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An Analysis of Hydrodynamic Change in the Nooksack River from 2005 to 2009

Abstract

The object of this study is to analyze the geomorphology of the Nooksack River near Deming from 2005 to 2009. The data used is LIDAR data from both time periods. The returns of the sensor was converted to ASCII in order to perform analysis. The analysis resulted in a classification of returns from 2005 and 2009, and a change in elevation from 2005 to 2009. The reasons for the varying density returns are a result in varying amounts of water, land cover, and vegetation. The increase or decrease of elevation in that time period are a result of fluvial processes of erosion and deposition of sediment as well as man-made influences.

Methods

Data Used:

To achieve the desired analysis of stream change, LIDAR data from both 2005 and 2009 was used. The data presented two sets of LIDAR of a stretch of the Nooksack River just east of Deming, WA, and just upstream from where the river meets the South Fork of the Nooksack. The data was initially in the form of 10 text files (5 from 2005, and 5 form 2009). Each text file contain data for the returns for each point in the study area. They were converted from text files to ASCII LIDAR Data so analysis could be performed. The image file from 2005 contained 560 rows by 451 columns and had an elevation ranging from 69 meters to 80 meters. The 2009 image file contained 1548 rows by 1811 columns and had an elevation ranging from 230 feet to 262 feet.

Analysis:

After converting the files to formats suitable for analysis, the images were loaded into a Fusion program in order to perform visual analysis. Once the images and raw data were loaded, an html file was derived in order to visualize and rank the elevation returns. In addition a bare earth file, a groundfilter, and a grid surface were generated from the ASCII files through further processing. All processing was first done for the 2005 files and then the 2009 files. Both the bare earth files from 2005 and 2009 were assigned projections (NAD 1983 UTM Zone 10 North for 2005, and State Plane NAD 1983 HARN Washington North FIPS4601 Feet for 2009), and then the 2009 file was reprojected into NAD 1983 UTM Zone 10 North so both files could have accurate analysis performed on them. Once both files were in the same projection the elevation data form each file was calculated, and the elevation from 2009 was subtracted from the elevation of 2005 in order to see the change in elevation over this time period. (All Methods are from Antonova and Wallin, 2014)

Results

Color Description	Percentage of Area with Data	Percentage of Total
Cells with no points (could be outside coverage area)	NA	33.74
Density less than minimum specification (less than 1.00 points per square unit)	9.72	6.44
Density within specification (1.00 to 2.00 points per square unit)	79.69	52.80
Density exceeds specification (more than 2.00 points per square unit)	10.59	7.02

