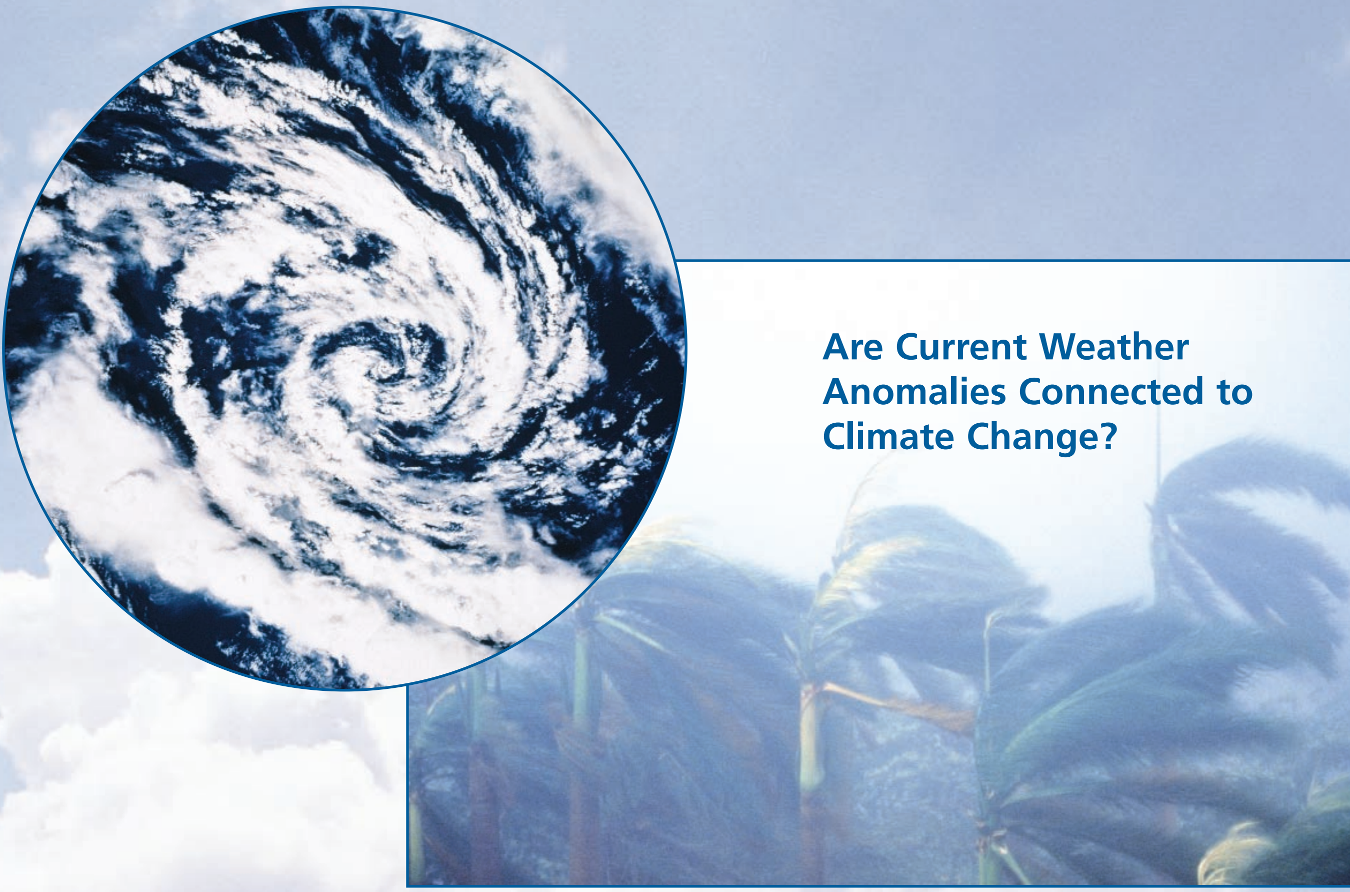


The Greenhouse Effect

The Earth without its atmosphere would be, on average, a much colder place. Warming to the familiar temperatures of sun-heated surfaces during the day, our planet would cool to far below freezing at night. The atmosphere retains much of the daytime heat by absorbing infrared radiation (this is the familiar warmth felt a few feet from a west-facing wall on a summer evening). A similar phenomenon occurs when sun shines through a window into a closed room, hence the term "greenhouse effect."

All gases absorb infrared radiation, but some are particularly effective. Water vapor is the most important greenhouse gas, mostly because it is so abundant. Next in importance are carbon dioxide and methane. Water vapor varies naturally, but human activities have produced significant amounts of additional atmospheric carbon dioxide and methane, particularly since the start of the industrial revolution in the late eighteenth century. (Current United States per capita production of carbon dioxide is about six tons per year.) As early as a century ago scientists speculated that increasing carbon dioxide from burning coal and oil might warm the Earth. And as Earth warms, evaporation increases, sending more water vapor into our atmosphere.

