NASA Facts

National Aeronautics and
Space Administration

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NASA'S Earth Science Enterprise and the Goddard Space Flight Center

From the local weather to the larger environment, our home planet Earth changes every day. These changes have a direct affect on our quality of life, our health and our economy.

These changes can be big, like the deadly destruction to lives and property from a hurricane, or they can be small, like the last slushy ice melting from late winter sidewalks. These changes may last just a few seconds or many, many years. Some of the changes are natural, while others are started or altered by human activity in ways we do not completely understand. Some of the resulting causes-and-effects are clear, but many are incredibly complex, and others may be so subtle that we have yet to become aware of them at all.

Since the first days of observing Earth from space in the early 1960s, NASA and its Goddard Space Flight Center have been pioneers in helping scientists, policymakers and the general public gain a better understanding of how and why these changes occur. This research, and the new technology that pushes it forward, has matured to the point where we can begin to understand the details of how Earth's land, atmosphere, oceans, ice and life interact with each other, both in local neighborhoods and across vast regions of the globe.

Goddard Space Flight Center is home to the largest collection of scientists and engineers dedicated to exploring Earth from space that can be found anywhere in the world. They contribute daily to NASA's Earth Science Enterprise, which consists of three major pieces:

- research studies that transform raw data from Earth-observing missions into new scientific knowledge. Commercial applications can then emerge through partnerships with industry.
- satellites and aircraft missions that obtain the necessary measurements of Earth with high accuracy and frequent repetition.
- advanced computer networks that transmit the data and the resulting information to a wide variety of users across the world. Other computers run enormously complex software programs that model the behavior of natural forces and predict how they might change in hours, days, months or years from now.

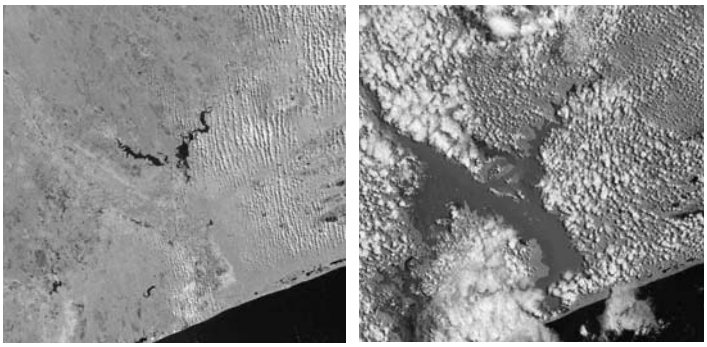
SCIENCE & APPLICATIONS

Satellites and airplanes use electronic cameras and other sensors that can "see" far beyond the limited range of the human eye. These amazing instruments can take images and precise measurements of vegetation and urban development on land, the variability of gases and particles in the atmosphere, the circulation of oceans, the flow of rivers and their nutrients, and even the imperceptible movement of glaciers. The instruments often make these observations from a distance of many miles, so this activity is often called "remote sensing."

The data sent back to Earth by NASA missions are used by scientists in government, universities, non-profit organizations and industry to study every aspect of our planet and how it changes over time.

The most extensive archive of images of Earth — nearly four million of them — originates from a series of orbiting NASA satellites called Landsats. This archive is an invaluable record of changes in the land surfaces of Earth, from natural causes like volcanic eruptions to accelerating human development of urban areas, where more than 60 percent of the world's population will live by the year 2025.

Landsat data has been used for everything from agricultural planning, real estate forecasts and forestry management to mapmaking, oil exploration and airline pilot training.



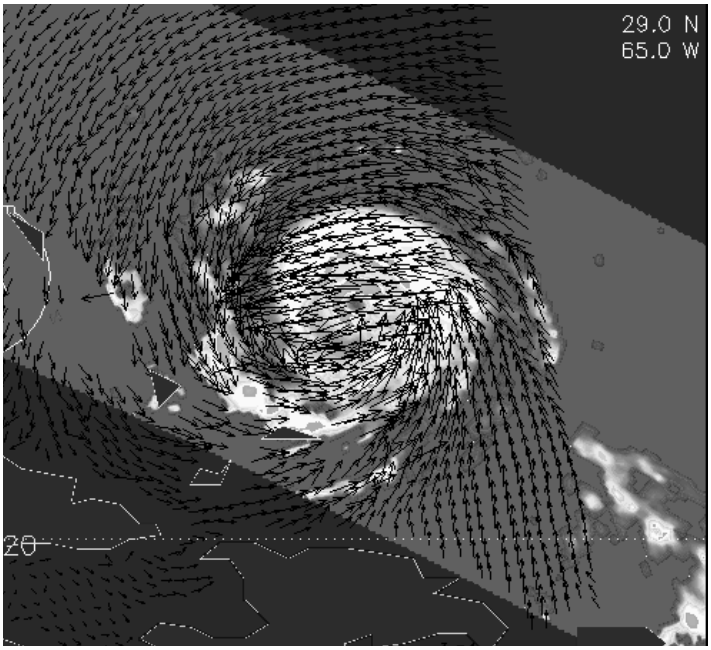
Landsat 7 shows Mozambique floods before and after

