NASA Facts

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FS-2002-2-039-GSFC

THE EARTH OBSERVING SYSTEM AQUA

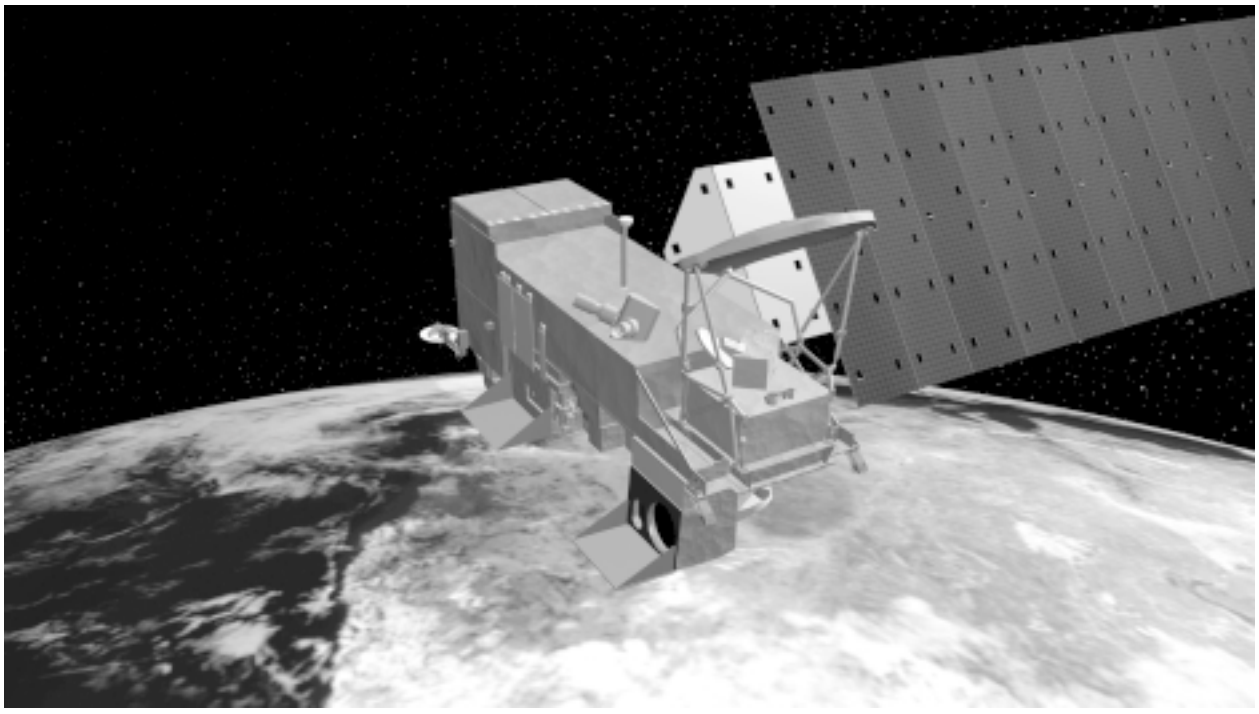
Earth System Science

Beginning in the 1960s, NASA pioneered the study of the atmosphere from the unique perspective of space with the launch of its Television Infrared Observation Satellite (TIROS-1). Thanks to new satellite and computer technologies, it is now possible to study the Earth as a global system. Through their research, scientists are better understanding and improving their forecasting of short-term weather phenomena.

Long-term weather and climate prediction is a greater challenge that requires the collection of better data over longer periods. Since climate changes occur over vast ranges of space and time, their causes and effects are often difficult to measure and understand. Scientists must obtain long-term data if they are to reach a full understanding of the interactions among the Earth's physical and biological systems. NASA's Earth Observing System (EOS) will help us to understand the complex links among air, land, water and life within the Earth system.

What is Aqua?

NASA's commitment to studying the Earth as a global system continues with the Aqua spacecraft



(originally called EOS PM-1), representing a key contribution by NASA to the U.S. Global Change Research Program. Aqua carries six state-of-the-art instruments to observe the Earth's oceans, atmosphere, land, ice and snow covers, and vegetation, providing high measurement accuracy, spatial detail, and temporal frequency. This comprehensive approach to data collection enables scientists to study the interactions among the four spheres of the Earth system—the oceans, land, atmosphere, and biosphere.

Aqua, Latin for "water," is named for the large amount of information that the Aqua spacecraft will collect about the Earth's water cycle. In particular, the Aqua data will include information on water vapor and clouds in the atmosphere, precipitation from the atmosphere, soil wetness on the land, glacial ice on the land, sea ice in the oceans, snow cover on both land and sea ice, and surface waters throughout the world's oceans, bays, and lakes. Such information will help scientists improve the quantification of the global water cycle and examine such issues as whether or not the cycling of water might be accelerating.