Our planet has experienced a rapid temperature increase since the 1970s, and six of the ten warmest years of the past century were in the 1990s. Significant changes in climate have accompanied this warming. Are these changes caused by increasing greenhouse gases, notably carbon dioxide? While many climate researchers believe so, the causes of climate change are not well understood. A goal of the AIRS/AMSU/HSB science team is long-term, stable observation of the atmosphere for monitoring global warming and other types of climate change.



Are Current Weather Anomalies Connected to Climate Change?

Change in global-mean temperature would not draw much attention if we did not foresee that relatively small variations in the global environment can entail changes of much greater significance in regional weather, water resources and agricultural productivity. The striking manifestations of "El Niño weather" are but one example of such climate-weather connections.

Much remains to be learned, however, about the relationship between observed year-to-year changes or long-term trends in planetary climate, and corresponding changes in storm tracks and intensity. We already know that the frequency and distribution of tropical cyclones, hurricanes or typhoons, between the Atlantic and Pacific oceans changes from year to year, governed in part by El Niño events or their counterparts, but they are also sensitive to other, longer term changes in global winds, the water content of the lower atmosphere, the temperature of the ocean and probably more. Likewise, the intensity and path of mid-latitude storms respond to planetary-scale patterns or "oscillations" of the global atmosphere, of yet unknown origin. We surmise that these phenomena hold the key to effective predictions of the anticipated regional effects of climate variations. We want to know the extent to which variations in local weather, precipitation and water resources are related to global climate change.

Furthermore, weather disturbances govern the distribution of clouds, their water content, and resulting rainfall, as well as solar radiation that reaches the surface. In order to understand and predict climate change, it is not sufficient to consider atmospheric, oceanic or land processes in isolation from the atmospheric circulation that controls the fluxes of radiant energy, heat, and water among the atmosphere, ocean and land surface. Such connections are transient and can only be understood by comparing meteorological and hydrological forecasts with observations at the same place and time.

To learn more, we need to capture both the large-scale patterns of the global atmosphere and the details of individual storms or dry spells. Satellite observation is the ideal tool for this purpose; only space-based sensors can provide at the same time detailed information on current weather events and a global view of the atmosphere. The most directly applicable information is delivered by atmospheric sounders like AIRS/AMSU/HSB, which can resolve the vertical structure of weather systems.

Percent Cloud Cove

from the data of the Televisi
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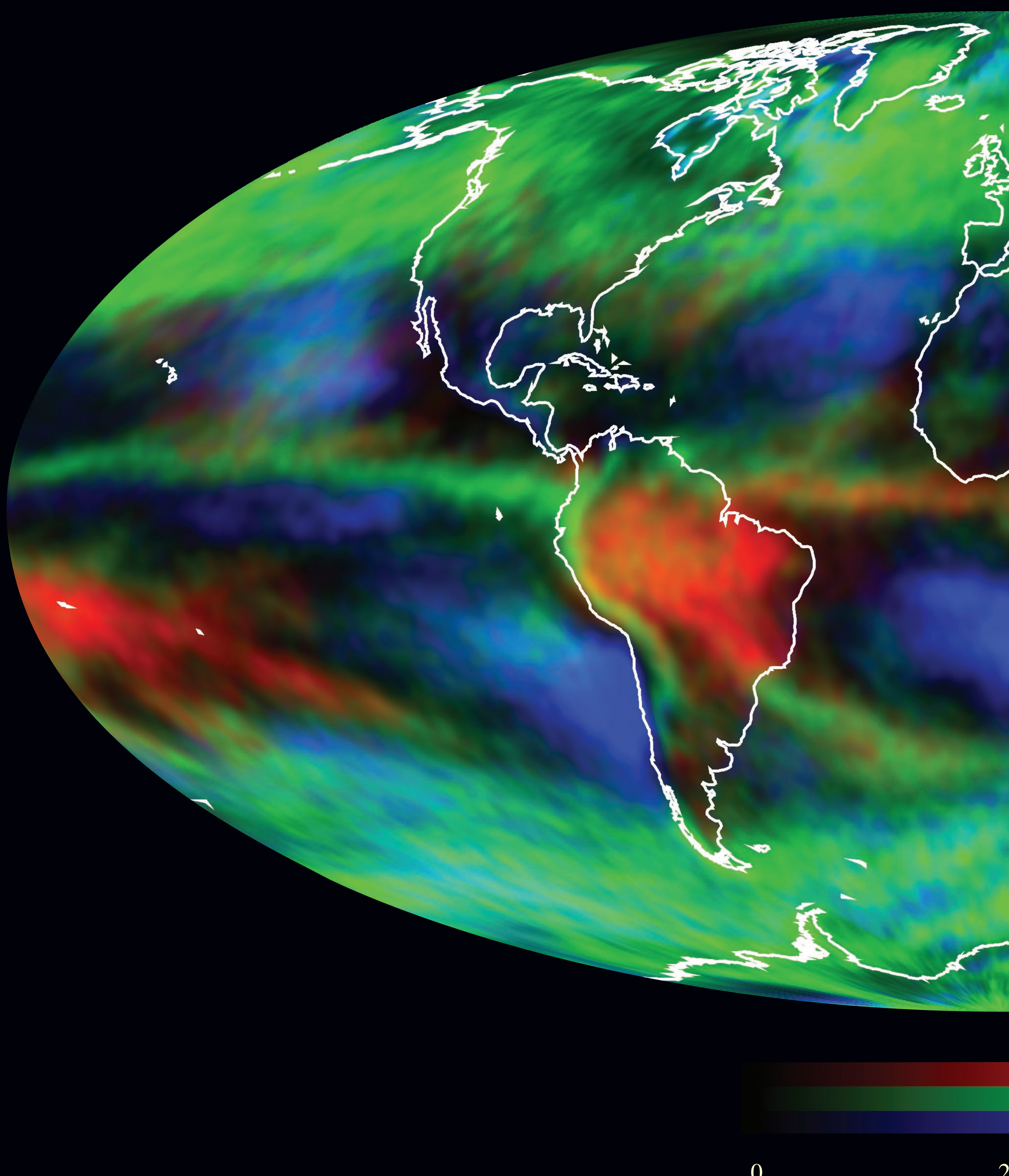

