Linking biogeochemical and hydrological perspectives to model coastal plain wetland ecosystems

Mapping Project Report

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1. LiDAR System Description and Specifications

This survey was performed with an Optech 3100 Airborne Laser Terrain Mapper (ALTM) serial number 03SEN144 mounted in a twin-engine Piper PA-31 Chieftain aircraft (Tail Number N31PR). The instrument nominal specifications are listed in table 1.

Operating Altitude	80- 3500 m, Nominal
Horizontal Accuracy	1/5,500 x altitude (m AGL); 1 sigma
Elevation Accuracy	5 - 30 cm; 1 sigma
Range Capture	Up to 4 range measurements, including 1^{st}, 2^{nd}, 3^{rd}, last returns
Intensity Capture	12-bit dynamic range for all recorded returns, including last returns
Scan FOV	0 - 50 degrees; Programmable in increments of ±1degree
Scan Frequency	0 – 70 Hz
Scanner Product	Up to Scan angle x Scan frequency = 1000
Roll Compensation	±5 degrees at full FOV – more under reduced FOV
Pulse Rate Frequency	33 - 100 kHz
Position Orientation System	Applanix POS/AV 510 OEM includes embedded BD960 12-channel 10Hz GPS receiver
Laser Wavelength/Class	1047 nanometers / Class IV (FDA 21 CFR)
Beam Divergence nominal (full angle)	Dual Divergence 0.25 mrad (1/e) or 0.80 mrad (1/e)

Table 1 – Optech GEMINI specifications (http://www.optech.ca/pdf/Brochures/ALTM3100EAwspecsfnl.pdf).

See http://www.optech.ca for more information from the manufacturer.

2. Description of PI's Areas of Interest.

The survey area consisted of three polygons located over the city of Boulder, covering the University of Colorado, Boulder campus and just west of Boulder, enclosing 17 square kilometers. The survey location is shown below in Figure 1.

