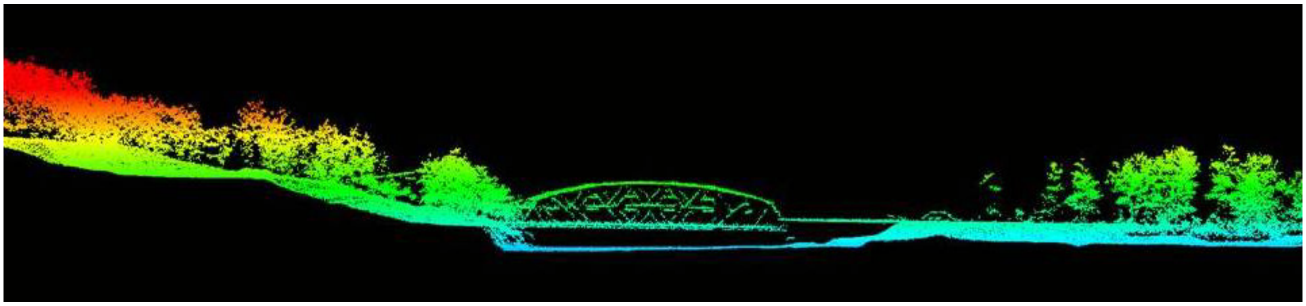


# Matanuska-Susitna Borough LiDAR & Imagery Project Quality Assurance Report Matanuska Block V2


**Written by Rick Guritz**

**Alaska Satellite Facility**


**March 28, 2013**

# Contents

## Study Area – Matanuska Block

The study area for this report is the Matanuska block, which includes 472 square miles covering the next block east of Core Area block. In the delivery blocks and tile map, it is shown in red (see Figure 1).

## Basis for Evaluation

The Software used for the evaluation includes:

- ESRI ArcMap and ArcCatalog 10.0
- Applied Imagery Quick Terrain Modeler v7.1.5 64-bit
- Blue Marble Geographics, Global Mapper v13.1.2

Each block of LiDAR will be evaluated in the following ways:

- Check formatting and completeness of data delivery,
- Check completeness, clarity, and compliance of metadata,
- Assess the planimetric accuracy of the LiDAR data,
- Assess the vertical accuracy of the LiDAR data,
- Assess the LiDAR point cloud data of return density and classification accuracy,
- Assess the LiDAR bare-Earth and first-return surface data by mosaic and shaded relief analysis, identifying gaps, seams, anomalies, and hydro-flattening of data,
- Verify consistency of various derived products being provided by LiDAR contractor.

Itemized products to be evaluated include:

- Metadata
- Classified point cloud data in LAS format
- Bare-Earth surface (below canopy raster DEM)
- First-Return surface (top of canopy raster DSM)
- Intensity image composite
- Hydro-flattening breaklines (single and double line) and lake polygons
- Contours (elevation)
- Shaded relief mosaics
- Tile Index (full and quarter tile) and building feature classes (structures >400 square feet)

## Format and Completeness of Data Delivery

Twelve separate data deliveries were required to correct all identified data anomalies.  Each delivery provided data on an external computer disk organized by block and data type or smaller tile fixes were staged to FTP. The Caswell Lake block deliveries included:

- Metadata – A single metadata file for each major product type including point clouds, raster bare-Earth DEM, raster first-return DSM, elevation contours, elevation contours in DXF.
- LiDAR DATA - LAS point cloud data for 272 quarter tiles covering 85 full tiles of data.
- Contours – DXF format contours for 272 quarter tiles covering 85 full tiles of data.
- Block Geodatabase which contained the following elements:
    - Bare-Earth DEM raster catalog,
    - Buildings feature dataset,
    - Contours feature dataset,
    - First-return DSM raster catalog,
    - Hydro features dataset including single and double breaklines and lake polygons,
    - Intensity Imagery raster catalog,
    - Tile index feature datasets including full and quarter tile,
    - Block boundary polygon.

The contents of the LiDAR point cloud files were verified to include the expected LiDAR classification layers. Then each layer was loaded into Quick Terrain Modeler (QTM) to verify coverage and extent of each classification layer. Each layer was captured to a computer graphic image in jpeg format for review. In some cases, the number of points within a classification layer needed to be separated into quarter block areas to keep within available memory (16 GB) to optimize RAM use. In these cases up to four jpeg images were saved for the layer. Although this process was time consuming, it proved very useful in identifying omissions in coverage for particular classifications. By saving each layer in QTM, the number of points included in each classification layer was compiled to verify that the data was distributed appropriately between classification layers.

The contractor supplied GIS layers including block boundary, full and quarter tile indexes were displayed and evaluated to insure consistency with the original project coverage feature class (see Figure 2). The raster catalogs stored in the block geodatabase were combined into large scale raster mosaics and stored as geotiff products for evaluation purposes. Shaded relief images were produced from each of the surface elevation products to evaluate completeness of coverage, gaps, seams, or other data anomalies. The intensity image mosaic was also evaluated for completeness of coverage and quality of data. We observed variability in the LiDAR intensity data that is typical for this type of data. This is due to variations in sunlight conditions at time of acquisition and other factors that are beyond the contractor's control.

## Completeness, Clarity, and Compliance of Metadata

Each metadata file was examined for both content and clarity of the included metadata descriptions. Minor changes were requested when UAF spotted inaccuracies or omissions. In general, UAF found the metadata to be very good. To test for FGDC metadata format compliance, we used the USGS Metadata Parser (MP) program. No metadata errors were reported with the revised metadata after the initial errors reported in Point Mackenzie block.

## Planimetric Accuracy of the LiDAR Data

There were eighteen checkpoints for the developed classification in the Matanuska block. The survey contractor, Lounsbury & Associates, identified and surveyed paint markings on the asphalt surface of roads and parking lots. Although these points provide a reliable elevation, they were not identifiable within the LiDAR data or complement ortho imagery. I understand from MSB staff that the contract language did not convey correctly map identifiable features such as road intersections, corners of buildings, or unique lake shoreline features that would not be influenced by water level change. In this area the ortho and the LiDAR intensity was consistent in geolocation. For each point, image chips were extracted from both the LiDAR intensity and ortho imagery at two different scales were compiled into a power point presentation file for review along with pictures of each point as provided by the survey contractor.

## Vertical Accuracy of the LiDAR Data

There were one hundred and nine checkpoints within the Matanuska block. These included eighty-one barren land, eleven developed, six forested, six shrub, and five wetlands points in separate land cover classifications. Using ArcMap, a Bare-Earth DEM mosaic was produced and elevation values for all checkpoints were extracted from the DEM. This was compiled into a spreadsheet and organized by land cover classifications on separate worksheets (see Figure 3). A vertical accuracy assessment was done for each land cover classification and compared to target accuracy specifications included in the LiDAR contract. For the Matanuska block, the barren ground class used the RMSE at 95%, and all other classes used the 95 percentile method of evaluating accuracy. Which method to use is based on the expected error distribution for a given land cover classification. UAF also looked at the combined class statistics which are included below. The target accuracy specifications are listed to the right of each accuracy measurement. The target accuracy is colored green if it passed or red if it failed to meet the target vertical accuracy specification. For Matanuska block, the forested and shrub class were not accurate enough to meet the target vertical accuracy specification. Each of these classes failed due to one bad point. All other classes were accurate enough to meet the target vertical accuracy specification. The combined accuracies of all points were also accurate enough to meet the target vertical accuracy specification. **It should be noted for these methods to be statistically valid; at least 20 points should be**

**used per class. This will be the case for the project wide assessment only, and not the individual block assessments.**

| **Barren Land (FVA)** | | | **Target** |
|---|---|---|---|
| **Statistical Summary:** | **Feet** | **Meter** | **Accuracy** |
| Count = 81 pts | | | |
| Min = | -1.460 | -0.445 | |
| Max = | 1.062 | 0.324 | |
| Mean = | -0.049 | -0.015 | |
| RMSE = | 0.274 | 0.084 | |
| RMSE*1.96 (95%) = | 0.537 | 0.164 | < 0.245 m |
| Stddev = | 0.269 | 0.082 | |

Table 1, Barren Land Class (SVA) Accuracy Assessment Summary

| **Developed (CVA)** | | | **Target** |
|---|---|---|---|
| **Statistical Summary:** | **Feet** | **Meter** | **Accuracy** |
| Count = 11 pts | | | |
| Min = | -0.887 | -0.270 | |
| Max = | 0.131 | 0.040 | |
| Mean = | -0.230 | -0.070 | |
| RMSE = | 0.342 | 0.104 | |
| 95 Percentile = | 0.682 | 0.208 | < 0.363 m |
| Stddev = | 0.253 | 0.077 | |

Table 2, Developed Class (SVA) Accuracy Assessment Summary

| **Forested (CVA)** | | | **Target** |
|---|---|---|---|
| **Statistical Summary:** | **Feet** | **Meter** | **Accuracy** |
| Count = 6 pts | | | |
| Min = | -0.501 | -0.153 | |
| Max = | 1.354 | 0.413 | |
| Mean = | 0.270 | 0.082 | |
| RMSE = | 0.796 | 0.243 | |
| 95 Percentile = | 1.317 | 0.402 | < 0.363 m |
| Stddev = | 0.749 | 0.228 | |

Table 3, Forested Class (SVA) Accuracy Assessment Summary

| Shrub (CVA) | | | Target |
|---|---|---|---|
| **Statistical Summary:** | **Feet** | **Meter** | **Accuracy** |
| Count = 6 pts | | | |
| Min = | -0.275 | -0.084 | |
| Max = | 1.453 | 0.443 | |
| Mean = | 0.248 | 0.076 | |
| RMSE = | 0.641 | 0.195 | |
| 95 Percentile = | 1.210 | 0.369 | < 0.363 m |
| Stddev = | 0.591 | 0.180 | |

Table 4, Shrub Class (SVA) Accuracy Assessment Summary

| Wetlands (CVA) | | | Target |
|---|---|---|---|
| **Statistical Summary:** | **Feet** | **Meter** | **Accuracy** |
| Count = 5 pts | | | |
| Min = | -0.134 | -0.041 | |
| Max = | 0.267 | 0.081 | |
| Mean = | 0.134 | 0.041 | |
| RMSE = | 0.196 | 0.060 | |
| 95 Percentile = | 0.260 | 0.079 | < 0.363 m |
| Stddev = | 0.143 | 0.044 | |

Table 5, Wetlands Class (SVA) Accuracy Assessment Summary

| Combined (SVA) | | | Target |
|---|---|---|---|
| **Statistical Summary:** | **Feet** | **Meter** | **Accuracy** |
| Count = 109 pts | | | |
| Min = | -1.460 | -0.445 | |
| Max = | 1.453 | 0.443 | |
| Mean = | -0.025 | -0.008 | |
| RMSE = | 0.356 | 0.109 | |
| 95 Percentile = | 0.829 | 0.253 | < 0.363 m |
| Stddev = | 0.355 | 0.108 | |

Table 6, Combined (CVA) Accuracy Assessment Summary

## LiDAR Point Cloud Data Density and Classification Accuracy

Point Density was determined using LAS tools provided by Aerometric. The application provides an ability to count point density creating ESRI ASCII GRID files for each tile. Global Mapper was used to read and display all of these grid files for the block (see Figure 4). We had to limit the point density per cell to a maximum of 12 points clamping values greater to that value so that the color map would show sufficient color variation at the low end. Point density is displayed using a color map from blue (low) to red (high). The grid spacing used for the evaluation was 4 feet per pixel, 2*NPS of 0.6 meter as specified in the contract. The First-Return of all valid classes (2-6, 8-11, and 13-14), excluding withheld bit data classes (1 and 7). At least 90% of the cells should contain at least one LiDAR point. For the Matanuska block, first-return density was confirmed to exceed 90% for all interior cells of the combined point cloud data.

Each classification layer in the LAS point cloud was loaded into Quick Terrain Modeler to verify extent and completeness of coverage, number of points per class, and accuracy of classification. Given the number of points included in some of the larger classifications, it is necessary to split the block into quarters (i.e. SW, SE, NW, and NE). Some classes such as the low, medium, and high vegetation are texture mapped using a solid color such as light, medium, and dark green respectively. Otherwise, the data is displayed with a color ramp for the elevation range of the block. In this way, the four quarters can be assembled into complete block coverage with a consistent color map for the height variation. During the assessments, UAF found and reported inconsistencies where data were omitted. Aerometric used the improved class definitions of previously processed blocks such as separation of unclassified data swaths ends (CLASS 1) from surface clutter data (class 13), and redefining low vegetation from 1 to 6 feet. For the Matanuska block, there were five separate glacier point classes to separate data by date of acquisition. This was necessary due to the glacier motion between acquisitions.

The classifications included in the LAS point cloud data are listed below in order of class with point count totals per class:

| **Class # - Class Description** | **Point Count** | **Reference** |
|---|---|---|
| Class 1 - Unclassified Data (marked as withheld) | 127,994,278 | Figure 5 |
| Class 2 - Ground | 1,796,224,005 | Figure 6 |
| Class 3 - Low Vegetation | 385,263,640 | Figure 7 |
| Class 4 - Medium Vegetation | 543,309,145 | Figure 8 |
| Class 5 - High Vegetation | 2,085,765,702 | Figure 9 |
| Class 6 - Buildings | 7,990,410 | Figure 10 |
| Class 7 - Error Points (Noise) | 8,103,639 | Figure 11 |
| Class 8 - Ground Model Keypoints | 114,866,071 | Figure 12 |
| Class 9 - Water | 42,044,491 | Figure 13 |
| Class 10 - Breakline Proximity | 3,160,353 | Figure 14 |
| Class 11 - Power Transmission Lines | 372,102 | Figure 15 |
| Class 13 - Surface Clutter (within foot of surface) | 2,575,629,998 | Figure 16 |
| Class 14 - Bridge Decks | 85,420 | Figure 17 |
| Class 18 - Glacier | 2,322,441 | Figure 18 |
| Class 19 - Glacier | 3,075,172 | Figure 19 |
| Class 26 - Glacier | 1,625,205 | Figure 20 |
| Class 27 - Glacier | 36,665 | Figure 21 |
| Class 28 - Glacier | 304,252 | Figure 22 |

Table 7, LiDAR Point Cloud Classes Summary Table

Cross validation analysis was performed between each of the class layers and other source data. Quick Terrain Modeler was used initially to produce height profiles of multiple layers from a point cloud. This capability was used to verify issues with the low vegetation layer extending across rivers and streams (see Figure 23). This shows the presence of LiDAR returns from each vegetation layer, low, medium, high, ground and water surfaces. Another example, a canopy height can be estimated by subtracting the bare-Earth surface DEM from the first-return DSM (see Figure 24). This product could then be colorized based on a number of classifications to match each of the three vegetation layers (see Figure 25), i.e. 1-6 feet for low vegetation (light green), 6-15 feet for medium vegetation (medium green), and greater than 15 feet for high vegetation (dark green). Barren ground could have height differences from -1 to 1 foot. Other classes could draw attention to outlier heights such as values less than one (red) and values greater than 120 feet (violet). The individual layer product could be compared to this classified product, keeping in mind that in high vegetation, there may also be returns for medium vegetation, low vegetation, or even ground. Other layers such as water can be compared to bare Earth elevations of the lakes and rivers by using the contractor supplied polygons of lakes and single and double breakline polyline feature files to clip and compare elevations of hydro flattened water to the LiDAR point cloud elevations. Similarly, the buildings layer can be compared to both the buildings feature class and to the ortho imagery for the block to verify the accuracy of the buildings layer.

## LiDAR Gridded Products

There are three gridded products being delivered for each block. These include the bare-Earth DEM, the first-return DSM, and the LiDAR intensity image. Each of these raster data sets are being delivered as raster catalogs within the block geodatabase. For each type of data, a mosaic product was produced from each raster catalog (see Figure 26, 27, and 28). Then for the two surface products, a shaded relief image is produced with consistent elevation and angle of the sun to provide consistency (see Figure 29 and 30). These derived images are then evaluated visually by zooming up to a quarter tile per screen and panning through the mosaic, left to right, and top to bottom. Any height discontinuity between swaths or tiles would show up as a darker linear feature with a common orientation (to detect seams). Any regions of missing data will show up as dark edge to white interior of the missing data (to detect voids). Surface texture gives clues to intermittent vegetation (to detect corn rows) which may or may not be valid depending on the surface type. If anomalies are detected, then comparison to tile edges or swath edges can be made by bringing in other GIS layers for comparison. For the Matanuska block, seams and artifacts were found in the first return DSM and documented with seven screen captures that showed shifts in the delivered data. There were six missing quarter tiles of LiDAR intensity data. These problems were reported and later fixed in subsequent deliveries. Other issues such as power transmission lines and related height anomalies over water were reported as a result of redelivery of data, requiring multiple deliveries of the same product.

The bare-Earth gridded DEM is hydro flattened according to contract specifications. To verify this and to insure consistent heights were retained over water features, GIS analysis was performed on the contractor supplied data. The hydro breaklines include lake polygons, and either single for small streams and double breaklines for larger streams are included (see Figure 31). First the lake polygons were used to clip the bare-Earth DEM elevations for lake heights. This was compared to the water heights layer from the point cloud data. By loading consistent color map, contract stretch method to linear and minimum/maximum height range into both ArcMap and Quick Terrain Modeler the resulting images can be compared for consistency. Streams greater than 100 feet nominal width and a list of nineteen streams supplied by the Matanuska-Susitna Borough should be delineated with double breaklines. These polyline structures are combined to create polygons for each stream or river contained in the block. The hydro breaklines were delivered as polylines, so additional editing was needed to separate major rivers and streams from each other as individual polygons. Then the bare-Earth DEM was clipped for each river, stream, or slough, colorized and compared to the point cloud layer for that specific water body. A similar approach is taken within Quick Terrain Modeler for the specific water body so that the heights of the flattened water can be compared to the original LiDAR returns over that water surface. In this way, all streams could be checked for flow direction, magnitude, and consistency to the original LiDAR returns over that water body. In some cases, stream width and long length of smaller streams required dividing a stream into multiple equal length sections to retain visibility of the resulting image. For the Matanuska block, we analyzed lakes (see Figure 32) and streams including Bodenburg Creek (see Figure 33), Chickaloon River (see Figure 34), Eklutna Powerhouse Creek (see Figure 35), Ezi Slough (see Figure 36), Fortress Creek (see Figure 37), Glacier Fork Knik River (See Figure 38), Jim Creek (See Figure 39), Knik River (See Figure 40), Matanuska River (see Figure 41), and Tsadaka Creek (See Figure 42). All water bodies looked good.

## LiDAR Derived Products

Derived products include a variety of GIS layers including tile index, hydro breaklines of lakes and streams, building feature class and topographic contours. These are delivered as elements in a block geodatabase. The tile index feature class provides both full tile and quarter tile. Aerometric was asked to include a block boundary feature class for each block that defines the geographic extent of each block. This should align where blocks join each other and provide a 100 meter buffer where no adjacent blocks are present. The boundary file is first checked against the original block definition provided with the LiDAR contract by Matanuska-Susitna Borough. The desired coverage and added buffer distance has been verified.

The building feature class is verified by performing a detailed examination of the quarter tile with the most buildings. Visual verification is performed on each building to the ortho imagery or canopy height difference classification (see Figure 43 and 44) looking for buildings that were missed or classified building that were incorrectly identified (false positives). Buidings of greater than 400 square feet should be included at 97% success rate. Separate feature classes are created for new buildings and buildings that were misclassified (false positives). Areas are calculated for new buildings and the accuracy for this quarter tile is checked and reported. Given the limited time, the quarter tile with the highest building density was checked for accuracy and reported as representative of the block. For the Matanuska block, tile MAT_024_SW was identified as the quarter tile with the most buildings in it, including 1197 buildings. I then performed my analysis and found 13 false positives of which 3 were greater than 400 square feet. There were 6 missed buildings of which 1 was greater than 400 square feet. If we only consider buildings with 400 square feet or more, then there were 3 false positives and 1 missed building from 1043 correctly identified buildings. There were 4 errors from 1044 buildings giving a failure rate of 0.36% or an accuracy of 99.64% which exceeds the target accuracy of 97%. A final building analysis graphic (see Figure 45) was produced with accurate buildings (light blue), incorrect buildings (red), and new buildings (dark blue) to document results from the analysis. Separate feature classes for each of the three categories are also produced for further analysis and provided to the Matanuska-Susitna Borough GIS staff.

The elevation contours are supplied in two different formats, one as a polyline feature for each tile in the block geodatabase, and the other is in AutoCAD format DXF format. A set of four contour tiles are displayed as an overlay to the bare-Earth DEM and visually examined for consistency. Due to limited time, only a statistical sample of the data is evaluated. The Matanuska-Susitna Borough GIS staff suggested that UAF pick contour tiles with the steepest slope as candidates for testing. A slope map in degrees was first generated from the bare-Earth DEM mosaic and colorized with a blue to red color map with steepest terrain in red (see Figure 46). From this map, tiles with the steepest terrain were selected. Each of four tiles were displayed and compared with the bare-Earth DEM elevations for that tile. The tighter the space between contours, the steeper the slope should be in the corresponding DEM. This can be visually compared to how rapid the change in color is of the underlying DEM. Next, UAF created topologies for each of the selected tiles, testing for contour topology errors based on four selected rules. These rules include: there are no intersects, there are no overlaps, there are no dangles (except at tile edges), and must be single part. Each contour tile was then evaluated to these topology rules and errors were documented and reported to Aerometric. For Matanuska block, four tiles tested initially showed topology errors that needed to be fixed. After subsequent analysis and testing, the problem was tracked to a service pack upgrade of ESRI software on the UAF computer. After upgrading the software, we doubled the number of tiles tested to verify that everything was good (see Figure 47 and 48).

Quick Terrain Modeler has an ability to drape the AutoCAD contour files in DXF format over a corresponding DEM and visualize it in either 2D or 3D. This capability was used to spot check the DXF files for problems (see Figure 49 and Figure 50). The selected Matanuska contour products were spot checked for completeness and accuracy.

## Matanuska Block Results and Recommendations

After significant effort testing, documenting data quality issues, consulting with Aerometric and the Matanuska-Susitna Borough GIS staff, and testing ten redeliveries. UAF is confident that the Matanuska block is of acceptable quality. The spatial extent, coverage provided, vertical accuracy, completeness and consistency of products makes this block the sixth of which we recommend acceptance. Aerometric has worked hard to address all of the identified quality issues to date. UAF has thoroughly documented the results of its assessments, including a complete record of all quality issues to date and what the solution was for each case.

