ICESat elevations in East Antarctica validated with ground-based GPS measurements

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The 2007-09 Norway-USA Traverse of East Antarctica collected over 5,000 km of dual-frequency GPS data at 5 second intervals. We compared these elevation measurements with those of the ICESat mission, where the ground tracks of ICESat and the traverse intersect in the first large-scale validation study of ICESat in Antarctica.

Since GPS and ICESat data were collected at different times, we used the ICESat elevation time series to account for elevation change between the ICESat and GPS observations.

Comparison reveals mean differences of -0.36 cm, and a standard deviation of 12 cm (n=1151), demonstrating that ICESat met its stated goal of 15 cm accuracy.

Figure 1. GPS antenna mounted on roof of one of two traverse vehicles. Each vehicle collected over 5,000 km of elevation data.

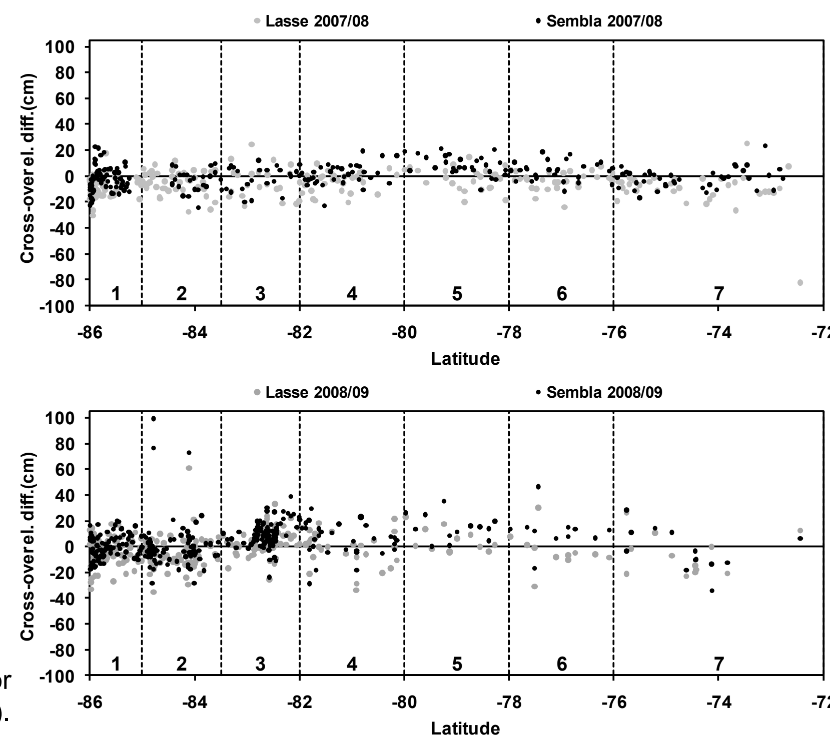

Figure 2. Cross over differences (ICESat – GPS) plotted by latitude for 2007/08 (upper) and 2008/09 (lower).

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References:

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Data Sources: The ground-based GPS data were collected as part of the Norway-USA International Polar Year Scientific traverse of East Antarctica, a joint venture funded by the Norwegian Polar Institute, the U.S. National Science Foundation, and NASA. The project consists of 14 Principal Investigators from the United States and Norway, lead by Dr. Mary Albert (Dartmouth College, and Dr. Jan-Gunnar Winther (Norwegian Polar Institute).

ICESat elevations were derived from ICESat data collected and processed by the ICESat Project Science Office (Dr. H.J. Zwally, Project Scientist) at NASA-GSFC. ICESat data are archived at the National Snow and Ice Data Center. Since ICESat and ground-based GPS data were collected at different times we used the method of Zwally et al. (2011) to determine the elevation-change rate at ICESat-GPS crossovers can correct ICESat elevations to the month of the GPS observations.

Technical Description of Image:
Figure 1: GPS antenna mounted on roof of traverse vehicle. For redundancy, a second antenna was mounted on a second traverse vehicle. Together, these two vehicles generated over 10,000 km of GPS-based surface elevation measurements. We use the GPS data to assess the accuracy and precision of ICESat elevations.

Figure 2: Comparison of of ICESat and GPS elevations at intersection points of satellite and traverse ground tracks. Upper panel shows elevation differences (ICESat – GPS) for the 2007-08 traverse for both sets of GPS data; the lower panel shows the differences for the second year (2008-09).

Scientific significance: This is the first large-spatial scale study to assess the overall accuracy of ICESat over snow and ice (which was ICESat's primary measurement objective). Our analysis shows that ICESat elevations are consistent with the GPS-measured surface (mean difference of ~0.36 cm; standard deviation of 12 cm; n = 1151) and that ICESat meets the stated goal of measuring elevation to 15 cm accuracy in the polar regions.

