



HEXAGON
GEOSPATIAL

CREATING CUSTOMIZED SPATIAL MODELS WITH POINT CLOUDS **USING SPATIAL MODELER OPERATORS TO PROCESS POINT CLOUDS IN IMAGINE 2014**

White Paper
December 22, 2016

Contents

1. Introduction	3
2. ERDAS IMAGINE 2014 – A Product Overview.....	3
2.1. Overview.....	3
2.2. Features	3
2.3. Benefits.....	4
2.4. Architecture	4
3. Texas Department of Transportation – A Case Study	5
3.1. Overview of Texas Department of Transportation.....	5
3.2 Current Bare Earth Solution.....	5
3.3. Problem Description – Streamlined Point Cloud Editing	6
3.4. Workflows Used to Create bare Earth DTMs	6
Workflow 1 - RGB Encode the Point Cloud	
Workflow 2 - Classify the Point Cloud	
Workflow 3 - Select and Subset Point Classes	
Workflow 4 - Rasterize and Perform Topographic Analysis	
3.5. Solution Architecture.....	9
3.6. Data.....	10
4. Results	10

1. Introduction

ERDAS IMAGINE 2014 provides point cloud tools in the Spatial Modeler previously available only from the ribbon interface. When creating point clouds even the best sensors and photogrammetry techniques collect unwanted features. Powerful new tools available in the Spatial Modeler allow editing, classification, filtering, and surfacing of the point cloud data. The data in spatial modeler is to be used in its native .las format or as a gridded raster. If rasterized, additional Spatial Modeling raster operators are available to process the data.

Producing a bare earth model from point cloud data can be challenging. Having unwanted features in a point cloud can interfere with its intended use. The ability to run Spatial Model operators such as point classification and access to remote sensing operators, allows for a detailed editing environment. Once complete, the edited data can be used in many applications, including high-accuracy orthorectification.

The case study in this paper will demonstrate how spatial model operators are used to remove unwanted features to create a bare-earth elevation source. This data can then be used to orthorectify imagery.

2. ERDAS IMAGINE 2014 – A Product Overview

2.1. Overview

The latest release of ERDAS IMAGINE 2014, supports point cloud processing within the Spatial Modeler. The operators allow for advanced point cloud editing and visualization. Point cloud classification and RGB encoding operators allow for visual enhancement of point cloud data. Advanced editing tools like class selection and subset allow for filtering of the point clouds to keep only the ground data and the bare earth model as a result.

With the use of Spatial Modeler, additional operators would be available to not only streamline a workflow process but add additional functionality for a more accurate bare earth extraction. Rasterizing this point cloud data is now an option within the spatial modeler. If you take the point cloud dataset and rasterize it, it now becomes a surface file where remote sensing applications can be used to further enhance a bare earth solution for additional downstream processes. Having access to the decades of remote sensing functionality available within ERDAS IMAGINE, allows for limitless point and raster functionality in a spatial modeling environment.

2.2. Features

Features include:

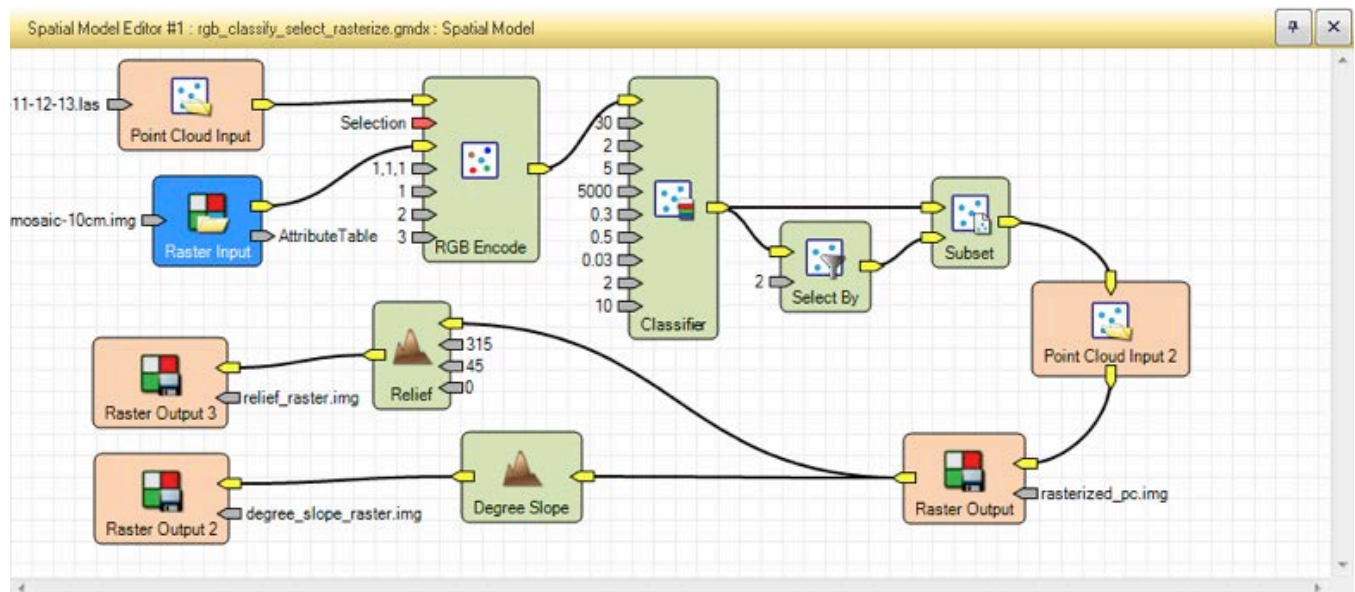
- Point cloud operators in a spatial modeling environment
- Graphical dataflow construction
- Preview the results of the spatial model
- Additional point cloud tools available in the ERDAS IMAGINE ribbon interface
- Select and subset out classes of points
- The ability to rasterize and surface point clouds
- Being able to string together multiple operators for point cloud and raster processing
- Ability to batch these point cloud operations and workflows

2.3. Benefits

- Modeling these point clouds allows for streamlined repeat pass processing
- The spatial modeling environment extends operations and use of point clouds into a remote sensing environment
- Enables you to rasterize your point clouds to increase the functionality using remote sensing applications
- Simple sharing of standardized Models
- Enables you to use point cloud files and keep them in their native *.las file format
- Build once, repeat indefinitely using batching and distribution
- Automate several manual steps into a single process

2.4. Architecture

The setup and design of the spatial modeling environment is very modular to add or remove certain operators. This allows for a smaller portion of the model you are creating to be tested first and if the previewed results are satisfactory you can append more operators on creating a streamlined process. Many inputs including point cloud, raster and even vector files can be introduced into your models as well as varying outputs. Merging all of operators together creates a string of processes that can be batched to run on multiple files. Below is a larger model that is comprised of an amalgamation of smaller models so only the input need be defined. This black box architecture saves time as well as reducing human error.



3. Texas Department of Transportation – A Case Study

3.1. Overview of Texas Department of Transportation

The Texas Department of Transportation (TXDOT) is responsible for ensuring the quality and up keep of the road infrastructure in the state of Texas. The TXDOT requires accurate orthorectification of their imagery which includes limiting unwanted features in their elevation source to create these accurate orthorectified images. Trees and other such features close to the roads, if included in the surface model greatly influence the accuracy of the orthorectification by way of smearing, ghosting or misregistration. The workflows described in this paper show how to eliminate these unwanted features from point clouds for a more precise orthorectification.

3.2 Current Bare Earth model Solution

Orthorectification of imagery can be difficult if the bare earth digital terrain model (DTM) is not accurate. Automated terrain extraction engines currently used, produce point clouds or Digital Surface Models (DSM's) and require manual editing strategies in order to produce an accurate DTM. The difference between DSM and DTM being the surface model has features like trees and buildings that are not present in a bare earth DTM. Having the tools available in a point cloud environment adds the functionality of a modeling environment, to string these operations together, which increases productivity immensely.