**Upon completion of writing this report and reviewing the results of our assessments, UAF recommends that the Matanuska block be accepted. We are very pleased with the quality of data for this block. Aerometric is applying lessons learned from each reported data quality issue to subsequent block deliveries.**

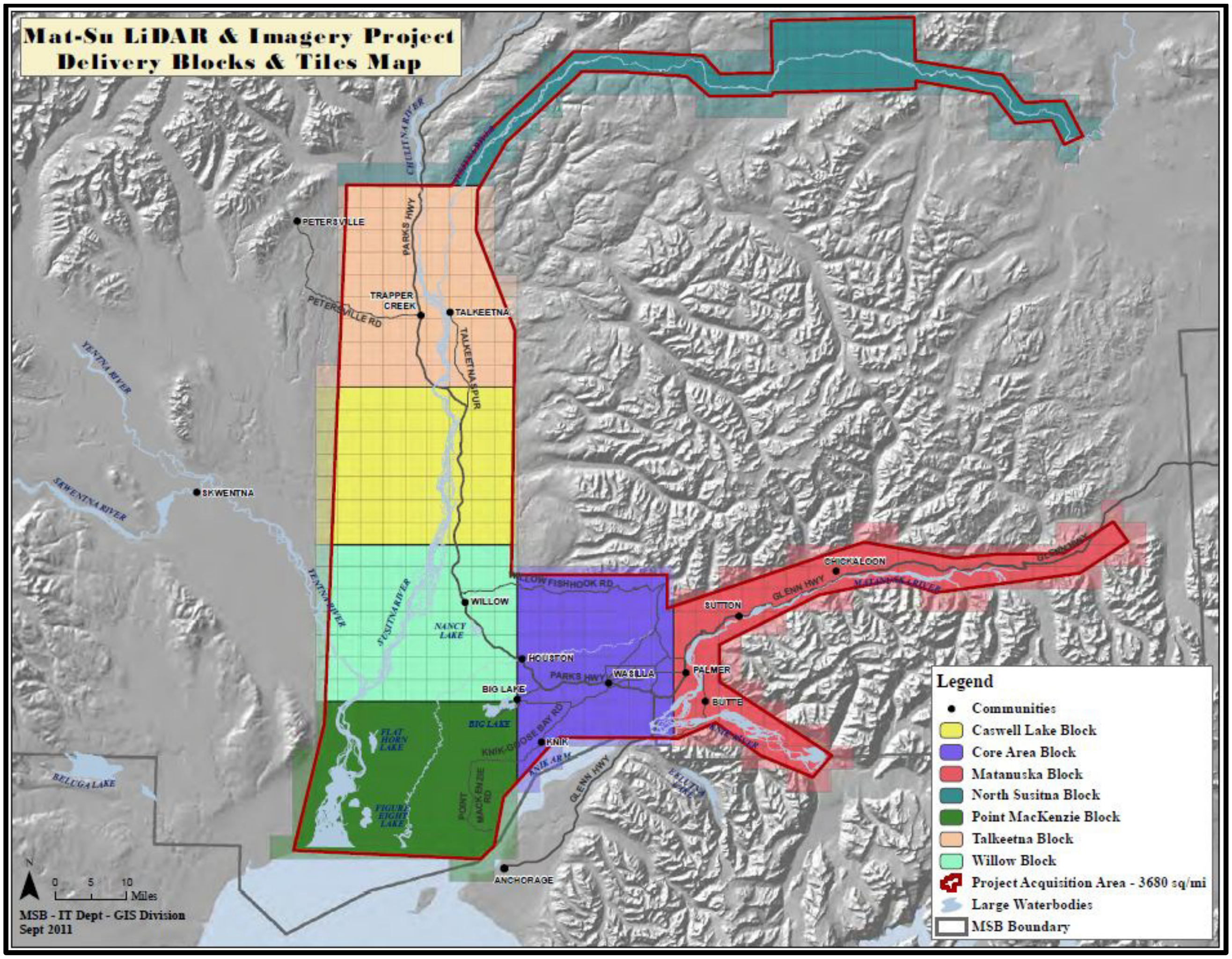



Figure 1, Mat-Su LiDAR & Imagery Project Delivery Blocks & Tiles Map

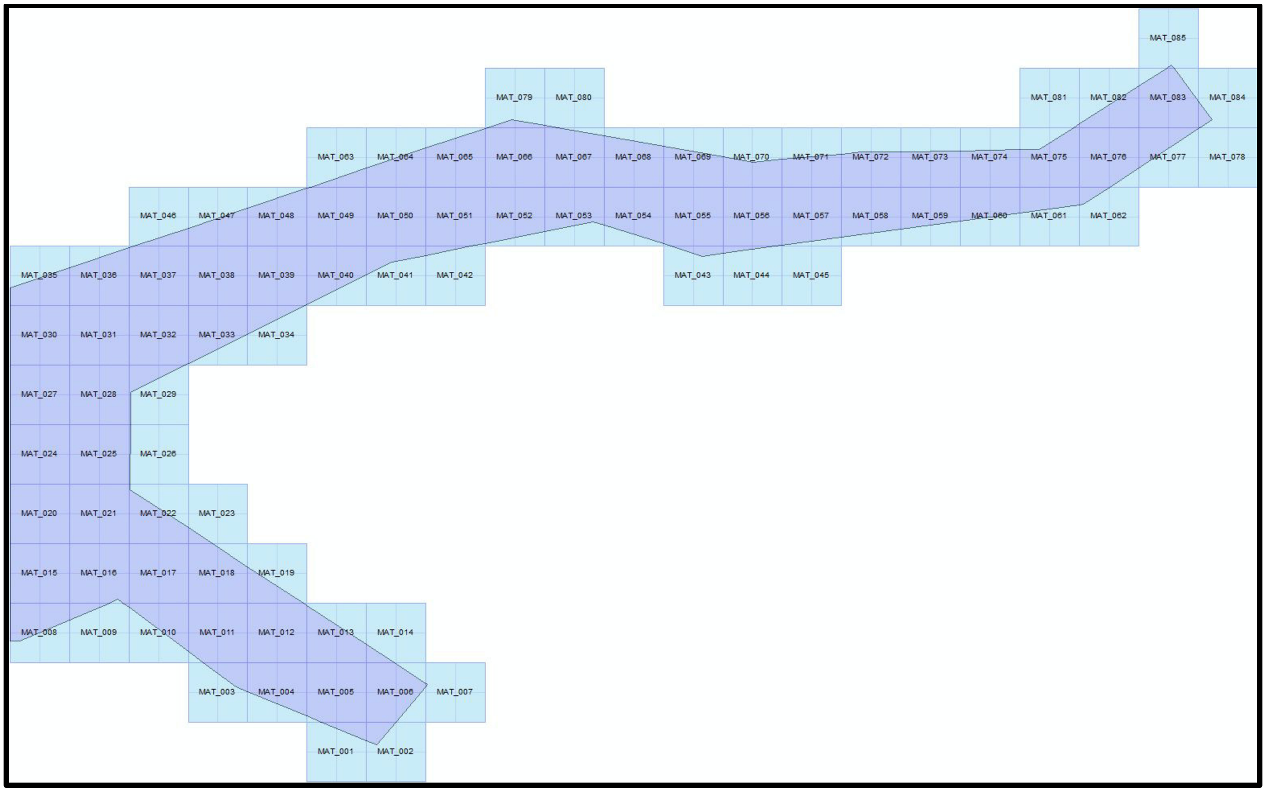
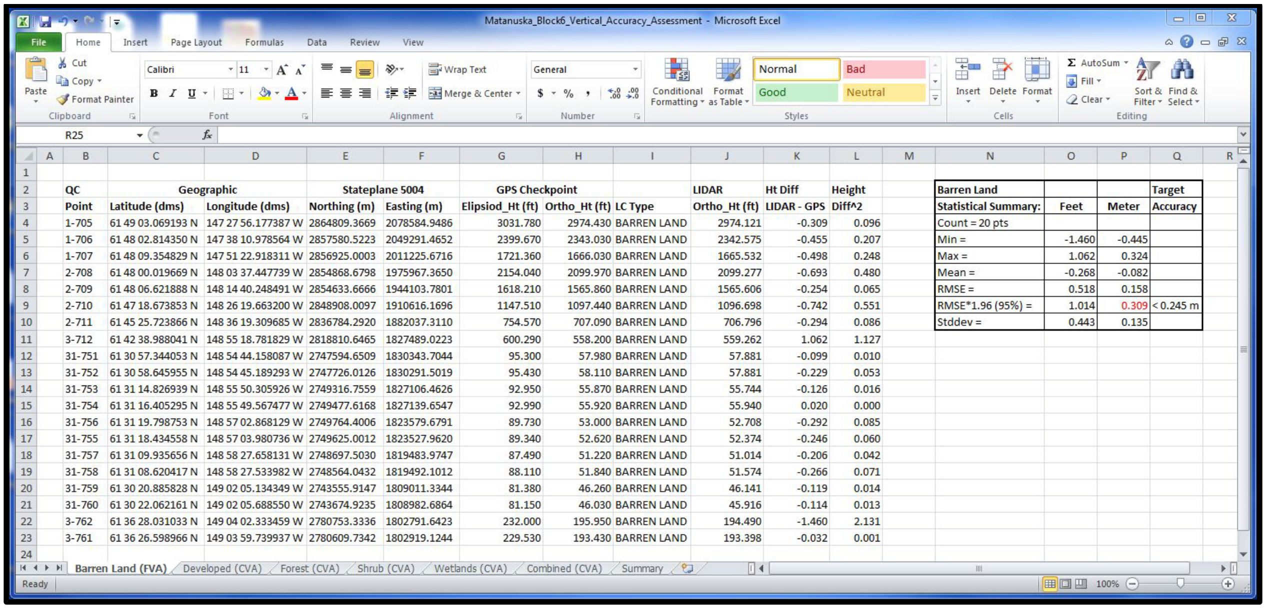



Figure 2, Contractor Supplied GIS Layers. Full tile (green), quarter tile (light green), and block boundary (green).



Matanuska_Block6_Vertical_Accuracy_Assessment - Microsoft Excel

| QC | Geographic | | Stateplane 5004 | | GPS Checkpoint | | | LIDAR | Ht Diff | Height |
|---|---|---|---|---|---|---|---|---|---|---|
| Point | Latitude (dms) | Longitude (dms) | Northing (m) | Easting (m) | Elipsiod_Ht (ft) | Ortho_Ht (ft) | LC Type | Ortho_Ht (ft) | LIDAR - GPS | Diff^2 |
| 1-705 | 61 49 03.069193 N | 147 27 56.177387 W | 2864809.3669 | 2078584.9486 | 3031.780 | 2974.430 | BARREN LAND | 2974.121 | -0.309 | 0.096 |
| 1-706 | 61 48 02.814350 N | 147 38 10.978564 W | 2857580.5223 | 2049291.4652 | 2399.670 | 2343.030 | BARREN LAND | 2342.575 | -0.455 | 0.207 |
| 1-707 | 61 48 09.354829 N | 147 51 22.918311 W | 2856925.0003 | 2011225.6716 | 1721.360 | 1666.030 | BARREN LAND | 1665.532 | -0.498 | 0.248 |
| 2-708 | 61 48 00.019669 N | 148 03 37.447739 W | 2854868.6798 | 1975967.3650 | 2154.040 | 2099.970 | BARREN LAND | 2099.277 | -0.693 | 0.480 |
| 2-709 | 61 48 06.621888 N | 148 14 40.248491 W | 2854633.6666 | 1944103.7801 | 1618.210 | 1565.860 | BARREN LAND | 1565.606 | -0.254 | 0.065 |
| 2-710 | 61 47 18.673853 N | 148 26 19.663200 W | 2848908.0097 | 1910616.1696 | 1147.510 | 1097.440 | BARREN LAND | 1096.698 | -0.742 | 0.551 |
| 2-711 | 61 45 25.723866 N | 148 36 19.309685 W | 2836784.2920 | 1882037.3110 | 754.570 | 707.090 | BARREN LAND | 706.796 | -0.294 | 0.086 |
| 3-712 | 61 42 38.988041 N | 148 55 18.781829 W | 2818810.6465 | 1827489.0223 | 600.290 | 558.200 | BARREN LAND | 559.262 | 1.062 | 1.127 |
| 31-751 | 61 30 57.344053 N | 148 54 44.158087 W | 2747594.6509 | 1830343.7044 | 95.300 | 57.980 | BARREN LAND | 57.881 | -0.099 | 0.010 |
| 31-752 | 61 30 58.645955 N | 148 54 45.189293 W | 2747726.0126 | 1830291.5019 | 95.430 | 58.110 | BARREN LAND | 57.881 | -0.229 | 0.053 |
| 31-753 | 61 31 14.826939 N | 148 55 50.305926 W | 2749316.7559 | 1827106.4626 | 92.950 | 55.870 | BARREN LAND | 55.744 | -0.126 | 0.016 |
| 31-754 | 61 31 16.405295 N | 148 55 49.567477 W | 2749477.6168 | 1827139.6547 | 92.990 | 55.920 | BARREN LAND | 55.940 | 0.020 | 0.000 |
| 31-756 | 61 31 19.798753 N | 148 57 02.868129 W | 2749764.4006 | 1823579.6791 | 89.730 | 53.000 | BARREN LAND | 52.708 | -0.292 | 0.085 |
| 31-755 | 61 31 18.434558 N | 148 57 03.980736 W | 2749625.0012 | 1823527.9620 | 89.340 | 52.620 | BARREN LAND | 52.374 | -0.246 | 0.060 |
| 31-757 | 61 31 09.935656 N | 148 58 27.658131 W | 2748697.5030 | 1819483.9747 | 87.490 | 51.220 | BARREN LAND | 51.014 | -0.206 | 0.042 |
| 31-758 | 61 31 08.620417 N | 148 58 27.533982 W | 2748564.0432 | 1819492.1012 | 88.110 | 51.840 | BARREN LAND | 51.574 | -0.266 | 0.071 |
| 31-759 | 61 30 20.885828 N | 149 02 05.134349 W | 2743555.9147 | 1809011.3344 | 81.380 | 46.260 | BARREN LAND | 46.141 | -0.119 | 0.014 |
| 31-760 | 61 30 22.062161 N | 149 02 05.688550 W | 2743674.9235 | 1808982.6864 | 81.150 | 46.030 | BARREN LAND | 45.916 | -0.114 | 0.013 |
| 3-762 | 61 36 28.031033 N | 149 04 02.333459 W | 2780753.3336 | 1802791.6423 | 232.000 | 195.950 | BARREN LAND | 194.490 | -1.460 | 2.131 |
| 3-761 | 61 36 26.598966 N | 149 03 59.739937 W | 2780609.7342 | 1802919.1244 | 229.530 | 193.430 | BARREN LAND | 193.398 | -0.032 | 0.001 |

| Barren Land | | | Target |
|---|---|---|---|
| Statistical Summary: | Feet | Meter | Accuracy |
| Count = 20 pts | | | |
| Min = | -1.460 | -0.445 | |
| Max = | 1.062 | 0.324 | |
| Mean = | -0.268 | -0.082 | |
| RMSE = | 0.518 | 0.158 | |
| RMSE*1.96 (95%) = | 1.014 | 0.309 | < 0.245 m |
| Stddev = | 0.443 | 0.135 | |

Barren Land (FVA) | Developed (CVA) | Forest (CVA) | Shrub (CVA) | Wetlands (CVA) | Combined (CVA) | Summary

Figure 3, Vertical Accuracy Assessment using Lounsbury Checkpoint Survey.

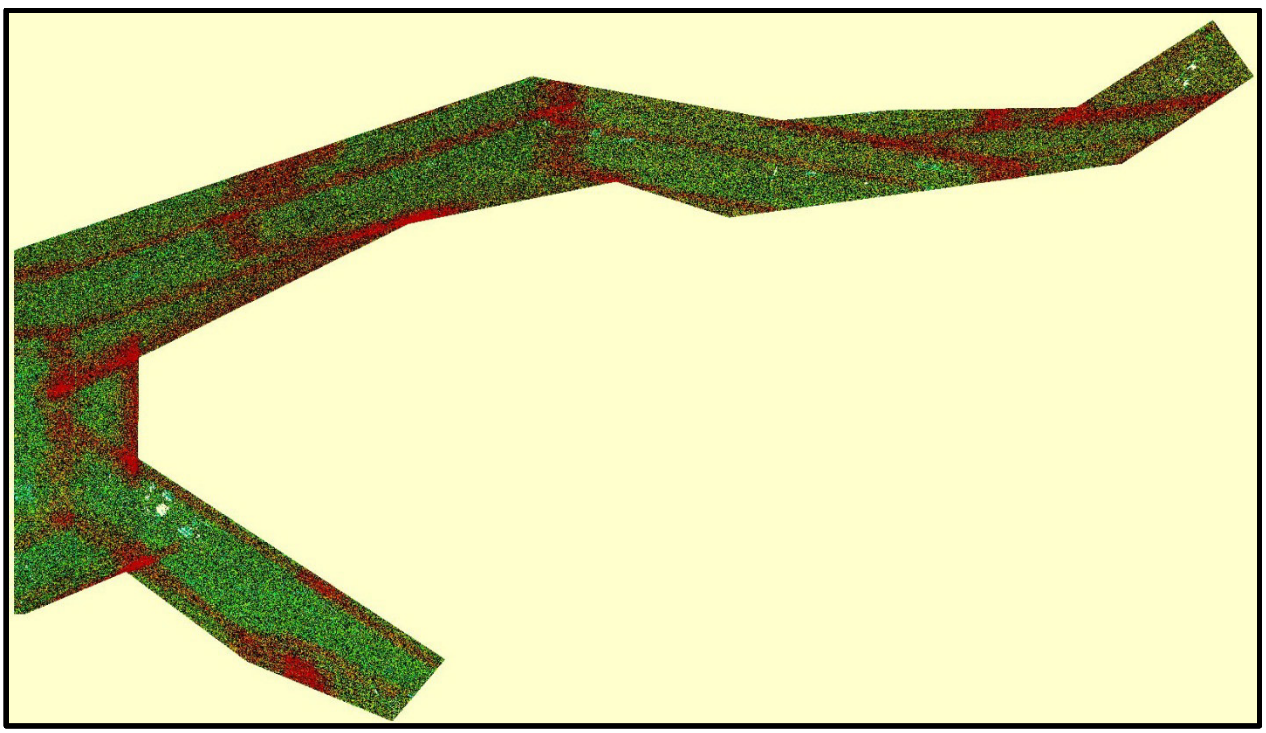


Figure 4, LiDAR Point Count

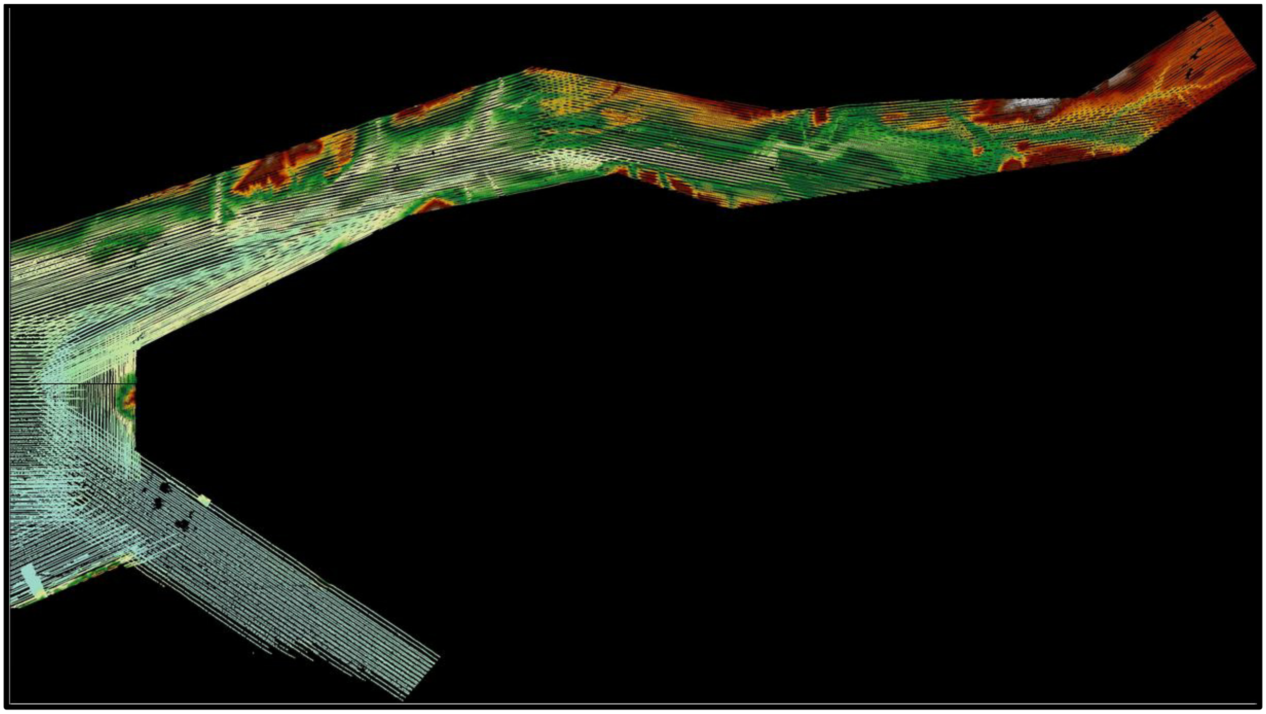


Figure 5, Class 1 – Unclassified.

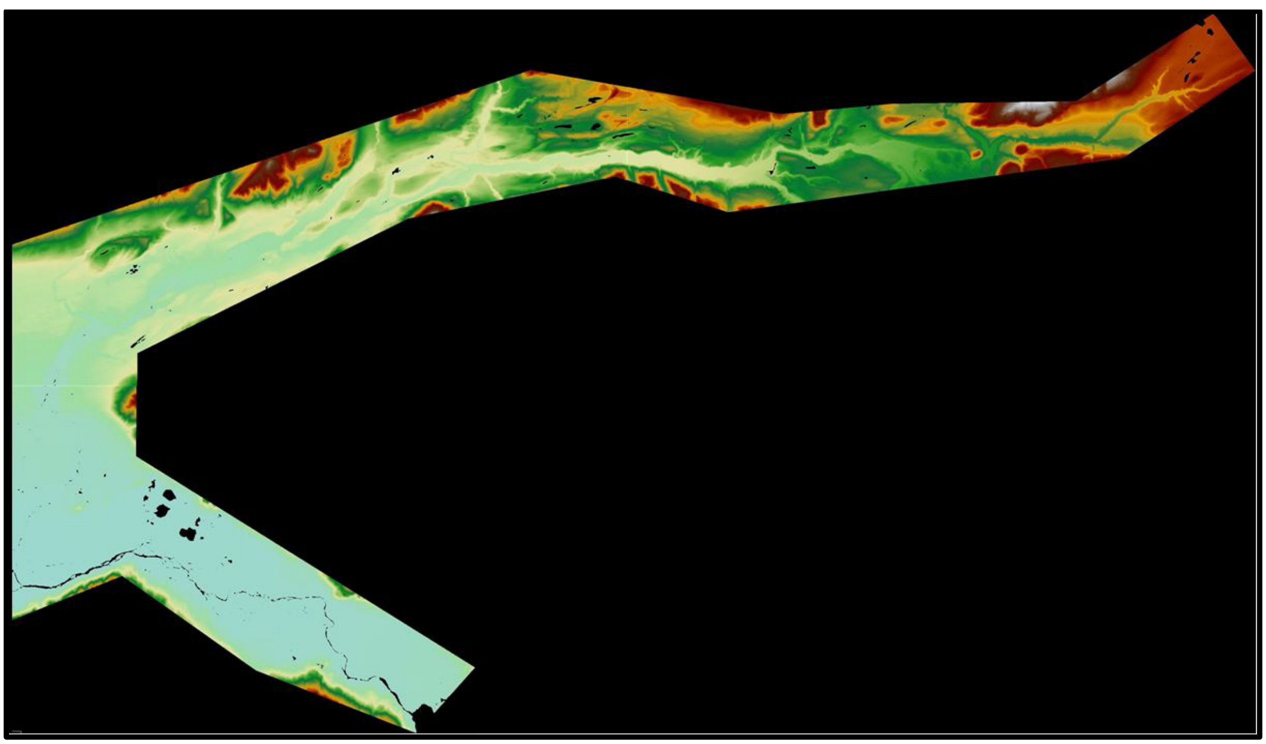


Figure 6, Class 2 – Ground.

Figure 7, Class 3 – Low Vegetation.

