Conservation Applications of LiDAR

Basics of Using LiDAR Data

Exercise #5:
Re-projecting LAS Data to County Coordinate Systems

August, 2013

M. Taylor Long, U-Spatial, University of Minnesota

Prepared under the supervision of Tim Loesch,

MN.IT Services @ Department of Natural Resources

Basics of Using LiDAR Data
Exercise #5: Re-projecting LAS Data to County Coordinate Systems

Exercise 5: Re-projecting LAS/LAZ Files

INTRODUCTION

This document contains instructions for projecting LiDAR data (LAS/LAZ files) into Minnesota county coordinate systems using LAStools. Prepared LiDAR data in vector or raster format can be re-projected into County Coordinate Systems using ArcGIS (see Exercise 4), but re-projecting raw LAS or LAZ files requires the use of LAStools.

SET UP

Downloading LAStools

LAStools is a set of command line tools that perform a wide variety of processing methods on LAS formatted files.

LICENSING: The tools used in this exercise (laszip, las2las) are, for most organizations, open-source and licensed as LGPL. Please consult http://lastools.org/download/LICENSE.txt for a listing of the tools and their licensing requirements.

Download LAStools here: http://lastools.org

The link at the top of the above-linked page will initiate a download of the entire tool set in one zip file (each tool can also be downloaded individually, if necessary). There is no installation routine, if you are using Windows you simply unzip the files to a folder on your hard drive, and run the tools from this folder.

TIP: I suggest that you unzip LAStools to your C:\ drive and don't put in a folder that has a space in the name. Simply taking the default and unzipping to the C:\ folder will result in a folder named "C:\lastools" that contains a number of subfolders. All of the executable LAStools programs are stored in a folder named "bin".
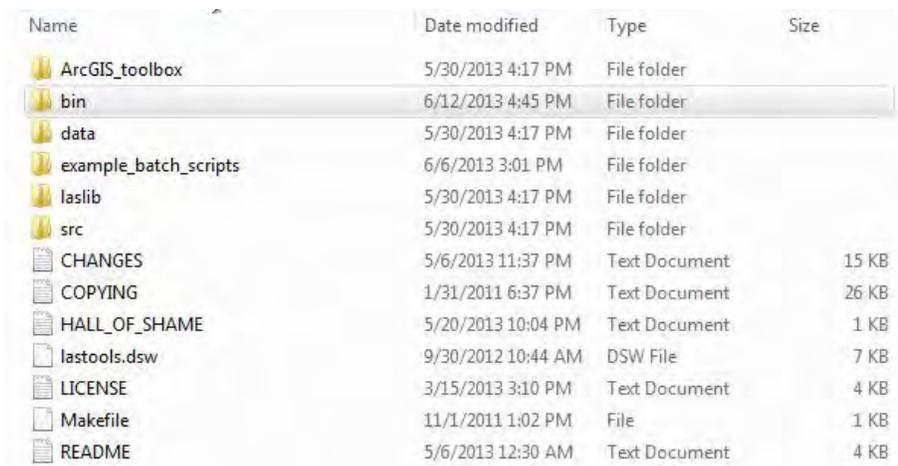
| Name	Date modified	Type	Size
ArcGIS_toolbox	5/30/2013 4:17 PM	File folder	
bin	6/12/2013 4:45 PM	File folder	
data	5/30/2013 4:17 PM	File folder	
example_batch_scripts	6/6/2013 3:01 PM	File folder	
laslib	5/30/2013 4:17 PM	File folder	
src	5/30/2013 4:17 PM	File folder	
CHANGES	5/6/2013 11:37 PM	Text Document	15 KB
COPYING	1/31/2011 6:37 PM	Text Document	26 KB
HALL_OF_SHAME	5/20/2013 10:04 PM	Text Document	1 KB
lastools.dsw	9/30/2012 10:44 AM	DSW File	7 KB
LICENSE	3/15/2013 3:10 PM	Text Document	4 KB
Makefile	11/1/2011 1:02 PM	File	1 KB
README	5/6/2013 12:30 AM	Text Document	4 KB

Downloading LAS/LAZ Data

When you download data from the Minnesota LiDAR ftp site (ftp.lmic.state.mn.us) you'll receive LAZ files (filename.laz). Raw LiDAR data comes in a standard LAS file format (filename.las), and an LAZ file is simply an LAS file that has been zipped (compressed) using one of the LAStools called laszip. The LAZ files are much smaller and easier to upload/download.

If you are using LAStools, you don't necessarily need to uncompress these LAZ files because LAStools will operate on compressed files. However, if your intent is to use the LAS files in some other software that cannot read LAZ compressed files, then you will need to uncompress them. To do this use the laszip tool (instructions provided below).

Choosing a Method: General User Interface vs. Command Prompt

LAStools are designed to be run in your computer's Command Prompt, but you can also run each tool through a very basic general user interface (GUI) window. While using the Command Prompt can seem intimidating, it offers a simple means of entering a series of commands to run the tools. The GUI offers a more familiar interface for defining the use of these tools, but you'll see that it is simply used to construct the command that you would enter in the command prompt (you'll see the command line statement after you click "run" in the GUI).
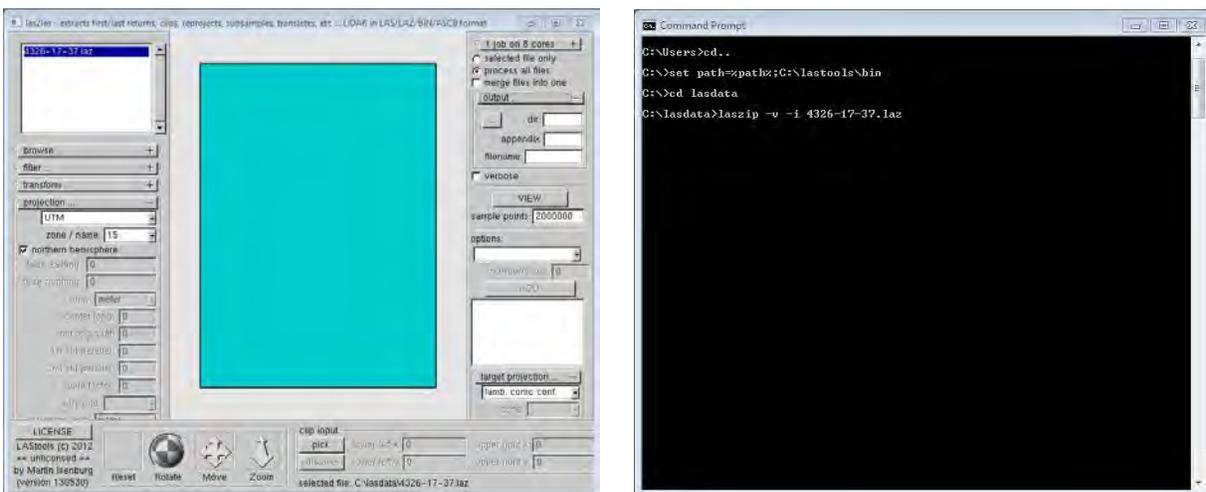
New users may find the GUI more approachable at first, especially when learning how to construct the commands, but after a few uses might consider switching over to the Command Prompt method. This document includes instructions for projecting LAS/LAZ files using both the GUI and Command Prompt methods.

