Performance Assessment of a Small LiDAR Altimeter Deployed on Unmanned Aircraft for Glacier and Sea Ice Surface Topography Profiling

R.I. Crocker\textsuperscript{1}, J.A. Maslanik\textsuperscript{1}, S.E. Palo\textsuperscript{1}, C. Fowler\textsuperscript{1}, J. Adler\textsuperscript{2,3}, U.C. Herzenfeld\textsuperscript{4}, M.M. Fladeland\textsuperscript{5}, B. Weatherhead\textsuperscript{1,3,4}, M. Angier\textsuperscript{5}

\textsuperscript{1} Colorado Center for Astrodynamics Research (CCAR), Aerospace Engineering Sciences, University of Colorado
\textsuperscript{2} CIRES, University of Colorado; \textsuperscript{3} Ames Research Center, NASA; \textsuperscript{4} NOAA, Boulder, CO; \textsuperscript{5} Advanced Ceramics Research, Inc.

Funding provided by NASA Cryospheric Sciences Program and NASA Graduate Student Researchers Program

Inefficiency

The University of Colorado (CU) LiDAR Profilometer and Imaging System (CULPIS) is a relatively small, lightweight (\textlessthan}2 kg) and low-cost ($\textless$100K) payload that provides high-resolution surface elevation measurements and imagery. The CULPIS consists of a near-IR laser rangefinder, a GPS module, an inertial Measurement Unit (IMU), still and HD video cameras, and a data acquisition system. Arctic and Antarctic Unmanned Aircraft (UA) campaigns have employed the CULPIS to study glacier and sea ice topography and roughness characteristics. Initial results from two Arctic campaigns illustrate the CULPIS performance and the capabilities of UA-based cryospheric studies.

Arctic MUSCOX

The Arctic Multi-Sensor Cryospheric Observation eXperiment was carried out in July 2008 from Ny-Ålesund, Svalbard. The CULPIS was flown onboard Advanced Ceramics Inc.’s Manta UA to study ice sheet surface topography as it relates to supraglacial melt pond formation, volume and dynamics.

The top panel of the figure on the left is a MUSCOX satellite image that depicts three supraglacial melt ponds located in the MUSCOX study region. The bottom panel is a digital elevation model constructed from data collected during the MUSCOX campaign. It is evident that the CULPIS surface measurements accurately depict the location, shape and size of the three melt ponds.

CULPIS

In an effort to quantify the precision of CULPIS-derived surface profiles, the SERRA was based along the Ny-Ålesund runway to obtain a ground-based “truth” reference profile. The aircraft was then flown repeatedly over the runway, and surface elevation profiles were generated. As shown in the figure on the left, the profiles compared using standard GPS (dGPS) differ from the reference profile by \$\textless$1.17 m. Applying dGPS corrections reduces the error to \$\textless$0.12 cm.

The surface elevation profile along a 2 km stretch of sea ice is shown below. The sea ice surface elevations span a range of approximately 2 meters. The profile ridges and open leads align quite well with the features in the photo mosaic.

Conclusions

The CULPIS has proven itself as a suitable payload for small UA that provides high-resolution surface elevation measurements and imagery. It has been utilized in Greenland during the 2008 Arctic MUSCOX campaign to map ice sheet surface topography, and during the 2009 CULPIS campaign to measure sea ice roughness in Fram Strait off the coast of Svalbard. Recent analysis indicates that the elevation measurements are accurate to within \$\textless$0.12 cm.

Cryospheric Measurement by Unmanned Aircraft System