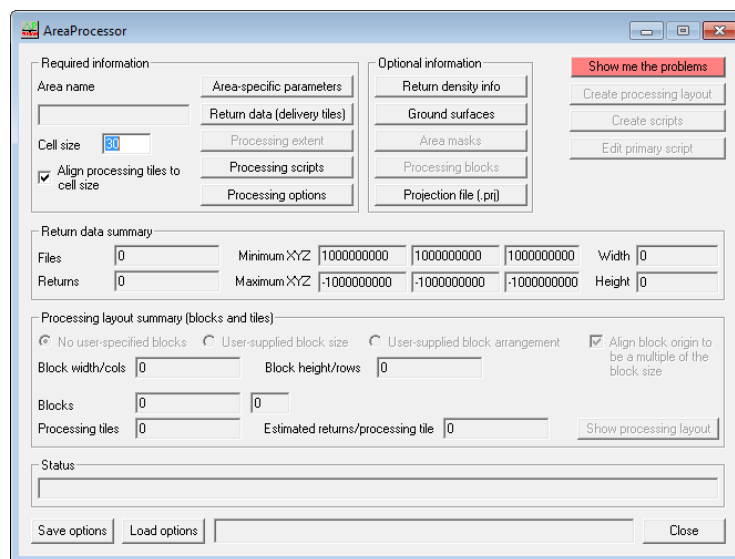


EXERCISE 4

Generate Canopy Metrics Using FUSION's AreaProcessor



Introduction

Originally, the process for producing canopy related statistics from lidar point clouds in FUSION was rather cumbersome. It consisted of running the GridMetrics utility, and then converting and merging the outputs to produce ASCII and DTM layers for the entire acquisition area. However, this method produces artifacts on the tile boundaries and the artifacts are reflected in the final layers and subsequent analysis. To address this problem, new switches were added to the GridMetrics utility that allow the user to retile the data and create analysis buffers around the new tiles. When the output metrics are calculated, the buffer ensures there are no artifacts. In the final output, only the metrics for the actual tiles are saved (not for the buffered areas).

The AreaProcessor Interface was created to direct the processing workflow and create the complex batch file needed for the retiling/buffering workflow, as well as setting up processing to take advantage of multiple processing cores. In this exercise, you will walk through the process of generating a variety of canopy metrics using the AreaProcessor.

Objectives

- The objective of this exercise is to generate seamless rasters that represent statistical information about the canopy (canopy metrics) from the lidar point cloud for the entire study



area. We will accomplish this task by using FUSION's AreaProcessor, which coordinates large area processing using the GridMetrics utility in conjunction with a series of batch files.

Prerequisites

- Completion of Advanced Lidar Processing Exercises 1-3.
- Familiarity with a variety of FUSION command line utilities.



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Part 1: AreaProcessor Batch Files

Before we setup the AreaProcessor interface, it is important that you review the GridMetrics FUSION utility and the batch files that are utilized in the AreaProcessor Interface. We advise that you read about GridMetrics in the FUSION manual before moving on to read a brief description of each of the AreaProcessor batch files below.

A. Review Batch Files

1. Navigate to your APScripts folder. If you installed FUSION on your C drive, the folder is likely at **C:\FUSION\APScripts**.
2. In this folder are the batch files (.bat) that handle most of the processing in AreaProcessor.
 - i. **Basic_setup.bat** — defines the directory structure and canopy metric parameters. This is the script that rules them all!
 - ii. **Tile.bat** — contains the GridMetrics script used to process the las tiles
 - iii. **Buildlayers_allreturns.bat**—creates the final seamless layers for metrics including all returns
 - iv. **Buildlayers_firstreturns.bat**—creates the final seamless layers for metrics including first returns
 - v. **Doextractmetric.bat**—extracts metrics from CSV files and writes them to a grid format (ASCII)
 - vi. **Extract_metric.bat**— produces multiple metric ASCII files for each tile
 - vii. **Extract_strata_layer.bat**—extracts a single strata layer from the overall strata output
 - viii. **Buildstrata.bat**—extracts strata metrics from CSV files and merges them into a single coverage for each layer and metric

Note: the only batch file you should need to edit to use this work flow in the future is the **Basic_setup.bat**.