METHOD 1: GENERAL USER INTERFACE (GUI)

Running the Tools

All of the LAStools can be run using a General User Interface (GUI). Basically, this means that when you double click on a tool in the lastools\bin folder, a window will appear that guides you through inputting that tool's parameters. For example, to run the las2las tool, search the bin folder for the file named las2las.exe, double-click it, and the GUI window will appear.

The GUI offers a series of expandable accordion bars on the left and right sides of the window. Clicking to expand these bars will reveal areas to enter various parameters for running the tool.

- **Selecting files using the browse… bar**
  - To point the tool to the file(s) on which you will run the tool, you'll need to expand the **browse…** bar.
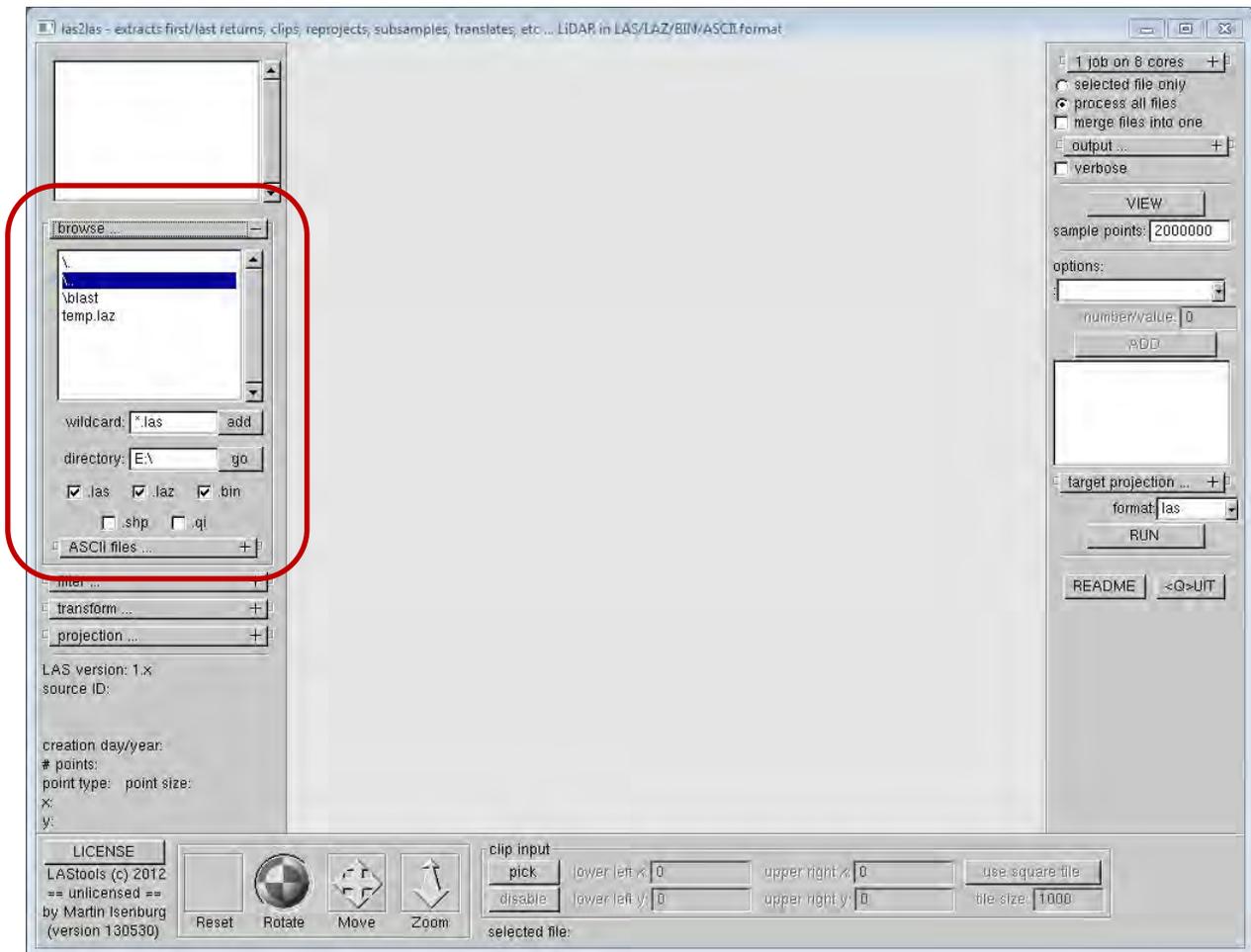
  - The larger white window is where you navigate to the folder that houses your LAS/LAZ files. Double-clicking on a folder name will navigate inside the folder. Clicking on the **\..** line will navigate out one level from the current directory to its parent directory (sort of like a "Back" button). To navigate to a folder more directly, enter its path in the

directory window below and click the **go** button. When you double click on a LAZ or LAZ file, it will be added to the top-left window in the GUI. Any file(s) in this window will be part of the tool's processing.