With automated terrain extraction, comes inherent errors in the elevation output like the initial DSM (including trees/buildings) generation mentioned earlier. These errors can be manually corrected, but at the expense of effort and time. Minimizing this editing procedure save time and yields a higher return on investment. Semi-global matching algorithms (SGM) from photogrammetry are available for high accuracy point cloud creation, but they still require editing much like Lidar point clouds do. However, this editing can be largely minimized. Part of this procedure requires some processing to create value added products for the aid in removal of these features. Creating a workflow and batching this is how ERDAS IMAGINE point cloud tools and operators available in the spatial modeler create this ROI.

TXDOT is already an Intergraph geospatial software solutions customer. Using older more manual applications their workflow is sound, just more time consuming than Intergraph's new Spatial Modeling environment for point cloud and DTM processing. TXDOT personnel make use of the following Intergraph geospatial software solutions:

- ImageStation Automatic Triangulation (ISAT) – for triangulation
- ImageStation OrthoPro (ISOP) – to orthorectify and mosaic their imagery
- ImageStation Automatic Elevations (ISAE without SGM) – to create their DTM's
- ImageStation DTM Collection (ISDC) – For generating a DTM

The workflow TXDOT is currently using for a typical orthophotography project is to run ISAE without SGM to generate a surface. This, of course, consists of a grid of elevation points in a MicroStation design file. Using ISDC, they generate a DTM and will use this preliminary surface in ISOP to create a preliminary orthophoto(s). They take this back into MicroStation and load the design file with the elevation points and then attach the orthophotography as a reference image. A close inspection of the orthophoto is needed (particularly in areas with buildings) to see if the DTM has caused distortions in the orthorectified imagery. Sometimes contours are created to help find places where ISAE has placed elevation points on rooftops or on top of trees. This typically requires a lot of edits to the elevation points to be able to create a useable surface. Once the edits are done, the generation of a new DTM is required along with the creation of a revised orthophoto. Of course, the orthophoto has to be inspected again to make sure that all of the surface induced distortions have been removed.

If working in an area with a lot of buildings, sometimes it's necessary to forego using ISAE altogether and will use ISDC to collect elevation points using the stereo viewing environment. This obviously takes a long time but, depending on the complexity of the area, it may take less time than trying to edit the ISAE generated surface. With the addition of the new Semi-Global Mapping algorithm now available in the ImageStation Automatic Elevations - Extended and IMAGINE Photogrammetry software, it is possible that the editing time will be reduced. However, no photogrammetrically derived nor LIDAR derived point cloud generation is going to be void of unwanted features and will therefore almost always require editing. With these methods described in this paper we hope to minimize these manual efforts.

3.3. Problem Description – Streamlined Point Cloud Editing

The primary focus of TXDOT using Intergraph's products is to create accurate orthorectified imagery and the accurate point cloud collection and editing is a key component to that end. A raster DTM can be created from this edited point cloud by essentially rasterizing the points into a surface by interpolating in between any missing points to create a seamless raster grid file. With an accurate DTM (void of features) the orthophotography can be registered much more accurately avoiding improper overlap from this rectification including terrain relief displacement correction from this elevation source. That elevation source for these orthophotos can be a raster DTM or point cloud. The inaccuracies resulting in road shift, smearing and ghosting can be avoided by using these streamlined operators to fine tune the point cloud, so that little or no manual editing is necessary.

Adding the Semi-global matching algorithm to this workflow will increase the accuracy of the point cloud file. If you couple the SGM output with the new spatial modeling capabilities to work the kinks out of the point cloud data, the TXDOT is now creating more accurate DTM's. With this increased accuracy also comes quicker Orthophoto generation, which creates not only a better product, but higher return on investment.