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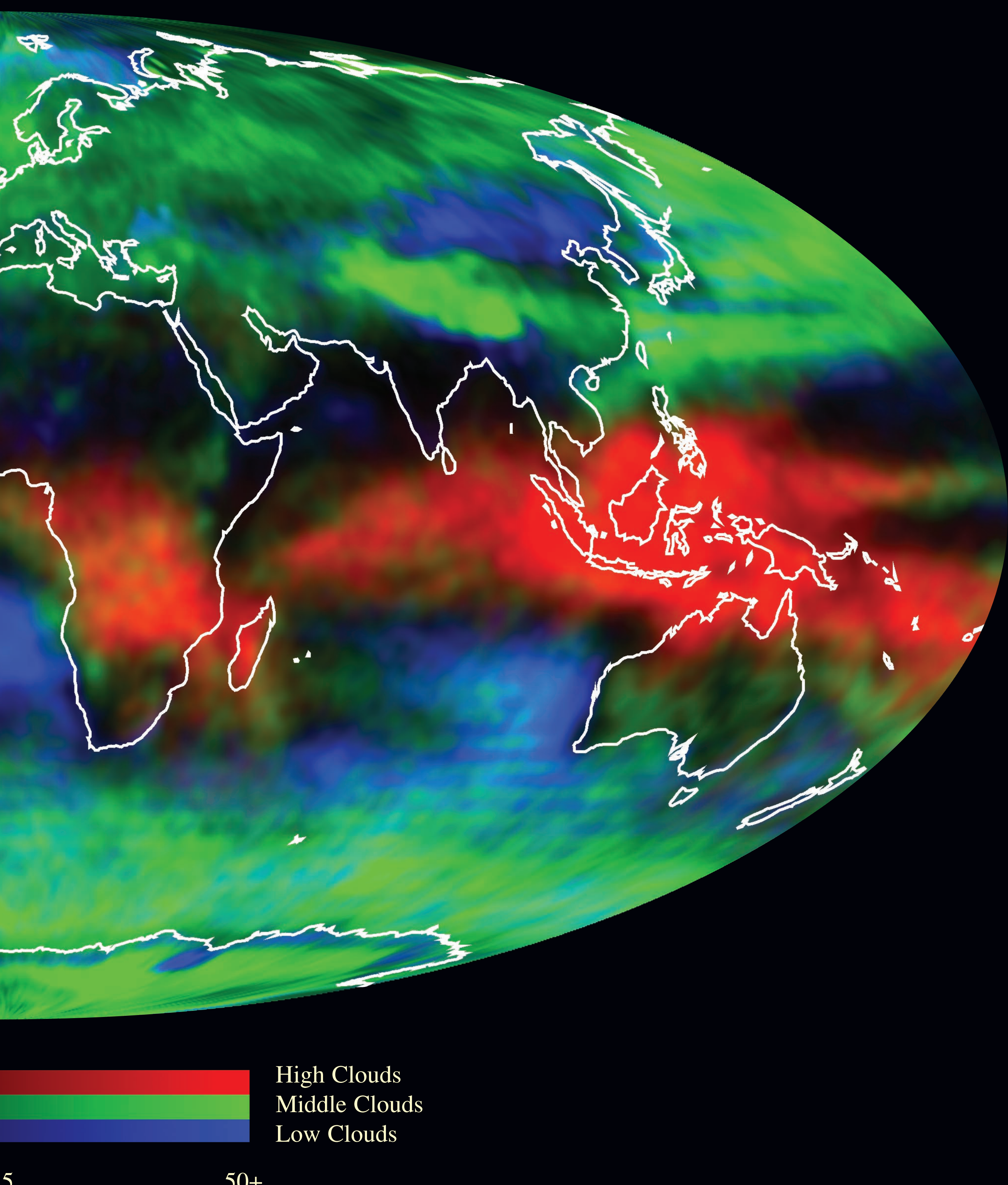
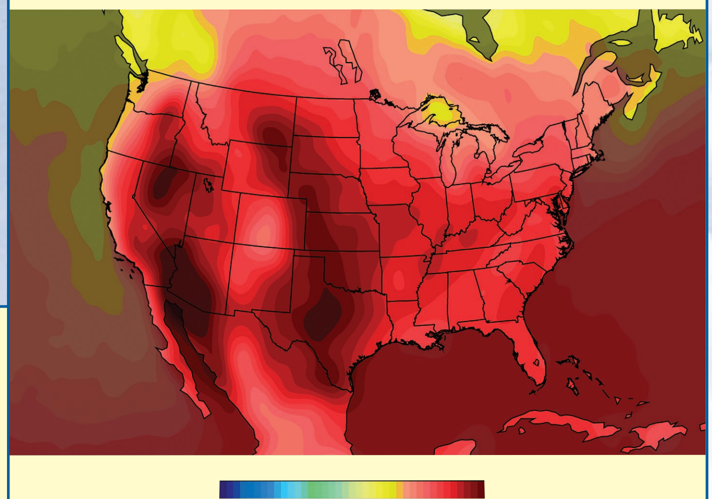