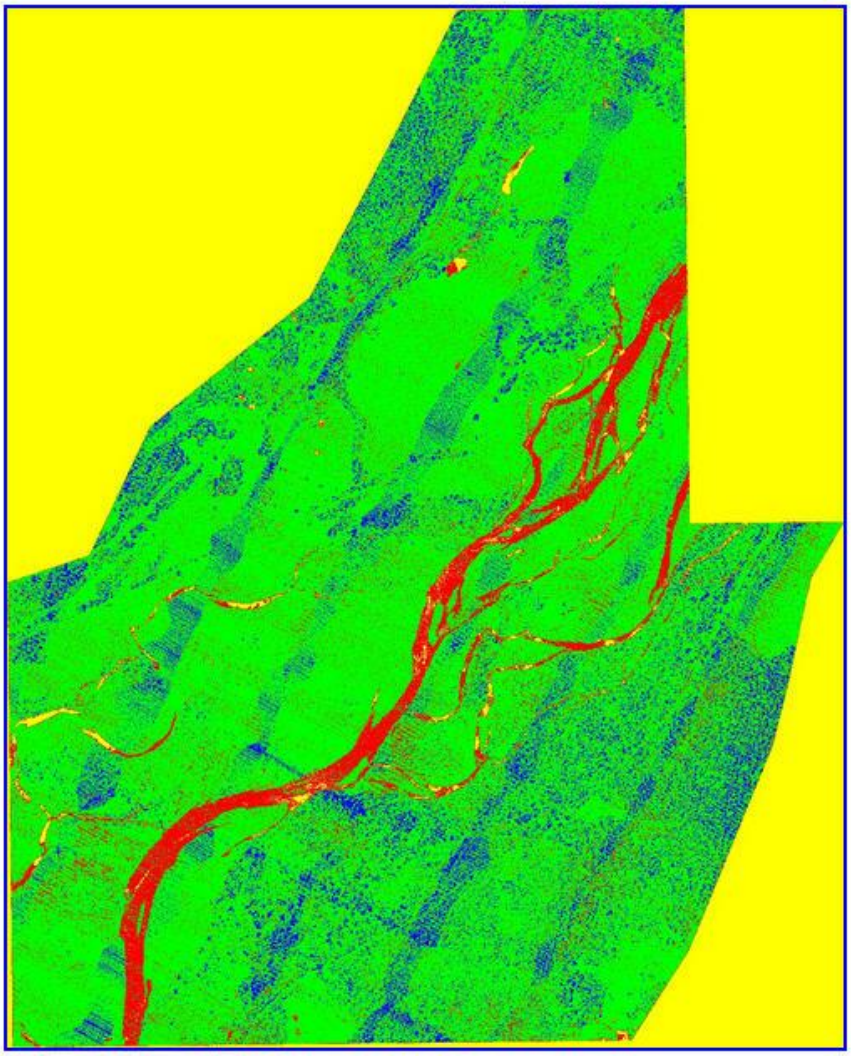

Figure 1. 2005 Return Density image of the Nooksack study area

The Return Density image for 2005 is comprised of 1400 rows by 1125 columns. The minimum return density was .25 returns per square unit. The minimum would be somewhere in the red area of the image. The maximum return density was 6.25 returns per square unit. These are somewhere in the blue areas of the image. The image also had an average return density of 1.47 per square unit.

Color	Description	Percentage of Area with Data	Percentage of Total
(yellow)	Cells with no points (could be outside coverage area)	NA	33.74
(red)	Density less than minimum specification (less than 1.00 points per square unit)	53.39	35.38
(green)	Density within specification (1.00 to 2.00 points per square unit)	38.28	25.37
(blue)	Density exceeds specification (more than 2.00 points per square unit)	8.33	5.52

