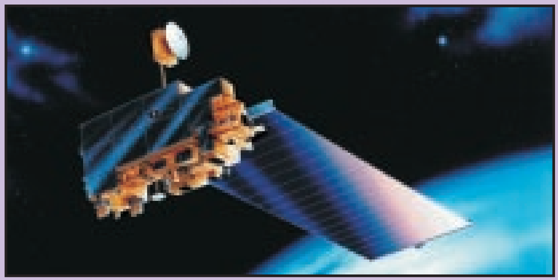
ASTER

ADVANCED SPACEBORNE THERMAL EMISSION AND REFLECTION RADIOMETER

Front Cover image: Simulated ASTER images of Death Valley, California. The visible image (left) shows vegetation in red, salt deposits in white, blue and gray, and rocks in dark green. The shortwave infrared image (center) shows salt deposits in white and dark blue, rocks in brown and green, vegetation in dark green. The thermal infrared image (right) shows quartz-rich rocks in red, salt deposits in greens, and other rocks in purple. These data were acquired by the airborne Advanced Visible and Infrared Imaging Spectrometer and the Thermal Infrared Multispectral Scanner instruments.

EOS AM-1 Spacecraft.



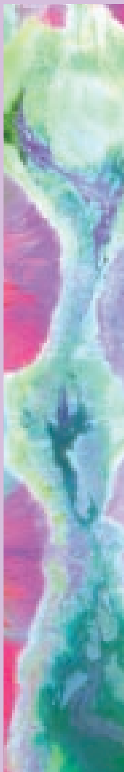
Viewing the Earth

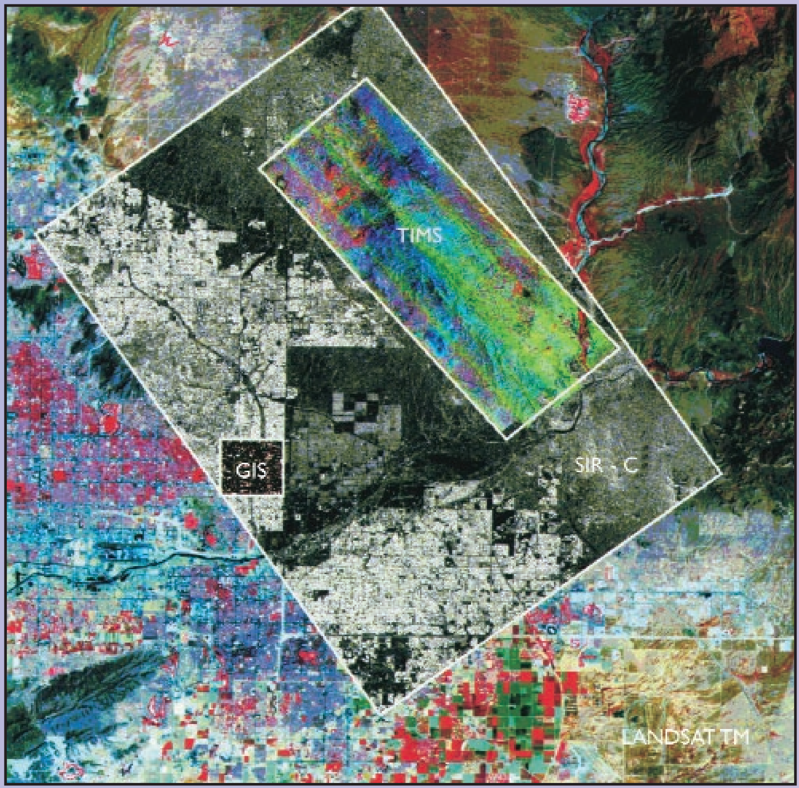
NASA's Earth Science Enterprise (ESE) captures our spirit of exploration and focuses it back on the Earth. Its goal is to advance scientific understanding of the entire Earth system by developing a deeper understanding of the components of that system and the interaction among them. NASA and its interagency and international partners are striving to discover patterns that will allow us to predict environmental events such as droughts and floods well in advance of their occurrence. Nations, regions, and individuals can then use this knowledge to prepare for these events, likely saving countless lives and resources. We will improve our ability to monitor and evaluate changes in land use and land cover; to monitor our impacts on marginal environments such as wetlands, lakes, and estuaries; to better understand Earth processes that lead to natural disasters; and to observe short-term climate variability and improve both short-term and seasonal weather predictions. By using the unique vantage point of space, we can expand our knowledge of the Earth system and help mankind solve global problems.

NASA's Earth Observing System

Satellite sensors provide the only method to collect global data on a regular basis. The perspective from space is critical. Only from above can we observe and monitor places where it is impossible (or very difficult) to make on-site observations—such as distant parts of the world's oceans, deserts, and polar regions. NASA's Earth Science Enterprise is working with interagency and international partners to design, build, and launch advanced instruments to observe phenomena related to global change. ESE is comprised of four parts: 1) a series of satellites called the Earth Observing System (EOS); 2) a series of smaller satellites called Earth System Science Pathfinders; 3) a scientific research program; and 4) an EOS Data and Information System (EOSDIS) that will provide a mechanism for storing and processing the data, and distributing them to the research community.

The first EOS satellite is scheduled for launch in 1998. Dubbed EOS AM-1, the satellite will fly in a sun-synchronous polar orbit, crossing the equator in the morning. It will be followed by a series of satellites that will be launched by NASA and its interagency and international partners through the year 2012. The objective is to gather a *continuous* stream of data for at least 15 years. Although NASA has gathered data for many years, this is NASA's first attempt to gather a continuous and well calibrated data set with no gaps. This will enable research scientists to gain a better understanding of how our Earth works as a system, and determine the effects of natural and human-induced changes on the Earth's environment.