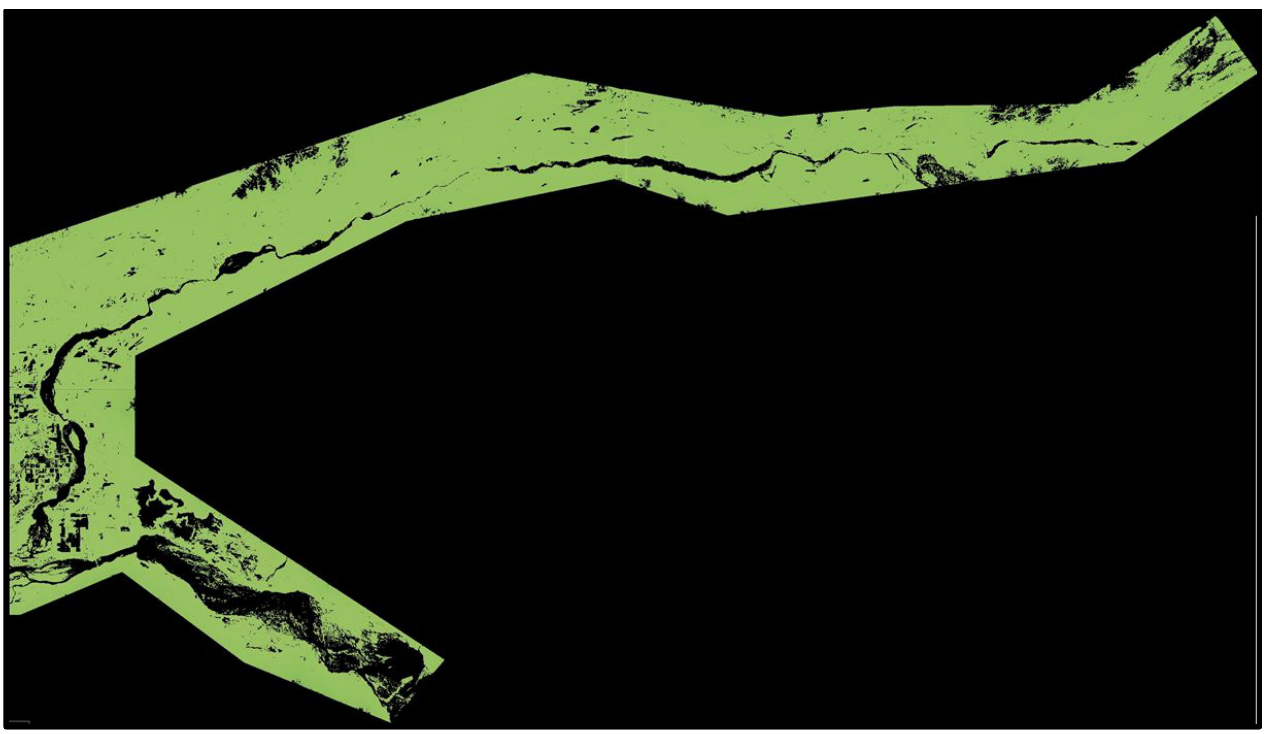


Figure 8, Class 4 – Medium Vegetation

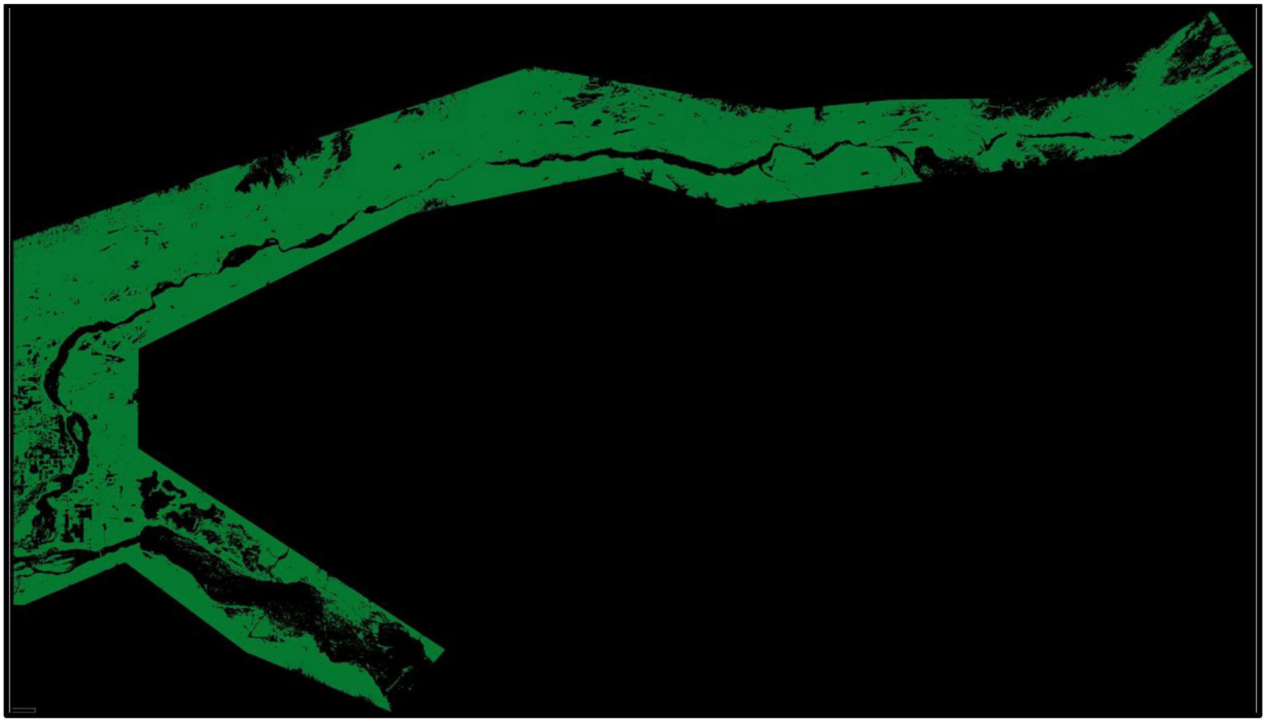


Figure 9, Class 5 – High Vegetation.

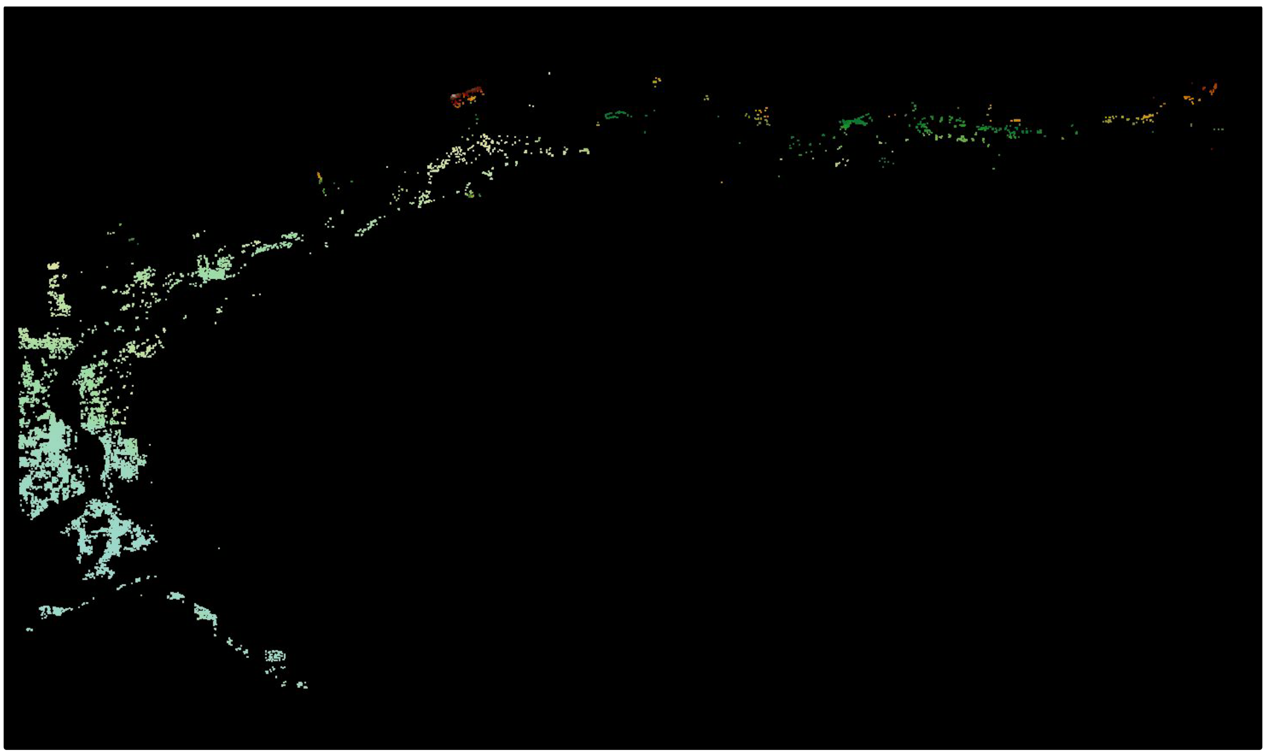


Figure 10, Class 6 – Buildings.

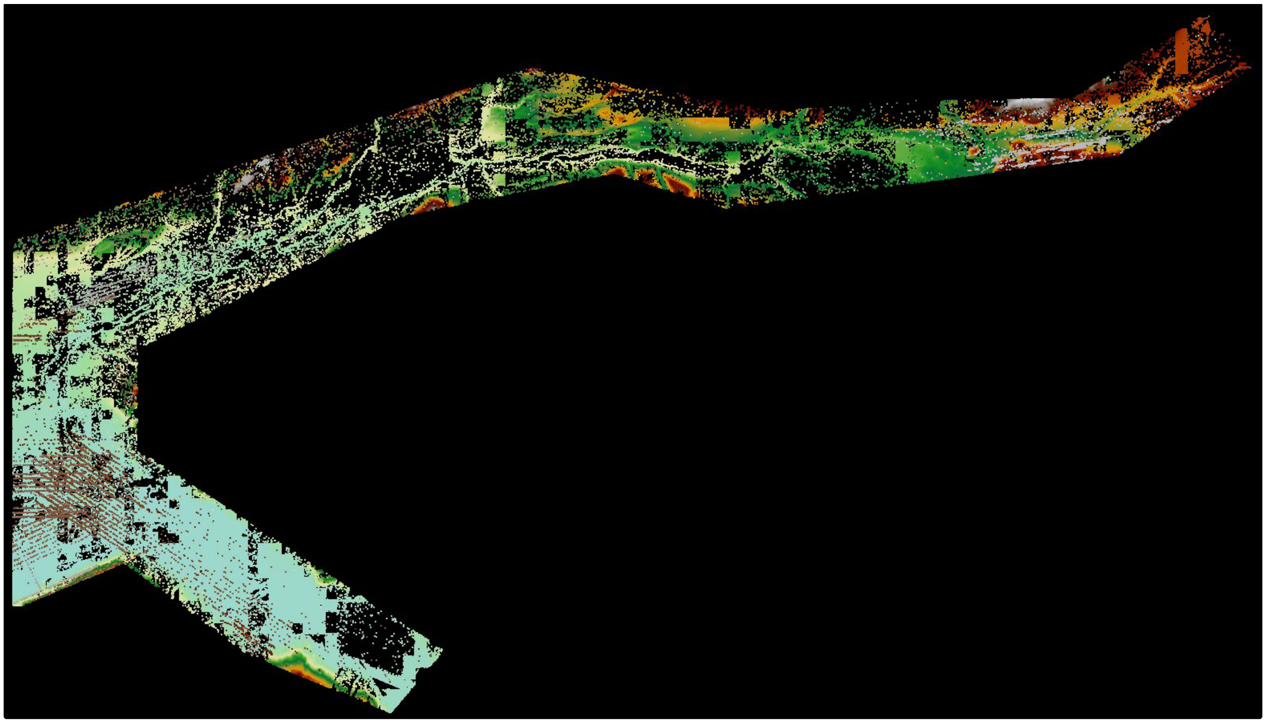


Figure 11, Class 7 – Noise

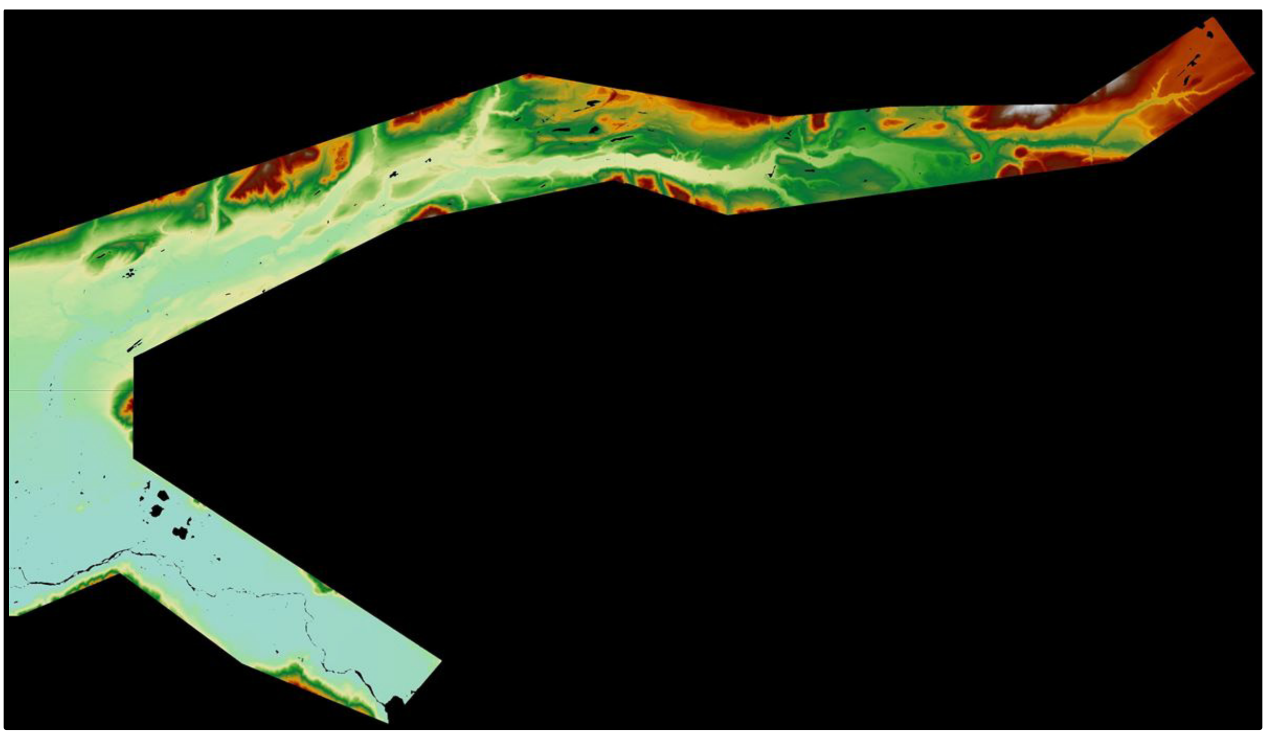


Figure 12, Class 8 – Ground Model Keypoints.

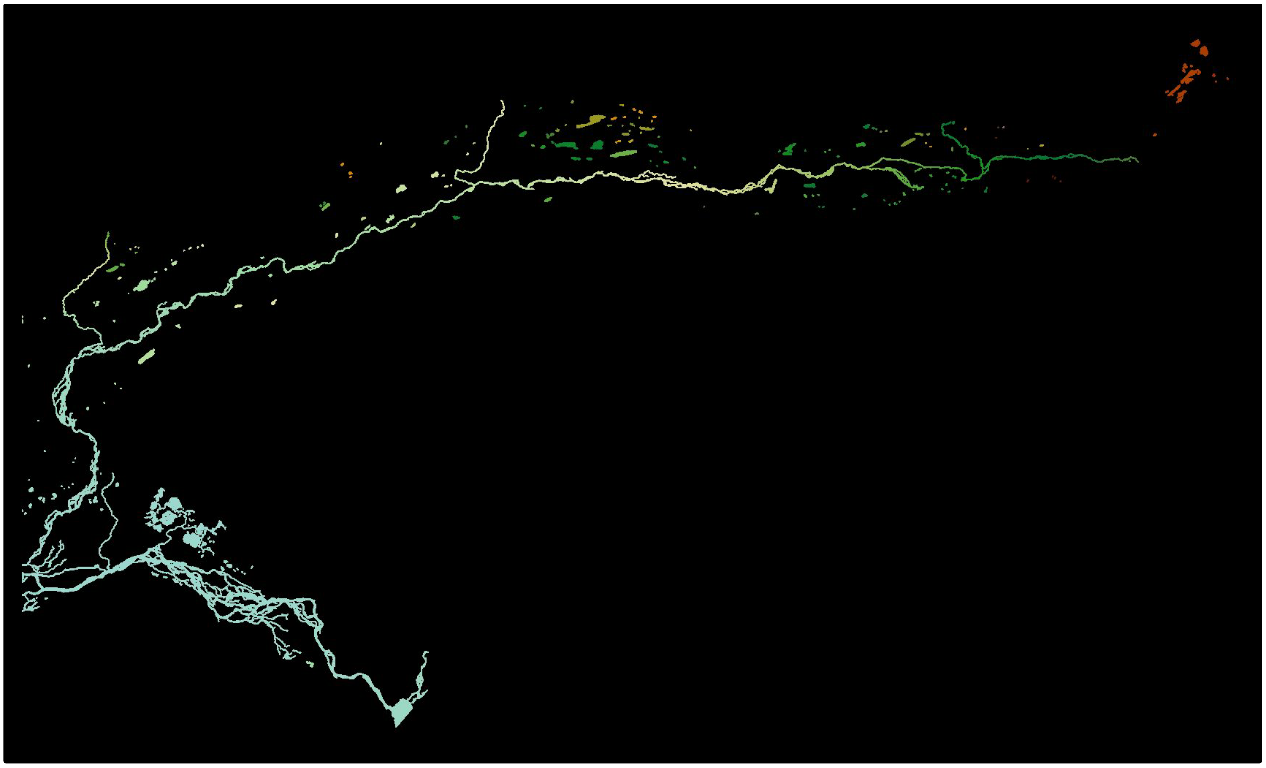


Figure 13, Class 9 – Water.

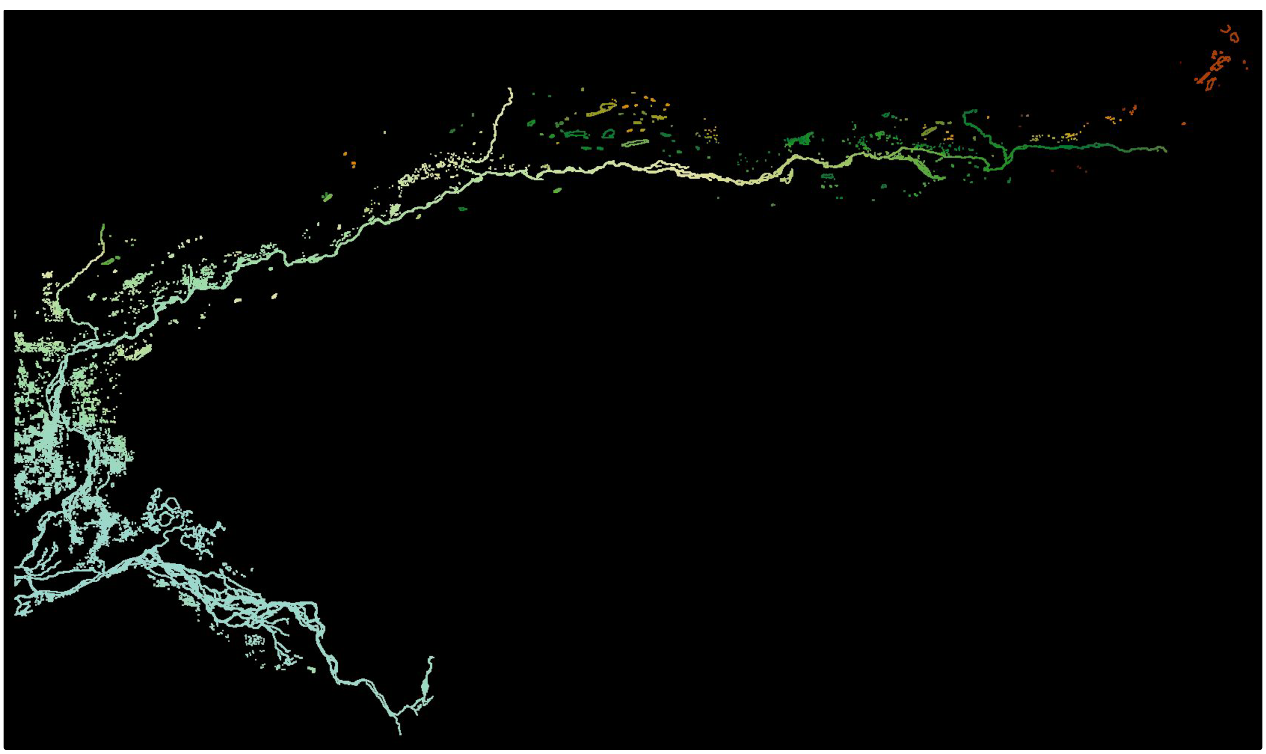


Figure 14, Class 10 – Breakline Proximity.

Figure 15, Class 11 – Power Transmission Lines.

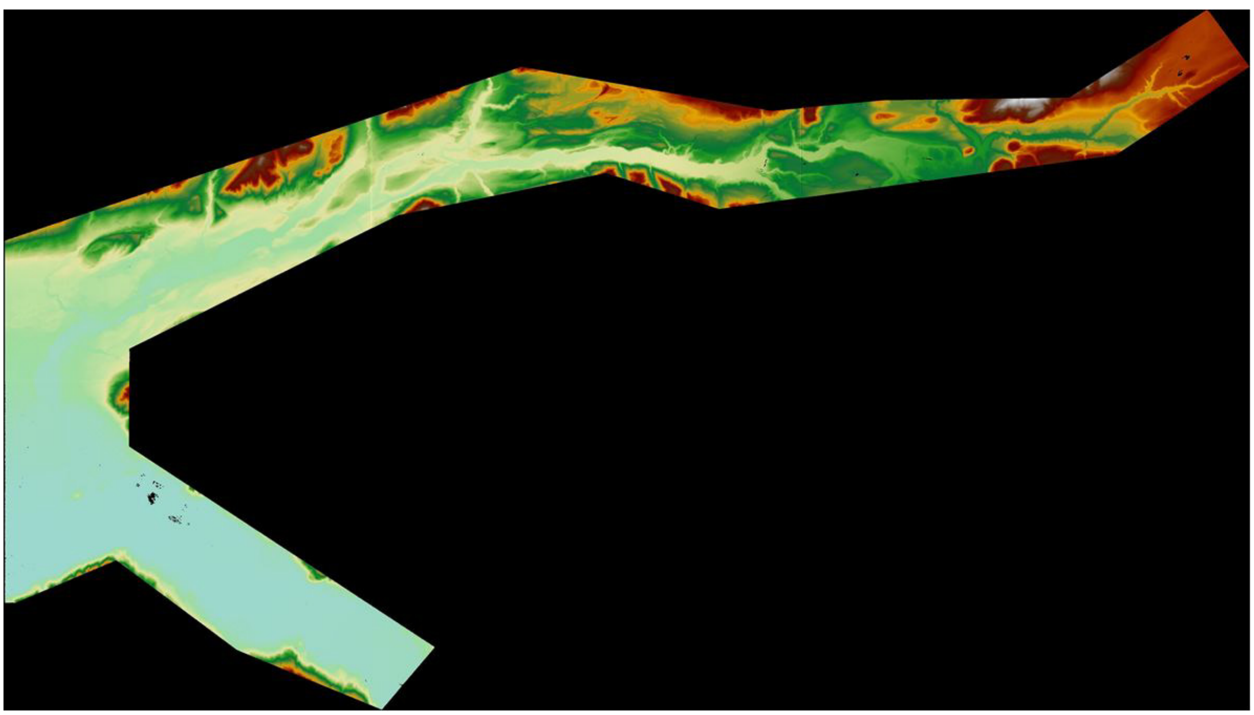


Figure 16, Class 13 – Surface Clutter.

Figure 17, Class 14 – Bridge Decks with Zoom showing one Bridge Deck.