- o If you want to run the tool on all the LAS or LAZ files in a folder, you can use the **wildcard** window to enter *.las or *.laz then click the **add** button. This will add all files within the current folder that end in .las or .laz respectively.
- o Once you see all the files you have selected in the top-left window, you're ready to start entering tool parameters.
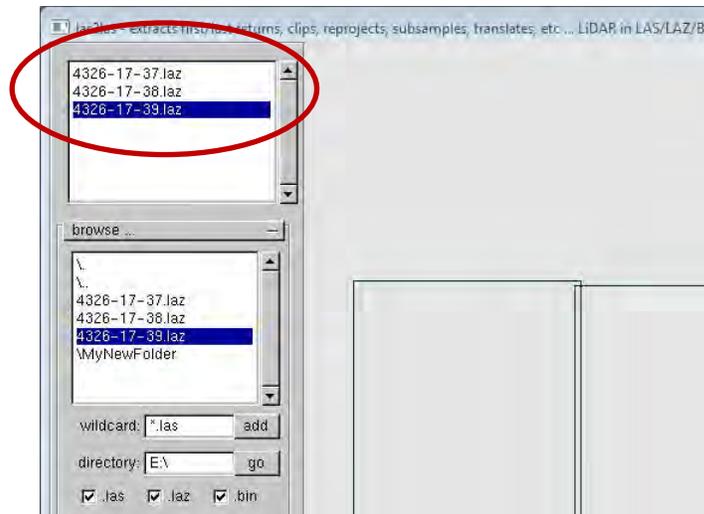
- **Defining output file names and locations using the browse... bar**
  - o On the right side of the GUI window, you'll find the **output...** bar. You can use these windows to enter information that will determine how your output files will be named and where they will be saved.
  - o Clicking the **...** button will open a pop-up window in which you can navigate to a particular directory.
  - o To append a phrase to the end of each output file name, enter text in the **appendix** window. Example: If all your files are named "filename1.las," "filename2.las," etc. and you enter "_new" in the **appendix** window, the output files will be named "filename1_new.las," "filename2_new.las," etc.
  - o The **filename** window may be used to rename an output file if there is only one input file in the top-left window of the GUI.
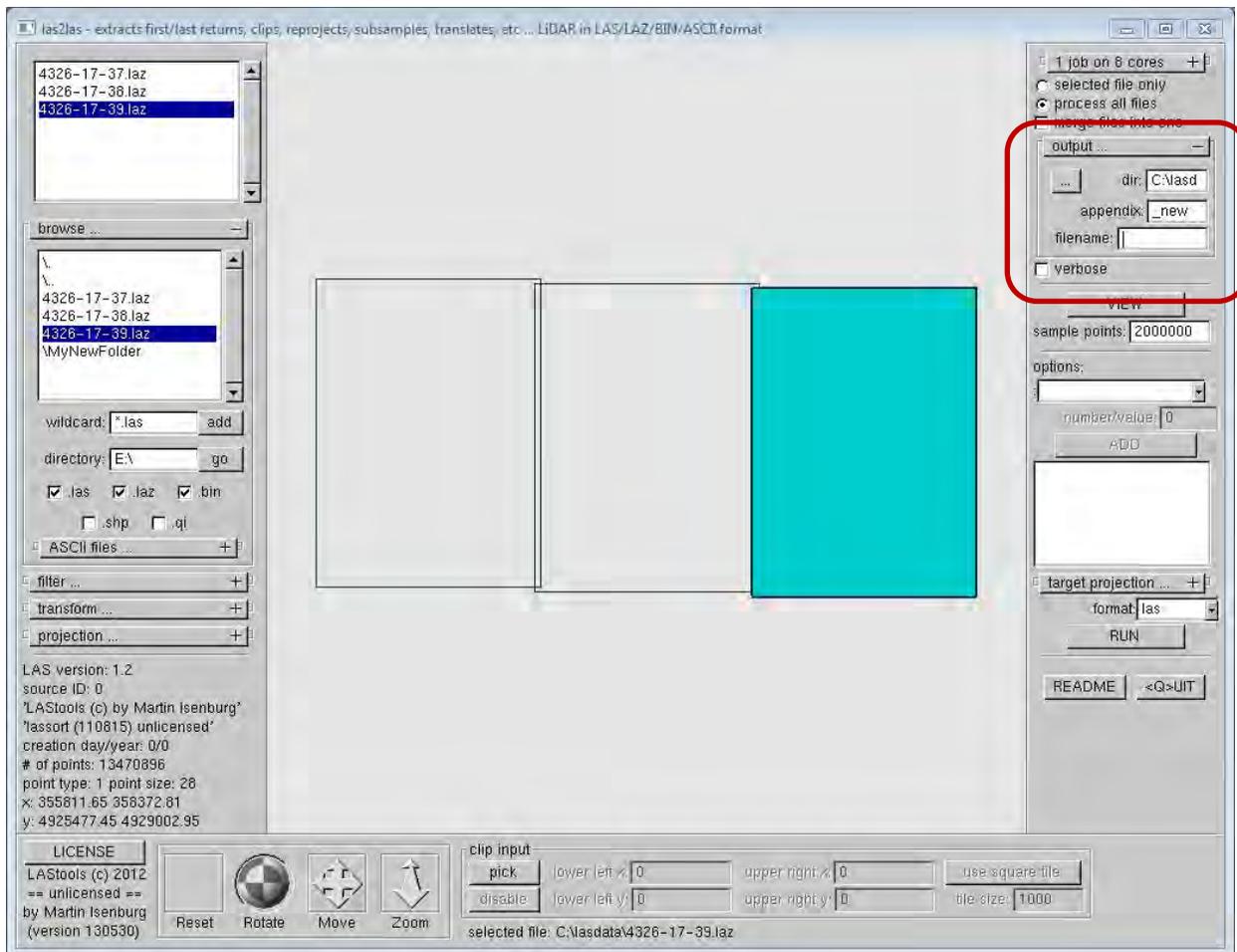
Uncompressing LAZ files (optional)

LiDAR data downloaded from the MnGeo site comes in the compressed LAZ file format. All of the LAStools will work on compressed LAZ files as well as uncompressed LAS files. If you'd like to uncompress the LAZ files to LAS files for compatibility with another program, you can do so with the **laszip** tool.

- Navigate to the **lastools/bin** folder and open the **laszip** tool (laszip.exe).
- Select the LAZ files you wish to uncompress using the **browse…** bar. (see instructions above)
- Enter the output file settings using the **output…** bar. (see instructions above).
  - **TIP:** If you leave the output settings blank, the output files will have the same name as the input files, but with a ".las" extension instead of an ".laz" extension.
- Make sure the **LAS** radio button is checked (right side of the GUI screen under the **DECOMPRESS** button).
- Click the **DECOMPRESS** button. A RUN pop-up window appears that shows the command line code about to be run (remember, the GUI is just a user-friendly way of running tools that can all be run through the command prompt).

