ICESat's Observations of Polar Sea Ice and Ice Sheets

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NASA's Ice, Cloud, and Land Elevation Satellite (ICESat), launched in January 2003, has been measuring surface elevations of ice and land, vertical distributions of clouds and aerosols, vegetation-canopy heights, and other features with unprecedented accuracy and sensitivity. The ICESat mission, which was designed to operate continuously for 3 to 5 years, has so far acquired science data during five periods of laser operation ranging from 33 to 54 days each. The primary purpose of ICESat is to acquire time-series of ice-sheet elevation changes for determination of the present-day mass balance of the ice sheets, study of associations between observed ice changes and polar climate, and improve estimates of the present and future contributions to global sea level rise. The recently reported acceleration of glaciers in the Antarctic Peninsula, following ice shelf disintegration, and the increased ice thinning rates on part of the West Antarctic ice sheet have been based on ICESat data. The unique capability of ICESat's lasers to make accurate elevation measurements over the steeper and more rapidly changing ice margins has been crucial. Over the vast inland ice areas where the elevation changes are believed to be smaller and slower, but nevertheless critical, ICESat is collecting accurate data for long-term studies of the overall ice mass balance. An unplanned achievement of ICESat is its ability to precisely measure sea ice freeboards (elevation of snow/ice surfaces above the ocean), which average about 30 to 40 cm and enable estimates of the ice thickness distributions of the Arctic and Antarctic sea-ice packs. While the area of the Arctic sea ice pack has been declining dramatically in recent years, information on possible corresponding changes in ice thickness has been very limited in space and time. ICESat maps of freeboards and thicknesses for the winters (February/March) of 2003 and 2004 show significant interannual variations. In 2004, thicker ice is more compacted in its usual distribution near the Canadian Arctic than it was in 2003, with a larger area of thinner ice in the Beaufort and Chukchi Seas where the summer ice cover has been rapidly decreasing. ICESat has a 1064 nm channel for near-surface altimetry with a designed range precision of 10 cm that is 2 cm on-orbit. Vertical distributions of clouds and aerosols are obtained with 75 m resolution from both at 1064 nm and the more sensitive 532 nm. The laser footprints are about 70 m spaced at 170 m along-track. The accuracy of the satellite-orbital heights is about 3 cm. The star-tracking attitude-determination system enables footprints to be located to about 10-15 m horizontally (6 m goal). The spacecraft attitude is controlled to point the laser beam to within 100 m (35 m goal) of reference surface tracks at high latitudes and to point off-nadir up to 5 degrees to targets of interest. The first ICESat was intended to be followed by successive missions to measure changes over 15 years, and has clearly proven the unique capability of laser measurements to meet multi-disciplinary science objectives.