



Esri International User Conference | San Diego, CA
Technical Workshops | July 2011

Lidar Solutions in ArcGIS

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Outline

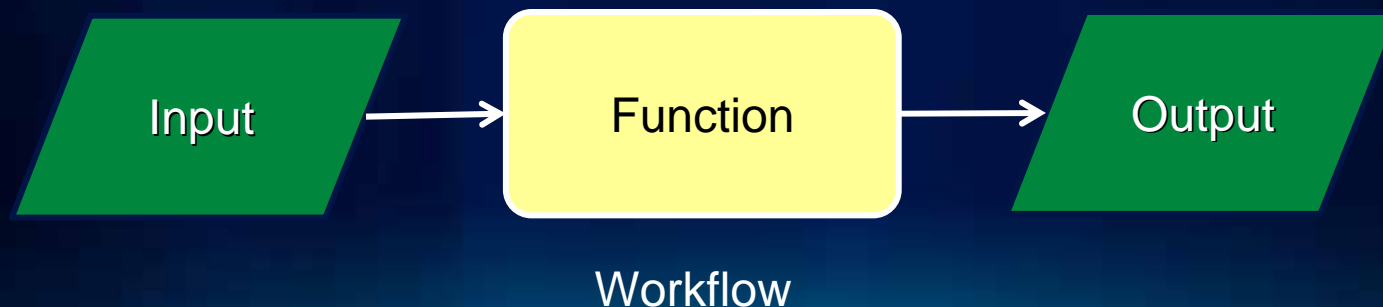
- **Data structures, tools, and workflows**
- **Assessing lidar point coverage and sample density**
- **Creating raster DEMs and DSMs**
- **Data area delineation**
- **Estimating forest canopy density and height**
- **Creating intensity images**
- **Reducing noise for contouring and slope analysis**
- **Floodplain delineation**

Big Picture

- **Solutions for GIS end users**
 - Not about lidar data production
- **Operate on clean/classified lidar points**
- **Produce useful derivatives**
- **Perform analysis**
- **Handle large datasets**
- **Database oriented**

Supporting Data structures and Tools

- **Vector features**
 - points
 - *multipoints*
 - lines
 - polygons
- ***Raster***
- **TIN**
- ***Terrain Dataset***
- **Point File Information**
- **LAS To Multipoint**
- **ASCII 3D To Feature Class**
- **Point To Raster**
- **Terrain To Raster**
- **Terrain To TIN**












Relative Storage Costs

- **One LAS* file**
 - LAS file (with attributes) 44MB
 - Shapefile (geom only) 52MB
 - PersonalGDB (geom only) 40MB
 - FileGDB (geom only) 7MB
- **Project of many LAS files**
 - 338 LAS files 12.5GB
 - Bare earth terrain 1.3GB
 - 1st return terrain 2.2GB

* LAS is industry standard format for lidar data

Lidar point coverage and sample density

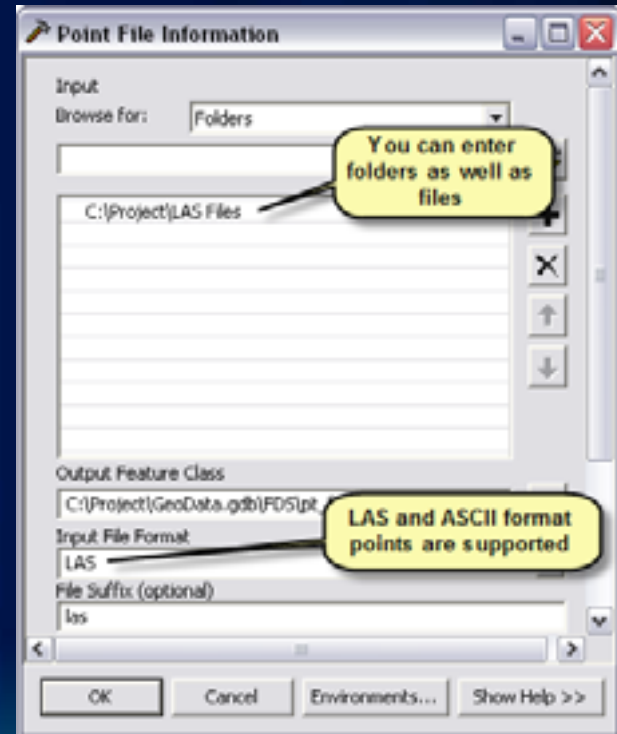
- Basic QA/QC before loading data into geodatabase
- Verify xy and z extent
- Examine point spacing

Name ▲	Size	Type	Date Modified
 472599.las	5,645 KB	LAS File	10/5/2007 1:37 PM
 472600.las	8,155 KB	LAS File	10/5/2007 1:37 PM
 472602.las	5,158 KB	LAS File	10/5/2007 1:37 PM
 474597.las	6,492 KB	LAS File	10/5/2007 1:37 PM
 474599.las	52,065 KB	LAS File	10/5/2007 1:37 PM
 474600.las	50,118 KB	LAS File	10/5/2007 1:38 PM
 474602.las	53,623 KB	LAS File	10/5/2007 1:38 PM
 474603.las	5,999 KB	LAS File	10/5/2007 1:38 PM
 475597.las	41,957 KB	LAS File	10/5/2007 1:38 PM

= ?

Point File Information Tool

- Inputs files (LAS and ASCII) and folders of files and outputs a polygon feature class.
- Each output record includes
 - Polygon of file's data extent
 - Source filename
 - Point count
 - Point spacing estimate
 - Z min
 - Z max



Point File Information Tool

The image illustrates the workflow of the Point File Information Tool. On the left, a list of LAS files is shown with columns for Name, Size, Type, and Date Modified. An arrow points from this list to the ArcMap interface. In the center, the ArcMap window displays a map of Jasper County with a grid overlay and a single cyan point selected. On the right, the 'Attributes of Jasper County LAS Info' window is open, showing a table of attributes for the selected point.

Name	Size	Type	Date Modified
472599.las	5,645 KB	LAS File	10/5/2007 1:37 PM
472600.las	8,155 KB	LAS File	10/5/2007 1:37 PM
472602.las	5,158 KB	LAS File	10/5/2007 1:37 PM
474597.las	6,492 KB	LAS File	10/5/2007 1:37 PM
474599.las	52,065 KB	LAS File	10/5/2007 1:37 PM
474600.las	50,110 KB	LAS File	10/5/2007 1:38 PM
474602.las	53,623 KB	LAS File	10/5/2007 1:38 PM
474603.las	5,999 KB	LAS File	10/5/2007 1:38 PM
475597.las	41,957 KB	LAS File	10/5/2007 1:38 PM