- To confirm running the tool, click the **START** button in the RUN pop-up window.
- Your LAZ files will be uncompressed into LAS files.
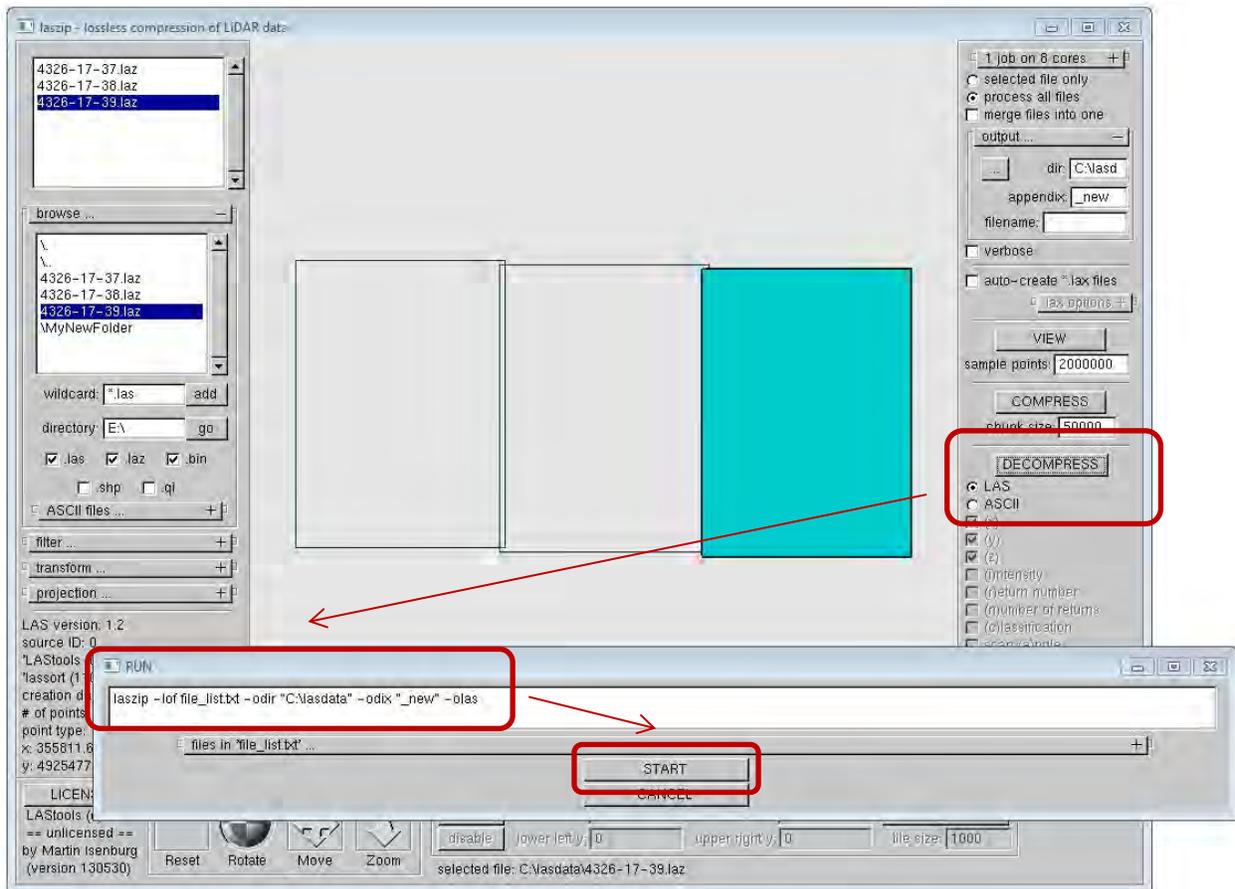
Projecting to County Coordinate System

Converting LAS files from UTM Zone 15N to their respective County Coordinate Systems can be accomplished using the **las2las** tool. To project to a particular county coordinate system, you'll need to enter the specific parameters of that coordinate system.

NOTE: A few Minnesota counties use an Oblique Mercator projection (Cook/North Shore, Lake/North Shore, St.Louis/NorthShore). At the time this document was written, the las2las tool could not project from UTM to Oblique Mercator.

Minnesota County Coordinate System parameters can be found at:

http://maps.umn.edu/lastools/MNCountyParameters.html

- **Project one LAS file to a County Coordinate System (Ex: Anoka County)**

- In this example, my input LAS file is stored in the directory **C:\lasdata** will be **filename.las** and I'll name my output file **filename_proj.las**. I'll project my LAS file into Anoka County's county coordinate system.
- Navigate to the **lastools/bin** folder and open the **las2las tool** (las2las.exe).
- Select the LAS files you intend to reproject using the **browse…** bar on the left side of the GUI. (see instructions above)
- Enter the current projection information under the **projection…** bar on the left side of the GUI. All the LiDAR data downloaded from MnGeo comes with the standard Minnesota UTM Zone 15N projection.

  UTM ZONE 15N PARAMETERS (for all MnGeo LAS files):

  - Projection: UTM
  - Zone / name: 15
 - Northern Hemisphere: checked
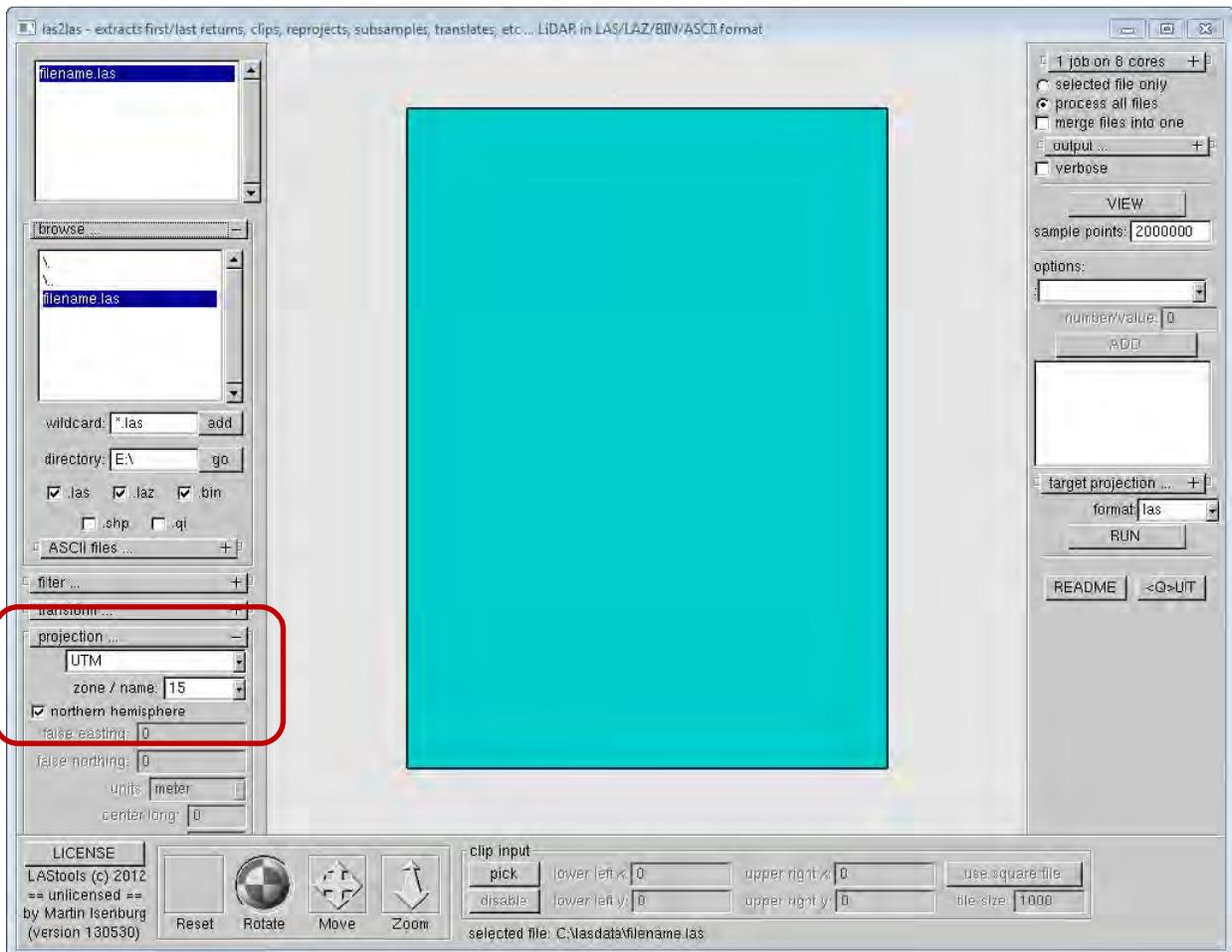
- Enter the output file settings using the **output…** bar on the right side of the GUI. (see instructions above).

o   Enter the target projection parameters (in this case, the Anoka County parameters), using the **target projection…** bar on the right side of the GUI.

