Lidar and GIS
Applications and Examples

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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

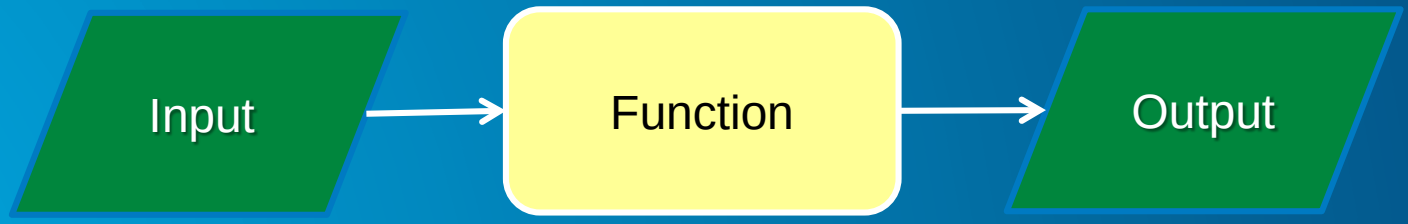
Big Picture

- Solutions for GIS end users
  - Not about lidar data production
- Operate on clean/classified lidar points
- Produce useful derivatives
- Perform analysis
- Handle large datasets
- Both file and database oriented solutions

Supporting Data structures and Tools

- **Vector features**
  - **points**
  - ***multipoints***
  - **lines**
  - **polygons**
- **Raster**
- **TIN**
- ***Terrain Dataset***

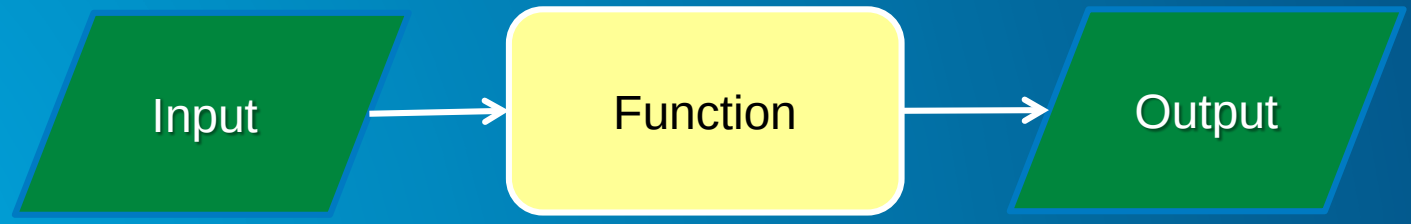
- **Point File Information**
- **LAS To Multipoint**
- **ASCII 3D To Feature Class**
- **Point To Raster**
- **Terrain To Raster**
- **Terrain To TIN**



Workflow

Supporting Data structures and Tools (10.1)

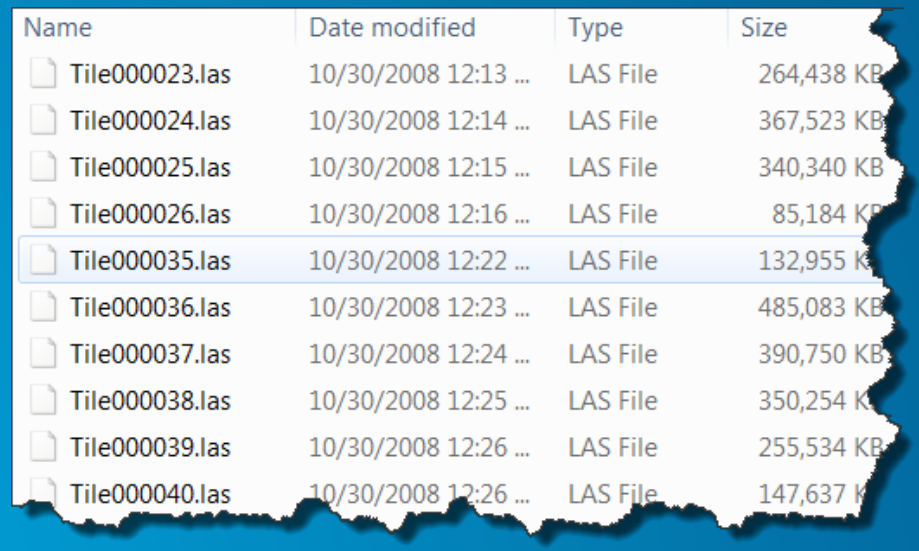
- **LAS dataset**
  - **LAS Dataset Statistics**
  - **LAS Dataset To Raster**
  - **LAS Point Statistics As Raster**
  - **LAS Dataset To TIN**
- **Mosaic dataset**
  - **Extensive collection of raster tools**