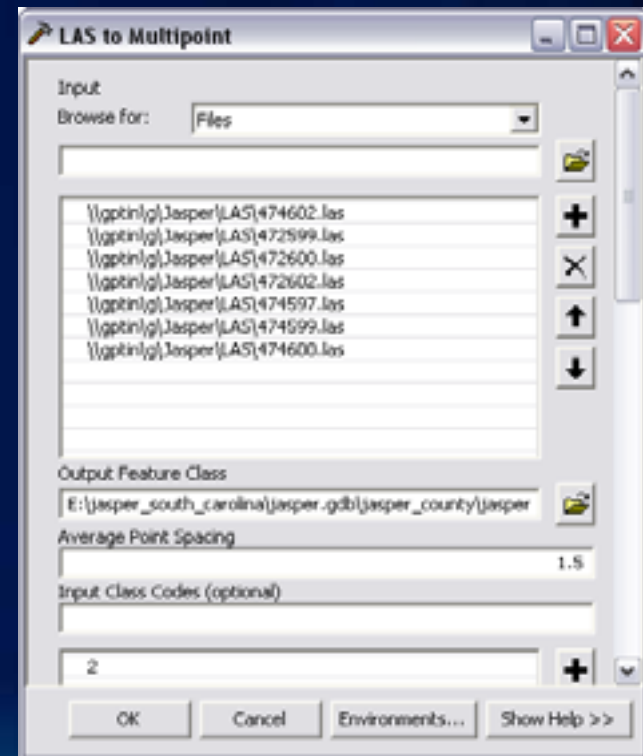
Attributes of Jasper County LAS Info

OBJECTID	SHAPE	Name	Pt. Count	Spacing	ZMin	ZMax
271	Polygon	400600.las	2341134	0.980324	82.980962	174.489431
272	Polygon	400602.las	3031205	1.052468	85.023375	172.229483
273	Polygon	400603.las	1803580	1.118918	85.420008	190.812629
274	Polygon	400605.las	1794243	1.118019	84.566051	184.887732

Record: 1 of 1 Show: All Selected Records (1 out of 880)

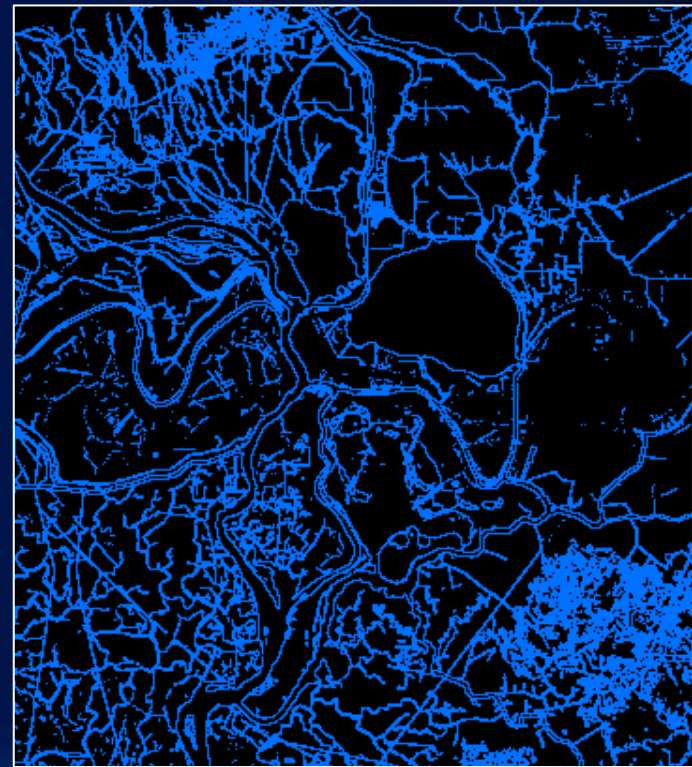
Loading Data: LAS To Multipoint Tool

- **LAS** = industry standard file format for lidar
- **Multipoints** used for efficiency
- **Filter options**
 - By class
 - By return



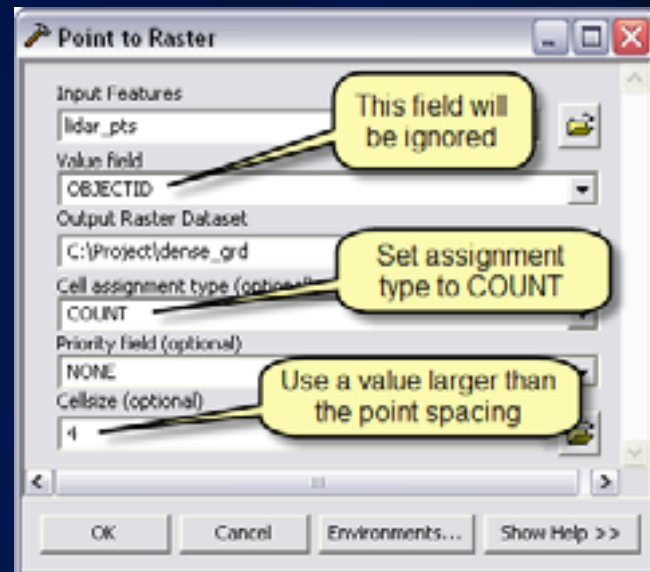
Loading Data: ASCII 3D To Feature Class Tool

- **Points, lines, polygons**
- **Recommendations:**
 - Use ASCII as 'open' format for breakline data (otherwise shapefile)
 - Use LAS for lidar points