Just a few years after the first Landsat reached space, NASA sent the first Goddard-managed Total Ozone Mapping Spectrometer (TOMS) instrument into an orbit over the poles of the Earth in 1978 aboard the Nimbus-7 satellite. TOMS helped make "ozone" a household word through its false color images of the intense ozone depletion over the Antarctic between late August and early October, discovered by British researchers using ground-based observations.

TOMS data also showed record lows of ozone in the Northern Hemisphere in late 1992 and early 1993, raising concerns about increased solar ultraviolet radiation reaching Earth's surface during the beginning of plant growing season. Recent experimentation with TOMS data sent to ground stations as soon as it is gathered overhead has shown valuable aircraft safety applications by monitoring the movement of volcanic ash clouds at altitudes used by commercial airlines.

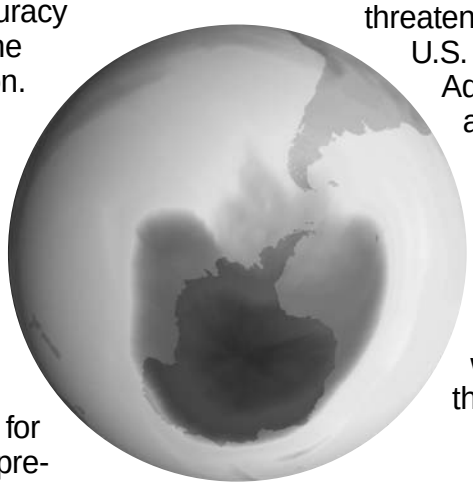
Another transportation industry, ocean shipping, is greatly impacted by sea surface winds, a property being measured with greater accuracy and coverage than ever before by the Goddard-managed QuikScat mission. Built swiftly in partnership with NASA's Jet Propulsion Laboratory using a unique "catalog"-style procurement, QuikScat features a microwave radar instrument called Seawinds that can measure the direction and speed of near-surface ocean winds without any limitations from clouds or darkness. QuikScat was developed and ready for launch less than two years after its precursor instrument was lost aboard the Japanese ADEOS mission.

Scientists are gaining many new insights by combining measurements from different sensors and spacecraft. This effort is just beginning with data from QuikScat and another Goddard mission, the Tropical Rainfall Measuring mission. This combination tells scientists more about precipitation air currents. TRMM also has shown us a towering "chimney cloud" stretching thousands of feet above Hurricane Bonnie. In the tropics, its data is being used to double the accuracy of three-day rainfall forecasts.

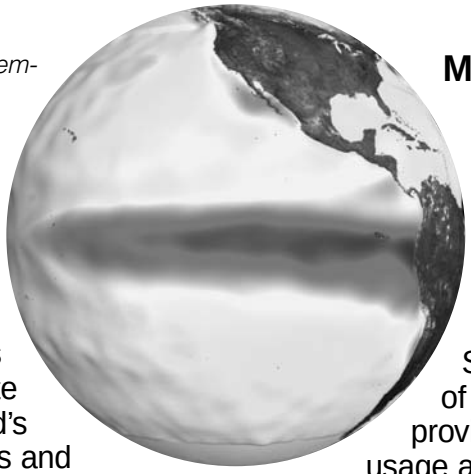


QuikScat and TRMM show Hurricane Floyd's precipitation air currents

Many other NASA missions are delivering new insights into natural hazards like storm systems and their causes. The 1997-98 El Niño marked the first time in human history that climate scientists were able to predict abnormal flooding and droughts months in advance, allowing time for threatened populations to prepare. The U.S. National Oceanic and Atmospheric Administration (NOAA) first announced a possible El Niño in April 1997. NASA tracked this phenomena from start-to-finish. The sensors of missions like the U.S.-French TOPEX-Poseidon radar satellite were able to physically monitor the movement of warm water from the western Pacific to the coast of South America.

