DELIVERABLE 5.3

2005 Mississippi Lidar Data Validation Report

IMSG/PSGS Project Lead
Andrew Meredith

IMSG/PSGS Project Team
Jamie Carter
Christiana Pollack

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I. M. Systems Group, Inc.

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Introduction

The National Oceanic Atmospheric Administration (NOAA) Coastal Service Center Topographic Change Mapping (TCM) project seeks to aid coastal managers with their topographic needs. This can include issues ranging from beach geomorphologic change to storm surge inundation to determination of invasive species habitat. Additionally, the TCM project creates derived information products and analysis tools to facilitate the coastal resource manager's decision-making process. The TCM project received Light Detection and Ranging (Lidar) data collected along the coast of Mississippi in May 2005 and will distribute the data from its web-based Lidar Data Retrieval Tool (LDART).

EarthData International collected elevation point data derived from multiple return (first through fourth) lidar measurements from Jackson and Hancock coastal counties in Mississippi on February 25 and March 1, 10, 11, and 12, 2005. Final data were delivered in the LAS format with several embedded attributes: return number, number of returns, intensity, and classification ("bare ground" or "not bare ground"). Average ground sample distance was 5.0 meters. The survey area covered approximately 3,538 square kilometers (*Figure 1*). The survey was conducted under tidally controlled conditions to ensure maximum shoreline exposure during the data collection. The contract with EarthData International specified a vertical accuracy requirement of ±0.185-meter root mean square error ($RMSE_{(z)}$).

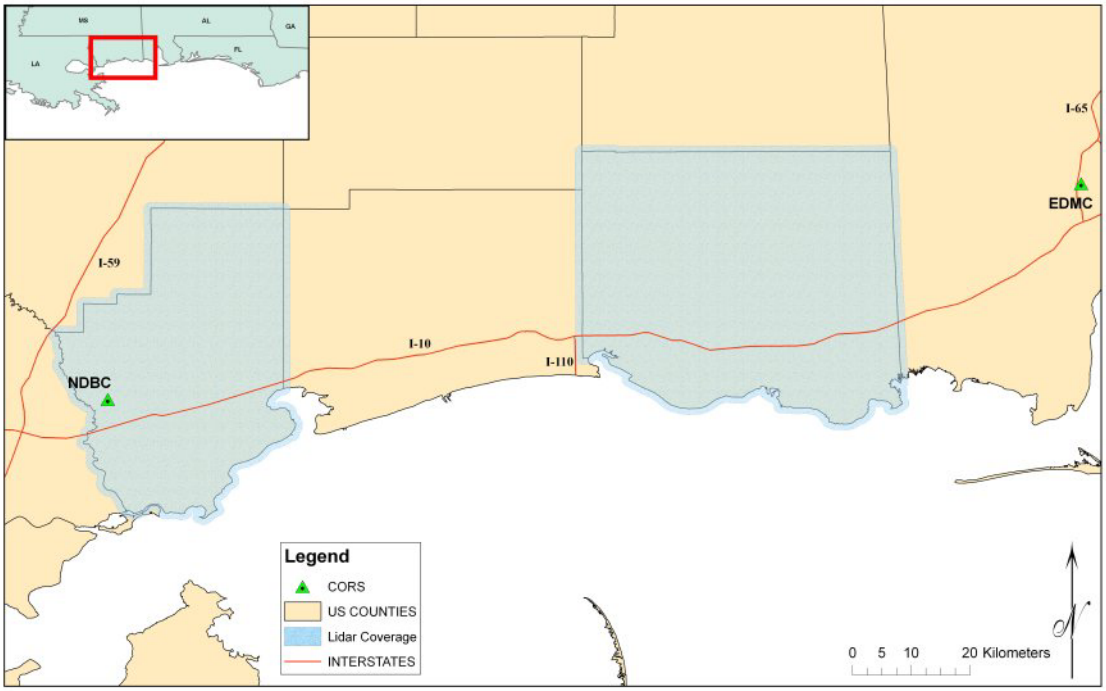

Figure 1. Extent of the Mississippi lidar survey.