Relevance for future science and relationship to Decadal Survey: NASA's ICESat-2 mission is the next generation laser altimetry, and follows the heritage of ICESat in many respects. Our study shows a clear path forward for verification of ICESat-2's measurement requirements for elevation and elevation change in the polar regions through use of ground-based GPS observations.

Improved soil moisture retrieval in agricultural regions

Alicia Joseph, Code 617, NASA GSFC

Recent analyses of ground based observations have shown that the **tau-omega** model performs reasonably well under peak biomass. However, crop row orientation effects reduces its performance at the beginning and at the end of the growth cycle. Improved soil moisture retrievals in these parts of the growing season will help soil moisture retrieval accuracy and agricultural management.

SMAP has a need to retrieve soil moisture accurately year-round. To accomplish this, SMAP needs to understand how to change vegetation parameters in the tau-omega model caused by seasonal variations in the crop morphology.

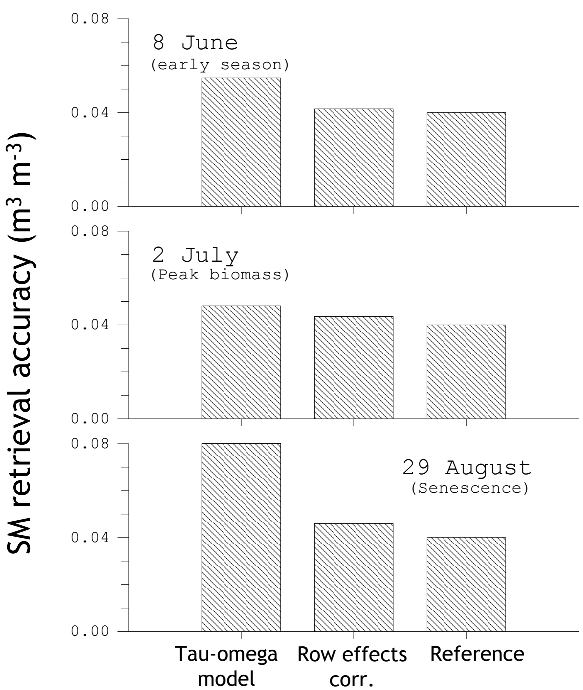

Figure 1: Results from the 2002 OPE^3 LRAD field campaign.

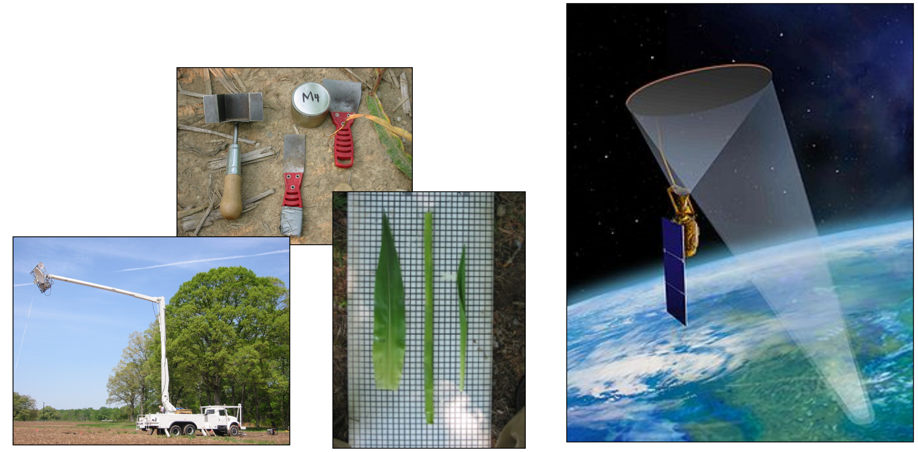

Figure 2: Further Investigation: via data sets collected in-situ and ground based radar/radiometer system (called: ComRad) a method will be developed that can be used for SMAP soil moisture retrieval.