3. It is recommended that you open each batch file listed above and read through the scripts for a better understanding. Remember, don't double click on them or they will run. Just right-click and select edit to view them in a text editor.
4. It is also recommended that you refer to the FUSION manual to ensure you understand the **GridMetrics** command.

Part 2: Inspect Basic_setup.bat

Although there are numerous batch files that are coordinating the processing, the one that you will need to focus on and edit is the Basic_setup.bat file. This file contains parameters that control the types of metrics to be created, the spatial resolution of outputs, strata thresholds, and many other important nuances of the processing.

A. Edit Basic_setup.bat

Note: If you edit batch files in notepad (the default text editor), it doesn't list the line of text next to each line. This can make it difficult to keep track of which line you're on when editing long batch files, as we

*will do in this section. An alternative text editor is **Notepad++**, which conveniently displays the line of text and color codes your batch files for you to make them easier to read.*

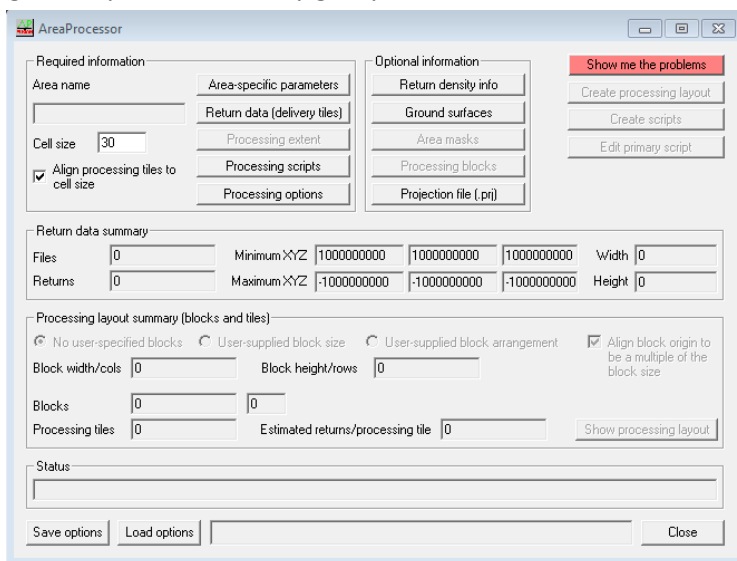
Having notepad ++ will make this exercise easier to follow. To download, navigate to: <https://notepad-plus-plus.org/>

1. In the **APScripts** folder, right-click on **Basic_setup.bat**, and click **edit**. Alternatively you can open the batch file in your favorite text editor. Remember not to double-click the batch file to open it, or it will try to run.
2. Go through the batch file line by line to understand the inputs to AreaProcessor. Some of the key lines are listed below.
 - i. Lines 21 -27 allow you to select what layers AreaProcessor will output. Read the remarks (indicated with “REM”) above that section to understand what each line controls.
 - ii. The section from lines 60 – 155 are variables that Basic_setup.bat collects from the AreaProcessor interface. You should not change these lines, as they will be updated from the AreaProcessor.
 - iii. Lines 193 – 207 are settings for an AreaProcessor processing run if the units are in feet. You can find the same setting in lines 209 – 222, but converted to meters.
 - iv. Lines 209 – 222 are settings for an AreaProcessor run if the units are in Meters.
 - (a) Line 209 is the cell size of the final metrics. **It needs to be the same on this line as what you will enter into AreaProcessor later in the exercise.**
 - (b) Line 210 is the height cutoff. This means that for elevation metrics, returns below this cutoff will not be included in processing.
 - (c) Line 211 is the cover cutoff. For cover metrics, returns below this cutoff are assumed to not be part of the canopy, and will thus not be included in processing.
 - (d) Line 212 is the coordinate information. Make sure that the horizontal and vertical units of your data are in meters (m m).
 - (e) Line 213 allows you to set a low and high outlier to be excluded in processing.
 - (f) Lines 214-217 allow you to set cell characteristics of the topo metrics and intensity images.
 - (g) Lines 218-222 allow you to set a window size for statistics such as standard deviation to be calculated.
 - v. Lines 228 and 230 allow you to set the thresholds for the strata layers depending on if your data is in feet or meters.
 - vi. Lines 235, 236, 238, and 239 allow you to set the spatial resolution of the canopy height model for data in feet or meters, respectively. This is completely separate from the above cell size parameter on lines 194 (feet) and 209 (meters).
 - vii. Lines 276-295 set the labels for the output files and folders. These do not need to be changed.
 - viii. Lines 306-352 set up the output folder structure and copies the batch files into your Project_home folder structure. These can be changes, but for this workflow it is not recommended.
3. The FUSION manual notes: ***If you just want to produce the “standard” set of FUSION metrics using 30 m cells, you really don’t need to change any of the batch files.*** If you’d like to make changes to the outputs, that can be done in the Basic_setup.bat file on the lines listed above.

