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Measuring of Channel Migration in the North Fork of the Nooksack using LiDAR

ABSTRACT:

The North Fork of the Nooksack River experiences channel migration throughout time as it entrains and deposits sediment. I use light detection and ranging (lidar) images collected on the North Fork of the Nooksack River east of Demming Washington between 2005 and 2009 to quantify the migration of the channel and the amount of sediment movement. I take original all returns lidar data for the study area and convert it to a bare earth image using functions built into the FUSION software package. Using ArcGIS I then subtract the 2005 image from the 2009 image to show that the channel has moved a significant amount over those 4 years. I also show that a majority of the elevation change within the channel area is between 3 meters loss and 3 meters of gain. The study is a success and easily shows that repeatability of this type of study given the availability of lidar data.

METHODS:

Light detection and ranging (lidar) is an active sensor which emits EM energy and collects information about the return time (Campbell and Wynne, 2011). Original data collection for the 2005 lidar for the region was collected on March 23rd and April 11th 2005 with a spatial resolution of 2 meters. The 2009 Lidar image was collected on June 15th, 2009 with a spatial resolution of 6 feet. Both images are complete all return images.

The analysis I carried out generally follows Dr. Wallin's instructions. The first part of the analysis is primarily data processing which I did using FUSION, a lidar viewing and processing software produced by the United States Forest Service (Wallin, 2015). I downloaded the original 2005 data as text files which were converted to .las files which are used in FUSION. I used these .las files to create a mosaicked image of the area to better orient myself. I then used a series of batch commands created by Dr. Wallin to run through FUSION functions and the bare earth image used in analysis (Wallin, 2015). I first ran the ‘groudfilter’ and ‘gridsurfacecreate’ tools to generate a bare earth image which has eliminated high elevation points to create a ground surface. I then exported the bare earth image as an ASCII file using ‘dtm2ascci’ (Wallin, 2015). I did same process for the 2009 image, with the exception of creating .las files, because most of the preprocessing was done by Dr.Wallin.

In ArcGIS, I created raster digital elevation models using the ASCII to raster function. After defining projections and re-projecting the images to match, I used the raster calculator to simultaneously convert the 2009 image into meters from feet, and subtract the 2005 image. By subtracting images, I show the areas of change and channel migration.

RESULTS:

A majority of the mapping area experienced a minor loss of between 0.9 and 0 meters (Fig. 1). Throughout the relevant channel migration area a there is a relatively even distribution of minor loss in elevation between 0.9 and 0 meters, and moderate gain, between 0 and 3 meters (Fig. 1). Some areas within the channel migration area match the moderate gain with moderate loss of between 3.9 and 1 meter of elevation. The pattern of distribution is generally curvilinear running from the north east to the southwest portion of the map area.

Outliers of large gains in elevation between 3.1 and 27 meters, and large to extreme loss between 4 and 50 meters of elevation are concentrated on the edge of the mapping area generally to the south and south east, and in the north and northwest. The area of large elevation loss between 4 and 9 meters near the channel migration zone appears to be the only significant exception.