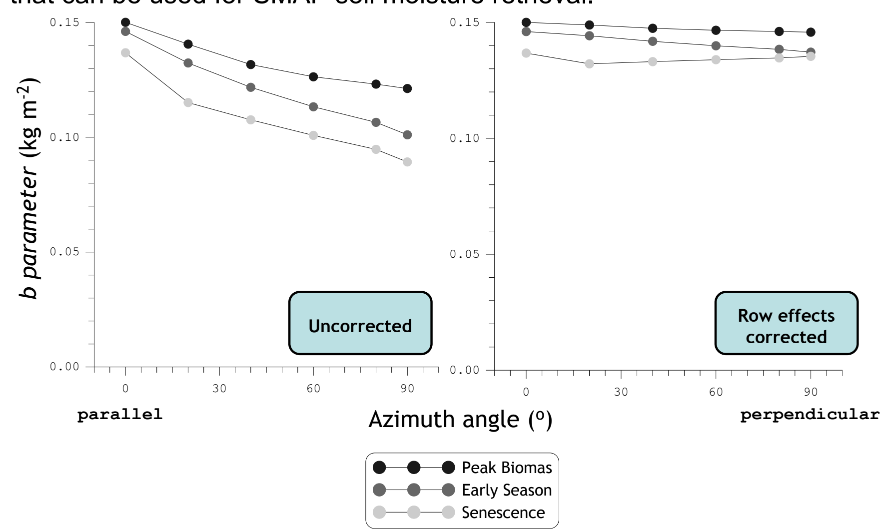

Figure 3: *b* parameters derived for a 40° incidence angle plotted against the azimuth angle, uncorrected and correction for crop row effects.

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Joseph, A.T., R. van der Velde, P.E. O' Neill, B.J. Choudhury, R.H. Lang, E. Kim, and T.Gish: L-band H polarized microwave emission during the corn growth cycle. *Submitted to Remote Sensing of Environment*.

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Data Sources: This research has been conducted using the data set collected during the 2002 corn growth cycle at OPE^3 site near Beltsville (Maryland, USA). Continuity is assured via a field campaign in 2012 with the ComRad radar/radiometer system, which is also designed for SMAP Cal/Val activities. Resources for the 2013 and 2014 ComRad field campaigns are pending.

Technical Description of Image:

***Figure 1*:** Results from the 2002 OPE^3 LRAD field campaign showing that the **tau-omega** model does not perform well at the start of the growth cycle and during senescence.

Figure 2: Further Investigation: via data sets collected in-situ and ground based radar/radiometer system (called: ComRad) a method will be developed that can be used for SMAP soil moisture retrieval.

Figure 3: *b* parameters derived for a 40^{o} incidence angle plotted against the azimuth angle, uncorrected and correction for crop row effects.

Scientific significance: The effects of crop row orientation on both active and passive microwave observations are largely unknown. Results from the 2002 OPE^3 campaign have shown that specifically near senescence the crop row effects are significant reducing the reliability of soil moisture retrievals. At the satellite scale (40 km for SMAP) these effects may average out. Uncertainties like these affect the overall reliability of soil moisture products. This understanding at a small scale is needed for developing meaningful up-scaling procedures from a low to a high resolution.

Relevance for future science and relationship to Decadal Survey: In the Decadal Survey, global soil moisture monitoring from space has been identified as a top priority because it will have applications in numerical weather prediction, drought monitoring and flood forecasting. Soil moisture retrieval over a wide range of vegetated conditions require accurate remote sensing observations collected by low frequency microwave instruments (<1.4 GHz). Currently, the NASA has launched and is preparing to launch missions carrying both passive and active L-band (~ 1.4 GHz) microwave sensors: Aquarius (launched in 2011) and Soil Moisture Active Passive (SMAP, expected launch in 2014).

G-LiHT: Goddard's LiDAR, Hyperspectral, and Thermal airborne imager

Bruce Cook (PI), Larry Corp, Jeff Masek, Betsy Middleton, Doug Morton, Ross Nelson, and Jon Ranson, Code 618, NASA GSFC

***G-LiHT** is a portable airborne system that simultaneously maps the composition, structure and function of terrestrial ecosystems.*

G-LiHT was designed to:

•acquire fine-scale (<1 m), co-registered *LiDAR, optical, and thermal data* for ecosystem studies;

•simplify worldwide deployment; and

•minimize collection costs.

***G-LiHT* features:**

•eye safe lasers;

•portability (compact, lightweight);

•single solution GPS-INS;

•up/downwelling spectrometers;

•ease of installation on common aircraft; and

•non-ITAR instruments.

***G-LiHT is currently being used to estimate forest biomass in the CONUS/Mexico in support of*:**

•NASA's Carbon Monitoring System (*CMS*) Biomass Pilot Project

•American ICESat GLAS Assessment of Carbon (*AMIGA-Carb*)