Improving Weather Forecasts

Only 50 years ago, weather forecasting was an art, based on the inspired interpretation of scarce data from a loose array of ground-based observing stations, balloons, and aircraft. The ability to conduct appropriate weather reconnaissance over the ocean was a decisive advantage. The timely exchange of terse meteorological messages was the essence of a successful "synoptic" (instantaneous) analysis of the weather situation over the region. Thirty years ago, meteorologists had their first opportunity to use global observations collected for the scientific purpose of demonstrating the feasibility of one-to-two-week weather prediction using computer models of the atmosphere. We are now finally on the verge of achieving this objective, thanks to successive breakthroughs in global weather observation from the Earth's surface and from space, a sweeping acceleration in worldwide communications, and the ever increasing computer capabilities.

Satellite-based sensors can only detect radiation emerging from the Earth's atmosphere, not measure directly the meteorological properties of interest. The interpretation of satellite measurements requires a complicated mathematical procedure that consists of recreating as best we can the radiation signature of the partially absorbing, partially transparent atmospheric medium below. This procedure was hitherto limited by the accuracy and resolution of the basic radiation measurements and incapable of matching the accuracy of measurements made directly in the atmosphere. For this reason, satellite observations added to the available information only where local measurements were scarce, such as most of the southern hemisphere and large oceanic regions in the northern hemisphere. These technical limitations have been overcome. We expect that satellite sounding data will finally match the accuracy of balloon-borne sensors and deliver the same precision worldwide as was possible so far only over the developed regions of the northern hemisphere, with corresponding improvement in the quality and range of extended weather forecasts.

Daytime Atmospheric Surface Temperature
TOVS data, July 1999



Predicting the Weather

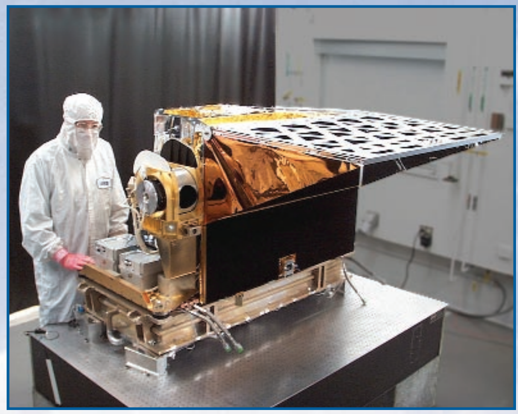
The simplicity of tomorrow's weather forecast masks a remarkably complex and difficult activity. The forecast process begins with the timely gathering of atmospheric observations. These data sets are very large, but also surprisingly incomplete: current satellites take limited numbers of observations, and radiosondes are confined to the continents twice daily. Large areas of our planet, especially over the oceans, are poorly observed. (Oceans may seem inconsequential to those of us living on land, but many weather disasters have featured poorly forecast oceanic storms moving ashore.)

