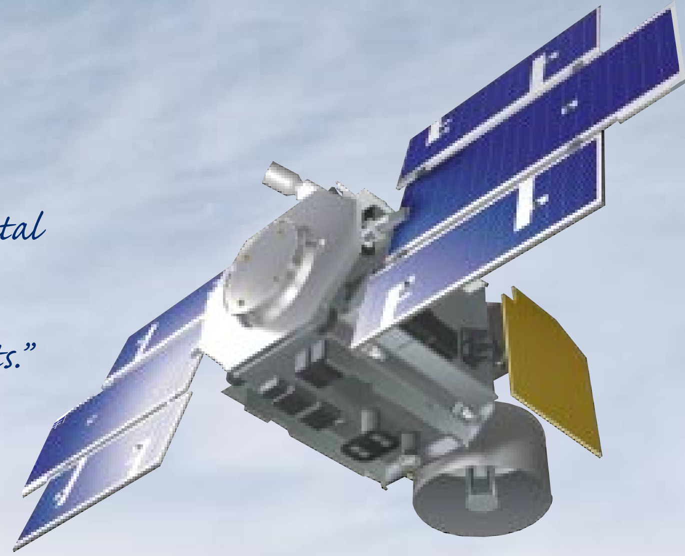
ICESat

ICE, CLOUD & LAND ELEVATION SATELLITE

An element of NASA's Earth Science Enterprise

"Possible changes in the mass balance of the Greenland and Antarctic ice sheets are fundamental gaps in our understanding and are crucial to the quantification and refinement of sea-level forecasts."

—National Academy of Sciences (1990)

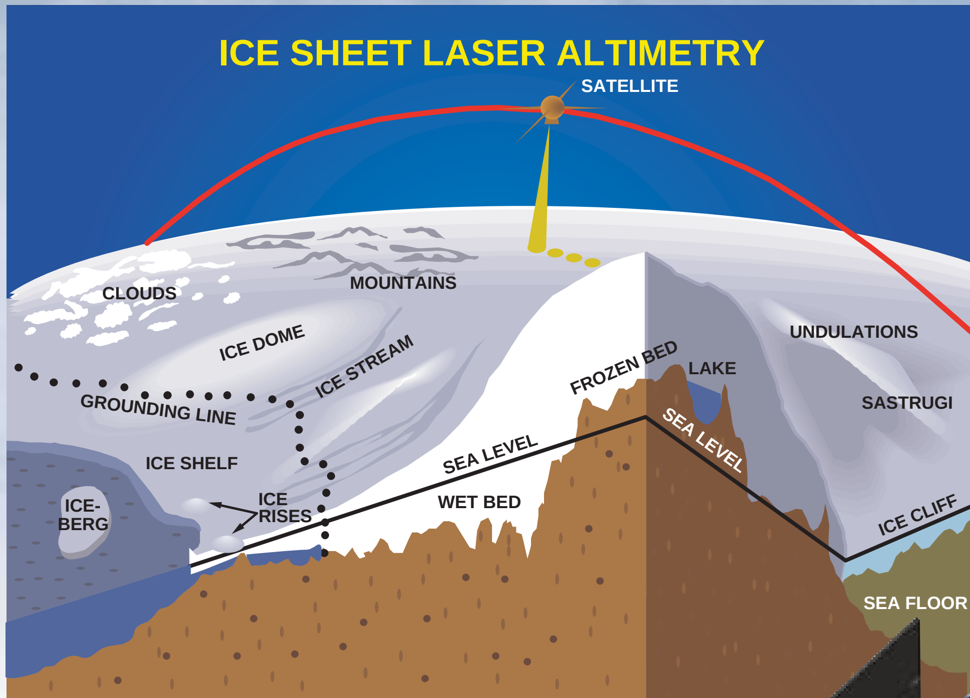


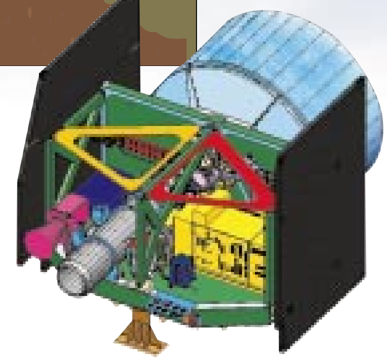
ICE, CLOUD & LAND ELEVATION SATELLITE (ICESat)

Are the ice sheets that blanket the Earth's poles growing or shrinking? Will global sea level rise or fall?