URBAN CHANGE: Scottsdale, Arizona seen with different instruments. The Landsat Thematic Mapper (TM) component depicts vegetation in red, and streets and buildings in gray. The Shuttle Imaging Radar-C (SIR-C) radar image reveals bright reflectances from buildings. The Thermal Infrared Multispectral Scanner (TIMS) thermal data show different soil and rock types in blues and red. The Geographic Information System (GIS) data are map data. Combined, these data allow monitoring change in the urban environment.

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on EOS AM-1

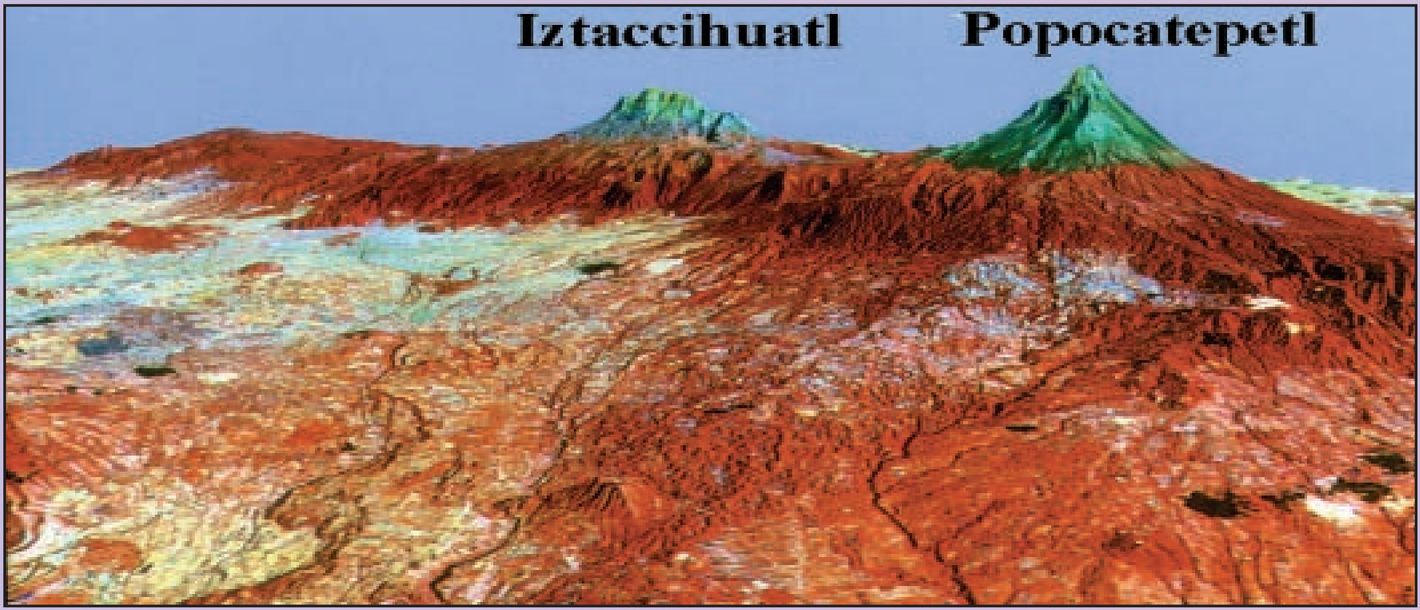
The only instrument to fly on the EOS AM-1 platform that will acquire high-resolution images is ASTER. The primary goal of the ASTER mission is to obtain high-resolution image data in 14 channels over targeted areas of the Earth's surface, as well as black-and-white stereo images. With a revisit time between 4 and 16 days, ASTER will provide the capability for repeat coverage of changing areas on the Earth's surface.

ASTER data will be used by Earth scientists to address a wide range of global-change topics. In addition, ASTER data, with spatial resolutions of between 15 and 90 m, will provide information to complement data from other, moderate-resolution (250 - 1000 m) EOS instruments, such as MODIS and MISR.

Land Use and Land Cover

The basic information used by almost every Earth science discipline is the composition and distribution of materials on the Earth's surface. In addition, the changing nature of the surface is critical to understanding the impact that humans and nature have on the habitability of the surface on which we live. Processes that directly affect our daily lives include desertification, whereby arable agricultural and pasture land changes to unusable, soil-depleted land; conversion of farmland to residential developments; unrestricted growth of cities with accompanying pressures on water, air, and food resources; and uncontrolled use of natural resources such as forests and mineral deposits.

The first step in properly managing our natural resources is inventorying what currently exists to provide a baseline for rational development decisions. Satellite instruments that acquire high spatial resolution image data are the ideal tools to efficiently create this inventory map. ASTER, with its 14 channels of image data, was designed as a mapping instrument to meet this need. One of the primary goals of the ASTER mission is to acquire a one-time cloud-free



MEXICAN VOLCANOES: The combination of Landsat Thematic Mapper satellite image data and digital topographic data was used to produce this simulated perspective view of Popocatepetl and Iztaccihuatl volcanoes near Mexico City. Vegetation is shown in red, and bare rocks appear green. Analyses of these types of images improve the mapping of volcanic eruption hazards where 30 million people are at risk should Popocatepetl erupt again.

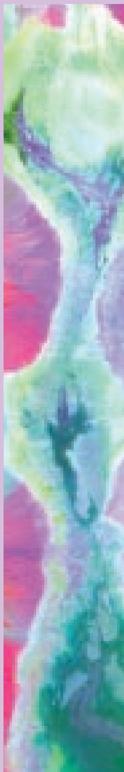
image of the entire land surface of the Earth. Numerous regions will be targeted for repeat coverage to monitor temporal changes. In the Amazon Basin, for example, data will be obtained to monitor the progress of deforestation of the tropical rain forest. Along the U.S.-Mexico border, ASTER data will be used to study agricultural and urban development of this rapidly growing area. Derived maps of surface composition will be used by geologists to evaluate the potential for finding new mineral and petroleum deposits in poorly explored regions.