Part 3: Set up the AreaProcessor

A. Open AreaProcessor and set Area-specific parameters

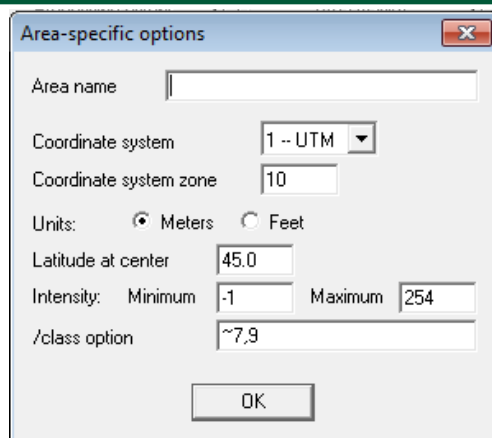
1. Navigate to the FUSION folder and double click on the AreaProcessor.exe file. This will open the AreaProcessor tool, shown below. Because of the way AreaProcessor references other tools in the FUSION folder, it is not recommended that you make a shortcut to AreaProcessor or move the program anywhere or it may give you an error.



2. You can see that AreaProcessor gives you many options to adjust your processing. But there are a number of steps you must go through before you begin. Click the red button that reads, **Show me the problems**. This will open a pop-up window, shown below.



3. The AreaProcessor is designed so that it won't start running if there are errors in the setup that you provide. The Show me the problems button lists the steps you still need to take care of before you can begin processing. Close the pop-up window.
4. In the AreaProcessor interface, click the button, **Area specific parameters**. This will open the pop-up window, shown below.



5. This is where you'll set a few parameters specific to this processing run.
 - i. Name the Area something intuitive like **GTAC_Lidar_training**.
 - ii. Set the coordinate system and zone. The example data for the course is in **UTM zone 12**.
 - (a) You can open PRJ files in Notepad or Notepad++ to view this information
 - iii. The units should be in **meters**.
 - iv. Set the **latitude at center** to **36.6** for the Kaibab data. When you receive your lidar data from a vendor, the report they include should have this information. This is used for solar radiation calculations, so it should not cause any projection changes.

Note: You can use the Identify tool in ArcMap to discover the latitude at the center of your lidar data.

- v. You can **leave the intensity values at default**.
- vi. The **/class option can be left at 7 and 9, but add 18 as well**. This excludes .las points that are given as 7, 9 or 13, which by ASPRS specifications are low points or water. To read more about ASPRS .las classification and file format, see: http://www.asprs.org/wp-content/uploads/2010/12/LAS_1_4_r13.pdf

Note: Sometimes vendors use class 18 to identify "high noise." To see if this class was used in your dataset, refer to the Classification Summary section of the QAQC.html output you created in exercise 3. If points were classified as class 18, add it here. Otherwise, you may end up with erroneous high values in your canopy height model.

6. Click **OK** to close the window.
7. In the AreaProcessor window, set the cell size box to 30. This needs to be the same as it was set in the Basic_setup.bat file that you reviewed earlier.

B. Adding Return Data, Batch Files, and Processing Options

1. Click **Return data (delivery tiles)** to open the point data files pop-up window
2. Add your .las files to this window by adding the filelist.txt file you created earlier. Click **Add list**, then navigate to your Project_home\point\LAS\all_points folder in the window that opens and double-click **filelist.txt**. This will populate the window with las files. See image below.

