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Metadata for North Shore Coastal Bluff Survey Project

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Description:

Six bluffs were surveyed 2-3 times each between 2016 and 2018 using a Faro Focus 3D terrestrial laser scanner (TLS) and four bluffs were surveyed once via photogrammetry from a DJI Phantom 4 UAV (uncrewed aerial vehicle). The photogrammetry data were turned into high-resolution topographic data using Structure-from-Motion (SfM) processing. Dates of the surveys are listed below in Table 1 with site locations in Table 2.

Table 1: Dates of data collection on Amity Creek and Knife River study bluffs

Study Bluff	TLS Survey Date	UAV/SfM Survey Date
Amity H	11/6/16, 5/23/17, 5/1/18	5/23/17
Amity SW	11/2/16, 5/27/17, 5/1/18	5/27/17
Amity CT	6/2/17, 5/2/18	N/A
Amity BW	11/16*, 5/29/17, 5/2/18	N/A
Knife JL	11/6/16, 6/6/17, 5/15/18	6/6/17
Knife BD	6/7/17, 5/15/18	5/13/18

*Specific date not recorded, but likely between 11/2/16 and 11/6/16

N/A = not applicable

Table 2: Site locations

Study Bluff	Latitude	Longitude
Amity H	46°51'19" N	92°00'45" W
Amity SW	46°51'29" N	92°00'40" W
Amity CT	46°51'28" N	92°01'51" W
Amity BW	46°51'36" N	92°00'40" W
Knife JL	46°59'04" N	91°47'08" W
Knife BD	46°58'15" N	91°47'25" W

Data included in the archive:

SfM Surveys

Overlapping photogrammetry data were collected using a DJI Phantom IV UAV with side-looking camera orientations. The photos were input into Agisoft Metashape where they were analyzed using Structure-from-Motion to develop point cloud datasets with resulting point cloud densities of 3.3 to 31.5 points/cm². The SfM data were georeferenced to the local coordinates within the TLS data collected simultaneously, providing a scale and an internally-consistent orientation to the data.

Point clouds were analyzed in two different frames of reference: rotated and floodplain normal. The floodplain normal point clouds have the Z axis oriented in the up-down direction. The rotated datasets have the Z axis rotated to be oriented perpendicular to the bluff face. The point cloud data are available as .txt files in both orientations. The rotated point cloud datasets end in “_append”, while the floodplain normal point cloud datasets do not. File names indicate the site and survey date (season and year). Because point cloud files are so large, each site has been uploaded individually as

>>SfM_PC_xxx_yyy where xxx is the date of the survey and yyy is the site location

Point cloud files are saved as ASCII .txt files with the form (x y z R G B Nx Ny Nz), where (x, y, z) are the point locations, (R, G, B) are the colors, and (Nx, Ny, Nz) are the normal vectors. They can be opened in CloudCompare or other point cloud analysis program.

DEMs (digital elevation models) were generated from the point cloud data in both orientations. The Z direction becomes the elevation recorded in each cell of the DEM. DEMs are 10cm x 10cm resolution and were generated in two different ways. Those with “sfmave” in their title were created using the average elevation over a 10cm x 10cm moving window. Those with “sfmmin” in their title were created using the minimum elevation over a 10xm x 10xm moving window. DEMs are stored as ArcGIS raster files in separate folders for floodplain normal and rotated orientations.

Floodplain Normal: >> SfM_DEMs/FloodplainNormal

Rotated: >> SfM_DEMs/Rotated

GCDs (geomorphic change detection) files show the difference between the data collected using TLS and the SfM data. They are ArcGIS 10.6 project files that contain DEMs from TLS and SfM and the DoD (DEM of Difference) showing the TLS surveys subtracted from the SfM surveys. More information about the GCD files can be found at the end of this document.

>> SfM_GCD

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Within each of the site folders there are individual folders for Rotated and FloodplainNormal analyses, using average and minimum elevation values (per DEMs – see above). In each site folder, there is an ArcMap project and a data folder. Within the data folder, the DEM data can be found under “Inputs”, and the DoD (DEM of Difference) can be found under Analyses. “Raw” is the raw DoD, and “thresh” is the DoD with a threshold of 0.10 m applied as the LoD (Level of Detection). Opening the .gcd files directly requires installation of the Geomorphic Change Detection ArcGIS plug-in or standalone software which can be found at <http://gcd.riverscapes.xyz/>.