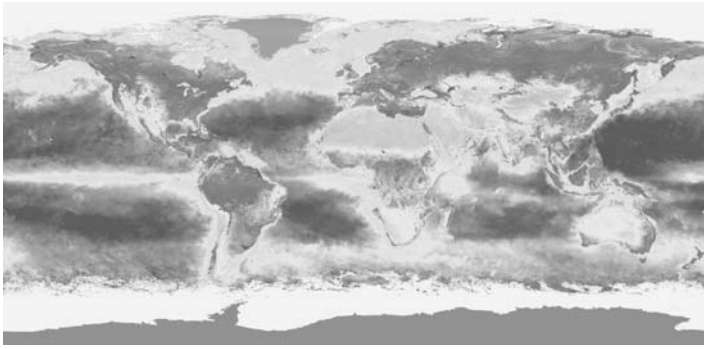


TOMS observes Antarctic ozone depletion on October 3, 1999



El Niño-driven sea surface heights and temperatures

The Goddard-led Sea-viewing Wide Field-of-view Sensor (SeaWiFS) mission used its unique infrared "ocean color" instrument to observe how El Niño suppressed the Marine food chain in the equatorial Pacific, and how its successor, La Niña, had the opposite effect. The color of most of the world's oceans varies according to the types and concentration of microscopic marine plants, called "phytoplankton." These plants contain chlorophyll, which has green pigments. Measuring phytoplankton concentrations is essential in understanding the role of the oceans in the global carbon cycle—the process by which carbon travels through the Earth's atmosphere, oceans, land, and living organisms—a key variable in global climate change.



SeaWiFS observes the global biosphere

Goddard also works in partnership with NOAA to develop and launch the weather satellites that help forecasters make predictions. Above the Atlantic and Pacific Oceans, near a region in space over the equator where their orbital speed matches the turning of Earth, two Geostationary Operational Environmental Satellites hover to give constant views of North America (GOES-8 and GOES-10.) GOES-12, launched in July 2001, is stored in orbit and will replace GOES-8 or GOES-10, as needed. Meanwhile, the NOAA-15 and NOAA-16 satellites pass over the poles of Earth to provide complementary measurements.

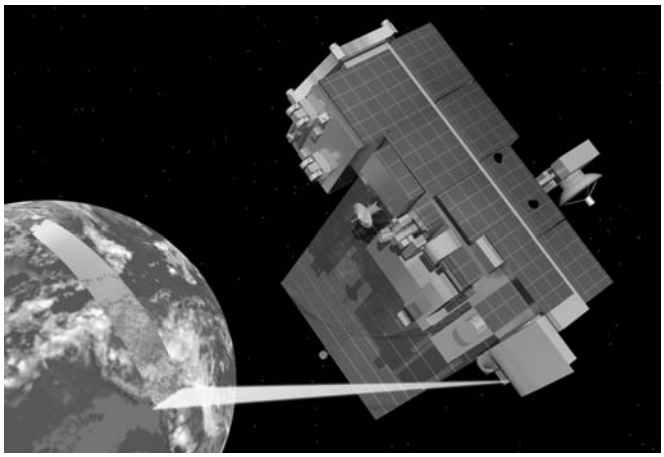
Images, maps and computer animations based on these weather satellite data appear every day in the news. Looking toward the future, Goddard researchers are working to extend these forecasts into useful seasonal and year-to-year predictions, down to the county level. Goddard is also working with NOAA and the Department of Defense to define and develop the next generation of weather satellites.

MISSIONS

The first weather satellite, TIROS, was launched by NASA in 1960. In many ways, the modern age of remote sensing began in 1972 with the launch of the first Landsat satellite (known then as the Earth Resources Technology Satellite.) Built under the leadership of Goddard, the Landsat series has provided a record of changes in land usage across the globe that are unprecedented in human history. Landsat-7 was launched in April 1999 and already has returned more than 90,000 essentially cloud-free images of the Earth, with even better quality than its predecessors.

NASA's Earth Observing System (EOS) aims to carry these focused measurements into a new era where they can be more easily combined to generate a better understand of Earth as a complete global system. EOS is managed by Goddard, with important contributions from the Jet Propulsion Laboratory, Langley Research Center, Marshall Space Flight Center, Wallops Flight Facility and Stennis Space Center, along with many partners in industry, universities and other international space agencies.

The first EOS mission, Terra, was launched in December 1999 with five advanced instruments to study land and ocean surfaces, sea surface temperature, cloud patterns, small particles in the atmosphere called aerosols, and the balance of solar energy absorbed and reflected by Earth. It is a joint mission with Japan and Canada.