As an important part of its Earth Observing System (EOS), NASA has developed the ICESat mission to better understand how the Earth's atmosphere, ocean, land, ice, and biosphere interact with each other. The goal is to answer questions concerning many related aspects of the Earth's climate system, from global warming to ice sheet growth and retreat, to changes in sea level.

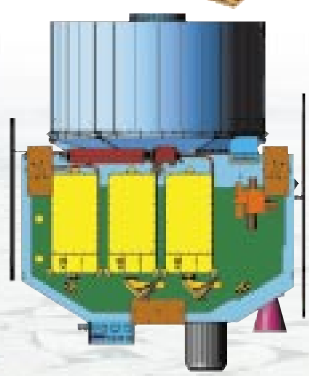
The ICESat mission, scheduled for launch in July 2001, will carry the Geoscience Laser Altimeter System (GLAS) onboard to measure ice sheet elevation, the height of clouds, and land topography for a variety of scientific and practical applications, including climate prediction models. Future ICESat missions will improve the assessments from the first mission and monitor ongoing changes that global warming might cause. Together with its sister EOS satellites, ICESat will enable scientists to study the Earth's climate and, ultimately, predict how ice sheets and sea level will respond to future climate change.





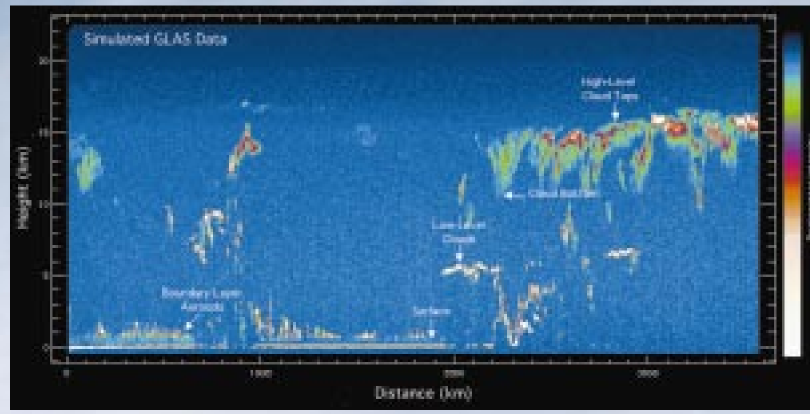
WHAT IS THE GEOSCIENCE LASER ALTIMETER SYSTEM?

The GLAS instrument on ICESat uses a laser system that accurately measures the distance that the spacecraft is from the Earth and clouds, and a star-tracker attitude-determination system that precisely determines where on the Earth's surface the laser is being pointed. The laser transmits short pulses of infrared and visible light. Photons are reflected back to the spacecraft from the surface of the Earth and from the atmosphere, including the inside of clouds, and collected in a 1 m diameter telescope. Laser pulses at 40 times per second illuminate areas, called "footprints," that are 70 m in diameter and are spaced at about 170 m intervals along the Earth's surface.



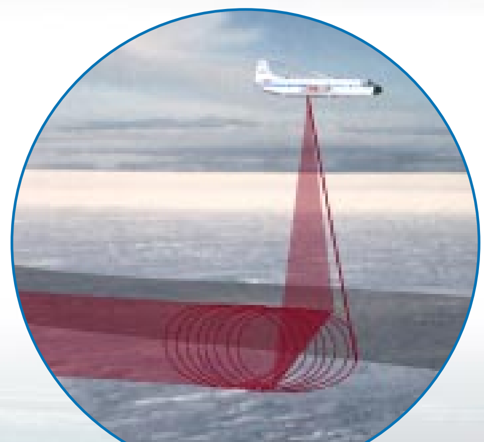
ICESat will scan over the entire Earth every 183 days. The tracks of the satellite will be closer together near the poles than at middle latitudes and the equator. The satellite will pass within 4 degrees of the poles, not exactly over them, but repeat measurements can be made at places where the ascending and descending paths cross, and data obtained at these places can be used for analysis of elevation changes in the polar regions. In 183 days, there will be several million such crossover points over Antarctica.