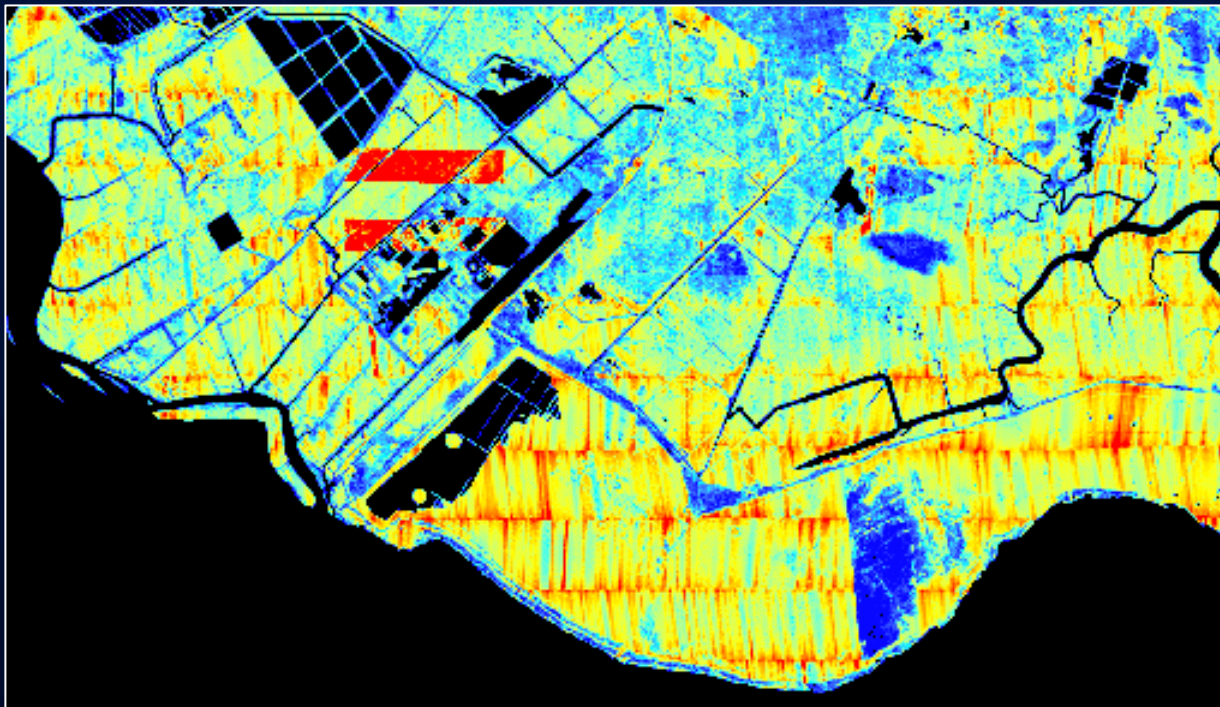


Point to Raster Tool

- Used after points are loaded into geodatabase
- More detailed assessment than Point File Information
- Based on actual points loaded (i.e., filtered by class code or return) rather summary of entire file.



Point To Raster: Sample Density



Demo



Creating Raster DEMs and DSMs

Digital Elevation Model



Bare earth surface made using only ground hits.

Digital Surface Model

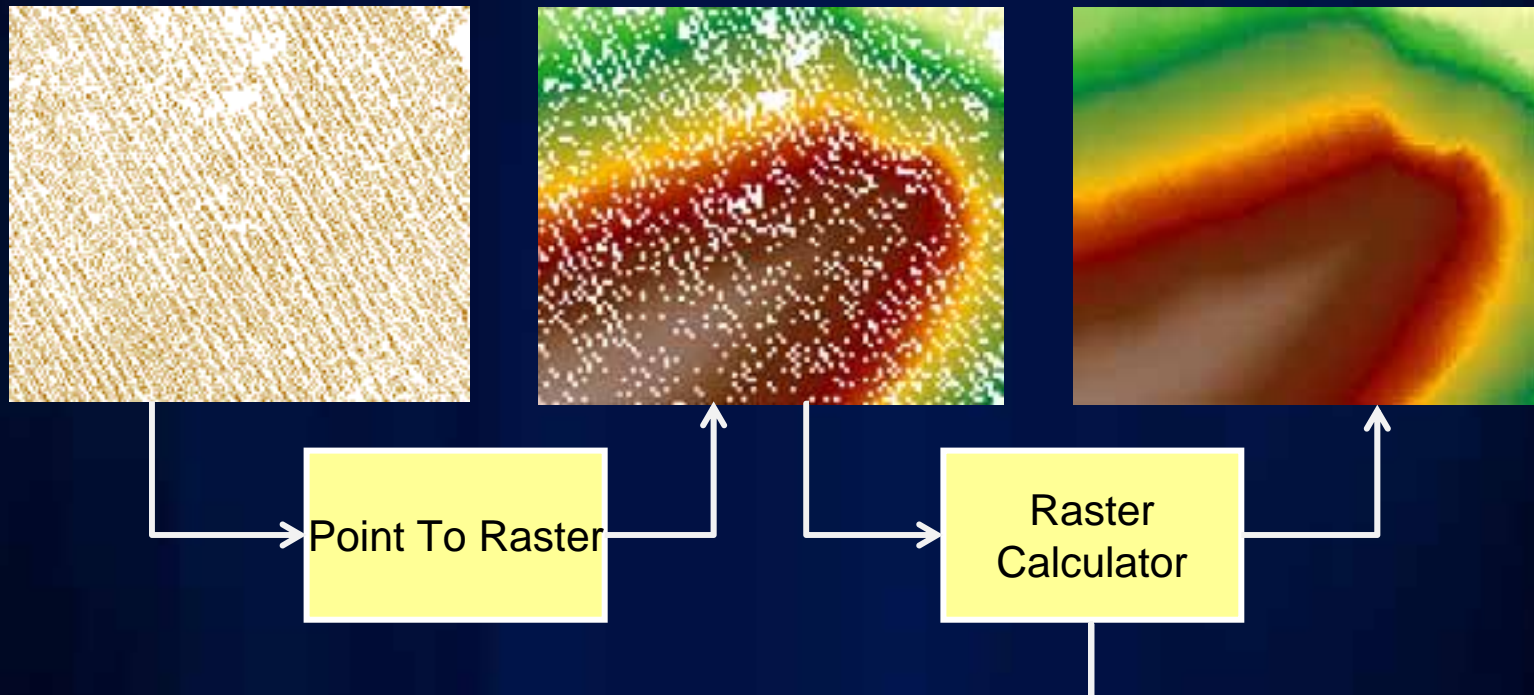


Includes ground, trees, and buildings made using first returns.

Point to Raster Tool

- *Fast*
- Rasterize based on multipoint vertex z
- Not true interpolation
- Doesn't support breaklines
- Data gaps
- Arguably works best with 1st return data because there are fewer and smaller data voids to deal with.

Point to Raster Post-process: Void Filling

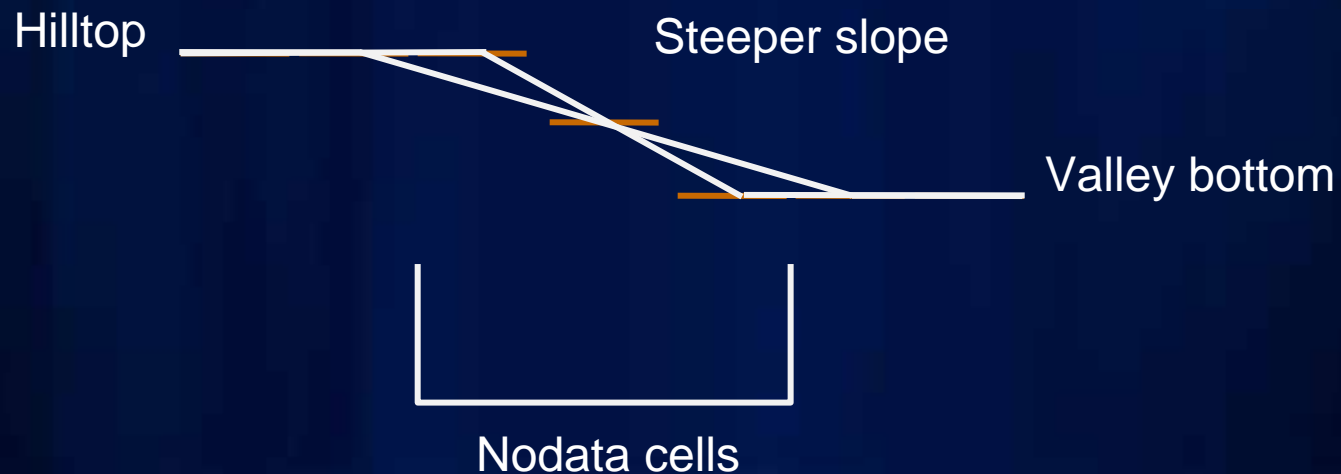


```
Con(IsNull("pt2ras"), FocalStatistics("pt2ras", NbrRectangle(3, 3, "CELL"), "MEAN", "DATA"), "pt2ras") 10.0
```

```
Con(IsNull([pt2ras]), FocalMean([pt2ras], Rectangle, 3, 3, DATA), [pt2ras])
```