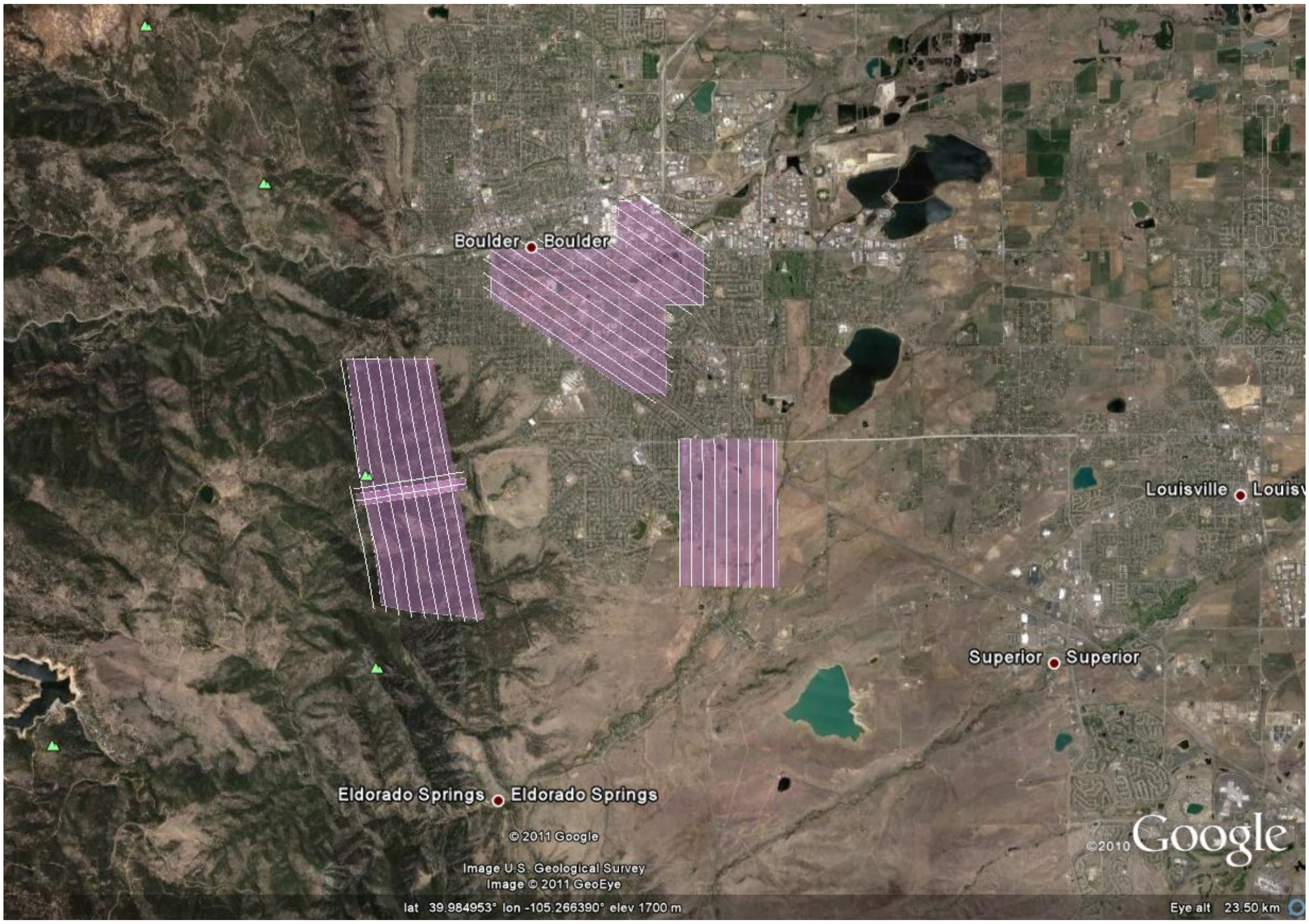

Figure 1 – Shape and location of survey polygon (Google Earth).

3. Airborne Survey Planning Process.

The survey planning was performed considering nominal values of 600m for flight altitude above the terrain, a mean flying speed of 65 m/s and a swath overlap of 50%. Taken into account these values and the layout of the area of interest the optimized flight plan consisted of 33 flight lines. The survey parameters are provided in Table 2 below

Nominal Flight Parameters		**Equipment Settings**		**Survey Totals**	
Flight Altitude	600 m	Laser PRF	70 kHz	Total Passes	33
Flight Speed	65 m/s	Beam Divergence	0.25 mrad	Total Length	101.8 km
Swath Width	389.9 m	Scan Frequency	40 Hz	Total Flight Time	3.06 hrs
Swath Overlap	50%	Scan Angle	± 21°	Total Laser Time	0.43 hrs
Point Density	6.3 p/m²	Scan Cutoff	3°	Total Swath Area	19.85 km^2
		Scan Offset	0	Total AOI Area	17.03 km^2

Table 2 – Survey totals. Area of Interest is abbreviated AOI.

4. LiDAR and GPS Data Collection Campaign.

This survey was flown on May 03, 2010 (DOY 123) and May 05 (DOY 125). The survey required 33 flight lines. Data were collected following the instrument parameters prescribed by the original mission planning as described in the previous section.

Two GPS reference station locations were used during the survey; labeled P041 and KBDU. KBDU was a temporary station set by NCALM on the grounds of the Boulder Municipal Airport during the survey. P041 is part of the UNAVCO PBO network. All reference GPS observations were logged at 1 Hz. The airborne receiver is an integrated GPS receiver module Trimble BD950, logging at 10 Hz. Table 3 gives the coordinates of the stations.

GPS station	P041	KBDU $_{\text{snow-on}}$
Operating agency	UNAVCO	NCALM
Latitude	39.949492	40.0394297
Longitude	-105.194266	-105.2258217
Ellipsoid Height (m)	1728.8417	1612.555

Table 3 – Survey totals. Area of Interest is abbreviated AOI.