Natural Disasters

It seems that every day we are confronted with news of another natural disaster: volcanic eruptions, floods, forest fires, earthquakes, and windstorms. Space-based observations can make important contributions in two ways to ease the impact of these events: 1) in improving prediction capabilities, and 2) in monitoring once an event has occurred.

In any given year, about 100 volcanoes erupt worldwide. Since 10% of the global population lives within areas potentially affected by volcanoes, ASTER is devoting resources to monitoring gas emissions and thermal changes of hundreds of volcanoes to better develop eruption prediction capabilities. In addition, in the event of an eruption, the high spatial resolution of ASTER will allow detailed observations of ongoing activity to aid in logistical relief planning.

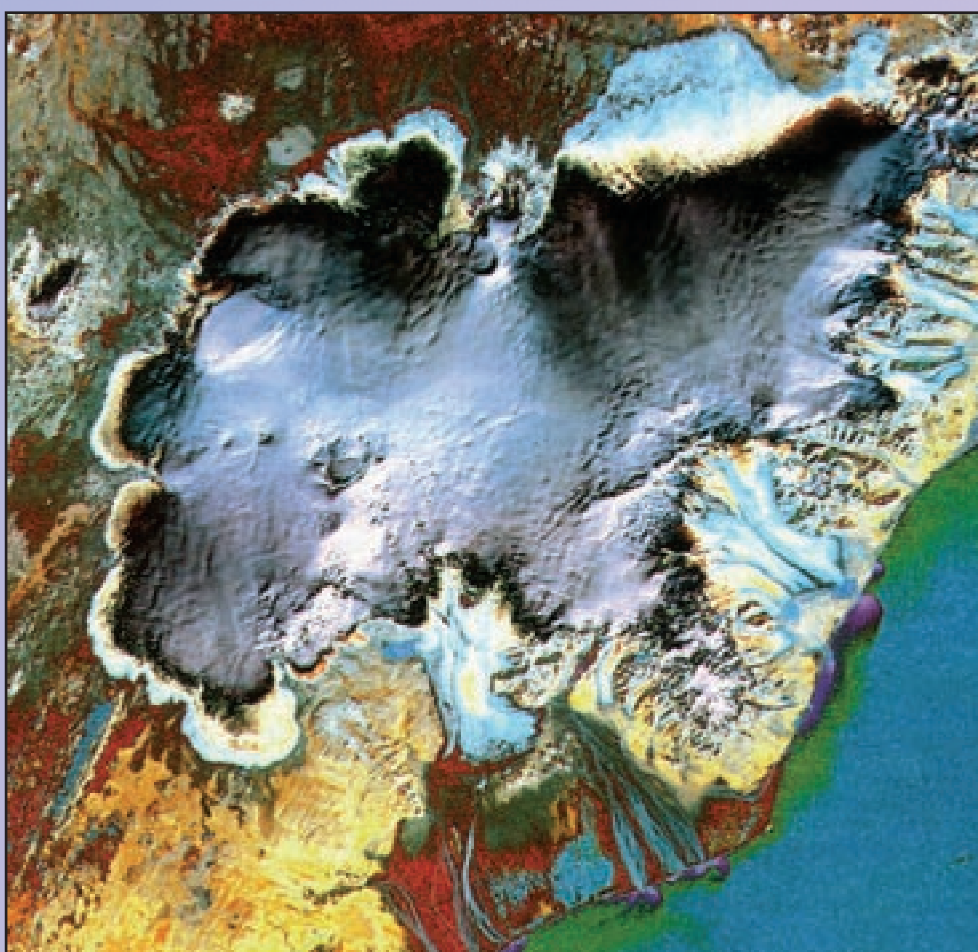
Similarly, in the event of major flooding, such as the 1993 and 1997 upper Mississippi Basin floods, ASTER data will contribute to assessing the impact of flood waters and aid in mapping damaged areas. The high spatial resolution and ASTER's detailed topographic maps will assist in defining potential flood zones; planners can then use this information to better plan relief efforts.



Short-Term Climate Variability

Seasonal-to-interannual climate system variability has great economic and social impact: recent droughts in the southeast U.S. and floods in the midwest are but two examples. The ability to accurately monitor changes and, especially, to improve forecasting will be of great value.

