NASA Facts

National Aeronautics and
Space Administration

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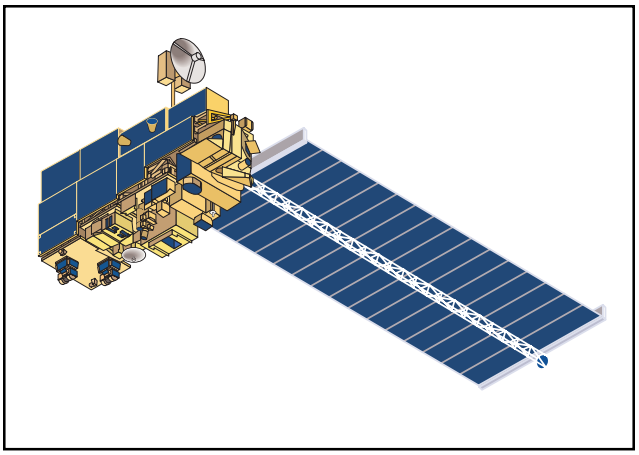
TERRA
THE EARTH OBSERVING SYSTEM (EOS) AM-1

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. *Earth System Science* integrates many disciplines of scientific research that focus on understanding the planet as a whole, its integral parts and how its parts interact. Through their research, scientists are better understanding and improving their forecasting of short-term climate phenomena. For instance, NOAA scientists predicted the onset of the 1997-98 El Niño about 10 months before it occurred. Although we are gaining new insights into El Niño, we are currently unable to fully understand the large-scale impacts of the phenomenon, thus diminishing our ability to respond both before and after the event.

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,



The Terra Spacecraft

their causes and effects are often difficult to measure and understand. Scientists must obtain long-term data if they are to reach a clearer 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 Terra?

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

Terra Spacecraft (originally called EOS AM-1), representing a key contribution by NASA to the U.S. Global Change Research Program. Terra is the flagship in a series of EOS spacecraft. Terra carries five state-of-the-art instrument sets with measurement and accuracy capabilities never flown before, enabling it to observe the cycling of water, trace gases, energy, and nutrients throughout the Earth's climate system. This comprehensive approach to data collection enables scientists to study the interactions among the four spheres of the Earth system – the oceans, lands, atmosphere, and biosphere.

Terra simultaneously will study clouds, water vapor, small particles in the atmosphere (called "aerosol" particles), trace gases, land surface and oceanic properties, as well as the interaction between them and their effect on the Earth's energy budget and climate. Moreover, Terra will observe changes in the Earth's radiation energy budget - which is the amount of incoming energy from the sun minus outgoing energy from reflected sunlight and emitted heat. If we are to succeed in building predictive computer models of these complex interactions, we must clearly comprehend global climatic processes and parameters. The Terra team estimates that it will complete the first Earth system models within five years after launch.

Mission Facts

NASA's Goddard Space Flight Center, Greenbelt, Md., provided the spacecraft or "bus" and one instrument (MODIS). Under Goddard management, Lockheed Martin assembled and tested the Terra spacecraft at its production facility in Valley Forge, Pa.

A polar-orbiting spacecraft, Terra is scheduled for launch in late of 1999 aboard an Atlas IIAS launch vehicle from Vandenberg Air force Base, Calif. Synchronized with the sun, Terra's descending orbit will cross the equator at 10:30 a.m. local time during each orbit—hence the original term "AM." Clouds typically form over tropical land in the afternoon as the surface warms, creating updrafts; hence, Terra's morning view will provide clearer images of the Earth's lands. The satellite will orbit the Earth once every 99 minutes at an inclination of 98 degrees relative to the equator, at a mean altitude of 438 nautical miles (705 kilometers). Over the tropical oceans, there are fewer clouds in the afternoon. Terra will be followed by its "PM" spacecraft counterpart in the year 2000. EOS PM-1 will fly in an *ascending* orbit with a 1:30 p.m. equatorial crossing time, thus complementing and extending Terra's measurement capabilities.

Terra is a joint project between the United States, Japan, and Canada. The U.S. provided the spacecraft and three instruments developed by NASA Field Centers—the Clouds and the Earth's Radiant Energy System (CERES), the Multi-angle Imaging SpectroRadiometer (MISR), and the Moderate-resolution Imaging Spectroradiometer (MODIS). Langley Research Center, Hampton, Va. provided two CERES units, the Jet Propulsion Laboratory, Pasadena, Calif., provided MISR, and Goddard Space Flight Center provided the MODIS instrument. The Japanese Ministry of International Trade and Industry provided the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The Canadian Space Agency provided an instrument called Measurements of Pollution In The Troposphere (MOPITT).