NASA is developing ICESat through a partnership with industry and university teams. A Delta II rocket will launch ICESat along with another small satellite into an orbital altitude of 600 km and at 94 degrees inclination to the equator.

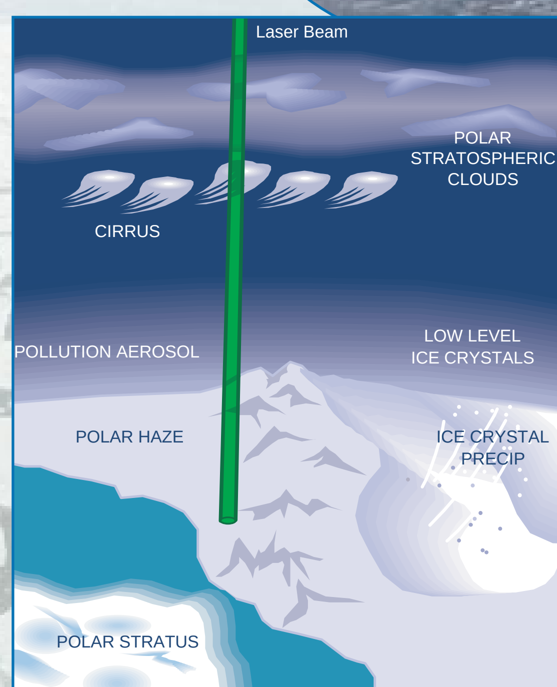


The spacecraft data system will collect science and spacecraft health and safety data in state-of-the-art solid-state memory. When the satellite establishes contact with a ground antenna, the data will be automatically transferred rapidly to the ground automatically. The ground system will collect the data from the antenna and convert them into science data products for use by the science community.

WHAT WILL GLAS's ATMOSPHERIC MEASUREMENTS TELL US?

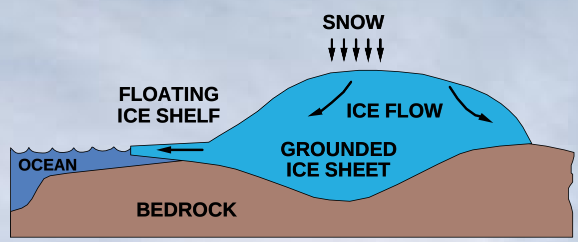


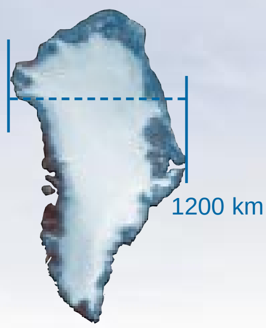
GLAS will make atmospheric observations as an important component of the EOS global change research program. It will provide global lidar observations of cloud heights and bases, cloud optical properties, planetary boundary layer heights, lifting condensation levels, tropospheric and stratospheric aerosols, and polar stratospheric clouds. When combined with radiometric observations, important meteorological parameters such as the optical thickness of cirrus clouds and the moisture content of the planetary boundary layer will be inferred. In addition, the lidar data will be valuable for supplementing and confirming other EOS measurements of clouds.



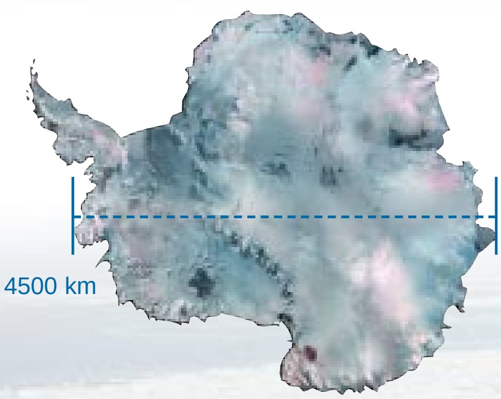
Laser measurements of clouds obtained from an aircraft have been adjusted to simulate measurements from a spaceborne GLAS, demonstrating the capability of ICESat to observe the vertical distribution of clouds and aerosols.

High cirrus clouds, typically found between heights of 9.7 to 14.5 km, generally exhibit low lidar scattering. The simulation shows that even thin cloud layers will be detected. Such invisible cirrus clouds, which are difficult or impossible to detect using passive remote sensing techniques, are very important in determining the atmospheric radiative balance. Aerosols in lower levels of the atmosphere will also be detected.





