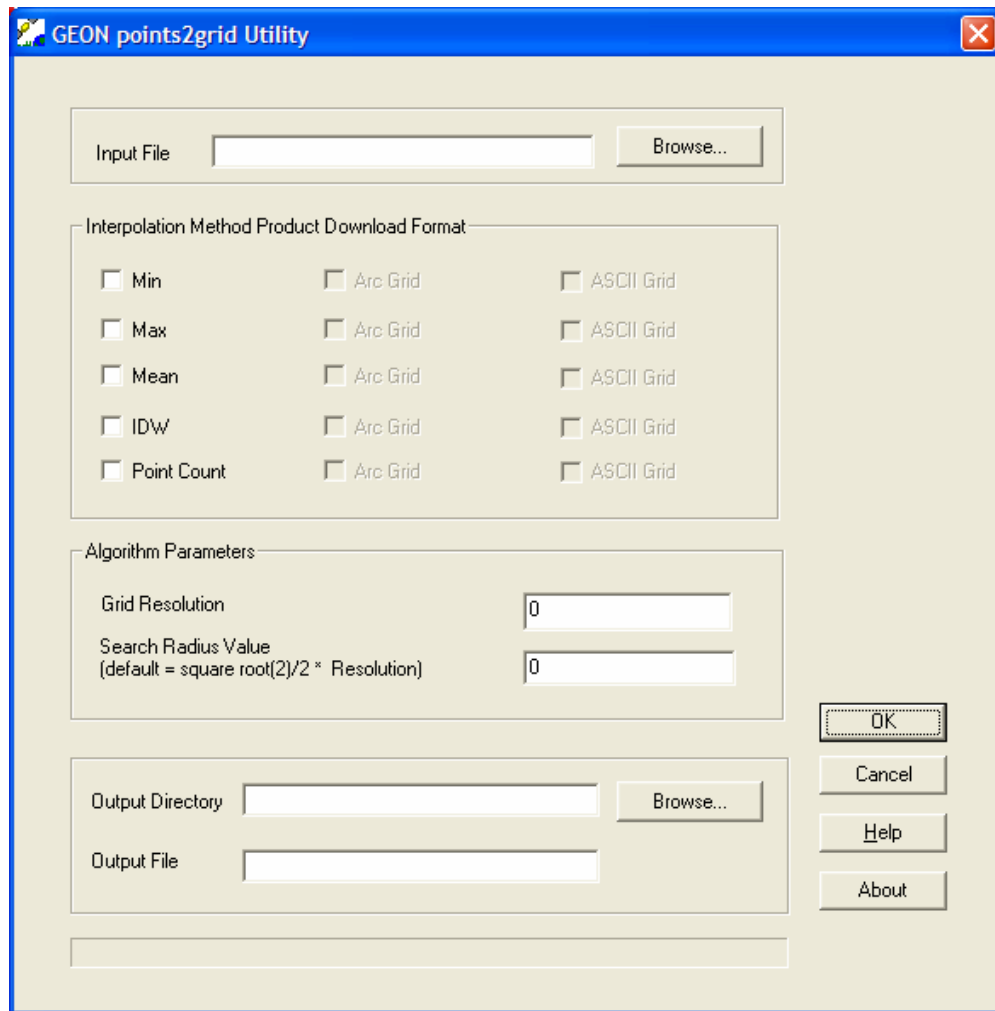GEON Points2Grid Utility Instructions
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Interface Screen Capture:

1) Introduction:
The GEON Points2Grid Utility is a lightweight tool for the generation of Digital Elevation Models (DEMs) from LiDAR point cloud data. The utility was developed by a team of geoscientist and computer scientists at Arizona State University and University of California, San Diego under National Science Foundation funding to the GEON Project (http://www.geongrid.org/). The Points2Grid Utility utilizes a local binning algorithm to offer rapid generation of DEMs from large volumes of LiDAR point return data.

The tool offers user control over DEM resolution and the local bin (search) radius. Points2Grid operates on delimited ascii LiDAR return data (one point per line, x,y,z + attributes) and DEMs are output from the tool in either ESRI's Arc ascii grid or a standard ascii grid format. Points2Grid is currently only compatible with Windows operating systems. Although originally conceived for DEM generation from LiDAR point data, Points2Grid can be used to grid any 3D point cloud data such as seismicity or gravity.