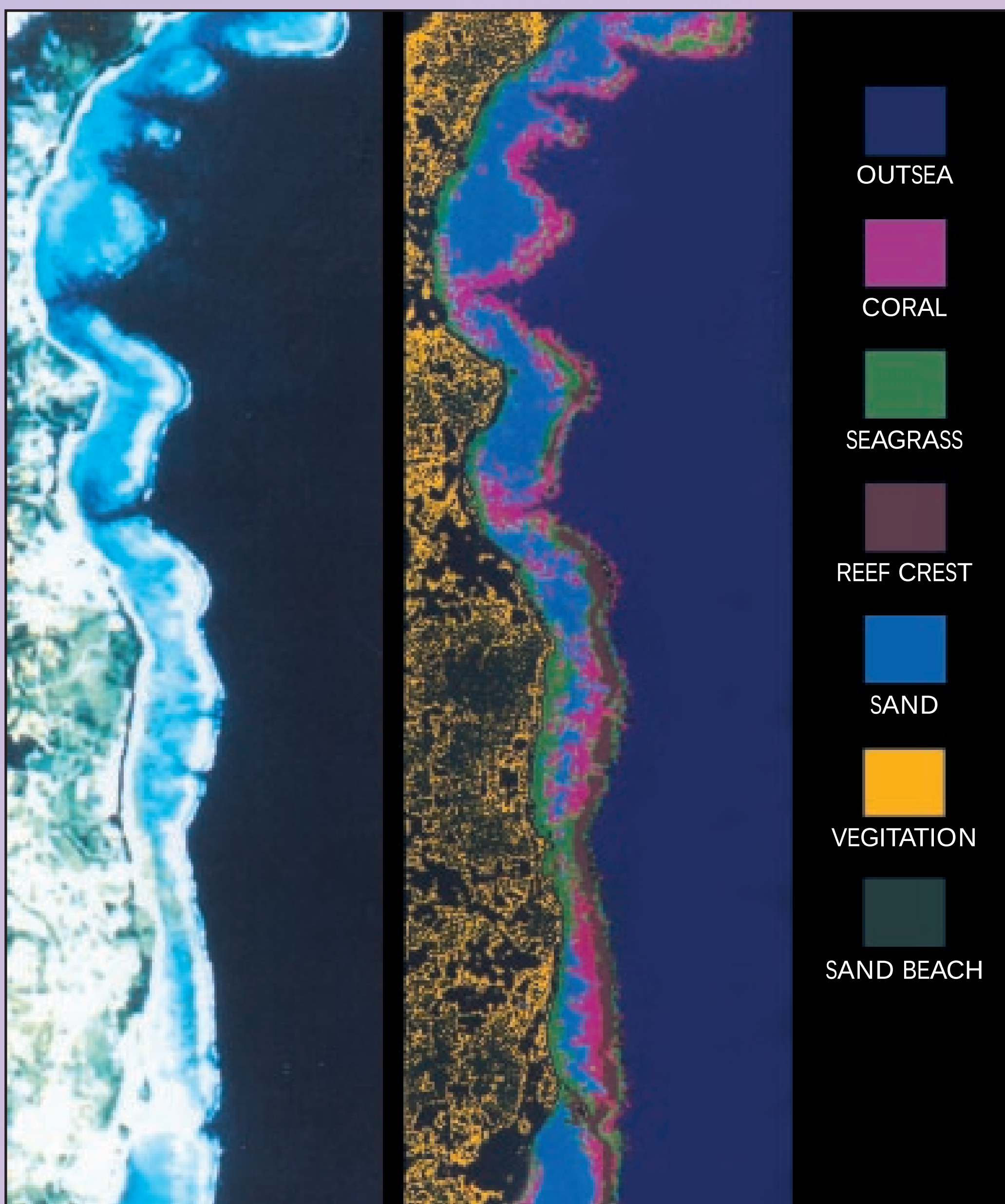
Space-based observations of key parameters such as water vapor and precipitation, cloud properties, sea surface temperature, sea ice, soil moisture, land vegetation, and radiation fluxes must be obtained to ultimately improve our ability to predict climate variations. ASTER data, for example, will provide scientists with the ability to determine the rates of advancement or recession of glaciers. Glaciers are sensitive indicators of precipitation and temperature changes that could well signal global climatic events. Yearly observations will provide a database to measure displacements of the glaciers' fronts and to search for regional correlations that could indicate a climatically induced pattern.



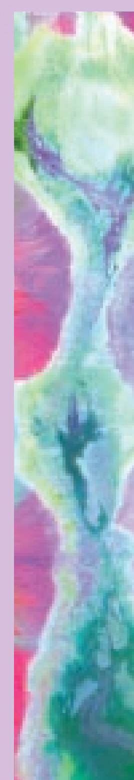
ICELAND ICECAP: The Vatnajokull Icecap, Iceland and its glaciers are clearly shown in this Landsat Thematic Mapper image. Monitoring of glacial movement contributes to understanding climate change, as glaciers are sensitive indicators of seasonal temperature variations. In this image, the ocean is blue, the icecap is gray, vegetation is red, and bare rocks are yellow. Note the green-colored sediment plumes coming off of the glaciers.

Hydrology

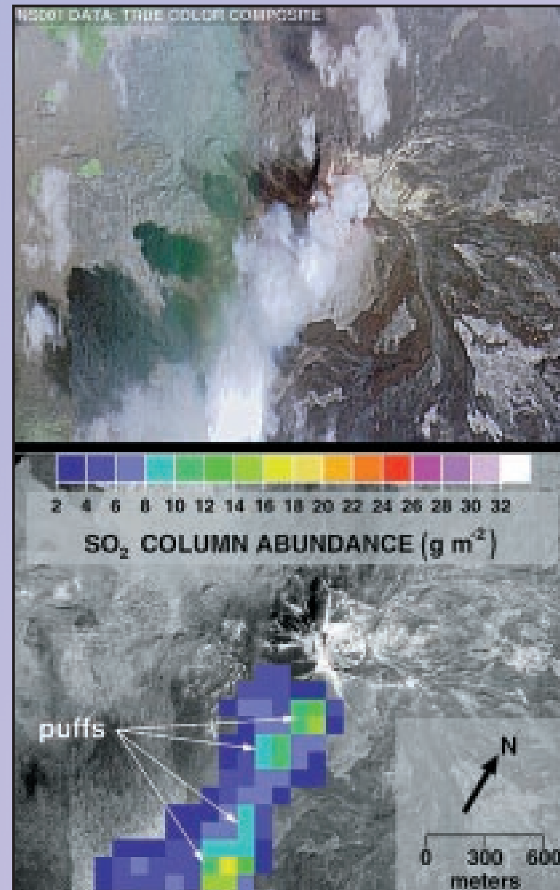
Hydrology is the study of the Earth's water system, including the oceans, lakes, rivers, and the interaction between the oceans and atmosphere. Because the oceans cover about 70 percent of the Earth's surface, they make a significant contribution to weather and climate. Lakes and rivers are an integral part of our urban environment, providing transportation, drinking water, food, and recreation. Human impact on these systems is profound, and remote sensing can provide a means to monitor and assess this impact.