This report presents the results of a quantitative error assessment conducted to verify the vertical accuracy of the lidar data in open terrain using independent ground check points as validation points. This assessment followed procedures and recommendations presented in the *Guidelines for Digital Elevation Data* prepared by the National Digital Elevation Program (NDEP) and the *ASPRS Guidelines for Vertical Accuracy Reporting for Lidar Data* prepared by the ASPRS Lidar Committee.

Methods

The Center conducted a survey to collect ground check points on October 17-20, 2005. A survey network was established and tied to the North American Datum 1983 (NAD83) Continuous Operating Reference Station (CORS) network. Points in flat, open terrain distributed throughout the study area were selected for occupation. Three Thales Z-Max dual frequency GPS receivers were operated in static differential mode to collect vector information. The vector data was post-processed and adjusted using *Thales Navigation's* GNSS Studio software. The final independent ground control data set consisted of thirty-two check points that were believed to have a vertical accuracy of 0.065 meters at 95 % confidence.

The post edited bare earth lidar data were used by the Center to perform this data validation. The nature of topographic lidar data collection limits the ability to survey precise horizontal (xy) locations; therefore, a form of interpolation of lidar data is required to accurately compare check points and lidar derived elevation models. The Guidelines for Digital

Elevation Data by NDEP recommends interpolation from a surface generated from a triangulated irregular network (TIN) derived from the lidar point data for assessing the accuracy of mass points. This method was employed in this evaluation. Elevation values at the location of each of the 32 check points were interpolated from the triangulated bare earth point data. The vertical error at each check point location was calculated by subtracting the interpolated lidar elevation value from the check point elevation value. After calculating the error at each check point, the overall root mean square error ($RMSE_{(z)}$) for the survey was calculated. The overall vertical accuracy at the 95th percentile was then calculated with the following equation:

Vertical Accuracy at 95% confidence level = 1.9600 * $RMSE_{(z)}$
(assuming errors were normally distributed)

Results

The overall $RMSE_{(z)}$ error was ±0.1197 meters which is based on 32 samples (i.e., n = 32). A Shapiro-Wilk statistical test performed on the errors for the quantitative assessment indicated the errors were normally distributed (W = 0.9814; p = 0.83). The Shapiro-Wilk test was chosen because it works well with a small sample size as long as there are no identical values.

Error! Reference source not found. shows the elevation difference calculated at each of the ground control stations. A mean error of 0.004 meters and a standard deviation of 0.12 meters were reported. The greatest elevation difference was 0.287 meters at station 2001 (see *Appendix A*).