Please see the "About" dialog for copyright and authorship information. Questions, suggestions and error reports about the GEON Points2Grid Utility should be directed to: chris.crosby@asu.edu.

2) Input File:
The GEON Points2Grid Utility reads in LiDAR point cloud data from a one-point-per-line, comma delimited ascii file where column one is x (easting), column two is y (northing) and column three is z (elevation). The presence or lack of additional attribute columns is unimportant since Points2Grid only looks at the first three columns of the file. Delimiters other than comma (or comma followed by a space) will cause Points2Grid to crash. A header on the input file is not necessary but if one is present, Points2Grid will not be affected.

Example Input files:

```
x,y,z,date,time,returnnumber,noreturns,offnidar,returnint,classification
6079558.34,2121999.58,69.06,1204,+1.39915067000000E+003,1,5,15.63,116,"G"
6079533.28,2122000.47,69.28,1204,+1.39915091000000E+003,1,5,15.18,114,"G"
6079507.99,2122001.37,69.11,1204,+1.39915115000000E+003,1,5,14.72,86,"G"
6079483.27,2122002.25,68.84,1204,+1.39915139000000E+003,1,5,14.27,84,"G"
6079555.62,2121995.47,68.74,1204,+1.39916953000000E+003,1,5,15.58,104,"G"
6079530.13,2121996.37,68.91,1204,+1.39916977000000E+003,1,5,15.12,132,"G"
6079505.12,2121997.26,68.86,1204,+1.39917001000000E+003,1,5,14.67,100,"G"
6079480.27,2121998.14,68.53,1204,+1.39917025000000E+003,1,5,14.21,77,"G"
6079455.95,2121999.00,68.28,1204,+1.39917049000000E+003,1,5,13.77,61,"G"
…


x,y,z
6211354.52,1947367.55,204.77
6211350.54,1947354.89,203.97
6211375.19,1947368.04,205.93
```

```
6211375.17,1947363.42,205.60
6211359.11,1947337.27,203.67
6211379.52,1947342.71,204.80
6211375.44,1947335.12,204.33
6211353.98,1947305.10,201.90
6211381.05,1947296.57,202.99
6211360.74,1947281.79,200.99
…
```

3) Grid Type:
The Points2Grid Utility utilizes a local binning algorithm to offer rapid generation of
DEMs from large volumes of LiDAR point return data. The algorithm utilizes the
elevation information from only the points inside of a circular search area of user-specified
radius. For each node in a grid, five values may be computed: the minimum, maximum,
mean, and inverse distance weighted mean of the local points, and the number of points in
the search area. In the GEON Points2Grid Utility, the user is given the option of choosing
which grids they would like to receive. For each Grid Type check box selected in the
Points2Grid interface, the user will receive a DEM product – thus, if all five boxes are
selected, the user will receive five grid products.

> *Grid Type* Guidelines:
> **Min**: The minimum surface DEM product emphasizes the lowest portions of the
> landscape. It assigns the minimum elevation of the points in the search radius to
> the grid node. In an unfiltered LiDAR point cloud, this product acts as a pseudo
> vegetation filter and may provide a reasonable bare earth representation. Tuning of
> the Search Radius parameter may be necessary to optimize vegetation removal (see
> *Algorithm Parameters* below for more information on search radius)
>
> **Max**: The maximum surface DEM emphasizes the highest portions of the
> landscape. It assigns the maximum elevation of the points in the search radius to
> the grid node. If applied to an unfiltered LiDAR point cloud this surface represents
> a "full feature" or "first return" surface.
>
> **Mean**: The mean surface DEM represents the average elevation of the points
> within the search area. It assigns the mean elevation of the points in the search
> radius to the grid node. For filtered (classified) point clouds, this surface is best
> applied to ground returns to produce a bare earth DEM.
>
> **IDW**: The IDW surface DEM is similar to the mean surface product except that it
> uses an Inverse Distance Weighted mean to calculate the elevation at the DEM
> node where points closer to the DEM node are given a greater weight than those
> further from the node. We use a $1/r^2$ weighting in the current implementation. Like
> the mean surface, the IDW product is best suited to bare earth terrain model
> production in areas of little to no vegetation or from a filtered (classified) point
> cloud.
>
> **Point Count**: The point count grid provides a powerful way to evaluate LiDAR
> point return densities and the spatial heterogeneity of your dataset. Each grid cell

in this product shows the number of points found within the search radius at that node. Therefore, the point count grid can be utilized to determine what DEM resolution is supported by the dataset. In order for the local binning algorithm to produce a reasonable DEM, there must be at least a single LiDAR return in each grid cell. Multiple returns per grid cell may suggest that the dataset supports a DEM of finer resolution.