Figure 18, Class 18 – Glacier

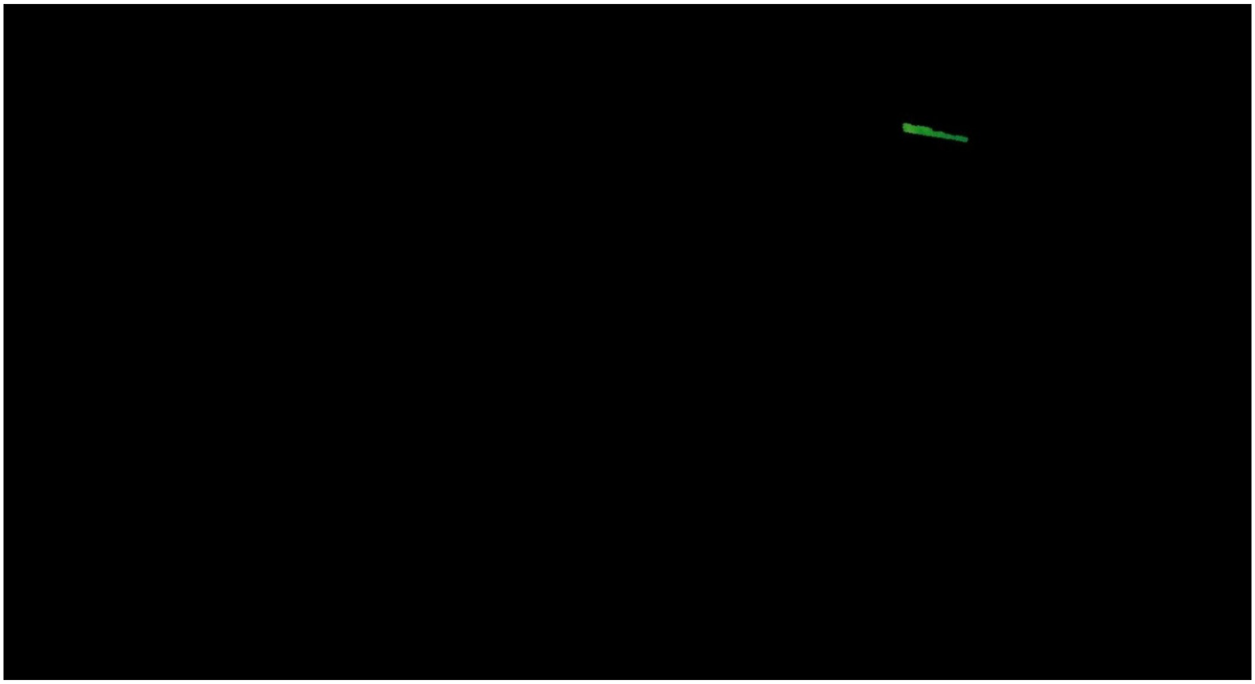


Figure 19, Class 19 – Glacier

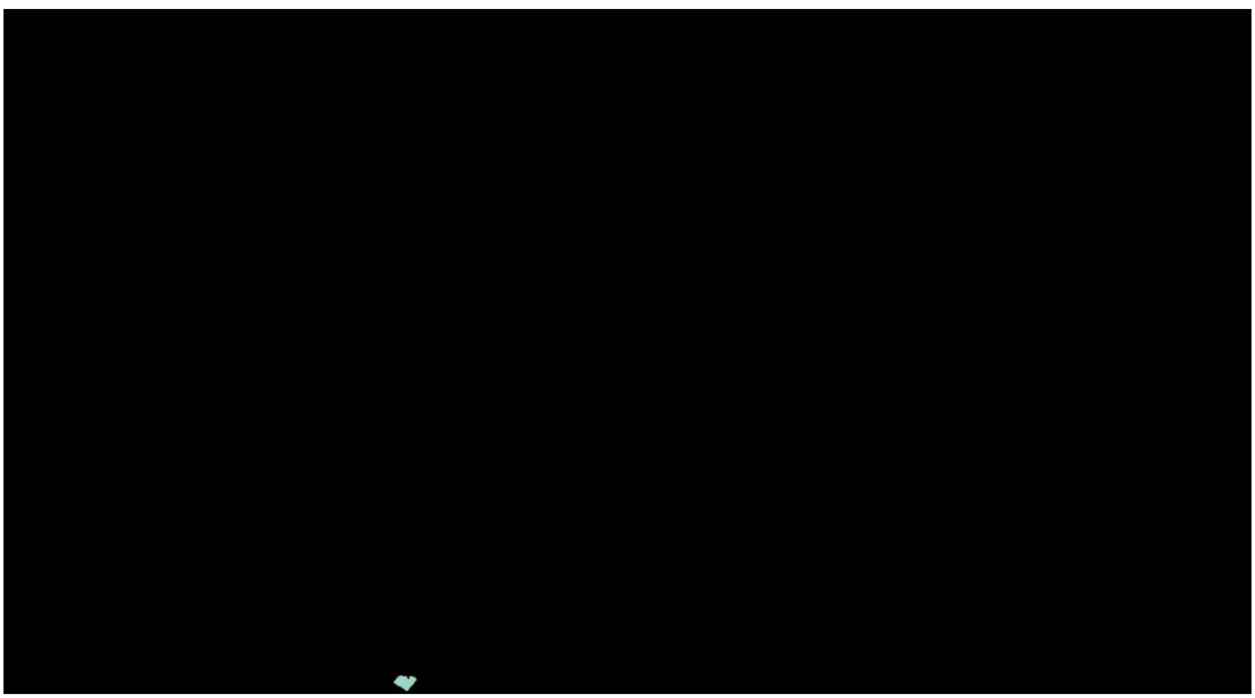


Figure 20, Class 26 – Glacier

Figure 21, Class 27 – Glacier

Figure 22, Class 28 – Glacier

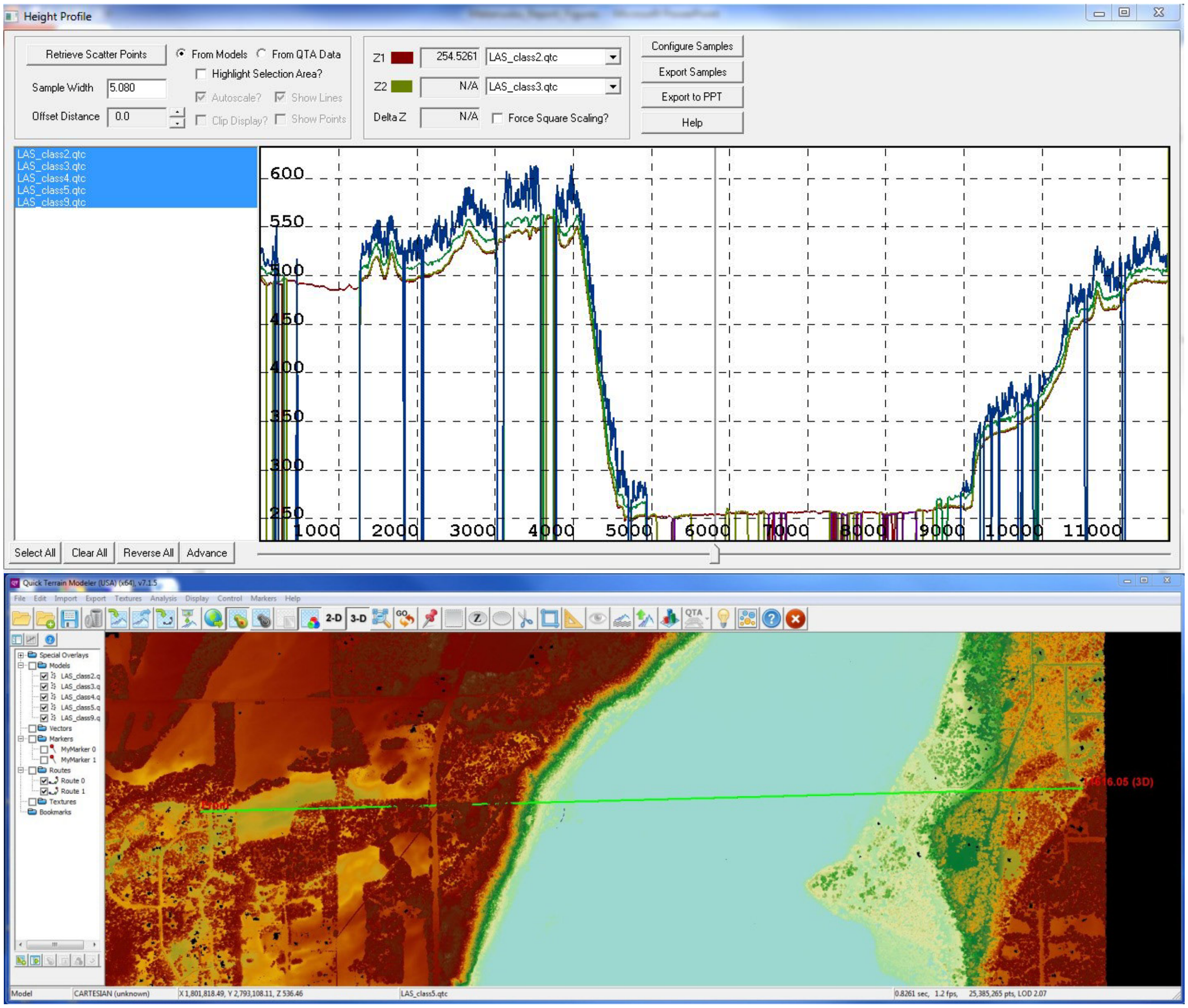



Figure 23, Vegetation Class Height Profile.

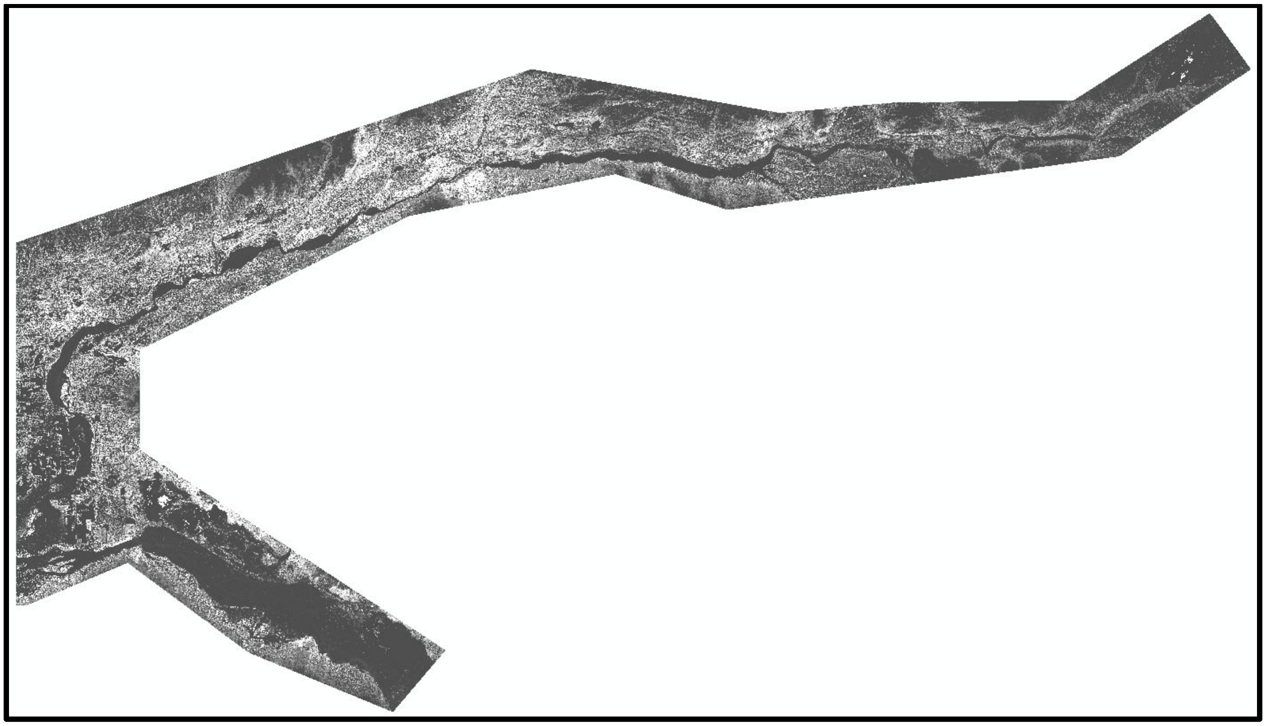


Figure 24, Canopy Height Difference (DSM –DEM).

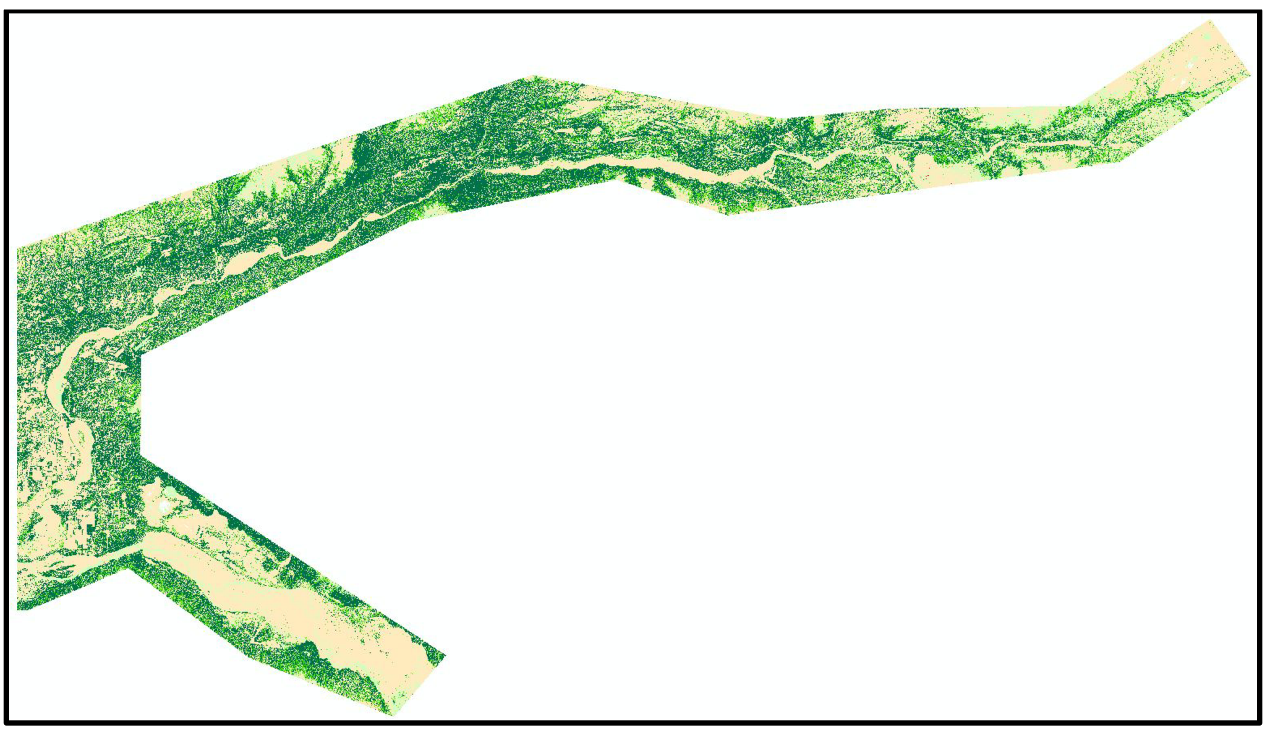


Figure 25, Canopy Height Classification.

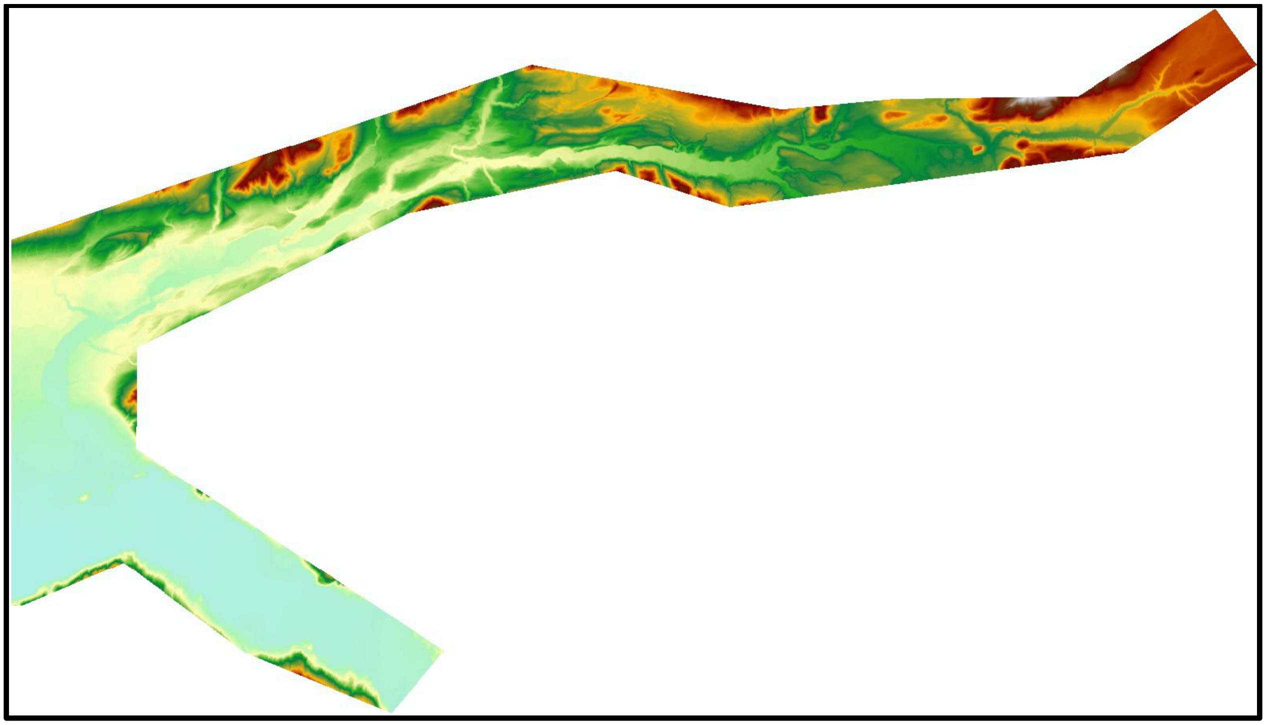


Figure 26, Bare-Earth Gridded DEM.

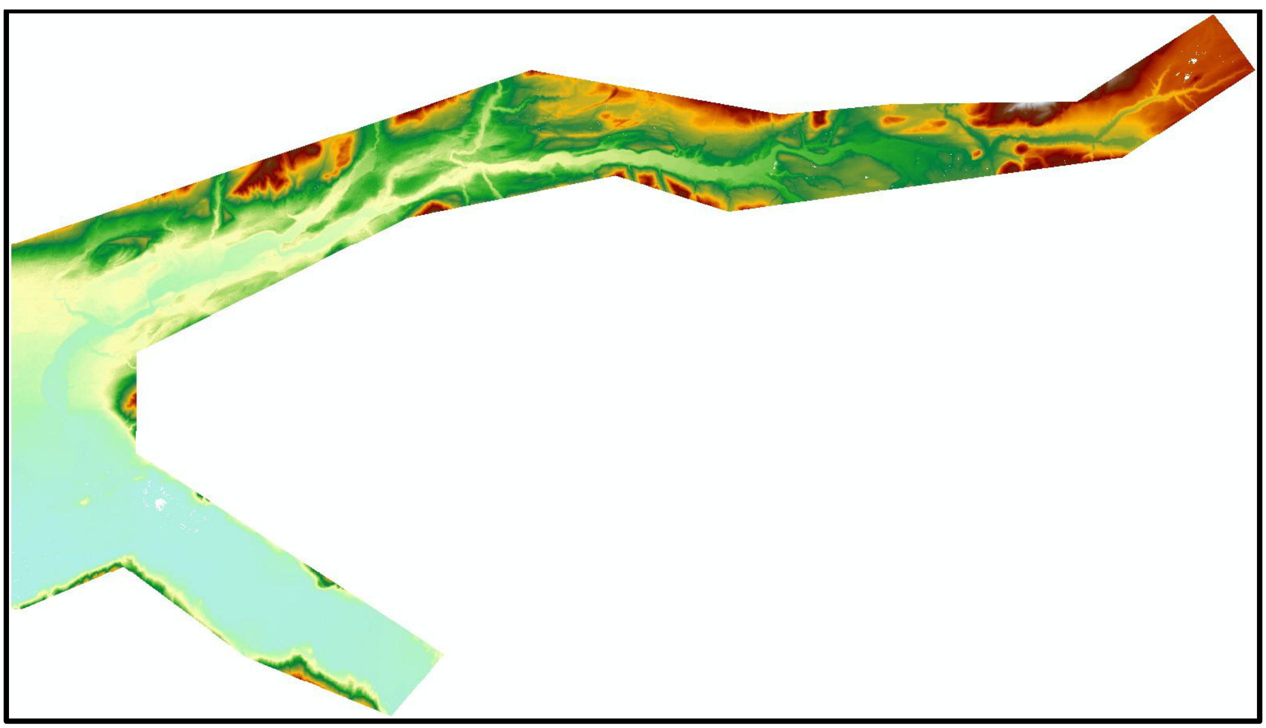


Figure 27, First-Return Gridded DSM.

Figure 28, LiDAR Intensity Gridded Mosaic**.**

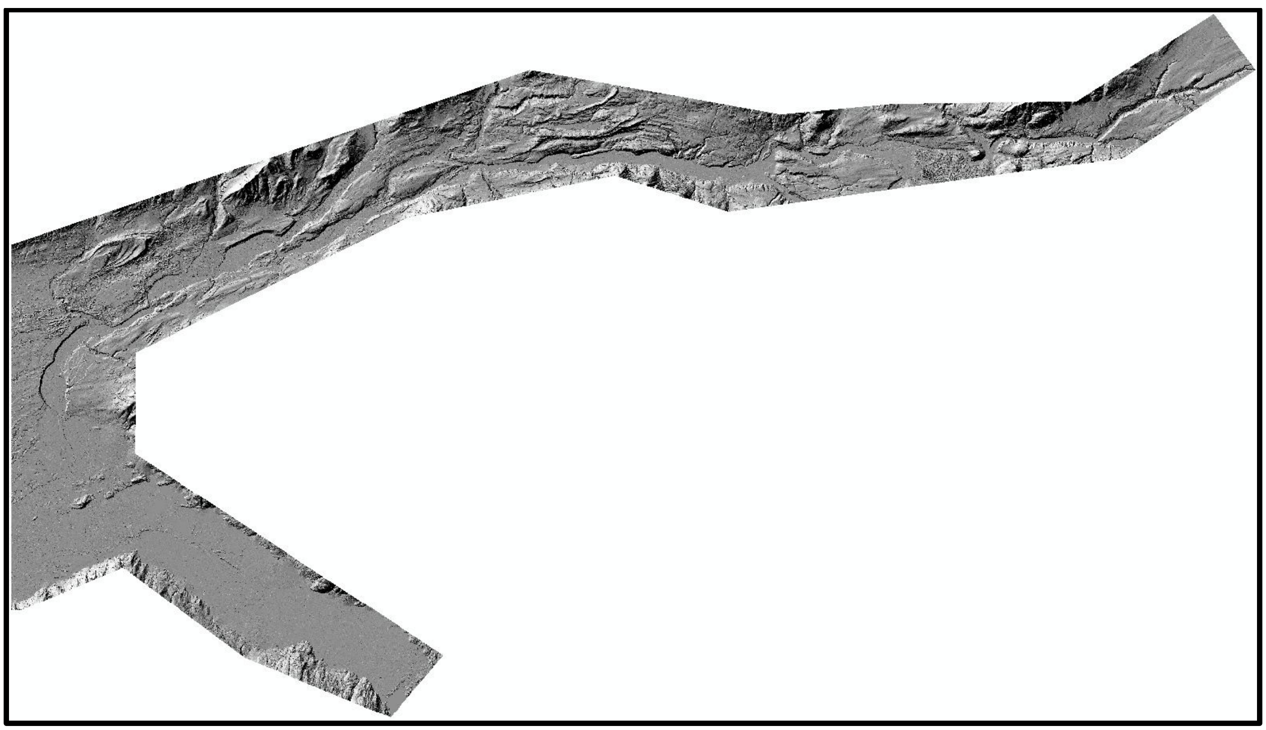


Figure 29, Shaded Relief Bare-Earth Gridded DEM.