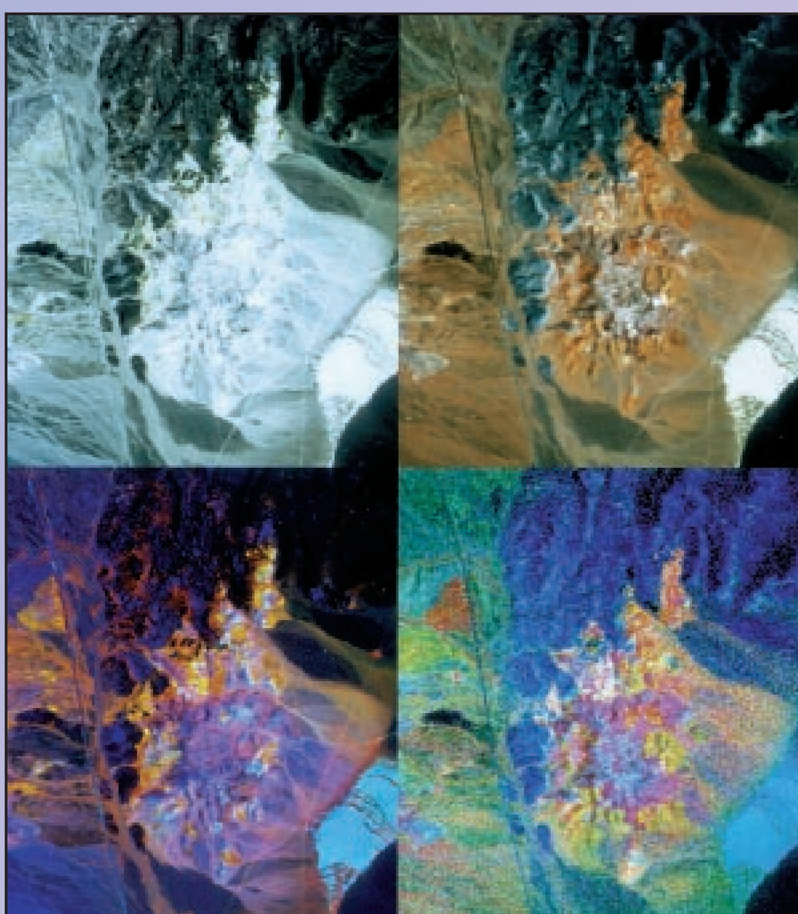
CORAL REEFS: Coral reefs are sensitive indicators of environmental quality and sea level fluctuations. Human and natural impacts can be assessed through careful monitoring. The Landsat Thematic Mapper image (left) has been classified to map the different types of materials present (right) such as the coral reef, sand beaches, etc.



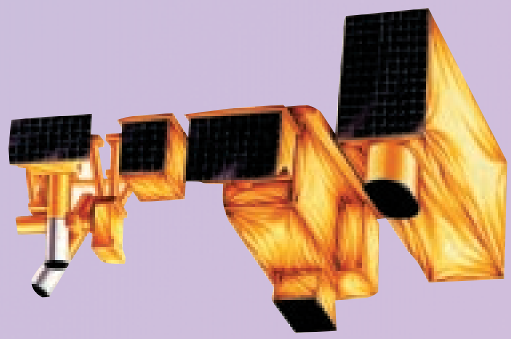
High-resolution data, such as those acquired by ASTER, are ideal for studying and monitoring the transitional environments between water and land, such as wetlands, beaches, estuaries, and rivers. Pollution entering our bodies of water can be observed and measured from space, providing a means to plan effective remediation programs. Commercial fisheries can benefit from space data to help in finding fish, evaluating habitats, and improving regulations controlling over-fishing.



VOLCANIC PLUMES: The visible image of the Puu Oo, Hawaii plume (top), acquired by an airborne Thematic Mapper Simulator instrument, shows mostly water vapor clouds in white, and their shadows, over a field of lava flows. The thermal image (bottom), acquired by the airborne Thermal Infrared Multispectral Scanner at the same time, shows SO_2 gas coming from the volcano, and is not affected by the water clouds. Sulfur concentrations are color coded from blue (low) to yellow and red (high). Changes in SO_2 can be precursors of eruptions.



SURFACE MAPPING with images created from visible data (left) and infrared data (right) allows geologists to efficiently explore for mineral and petroleum resources. ASTER's improved mineral detection capability will be of great value for resource exploration. The upper two images are unenhanced presentations of the data; the lower two have been computer enhanced to increase the vividness of the colors. In the top pair, a dry lake bed and bright silicified rocks are in white, rocks are in gray and brown. The colors in the bottom pair show different rock type in various, more easily mapped colors. These simulated ASTER data were acquired by the airborne Advanced Visible and Infrared Imaging Spectrometer.