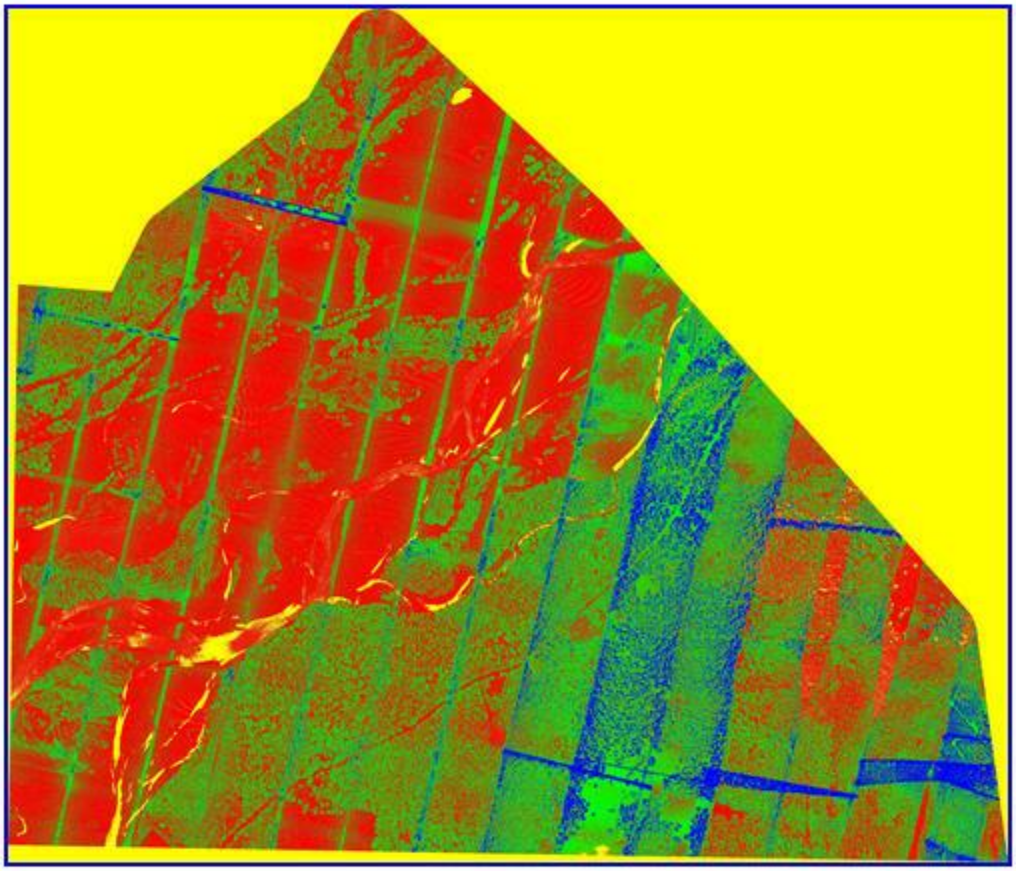

Figure 2. 2009 Density Return Image of the Nooksack study area

The Return Density image for 2009 is comprised 3869 rows by 4526 columns. The minimum return density was .25 returns per square unit. The minimum would be somewhere in the red area of the image. The maximum return density was 114 returns per square unit. These are somewhere in the blue areas of the image. The image also had an average return density of 1.07 per square unit. The 2009 Image was a much better resolution than the 2005 and thus had a greater return maximum, yet it did not have a larger average.

