Putting on AIRS aids weather forecasts

In the often-quoted words of Mark Twain, everyone talks about the weather, but nobody does anything about it. They cannot change the weather, but NASA and the National Oceanic and Atmospheric Administration (NOAA) have recently outlined research that has helped to improve the accuracy of medium-range forecasts in the Northern Hemisphere.

NASA and NOAA scientists at the Joint Center for Satellite Data Assimilation (JCSDA) in Camp Springs, Md., came up with procedures to improve forecasting accuracy. The scientists worked with experimental data from the Atmospheric Infrared Sounder (AIRS) instrument on NASA's Aqua satellite. They found that by incorporating AIRS data into numerical weather prediction models, they can improve the accuracy range of experimental six-day Northern Hemisphere weather forecasts by up to 4%—a 6-hr increase.

AIRS is a high-spectral-resolution infrared instrument that takes 3D pictures of atmospheric temperatures, water vapor, and trace gases. The instrument data have been officially incorporated into NOAA's National Weather Service operational forecasts.

"NASA is assisting the world's weather prediction agencies by providing very detailed, accurate observations of key atmospheric variables that interact to shape our weather and climate," says Mary Cleave, associate administrator for NASA's Science Mission Directorate. "The forecast improvement accomplishment alone makes the AIRS project well worth the American taxpayers' investment."

Unprecedented improvement

No other single instrument has provided such a large increase in forecast improvement in its time range as the AIRS instrument has, according to retired Navy Vice Adm. Conrad Lautenbacher Jr., undersecretary of commerce for oceans and atmosphere and NOAA administrator. "Climate and weather forecasts are dependent upon our understanding current global ocean and atmosphere conditions. If we want to be able to predict what the weather will be like in the future, we must adequately define the global conditions today," says Lautenbacher. The satellite data provided by AIRS are "a vital link for NOAA to continuously take the pulse of the planet," he says.

"A 4% increase in forecast accuracy at five or six days normally takes several years to achieve," says John LeMarshall, director of JCSDA. "This is a major advancement, and it is only the start of what we may see as much more data from this instrument is incorporated into operational forecast models at NOAA's Environmental Modeling Center."

The European Center for Medium Range Weather Forecasts began incorporating data from AIRS into its operational forecasts in October 2003. The center reported an improvement in forecast accuracy of 8 hr in Southern Hemisphere five-day forecasts.

Goals and breakthroughs

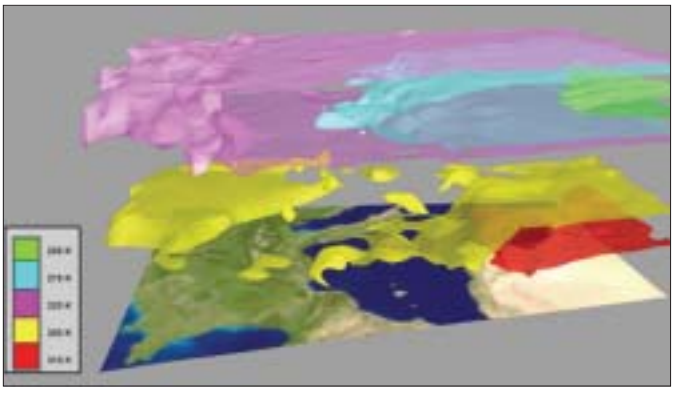
AIRS is the result of more than 30 years of atmospheric research. Leading the effort is Moustafa Chahine of JPL in Pasadena, Calif. The AIRS instrument is the first in a series of advanced infrared sounders that will provide accurate, detailed atmospheric temperature and moisture observations for weather and climate applications.

The JCSDA is operated by NOAA, NASA, the Air Force, and the Navy. The goals of the center are to accelerate the use of observations from Earth-orbiting satellites to improve weather and climate forecasts, and to increase the accuracy of climate data sets.

Although there have been satellites measuring Earth's atmosphere since the 1970s, most have been designed for weather forecasting. Climate studies, which require the detection of subtle trends and changes that can take years to appear, require a new generation of spaceborne devices.

AIRS is the first spaceborne instrument designed specifically to measure global climate change indicators. Its cutting-edge technology allows it to measure water vapor and greenhouse gases with remarkable accuracy. As a result, scientists are now beginning to gather space data of sufficiently high quality that it will allow

Storms are imaged in 3D through an AIRS infrared window channel. Window channels measure the temperature of the cloud tops or the surface of the Earth in cloud-free regions. The lowest temperatures are associated with high, cold cloud tops that make up the top of the hurricane. The infrared signal does not penetrate through clouds, so the purple color indicates the cool cloud tops of the storm. In cloud-free areas, the infrared signal is retrieved at the Earth's surface, revealing warmer temperatures. Cooler areas are pushing to purple and warmer areas are pushing to red.



them to address many of the scientific questions related to Earth's climate and to global change in the atmosphere.

The AIRS system has been operating only since August 2002, not long enough to address many of the climate questions. But apparently it is already providing data of unprecedented accuracy. Although still under evaluation, the AIRS data appear to be better than what is available from the current "gold standard"—weather balloons. It is as if more than 300,000 greatly improved balloons were released every day all over the globe—even from uninhabited or totally inaccessible areas. For the first time, scientists are able to form a precise picture of the 3D global distribution of water vapor—the primary greenhouse gas.