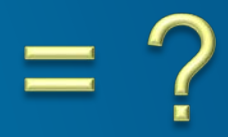
Workflow

Lidar point coverage and sample density

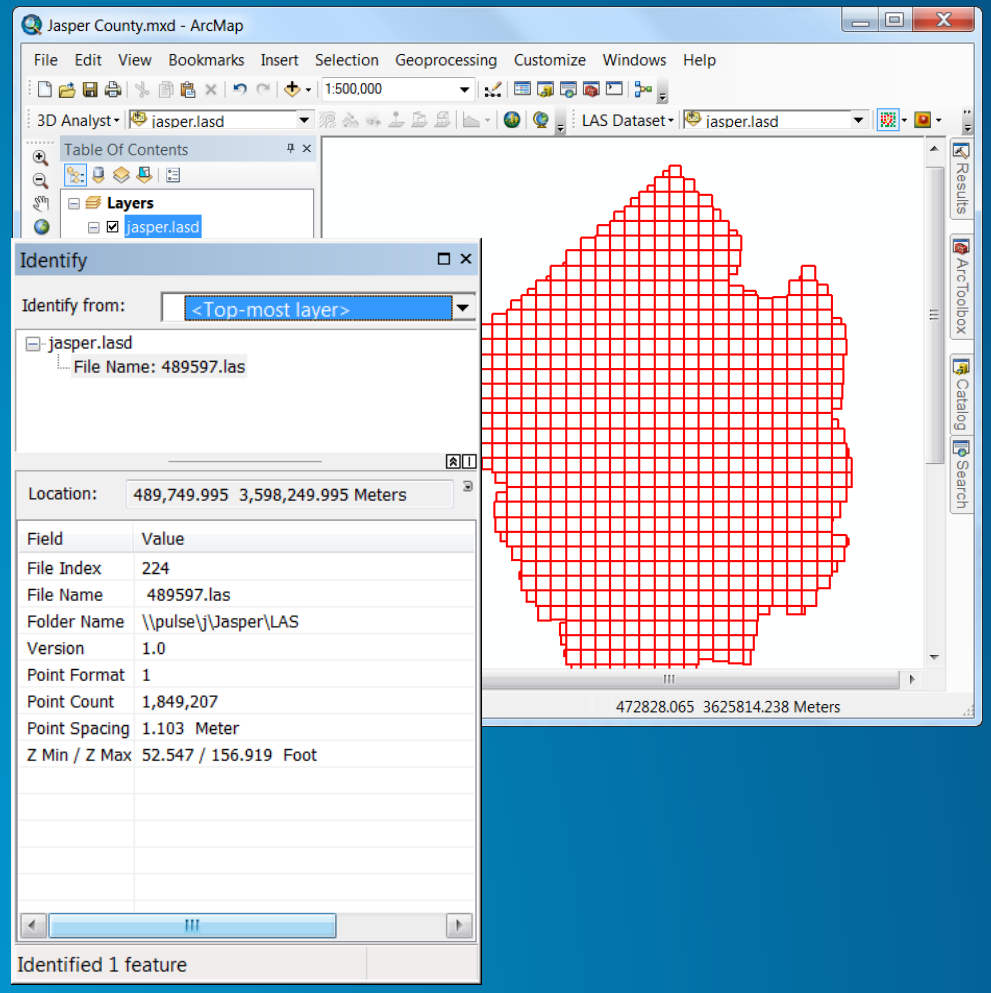
- Basic QA/QC before loading data into geodatabase
- Verify xy and z extent
- Examine point spacing