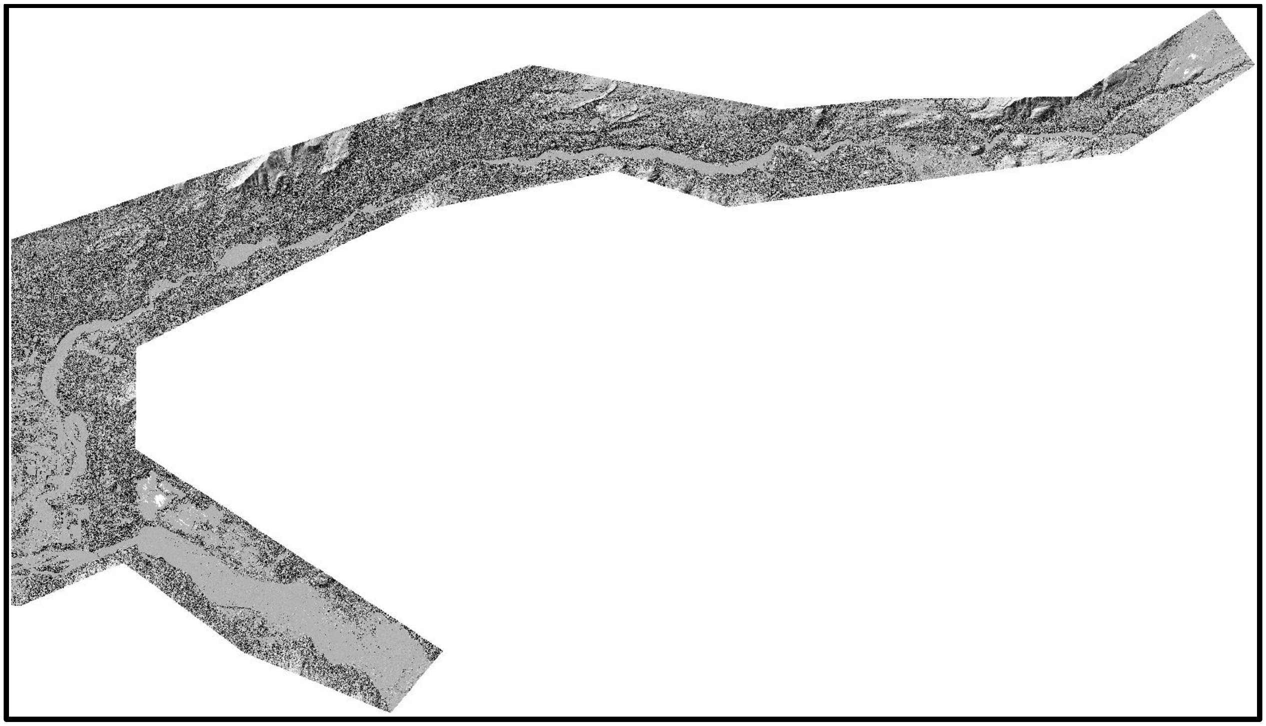


Figure 30, Shaded Relief First-Return Gridded DSM.

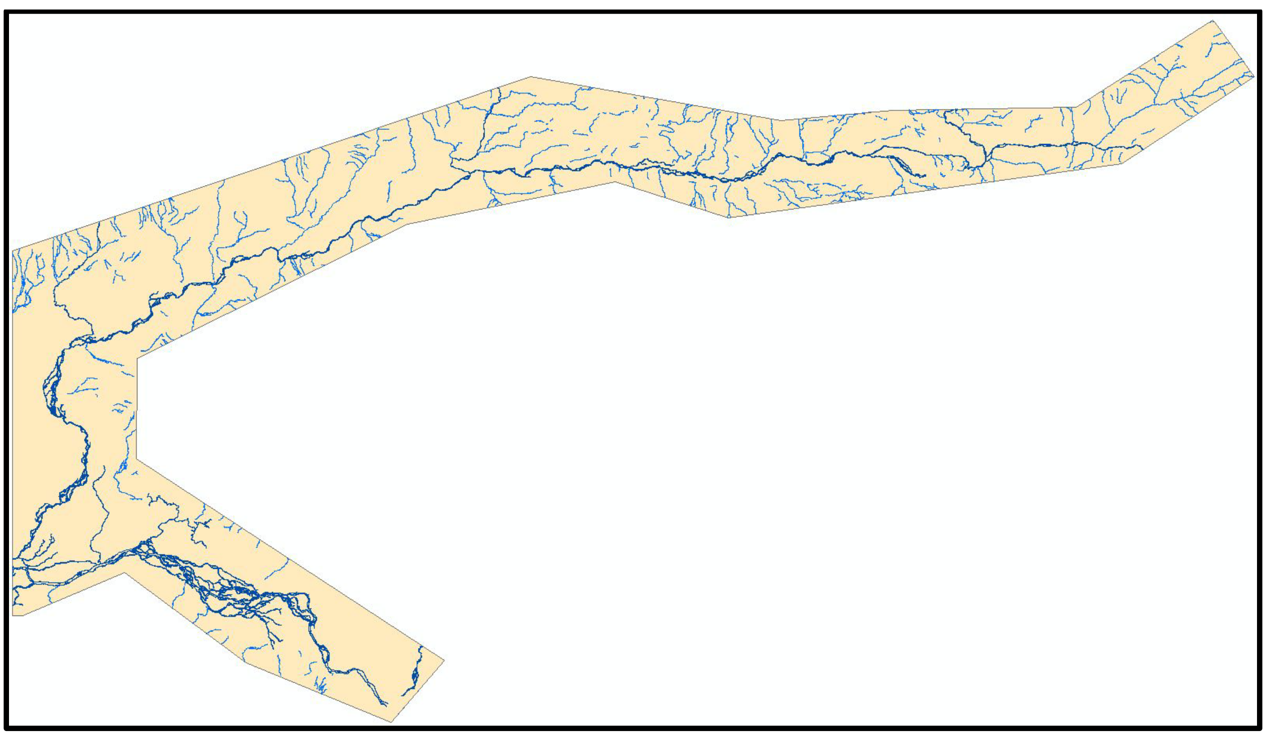


Figure 31, Contractor Supplied Hydro GIS Layers.

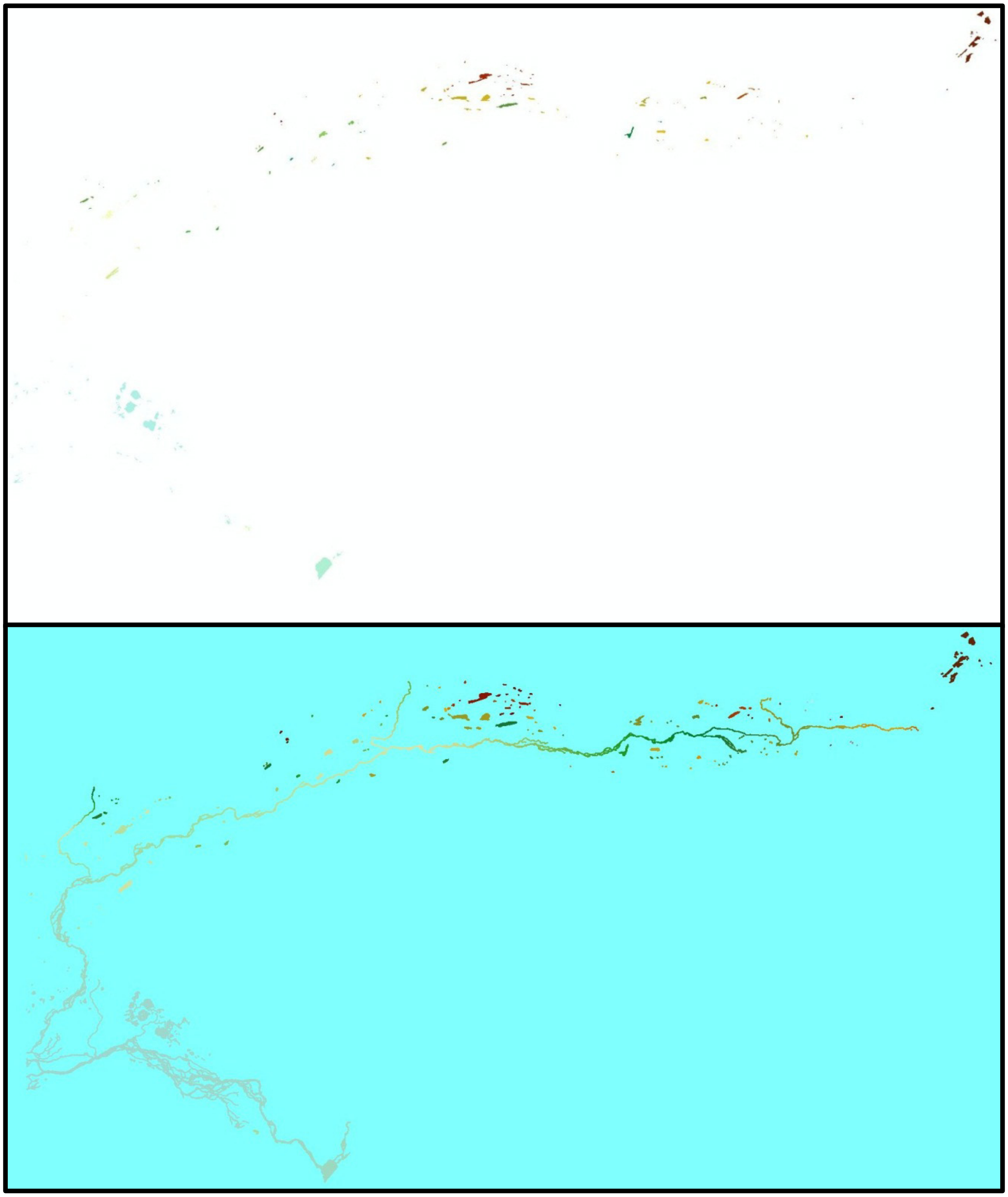


Figure 32, Lake Elevations (top Hydro Flattened DEM, bottom LiDAR Point Cloud).

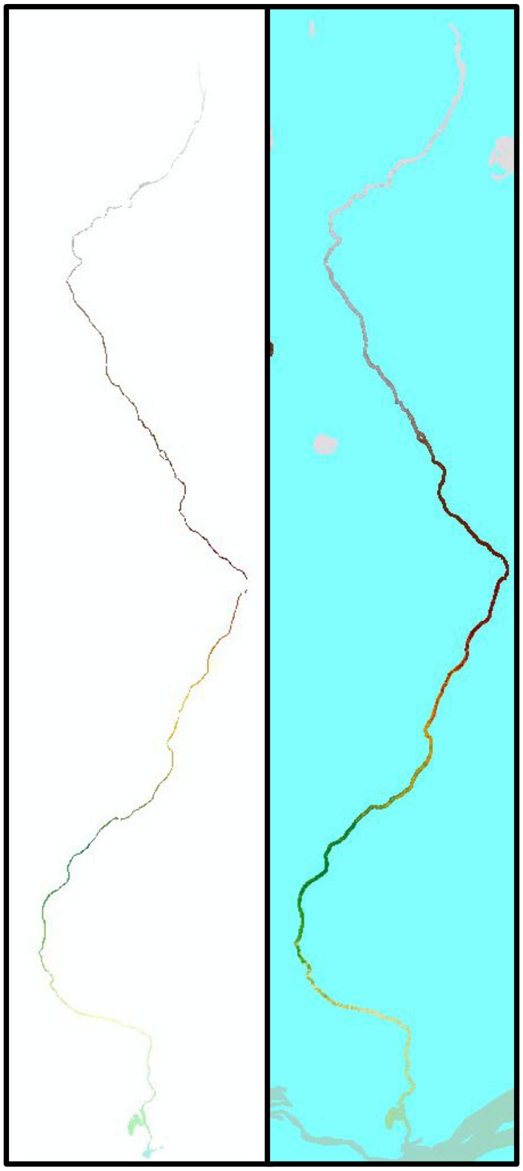


Figure 33, Bodenburg Creek Elevations (left Hydro Flattened DEM, right LiDAR Point Cloud).

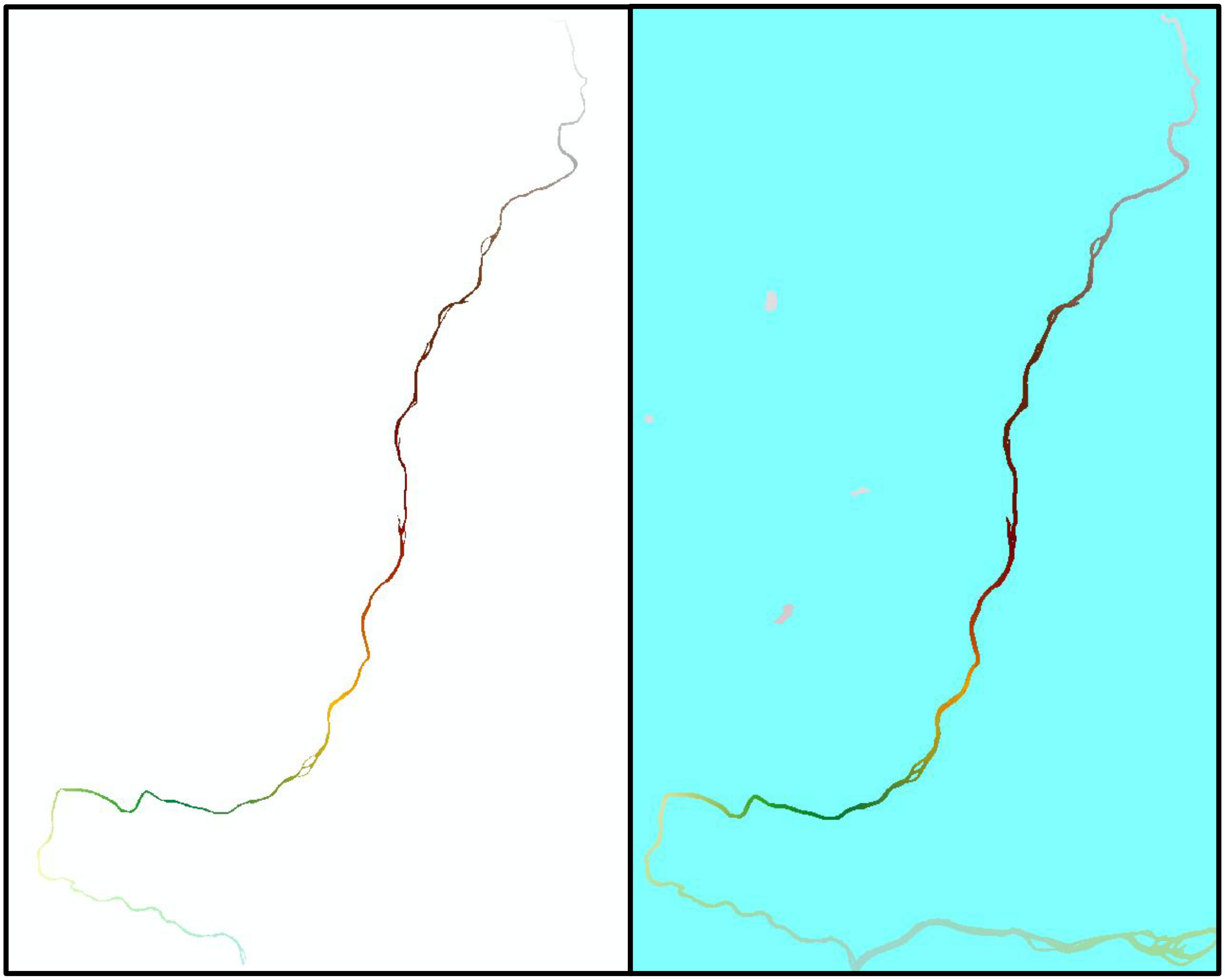


Figure 34, Chickaloon River Elevations (left Hydro Flattened DEM, right LiDAR Point Cloud).

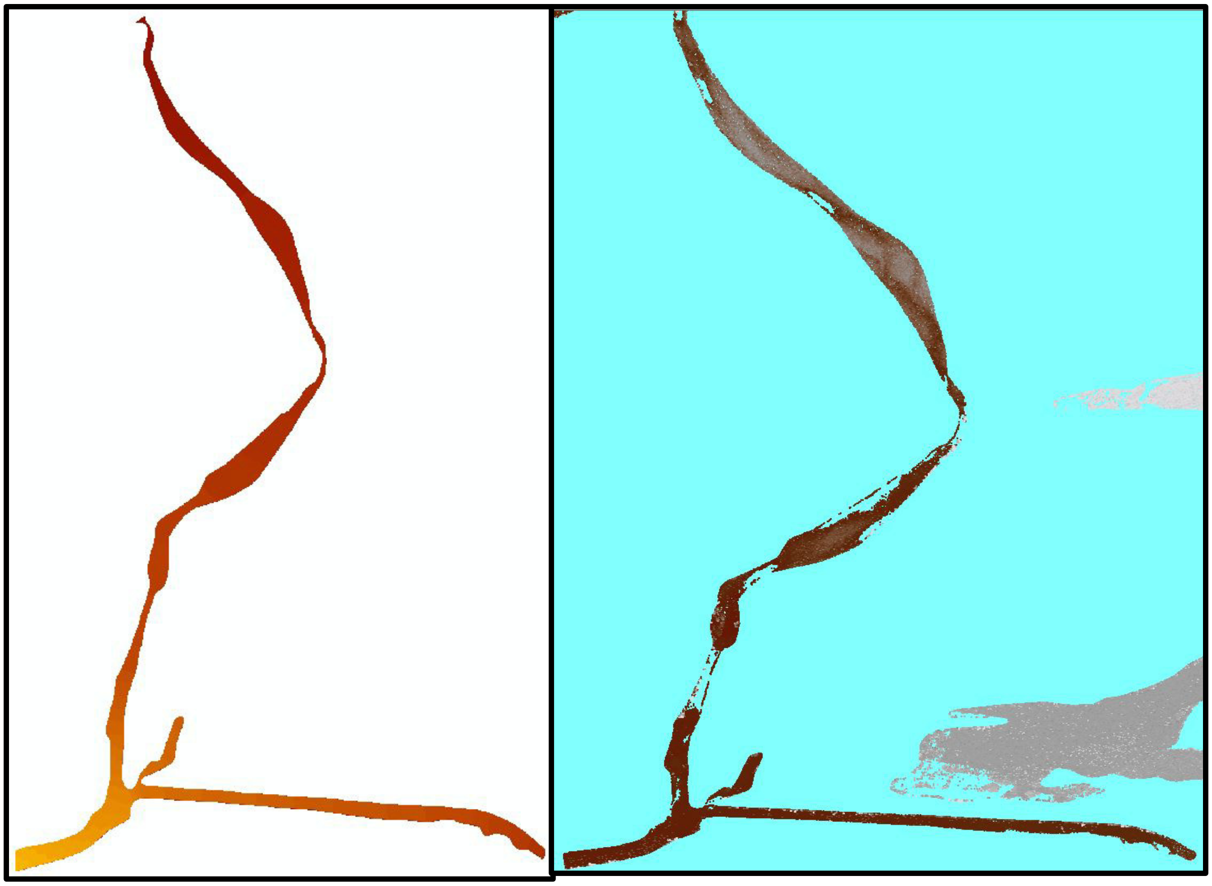


Figure 35, Eklutna Powerhouse Creek Elevations (left Hydro Flattened DEM, right LiDAR Point Cloud).

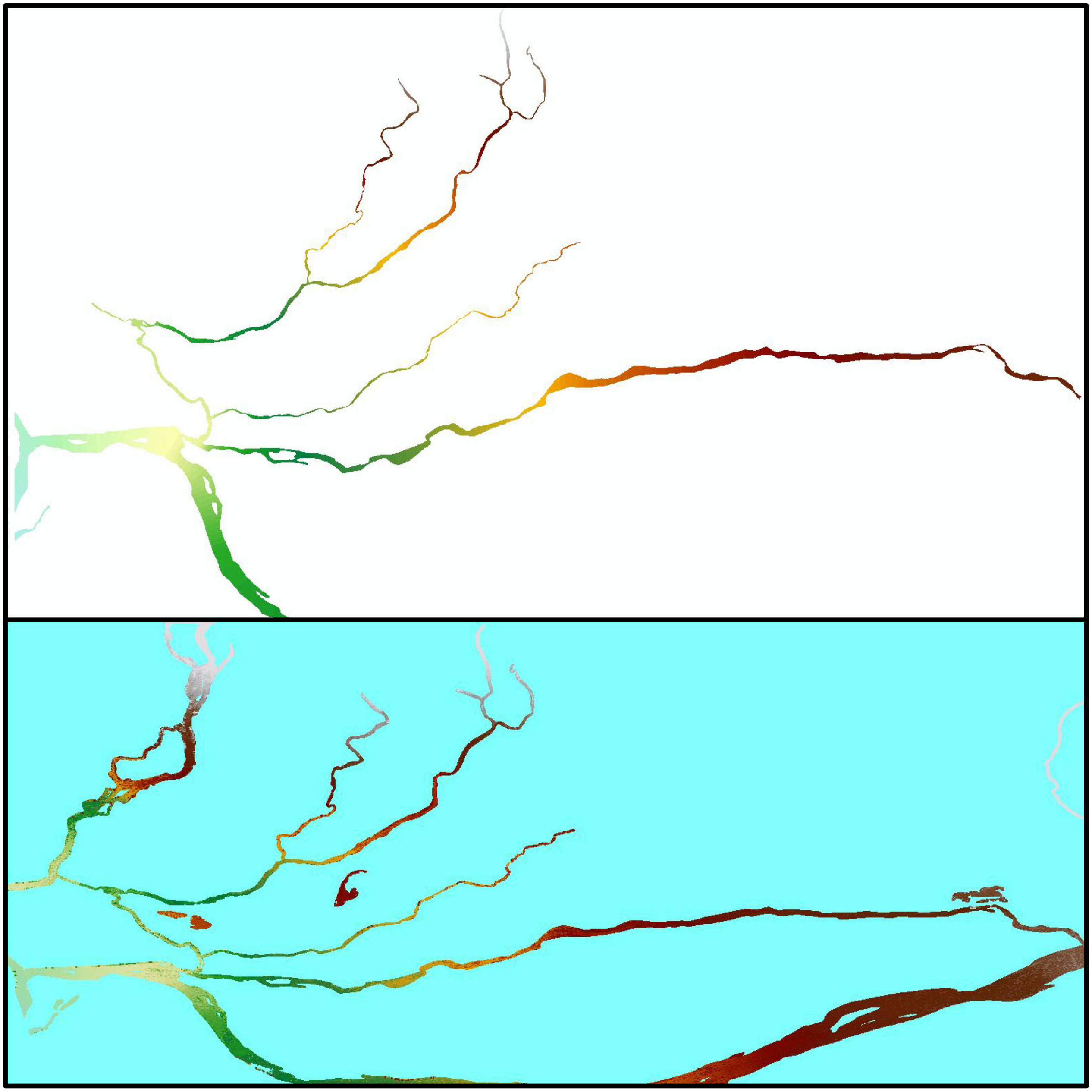


Figure 36, Ezi Slough Elevations (top Hydro Flattened DEM, bottom LiDAR Point Cloud).