In addition to information about the water cycle, Aqua will also provide information on many additional elements of the Earth system. For instance, Aqua will enable studies of the fluxes of radiation from the Sun and from the Earth that combine to constitute the Earth's radiation balance. It will also enable studies of small particles in the atmosphere termed "aerosols" and such trace gases in the atmosphere as ozone, carbon monoxide, and methane. The trace gases each have a potential contribution to global warming, whereas the aerosols are more likely to have a cooling effect. Aqua will also provide observations on vegetation cover on the land, phytoplankton and dissolved organic matter in the oceans, and the temperatures of the air, land, and water. All of these measurements will have the potential to contribute to improved understanding of the changes occurring in the global climate and the role of the interactions among the various elements of the climate system.

One of the most exciting of the potential practical benefits likely to derive from the Aqua data is improved weather forecasting. Aqua will carry a sophisticated sounding system that will allow determination of atmospheric temperatures around the world to an accuracy of 1° Celsius in 1-km-thick layers throughout the troposphere, the lowest portion of the atmosphere. The troposphere extends to an altitude of about 10–15 km, depending on location, and contains most of the global cloud cover. The anticipated 1° Celsius accuracy far exceeds current accuracies from satellite observations and, in conjunction with the moisture profiles also obtainable from the Aqua sounding system, will offer the potential of improved weather forecasting. NASA is working with the U.S. National Oceanic and Atmospheric Administration and the European Centre for Medium-Range Weather Forecasts to facilitate the incorporation of the Aqua data in their weather forecasting efforts.

International Collaboration

Aqua is a joint project of the United States, Japan, and Brazil.

The Spacecraft

The spacecraft was designed and built by TRW in Redondo Beach, California. Aqua is based on TRW's modular, standardized AB1200 common spacecraft bus. This design features common subsystems scalable to the mission-specific needs of Aqua as well as future missions. Instrument payloads can be attached on a "mix and match" basis without changing the overall design or subsystem support requirements.

The Instruments

The Atmospheric Infrared Sounder (AIRS), built by BAE Systems, was provided by NASA's Jet Propulsion Laboratory in Pasadena, California. AIRS will be the highlighted instrument in the AIRS/AMSU-A/HSB triplet centered on measuring humidity, temperature, cloud properties, and the amounts of greenhouse gases throughout the atmosphere. AIRS/AMSU-A/HSB will improve weather forecasting, establish the connection between severe weather and climate change, examine whether the global water cycle is accelerating, and detect the effects of greenhouse gases.

The Advanced Microwave Scanning Radiometer for EOS (AMSR-E), built by Mitsubishi Elec-

tronics Corporation, was provided by Japan's National Space Development Agency. AMSR-E measures precipitation rate, cloud water, water vapor, sea surface winds, sea surface temperature, ice, snow, and soil moisture.

The Advanced Microwave Sounding Unit (AMSU-A), built by Aerojet and provided by NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, will obtain temperature profiles in the upper atmosphere (especially the stratosphere) and will provide a cloud-filtering capability for tropospheric temperature observations. The EOS AMSU-A is part of the closely coupled AIRS/AMSU-A/HSB triplet.

The Clouds and the Earth's Radiant Energy System (CERES), built by TRW, was provided by NASA's Langley Research Center in Hampton, Virginia. This instrument will measure the Earth's total thermal radiation budget, and, in combination with Moderate Resolution Imaging Spectroradiometer (MODIS) data, will provide detailed information about clouds. The first CERES instrument was launched on the Tropical Rainfall Measuring Mission (TRMM) satellite in November 1997; the second and third CERES instruments were launched on the Terra satellite in December 1999; and the fourth and fifth CERES instruments will be on board the Aqua satellite. The pairs of CERES on both Terra and Aqua satellites allow coincident measurements by one CERES scanning in lines perpendicular to the path of the satellite and by the other CERES scanning in lines at various angles with respect to the satellite's path.

The Humidity Sounder for Brazil (HSB), built by Matra-Marconi, was provided by Brazil's Instituto Nacional de Pesquisas Espaciais, the Brazilian Institute for Space Research. The HSB will obtain humidity profiles throughout the atmosphere. The HSB is the instrument in the AIRS/AMSU-A/HSB suite that will allow humidity measurements even under conditions of heavy cloudiness and haze.

MODIS, built by Raytheon Santa Barbara Remote Sensing, was provided by GSFC. MODIS is a 36-band spectroradiometer measuring visible and infrared radiation and obtaining data that will be used to derive products ranging from vegetation, land surface cover, and ocean chlorophyll fluorescence, to cloud and aerosol properties, fire occurrence, snow cover on the land, and sea ice cover on the oceans. The first MODIS instrument was launched on board the Terra satellite.