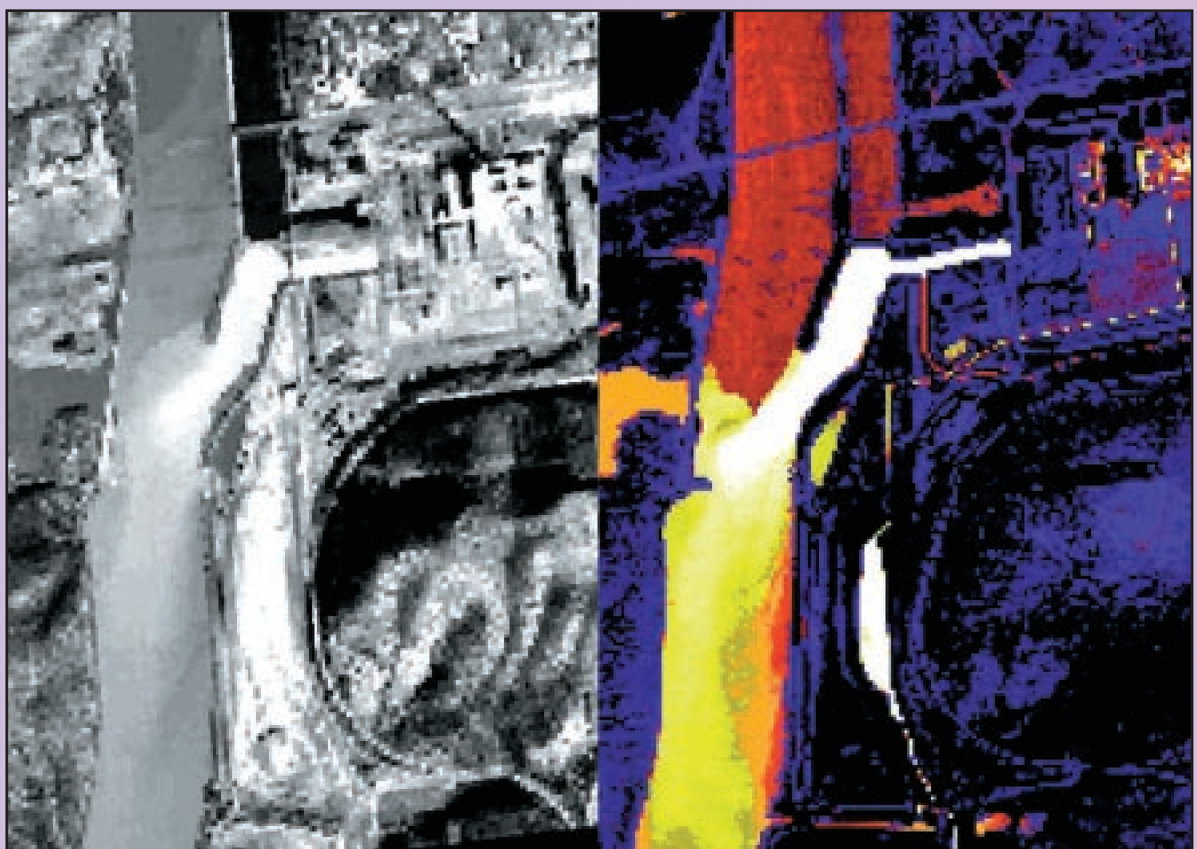
The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) will gather data at spatial resolutions between 15 and 90 m, and will revisit any place on Earth at least every 16 days.

ASTER Science Team

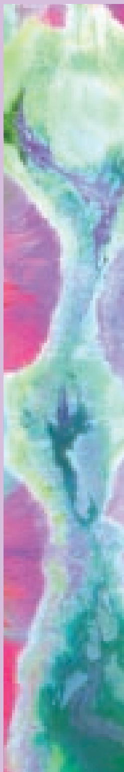
The Science Team is an international collaboration of scientists, primarily from the United States and Japan. One of their primary responsibilities is to develop the algorithms by which raw ASTER data are converted to usable measurements to conduct the science discussed previously. Other responsibilities include calibration of the sensors, monitoring the performance of the sensors, and performing focused research projects.

ASTER Instrument

ASTER will provide data in scenes nominally 60 × 60 km. It will be capable of revisiting any place on the Earth at least every 16 days. Data are acquired in 14 spectral bands from the visible through the thermal infrared part of the electromagnetic spectrum. In addition, nadir- and aft-looking telescopes in the visible will provide stereo images used to produce digital elevation topography models. Because of a limited duty cycle (about 750 scenes per day), ASTER will