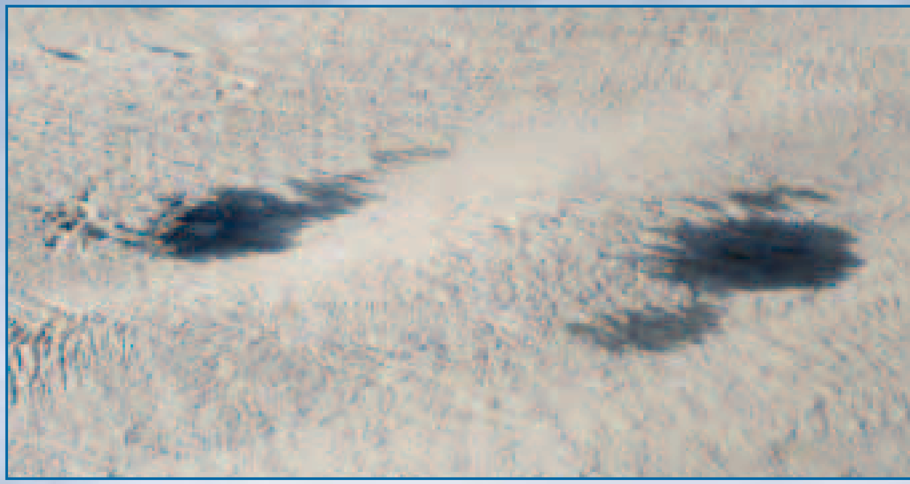
ARE THE GREENLAND AND ANTARCTIC ICE SHEETS GROWING OR SHRINKING?



The Greenland and Antarctic ice sheets are an average of 1.9 km thick, cover 10 percent of the Earth's land area, and contain 77 percent of the Earth's fresh water. The average accumulation of new ice is about 25.4 cm per year on Greenland and about 15.2 cm per year on Antarctica; however, the Antarctic ice sheet has 10 times more ice than Greenland because the Antarctic ice sheet is a larger land area than Greenland. The West Antarctic ice sheet, which is the portion of Antarctic ice lying mostly in the Western Hemisphere, dips 2.4 km below sea level.

Fifteen thousand years ago, huge ice sheets covered much of North America and parts of Eurasia. As the climate warmed during the end of the last Ice Age, many of the ice sheets melted and global sea level rose an average of 2.5 cm per year over about 5,000 years.

ICESat is designed to detect changes in surface elevation as small as 0.8 cm per year in regions as small as 193 km by 193 km. ICESat will also detect changes in ice sheet mass balance, which is the ice forming minus the ice melting over a given time period, that scientists expect as the result of changes in polar temperatures as small as 1 Celsius degree. Observations of elevation changes will help scientists assess the changes in the ice within individual drainage basins and major outlet glaciers, as well as for the entire ice sheet. The continuous satellite observations will also detect seasonal and interannual changes and show whether the changes are caused by recent or long-term changes in climate, or whether they are caused by ice and snow dynamics.



Greenland Melt Lakes

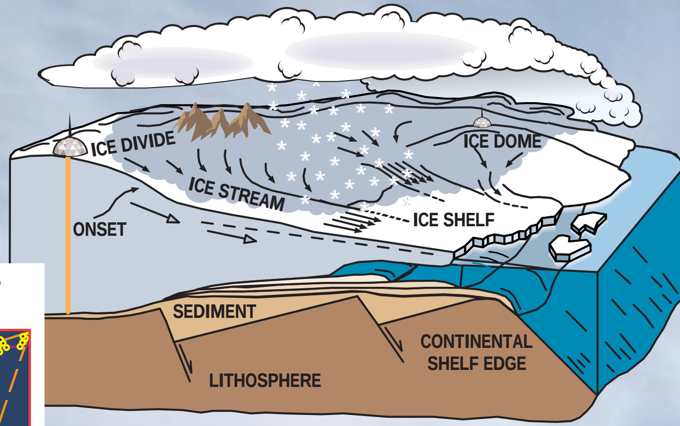
WILL THE ICE SHEETS MELT OR GROW IN A WARMER CLIMATE?