3.4. Workflows Used to Create Bare Earth DTMs

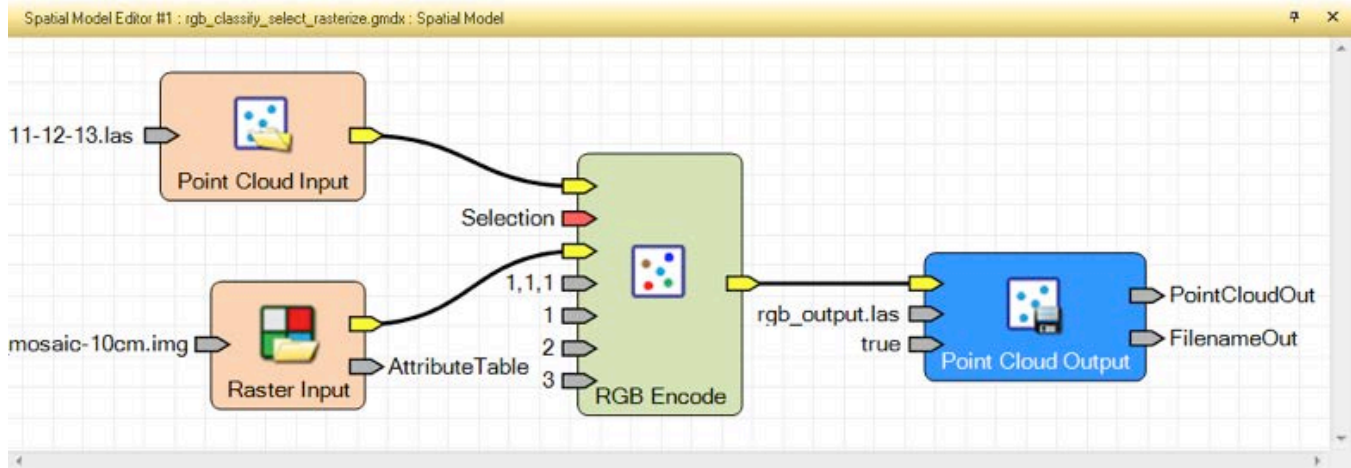
The workflows described below employ the techniques necessary to auto mate the removal of features turning DSM's into DTM's. Each workflow model can be used separately or combined together to create a single black box approach. Furthermore, this black box approach can be batch and distributed across multiple nodes for a streamlined push button approach. Creating an accurate Bare Earth model can be very difficult since so many factors influence where the points are located, regardless of if they are collected from a Lidar sensor or Photogrammetrically derived using an algorithm like Semi-Global Matching.

Workflow 1 – RGB Encode the Point Cloud

Problem Description

Point clouds generated from LIDAR sources do not contain the RGB values that imagery does for ease of feature identification. Adding the RGB values to a point cloud allow for a photo realistic view of the view point cloud. These RGB values can be added to a LIDAR source or any point cloud that does not have already have the RGB value assigned to each point, using this "RGB encode" operator. This makes decisions much easier for operations like classifying the points easier and more relatable with the points being in true color for ease of this class separation. This starting workflow may not even be necessary if using a point cloud file as the input from SGM generated using ISAE-Extended or IMAGINE AutoDTM software.

Workflow Diagrams



Product / Functional View

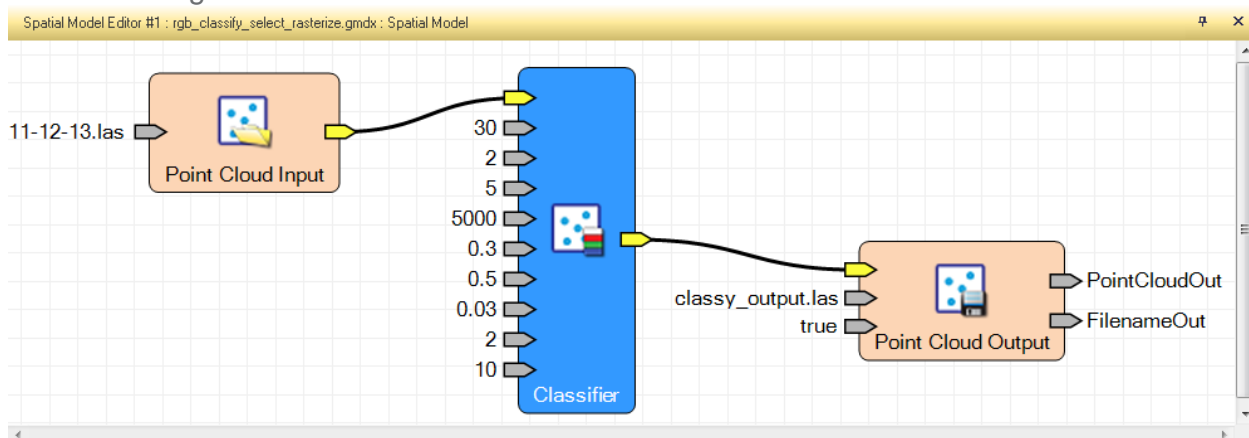
This RGB encode model requires two input sources. One being the point cloud you wish to encode and the other being the source of the RGB encoding. This can be any multispectral or panchromatic orthorectified image. It is important that both sources be in the same projection to ensure quality of encoding. Each workflow can be appended to others providing the input types match. Having all of these separate workflows combined into one workflow allows for seamless batch processing of multiple functions on multiple input files.