ANOKA COUNTY PARAMETERS:

- Projection: lamb. conic conf. (Lambert Conic Conformal)
- False Easting (easting): 500000
- False Northing (northing): 100000
- Horizontal Units (units): feet
- Central Meridian (center long): -93.266666666
- Latitude of Origin (nat origin lat): 45.0352777778
- Standard Parallel 1 (1st std paral): 45.0666666667
- Standard Parallel 2 (2nd std paral): 45.3666666667
- Elevation Unit (elev): feet (Optional – could be meter or survey feet as well)
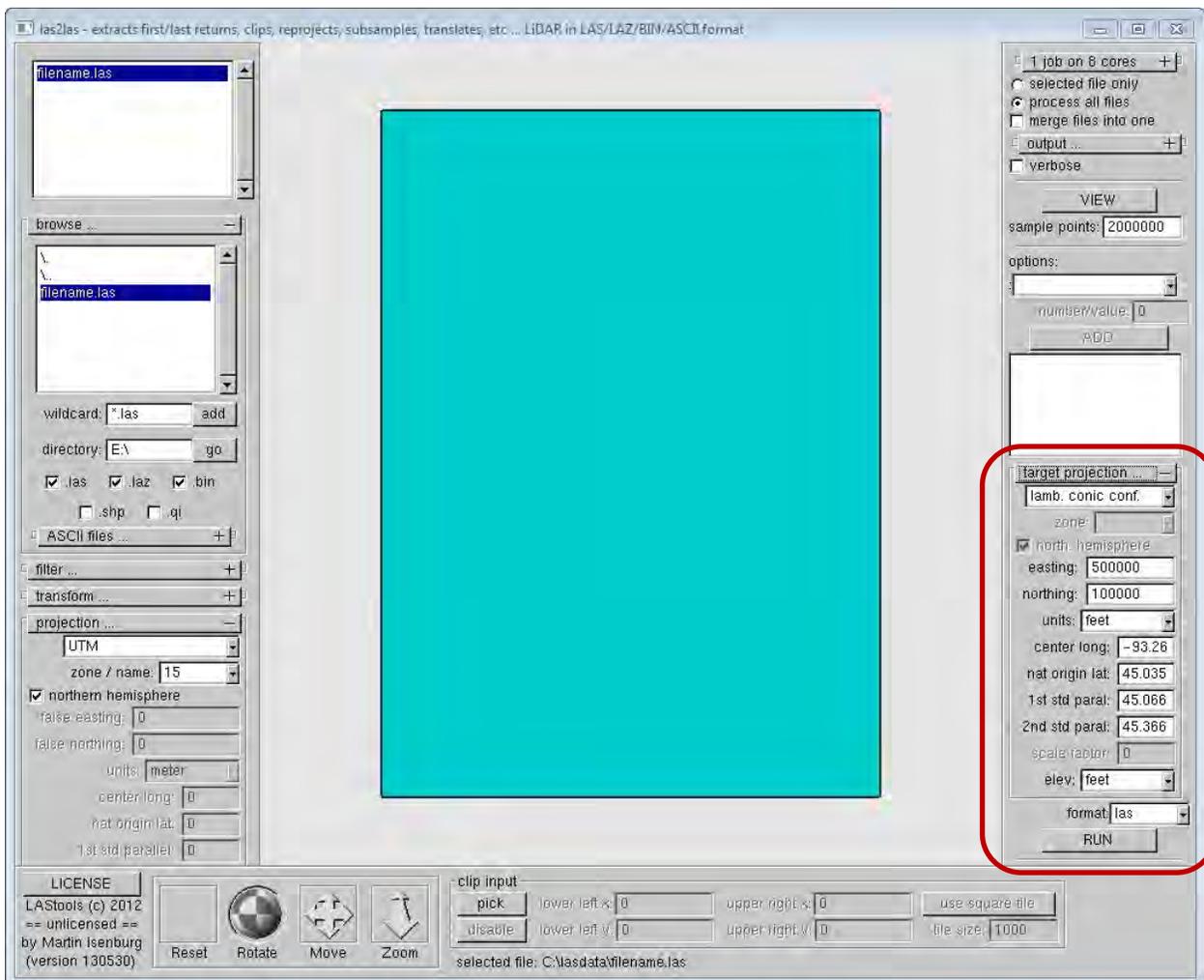
o   After entering the above parameters into the windows under the **target projection…** bar, you can click the **RUN** button. A RUN pop-up window will appear, confirming the command line for the process you are about to run. In our example, it is as follows:

```
las2las –i "C:\lasdata\filename.las" –target_lcc 500000
100000 feet 45.0352777778 -93.2666666667 45.0666666667
45.3666666667 –target_elevation_feet –olas –utm 15N
```

- o TIP: Sometimes, the RUN button gets pushed out of view in the GUI window. You might have to collapse the **target projection…** bar or expand the height of the GUI window to view the **RUN** button.

- **Project a folder of multiple LAS files to a County Coordinate System**

  - o To project multiple LAS files, follow the steps above, but in the first step (choosing your files under the **browse…** bar) select multiple LAS files. You can do this by double-clicking on LAS files one-at-a-time in the main window underneath the **browse…** bar. You can also add all the LAS files in the current folder by entering ***.las** in the wildcard window and clicking **add**.