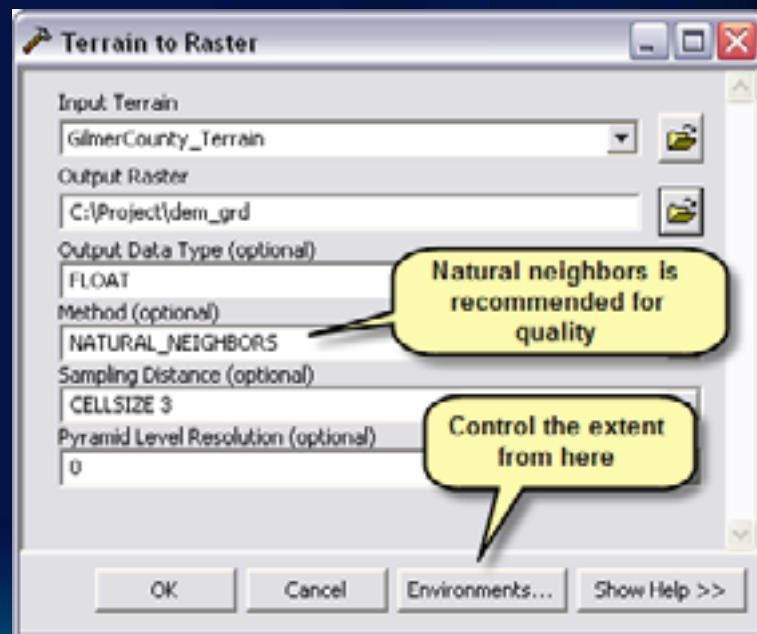

Don't Abuse Con

- Introduces anomalies if used repeatedly

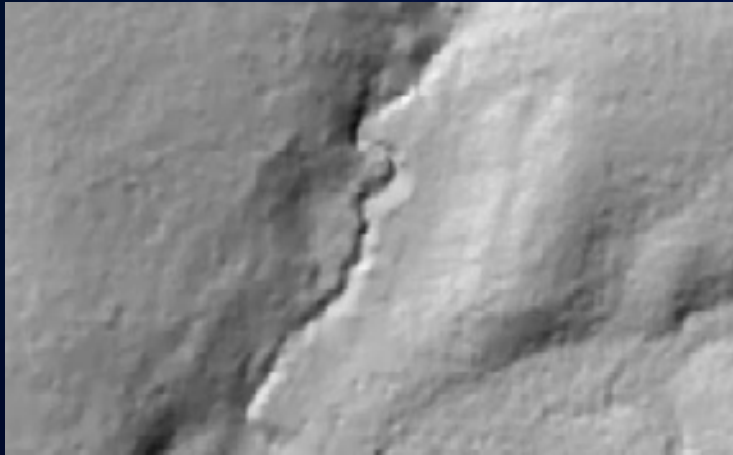


Terrain to Raster

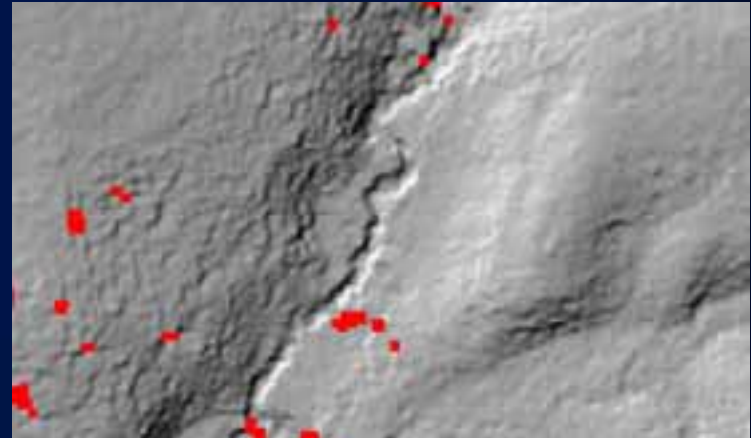
- *Quality*
- Supports ancillary data (breaklines, water bodies, etc.)
- True interpolation
- Can handle large datasets



Void Filling - Comparison



Terrain to Raster - interpolation

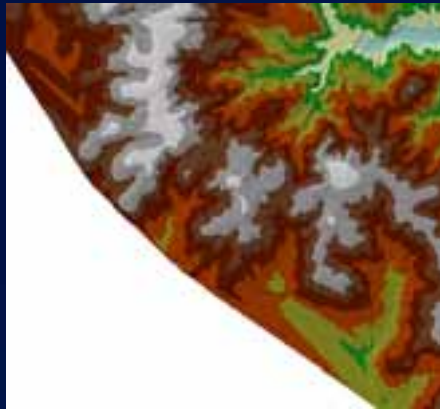


Point to Raster followed by
several iterations of Con to
reduce voids

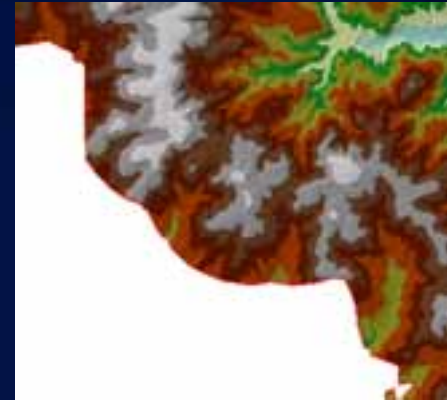
Data Area Delineation



Dense collection of source measurement points (green).