Workflow 2 – Classify the Point Cloud

Problem Description

Using the “Classifier” operator in the spatial modeler, you can account for features (like buildings and Vegetation) above the Bare Earth surface and classify them based on certain building and vegetation criteria. The “Classifier” operator accounts for these points that are considered above the ground features based on predefined and editable criteria. The result allows for the eventual removal or reworking of features and creation of a bare earth DTM.

Workflow Diagram



Product / Functional View

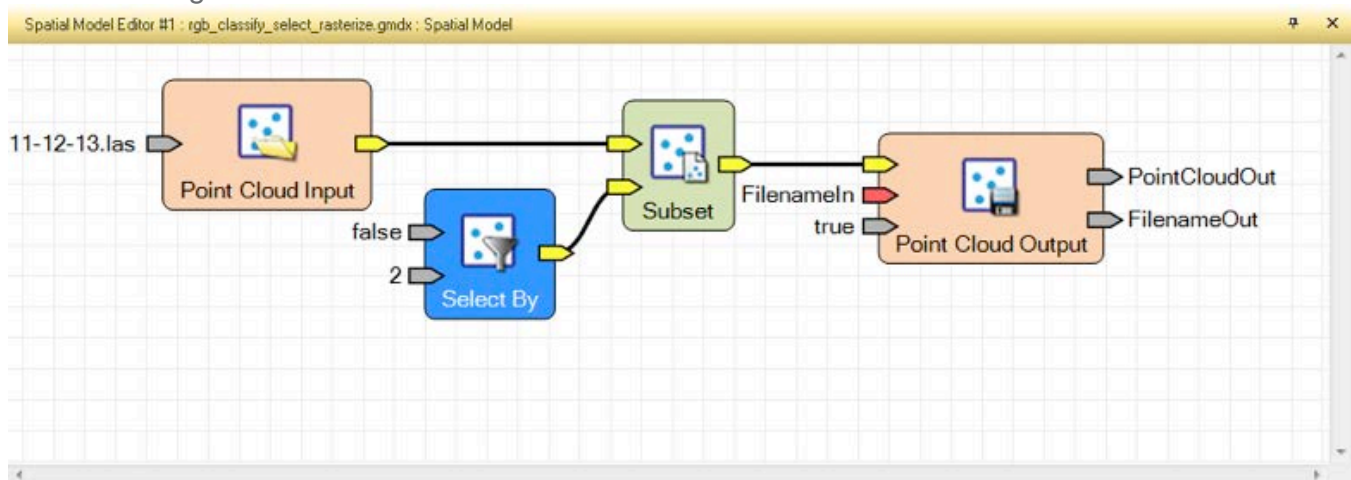
For this operator the input required is point cloud which may or may not be RGB encoded. Attach it to the Classifier operator and open the configure operator dialog. Here you make changes to object and vegetation parameters based on your area on interest. Create an output to a point cloud. This workflow can be appended to others providing the input types are still LAS files. Having all of these separate workflows combined into one workflow allows for seamless batch processing of multiple functions on multiple input files.

Workflow 3 – Select and Subset the Point Classes

Problem Description

With a classified point cloud you can separate out the features that interfere with the average ground elevation. Using the “Select By” operator in the spatial modeler you can chose to output only the points you want to include in your refined point cloud. This selection operator is used in conjunction with the subset operator and has many options available to filter or clip out the points you wish to include or exclude. For this workflow only the points classified as ground are included since everything else may influence the orthorectification. This will eliminate the problems with terrain relief displacement at or near features like building edges or vegetation. These areas that once included these features will be classed or specified as null data values. As such the orthorectification engine will simply overlook these areas instead of influencing the warping of the images in a negative manner. This creates a very simple automated approach to eliminating the features that would otherwise have needed manual editing to remove them.

