2002 Willapa Bay, WA LIDAR Data Validation Report

Prepared by Perot System Government Services for the NOAA Coastal Service Center

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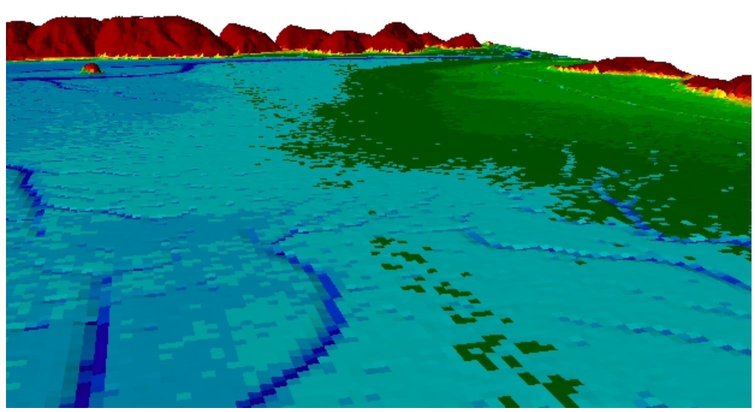

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Introduction

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 geomorphological change to storm surge inundation to determination of invasive species habitat. The TCM project has been collecting topographic Light Detection and Ranging (LIDAR) data since 1996 and distributing the data via the a web-based delivery system, LIDAR Data Retrieval Tool (LDART). Additionally, the project creates derived information products and analysis tools to facilitate the coastal resource manager's decision-making process.

In the spring of 2002, the NOAA Coastal Service Center (CSC), working in partnership with the Washington State Department of Natural Resources, contracted for the collection of high-resolution topography for Willapa Bay, Washington to address an invasive species issue (*Spartina alternaflora).* The survey area covered approximately 470 square kilometers (Figure 1). The survey was conducted under tidally controlled conditions to ensure maximum mud flat exposure during the data collection. Data postings were required every 3 meters and a vertical accuracy requirement of ±15 centimeters root mean square error (RMSE) was specified.

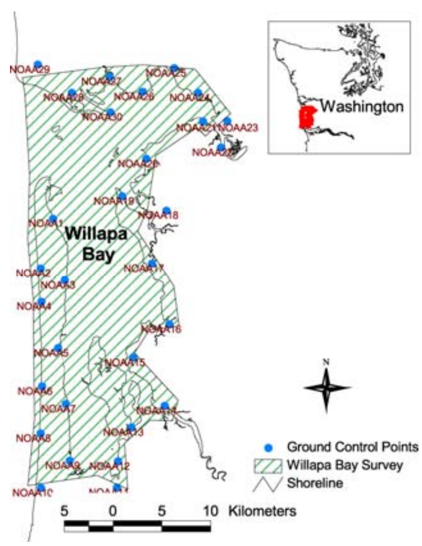

Figure 1 Extent of the spring 2002 Willapa Bay LIDAR survey and ground control point locations.

In conjunction with the LIDAR survey, the Center contracted an independent survey company to collect ground control points (GCP) for use in validating the accuracy of the topographic LIDAR data (Figure 1). The contract specified the following requirements for the collection of the GCP data:

- Tie to the same Global Positioning System (GPS) reference Network used by the LIDAR Contractor.
- All horizontal (*x, y*) and vertical (*z*) GCP data shall be collected by static positioning techniques, not kinematic positioning.
- The geometric vertical (*z*) and horizontal (*x, y*) accuracy required for GPS GCP delivered by the Contractor shall be 2 cm Root Mean Square Error (RMSE) or less from their true geographic location.
- A total of 30 GCP shall be collected and delivered from the Contractor.
- The locations of GCP shall be evenly distributed throughout the specified project region.
- All GCP data shall be collected where terrain is flat within a 5-meter radius of collection point. The term "flat" is defined for this GCP collection as any non-vegetated area with little to no change in elevation.

The report presents the results of an error assessment conducted to verify the vertical accuracy of the LIDAR data in open terrain using the GCP as the check points. The assessment followed procedures and recommendations presented in the *Guidelines for Digital Elevation Data* prepared by the National Digital Elevation Program (NDEP).

Methods

The nature of topographic LIDAR data collection limits the ability to survey precise xy locations; therefore, some form of interpolation of LIDAR data is required to accurately compare GCP and LIDAR elevation measurements. The *Guidelines for Digital Elevation Data* by NDEP recommends interpolation from a surface generated from a triangular-irregular-network (TIN) derived from the LIDAR point data for assessing the accuracy of mass points. This method was employed in this evaluation. The error at each GCP point was calculated by subtracting the GCP elevation from the interpolated elevations from the LIDAR survey at the xy location of the GCP. After calculating the error at each GCP, the overall root mean square error (RMSE) for the survey was calculated.