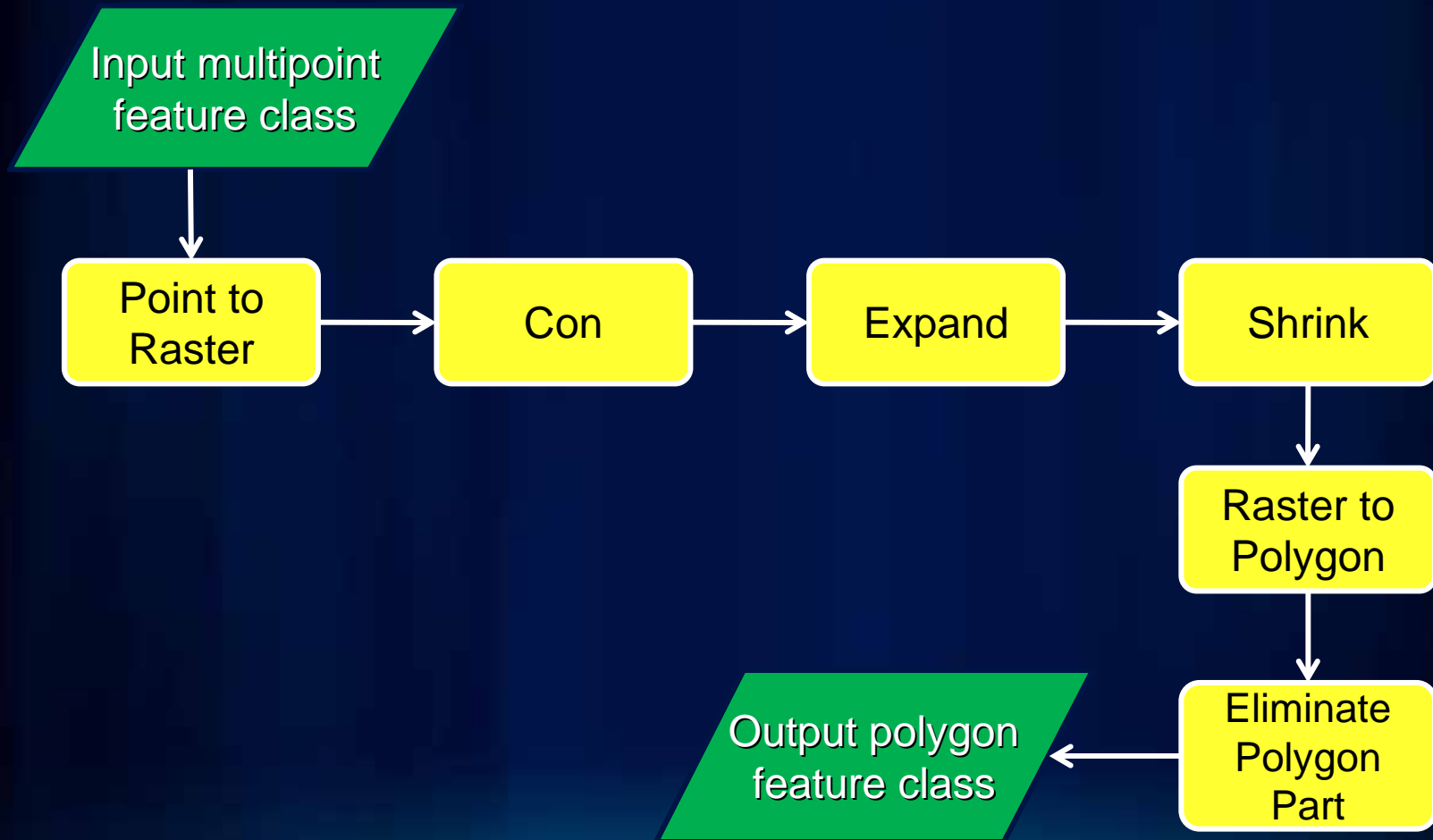


Triangulation of those points without a boundary constraint.



Constraint applied.

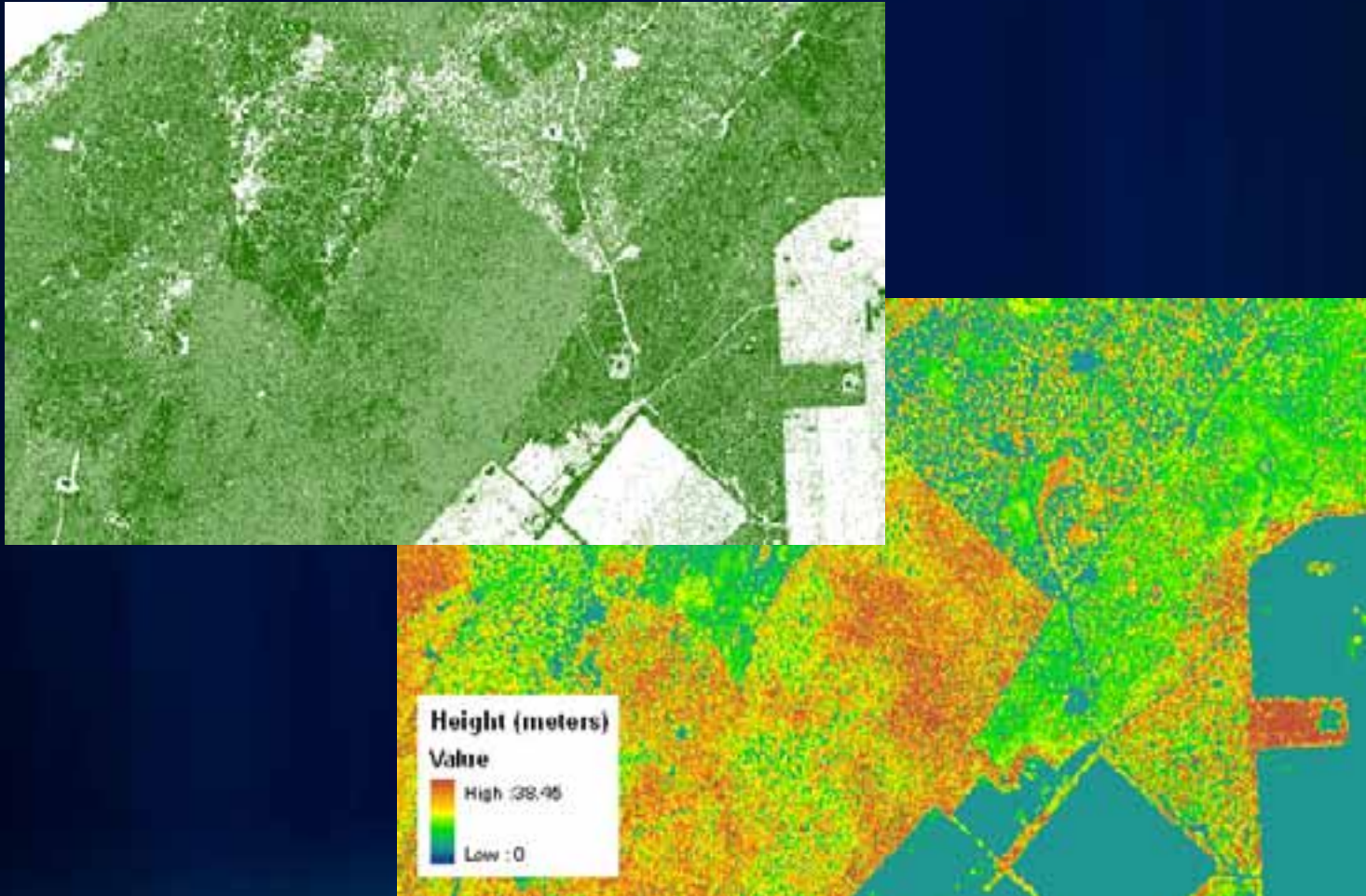
Workflow to Calculate a Data Area Polygon