Workflow Diagram



Product / Functional View

For this operator the input required is point cloud which may or may not be RGB encoded. Attach it to the classifier and open the configure operator dialog. Here you make changes to object and vegetation parameters based on your area on interest. Create an output to a point cloud. This workflows can be appended to others providing the input types are still LAS files. Having all of these separate workflows combined into one workflow allows for seamless batch processing of multiple functions on multiple input files.

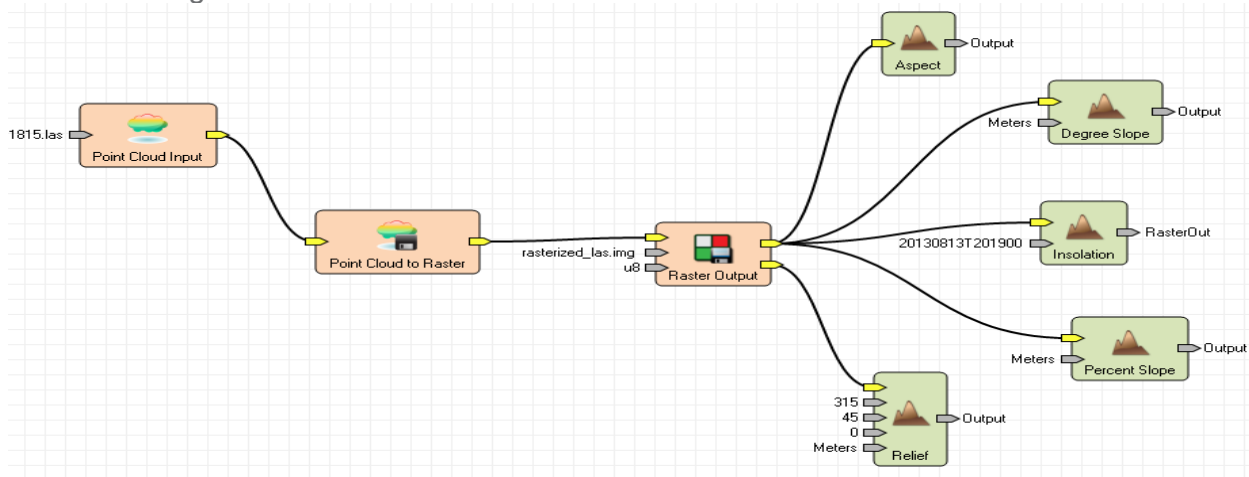
Workflow 4 – Rasterize and Perform Topographic Analysis

Problem Description

Having to work with only LAS files as your input and output type, allows for only point cloud operators to be used. If the LAS files are rasterized (Voxelization) or turning point clouds into a gridded raster surface file, then you have all of the capabilities that have been created for raster files over the decades of IMAGINE Professional

development. With all of the Remote Sensing functionality at your disposal the possibilities for value added products are virtually limitless. This final workflow shows how the spatial modeling environment allows for the voxelization of the point clouds so that topographic raster outputs can be created for additional analysis.