  - o When projecting multiple files, it might be wise to direct the output towards a new folder and give the output files new names. In this example, I will direct the output to a new folder I have created within **C:\lasdata** called **MyNewFolder**. (see instructions above)
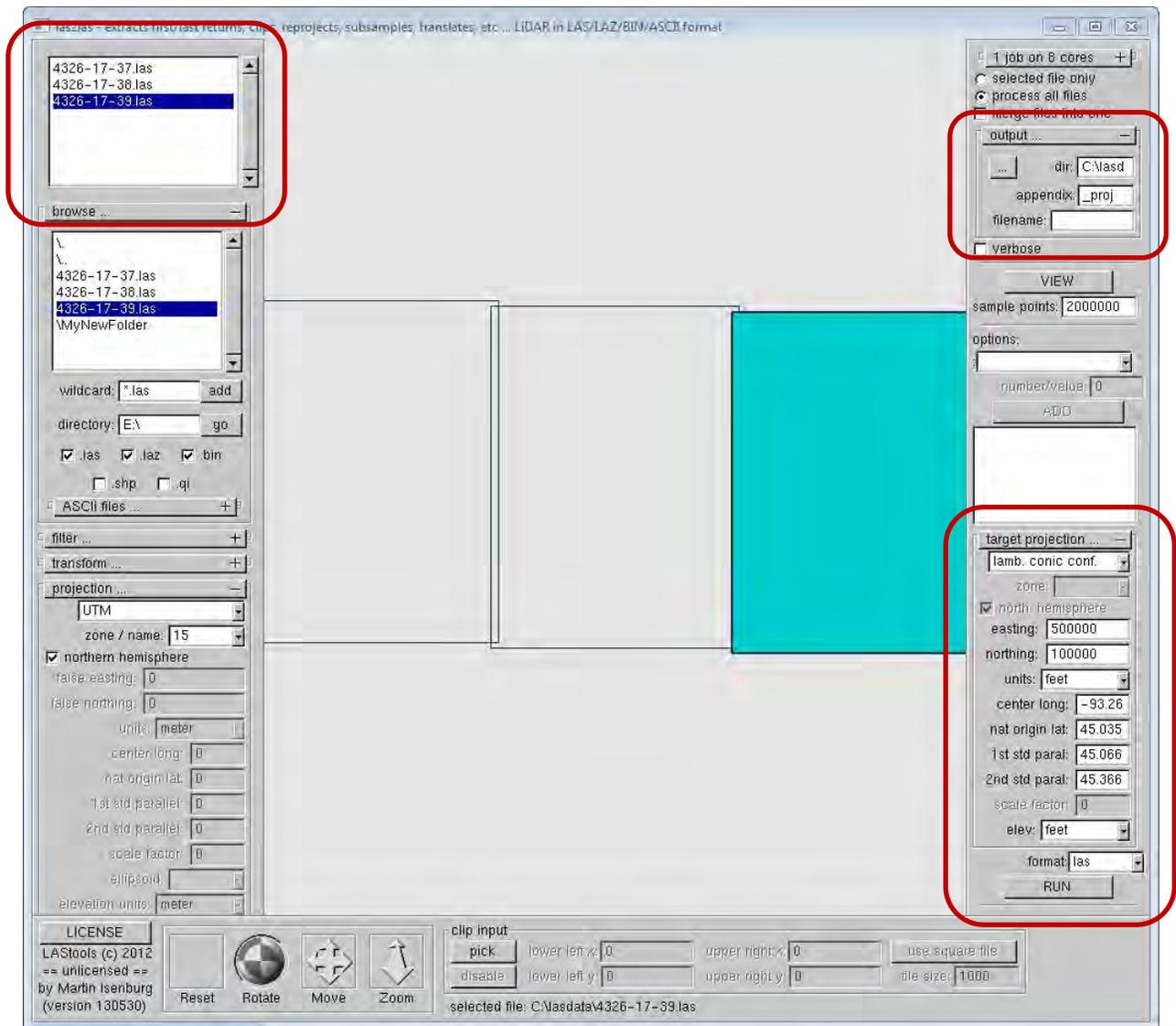
o After entering all the appropriate parameters for Anoka County, here's what the RUN pop-up window shows:

```
las2las –Iof file_list.txt –target_lcc 500000 100000 feet
45.0352777778 –93.2666666667 45.0666666667 45.3666666667 –
target_elevation_feet –odir "C:\lasdata\MyNewFolder" –odix
"_proj" –olas –utm 15N
```

- **Other variations using the las2las tool (Filter)**

o The commands explained above project all points in a LAS file to a particular county coordinate system, but additional statements can be added to run this process on different subsets of points within the file by entering information under the **filter…** bar.

- o Using the **filter…** bar, you can limit the output to certain classes of points based on LiDAR classification codes.

  LIDAR CLASSIFICATION CODES:

  - 0: Created, Never Classified
  - 1: Unclassified
  - 2: Ground
  - 3: Low Vegetation
  - 4: Medium Vegetation
  - 5: High Vegetation
  - 6: Buildings
  - 7: Low Point (Noise)
  - 8: Model Key-Point
  - 9: Water
  - 10: Reserved
  - 11: Reserved
  - 12: Overlap

- o Expand the **filter…** bar and under **by classification or return** select **keep_classification**. In the **number or value** window, you can enter any of the above classification codes to filter your results based on that code. After entering your number, click the **ADD** button below and it will show up in a larger window below that.
- o EXAMPLE 1: Keep only bare ground points (class 2) by entering a **2**, then clicking the **ADD** button. In the window below, you will see **keep_classification 2**. The resulting command line in the RUN window will look like this:

```
las2las –Iof file_list.txt –keep_classification 2
–target_lcc 500000 100000 feet 45.0352777778 –93.2666666667
45.0666666667 45.3666666667 –target_elevation_feet –odir
"C:\lasdata\MyNewFolder" –odix "_proj" –olas –utm 15N
```
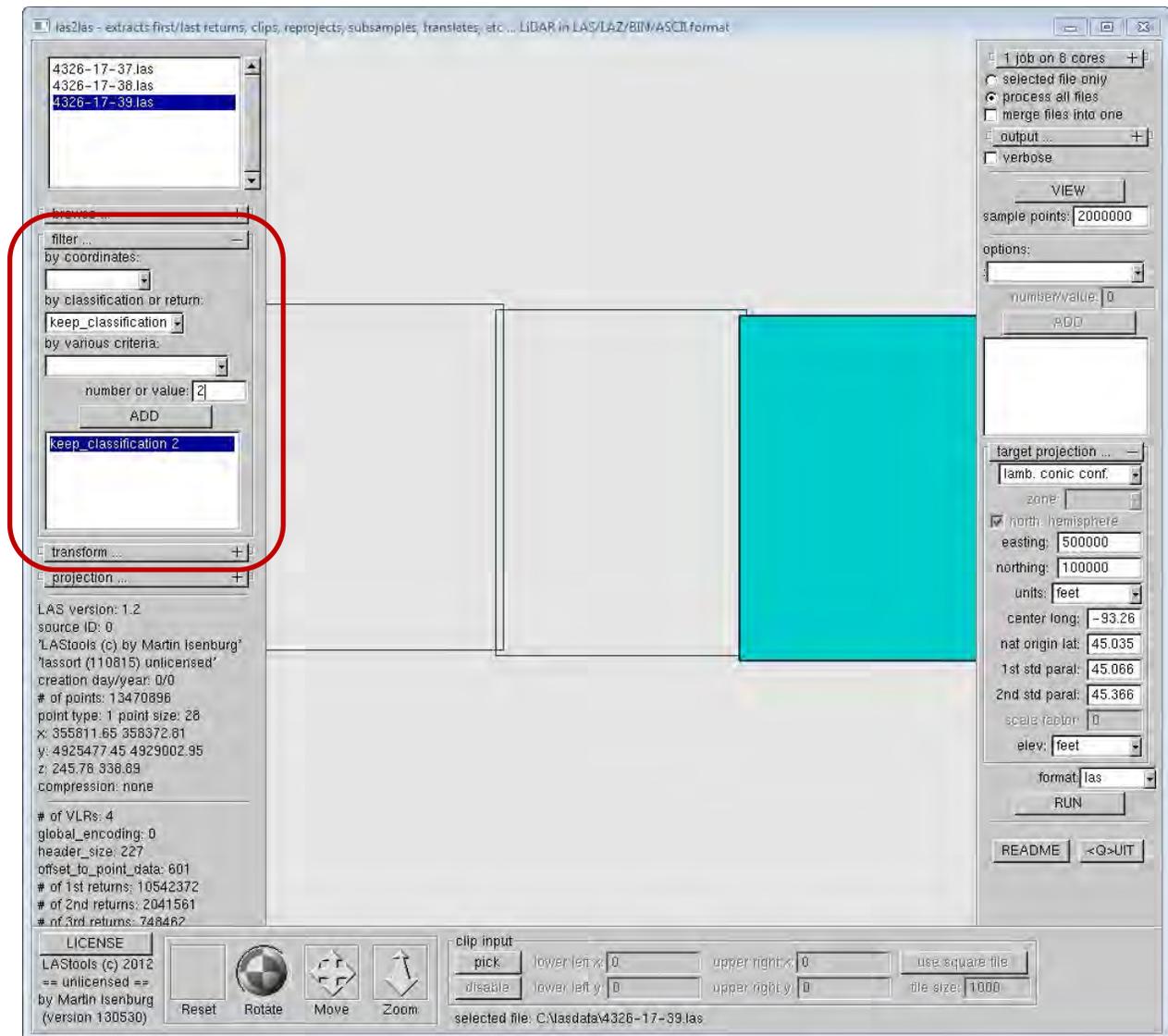
- o EXAMPLE 2: Keep bare ground points (class 2) and mass points (class 8) by repeating the above steps for both class numbers. In the window below, you will see **keep_classification 2** and **keep_classification 8**. The resulting command line in the RUN window will look like this:

```
las2las –Iof file_list.txt –keep_classification 2
–keep_classification 8 -target_lcc 500000 100000 feet
45.0352777778 –93.2666666667 45.0666666667 45.3666666667 –
target_elevation_feet –odir "C:\lasdata\MyNewFolder" –odix
"_proj" –olas –utm 15N
```