Demo



Estimating Forest Canopy Density and Height



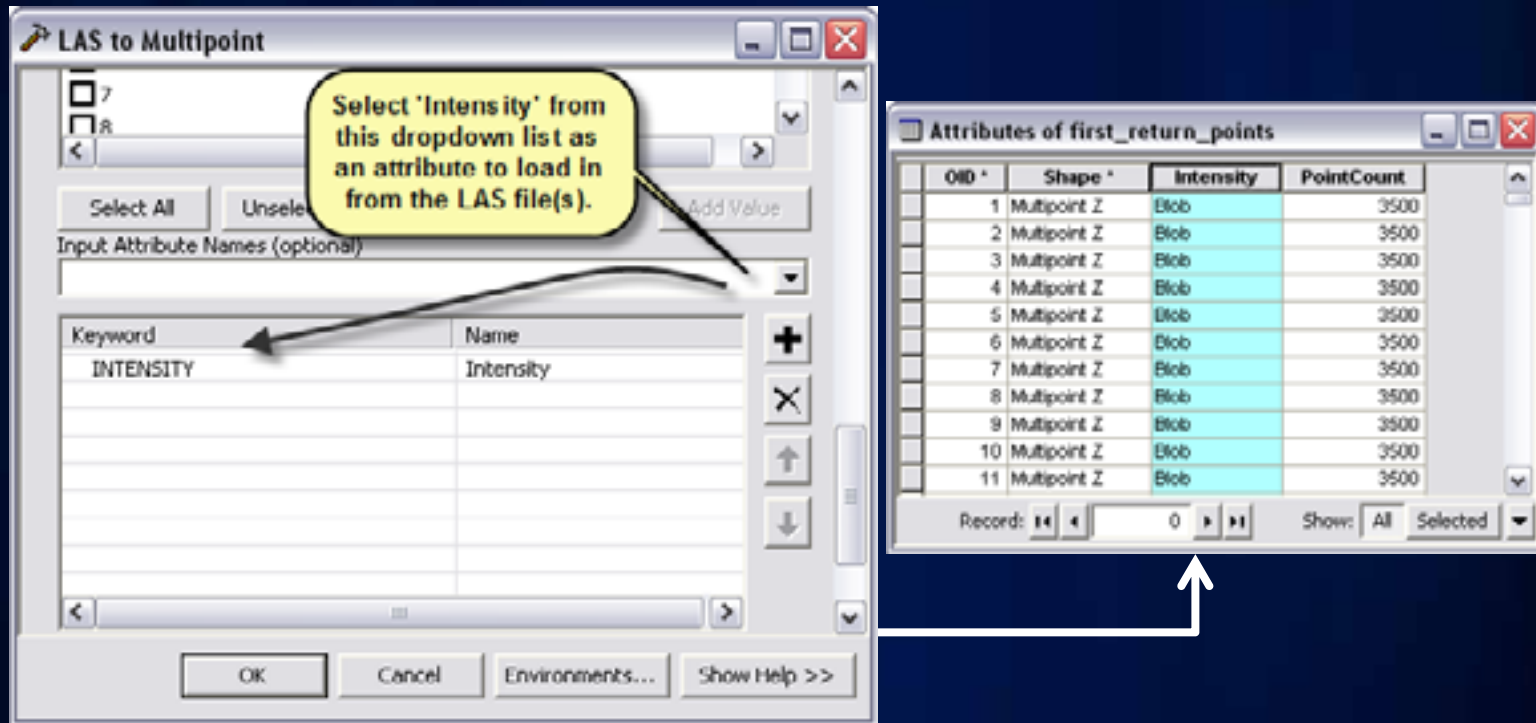
Canopy Density and Height

- **Density is the ratio of vegetation hits to total hits within a unit area (i.e., raster cell).**
 - LAS to Multipoint to make two feature classes: ground and non-ground.
 - Point to Raster to make 'count' grids.
 - Add ground and non-ground to make a 'total' grid.
 - Use Divide to get the ratio between non-ground and total.
- **Height is the difference between DSM and DEM**
 - Use Point to Raster or Terrain to Raster followed by Minus.