NASA's Kennedy Space Center, Fla., will conduct launch operations using the Atlas launch vehicle under a contract

with Lockheed Martin Astronautics, Denver.

Goddard will operate Terra via the Tracking and Data Relay Satellite System. It also will receive, process, and disseminate science data through the geographically distributed Earth Observing System Data and Information System (EOSDIS). EOS is managed by Goddard for NASA's Earth Science strategic enterprise, Washington, D.C.

The Instruments

The ASTER instrument will measure cloud properties, vegetation index, surface mineralogy, soil properties, and surface temperature and topography for selected regions of the Earth at very high resolution (up to 15 x 15 square meters per pixel). Additionally, because two of ASTER's subsystems are tiltable, it can obtain detailed three-dimensional measurements of surface topography.

The CERES instruments will measure the reflected and radiant energy coming from the Earth's surface and atmosphere, helping us to better determine our planet's energy balance. The critical components that affect the Earth's energy balance are the planet's surface, atmosphere, aerosols, and clouds. CERES will extend the data set begun in the 1980s by NASA's Earth Radiation Budget Experiment (ERBE).

With cameras pointed in nine different viewing directions, the MISR instrument will measure every part of the Earth system that scatters light differently at different angles: clouds, Earth's surface, and particles floating in the atmosphere. Measuring the reflective characteristics of each of these will help us learn about their changing physical properties, as well as quantify their impacts on Earth's energy budget. MISR also will provide unique three-dimensional views of clouds and volcanic plumes.

The MODIS instrument will measure the atmosphere, land, and ocean processes. This includes surface temperature (both the land and ocean), ocean color, global vegetation, cloud characteristics, snow cover, and temperature and moisture profiles. MODIS is capable of viewing the entire globe daily at moderate resolutions, ranging from 250-meters square to 1-kilometer square (about 0.5 square miles) pixels. MODIS is a global-scale, multi-spectral instrument useful for addressing questions in many scientific disciplines.

The MOPITT instrument is an infrared gas-correlation radiometer that will measure gaseous concentrations of carbon monoxide and methane (important air pollutants) in the lower atmosphere (troposphere), the lowest 10 miles of the atmosphere. MOPITT will provide global data on these pollutants as to their location on the planet and the season.

NASA supports about 800 scientists from the United States and abroad to meet global change research objectives using Terra data.

Goals and Objectives

NASA's Earth Science Enterprise identified several high-priority measurements that EOS should perform 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 Terra include:

• providing the first global "snapshot" of numerous Earth surface and atmospheric characteristics, the initial set of measure-

ments that will begin a 15-year monitoring program;

• improving the ability to detect human impacts on climate by identifying "fingerprints" of human activity;

• providing observations that will improve forecasts of the timing and the geographical distribution of severe climate events, such as drought and floods;

• improving seasonal and interannual weather predictions using Terra data;

• developing methods for disaster prediction, characterization, and risk reduction from wildfires, volcanoes, floods, and droughts; and

• beginning long-term monitoring of the Earth system to detect changes in global climate and the environment.

Data Processing and Distribution

Terra will provide the first major part of a 15-year environmental dataset focusing on global change. The Terra instruments will produce more than 850 gigabytes of data per day, which is 100,000 volumes of encyclopedias (or 85 personal computer hard disks at 10 gigabytes each) per day. This massive amount of information will be handled using the Earth Observing System Data and Information System (EOSDIS) being developed by the Goddard Space Flight Center with prime contractors Raytheon Systems Company and TRW. EOSDIS has components distributed throughout the U.S. The Terra data will be processed, archived, and distributed using distributed components of EOSDIS: Science Investigator-led Processing Systems, and Distributed Active Archive Centers. EOSDIS will provide the high-performance computing resources needed to process, store, and rapidly transmit petabytes (millions of gigabytes) of the incoming data. 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.

A New Perspective

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

For more information on EOS science, access the EOS Project Science Office Homepage at http://eospso.gsfc.nasa.gov. For further information on the spacecraft, access the Terra Project Homepage at http://eos-am.gsfc.nasa.gov. For details on the science goals, objectives, and new science results after launch, see http://terra.nasa.gov; or, visit the Earth Observatory web page for an interactive learning experience at http://earthobservatory.nasa.gov.