There are plenty of other ways to filter the results based on information stored in the LAS files. For more information on using the **las2las** tool, consult the las2las_README.txt file in the **lastools/bin** directory.

METHOD 2: COMMAND PROMPT

Command Prompt Set Up

What follows is a quick explanation of getting set up to run LAStools in the Command Prompt window. There are many different ways to do work with files in command line – a quick internet search of "command line basics" should point you to a number of helpful tips and alternate approaches. What follows is just one possible approach.

- **Open the Command Prompt window**
  - o Start > Programs > Accessories > Command Prompt
- **Navigate to the folder in which your data is stored**
  - o In this example, I have stored my files in a folder called **lasdata** on the **C:** drive.
  - o To work on a file within a certain folder, it's easiest to navigate to that folder within the Command Prompt window. The text before the blinking cursor tells you which folder you're currently in. Use the `cd` command to change the current directory location. Here's a hypothetical example – the blue text is the text you'll type into the command prompt:

Maybe your command line looks like this:

```
C:\Users\johnd001>
```

To navigate from the **johnd001** directory back to the **Users** directory, use the command `cd..`

```
C:\Users\johnd001> cd..
C:\Users>
```

Enter `cd..` again to go back one more level to the **C:** directory

```
C:\Users> cd..
C:\>
```

Now that you're in the **C:** drive, navigate to your **lasdata** folder, by entering the following command

```
C:\> cd lasdata
C:\lasdata>
```

With your command prompt window set to the directory that houses your data, you can easily apply commands to the files within that folder, calling them by name.

- **Set the PATH environment variable**
  - o One final step to get set up for simple command entry: In order to run the LAStools, the Command Prompt needs to know the folder in which the tools reside. You can write out the whole filepath each time your run a tool (Example for running laszip: `C:\lastools\bin\laszip`) *or* you can simply set the PATH environment variable to `C:\lastools\bin` so you need only write `laszip` to run that tool.

o To set the PATH environment variable enter the following in the Command Prompt window:

`C:\lasdata> set path=%path%;C:\lastools\bin`
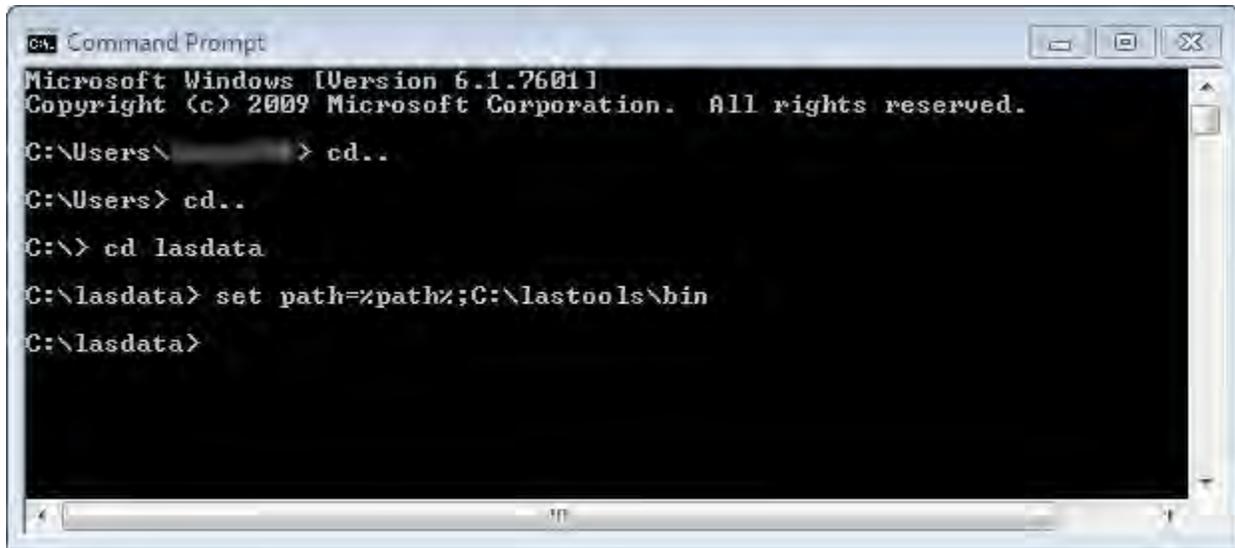
o REMEMBER: the above statement assumes that you unzipped your LAStools folder to the **C:** drive and named it **lastools**. If you saved it somewhere else, or gave it a different name, you'll need to change the above file paths accordingly.

Uncompressing LAZ files (optional)

LiDAR data downloaded from the MnGeo site comes in the compressed LAZ file format. All of the LAStools will work on compressed LAZ files as well as uncompressed LAS files. If you'd like to uncompress the LAZ files to LAS files for compatibility with another program, you can do so with the **laszip** tool.