| File name | Returns | MinX | MinY | MinElev | MaxX | MaxY |
|---|----------|-----------|------------|---------|-----------|------|
| C:\Project_Home\point\LAS\all_points\36112E2107.las | 25389843 | 389315.62 | 4051199.00 | 2527.30 | 390451.25 | 40 |
| C:\Project_Home\point\LAS\all_points\36112E2108.las | 26321255 | 390433.65 | 4051184.81 | 2536.33 | 391569.12 | 40 |
| C:\Project_Home\point\LAS\all_points\36112E2109.las | 25666650 | 391551.71 | 4051170.81 | 2544.19 | 392687.02 | 40 |
| C:\Project_Home\point\LAS\all_points\36112E2110.las | 22618622 | 392669.78 | 4051156.88 | 2566.43 | 393804.94 | 40 |

3. Click **OK** to close the window.
4. The **Processing Extent** button will allow you to choose a subset of your data that you might want to process. Feel free to open the window and explore the tool, but for now don't choose a subset.
5. Next, click **Processing scripts**. This is an important popup window, as it organizes the batch files you saw earlier in the exercise and where to place the outputs. Go down through the window line by line.
 - i. The primary output folder is where all of your metrics are going to be stored. For this exercise, click **Browse** and choose **Project_home** and then **products**. Click **OK**.
 - ii. The Primary batch file is a .bat file created by the AreaProcessor. To create it here, click **Browse**, navigate to **processing**, and in the file name text box type **GTAC_AP.bat**. Click **Open**.
 - iii. The Folder containing secondary batch files needs to point to the **APScripts** folder. This is the same folder that you looked through in part 1 of this exercise. Unless you moved the files, they will be at **C:\FUSION\APScripts**.
 - iv. In the box marked "Before processing all tiles in a block run this batch file" Click **Browse** and navigate to the **Basic_setup.bat** file in the APScripts folder.
 - v. In the box marked "For each tile in a block run this batch file" Click **Browse** and navigate to the **tile.bat** file in the APScripts folder.
 - vi. In the box marked "After processing all tiles in a block run this batch file" Click **Browse** and navigate to the **posttile.bat** file in the APScripts folder.
 - vii. In the box marked "Before starting to process any blocks run this batch file" Click **Browse** and navigate to the **preblock.bat** file in the APScripts folder.
 - viii. In the box marked "After processing all blocks run this batch file" Click **Browse** and navigate to the **postblock.bat** file in the APScripts folder.
 - ix. The processing scripts window should now look similar to the image below.

The 'Processing scripts' dialog box contains several fields for configuring the processing workflow. The 'Primary output folder*' field is set to 'C:\Areaprocessor_test\Project_Home\Products'. The 'Primary batch file' field is set to 'C:\Areaprocessor_test\Project_Home\processing\GTAC_ap.bat'. The 'Folder containing secondary batch files' field is set to 'C:\FUSION\APScripts'. Below these are sections for pre- and post-processing batch files for blocks and tiles, each with 'Clear', 'Edit', 'Create', and 'Browse' buttons. The 'Required' field is marked with an asterisk (*).

Note: Not all of the batch files are required for an AreaProcessor run. The only required fields are marked with an asterisk (*). This is why it is important to be familiar with what the batch files do and to read about processing workflows in the FUSION Manual. For the work being done in this exercise, these batch files provide a good logic.

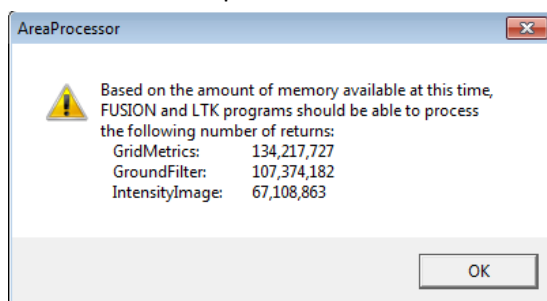
6. Click **OK** to close the window.
7. Click **Processing options** to open the pop-up window below.

The 'Processing options' dialog box has two main sections: 'Processing tile layout options' and 'Tile clipping options'. In the 'Processing tile layout options' section, option 5 is selected: '5--Overlay new grid using width and height, split tiles as needed using density'. In the 'Tile clipping options' section, 'Clip new data tiles before processing' is checked, and 'Delete newly clipped tiles after processing' is also checked. Other options include 'Use LTK log file specific to batch job', 'Create log files for individual processing tiles', 'Create batch files for each processing block to take advantage of multi-processor architectures', and 'Number of processing streams' set to 6. Fields for 'Tile width', 'Tile height', 'Buffer width', and 'Max returns' are also present.