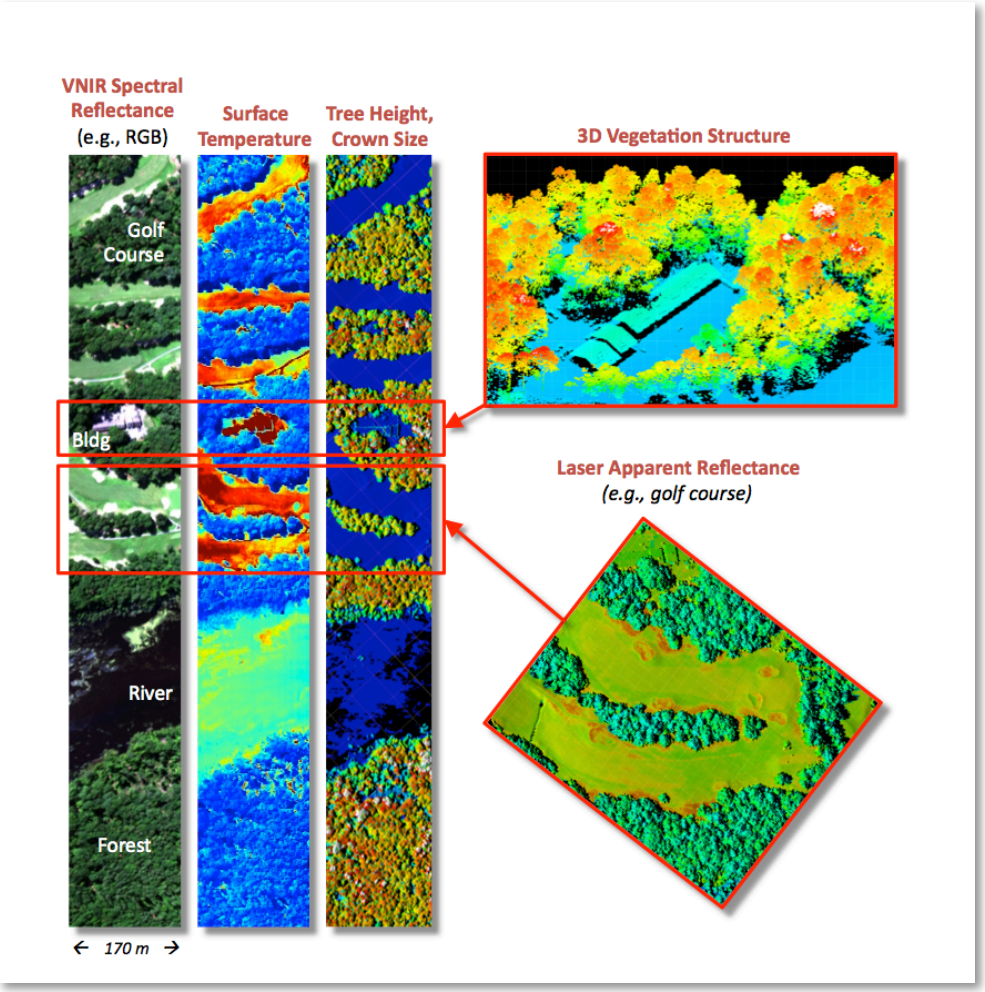

Figure 1: LiDAR, optical & thermal data for different cover types

Figure 2: Instrumentation

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Data Sources: G-LiHT – Goddard's LiDAR, Hyperspectral, and Thermal airborne imager.

Technical Description of Images: One of the major obstacles to the development of data fusion algorithms is the availability of accurately co-registered data of similar grain size. This is often the case when instruments are flown on different platforms and at different times during a field campaign. We believe that "instrument fusion" is a prerequisite to "data fusion", and we have developed a system the integrates a small footprint LiDAR, narrow band hyperspectral imager, and broad band thermal imager in a single, compact and portable instrument package that could be readily deployed on NASA suborbital aircraft (Figure 1).

Scientific Significance: To improve satellite-derived estimates of terrestrial plant production and exchange of CO2, water, and energy with the atmosphere, scientists need to consider ecosystem composition, structure, function, and health. This can be accomplished through the fusion of LiDAR data, which can provide 3D information about the vertical and horizontal distribution of vegetation; and hyperspectral remote sensing, which can inform us about variations in biophysical variables (e.g., photosynthetic pigments) and responses to environmental stressors (e.g., heat, moisture loss). The fully integrated airborne system will utilizes a single solution GPS/IMU subsystem to provide accurate geo-referenced datasets that are needed for 1) calibration and validation of satellite-derived land products; and 2) development of data fusion algorithms that combine observations from multiple sensors to characterize ecosystem composition, structure, function, and health.

Relevance for future science and relationship to Decadal Survey: This technology demonstration is directly applicable to the near term missions requested by the National Academy of Science's 2007 Decadal Survey. These NASA Earth mission concepts focus on overlapping sets of science objectives related to the measurement of both canopy structure and physiology. The G-LiHT system positions GSFC with the technology and expertise needed to meet the objectives called for by the Decadal Survey and provides a ground validation capability to assist in prototyping science requirements, integrated sensor systems, and science products for new Venture Class missions using a new hybrid hyperspectral-LIDAR approach for the detection of ecosystem responses to human land management and climate change. Furthermore, this system can provide a unique capability for the NASA's Earth Science: Carbon Cycle, Ecosystems dynamics themes, extending beyond the Decadal Survey and looking toward future capabilities.