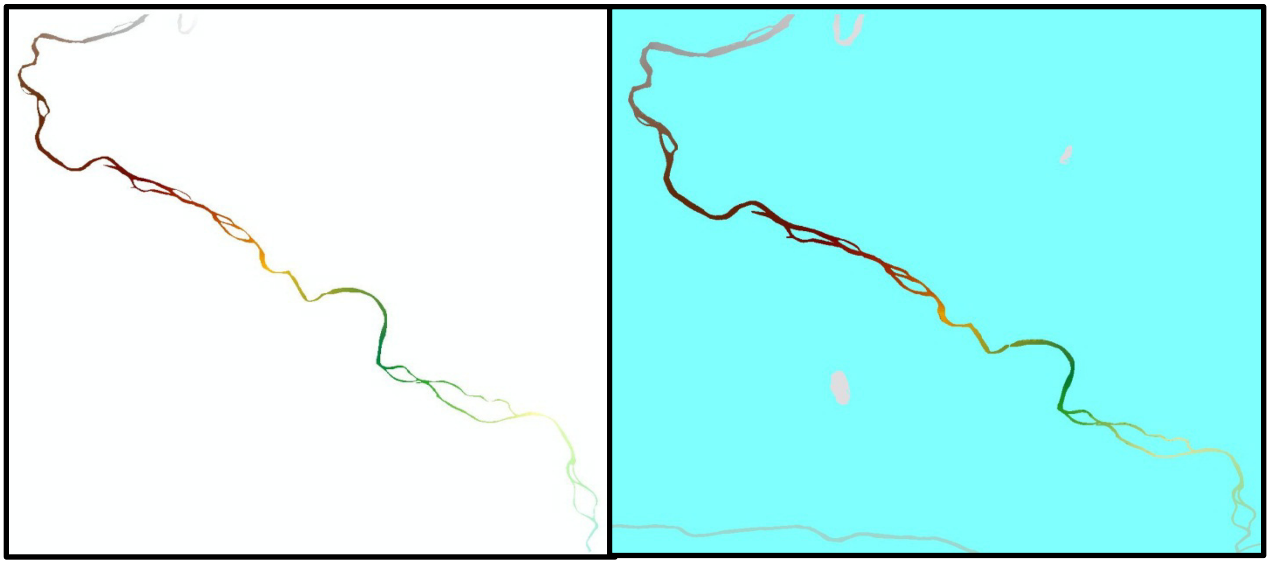


Figure 37, Fortress Creek Elevations (left Hydro Flattened DEM, right LiDAR Point Cloud)

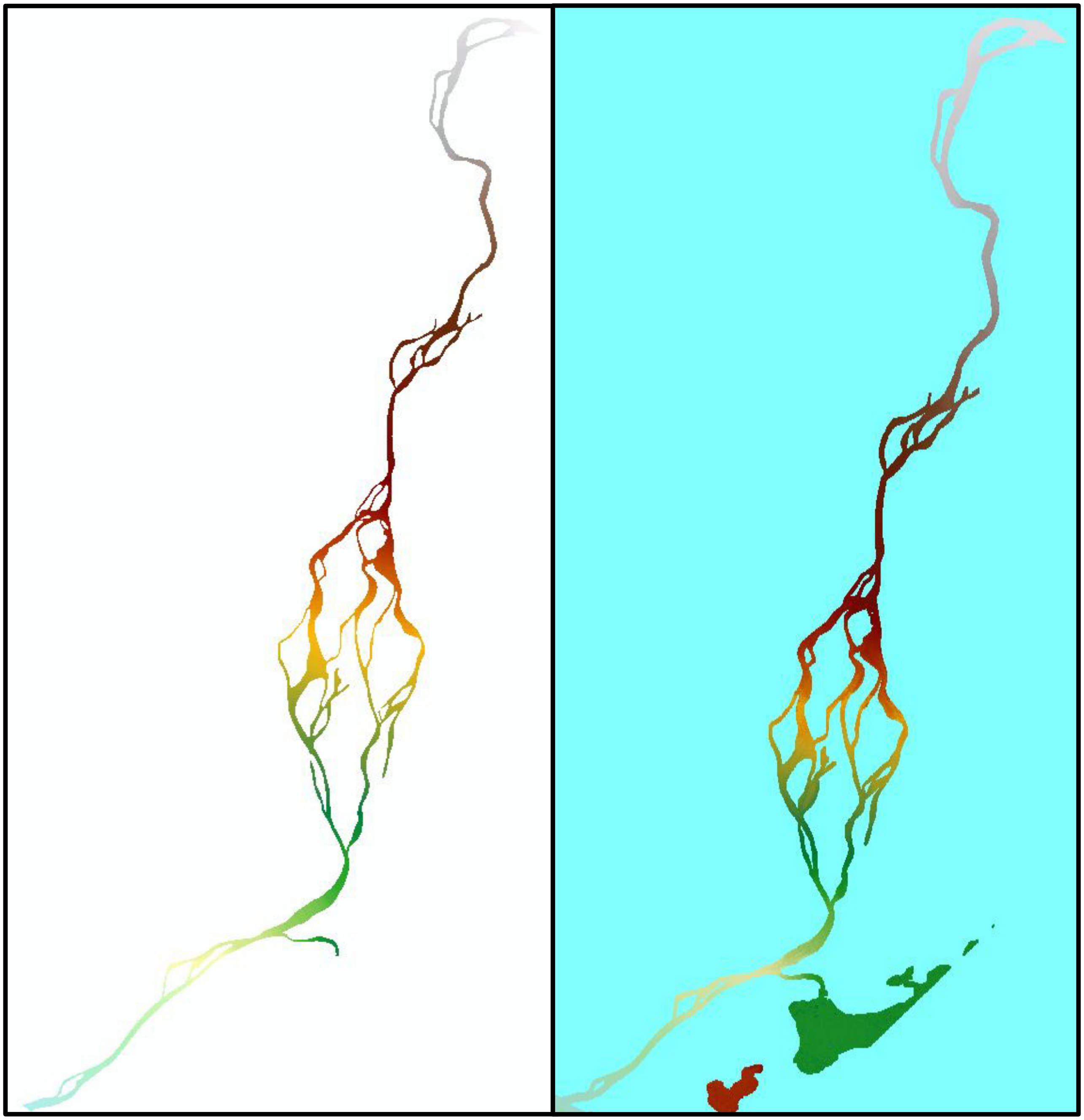


Figure 38, Glacier Fork Knick River Elevations (left Hydro Flattened DEM, right LiDAR Point Cloud)

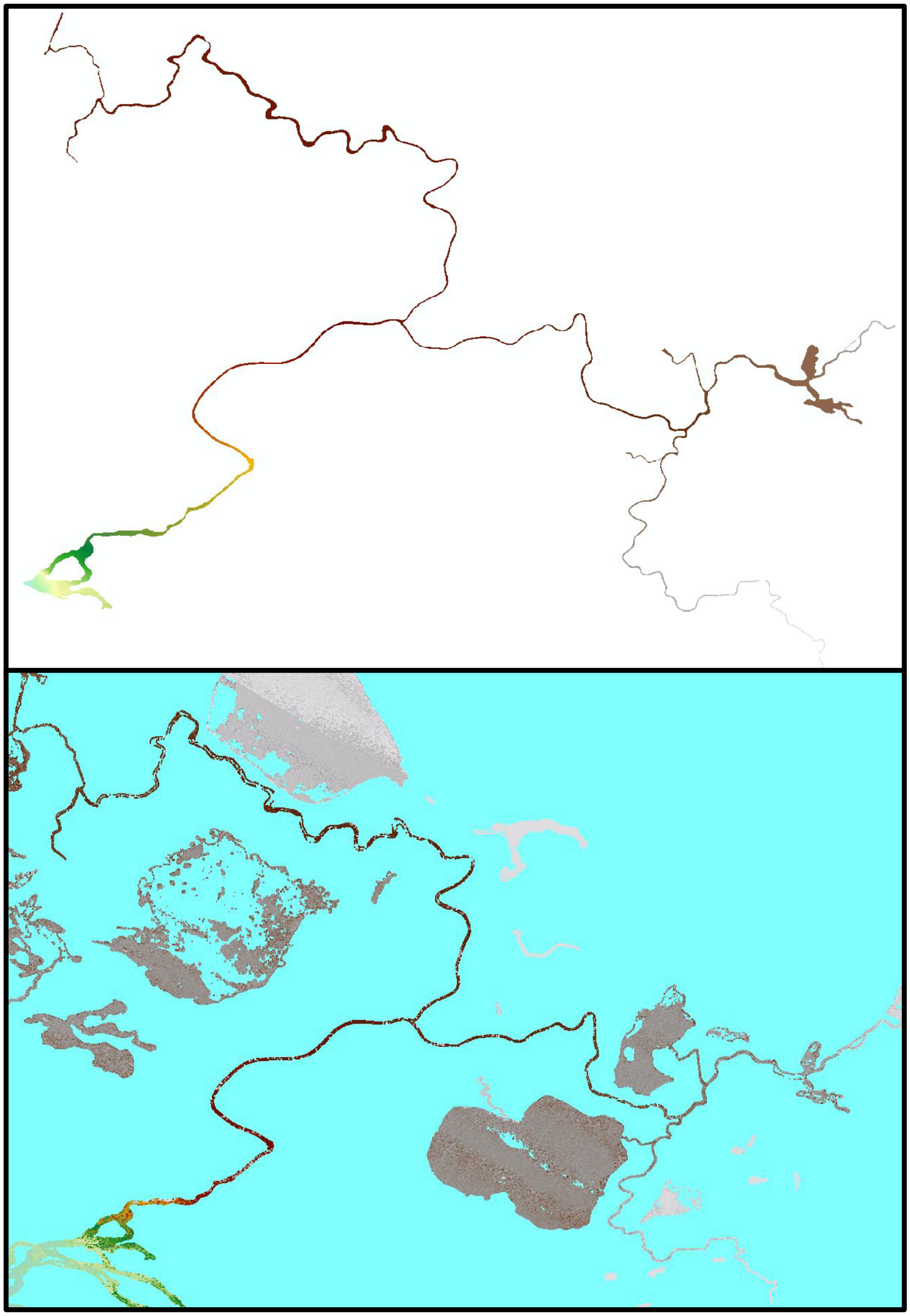


Figure 39, Jim Creek Elevations (top Hydro Flattened DEM, bottom LiDAR Point Cloud)

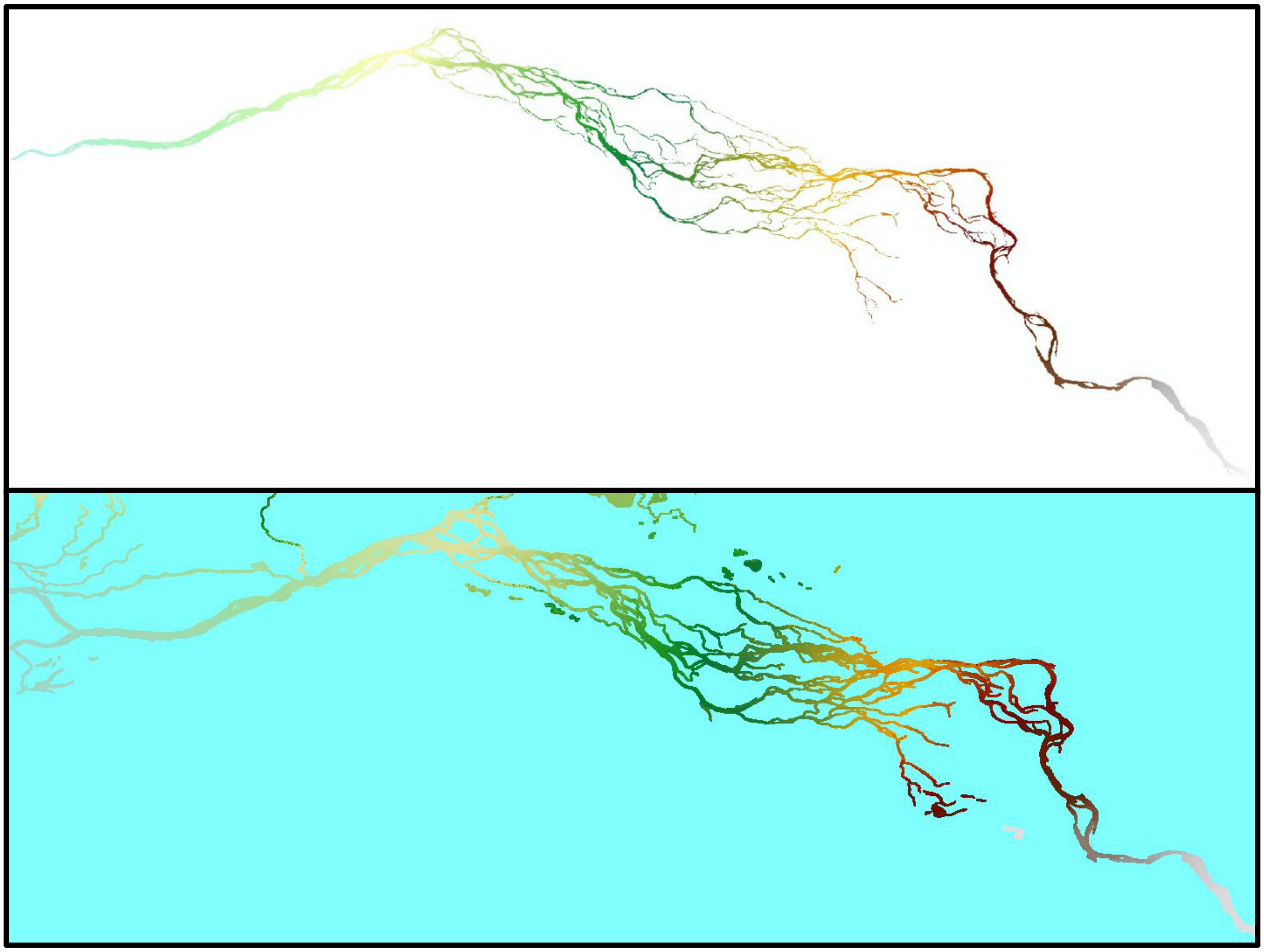


Figure 40, Knick River Elevations (top Hydro Flattened DEM, bottom LiDAR Point Cloud)

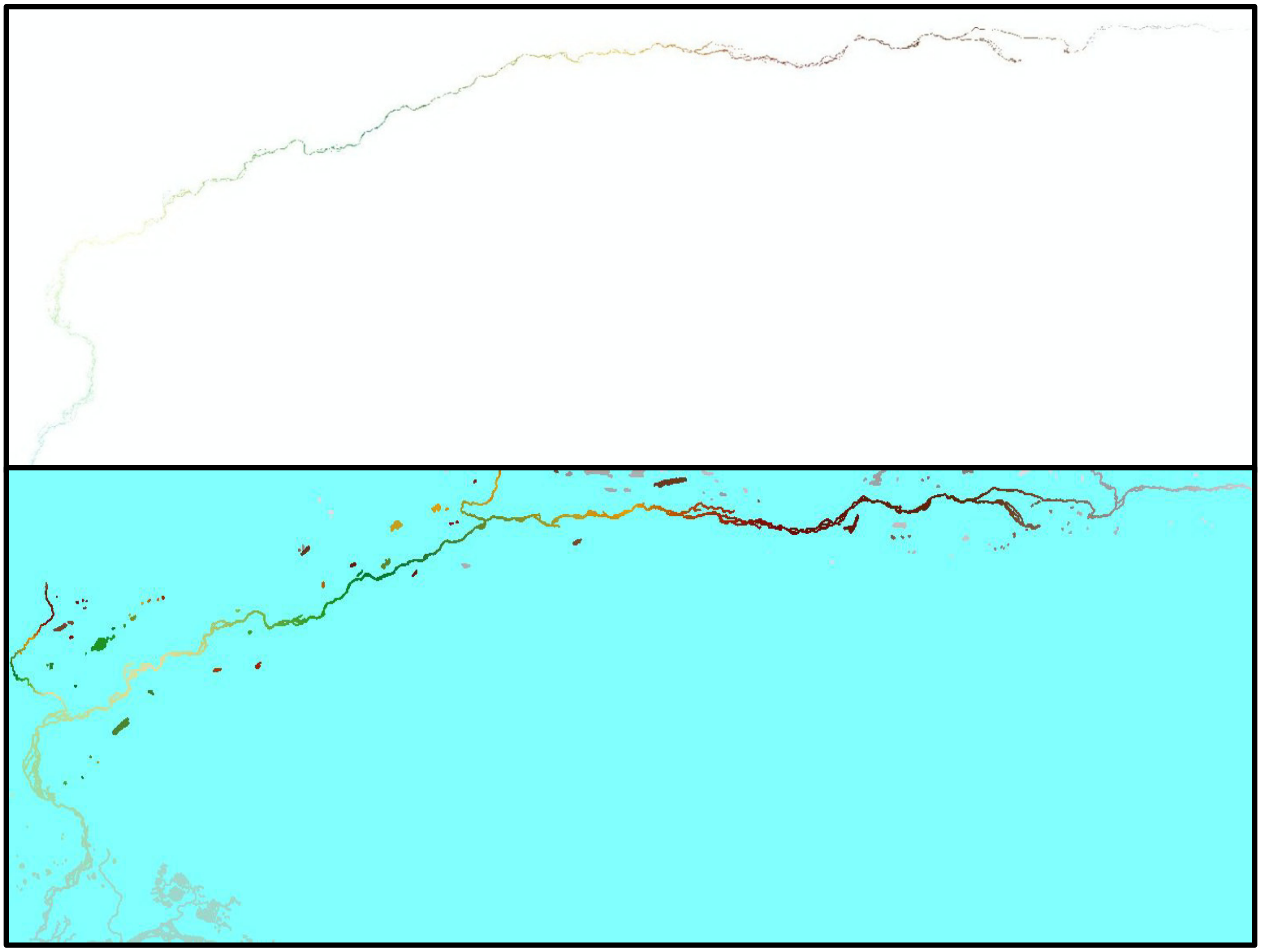


Figure 41, Matanuska River Elevations (top Hydro Flattened DEM, bottom LiDAR Point Cloud)

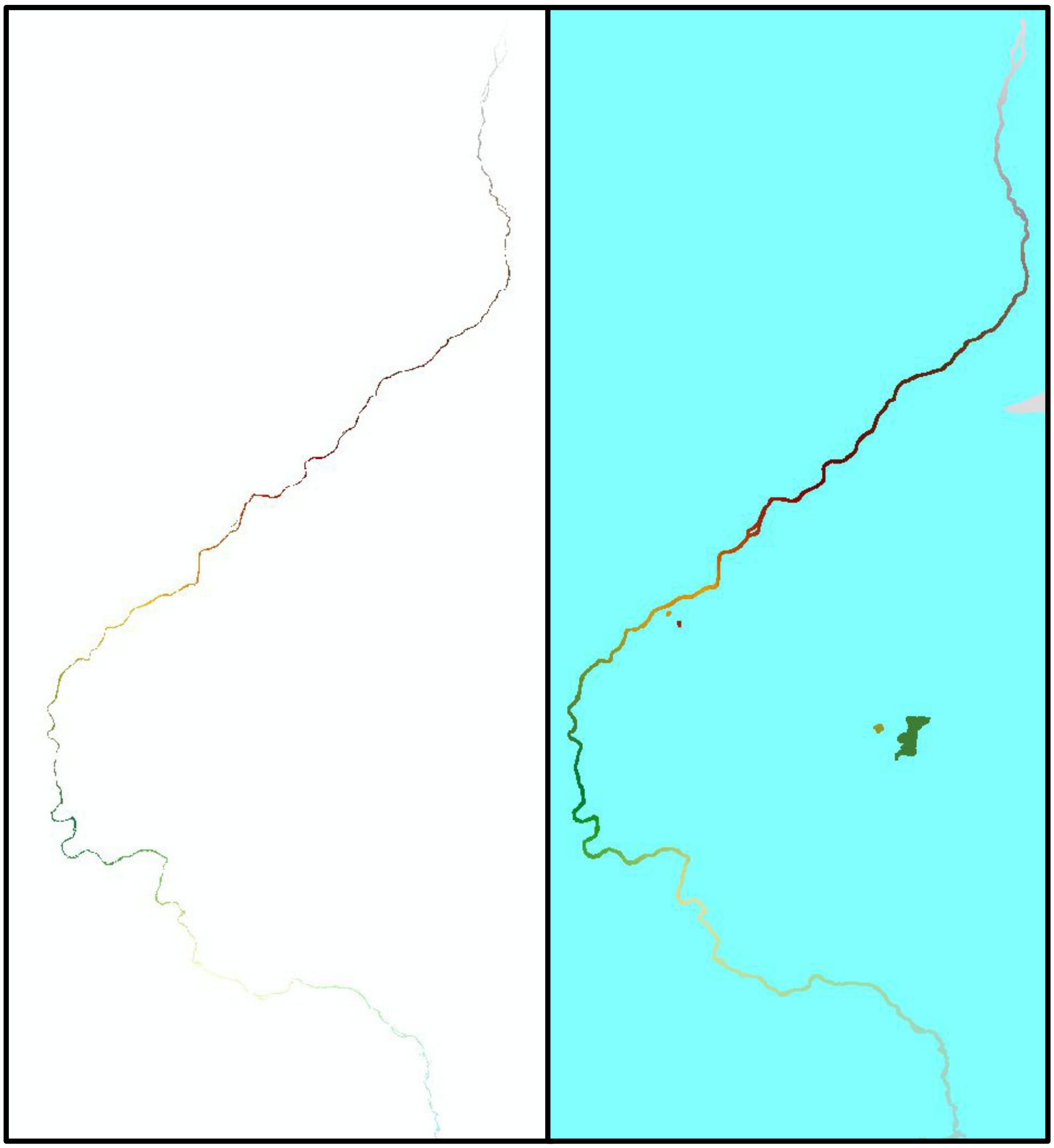


Figure 42, Tsadaka Creek Elevations (left Hydro Flattened DEM, right LiDAR Point Cloud)

Figure 43, Building Analysis – Ortho vs. Canopy Height Classification.

Figure 44, Building Analysis – Ortho vs. Canopy Height Classification with Building Footprint.