8. This processing options window lets you set some important parameters about the data that you'll be processing.
 - i. In the **Processing tile layout options** section there are 5 different options. Options 2 and 5 will create a tiling layout, which is important to this workflow. Option 5 should be used if

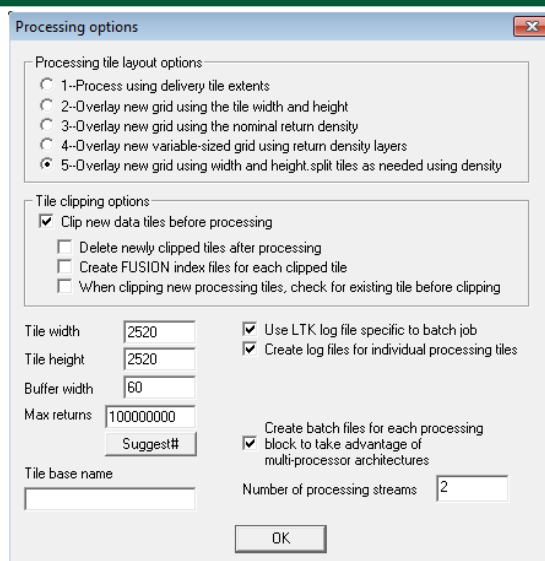
you have a return density layer, which you created in an earlier exercise while running the catalog command. **Select option 5.**

- ii. In the **Tile Clipping options** section, leave the clip new data tiles before processing option checked. For this workflow, leave the remaining options unchecked.
- iii. In the last section you have three options to check or uncheck
 - (a) Check both the “**use LTK log file specific to batch job**” and the “**create log files for individual processing tiles**” options. These will create a record of your processing runs, so if there are errors during a run, you can go back and read through where the errors occurred.
 - (b) The last option is “**Create batch files for each processing block to take advantage of multi-processor architectures**”. The example data for this course doesn’t cover a very large extent, so it may not be necessary to have this box checked. But for larger areas, this will greatly speed up processing. For the sake of learning to use this option, leave the box checked. Set the **number of processing streams** to **2**.
- iv. The remaining options allow you to set a tile size, buffer width, and max returns processed.
 - (a) For this exercise, set the **tile width and height** to **2520**. This will make the tile width and height a multiple of the cell size.
 - (b) The **buffer width** should typically be set to double the cell size. Because the cell size was set to 30, set the buffer width to **60**.
 - (c) For the Max returns, FUSION can recommend a number to you. Click the **suggest# button**. This will open a window like below.



Note: It is a good idea to choose a number ~75% of the maximum returns. Here the GridMetrics is showing maximum returns of ~134 million, so I will set the Max returns option to 100 million.

- v. Your processing options window should now look similar to the image below.



