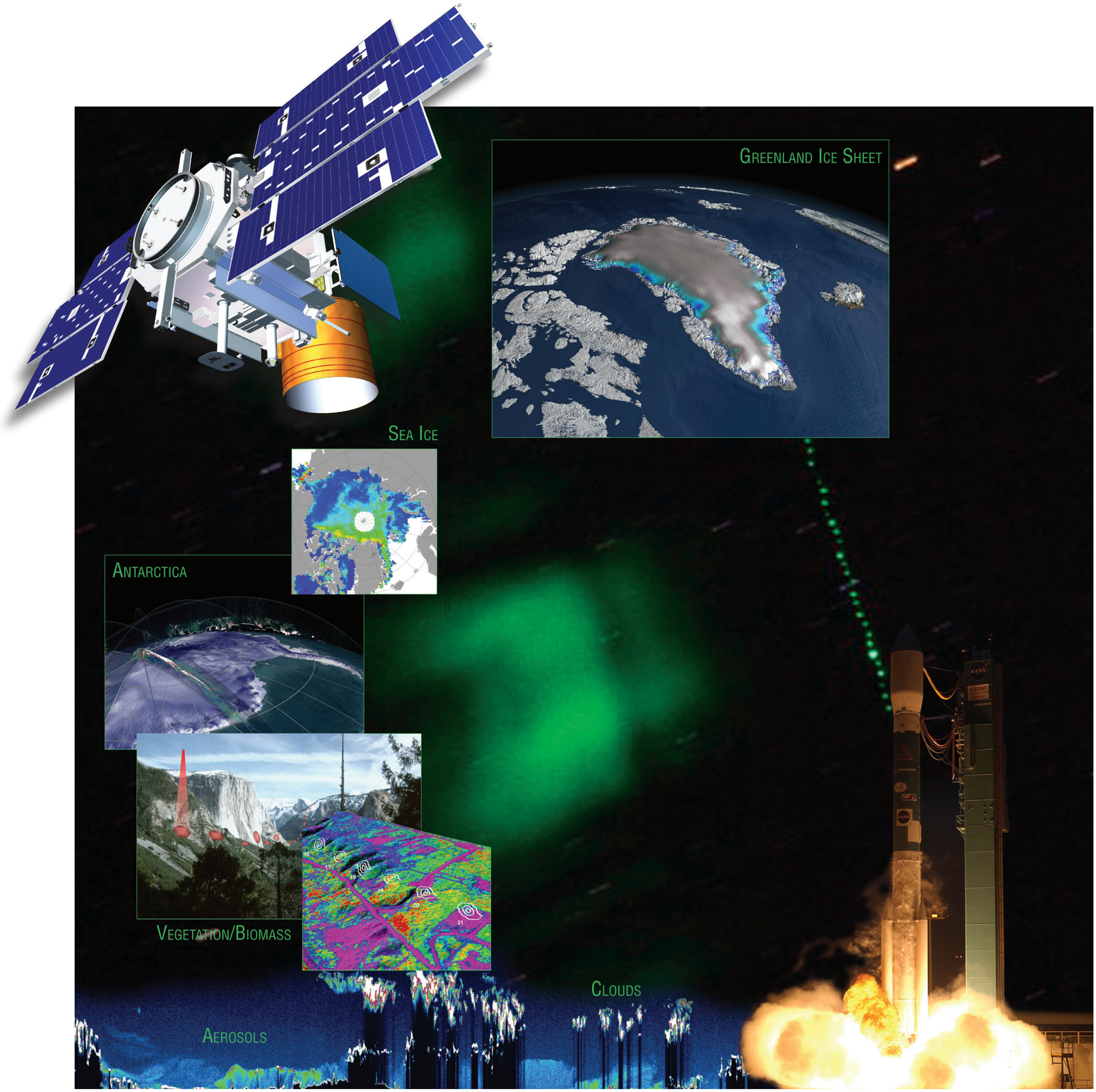
National Aeronautics and Space Administration



ICESat: Ice, Cloud, and land Elevation Satellite

ICESat (Ice, Cloud,and land Elevation Satellite) is the benchmark Earth Observing System mission for measuring ice sheet mass balance, cloud and aerosol heights, as well as land topography and vegetation characteristics. The ICESat mission provides multi-year elevation data needed to determine ice sheet mass balance as well as cloud property information, especially for stratospheric clouds common over polar areas. It also provides topography and vegetation data around the globe, in addition to the polar-specific coverage over the Greenland and Antarctic ice sheets. The background image on the front of the lithograph shows how the clouds scatter the green light photons emitted by the Geoscience Laser Altimeter System (GLAS) aboard ICESat.