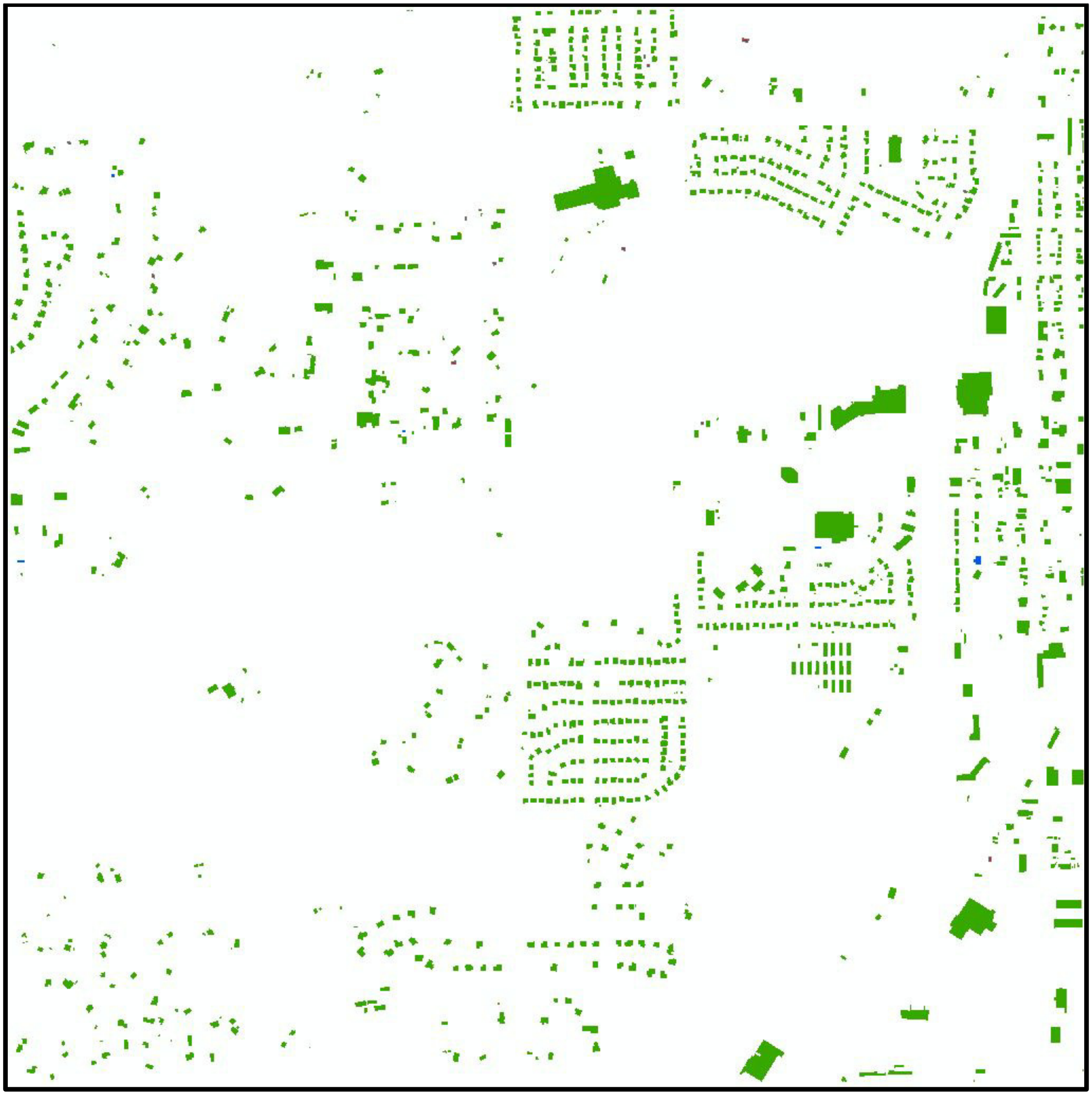


Figure 45, Building Analysis Results (Lt. Blue – Correct, Red – Incorrect, Dark Blue – Added)

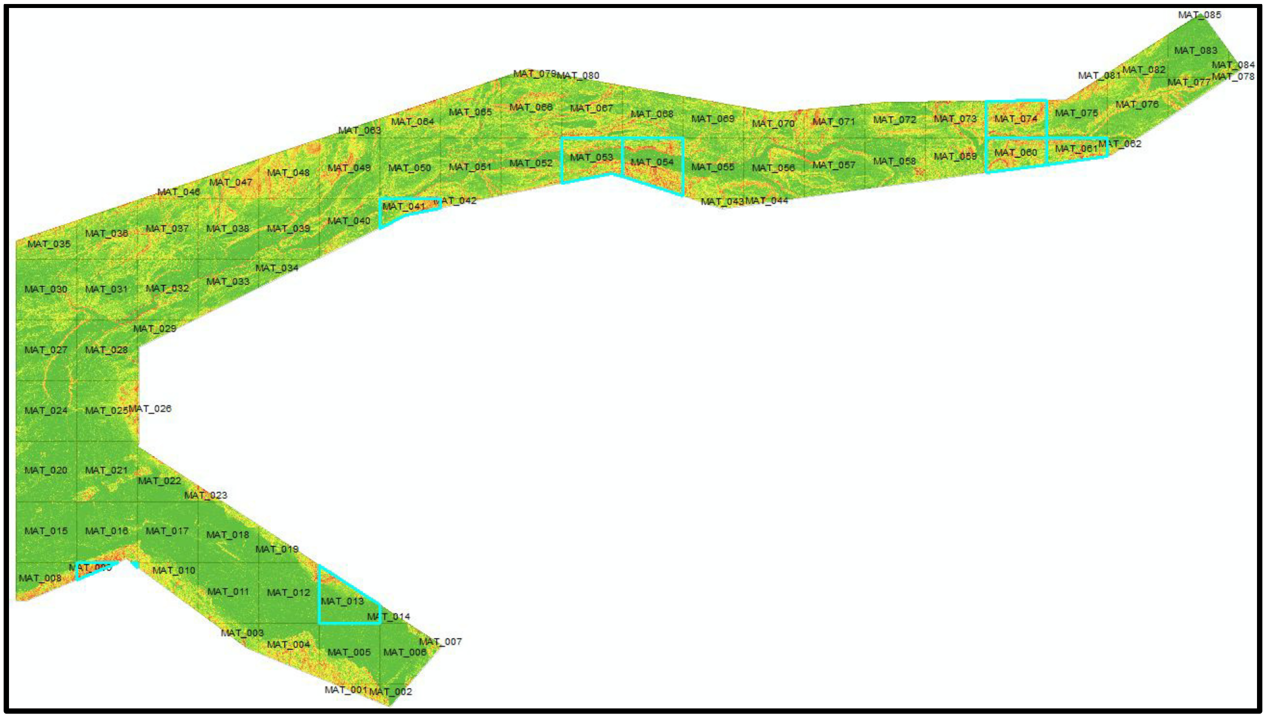


Figure 46, Degree Slope Selected Contour Tiles for Topology Testing.

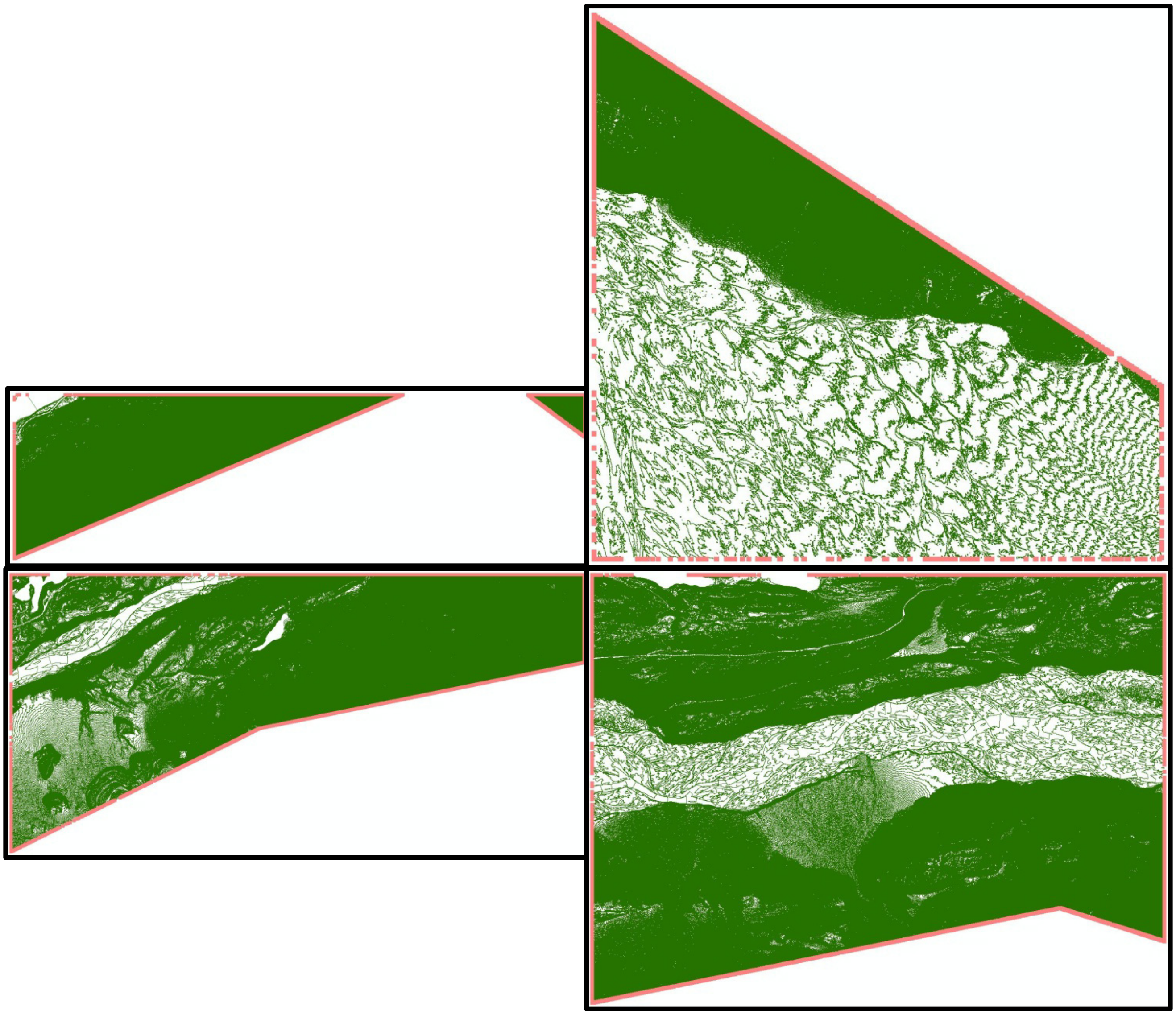


Figure 47, First Four Topology Checks.

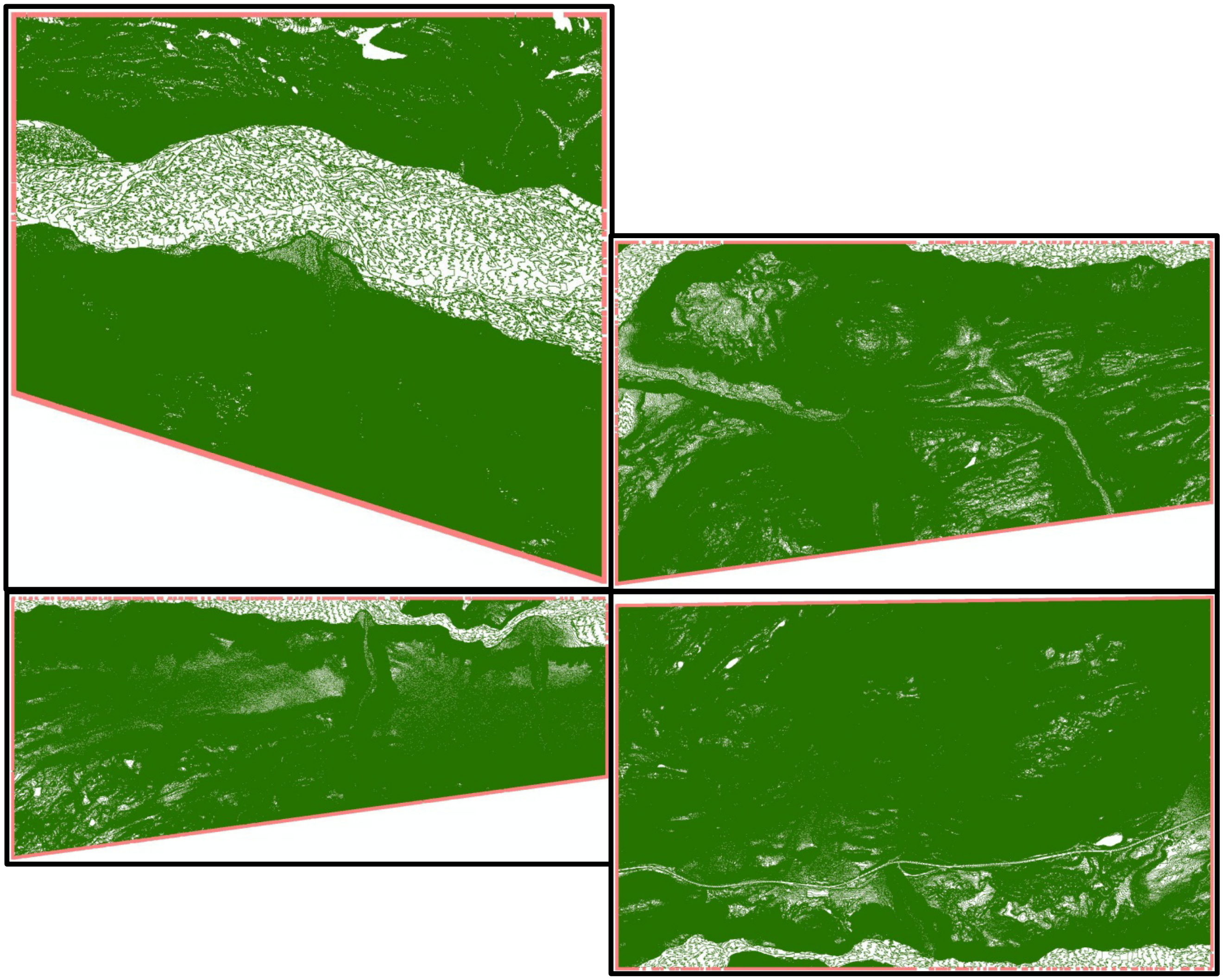


Figure 48, Second Set of Four Topology Checks.

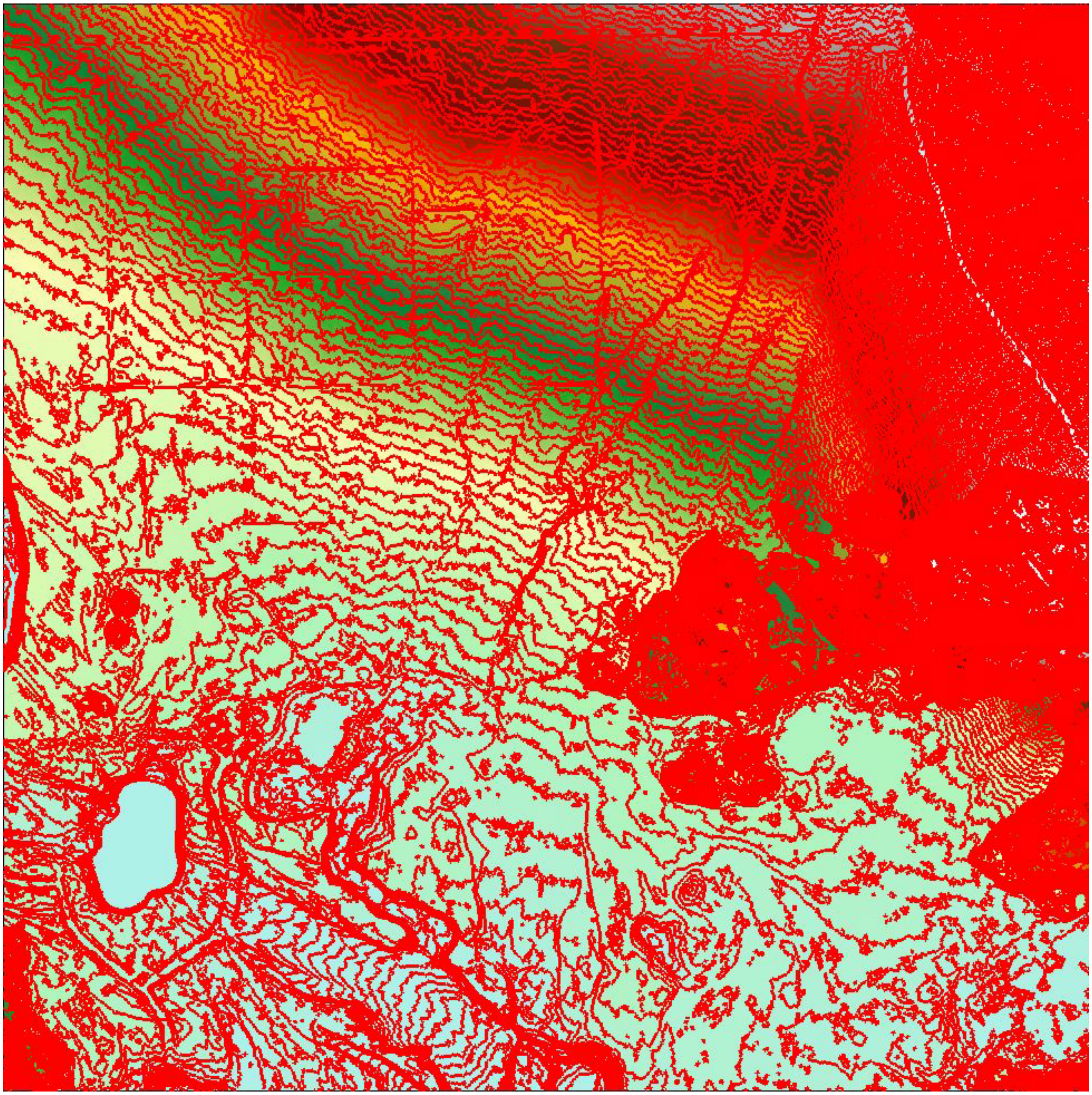


Figure 49, DXF Contour 2D Drape in QTM.

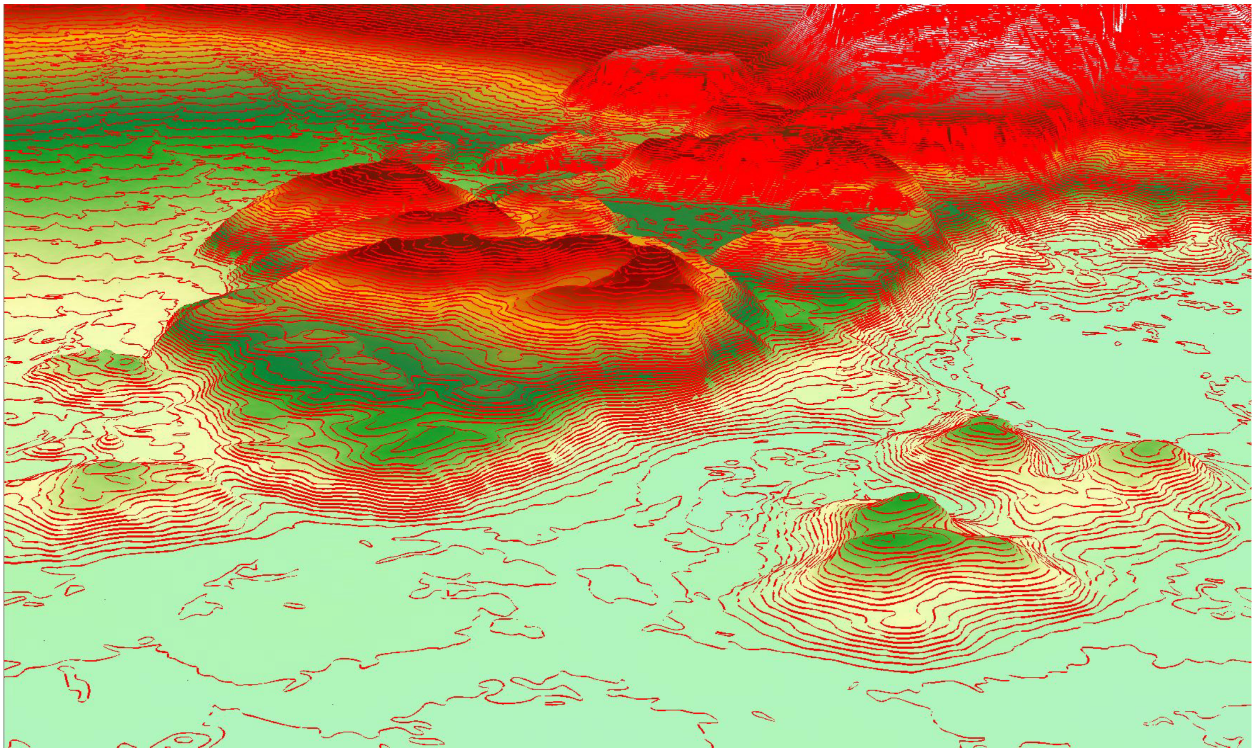


Figure 50, DXF Contour 3D Drape in QTM.

## Delivery History and Reported Data Quality Issues

**Delivery 1** – On 6/27/2012, Aerometric delivered to UAF a disk containing the LiDAR deliverables for Matanuska block minus the contours.

**Delivery 2** – On 6/29/2012, Aerometric delivered to UAF a disk containing a few minor corrections to Matanuska block.

**UAF reported results of the vertical accuracy assessment -** On 7/9/2012, UAF reported that forested and shrub classes did not meet the target vertical accuracy specification.

**UAF reported missing shorelines of Moose Creek in double line drainages –** On 7/10/2012, UAF reported issues with the double break line drainages. In particular, Moose Creek was missing one of its shorelines (see Figure 51).

**UAF reported seams and artifacts in first return DSM –** On 7/10/2012, UAF reported problems with the first return DSM. There were visible seams and discontinuities that looked like shifts in the data. Seven regions were identified as problem areas documented in screen captures (see Figures 52-55). Tiles affected include: MAT_025, MAT_035, MAT_065, MAT_070, MAT_071, MAT_075, and MAT_076.

**Delivery 3** – On 7/10/2012, Aerometric staged hydro break lines on their FTP site.

**Delivery 4** – On 7/17/2012, Aerometric delivered to UAF a disk containing contours and DSM/hill shades for Matanuska block.

**UAF reported redelivery of Matanuska DSM has incorrect data range by factor of 3.** On 7/19/2012, UAF reported that a recent redelivery of first return DSM had incorrect height range, more than three times larger than what it should be. The problem was tracked down to a vertical units issue during processing.

**Delivery 5** – On 7/23/2012, Aerometric delivered to UAF a disk containing corrected DSM's for Matanuska block.

**Delivery 6** – On 7/23/2012, Aerometric staged one bare-Earth DEM, hill shade, and LAS point cloud data for one tile of Matanuska block.

**UAF reported results of LAS point cloud assessment** – On 7/27/2012, UAF reported (1) cross calibration swaths that need to be removed from unclassified class 1 (see Figure 56), (2) low veg class 3 still contains points over water, (3) medium and high veg class should also be checked, (4) power transmission lines class 11 has discontinuous power lines (see Figure 57). UAF requested that these data quality issues be investigated.

**Delivery 7** – On 7/29/2012, Aerometric staged 7 corrected LAS point cloud tiles, in which cross calibration swaths were removed or water classifications were improved, on their FTP site.

**Delivery 8** – On 7/30/2012, Aerometric delivered to UAF a DVD containing 8 fixed LAS point cloud files for Matanuska block.

**UAF asked why tile scheme skipped MAT045** – On 8/2/2012, UAF asked why the tile numbering scheme skipped MAT045. Aerometric reported that this tile contained ortho imagery data but not LiDAR data. This inconsistency was not an issue for the MatSu GIS staff.

**UAF reported six missing LiDAR intensity tiles** – On 8/6/2012, UAF reported a section of missing LiDAR intensity data mosaic (see Figure 58). This was identified as six missing quarter tiles that were not included in the delivery.

**Delivery 9** – On 8/8/2012, Aerometric staged 6 corrected LiDAR intensity tiles for Matanuska block on their FTP site.

**Delivery 10** – On 8/13/2012, Aerometric delivered to UAF a disk containing LAS point cloud data with reclassified power lines for Matanuska and partial Core Area blocks. **This final delivery of data completed the final corrections that were needed for acceptance of the Matanuska block.**

*After the initial acceptance of this block, the data were delivered to USGS for review for inclusion into the National Elevation Dataset (NED). USGS identified some minor tinning issues in the hydro flattening of heavily braided streams that they considered unacceptable for inclusion into the NED. As a result, breaklines for hydro flattening, DEMs, and bare earth hillshades had to be reprocessed and redelivered for additional QC procedures. Deliveries 11 & 12 were a result of this unforeseen issue.*

**Delivery 11** – Aerometric delivered to UAF a delivery disk on 03/13/2013 containing a redelivery for Talkeetna, North Susitna, and Matanuska blocks. This final delivery was required to fix some tinning issues that USGS found in the hydro flattened DEM that needed to be fixed to meet National Elevation Data (NED) requirements. The delivery included gridded bare-Earth DEM, gridded first return DSM and updated hydro layers.

**UAF reported negative heights in canopy height estimate** – On 3/21/2013, UAF reported negative values in the canopy height estimate product. This test showed that some areas had a bare-Earth DEM that was higher than the first-return DSM (see Figure 59).

**Delivery 12** – Aerometric delivered to UAF a delivery disk on 03/25/2013 containing a redelivery for Talkeetna and Matanuska blocks which addressed the negative canopy height estimates. This was later identified as a resampling issue due to work flow inconsistencies.