Workflow Diagrams

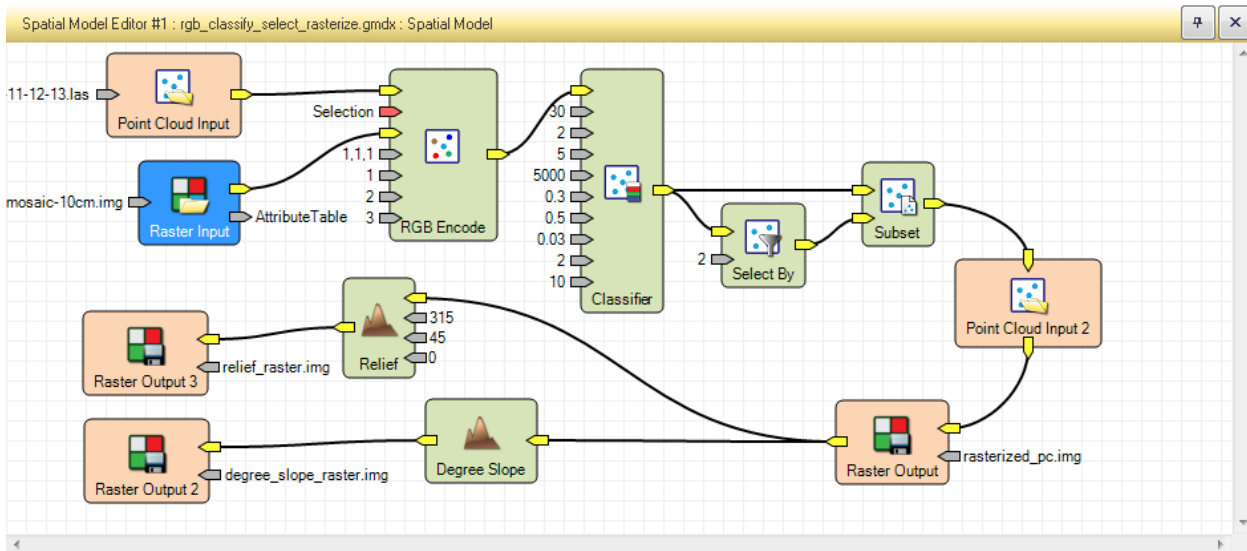


Product / Functional View

Here is an example of the outputs you could produce using the Topographic Analysis tools, but Rasterizing the point cloud input is required first. You could stop after rasterize the point cloud and output to a raster source, but this also shows how you can run additional processes. The rasterize operator creates a gridded surface like a typical greyscale raster DEM. All the functionality you would use with a raster DEM becomes available. In this paper the need to go beyond the point cloud for refining the surface model was not necessary as the resulting “Classifier” and “Select by” operator fulfilled the editing needs. However, some orthorectification software programs do require a gridded elevation surface where the point cloud to raster operator could be a final step. It is also possible to use the Topographic Analysis tools instead of the “Select By” filtering tools discussed and used in this example. Whether the output is a raster or a point cloud the result at this point should be that of a bare earth DSM.

3.5. Solution Architecture

The final solution to the problem of creating an accurate bare earth model can be stitched together in one seamless model shown below. It is as easy as opening each model if saved separately and copy and pasting it onto one template and attaching the models together. Where you would have an output from one model simply becomes the input to the next model. With all model pieces put together it forms one complete start to end solution. Not only does this all in one model require the designation of only one input file, but you can also set the model to run in batch mode to include a folder of input files with automated output naming conventions. Finally it is also possible to distribute the processing of the input files simultaneously across multiple processors.



3.6. Data

The following data was used during testing of the spatial modeling environment:

- Subset portion of the 5800 DMC II 140 frames
- ISAT Project files provided by TXDOT for point cloud generation
- Orthorectified imagery from project for RGB encoding of LAS files
- Individual models for each workflow
- Combined models into one for streamlined workflow

4. Results

This document provides some guidance on how to use point cloud operators in the ERDAS IMAGINE spatial modeler. Beyond the scope of this document, these operators could be combined with remote sensing and other operators that exist in the spatial modeler. Stringing operators together and batch processing the model on multiple files, while also taking advantage of multiple processors can dramatically increase productivity.

Coupling the point cloud operators now available in the spatial modeling environment of ERDAS IMAGINE with the Remote Sensing capabilities that already exist, greatly improves the bare earth output from point clouds. The methodology in this paper can be used with Lidar point cloud data or Photogrammetrically derived point cloud data. Both point cloud types can benefit from the new functionality found in the spatial modeler and if desired, create a black box approach to editing DSM's.

With these new operators in place the TXDOT is able to reduce processing time while improving their orthorectification results. By eliminating objects and vegetation from their point clouds they are able to produce accurate orthorectified imagery, especially along the interstate roads where they are most concerned about orthorectification quality. Furthermore, once the model is created, new datasets can be input to the model at any

time and processed when system resource are available. This black box approach allows the data to be processed during non-business hours, increasing productivity during working hours.

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