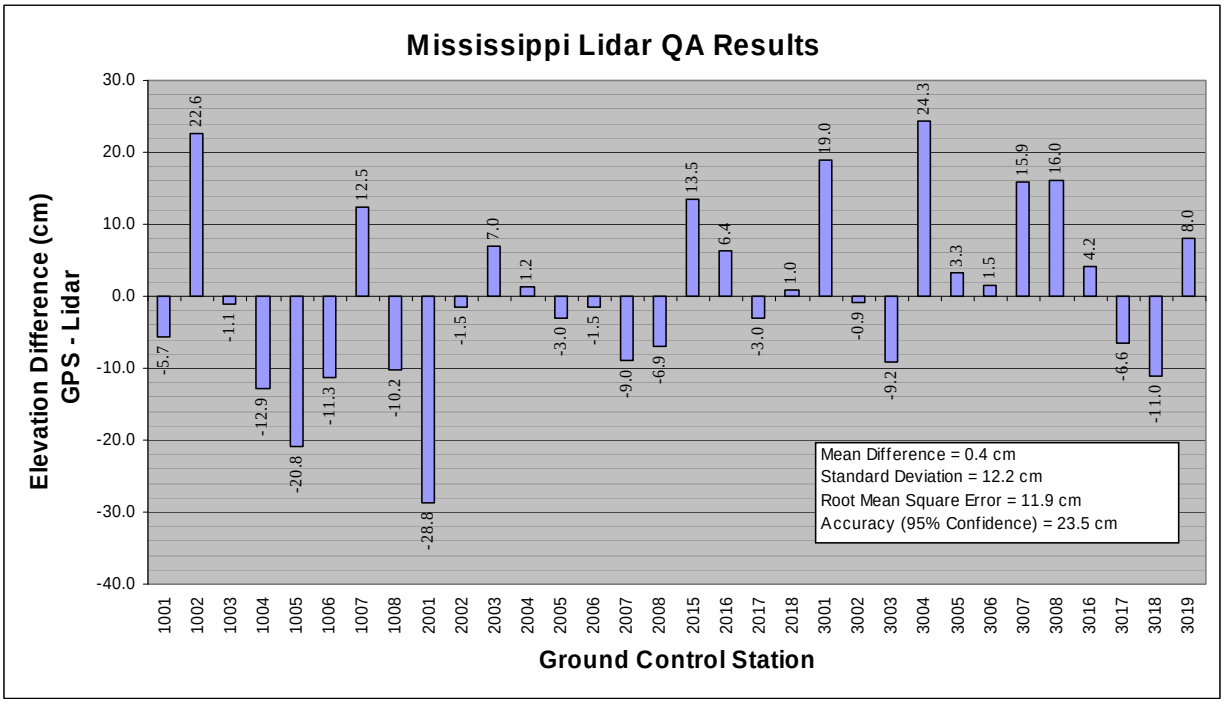

Figure 2. Elevation differences at each control station (check point elevation – Lidar elevation).

The spatial distribution of the elevation differences is presented in *Figure 3* and the actual values are presented in a table in *Appendix A.* Each check point is colored according to the magnitude of the error identified for the lidar elevation calculated at the station's horizontal (xy) location.