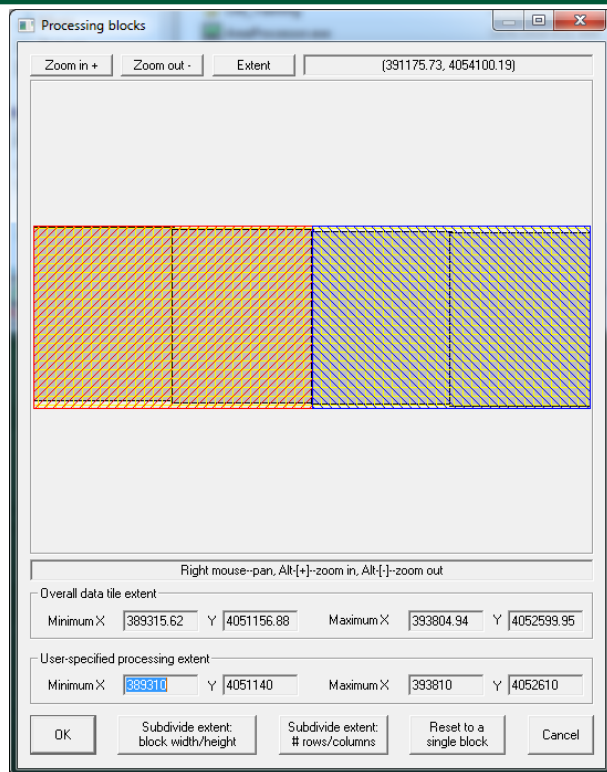
9. Click **OK** to close the window

C. Final Inputs and Processing Blocks

1. Now we should set some optional information for the AreaProcessor. These options aren't required for every AreaProcessor run, but they are required for the workflow outlined in this exercise. Begin by clicking **Return Density Info**.
2. In the window that opens, Click **Add file**. Navigate to the QAQC output from exercise 3 and select the **QAQC_return_count.dtm** file that you created in a previous exercise. AreaProcessor will use this layer to help form a tiling structure.
3. Click **OK** to close the window.
4. To add in the Bare Earth files you created in exercise 2, click **Ground Surfaces**. In the pop-up window that opens, click **Add file**. Navigate to the Bare Earth DTM you created in exercise 2 and click on the file. It should be saved in the deliverables folder under raster
(C: \Project_Home\deliverables\raster\BareEarth\doqq-dtm\kaibab_dem.dtm).

Note: for large data extents, it may be necessary to break your DEM into multiple tiles. For those instances, you can add all of the DEMs in .dtm format here.

5. Click **OK** to close the window.
6. To set up the Processing Blocks, click **Processing blocks**. This will allow AreaProcessor to take advantages of a multicore processor.
7. In the pop-up window that opens, you can see that there is a single block, covering the entire extent of the data. This will be a problem because in the Processing options in section B, we told AreaProcessor that there should be two data streams, so there must be at least two blocks, one for each stream. Over a larger acquisition area, it may lead to more efficient processing to have more blocks, but because this is such a small area, we're going to create two processing blocks. Click **Subdivide extent: # of rows/columns**.
8. In the option that opens, specify just 2 columns and 1 row. Click **OK**. This will change the window to show two blocks like in the image below.



9. Click **OK** to close the processing blocks window.
10. Notice that when you click ok, the “Show me the problems” button has turned yellow. This means that AreaProcessor is now organized in such a way that it could be run, though we still haven’t created our final tile layout and batch files.
11. Last, click the **Projection file** button. If you do not specify a .prj file, the output metrics will not have associated projection information.
12. In the window that opens, click **Browse**. Navigate through your project_home folder to \deliverables\vector and select **workshop-area.prj**.
13. Click **OK** to close the window.

D. Preparing Batch File for Processing

1. The main purpose of AreaProcessor is to take the input data and settings to create a series of batch files that will execute the processing of your data. To finalize this process, click **Create Processing Layout**.
2. Notice that the “Show me the problems” button turns green. Click **Show me the problems**. It will give you a message telling you that AreaProcessor should be able to process all of your data without error. If you are ever having trouble working with AreaProcessor, this button will be useful in showing you what inputs still need to be set.
3. Now click **Create Scripts**.
 - i. You can save all of the parameters that you just set to create the scripts by clicking the **Save options** button at the bottom left of the AreaProcessor window.
4. Open **Windows Explorer** and navigate to your Project_home folder, then open the processing subfolder. You’ll see that a series of files has been added there by AreaProcessor. These files will process your lidar data.