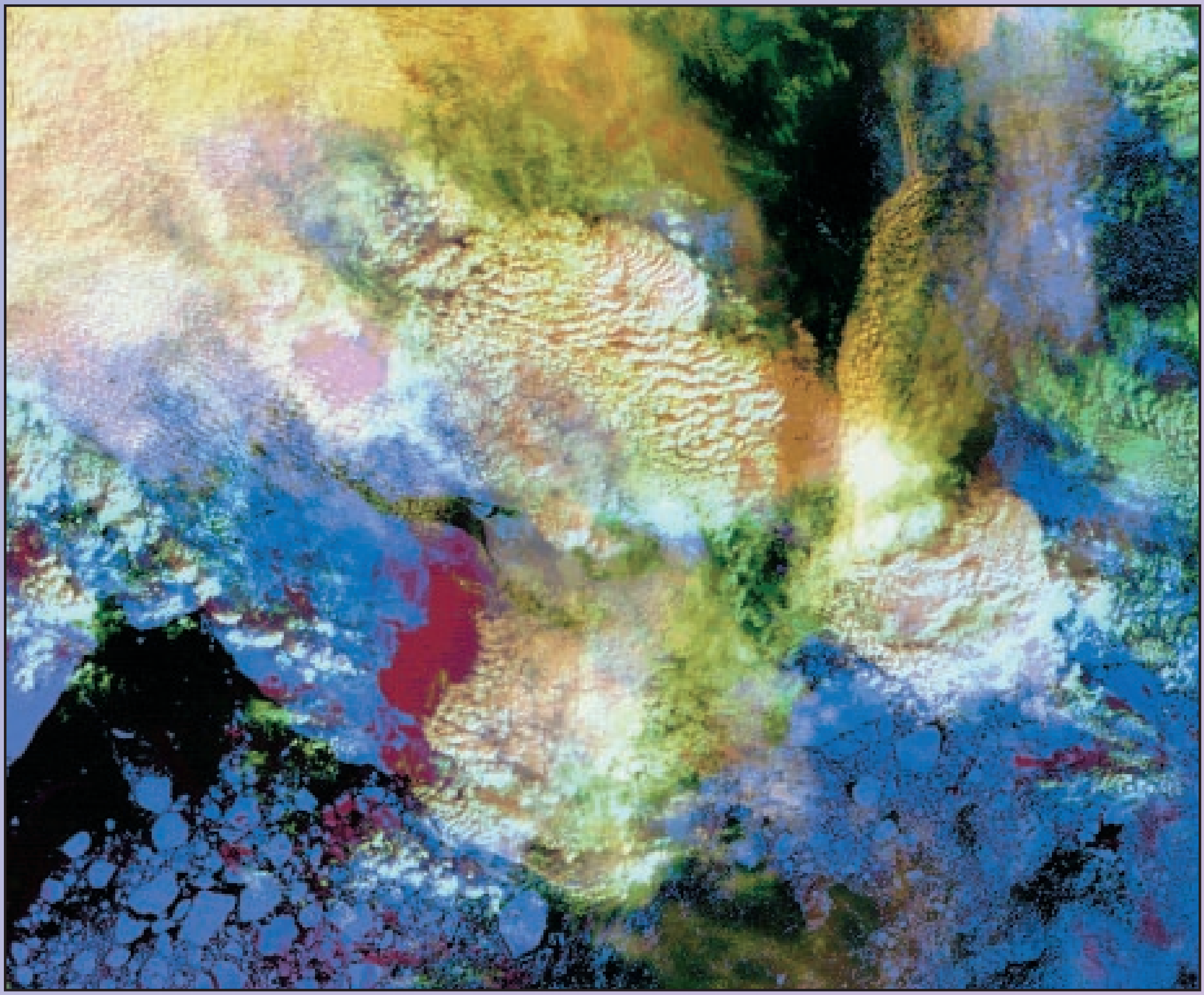


THERMAL PLUMES in the river next to a nuclear power plant are highlighted in the thermal infrared wavelength region. By color-coding the black-and-white temperature image (left), heat patterns are easier to distinguish. The right-hand image shows highest temperatures in white, and progressively cooler temperatures in yellow, orange, red, purple, and blue. These data were acquired by an airborne Thematic Mapper Simulator instrument.



be scheduled to selectively obtain images based on requests from researchers; to monitor areas selected by the Science Team for continual coverage due to potential surface changes; and to obtain one-time coverage of the entire land surface.

ASTER data, along with data from the other EOS instruments, will be available to the scientific community worldwide through EOSDIS. NASA encourages the interdisciplinary use of these data to solve global change problems.



CLOUDS AND SEA ICE in Antarctica are separated using data from different spectral regions including the visible and the thermal infrared. Ice is shown in blue, open ocean is black, clouds are white and yellow, and cloud shadows are dark red. ASTER data will provide the same information as depicted in this composite Landsat Thematic Mapper image.

Orbit:	705 km, 10:30 am descending node, sun-synchronous, near polar
Swath:	60 km (across track), by 60 km along track (nominal scene)
Size:	VNIR=58×65×83 cm; SWIR=72×134×90 cm; TIR=73×183×110 cm
Weight:	421 kg
Power:	463 W (average)
Data Rate:	89 Mbps (instantaneous)
Quantization:	8 bit (VNIR and SWIR), 12 bits (TIR)

Subsystem	*Band No.*	*Spectral Range (µm)*	*Radiometric Uncertainty*	*Spatial Resolution*
VNIR	1	0.52-0.60	<0.5%	15 m
(visible to	2	0.63-0.69	<0.5%	
near infrared)	3	0.76-0.86	<0.5%	
SWIR	4	1.60-1.70	<0.5%	30 m
(shortwave	5	2.145-2.185	<1.3%	
infrared)	6	2.185-2.225	<1.3%	
	7	2.235-2.285	<1.3%	
	8	2.295-2.365	<1.0%	
	9	2.36-2.43	<1.3%	
TIR	10	8.125-8.475	<0.3K	90 m
(thermal	11	8.475-8.825	<0.3K	
infrared)	12	8.925-9.275	<0.3K	
	13	10.25-10.95	<0.3K	
	14	10.95-11.65	<0.3K	

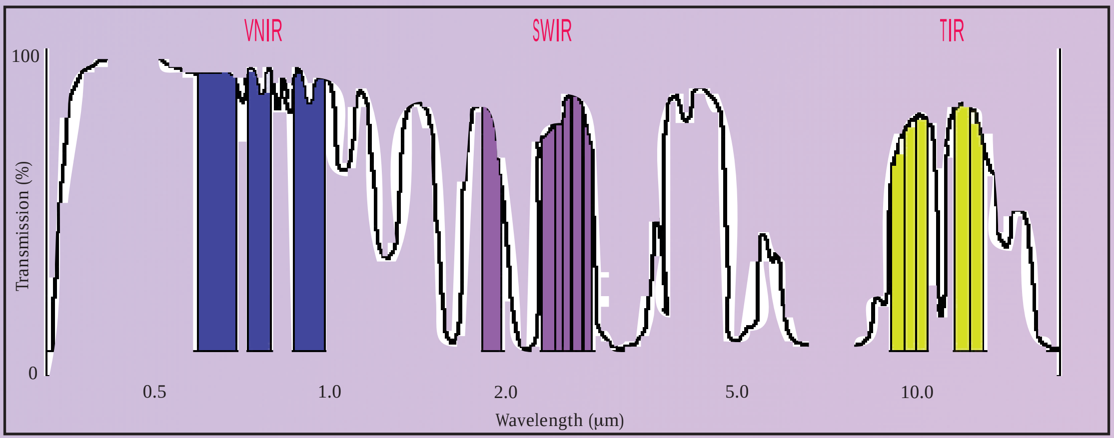
Stereo Base/Height ratio	0.6
Pointing capability in cross-track direction	+/- 136 km

ASTER Standard Data Products

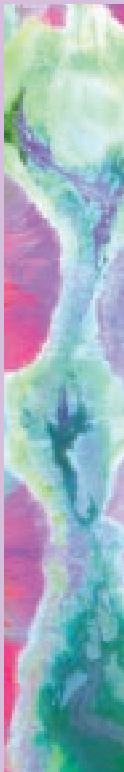
Below are the standard ASTER data products that will be available at launch of the EOS AM-1 spacecraft. Other, special products will be produced after launch by ASTER Science Team members.

