NASA Facts

National Aeronautics and
Space Administration

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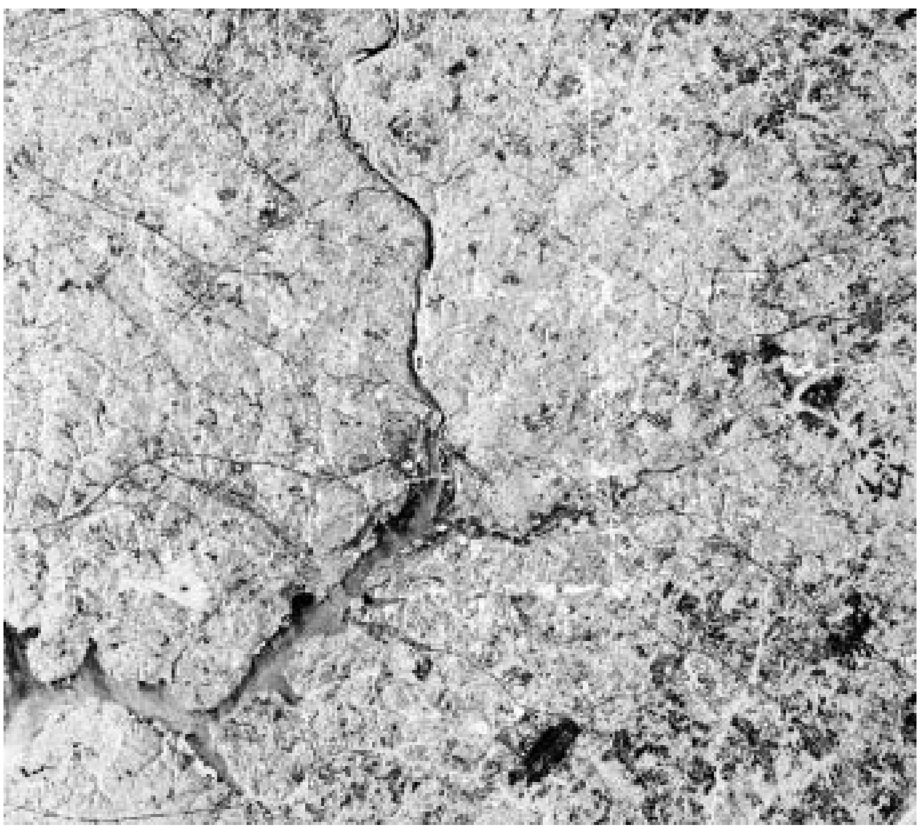
Imaging Radar

Scientists at NASA's Jet Propulsion Laboratory are using imaging radar as a tool for studying how the Earth's global environment is changing. Radar data provides information about how many of Earth's complex "systems" -- those processes that control the movement of land, water, carbon and heat -- work together to make this a livable planet. The science team is particularly interested in using radar to measure the amount of global vegetation coverage, the extent of snow packs, wetlands areas, geologic features such as rock types and their distribution, volcanic activity, ocean wave heights and wind speed.



Spaceborne Imaging Radar (SIR-C/X-SAR) view of Washington, DC

The unique feature of imaging radar is its ability to take images over virtually any region at any time, regardless of weather or sunlight conditions. Some radar waves can penetrate clouds, and under certain conditions, can also see through vegetation, ice and extremely dry sand. In many cases, radar is the only way scientists can explore inaccessible regions of Earth's surface.

Radar is an acronym for "radio detection and ranging." There are many different types of radar systems that can be used for scientific exploration. Imaging radar is also called synthetic aperture radar (SAR), which means the instrument transmits pulses of microwave energy toward Earth and measures the strength and time delay of the energy that is scattered back to the antenna.

The motion of a satellite, the space shuttle or an airplane is then used to "synthesize" an antenna (the aperture) that is much longer in length than the actual antenna hardware. A longer antenna produces images of finer resolution.

Conditions on Earth's surface influence how much radar energy is reflected back to the antenna.

An area with a variety of surface types, such as hills, trees and large rocks, generally reflects more energy back to the radar than a less complex area such as a desert. The resulting radar images of the varied terrains are brighter overall than the images of the simpler area.