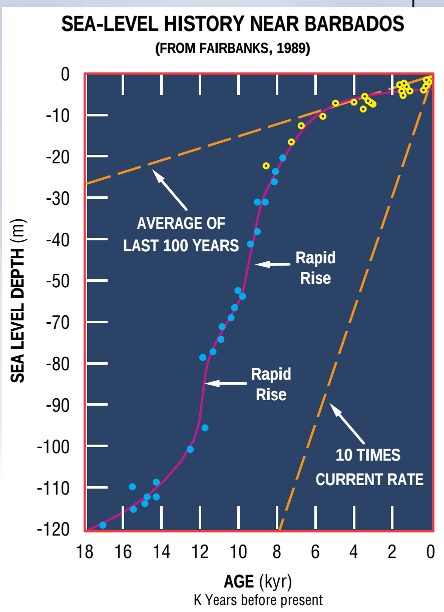
A warmer atmosphere carries more moisture, so more ice will melt and more snow will fall, but we do not know which will have the greater impact on ice sheet thickness—the increased melting at ice sheet edges, or the increased snowfall over the entire ice sheet. Increased snowfall could cause large areas of the ice sheet to thicken.

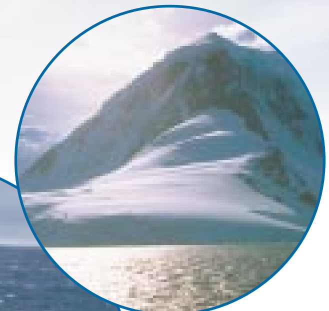
Other factors that must be considered are changes in atmospheric circulation, which may affect the quantity of snowfall, and decreases in the surrounding sea ice, which may affect the evaporation of snow over the ice sheets.

Considering all of these factors, the change in thickness of ice sheets could be -10 percent to +10 percent for each Celsius degree of climate warming, resulting in a change of -0.08 to +0.08 cm in global sea level per year for each degree of change.

ICESat is designed to observe seasonal and interannual variations in the surface caused by variations in snowfall and surface melting. Scientists will use these data in computer models to predict climate-induced changes.







HOW FAST IS SEA LEVEL RISING?

Global sea level is believed to be rising about 1.8 cm every 10 years. About one-fourth of the rise is caused by thermal expansion as the oceans warm; another fourth is caused by small glaciers melting around the world. Some of the rise may be attributed to human activities such as burning trees that release water through biomass burning, pumping ground water, and draining wetlands.

“Marine” ice sheets rest on beds below sea level and are made up of three components: the slowly-flowing main body of the ice sheet; fast-moving ice streams that flow a hundred times faster than the ice next to them; and floating ice shelves into which the ice streams flow. Some researchers believe that if the ice shelves were thinned significantly by increased ocean warmth, these shelves would no longer act like a “brake” for the flowing ice streams. This would result in more ice being emptied into the ocean, which could dramatically raise sea-level around the globe.

ICESat is designed to look for early indications of increased ice flowing into the oceans, and it will serve as an early warning system to detect increased numbers of icebergs in the oceans long before detection is possible through conventional methods.

HOW DO POLAR CLOUDS AND HAZE AFFECT CLIMATE?

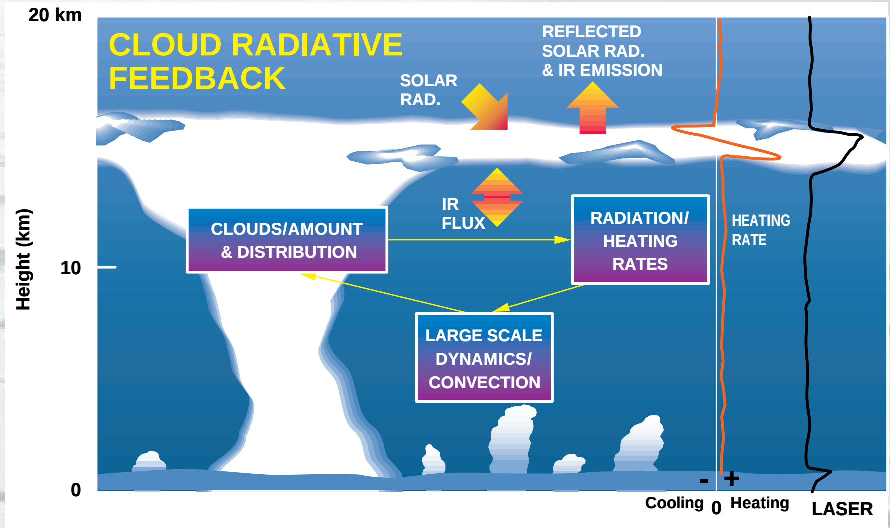
In polar regions, the atmospheric observations of the GLAS sensor will be especially important. Very low temperatures and long periods of darkness in these regions limit standard satellite techniques that use passive remote sensors. GLAS will be uniquely sensitive to polar cloud cover and important processes of the polar atmosphere. Polar stratospheric clouds affect the ozone hole and a phenomenon known as "clear-air precipitation," which happens when ice crystals fall from very thin cirrus clouds that appear invisible giving the illusion of "clear" air. "Clear-air precipitation" is thought to be a major factor in the mass balance of the Antarctic ice sheet. GLAS's laser signals can retrieve this critical information in the presence of low clouds, fog, or blowing snow.