Results

The overall RMSE error was 18.79 centimeters. Six GCP were located outside the extent of the LIDAR coverage, so the reported RMSE's are based on 24 samples (i.e., N=24). A Shapiro-Wilk statistical test performed on the errors for each assessment method indicated the errors were normally distributed. The Shapiro-Wilk test was chosen because it works well with a small sample size.

Figure 2 shows the elevation difference calculated at each of the GCP. A mean error of 13.72 centimeters and a standard deviation of 13.12 centimeters were reported. The maximum error was 36.58 centimeters at NOAA 8 (see Appendix A).

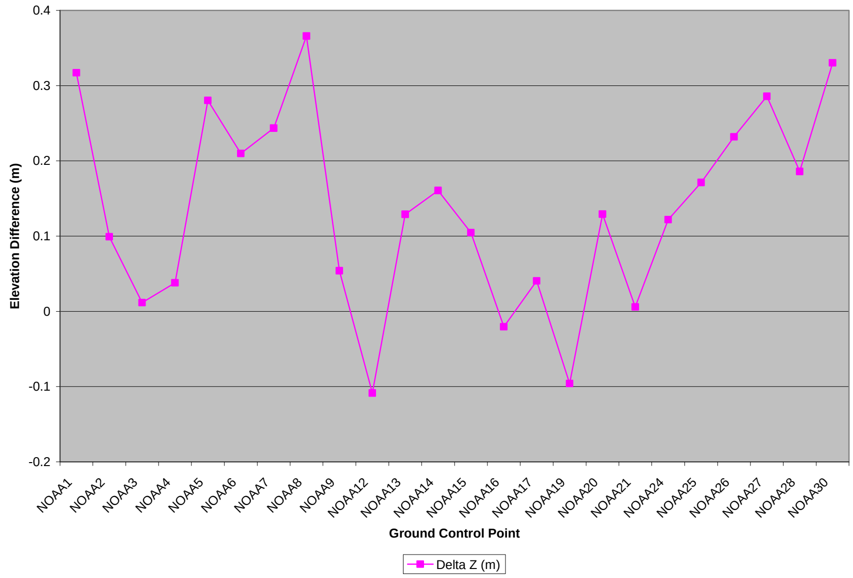

Figure 2: Plot of the elevation difference at each ground control point (GCP).

The spatial distribution of the elevation differences is presented in Figure 3. Each GCP is colored according to the magnitude of the error identified for the LIDAR elevation calculated at the GCP's xy location. LIDAR elevations higher than the ground control (i.e., negative differences) are symbolized with a black outlined circle and a black dot. LIDAR elevations lower that the ground control (i.e., positive differences) are symbolized with a solid single color circle.

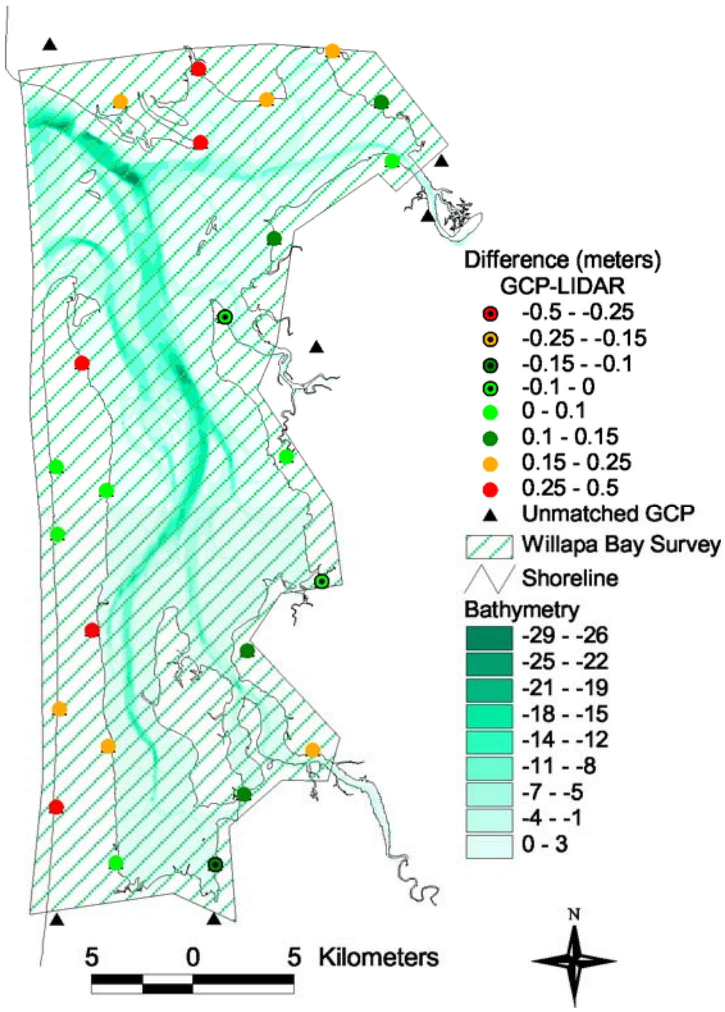

Figure 3: Map of the elevation differences between ground control points (GCP) and uncorrected LIDAR survey.