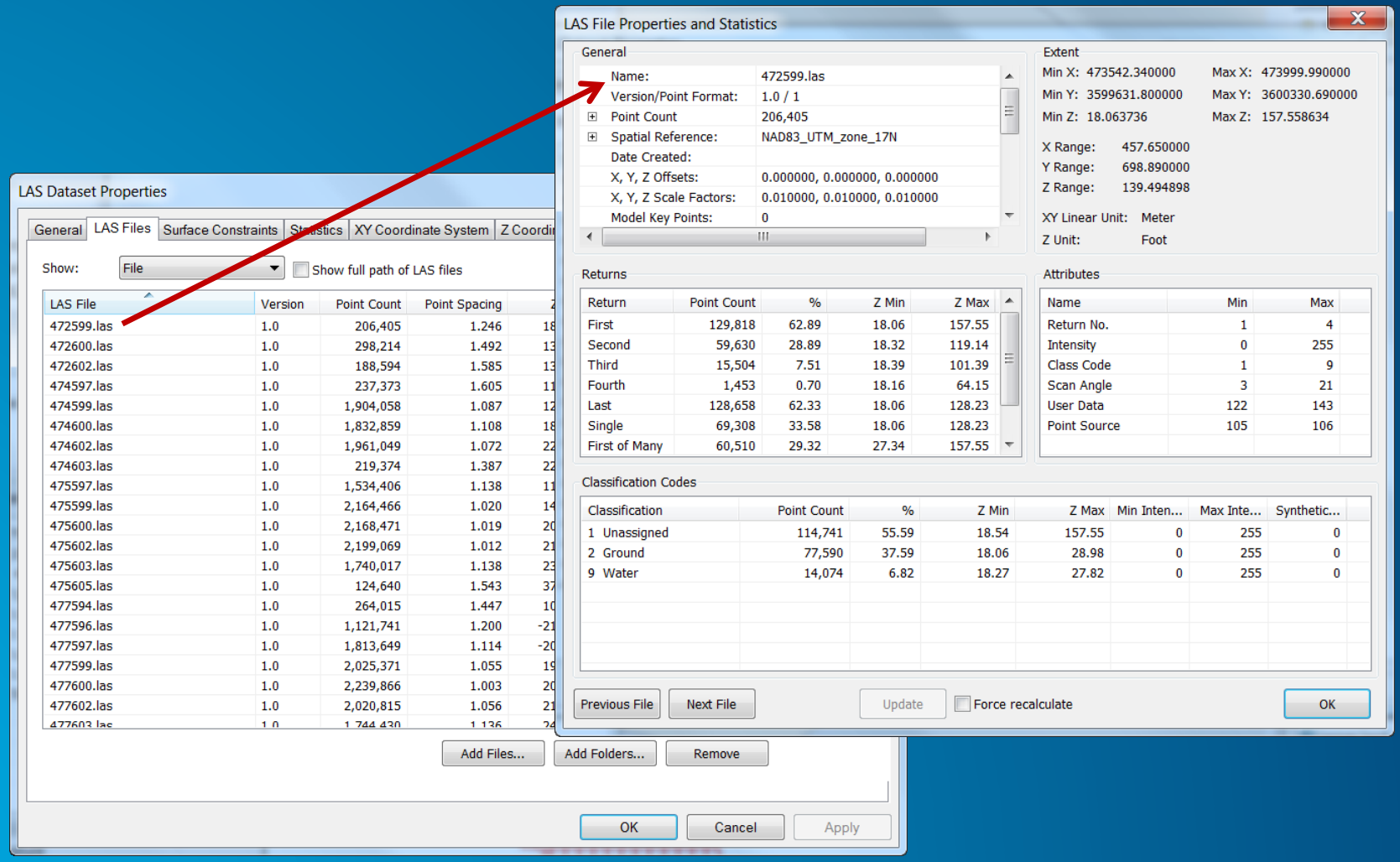
Name	Date modified	Type	Size
Tile000023.las	10/30/2008 12:13 ...	LAS File	264,438 KB
Tile000024.las	10/30/2008 12:14 ...	LAS File	367,523 KB
Tile000025.las	10/30/2008 12:15 ...	LAS File	340,340 KB
Tile000026.las	10/30/2008 12:16 ...	LAS File	85,184 KB
Tile000035.las	10/30/2008 12:22 ...	LAS File	132,955 KB
Tile000036.las	10/30/2008 12:23 ...	LAS File	485,083 KB
Tile000037.las	10/30/2008 12:24 ...	LAS File	390,750 KB
Tile000038.las	10/30/2008 12:25 ...	LAS File	350,254 KB
Tile000039.las	10/30/2008 12:26 ...	LAS File	255,534 KB
Tile000040.las	10/30/2008 12:26 ...	LAS File	147,637 KB



LAS Dataset Layer (10.1)

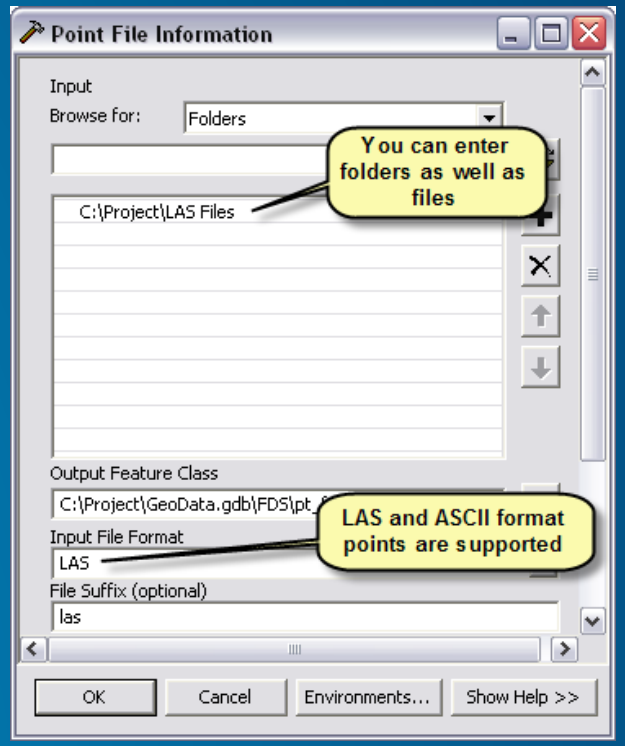


LAS Dataset Properties (10.1)