Observations are combined mathematically with computer models of the atmosphere. These models embody the equations describing the physical properties of the atmosphere. Despite their sophistication, they only partially describe the atmosphere's true behavior. For example, even a high resolution global model has gridpoints spaced every 100 km, so a single profile represents a volume of roughly 200,000 cubic km. The best possible observations entered into the most sophisticated forecast models sometimes yield questionable predictions.

This leads to the final step in the forecast process. Weather forecasters analyze weather observations and predictions from computer models. Forecasters use judgment and experience to sort through complex and sometimes contradictory information. The result is tomorrow's forecast.

A major goal of the AIRS/AMSU/HSB science team is improving weather forecasts. This will be achieved through more complete observations, especially over the oceans.

Science Objectives

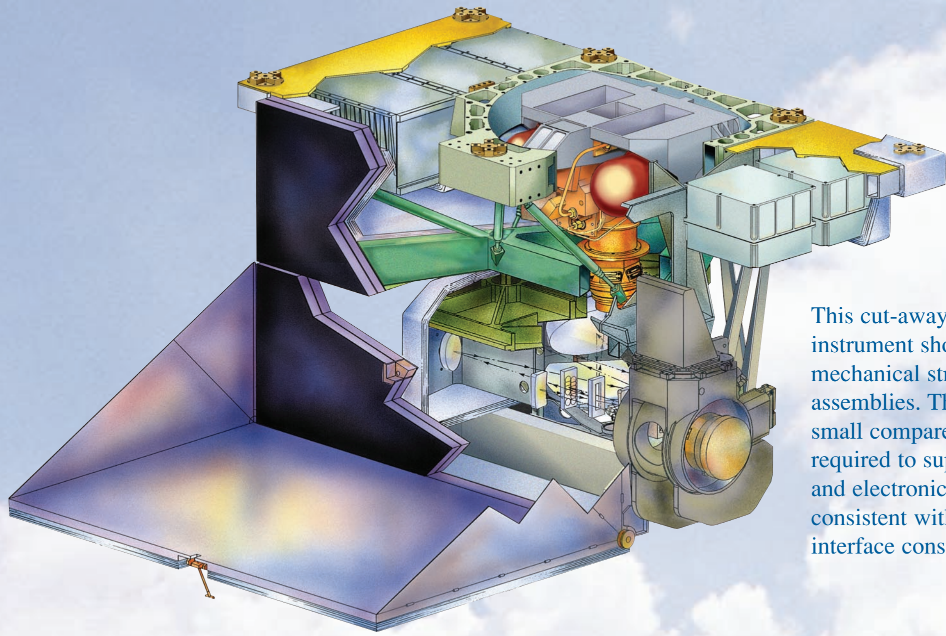


Understanding the dynamics of climate, the transport of chemical agents in the atmosphere and their distribution over the surface of the Earth, and the rainfall and evaporation that control the growth of vegetation requires a precise knowledge of the global atmospheric circulation, temperature profiles, and water vapor content.

AIRS/AMSU/HSB will observe and characterize the entire atmospheric column from the surface to the top of the atmosphere in terms of surface emissivity and temperature, atmospheric temperature and humidity profiles, cloud amount and height, and the spectral outgoing infrared radiation. These data and scientific investigations will answer long-standing questions about the exchange and transformation of energy and radiation in the atmosphere and at the Earth's surface.

1. **Determination of the factors that control the global energy and water cycles:** The study of the global hydrologic cycle and its coupling to the energy cycle is a key to understanding the major driving forces of the Earth's climate system. AIRS/AMSU/HSB will measure the major components of these driving forces including the thermal structure of the surface and the atmosphere, the outgoing longwave infrared radiation, and the atmospheric water vapor content.

2. **Investigation of atmosphere-surface interactions:** The high spectral resolution of AIRS will provide several spectrally transparent window channels that will observe the surface with minimal contamination by the atmosphere and will allow the determination of accurate surface temperature and infrared spectral emissivity. In addition, the narrow spectral channels in the short-wavelength infrared region will observe the atmospheric layers near the Earth's surface with the highest vertical resolution possible by passive remote sensing. The observations will enable investigations of the fluxes of energy and water vapor between the atmosphere and the surface, along with their effect on climate.



This cut-away view of the AIRS instrument shows the key mechanical structures and assemblies. The spectrometer is small compared to the volume required to support space radiators and electronics in a configuration consistent with the spacecraft interface constraints.