Ice Sheets

Knowledge of changes in the Greenland and Antarctic ice sheets is critical for understanding present and future sea level rise, as the ice sheets hold the greatest potential to raise sea level substantially. Since its launch in January, 2003, the Ice Cloud and land Elevation Satellite has been measuring the change in elevation of these ice sheets using sophisticated laser ranging techniques. The ice sheet image on the front shows the changes in elevation over the Greenland ice sheet between 2003 and 2006. The gray and white regions indicate no change to a slight thickening, while the blue and purple shades indicate a thinning of the ice sheet. These elevation-change characteristics hold important clues about the causes of ice sheet change, and by examining ice sheet elevation changes, scientists are not only able to determine how much and where the ice is changing, but also why it is changing.

Sea Ice

The sea ice image on the front shows sea ice thickness generated from ICESat-measured surface elevation profiles from February 18 to March 21, 2004. Sea ice forms as the cold air freezes sea water into solid pieces that can reach thicknesses of up to several meters. Just like ice cubes floating in a glass of water, sea ice floats in the ocean with just a small portion sticking up over the water. Scientists can measure how thick this ice is by using a satellite that shoots laser beams onto the ice and finding out how much of the ice is above the water. Studying sea ice is very important due to the large impact it has on the ocean and climate. Water at the bottom of the oceans starts out as sea ice near the poles, as the ice melts the water sinks to the bottom and drives ocean circulation. The ice also acts like a blanket over the ocean, insulating it from the cold polar air. This blanket reflects sunlight very well, so it helps keep the entire planet cooler. Sea ice is constantly changing as it melts and refreezes every year, so scientists are very interested in seeing how these changes affect the entire planet.

Clouds

The cloud image on the front depicts several orbital passes of GLAS cloud measurements over Antarctica. Laser pulses sent down from the satellite scatter off of clouds, aerosols and the surface. Each pulse produces a vertical profile at one spot and there are about ten such profiles along each mile of the orbit. By putting all the profiles together, a curtain image of the cloud structure, as in the image is created. Unlike imager observations in polar regions where the bright, cold surface obscures cloud detection, the laser measurements give a very accurate detection of all significant clouds and aerosol layers in the atmosphere. In the image of Antarctica on the front, we see the structure of an Antarctica storm system overlaid by polar stratospheric clouds. In addition the laser measures the height distribution, density and thickness of clouds with great accuracy, an important factor for weather and climate.

The climate in polar regions is changing more rapidly than anywhere else. As there is less sea ice, it is expected that there will be more moisture flux and an increase in clouds. It is thought, but not known, that the increase in clouds will accelerate the warming, a process called cloud feedback. It is critical therefore to observe and understand the changes in polar cloud cover. Laser observations such as by GLAS are an important tool to study the changes.

Aerosols

One of the most dramatic occurrences in the atmosphere is the generation of large clouds of dust off the Saharan desert that are transported around the world by winds. The aerosol image on the front shows an orbital track of data from the Geoscience Laser Altimeter System extending across western Africa and over the nearby Atlantic Ocean. The laser measurements, made directly below the satellite, produce a cross-section measurement of the atmosphere by distance and height. Here the height of the cross section is 20 km and the track extends over a thousand miles. The laser observations show the height distribution of clouds and aerosols in the atmosphere. In the image, clouds, high thunderstorms and lower clouds, are seen as white and green structures. The regions of blue and solid green are layers of Saharan dust. Since winds change with height, the directed measurement of the location of the dust makes it possible to accurately predict transport. The transport is very significant. The dust is thought to be a major source of nutrients for the oceans and the Amazonian forest controlling biological processes. It is also a major source of dust over the southeastern US. In recent studies it has been shown that heating due to sunlight absorbed by the dust controls the formation of Atlantic hurricanes in many cases.

Vegetation

Knowing how much carbon is stored in trees depends on the accurate determination of the height of forests. Vegetation height is a key indicator of the amount of above-ground carbon stored in forests, which is an essential component in the cycling of carbon dioxide between the Earth's atmosphere and land surface. Vegetation height is also a useful indicator of forest age and habitat quality. Traditional orbital remote sensing methods are not well suited to measure vegetation height. The laser altimeter waveforms recorded by the GLAS instrument on ICESat provide a global means to sample the height of vegetation along the ICESat profiles, making unprecedented global measurements of the forest canopy heights from space. These measurements are fundamental in adding the vertical dimension to data from optical imagers giving forest extent and other land cover information, and very valuable in determining the amount of carbon stored in vegetation. Measurements acquired through time can provide observations of changes in canopy structure due to large-scale disturbances caused by natural and man made events (e.g. hurricanes, crowning wildfires, forest clearing), monitoring the disturbance and recovery process. ICESat is making unprecedented global measurements of the forest canopy heights from space.

ICESAT-II

In the future, the "ICESat-II" mission is to deploy an ICESat follow-on satellite to continue the exceptional and important measurements pioneered by the ICESat mission, the National Research Council's Committee on Earth Science and Applications from Space has recommended an ICESat follow-on mission as a very high priority. The "ICESat-II" mission is intended to continue the assessment of polar ice changes and their relationship with climate, as well support the assessment of above-ground biomass through the measurement of vegetation canopy heights.

For more information about the ICESat mission, please visit
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