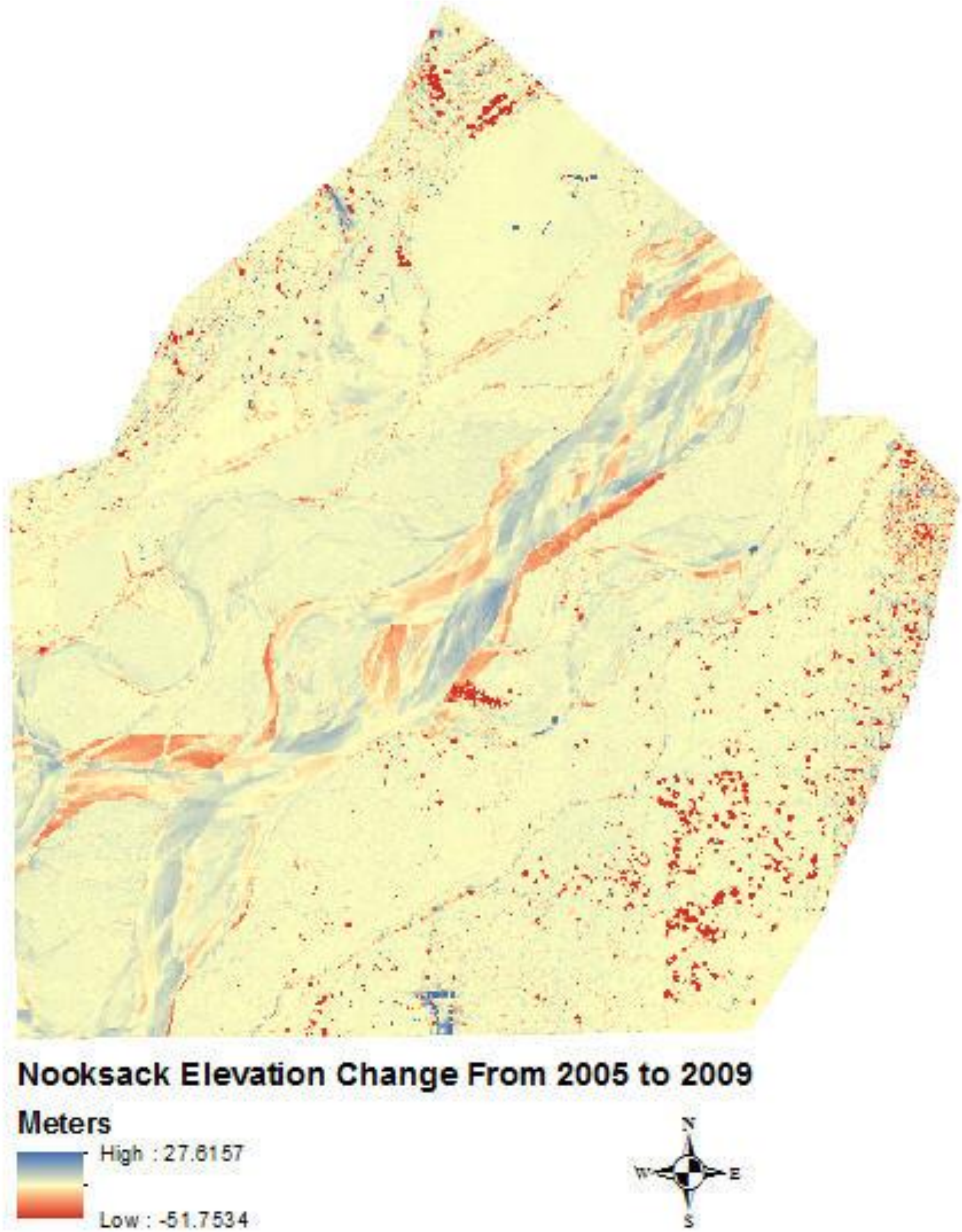

Figure 3. Bare Earth Elevation Change from 2005 to 2009 for the Nooksack Study Area

In Figure 3, the areas in the beige experienced little or no change over this time period, while the areas seen in blue underwent an increase in elevation and the areas in red experienced a decrease in elevation. Much of the change occurred in the traditional river bed of the Nooksack, however some areas outside of the drainage area also underwent change.

Discussion

The return density for 2005 was mostly what would be expected. Clearly the water has the lowest returns of the pulse. There are two possible explanations for this, one being that the pulses are absorbed upon contact with the water, the other is that the water changes the trajectory of the pulse and bounces it to another direction away from the sensor. The majority (80%) of the returns fall within a density of 1 to 2 points per square unit. Things like bare ground, and sparse to medium vegetation are likely to return these sorts of densities. The highest density is found in thicker canopied trees an also a series of straight swaths that intersect at nearly perfect right angles. These swaths are likely to be the flight path of the plane taking the reading. It seems to reason that areas directly below the sensor will have higher returns than other areas.

The 2009 image has similar results, although even with a higher resolution, the average return is much lower. The image shows a higher return in the southern and eastern part of the image. Once again the straight lines showing higher returns than the surrounding area are present. Also the water is consistently giving low returns or no returns. The reason for the low returns in the northeastern areas could be due to higher moisture levels, or possibly even standing water on the ground. Much of the area is actually pasture, and if the LIDAR was done after a large rain event, the ground could be saturated to the point of giving low returns. Another possibility could be atmospheric conditions. Usually cloudy days are not ideal for LIDAR sensing, yet if it was a clear day with a thin cloud, which could give lower returns than normal.

Overall the study was successful in determining the geomorphology of the Nooksack. By taking the difference of the two times it is clearly visible in Figure 3 to see how the river changed. The areas in red are new channels in which the river eroded away the bed resulting in a drop in elevation. Likewise the river will deposit sediment on the inside of a river bend as it erodes on the outside of a river bend. The inside bends are newly formed gravel bars that are displayed in the river bed as blue. Other areas are displayed that show a significant change in the land, although these are not a result of fluvial processes, but rather likely man made. A large number of dark red clusters are shown on the fringes of the extent. In most cases these are trees that were present in 2005, that no longer exist in 2009. Likewise housing developments that have been added since 2005 can be seen in dark blue.

The LIDAR data was an effective tool to see and evaluate changes in the landscape. In just the 4 years between the two data sets the resolution of the LIDAR increased dramatically. Any further studies in later time periods will have much more accurate datasets to work with, and will show greater and more detailed changes in the land.

Literature Cited

Antonova, N. & Wallin, D. 2014 *Lab 10: Using LIDAR Data to Monitor Channel Migration.* ESCI 442/542: Introduction into Remote Sensing < http://staff.wwu.edu/antonon/envr442/442_lidar_nooksack.htm>