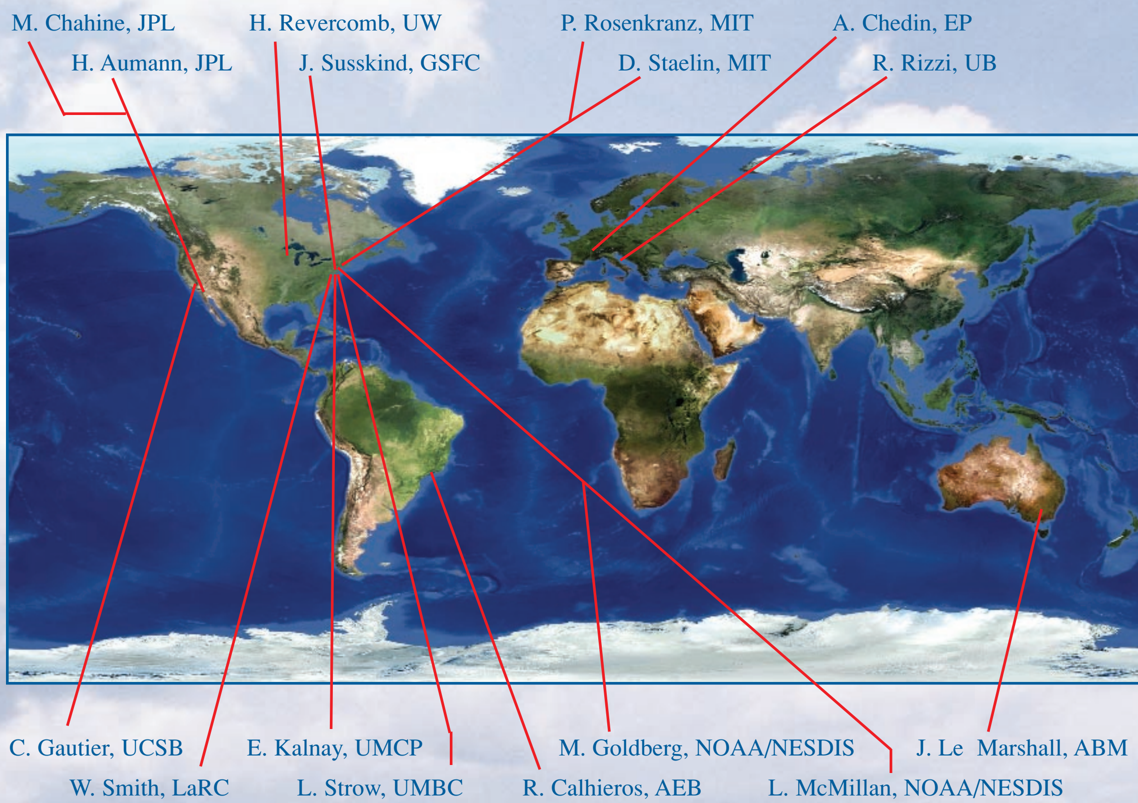
3. **Improving numerical weather prediction:** Numerical weather prediction models have now progressed to the point where they can predict atmospheric temperature profiles to an accuracy of 2 K, which is equivalent to the accuracy of current satellite data. Further improvement in our knowledge of temperature profiles is essential in order to improve forecasting accuracy. AIRS/AMSU/HSB temperature profiles with radiosonde accuracy of 1 K in 1 km-thick layers are key to improving the accuracy and extending the range of weather forecasts.

4. **Detection of the effects of increased greenhouse gases:** AIRS will map the concentration of carbon dioxide and methane globally. In addition, the ability to provide simultaneous observations of the Earth's atmospheric temperature, ocean surface temperature, and land surface temperature and infrared spectral emissivity, as well as humidity, clouds and the distribution of greenhouse gases, makes AIRS/AMSU/HSB a primary space instrument to observe and study the response of the atmosphere to increased greenhouse gases.

5. **Assessing climate variations and feedbacks:** The accuracy and high spectral resolution of AIRS provide a powerful new tool for climate studies. AIRS' high resolution infrared coverage from 3.74 to 15 µm will give researchers the ability to validate numerical models and to study different climate processes as needed. For example, emission to space by strong and weak water vapor lines is a critical climate feedback mechanism in the middle and lower troposphere. Numerical models must reproduce such lines as an indication of their ability to describe the climate system.

Science Team

The international science team for the AIRS instrument includes experts from the United States, France, Italy and Australia. Under the leadership of Dr. Moustafa Chahine at the Jet Propulsion Laboratory, the team guides the definition of the AIRS instrument and its scientific goals.



ABM	Australian Bureau of Meteorology
AEB	Agencia Espacial Brasileira (Brazilian Space Agency)
EP	Ecole Polytechnique, France
GSFC	Goddard Space Flight Center (NASA)
JPL	Jet Propulsion Laboratory (NASA)
LaRC	Langley Research Center (NASA)
MIT	Massachusetts Institute of Technology
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
UB	University of Bologna, Italy
UCSB	University of California, Santa Barbara
UMBC	University of Maryland, Baltimore County
UMCP	University of Maryland, College Park
UW	University of Wisconsin

Atmospheric Sounding

Atmospheric sounding for information about temperature and abundance of gases is based on the fact that thermal radiation received by a radiometer originates at wavelength-dependent depths in the atmosphere. This is caused by a non-uniform absorption spectrum, particularly by molecular absorption lines. (Note that in an atmosphere in thermal and radiative equilibrium, emission equals absorption. If that were not the case, the atmosphere would either cool down or heat up until balance is reached.) At wavelengths near the peak of such a line, absorption may be so strong that most of the underlying atmosphere is opaque, and only the top of the atmosphere is "seen." Conversely, at wavelengths away from the lines, often called a "window" region, the atmosphere may be nearly transparent, and the surface or the bottom of the atmosphere is seen. Through spectral sampling, i.e., by measuring narrow spectral bands or "channels," it is then possible to probe into different depths of the atmosphere.