WHY IS CLOUD RADIATIVE FEEDBACK IMPORTANT?

GLAS's atmospheric observations, especially the height of cloud layers, are important for understanding the Earth's climate. Clouds can either warm or cool the Earth. Low, thick clouds primarily reflect solar radiation and cool the surface of the Earth. High, thin clouds primarily transmit incoming solar radiation, but at the same time, they trap some of the outgoing infrared radiation emitted by the Earth and radiate it downward, thereby warming the surface of the Earth. Aerosols tend to cool the Earth's surface by scattering and absorbing incoming solar radiation. Thus, the net effect on heating and cooling the Earth depends strongly on the amount, thickness, and height of clouds, and the amount of aerosols present in the atmosphere.

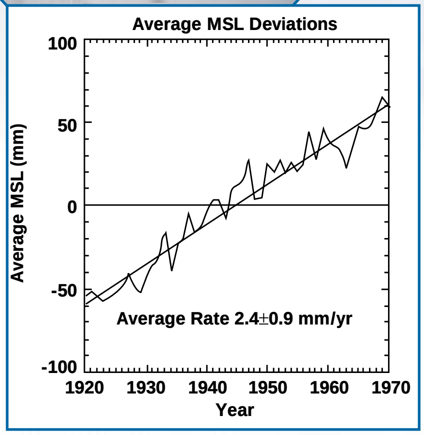
Knowledge of the height, coverage, and thickness of cloud layers, and the aerosols present in the atmosphere is essential both for modeling the interaction between clouds, radiation and aerosols, and for understanding climate change.

GLAS will provide scientists with an unprecedented global data set on the true vertical structure of clouds and aerosols, aiding research efforts aimed at understanding the affects of clouds and aerosols on climate and their role in climate change.