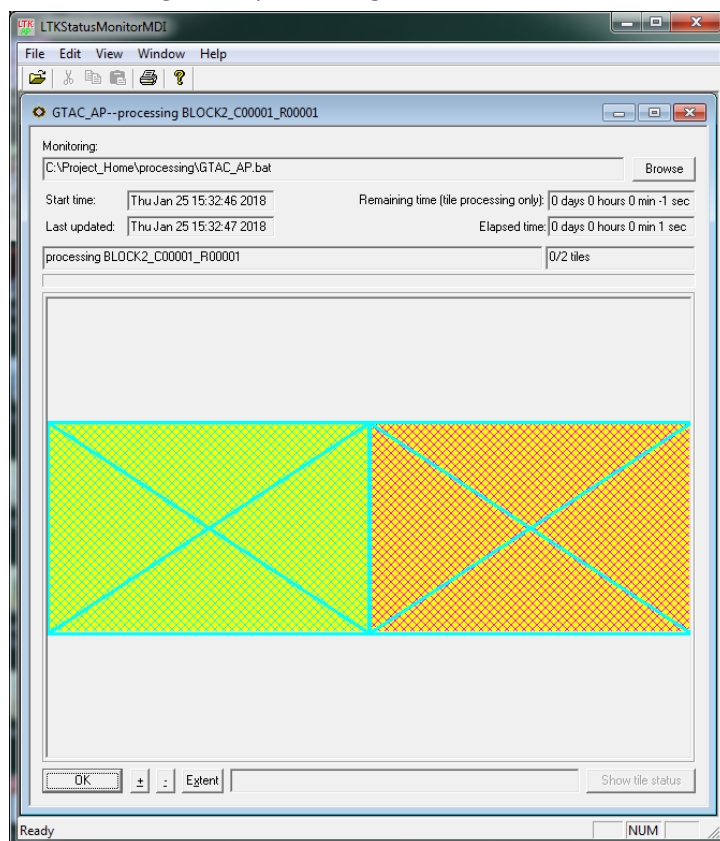
Part 4: Running AreaProcessor

A. Running Batch Files

1. Open a windows command prompt the same way you learned in previous exercises.
2. In the command prompt window, change the current directory to your processing folder in the Project_home folder structure, or wherever you saved the batch files created in part 3. To do so type **cd C:\Project_Home\processing**

Note: if your data is located on a different local drive (e.g., D drive), you will first have to enter **d:** into the command prompt, hit enter, and then change your directory.

3. Once your current directory is set to the folder containing your batch file created in part 3 (called GTAC_ap.bat), you can run the batch file. Type **GTAC_ap** and hit enter. There is no need to type the .bat extension.
4. You will see the windows command prompt begin to run the batch file. It will also open two subsequent command prompt windows which are the two processing streams that you specified in part 3. You will also see the LTKStatusMonitorMDI window open, which will show how far along in the processing AreaProcessor is and which tile is currently being processed.



5. This will take a little while to run. In the meantime you can move on to part 5.

Part 5: Import GIS ready layers to ArcMap

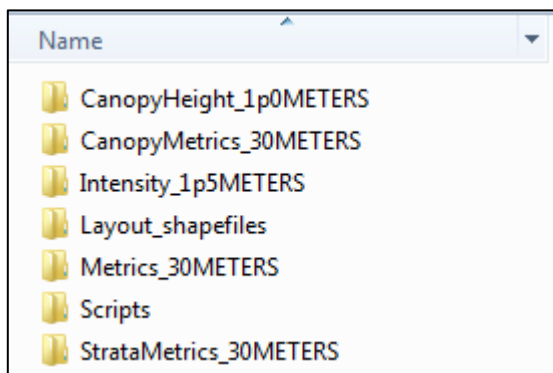
This section explains the content of the output folders and walks users through a basic analysis in ArcMap with one of the most useful outputs from the AreaProcessor, canopy cover. If your data hasn't finished processing, you can use the data available in the backup folder to perform the tasks in this section.

A. Review Outputs

1. Open **Windows Explorer**
2. Navigate to your **products** folder. You will see the **QAQC** folder where you stored your catalog outputs from exercise 3, and a folder that begins with **Products_GTAC_Lidar_training_** and ends with the date from your AreaProcessor run. Open that folder.

Note: this folder may have a different name – the folder name is pulled from the Area name that you specified during the AreaProcessor specifications.

3. In that folder you will find outputs from the two blocks you created, which have been stitched together to make the final products folder. Open the final folder.
4. Here you will see the following folder structure.



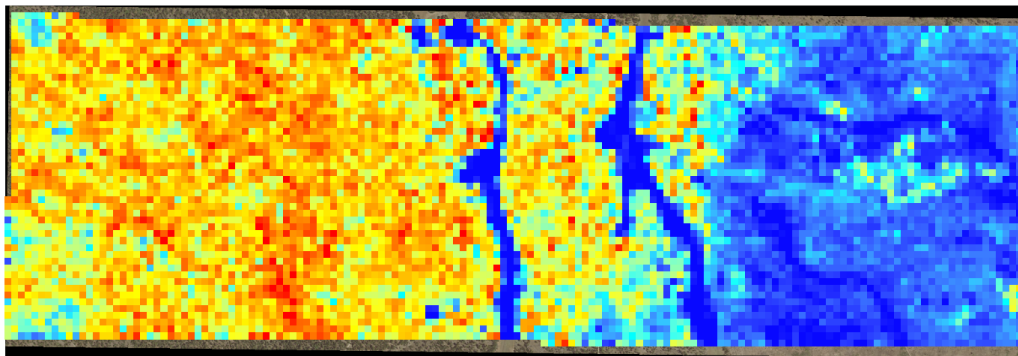
- i. **CanopyHeight_1p0METERS** contains canopy height products at a 1 meter resolution.
- ii. **CanopyMetrics_30METERS** contains 5 statistical outputs describing canopy height at a 30 meter resolution.
- iii. **Intensity_1p5METERS** contains intensity images generated at a 1.5 meter resolution.
- iv. **Layout_shapefiles** should be empty given the options selected for this run.
- v. **Metrics_30METERS** contains the bulk of the data produced by the AreaProcessor, and includes numerous metrics describing the vegetation.
- vi. **Scripts** conveniently copies the .bat files used for the AreaProcessor run, so you can go back and double check the settings you supplied.
- vii. **StrataMetrics_30METERS** holds the strata layer outputs at a 30 meter resolution.