It is possible to separate the effects of different atmospheric gases by using channels in different spectral regions where one gas has absorption features while the others do not. To measure temperature profiles, AIRS uses a large number of CO_2 absorption lines in the infrared spectral region, while AMSU-A uses a few O_2 absorption lines at microwave wavelengths. To measure water vapor profiles, AIRS uses many H_2O absorption lines throughout its spectral range, and HSB uses a single H_2O absorption line in the microwave region. Since the vertical distribution of CO_2 and O_2 are both stable and well known, the CO_2 and O_2 channels allow the temperature distribution to be determined. With that known, the H_2O channels allow the vertical distribution of water vapor density to be determined.

The infrared spectral range covered by AIRS also features absorption lines of other molecular species, such as O_3 and CH_4. This makes it possible to deduce ozone and methane profiles. Finally, while liquid water makes most clouds completely opaque in the infrared region, in the microwave region they are partially transparent. The microwave spectral absorption features of liquid water therefore make it possible to determine the vertical distribution of liquid water in clouds from AMSU-A and HSB measurements. This information is used to make the derived AIRS temperature and water vapor profiles more accurate.

The Instruments

AIRS measures upwelling radiances in 2378 spectral channels in the infrared (IR) from 3.74 μm to 15.4 μm. A set of 4 channels in the visible/near-infrared (Vis/NIR) observes wavelengths from 0.4 to 1.0 μm to provide cloud cover and spatial variability information. The microwave sounders provide sea ice concentration, snow cover, and additional temperature profile information, as well as precipitable water and cloud liquid water content. If cloud cover is too great for IR retrievals, the microwave measurements alone will provide a coarse, low precision atmospheric temperature profile and surface characterization.

AMSU-A is actually two completely separate sensor units, AMSU-A1 and AMSU-A2, but during data processing on the ground the observations from the two instruments are combined and treated as if they came from a single instrument. (This is possible because the two units are very similar and are operated in a synchronized way.) Together they provide measurements in 15 spectral channels. Most of them are used to derive temperature profiles, from the surface upward to about 40 km. Some are used to provide cloud information. The AMSU-A "footprint" is three times as wide as the AIRS footprint, and an AMSU-A spot therefore covers a cluster of nine AIRS spots. Data from a single AMSU-A spot are used to "cloud clear" a cluster of nine AIRS observations.

HSB provides measurements in four spectral channels, which are used to derive water vapor profiles, from the surface to about 10 km, and some supplemental cloud information. They are also used, together with AMSU-A data, to derive liquid water (i.e., cloud) profiles to help make the AIRS-derived profiles more accurate. Rain intensity can also be deduced from the HSB measurements.

The instruments are all cross-track scanners. They view their respective scan mirrors, which rotate around an axis along the flight direction. As a mirror is rotated, the "viewing beam" sweeps across the ground track below the satellite and is reflected into its instrument. As the spacecraft moves along this results in a scan "swath" that extends a little more than 800 km on either side of the ground track. The AMSU-A reflectors make a complete revolution in 8 seconds. The AIRS reflector and HSB reflector each make three revolutions in the same time (i.e., each makes one revolution in 2.67 seconds). About 99° of each 360° revolution is used to sample the atmosphere and surface below. This takes about 6 seconds for AMSU-A and 2 seconds for AIRS and HSB. AMSU-A takes 30 Earth-view samples in the 6-second period, and AIRS and HSB each take 90 Earth-view samples in the 2-second period. The sampling density of AIRS and HSB is therefore triple that of the AMSU-A instruments, both along and across the swath. Hence for each AMSU-A sample (or spot) there are nine HSB and nine AIRS spots.

The remainder of the rotation cycle is spent looking at empty space or internal calibration targets. Calibrating every scan cycle results in a very stable measurement system.