Radar Observations from Space

The first JPL mission to study the Earth using imaging radar was Seasat, a satellite specifically designed to observe the ocean. It was launched June 28, 1978, onboard an Atlas-Agena from Vandenberg Air Force Base, California. On October 10, 1978, the satellite suffered a massive short circuit in its electrical system and stopped functioning. Despite its brief 100-day lifetime, the satellite collected more information about the ocean than the previous 100 years of shipboard research and proved that imaging radar was a viable technique for studying our planet.

After the Seasat experiment proved to be so successful, JPL and NASA decided to fly a radar instrument on the space shuttle. The Shuttle Imaging Radar A (SIR-A) was launched on November 12, 1981 on the second test flight of the shuttle Columbia. The objectives of the experiment were to acquire radar images of a variety of different geologic regions, to demonstrate the capability of the shuttle as a scientific platform, and to analyze and interpret the data in the radar images.

SIR-A was a complete success. The radar sensor operated as expected and met all of its design goals despite the fact that the mission was shortened from four days to two and a half days in orbit. SIR-A collected more than 10 million square kilometers of imagery. One of the most exciting aspects of the experiment was the demonstration of the radar's ability to penetrate extremely dry surfaces which resulted in the discovery of ancient river channels buried beneath the Sahara desert.

The Shuttle Imaging Radar B (SIR-B) experiment was launched on October 5, 1984, onboard the shuttle Challenger. SIR-B built upon the lessons learned by the Seasat and SIR-A missions and was the next step in JPL's program of using imaging radar for Earth observations. During its flight, a faulty antenna on the shuttle prevented much of the SIR-B data from being transmitted to the ground. However, 15 million square kilometers of ocean and land surface data were collected during a 16 hour period. SIR B improved upon the other radar missions because its antenna could be mechanically tilted. This allowed SIR B to obtain multiple radar images of a given target at different angles during successive shuttle orbits.

In 1992, radar images collected by SIR-B were used by archeologists to locate the lost city of Ubar in the country of Oman on the Saudi Arabian peninsula.

The World's Most Powerful Radar

The next step for JPL was to work with the German and Italian space agencies to build a more powerful radar system that could look at the Earth in different ways. The result of that cooperation was the Spaceborne Imaging Radar C/X band Synthetic Aperture Radar (SIR C/X SAR) which was launched aboard the space shuttle Endeavour in April and October 1994 as part of NASA's Space Radar Laboratory (SRL). SIR-C/X-SAR used three separate radar frequencies that allowed scientists to look at three different scales of features in the radar images.

SIR-C/X-SAR's goal was to study a variety of scientific disciplines -- geology, hydrology, ecology and oceanography -- by comparing the radar images to data collected by teams of people on the ground. The ground teams at several sites made simultaneous measurements of vegetation, soil moisture, sea state, snow and weather conditions during each flight. Data were also collected from aircraft and ships to ensure an accurate interpretation of the radar data taken from space. In addition, the astronauts recorded their personal observations of weather and environmental conditions in coordination with SIR C/X SAR operations. In total, both crews took more than 20,000 photographs of Earth at the hundreds of radar targets around the globe.

The radar images revealed the existence of hidden river channels in the Sahara indicating that the area has undergone significant climate change and has evolved from an area of flowing streams to what is now an arid desert. The spaceborne radar also proved to be an ideal tool for volcano research because it provides a safe vantage point from which to look at hazardous and often inaccessible areas. Several of the volcanoes viewed by SIR-C/X-SAR included: Mt. Pinatubo in the Philippines, Mt. Nyiragongo in Zaire, Mt. Rainier in Washington state, the volcanoes on the Kamchatka peninsula, including Mt. Kluichevskoi, and a previously unknown volcano in Colombia that was discovered in imagery of the Andes volcanic arc.

SIR-C/X-SAR images are being used by archeologists to study the ancient city of Angkor in the Cambodian jungle and the remnants of the famed Silk Route in northwest China. Other scientists working with the Dian Fossey Gorilla Fund have used the radar data to create vegetation maps of the habitat of the endangered mountain gorilla.

In addition to recording dramatic environmental differences between the April and

October flights, SIR-C/X-SAR science team members experimented with the new technique of " radar interferometry" to produce three-dimensional images of the Earth's surface. In October, the radars were flown twice over nearly identical orbit passes to generate two long swaths of interferometric data at dozens of sites around the world. Digital elevation computer models were generated at all three radar frequencies to produce the 3-D effect. These data are now being used in NASA's Natural Hazards Program. The 3-D images allow scientists to study landscapes that are subject to flooding and other areas impacted by earthquake faults. The development of these technologies will lead to improved hazard evaluation and monitoring, and will ultimately improve public safety.