B. View Metrics in ArcMap

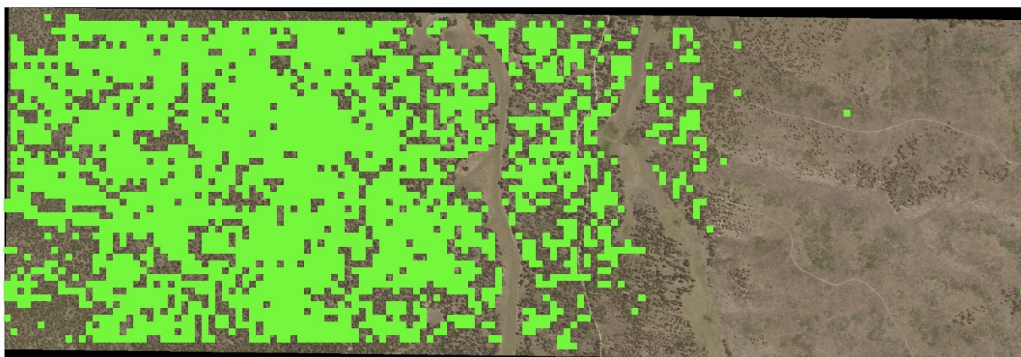
1. Open ArcMap
2. Click **Add data** and add **NAIP2015.tif** from \Project_Home\NAIP.
3. Click **Add data** and add the layer **1st_cover_above2_30METERS.img** from the Metrics_30METERS folder, under the FINAL products folder in your Project_home folder structure. This is the canopy cover raster.

Reminder: If your computer hasn't finished processing yet, use the same layer from the *Metrics_30METERS* folder in the **backup** folder in your *Project_Home* structure.

4. With the NAIP imagery and percent canopy cover layer you just loaded, your ArcMap window should look similar to the image below. This is a seamless % canopy cover layer produced from all your .las files!
 - i. Click the color ramp in the table of contents below the *1st_cover_above2_30METERS.img* and select an intuitive color ramp. Note that you can select the **invert** option to flip a color ramp.



5. Next, you will use the **Raster Calculator** to conduct a simple analysis in ArcMap. First, make sure the Spatial Analyst extension is enabled by opening the Extensions window under the Customize drop down menu.
6. Type **Raster Calculator** in the search bar or locate it by opening ArcToolbox, Spatial Analyst Tools, and Map Algebra.
7. Enter in the following equation: **1st_cover_above2_30METERS >= 50** using the available buttons. Double click on the percent canopy cover layer to insert it into the script, as this can help you avoid any potential typos from manually entering the raster name.
8. Make sure your output raster is set to your desired location and is given the name **cover_70.img**.
9. Click **OK**. The resulting raster will give the pixels with a percent canopy cover value of 50 or greater a value of 1 and the cells that don't meet that condition a value of 0. If you turn the color off for the cells with a value of zero, you should get a map similar to the following graphic. Do this by clicking the default color next to zero and selecting **Hollow** in the subsequent window.





Congratulations! You have successfully completed this exercise. You now know how to use the AreaProcessor in conjunction with multiple batch files to create seamless grid outputs of canopy metrics that can be used in modeling and analysis in a GIS environment. With just simple information extraction using AreaProcessor and FUSION, we are able to create useful derivatives from large lidar data sets in a systematic and efficient manner.