Creating Intensity Images

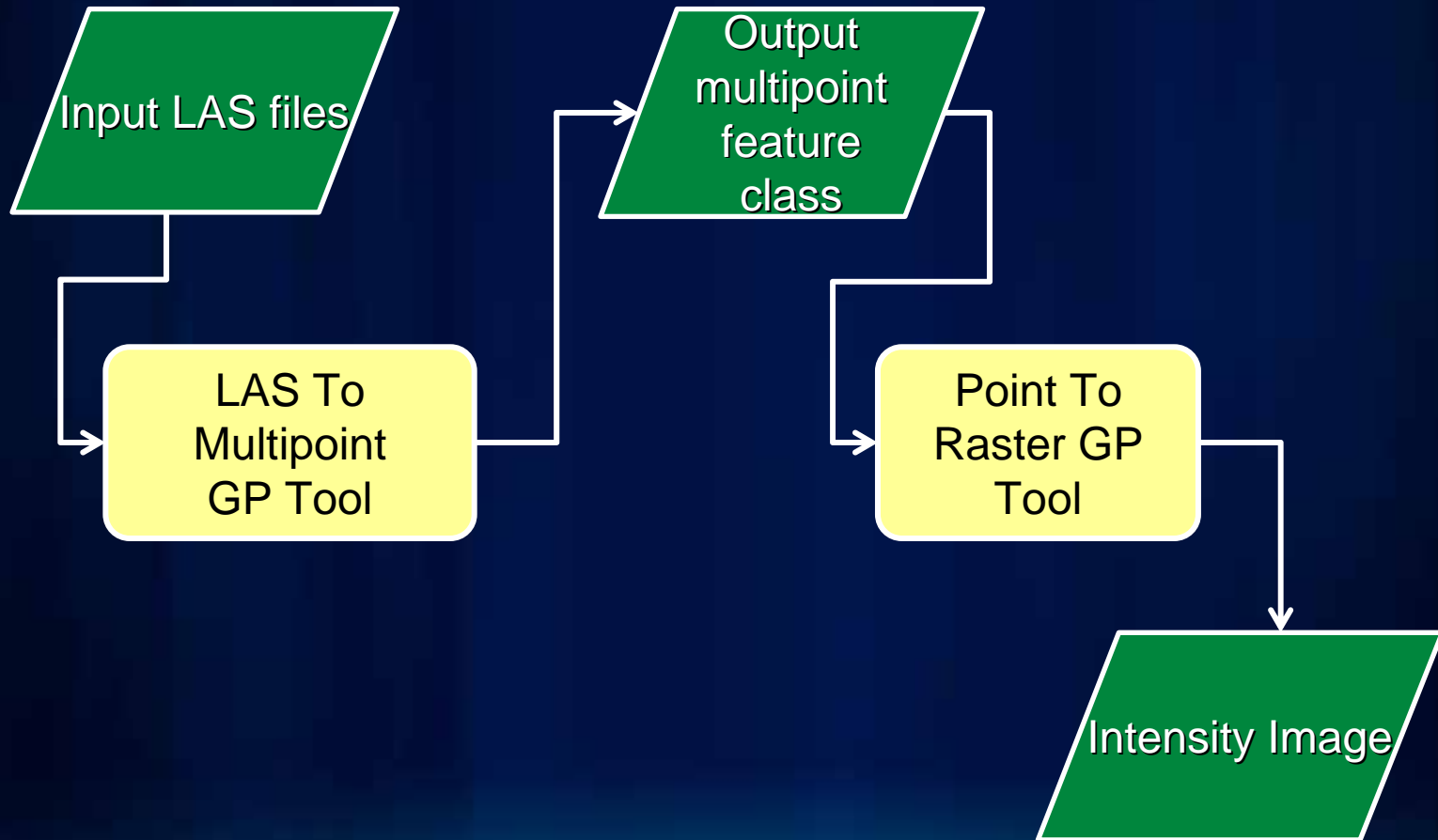


BLOB Based Storage of Intensity

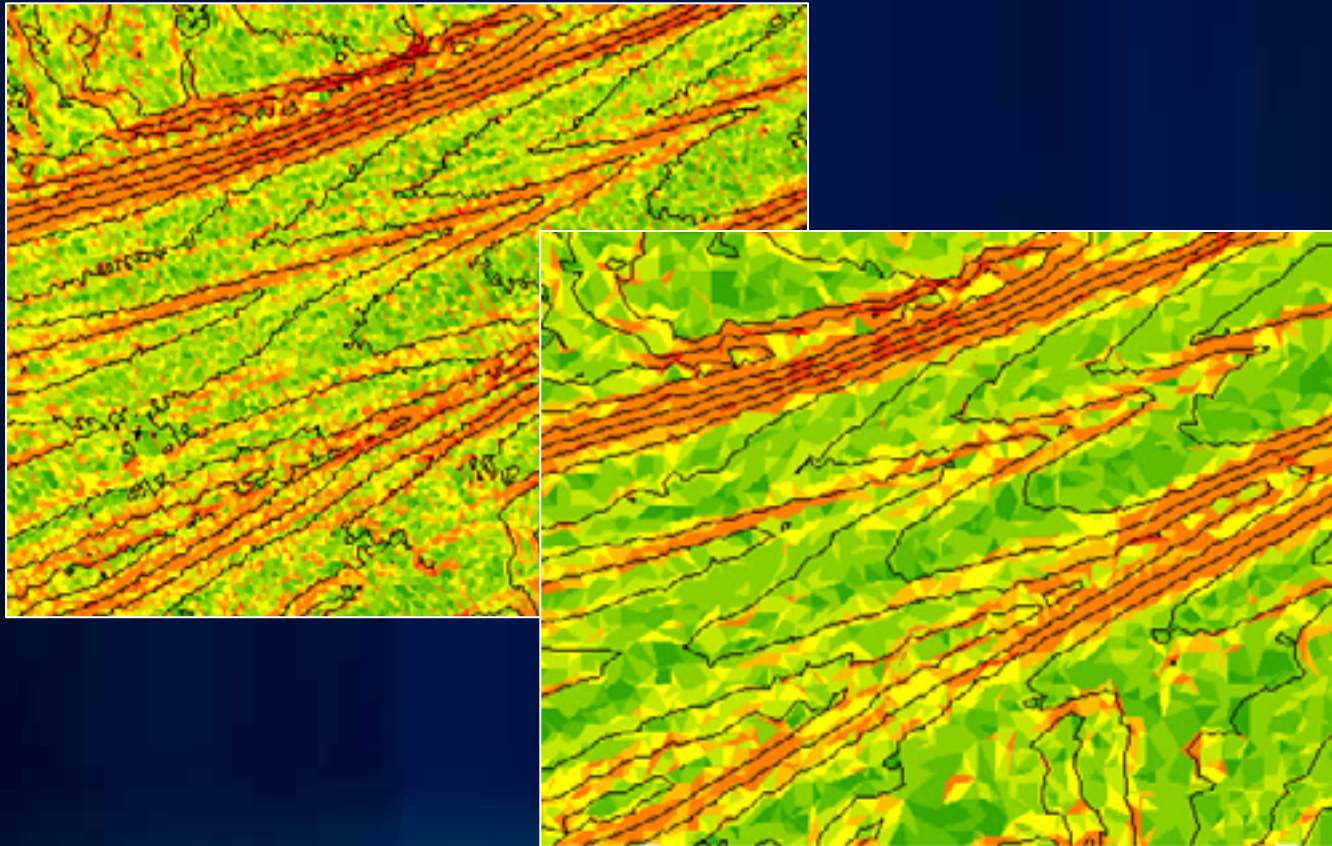


BLOBs are used, in the context of lidar, to store multiple numeric values together in one thing. Each BLOB contains as many values as there are vertices in the corresponding multipoint.

Intensity Image Workflow



Reducing Noise for Contouring and Slope Analysis



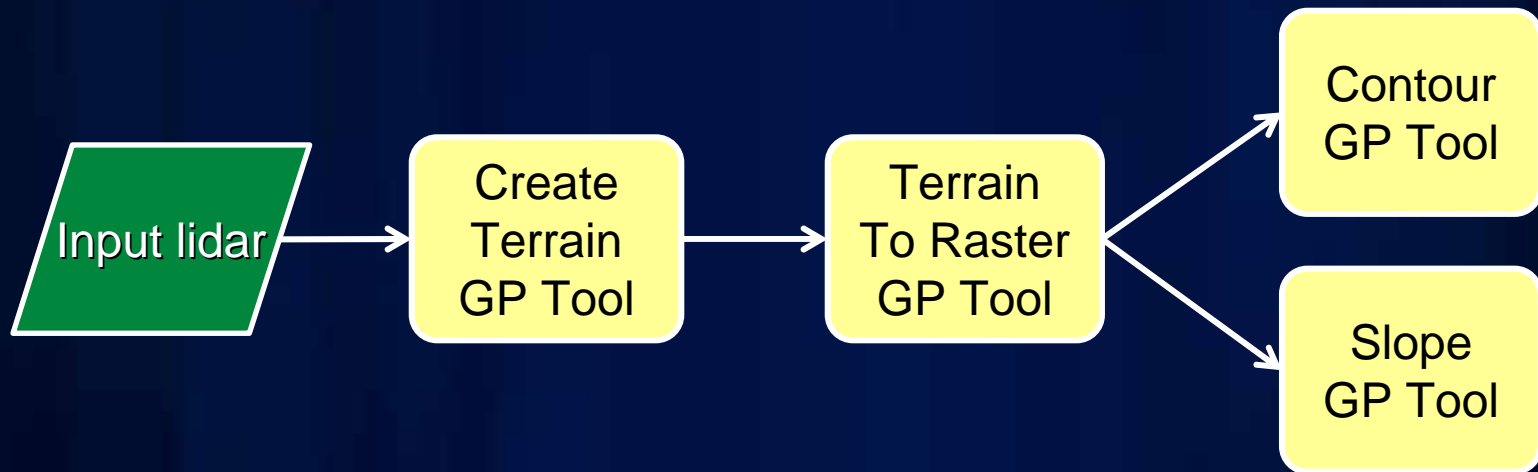
Lidar Is Noisy

- Lidar has measurement error
- Typically 12-15cm vertical accuracy
- Horizontal sample density is often 1m or less
- This results in high frequency noise
 - Extremely messy contours
 - Average slope skewed to be very high
- Goal is to reduce noise without degrading the accuracy