TLS Surveys

Terrestrial Laser Scanner (TLS) point cloud data were collected with a Faro Focus 3D instrument. Bluffs were scanned during snow-off, leaf-off conditions (see Table 1 for scan dates) to minimize vegetation interference. Multiple scans were taken at each site, with spheres used as ground control point targets for internal alignment. Point clouds were processed in Faro Scene software to internally align, rotate (floodplain normal or rotated (perpendicular to bluff face), and digitally remove vegetation or other erroneous data. Point clouds were exported as .txt files. Point cloud files that end in “_append” were rotated to have Z values be perpendicular to the bluff face. Point cloud files that do not are in floodplain normal orientations. File names indicate the site and survey date (season and year). Because point cloud files are so large, each site has been uploaded individually with multiple years (2-3) zipped together in a zip file.
>> TLS_PC_ yyy where yyy is the site name

DEMs (Digital Elevation Models) were created from each point cloud. They are created using the minimum Z value over a 10cm x 10cm moving window to better remove any lingering vegetation. For each scan, there are two DEMs that were generated: one with Z values in a floodplain normal orientation and one with Z values oriented perpendicular to the floodplain. DEMs are stored as ArcGIS raster files in separate folders for floodplain normal and rotated orientations.

Floodplain Normal: >> TLS_DEMs/FloodplainNormal

Rotated: >> TLS_DEMs/Rotated

GCDs (geomorphic change detection) files show the difference between the data collected on different dates. They are ArcGIS 10.6 project files that contain the two years and a DoD (DEM of Difference) with the older survey subtracted from the more recent survey. Names reflect the site location and the two years that were compared.

Floodplain Normal: >> TLS_GCD/FloodplainNormal

Rotated: >> TLS_GCD/Rotated

Within each of these folders there are individual folders with the site name and two dates on the folder. In each site folder under FloodplainNormal, there is an ArcMap project and a data folder. Within the data folder, the DEM data can be found under “Inputs”, and the DoD (DEM of Difference) can be found under Analyses. “Raw” is the raw DoD, and “thresh” is the DoD with a threshold of 0.10 m applied as the LoD (Level of Detection). Opening the .gcd files directly requires installation of the Geomorphic Change Detection ArcGIS plug-in or standalone software which can be found at <http://gcd.riverscapes.xyz/>.

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Notes on Geomorphic Change Detection (GCD) files:

Within the SfM_GCD and TLS_GCD Analyses folders are the following files and folders that contain the results of the geographic change detection analysis. These files were created using the ArcGIS GCD plug-in available from <http://gcd.riverscapes.xyz/>.

Path	Description
<code>raw.tif</code>	The spatial results of the change detection in raster format without applying any thresholding techniques. Simply DEM _{new} - DEM _{old} .
<code>thresh.tif</code>	The spatial results of the change detection in raster format with the error with the thresholding techniques applied.
<code>raw.csv</code>	Numerical results of the change detection in comma separated values format without applying any thresholding techniques. It contains the following fields Lower Elevation Range, Upper Elevation Range, Total Area, Total Volume, Number of Cells. This is the areal and volumetric changes placed into preset bins.
<code>Summary.xml</code>	Summary of numerical results of the change detection in Microsoft Excel format. It contains results both with and without applying thresholding. This the same table that is presented within the GCD software by right clicking on a change detection and choosing view change detection results .
<code>thresh.csv</code>	Numerical results of the change detection in comma separated values format with the thresholding techniques applied. Simply DEM _{new} - DEM _{old} . It contains the following fields Lower Elevation Range, Upper Elevation Range, Total Area, Total Volume, Number of Cells. This is the areal and volumetric changes placed into preset bins.
<code>Figs</code>	Folder of pre-generated figure graphics.
<code>Figs\ChangeBars_AreaAbsolute.png</code>	Bar chart of the actual area of change for erosion and deposition. Red is surface lowering and is represented by negative values. Blue is surface raising and is represented by positive values.
<code>Figs\ChangeBars_AreaRelative.png</code>	Bar chart of the relative area of change for surface lowering and raising, absolute values are used to allow for easier comparisons. Both raising and lowering are represented by positive values.
<code>Figs\ChangeBars_DepthAbsolute.png</code>	Bar chart of the actual average depth of change for erosion and deposition. Red is lowering and is represented by negative values. Blue is raising and is represented by positive values.
<code>Figs\ChangeBars_DepthRelative.png</code>	Bar chart of the absolute average depth of change for surface raising and lowering, absolute values are used to allow for easier

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Path	Description
	comparisons. Both raising and lowering are represented by positive values.
Figs\ChangeBars_VolumeAbsolute.png	Bar chart of the actual volume of change for erosion and deposition. Red is surface lowering and is represented by negative values. Blue is surface raising and is represented by positive values.
Figs\ChangeBars_VolumeRelative.png	Bar chart of the relative volume of change for erosion and deposition, absolute values are used to allow for easier comparisons. Both surface raising and lowering are represented by positive values.
Figs\Histogram_Area.png	Histogram of the area of change. Red is surface lowering. Blue is surface raising.
Figs\Histogram_Volume.png	Histogram of the volume of change. Red is surface lowering and blue is surface raising.

For more information about the geomorphic change detection files, see additional tutorials and documentation on the Geomorphic Change Detection Software website:

<http://gcd.riverscapes.xyz/Help/>