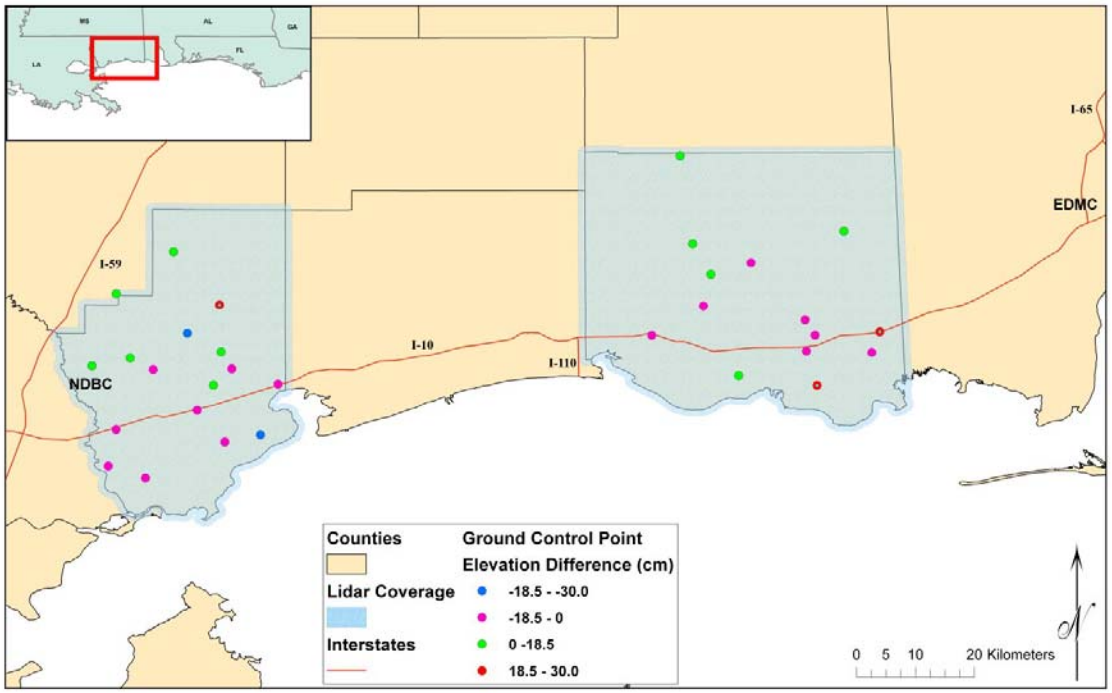

Figure 3: Map showing the spatial distribution of elevation differences between check point elevations and interpolated lidar elevations (Check point elevation – Lidar elevation).

Discussion

The overall vertical error calculated from the collection of check points is within the prescribed accuracy limits. Given that the control stations were located in flat and open terrain, these errors are generally believed to be random errors in the lidar sensor system as opposed to systematic errors generated from vegetated areas.

The horizontal accuracy of this lidar data was not assessed. The high vertical accuracy is indicative of good horizontal accuracy, though slight horizontal inaccuracies are difficult to detect using these check points because they were located in relatively flat terrain.

Based on this assessment, the 2005 Mississippi lidar survey data meet the prescribed vertical accuracy level since more than 95% of the measured positions have an error less than or equal to 36.3 cm (equivalent to root mean square error of 18.5 cm for normally distributed data). In accordance with the National Standard for Spatial Data Accuracy (NSSDA), the vertical accuracy is reported as:

> **"Tested 0.24 meter fundamental vertical accuracy at 95 percent confidence level in open terrain using $RMSE_{(z)}$ x 1.9600."**

Appendix A

The following table shows the elevation difference calculated at each of the ground control stations. The differences (Delta Z) were calculated by subtracting the interpolated (via tinning) orthometric lidar heights (meters) from the coincident check point heights.

Station	Longitude (dd)	Latitude (dd)	Delta z (m)	Delta z2 (m)
1001	-88.446772	30.429952	-0.057	0.003
1002	-88.434727	30.461605	0.226	0.051
1003	-88.533413	30.456486	-0.011	0.000
1004	-89.352515	30.381723	-0.129	0.017
1005	-89.379247	30.304560	-0.208	0.043
1006	-89.433649	30.293645	-0.113	0.013
1007	-89.451044	30.380148	0.125	0.016
1008	-89.423031	30.405077	-0.102	0.010
2001	-89.490905	30.459455	-0.288	0.083
2002	-89.542972	30.403910	-0.015	0.000
2003	-89.577915	30.421583	0.070	0.005
2004	-89.636297	30.409333	0.012	0.000
2005	-89.599511	30.312536	-0.030	0.001
2006	-89.611659	30.256505	-0.015	0.000
2007	-89.554823	30.238650	-0.090	0.008
2008	-89.475805	30.341938	-0.069	0.005
2015	-88.739272	30.730061	0.135	0.018
2016	-88.720103	30.595886	0.064	0.004
2017	-88.631071	30.566623	-0.030	0.001
2018	-88.489474	30.614970	0.010	0.000
3001	-88.530382	30.379767	0.190	0.036
3002	-88.546501	30.432245	-0.009	0.000
3003	-88.548478	30.479518	-0.092	0.008
3004	-89.441852	30.502515	0.243	0.059
3005	-89.439371	30.430878	0.033	0.001
3006	-89.636304	30.409332	0.015	0.000
3007	-89.599401	30.519715	0.159	0.025
3008	-89.511931	30.583765	0.160	0.026
3016	-88.692234	30.548831	0.042	0.002
3017	-88.703719	30.500993	-0.066	0.004
3018	-88.782373	30.456107	-0.110	0.012
3019	-88.649864	30.394566	0.080	0.006
			Mean dz (m)	0.004
			Standard Dev. (m)	0.12
			$RMSE_{(z)}$ (m)	0.12
			$Accuracy_{(z)}$ (m)	**0.23**