Point Thinning, Interpolation, and Rasterization

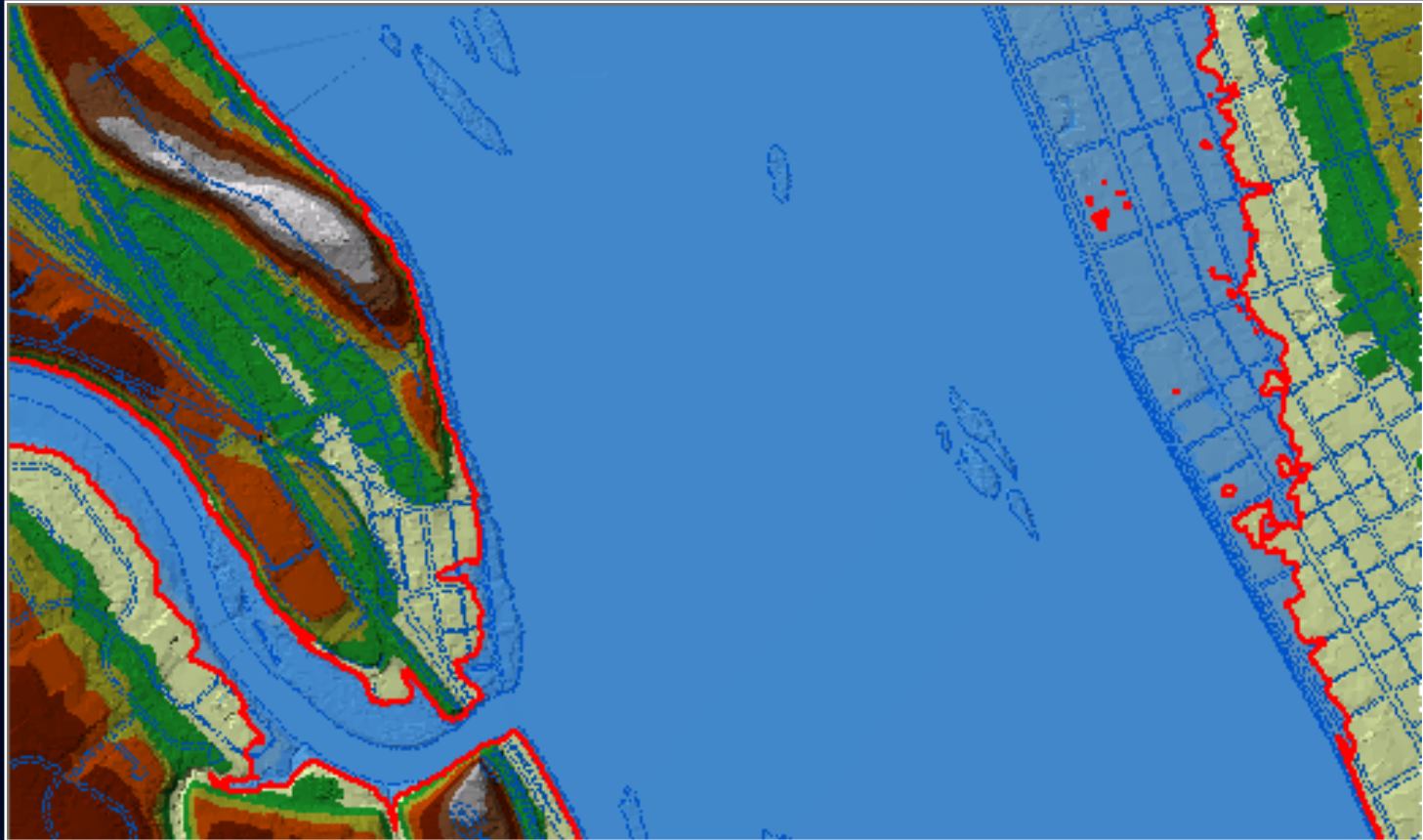
- Use only those points necessary
- Some applications refer to points selected for use in making contours as 'model key' points
- Terrain pyramids
 - Original points filtered into different levels of detail
 - Can specify which pyramid level to use when interpolating to raster or extracting TIN
- Natural neighbors
 - Conservatively smooth

Point Thinning, Interpolation, and Rasterization



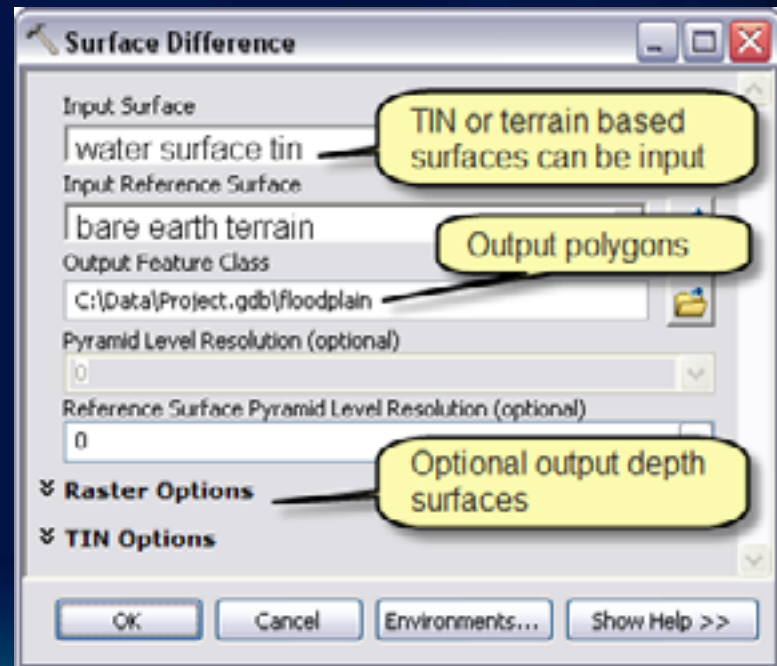
Workflow

Floodplain Delineation



Surface Difference Tool

- Subtract lidar based ground surface from modeled (e.g., HEC-RAS) water surface
- Output polygons used to delineate floodplain
- Optional output of depth surface(s)



Custom models:

<http://proceedings.esri.com/library/userconf/proc11/tech-workshops.html>

In 'Lidar Solutions.zip' containing Geoprocessing toolbox (tbx) file

Questions?

Please provide feedback in this workshop:

www.esri.com/sessionevals





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