FACTS ABOUT AIRS

Size:	stowed: 116.5 x 80 x 95.3 cm deployed: 116.5 x 158.7 x 95.3 cm
Mass:	177 kg
Power:	220 W
Data Rate:	1.27 Mbps
Spectral Range:	IR: 3.74 - 15.4 μm Vis/NIR: 0.4 - 1.0 μm
Channels:	IR: 2378 Vis/NIR: 4
Aperture:	10 cm
Instrument Field of View:	IR: 1.1° (= 13.5 km @ nadir) Vis/NIR: 0.2° (= 2.3 km @ nadir)
Swath Width:	99° (= 1650 km)
Scan Sampling:	IR: 90 x 1.1°
Pointing Accuracy:	IR: 0.1°
Thermal Control:	IR detectors: active cooler @ 60 K Passive radiator @ 150 K Electronics @ ambient
Prime Contractor:	British Aerospace Systems (formerly Lockheed-Martin)
Responsible Organization:	Jet Propulsion Laboratory

FACTS ABOUT AMSU

Instrument:	AMSU-A1	AMSU-A2
Size:	72 x 34 x 59 cm	73 x 61 x 86 cm
Mass:	49 kg	42 kg
Power:	77 W	24 W
Data Rate:	1.5 kbps	0.5 kbps
Spectral Range:	50 - 90 GHz	23 - 32 GHz
Channels:	13	2
Aperture:	15 cm (two)	30 cm (one)
Instrument Field of View:	3.3° (= 40.5 km @ nadir)	3.3° (= 40.5 km @ nadir)
Swath Width:	100° (= 1690 km)	100° (= 1690 km)
Scan Sampling:	30 x 3.33°	30 x 3.33 °
Pointing Accuracy:	0.2°	0.2°
Thermal Control:	None (ambient)	None (ambient)
Prime Contractor:	Aerojet	Aerojet
Responsible Organization:	NASA/GSFC	NASA/GSFC

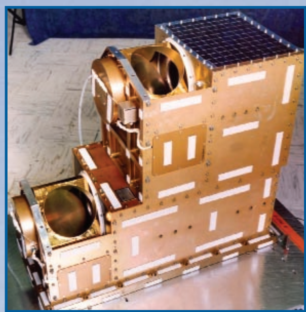
FACTS ABOUT HSB

Size:	70 x 65 x 46 cm
Mass:	51 kg
Power:	56 W
Data Rate:	4.2 kbps
Spectral Range:	150 - 190 GHz
Channels:	4
Aperture:	18.75 cm (one)
Instrument Field of View:	1.1° (= 13.5 km @ nadir)
Swath Width:	99° (= 1650 km)
Scan Sampling:	90 x 1.1°
Pointing Accuracy:	0.1°
Thermal Control:	None (ambient)
Prime Contractor:	Matra Marconi Space (UK)
Responsible Organization:	INPE (Brazil)

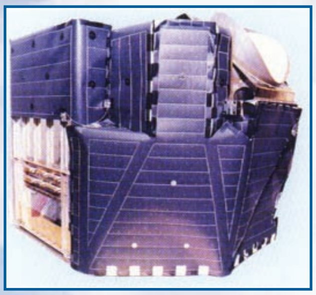
Data Products to be Derived from the AIRS/AMSU/HSB Data by the AIRS Science Team

Each of these products is described in the *EOS Data Products Handbook, volume 2*, published in 2000 and available from the EOS Project Science Office web site at http://eospso.gsfc.nasa.gov.

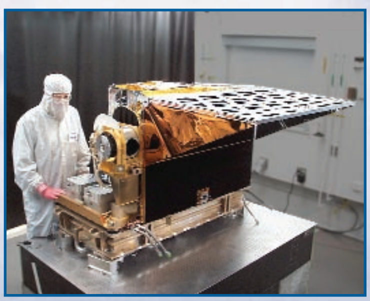
Level 2 Cloud-Cleared Radiances	
Flux Product	Clear-column radiance Outgoing longwave radiation at the top of the atmosphere Outgoing shortwave radiation at the top of the atmosphere Net longwave flux at the surface Net shortwave flux at the surface
Atmospheric Temperature Product	Temperature profile through the atmosphere (30 levels) Troposphere height Stratosphere height
Humidity Product	Water vapor profile through the atmosphere Total precipitable water Cloud liquid-water content Precipitation indication Cloud-ice indication
Cloud Product	Cloud-top pressure Cloud-top temperature Fractional cloud cover Cloud spectral properties Cloud type
Ozone Product	Ozone profile through the atmosphere Total ozone
Trace Constituent Product	Methane Carbon monoxide
Surface Analysis Product	Sea surface skin temperature Land surface skin temperature Infrared surface emissivity Microwave surface emissivity



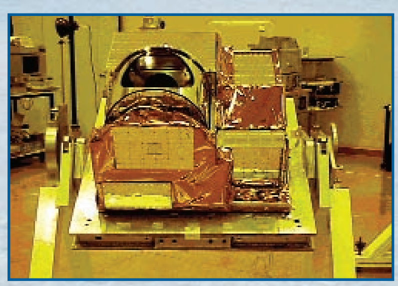
AMSU-A1



AMSU-A2



AIRS



HSB

The Aqua spacecraft under construction at TRW.