Aqua is scheduled for launch in 2002 aboard a Delta 7920-10L launch vehicle from Vandenberg Air Force Base, California. The stowed spacecraft is 8.8 ft (2.68m) x 8.2 ft (2.49m) x 21.3 ft (6.49m). Deployed, Aqua is 15.8 ft (4.81m) x 54.8 ft (16.70m) x 26.4 ft (8.04m). The spacecraft, at launch, weighs 6,784 lbs with a full propellant load of 508 lbs and is powered by 4.6 kilowatts of electric power from its solar array.

Aqua will be launched into a circular 680-km orbit. Over a period of days after separation from the launch vehicle, it will be commanded by the ground to raise its orbit to the prescribed 705-km (438-mile) orbit. This is necessary in order to allow for proper phasing of Aqua with other spacecraft in orbit and the polar ground stations used for communications. The spacecraft will ultimately be positioned in a near-polar (98°) orbit around the Earth in synchronization with the Sun, with its path over the ground ascending across the equator at the same local time every day, approximately 1:30 p.m. The early afternoon observation time contrasts with the 10:30–10:45 a.m. equatorial crossing time (descending in this case) of the Terra satellite. The two daytime crossing times account for why the Terra and Aqua satellites were originally named "EOS AM" and "EOS PM," respectively. The combination of morning and afternoon observations will allow studies concerning the diurnal variability of many of the parameters discussed above.

Management

Overall management of the Aqua mission is located at GSFC, which is managing the integration and testing of the spacecraft. The Aqua data will be processed, archived, and distributed using distributed components of the Earth Observing System Data and Information System (EOSDIS). EOSDIS also provides the mission operations systems that perform the functions of command and control of the spacecraft and the instruments. NASA's Kennedy Space Center is responsible for the launch operations, including Boeing's Delta launch vehicle and the prelaunch integrated processing

facility. The U.S. Air Force is responsible for all range-related matters. GSFC manages EOS for NASA's Earth Science Enterprise (ESE), headquartered in Washington, D.C.

Data Processing and Distribution

Aqua will provide a major part of a 15-year environmental dataset focusing on global change. The Aqua instruments will produce more than 750 gigabytes of data per day, which is equivalent to 75 personal computer hard disks at 10 gigabytes each per day. This massive amount of information will be handled using EOSDIS, in addition to its present accumulation of nearly 3000 gigabytes per day.

EOSDIS will provide the high-performance computing resources needed to process, store, and rapidly transmit terabytes (thousands of gigabytes) of the incoming data every day. EOSDIS has several distributed sites that perform these functions: Distributed Active Archive Centers (DAACs) that process, store and distribute the data, and Science Investigator-led Processing Systems that process the data and send them to the DAACs for storage and distribution. EOSDIS uses an "open" architecture to allow insertion of new technology while enabling the system to support the changing mission and science needs throughout the EOS Program.

Goals and Objectives

NASA's ESE identified several high-priority measurements that EOS should make to facilitate a better understanding of the components of the Earth system—the atmosphere, the land, the oceans, the polar ice caps, and the global energy budget. The specific objectives of Aqua include:

- achieving a safe launch and on-orbit check-out of the Aqua spacecraft and instruments;
- producing high-spectral resolution obtaining 1 K/ 1 km global root-mean-square temperature profile accuracy in the troposphere by 1 year after launch;
- extending the improved TRMM rainfall characterization to the extra tropics;
- producing global sea surface temperature daily maps under nearly all sky conditions for a minimum of 1 year;
- producing large-scale global soil moisture distribution for regions with low vegetation;
- producing calibrated global observations of the Earth's continents and ocean surfaces 150 days after the mission is declared operational;
- capturing and documenting three seasonal cycles of terrestrial and marine ecosystems and atmospheric and cloud properties;
- producing three sets of seasonal/annual Earth radiation budget records;
- producing improved measurements of the diurnal cycle of radiation by combining Aqua measurements with Terra measurements for months of overlap;
- producing combined cloud property and radiation balance data to allow improved studies of the role of clouds in the climate system; and,
- capturing, processing, archiving, and distributing Aqua data products, by 150 days after the mission is declared operational.

A New Perspective

Complemented by Terra, aircraft and ground-based measurements, Aqua data will enable scientists to distinguish between natural and human-induced changes. The EOS series of spacecraft are the cornerstone of NASA's ESE, a long-term research effort to study the Earth as a global environment.

More information on EOS and the science related to it can be found at the EOS Project Science Office website at http://eospso.gsfc.nasa.gov and at the Earth Observatory website at http://earthobservatory.nasa.gov. Further information on Aqua can be found at http://aqua.nasa.gov