On 3/28/2013, UAF completed verification of recently delivered fixes. **As a result, Matanuska block passed the second and final quality assurance screening for submittal, to USGS.**

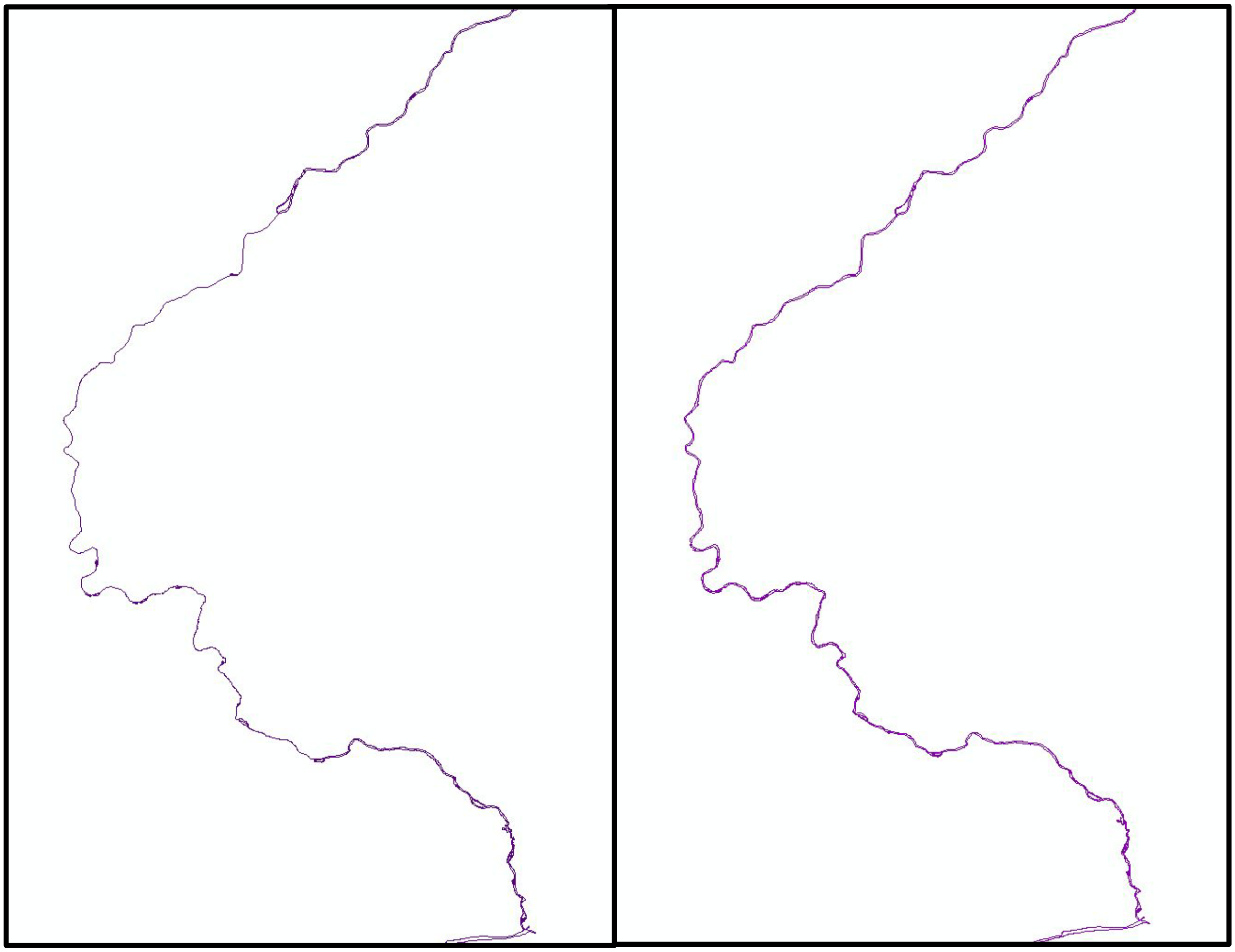


Figure 51, Moose Creek Double Breakline Drainage missing lines.

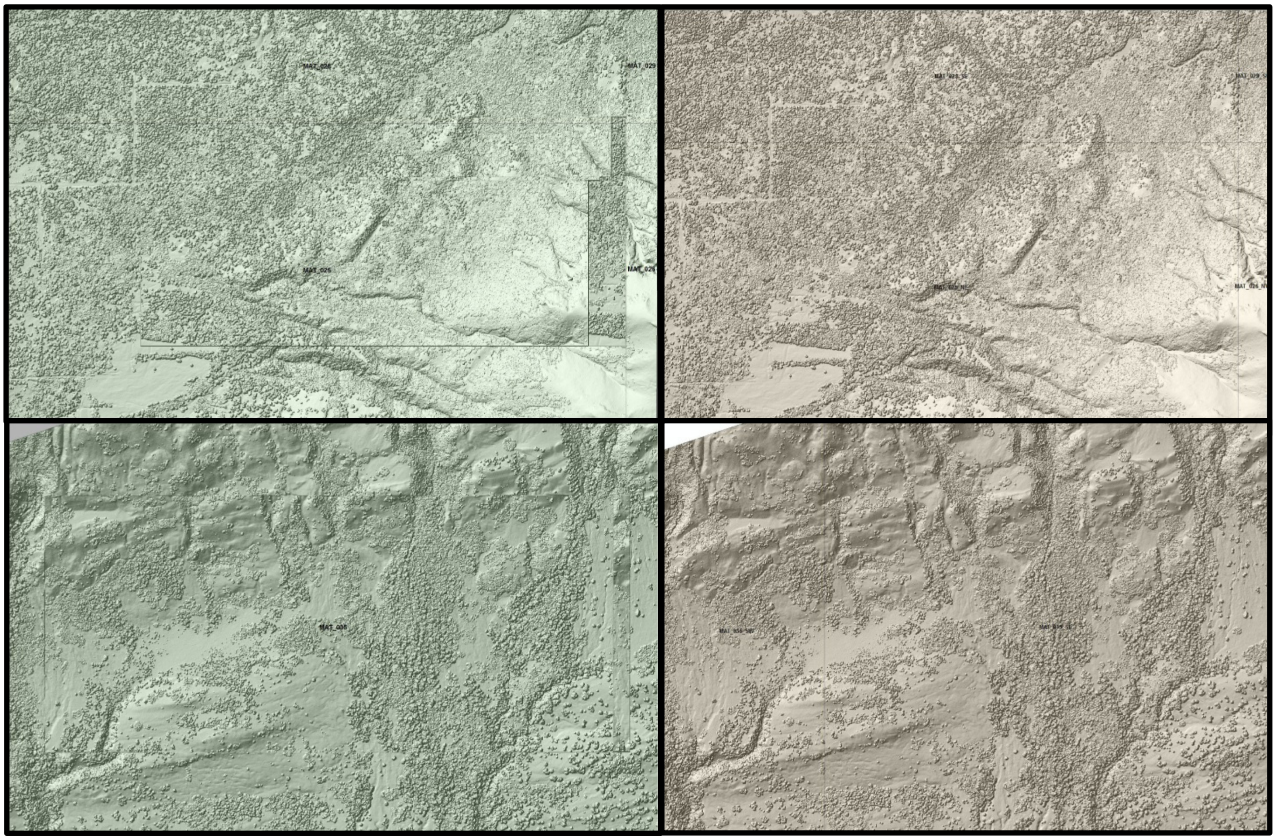


Figure 52, Seams and artifacts in shaded relief of first return DSM (MAT_025 and MAT_035).

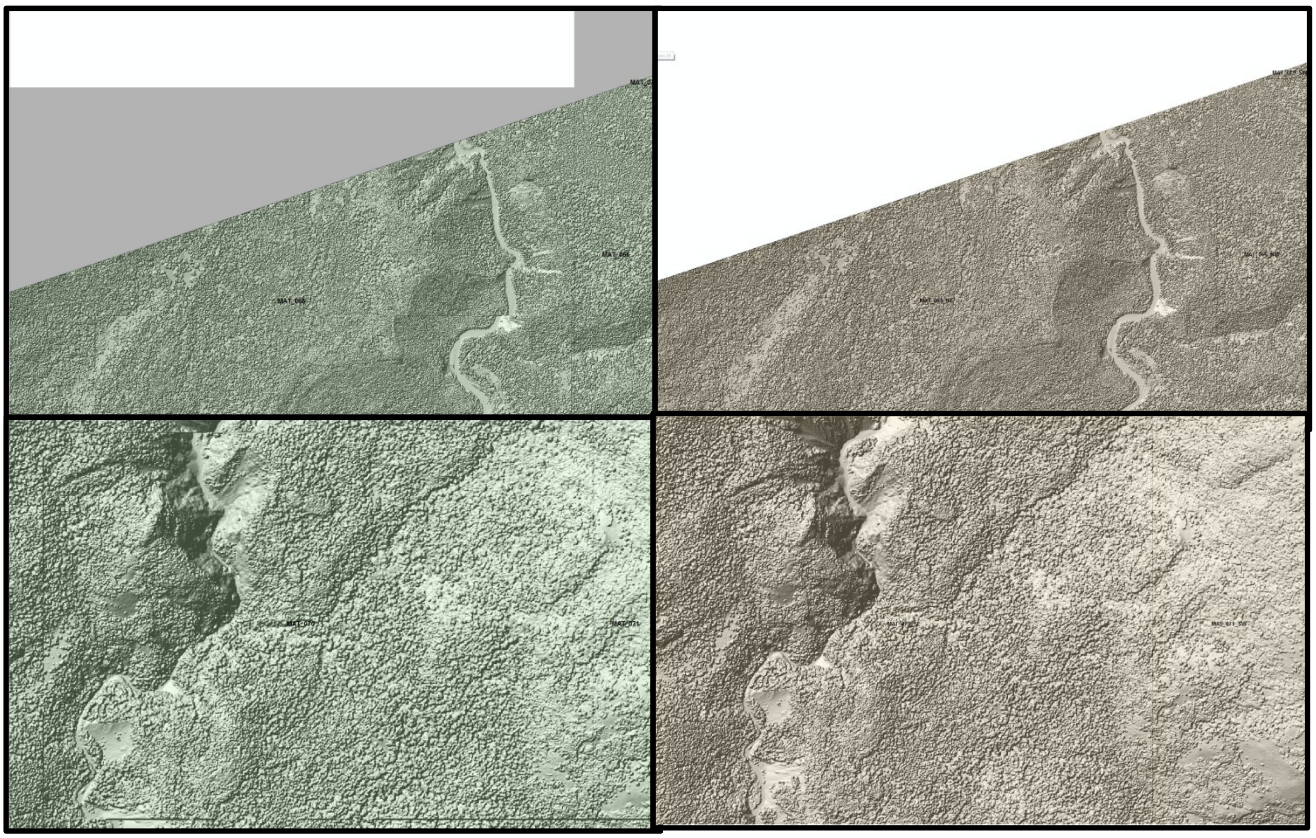


Figure 53, Seams and artifacts in shaded relief of first return DSM (MAT_065 and MAT_070).

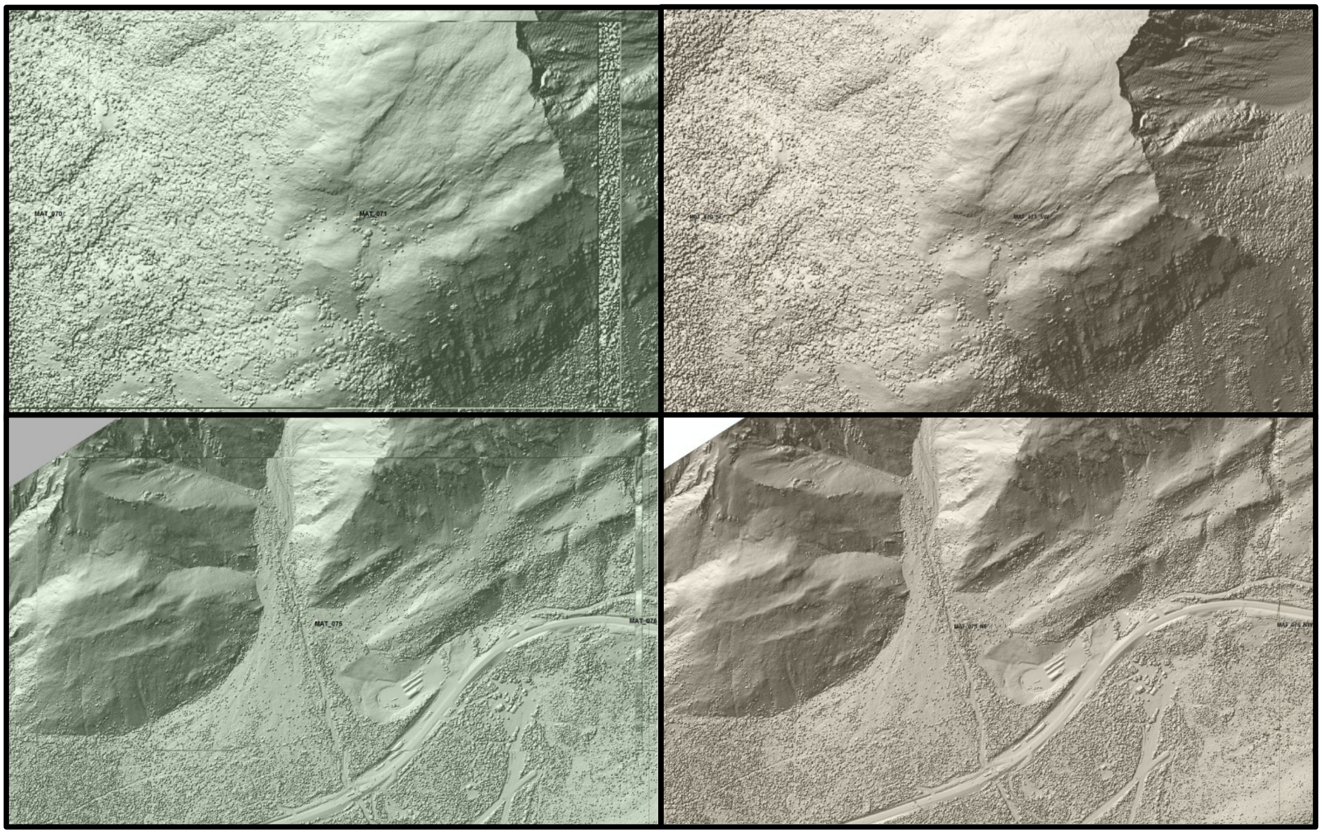


Figure 54, Seams and artifacts in shaded relief of first return DSM (MAT_071 and MAT_075).

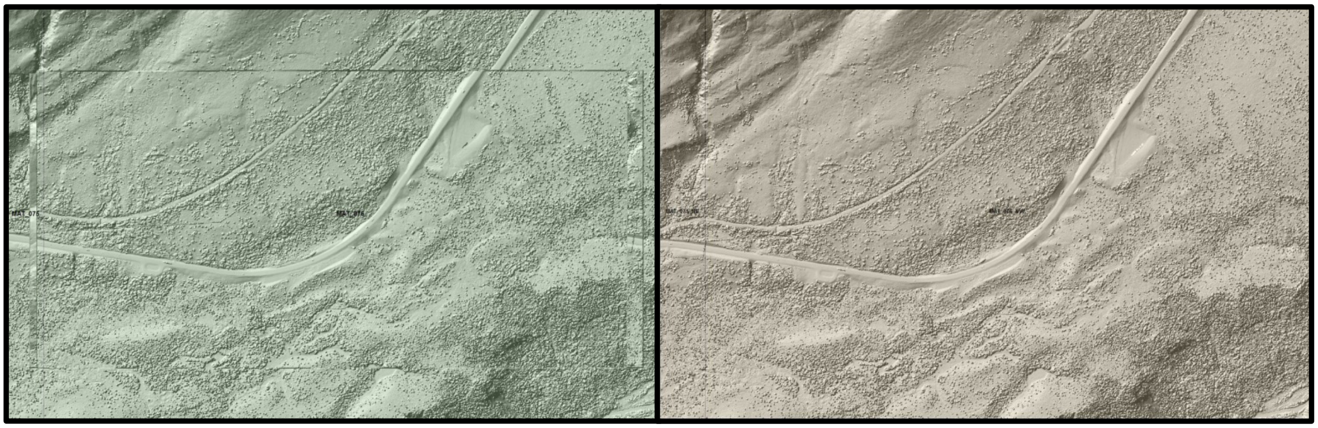


Figure 55, Seams and artifacts in shaded relief of first return DSM (MAT_076).

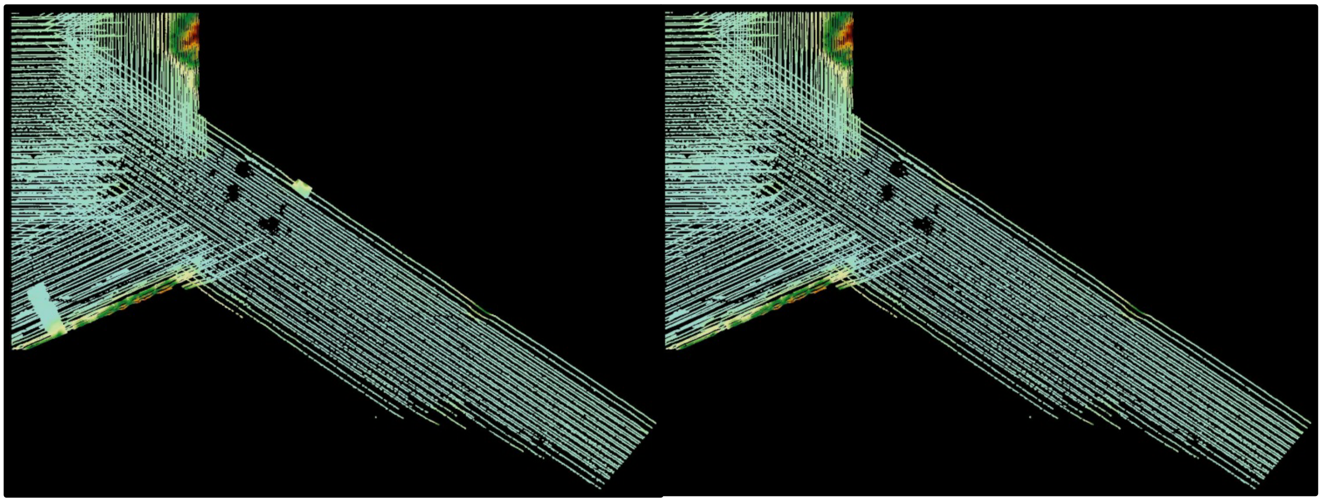


Figure 56, Cross calibration swaths removed from unclassified class 1 LAS point cloud data.

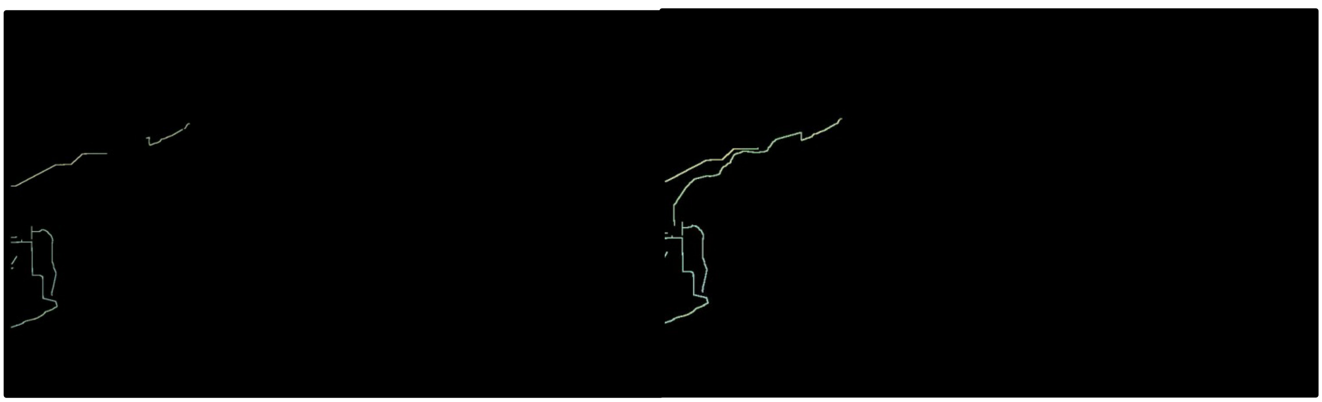


Figure 57, Power transmission lines class 11 discontinuous in Matanuska block.

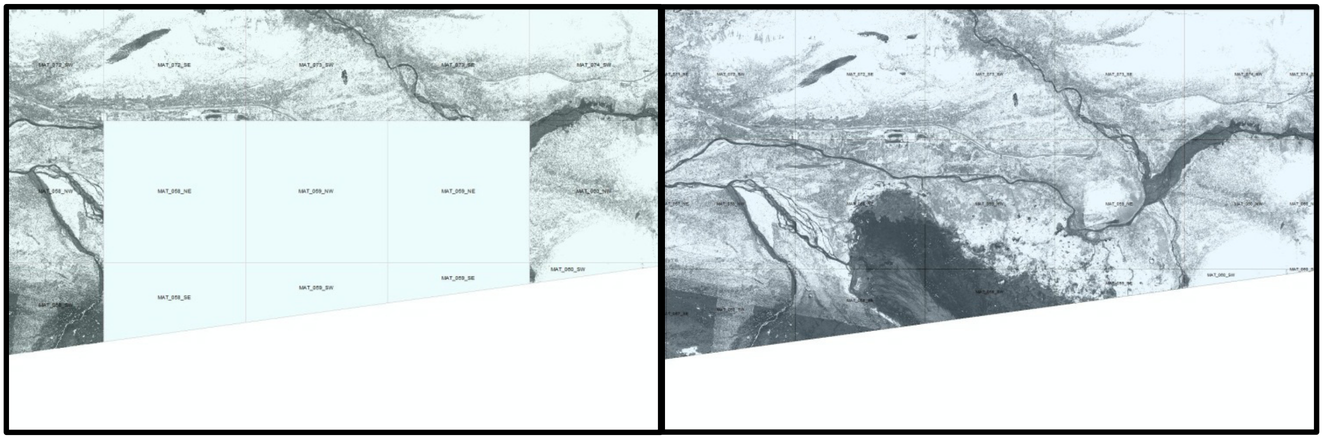


Figure 58, Six missing quarter tiles in LiDAR Intensity data.

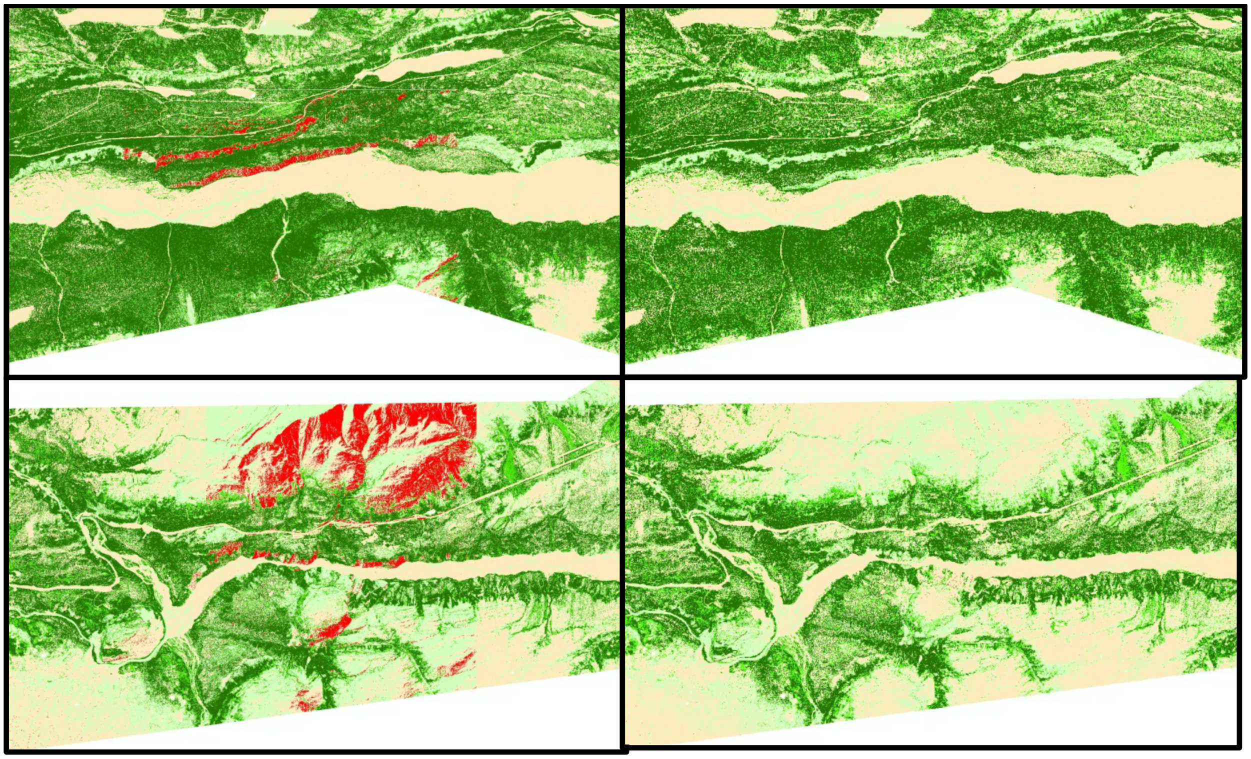


Figure 59, Negative heights detected in canopy height estimate when subtracting bare-Earth DEM from First-Return DSM (tiles: MAT_053 and MAT_074).