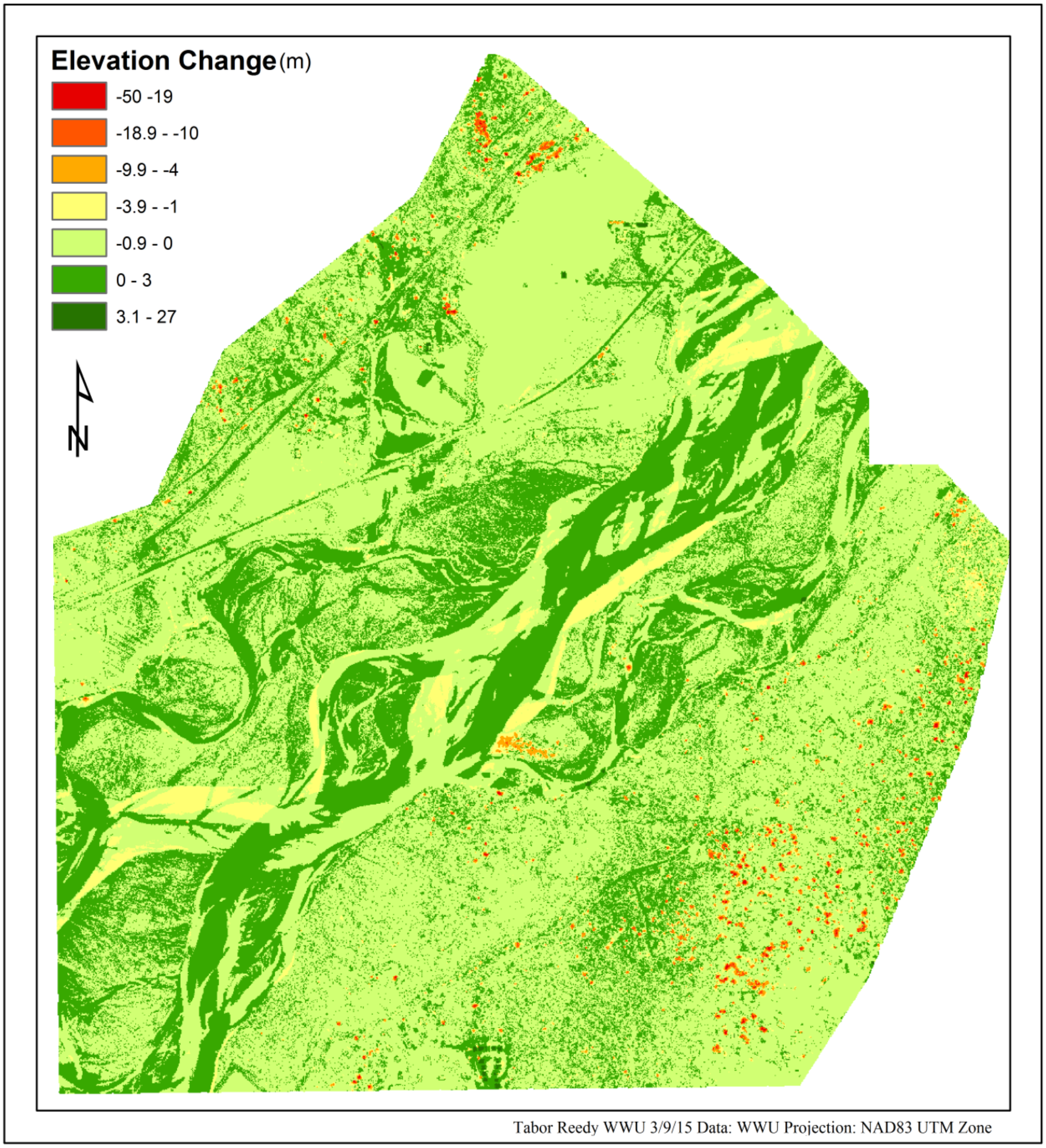

Figure 1. Channel migration in the North Fork of the Nooksack River between 2005 and 2009. Elevation changes have been binned based on Jenk's natural breaks with a slight modification for a meaningful zero point. The main focus of the study is on the curvilinear forms between the north east and the south west portions of the map which represents the active channel migration zone.

DISCUSSION:

This study succeeded in generating values that are within reason for elevation change throughout the channel migration area. The curvilinear area is generally interpreted to be the active channel area where meandering of the river channel moves and deposits large quantities of sediment. This interpretation is supported by google earth satellite imagery. With the help of satellite imagery, I interpret the large elevation loss area near the active channel to be from the death of trees from channel movement. Other areas of extreme loss are likely from logging or natural tree fall. I interpret the minor elevation gains in the northern portion of the mapping area as roads which possibly were resurfaced resulting in a gain.

The method of using bare earth lidar DEMs to observe changes in geomorphology is well accepted and is used in practice and research. The common use of lidar validated the methodology. The methods could potentially be improved with higher resolution data, which is quickly becoming more available. Auxiliary information such as rainfall, landslide, construction, and logging data all could provide better context and more accurate interpretations of changes. Though not included in the methods, I found satellite imagery useful in corroborating interpretations.

The only major bias affecting interpretation comes from the way I binned values. Different numbers of bins, and the distribution affects the general result and potentially the way it is interpreted. I decided to adjust the Jenk's natural breaks to give the mapping area a zero point. A majority of the bins have very few classes, which may lead to a generalization of the minor gain and minor loss in elevation categories. Generally the only problems are from my own error, but the original data were in different units and projections which are both rectified easily. A striped pattern in the original 2005 image from collection may also have a slight effect on results, I cannot discern any effect on the final result in figure 1.

Safety of human lives and infrastructure often depends a landscape that has high temporal variability such as active river channels. Knowing the patterns of movement and identifying areas that could potentially be at risk is valuable for both financial and human reasons. This method is a quick and easy way, given the availability of lidar for any given study area, to map, monitor, and predict landscape changes.

REFERENCES:

Campbell, J.B. and R.H. Wynne. 2011. Introduction to Remote Sensing, 5th Ed. The Guilford Press. New York, NY.

Wallin, D. 2015. Lab X: Using LIDAR Data to Monitor Channel Migration http://faculty.wwu.edu/wallin/envr442/442_lidar_nooksack.htm