Radar Studies from Aircraft

The Airborne Synthetic Aperture Radar (AIRSAR) is an instrument mounted on a DC-8 aircraft. It is a prototype of the shuttle-based SIR-C instrument. AIRSAR grew out of JPL's airborne synthetic aperture radar program which began in the early 1970s when an a radar instrument that originally flew on an Aerobee rocket was refurbished for flights on the Ames Research Center Convair 990 Airborne Laboratory. This early radar was a pathfinder for the Apollo Lunar Sounder, Seasat, the imaging radar on the Magellan mission to Venus and the Shuttle Imaging Radars.

AIRSAR serves both as a research tool for the development of new radar remote sensing techniques, and as a facility instrument for gathering radar data in support of scientific research programs conducted by principal investigators selected by NASA.

The Topographic Synthetic Aperture Radar (TOPSAR) is an aircraft radar interferometer that uses radar and interferometry to rapidly produce topographic maps of the Earth. TOPSAR operates as an adjunct to the AIRSAR instrument onboard the same NASA DC-8 aircraft. It uses two antennas mounted nearly vertically on the left side of the aircraft and like the shuttle-based interferometric images, TOPSAR produces three-dimensional views of the Earth's surface. TOPSAR is a precursor to a possible satellite system that could produce a global digital topographic map.

AIRSAR, TOPSAR and SIR-C data were used to map the Lisbon Bottoms and Jameson Island flood plains of the Missouri River in central Missouri. The flood plain was ravaged by the "Great Flood of 1993" and then again by the flood of 1995. The radar data revealed that the floods added at least five million metric tons of sand to the study area, and eroded about three million metric tons of soil. Scientists are using these radar images to help them understand the potential for future flooding in this region and how that might impact surrounding communities.

Future Missions

The tremendous success of the second flight of SIR-C/X-SAR in acquiring repeat pass interferometry data and generating elevation maps from these data have lead to plans for a third flight of the instrument. The National Imagery and Mapping Agency (NIMA) is providing funds to modify SIR-C by adding a 60-meter (197-foot) boom and an outboard antenna, operate the mission and process the data, while NASA will provide most all of the additional resources needed. This 11-day mission has been named the Shuttle Radar Topography Mapper (SRTM) and it would produce elevation maps of 80 percent of the Earth's land surface. The flight is currently on the shuttle manifest for May 2000, but restructuring of the shuttle's schedule may allow SRTM to fly sooner, perhaps as early as spring 1999.

Four industry teams have been selected to study potential partnering arrangements to implement LightSAR, a proposed new Earth-imaging satellite system that would use advanced technologies to reduce the cost and enhance the quality of radar-based information for scientific research, commercial remote-sensing and emergency management applications. A launch is planned for 2000.

LightSAR`s synthetic aperture radar measurements would provide high-resolution images on a nearly continuous basis, giving the project considerable capability to map changes in land cover, generate topographic maps and provide long-term mapping of natural hazards such as earthquakes, floods and volcanoes.

Potential commercial applications of LightSAR data include mapping and cartography, crop monitoring and health assessment, forestry management, resource exploration and environmental monitoring, including oil spills and coastal zone monitoring.

A geographic synthetic aperture radar called, GeoSAR, is being developed by a consortium made up of the California Department of Conservation, Calgis Inc. and JPL with funding provided by the Defense Advanced Research Projects Agency (DARPA). The project will develop a dual-frequency airborne radar system that will record 82 square miles (this needs to be in kilometers)of data every minute. GeoSAR is expected to fly in 1998. Maps created with the GeoSAR data will be used for seismic hazard mapping, mineral land classification, locating abandoned mines and farmland preservation.

During the first year, JPL will build the radar system and develop the data processing software that will be used to convert the radar data into digital elevation models, (DEMs). Calgis Inc., a geographic information systems company based in Fresno, California, will construct a geographic information systems (GIS) workstation that will convert the JPL radar images into user maps. The California Department of Conservation will design and lead the user validation experiments during the last year of the three year project. GeoSAR will initially map areas in California and the project will branch out into other states as users request data.

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