- **Uncompress one LAZ file within the current directory**

  o Assuming you have followed the instructions above for setting your PATH environment variable to the bin folder, and that your command prompt window is currently pointed to your data folder, the following command will uncompress one LAZ file (the file **4326-17-37.laz** in this example) within the current folder:

  `C:\lasdata> laszip -v -i 4326-17-37.laz`

  o In the command above, entering **laszip** told the command prompt to run the tool and entering **4326-17-37.laz** told it to run the tool on that file.

- **OR… Uncompress all the LAZ files within the current directory**

- To run the laszip tool on all of the LAZ files within the current directory, you can replace the file name (**4326-17-37** in the above example) with a *****. This applies the command to any file in the current directory that ends in **.laz**:

  ```
  C:\lasdata> laszip -v -i *.laz
  ```

- **OR… Uncompress LAZ files into a new directory**

  - In the interest of staying organized, you might want to have your newly uncompressed LAS files land in a new directory. In this example, I created a new folder in the lasdata folder called **MyNewFolder**. To save the output of my laszip command to the new folder, I add the command **–odir MyNewFolder** to the original command.

    ```
    C:\lasdata> laszip -v -i *.laz -odir MyNewFolder
    ```

  - This sends the uncompressed LAS files to the folder **MyNewFolder**. To run commands on these new LAS files, I would now need to change the current directory to **MyNewFolder** with the following command.

    ```
    C:\lasdata> cd MyNewFolder
    ```

    ```
    C:\lasdata\MyNewFolder>
    ```

Note that many of the procedures for moving files around at the command line might be more easily accomplished by simply opening a folder and dragging files around. It's up to you. While working in the command line, I like to keep the current directory open in another window to confirm the results of my commands as they are run.

Projecting to a County Coordinate System

Converting LAS files from UTM Zone 15N to their respective County Coordinate Systems can be accomplished using the **las2las** tool. To project to a particular county coordinate system, you'll need to enter the specific parameters of that coordinate system.

Minnesota County Coordinate System parameters can be found in the table:

http://maps.umn.edu/lastools/MNCountyParameters.html

- **Project one LAS file to a County Coordinate System**

  - In this example, my input LAS file stored in the directory C:\lasdata will be "filename.las" and I'll name my output file "filename_proj.las". I will project my LAS file into **Anoka County's** county coordinate system.
  - The important command line inputs in the **las2las** tool are as follows.

    IMPORTANT LAS2LAS INPUTS:

    - -i = input file name

- -o = output file name
- -target_lcc = output lambert conic conformal projection followed by projection parameters
- -target_feet = output horizontal units are feet
- -target_elevation_feet = output vertical units are feet

o I'll need to enter a few details into the command that identify the current projection of the file **filename.las**. All the LiDAR data downloaded from MnGeo comes with the standard Minnesota UTM Zone 15N projection.

UTM ZONE 15N PARAMETERS (for all MnGeo LAS files):

- Projection: utm 15N
- Ellipsoid: nad83

o I'll also need to enter parameters for my desired county coordinate system (Anoka):

ANOKA COUNTY PARAMETERS:

- Projection: lcc (Lambert Conic Conformal)
- False Easting: 500000
- False Northing: 100000
- Horizontal Units: feet
- Latitude of Origin: 45.0352777778
- Central Meridian: -93.2666666667
- Standard Parallel 1: 45.0666666667
- Standard Parallel 2: 45.3666666667

o The full statement to project the file **filename.las** to the Anoka County coordinate system is as follows:

```
C:\lasdata> las2las -i filename.las -o filename_proj.las
-utm 15N -nad83 -target_lcc 500000 100000 feet
45.0352777778 -93.2666666667 45.0666666667 45.3666666667
-target_feet -target_elevation_feet
```

o Note that after the **–target_lcc** statement, I included all the relevant parameters for Anoka county's coordinate system (False Easting, False Northing, Horizontal Units, Latitude of Origin, Central Meridian, Standard Parallel 1, and Standard Parallel 2). The **target_feet** statement indicates that the output horizontal units should be feet. The **target_elevation_feet** indicates that I want the output vertical units to be in feet (both of these could be changed to meter or survey_feet).

- **Project a folder of multiple LAS files to a County Coordinate System**

    o In this example, I'll project all the LAS files in my current directory into the Anoka County coordinate system, direct the output to a new folder within this directory named **MyNewFolder**, then append **_proj** to each output file name. First, I make sure that all the LAS files I want projected are in the current directory (**C:\lasdata**), then I create a new folder inside that directory called **MyNewFolder**.

    ```
    C:\lasdata> las2las -i *.las -odir MyNewFolder -odix _proj
    -olas -utm 15N -nad83 -target_lcc 500000 100000 feet
    45.0352777778 -93.2666666667 45.0666666667 45.3666666667
    -target_feet -target_elevation_feet
    ```

    o In this command, I set the input (-i) as ***.las** to apply the command to all files in the directory that end in .las. The **-odir** command set the output directory to **MyNewFolder**. The **-odix** command appended **_proj** to each output file name. The **-olas** command simply defined the output as LAS files. The rest of the command was entered exactly the same as in the first example.

- **Other variations using the las2las tool**

    o The commands explained above project all points in a LAS file to a particular county coordinate system, but additional statements can be added to run this process on different subsets of points within the file. Using the **–keep_las** command, you can limit the output to certain classes of points based on LiDAR classification codes.

    LIDAR CLASSIFICATION CODES:

    - 0: Created, Never Classified
    - 1: Unclassified
    - 2: Ground
    - 3: Low Vegetation
    - 4: Medium Vegetation
    - 5: High Vegetation
    - 6: Buildings
    - 7: Low Point (Noise)
    - 8: Model Key-Point
    - 9: Water
    - 10: Reserved
    - 11: Reserved
    - 12: Overlap

    o Based on the above classification codes, you can apply filter the results to include only bare ground points (class 2) by adding the command **–keep_class 2**:

```
C:\lasdata> las2las -i filename.las -o filename_proj.las
-utm 15N -nad83 -target_lcc 500000 100000 feet
45.0352777778 -93.2666666667 45.0666666667 45.3666666667 -
target_feet -target_elevation_feet -keep_class 2
```

- o To keep bare earth (class 2) and mass points (class 8) you would add **-keep_class 2 8**:

```
C:\lasdata> las2las -i filename.las -o filename_proj.las
-utm 15N -nad83 -target_lcc 500000 100000 feet
45.0352777778 -93.2666666667 45.0666666667 45.3666666667
-target_feet -target_elevation_feet -keep_class 2 8
```

For more information on using the **las2las** tool, consult the las2las_README.txt file in the lastools/bin directory.

Thanks for Reading

This document was prepared by Taylor Long, a graduate research assistant at U-Spatial (University of Minnesota). If you have any questions or comments about this content, feel free to e-mail Taylor at longx598@umn.edu. If you're interested in diving deeper into LAStools, you can explore the discussions on this Google Group and post your own questions.