# GEO/EVS 423 / EVS 523
# Exercise 9: Processing LiDAR images

One of the most important innovations in recent years has been the advent of LiDAR imagery. This imagery can be used in a lot of ways, but it is one of the most accurate ways we have of making maps of elevation. The potential uses of LiDAR go far beyond what we can do in this exercise, but we *can* begin to do some reasonably sophisticated analyses using the data we have.

**Imagery to be produced**

In this lab, we will produce three kinds of images. First will be a DEM (Digital Elevation Model). This is a model of the bare ground – i.e. what we would have if there were no trees or buildings. Second will be a DSM (Digital Surface Model). This is a model of the actual surface of the area in question, including trees, buildings, etc. Finally we will make a NDSM (Normalized Digital Surface Model). This is a model showing the absolute height above the ground of things *on* the ground – i.e. the trees, buildings, etc.

**How to proceed**

Raw LiDAR data come in several forms, but the most common is a tiled format designated .LAS. You can find LiDAR data for northern Ohio in R:\Ohio_Statewide_Imaging_Program\LiDAR. We also have LiDAR data for Cuyahoga County in R:\Cuyahoga_County_GIS\LiDAR. First, you need to choose a tile. Go to one of the LiDAR directories on the R: drive.

If you go to the State data set, you will see two kinds of tiles. One is of the form OSIP_XXX_LIDAR.zip. These are zipped files with all of the tiles in the county whose abbreviation is given in the XXX. The other shows the county name written out. These are the directories you want. Go to the directory containing the county you want to deal with and pick out a tile file. The files are named with the convention NYYYYZZZ.las and NYYYYZZZ.las.xml. The YYYY is the State Plane easting; the ZZZ is the State Plane Northing for the southwest corner of the tile. If, for example, you picked tile N2190655.las, the easting would be 2,190,000; the northing would be 655,000. Note that some of the tiles are not very well labeled, so you may be surprised when you actually pick out a tile in that it's not where you thought it was. You can blame the State's contractor for that little problem. You do *not* need to copy the tile to your X: drive, just know where it is.

If you go to the County data set, you will have to choose between the East side and the West side. The tiles have names like YYYY_ZZZ.las, where YYYY is the State Plane Easting and ZZZ is the State Plane northing. The designators are approximately correct for the northing, but you should subtract 31,500 from the easting you want to go to in order to get the right tile. Again, you do *not* need to copy the tile to your X: drive, just know where it is.

You will be using ArcGIS for this exercise, and you will carry it out twice – the old way (through ArcGIS 10.0) and the new way (beginning with ArcGIS 10.1). In either case, click on ArcMap to open a blank map.

1. You first need to create a personal geodatabase. If you've forgotten how, it's Data Management Tools -> Workspace -> Create File Geodatabase. Make sure this GDB is on your X: drive, and make it your default geodatabase. You do this by opening the Catalog tab (you may need to click on the catalog icon to do this), go to Folder Connections, choose X:, right-click on the GDB you've just created, and choose "Make Default Geodatabase."

2. The Old way (you don't have to do this, but it's useful to know what Arc users used to have to do):

a. You first need to read in your tile. You will actually need to do this twice, once for the DEM, once for the DSM. In both cases, from the Toolbox, choose 3D Analyst Tools -> Conversion -> From File -> LAS to Multipoint. Browse for the tile file on the R: drive. Be sure when you click on it that it's the .las file, not the .las.xml file! Give your feature class a name – and make sure both that it goes into the GDB you created in step 1 and that you give different feature-class names to the DEM and the DSM! For example, if you choose tile N2190655.las, you might name your DSM feature class N2190655S. Next enter the number 2.5 into the "Average Point Spacing" field. That's all you have to do for the DSM. For the DEM, you need to put the number 2 in the "Input Class Codes (optional)" field. Class code 2 indicates that these returns are "ground." In each case, you will be presented with a large black blotch on your map page, but you will have two multipoint feature classes in your geodatabase, one (N2190655S) for the DSM and the other (N2190655E) for the DEM.