Discussion

The results of the comparison between the ground control and the LIDAR survey indicate a systematic offset where the LIDAR elevations are 13.72 centimeters lower than the true ground. Applying a correction for the bias by adding 13.72 centimeters to the LIDAR elevations, the resulting RMSE may be reduced to 12.84 centimeters. The spatial distribution of the elevation differences is presented in Figure 4 and the actual values are presented in a table in Appendix B.

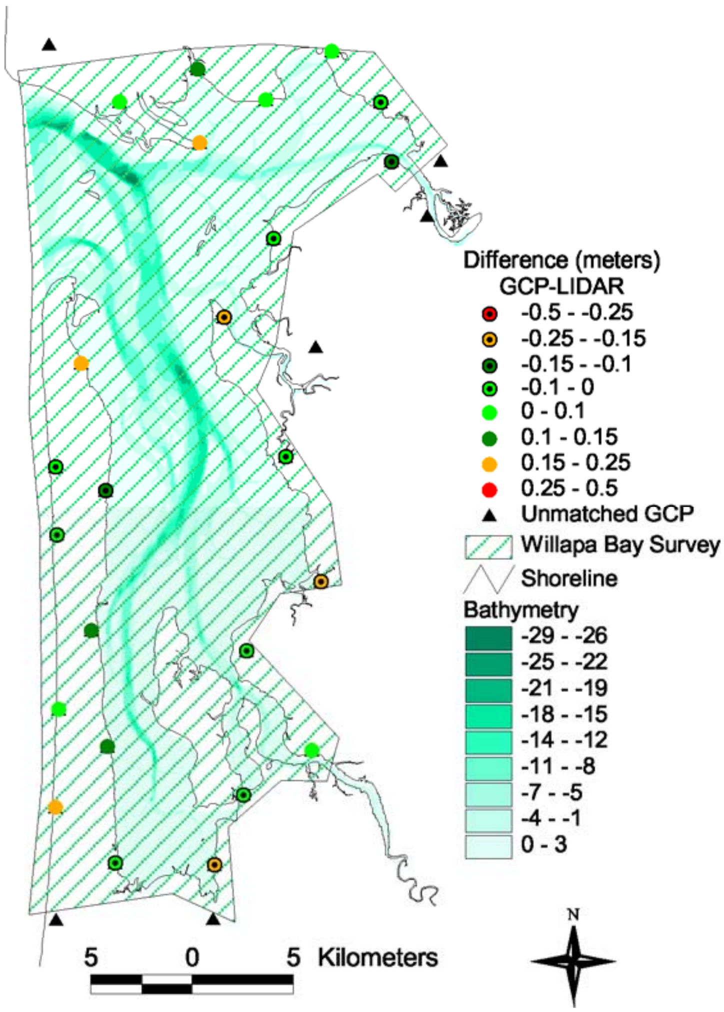

Figure 4: Map of the elevation difference at each ground control point (GCP) after applying a correction of 13.72 centimeters to the LIDAR elevation.

Based on this assessment and after applying the correction, the vertical accuracy for the 2002 Willapa Bay, WA survey may be reported according to the vertical accuracy reporting standard published in the National Standard for Spatial Data Accuracy as:

“Tested 0.25 meters fundamental vertical accuracy at 95% confidence level in open terrain”.

Appendix A

The following table shows the elevation difference calculated at each of the GCP before and after adding a 13.72 centimeter correction to the LIDAR elevations. The difference (Delta Z and Delta Z Corrected) were calculated by subtracting the LIDAR elevation from the GCP elevation.

GCP	GCP Z (m)	Delta Z (m)	Delta Z Corrected (m)
NOAA1	10.51	0.3171	0.180
NOAA2	5.41	0.0992	-0.038
NOAA3	3.34	0.0116	-0.126
NOAA4	5.86	0.0379	-0.099
NOAA5	3.64	0.2803	0.143
NOAA6	7.05	0.2098	0.073
NOAA7	4.42	0.2435	0.106
NOAA8	7.42	0.3658	0.229
NOAA9	4.29	0.0541	-0.083
NOAA12	3.15	-0.1085	-0.246
NOAA13	3.49	0.1289	-0.008
NOAA14	4.55	0.1607	0.024
NOAA15	123.39	0.1047	-0.032
NOAA16	17.08	-0.0205	-0.158
NOAA17	16.50	0.0405	-0.097
NOAA19	3.93	-0.0959	-0.233
NOAA20	16.22	0.1293	-0.008
NOAA21	2.56	0.0059	-0.131
NOAA24	5.41	0.1219	-0.015
NOAA25	3.44	0.1713	0.034
NOAA26	4.73	0.232	0.095
NOAA27	6.17	0.2859	0.149
NOAA28	4.92	0.186	0.049
NOAA30	4.77	0.3304	0.193
	mean	0.137	0.0
	sdev	0.131	0.131