5. Data Processing and Final Product Generation.

5.1. GPS & INS Navigation Solution.

Reference coordinates for all stations are derived from observation sessions taken over the project duration and submitted to the NGS on-line processor OPUS which processes static differential baselines tied to the international CORS network. For further information on OPUS see http://www.ngs.noaa.gov/OPUS/ and for more information on the CORS network see http://www.ngs.noaa.gov/CORS/ .

Airplane trajectories for this survey were processed using KARS (Kinematic and Rapid Static) software written by Dr. Gerald Mader of the NGS Research Laboratory. KARS kinematic GPS processing uses the dual-frequency phase history files of the reference and airborne receivers to determine a high-accuracy fixed integer ionosphere-free differential solution at 1 Hz. All final aircraft trajectories for this project are blended solutions from the two stations.

After GPS processing, the trajectory solution and the raw inertial measurement unit (IMU) data collected during the flights are combined in APPLANIX software POSPac MMS (Mobile Mapping Suite Version 5.2). POSPac MMS implements a Kalman Filter algorithm to produce a final, smoothed, and complete navigation solution including both aircraft position and orientation at 200 Hz. This final navigation solution is known as an SBET (Smoothed Best Estimated Trajectory).

5.2. Calibration, Matching, Validation, and Accuracy Assessment

Two types of calibration procedures were used on this project: relative calibration and absolute calibration.

Relative calibration is done for each flight by the following method:

1. Planning and flying swaths with 50% side lap.
2. Surveying crossing flight-lines over calibration areas and over the project polygon.
3. Analyzing these overlaps and cross-lines in TerraMatch software. (see http://www.terrasolid.fi/en/products/4).

TerraMatch employs a least-squares approach (minimizing the height differences between computed laser surfaces from individual crossing and/or overlapping flight lines) to calculate the best-fit values for four parameters: three bore sight angle alignments (roll, pitch, and yaw), and the scanner mirror-angle scale factor.

Absolute calibration was done by establishing a calibration site consisting of 814 check points surveyed with vehicle-mounted GPS. These check points were then surveyed with crossing flight lines using the ALTM. These check point heights were differenced with their nearest neighbor LiDAR height measurement: the RMS (Root Mean Square) of these differences was found to be between 0.02 and 0.03 meters.

Since the aircraft maintained the same parameters when surveying the calibration area (flying height = 600 meters AGL, scan frequency = 40 Hz, scan angle = +/- 21 degrees, laser PRF = 70 KHz) as used when doing the project survey, absolute calibration analysis can serve as an accuracy assessment for the LiDAR survey for surfaces similar to the calibration area.

5.3 Final Deliverables.

All the final deliverables are referenced in horizontal datum NAD83 and vertical datum NAVD88 (Geoid 03) and projected in UTM zone 13N. The final deliverables consist of

1. Point Cloud in LAS format, classified as ground or non-ground, in 1 km square tiles.
2. Point Cloud in LAS flight strips, if requested.
3. ESRI format 1-m DEM from ground classified points.
4. ESRI format 1-m Hillshade raster from ground classified points
5. ESRI format 1-m DEM from all points (canopy included).
6. ESRI format 1-m Hillshade raster from all points (canopy included).
7. ESRI Format 1-m DEM from Ground and building classified points as requested by PI
8. ESRI Format 1-m Hillshade raster from Ground and building classified points as requested by PI
9. SURFER grids (1 KM tiles), if requested.

1 Km tiles follow a naming convention using the lower left coordinate (minimum X, Y) as the seed for the file name as follows: XXXXXX_YYYYYYY. For example if the tile bounds coordinate values from easting equals 475000 through 47600, and northing equals 4425000 through 4426000 then the tile filename incorporates 475000_4426000. These tile footprints are available as an AutoCAD DXF or ESRI shape file.

The ESRI DEMs are single mosaic files created by combining together the 1KM tiles. Their name consists of prefix ‘fme’ and the lowest Easting coordinate rounded to the nearest 1000, for e.g. ‘fme475000’. The hillshade files have a prefix ‘sh’ after the name, for e.g. ‘fme475000sh’.