b. You now go to the catalog. Right-click on the GDB and choose "New >". A box will open; choose "Feature Dataset." It wants a name. Put in a name, but make sure it's different from the names of the feature class you created in step 2. Using the naming convention introduced above, you might pick N2190655EFD and N2190655SFD for your feature datasets. When you click OK on the name, a new box opens requesting your projection system. Choose "Projected Coordinate Systems" -> "State Plane" -> "NAD 1983 (US Feet)" -> "NAD 1983 State Plane Ohio North . . .". When you click "next", it will ask you for your Vertical Coordinate System. Choose "Vertical Coordinate System" -> "North America" -> "NAD 1983." When you click "next," you can use the defaults to complete setting up the feature datasets. Again remember that you have to do this twice, once for the DEM, once for the DSM.

c. Now you have to import your feature classes into the feature datasets. Again, you need to do this twice, once for the DEM and once for the DSM. In each case, go to the catalog, right-click on one of your feature datasets, and choose "import >". Click on "Feature Class (single)." A dialog box opens. Your Input Feature is the Feature Class you created in step 2. Your Output Feature Class needs to have a different name, and you have to be sure it's in your GDB. For example, if your GDB is named LiDAR, you might insert the name of the feature class as X:\LiDAR.mdb\N2190655EFC for the feature class corresponding to the DEM. If you don't use the X:\LiDAR.mdb, it will probably find the GDB, but it's better to be safe than to be sorry. It will take a little bit of time to carry out this operation, so be sure to let the job complete.

d. You are now ready to make a terrain for the DEM and the DSM. For each, go to the catalog, right-click on one of your feature datasets, and choose "New >". From the box that opens, choose "Terrain." Choose a name for your terrain that you like, and put the number 2.5 in the "Approximate Point Spacing" field. You can click "next" three times until you get to the Pyramid Properties box. Click on the "Calculate Pyramid Properties" button and click "next." Choose defaults until you get to the end. Click "Finish." The program will now create your terrain.

e. You are finally ready to make your raster files for the DEM and DSM. For these you go back to the Toolbox and click on 3D Analyst Tools -> Conversion -> From Terrain -> Terrain to Raster. Your input terrains are those you just created in step 5; your output raster can be named anything you want. You should change the "Sampling Distance" field. The drop-down at the right allows you to choose an absolute cell size (you might try 2.5, 5, or 10) or the number of pixels along the longest axis (Observations 250 means that your image will have a maximum dimension of 250 pixels).

f. When your two rasters are created, look at them. Get rid of the point clouds so that only the DEM and DSM rasters are visible in your map space. Give them a more meaningful color ramp than the gray-scale default.

g. The last step is to make the NDSM. To do this, you need to subtract the DEM from the DSM. Go to Spatial Analyst Tools -> Map Algebra -> Raster Calculator. The general form of the operation is DSM - DEM. The NDSM is the output raster. Give it a meaningful color ramp.

h. Now look at all of your images. Be sure that you understand what you did.

3. The new way (This is what you should do).

a. The first step in this process is to create a LAS dataset. Don't be confused if you thought that a LAS file was an LAS dataset; it isn't. To do that, go to Data Management Tools -> LAS Dataset -> Create LAS Dataset. Note that you can put several LAS files in a single dataset. If they are adjacent, Arc will mosaic them for you. Note also that you only need to do this once. A single dataset will generate both the DEM and the DSM. When the dataset is created, it will load into your viewer. Right-click on the dataset name, and go to the Filter tab. Here is where you can choose the classes you wish to consider. For the DEM, click on class 2 (ground) and unclick All Classes. For the DSM, click on All Classes.

b. The next step will generate either a TIN or a raster. For a TIN, click on 3D Analyst Tools -> From LAS Dataset -> LAS Dataset to TIN. For a raster, click on Conversion Tools -> To Raster -> LAS Dataset to Raster. You will need to do this twice, once for the DEM, once for the DSM.

c. You are now ready to make the NDSM. Again, go to Spatial Analyst Tools -> Map Algebra -> Raster Calculator. The general form of the operation is DSM - DEM = NDSM. Give it a meaningful color ramp.

d. Now look at all of your images. Be sure that you understand what you did.

**Portfolio**

9-1 A DEM of a tile (or mosaiced set of tiles) of your choosing
9-2 A DSM of a tile (or mosaiced set of tiles) of your choosing
9-3 An NDSMarch 18, 2014M of a tile (or mosaiced set of tiles) of your choosing