Terra mission scans Earth

Aqua, the next EOS mission, is slated for launch in 2002 with a synergistic instrument payload designed to observe how moisture cycles between Earth's land, oceans, air and ice. Future EOS missions will study the complex chemistry of

the atmosphere (Aura) and the precise elevations of Earth's ice sheets, clouds and land (IceSat.)

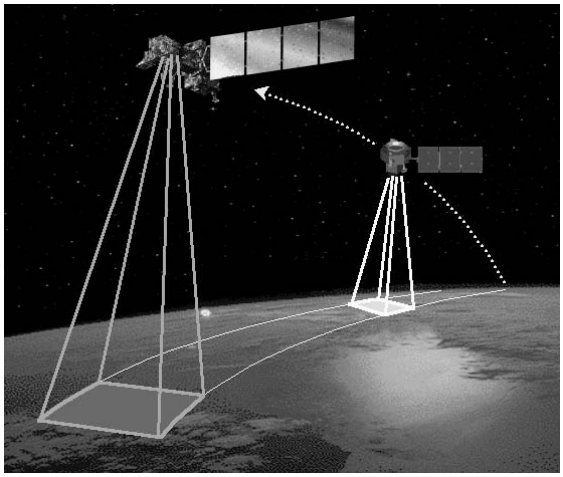
These EOS missions are complemented by smaller, cheaper missions proposed by the scientific community to address specific research questions. Known as Earth System Science Pathfinders, these missions are selected competitively, and then led from development through data distribution by the Principal Investigator who proposed it.

The first of these small missions to be selected is the Vegetation Canopy Lidar (VCL), led by Dr. Ralph Dubayah of the University of Maryland in College Park.

Its goal is to use eye-safe laser beams to produce the first highly accurate three-dimensional global inventory of tree heights, forest canopy structure and related biological material. The second Pathfinder mission, the Gravity Recovery and Climate Experiment (GRACE), will link two satellites precisely by laser beams to measure Earth's gravity field. A team led by Dr. Byron Tapley of the University of Texas in Austin will examine links between the gravity field and climate processes.

Goddard also helps develop cutting edge technology for future Earth science instruments and spacecraft, and then test flies it in space, via a NASA program called New Millennium. The first New Millennium mission, known as Earth Observing-1, launched in 2000. It carries an Advanced Land Imager designed to continue the measurements made by the Landsat series at a cost and size that is 4-5 times lower. Meanwhile, the Hyperion instrument on Earth Observing-1 will test so-called hyperspectral imaging techniques that can split up the signal returned from the surface into hundreds of separate informational bands, versus the ten observed by Landsat.

Earth Observing-1 flies in orbital formation with Landsat 7 and Terra so that their observations can be compared effectively, making them a physical emblem of the best in remote-sensing satellites of today, tomorrow and the decades to come.



Landsat 7 and Earth Observing-1 fly in formation

DATA DISTRIBUTION

None of this information would be useful if it was not received on Earth, processed and distributed electronically in an efficient way. The instruments from the Terra mission alone will produce 850 gigabytes of data per day, enough to fill 100,000 encyclopedia volumes.

This massive amount of information is handled using the Earth Observing System Data and Information System (EOSDIS), a computer network developed by Goddard and prime contractors Raytheon Systems Company and TRW. EOSDIS works in tandem with NASA's primary satellite network, the Goddard-operated Tracking and Data Relay Satellite System, and eight major remote sites called Distributed Active Archive Centers, each of which specializes in serving a particular scientific discipline.

EOSDIS has been handling existing data sets since 1994, and it began working with operational satellites following the launch of TRMM in November 1997. The system also manages data from Landsat 7 and it provides command and control functions for Terra. Scientific products from the Terra mission are being generated in partnership with the mission's principal investigators and their home institutions. This trend will grow with future EOS missions and competitive selections of creative data processing proposals from universities and commercial providers.

Accssible by the public as well as focused users, EOSDIS is based on an "open architecture" that can be updated as computer technology improves and research questions evolve over the next decades.

SUMMARY

In cooperation with other federal agencies, international space agencies, the education community and commercial businesses, Goddard and NASA's Earth Science Enterprise are dedicated to helping every citizen gain a better understanding of our planet and how it can best support future generations, in the 21st century and beyond.

For more information and fascinating images, visit these pages on the Internet:
Earth Observatory: http://www.earthobservatory.nasa.gov/
NASA Earth Science Enterprise: http://www.earth.nasa.gov/
Terra Mission Home Page: http://terra.nasa.gov/