Using new infrared technology, AIRS creates a 3D image of the Earth's atmosphere—in much the same way that a CAT (computer-aided tomography) scan machine can make a 3D image of the inside of your head or body.

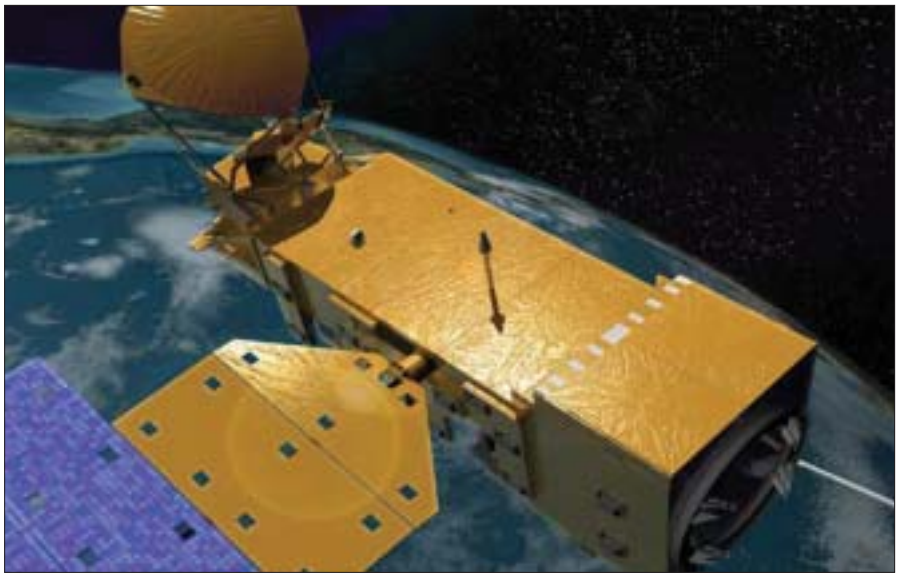
AIRS measures the spectrum of the atmosphere, allowing scientists to create 3D maps of temperature and water vapor. It can also measure trace greenhouse gases such as carbon dioxide, carbon monoxide, and methane. These greenhouse gases are "indicators" for global warming.

Applying the scientific method

The scientific method usually takes the form of posing a hypothesis based on observed phenomena, using that hypothesis to make predictions, and then testing those predictions against observations. One such hypothesis is that climate changes such as global warming will lead to wider swings in weather patterns and to more occurrences of more severe weather events.

To test this hypothesis it is crucial to have a system in place that can measure these weather events fully and very accurately, and measure subtle changes in climate as well. That is where AIRS comes in—it is a research instrument designed to address this issue. But can scientists be certain that their observations are good enough?

One way to tell is to determine if using AIRS data can lead to better storm forecasts. The science team has already demonstrated that it can lead to better forecasts of the location and intensity of "extra tropical cyclones" (midlatitude storms such as "northeasters," which often strike the U.S. East Coast). This is a good indication that AIRS data are much better than what is available to the weather service, and probably good enough to test the climate-weather connection hypothesis. Of course, scientists need a much longer time series of data than they have so far, but they expect that AIRS will help fulfill that requirement.



The Aqua satellite carries the AIRS instrumentation.

Cycles of change

Another hypothesis holds that climate change may cause the water—or hydrologic—cycle to accelerate. As water moves through its cycle, it takes many forms: It falls as rain or snow, soaks into the soil, runs into lakes and oceans, and evaporates again into atmospheric water vapor, where it can condense into cloud droplets, eventually repeating the cycle.

If Earth's water flows through this cycle at a faster pace, there will be more water vapor and clouds in the atmosphere and more rain falling out of it. The ability of AIRS to measure the humidity distribution in the atmosphere will make it possible to determine with sufficient accuracy if the water cycle is indeed accelerating.

People living in the Northern Hemisphere are familiar with the annual summer-fall-winter-spring cycle, but there are other such cycles. The topic of "interannual variability"—a term referring to natural cycles and changes that last longer than a year—is of intense interest among scientists as well as the general public.

The El Niño phenomenon is such a cycle. It seems to occur every 3-5 years on average. However, scientists believe there are also longer cycles—for example, the so-called decadal oscillation, which may be responsible for the prolonged drought that has plagued the western U.S. for several years. It also may have been responsible for the "dust bowl" drought of the 1930s. Some of these cycles must still be considered hypothetical and can only be confirmed and otherwise studied when a sufficient number of high-quality observations are available.

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When people talk about the weather, they are talking about conditions at one specific place and time. If they say "Yesterday we had an inch of rain in Los Angeles, but today it is clear and dry," they are talking about weather, which is constantly changing. When people talk about climate, they are describing the long-term average of weather—like speaking about a sports team having a winning year versus winning one game. If they say "Los Angeles usually gets 2 in. of rain in the month of November," they are talking about climate. Scientists have to make measurements for many years to get an idea of what the true climate is.

For information about AIRS on the Internet, visit http://airs.jpl.nasa.gov/.

Edward D. Flinn
edflinn@pipeline.com