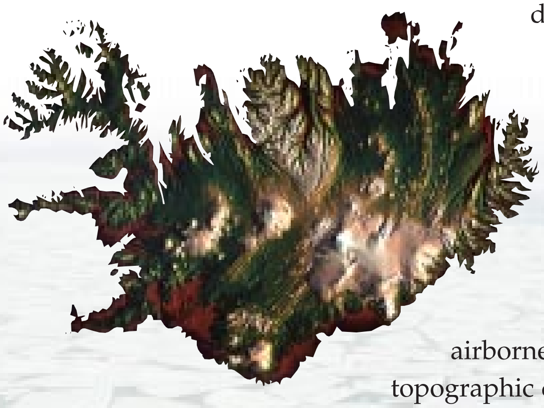
MEASURING EARTH'S

Coastal Erosion



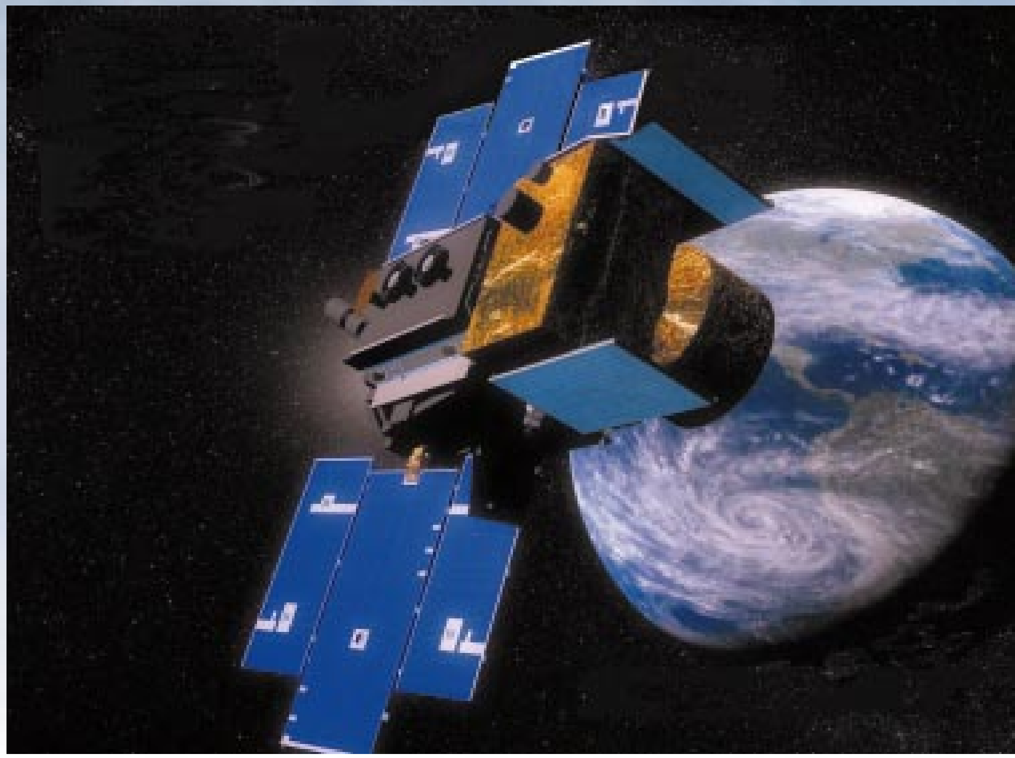
LAND SURFACE

ICESat will provide global measurements of the elevation of the Earth's land surface with unprecedented accuracy. Maps of the Earth's topography are needed for a variety of scientific studies in geology, hydrology, volcanology, population dynamics, land erosion, biology, and meteorology. Accurate maps are also necessary for a variety of commercial uses, such as resource development, land use, and navigation.



ICESat data will enhance data collected by ground-based and airborne surveys, and provide information on a long-term series of topographic changes, which are especially difficult to obtain. Topographic information will include active volcanoes, coastal erosion, and mass transport of soils. With ICESat data, the great sand sheet migration of Northern Africa and central Asia and its relation to desertification will be characterized, and volcanic processes in Alaska and the Aleutian Islands will be monitored more frequently than standard airborne techniques allow, thereby providing long-term data to study geomorphic changes.

More information on ICESat can be found on the World Wide Web at http://icesat.gsfc.nasa.gov/



Program Scientist: Kim Partington, NASA Headquarters
Project Scientist: Jay Zwally, NASA Goddard Space Flight Center

GLAS Science Team
Team Leader:
Bob Schutz, University of Texas-Austin
Team Members: Charles Bentley, University of Wisconsin-Madison
Jack Bufton, NASA Goddard Space Flight Center
Thomas Herring, Massachusetts Institute of Technology
Jean-Bernard Minster, Scripps Institution of Oceanography
James Spinhirne, NASA Goddard Space Flight Center
Robert Thomas, EGRG Corporation
Jay Zwally, NASA Goddard Space Flight Center

Instrument Scientist:
Jim Abshire, NASA Goddard Space Flight Center
David Harding, NASA Goddard Space Flight Center
Ron Follas, NASA Goddard Space Flight Center

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This brochure is written by Jay Zwally, NASA Goddard Space Flight Center
Edited by Charlotte Griner, Raytheon ITSS; David Herring, SSAI; Emilie Lorditch, Raytheon ITSS
Designed by Winnie Humberson, Raytheon ITSS
ICESat Logo Designed by Hailey King
Graphics Inputs: Bill Anselm, Cheryl Salerno, Jason Budinoff, NASA Goddard Space Flight Center

"There remains the possibility that, under the influence of global warming, the West antarctic Ice Sheet might become unstable and surge into the ocean, causing a global rise in sea level. . . ."

—Earth System Science: A closer View, 1988