4) Product Download Format:
The GEON Points2Grid Utility generates DEMs in one of two file formats: (1) Arc ASCII Grids or (2) ASCII Grids. Both formats are very simple and were chosen because they are easily imported into many common DEM/Grid analysis software packages. The two files have fundamentally the same format but have slightly different headers as shown below.

Arc ASCII Grid Example:
ncols 106
nrows 31
xllcorner 391008.500000
yllcorner 3826938.500000
cellsize 6.000000
NODATA_value -9999

ASCII Grid Example:
north: 3827123.990000
south: 3826938.500000
east: 391640.580000
west: 391008.500000
rows: 31
cols: 106

Users must consult their analysis software documentation to determine which of these file formats can be imported.

For users of ESRI software, the Arc ASCII Grids can be imported into ArcGIS via the ArcToolBox. In ArcToolBox, select: "Conversion Tools" > "To Raster" > "ASCII to Raster". "Output data type" should be set to "float".

Arc ASCII Grid files receive an ".arc.asc" extension while the ASCII Grids get a ".asc" extension. If users select all five *Grid Types* and both *Product Download Formats* the GEON Points2Grid Utility will return 10 files.

5) Algorithm Parameters:
The GEON Points2Grid Utility gives users the ability to control both the resolution of the DEMs they are producing and also the search radius used in the local binning algorithm.

Grid Resolution: This parameter controls the pixel resolution (or grid size) of the resulting DEM. The DEM resolution supported by a given dataset is a function of

the LiDAR shot densities achieved during the data acquisition. Therefore, it is useful to know something about the dataset acquisition parameters when producing your DEMs. The Point Count *Grid Type* produced by the Points2Grid Utility can be very useful for getting a feel for shot densities in your dataset. As a general rule of thumb, most LiDAR datasets are acquired to support DEMs with resolutions of 1-3 meters.

Search Radius Value: The search radius value controls the size of the bin used in the generation of the DEM. The larger the bin, the more LiDAR returns are used to perform the calculation for each DEM node. We have set a default search radius as *the (square root of 2) / 2 times the resolution* of the DEM. If a user leaves the Search Radius Value box empty in the Points2Grid interface, the default radius value is applied. Users may override the default by entering their own search radius. Larger search radii are necessary in lower shot density datasets or if the user is seeking to filter sparse vegetation in the production of a minimum surface DEM. Use to too large a search radius will result in generalization of the topography and loss of detail in topographic features.

By default, if there are no LiDAR returns found within a given search radius the Points2Grid algorithm populates the DEM node with a NO DATA value. Thus, DEMs that are produced at resolutions higher than supported by the LiDAR dataset will contain numerous NO DATA grid cells. In this case, the user is recommended to decrease their DEM resolution or to increase their search radius.

We have a number of resources on our webpage which help users to better understand the role of search radius and LiDAR return densities in the local binning algorithm. Please see the following documents for more information:

Exploration of search radius for GEON LiDAR Workflow
(http://lidar.asu.edu/KnowledgeBase/GLW_Search_Radius)

Consideration of point count and optimal resolution and search radius for B4 ALSM data in the Carrizo Plain. (http://lidar.asu.edu/KnowledgeBase/WCptcount)

6) Output directory:
Use this box to define the location of where the Points2Grid products will be written.

7) *Output File*:
Use this dialog to name the output files. By default, Points2Grid will use the *Input File* name as the *Output File* and will then append descriptive extensions to differentiate the products. For example, an input file named "LiDAR_data.txt" would result in outputs titled: "LiDAR_data.txt.min.arc.asc" for a minimum surface *Grid Type* in the Arc ASCII Grid format.