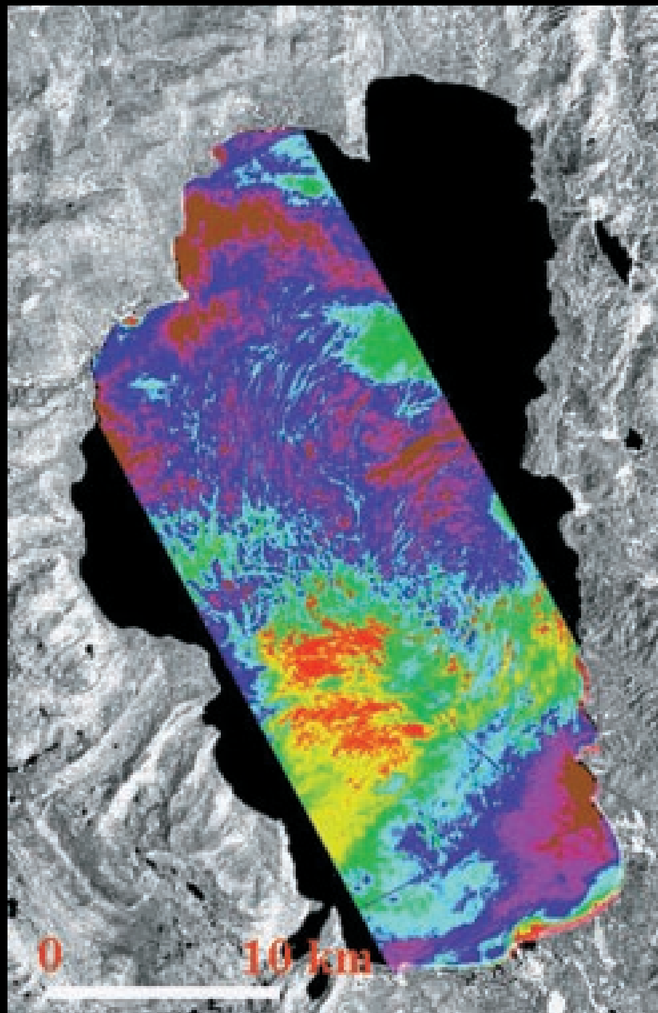
- *Brightness temperature at sensor, available both day and night*
- *Relative spectral reflectance, separate products for the VNIR and SWIR telescopes*
- *Relative spectral emissivity*
- *Surface radiance, corrected for atmospheric effects*
- *Surface reflectance, corrected for atmospheric effects*
- *Surface temperature, day and night, corrected for atmospheric effects and topography, with absolute accuracy goals of 1K*
- *Surface emissivity, corrected for atmospheric effects, with temperature effects eliminated*
- *Digital elevation model, with 10-50 m accuracy in x-y-z dimensions*

The ASTER instrument is provided by the Japanese Ministry of International Trade and Industry. The ASTER Science Team is jointly led by Dr. Hiroji Tsu, ERSDAC, and Dr. Anne B. Kahle, Jet Propulsion Laboratory. For further information contact Anne Kahle at Anne.B.Kahle@jpl.nasa.gov or Hiroji Tsu at tsu@gsj.go.jp or access the ASTER Homepage at http://asterweb.jpl.nasa.gov.

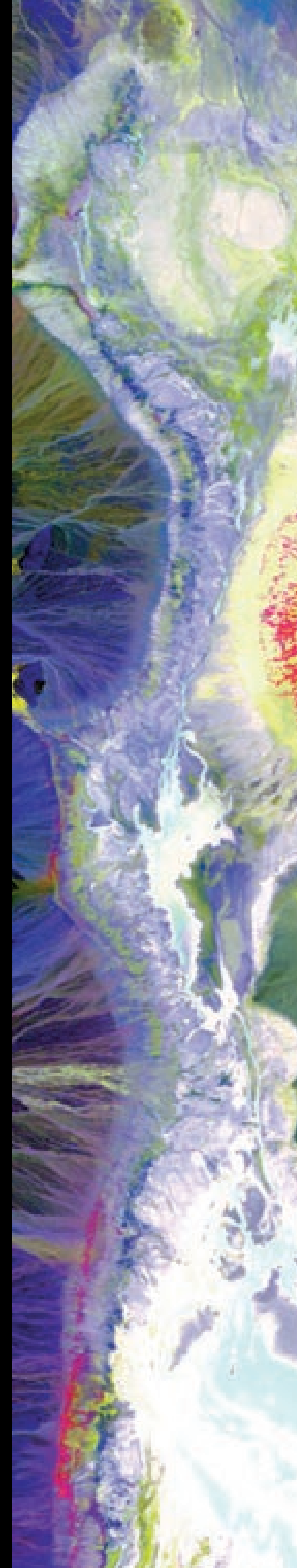


Relative atmospheric transmission as a function of wavelength, showing location of ASTER bands.





Simulated ASTER thermal infrared image of Lake Tahoe, California. Water temperatures are color coded from blue to purple (cooler) to yellow (warmer). Variations in temperature reveal current patterns in the lake, dominantly produced by winds. Linear features (2 purple lines at the top and 3 blue and purple lines at the bottom of this figure) are boat tracks where cooler water is brought to the surface by propellers.



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