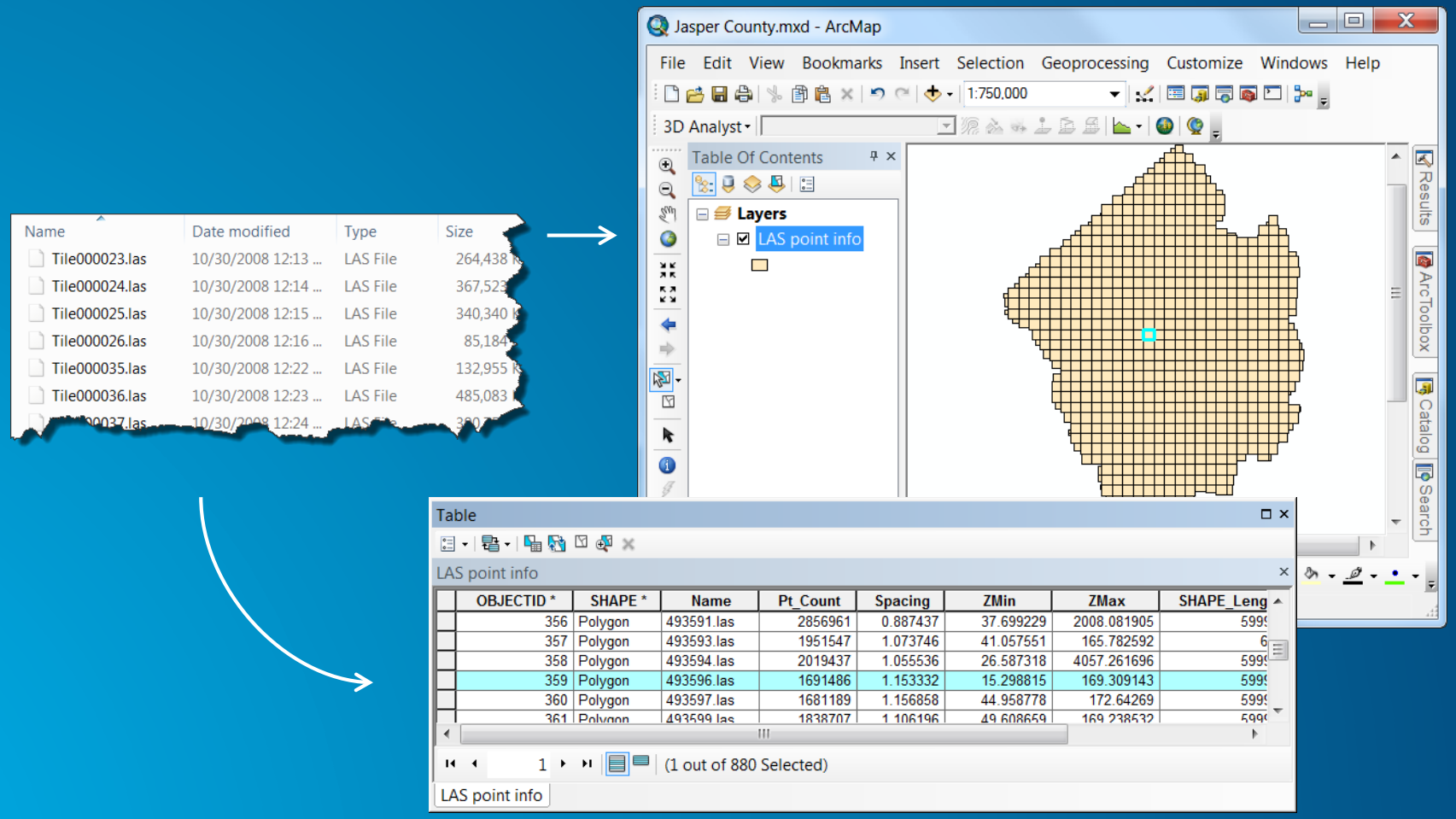


Point File Information Tool

- 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

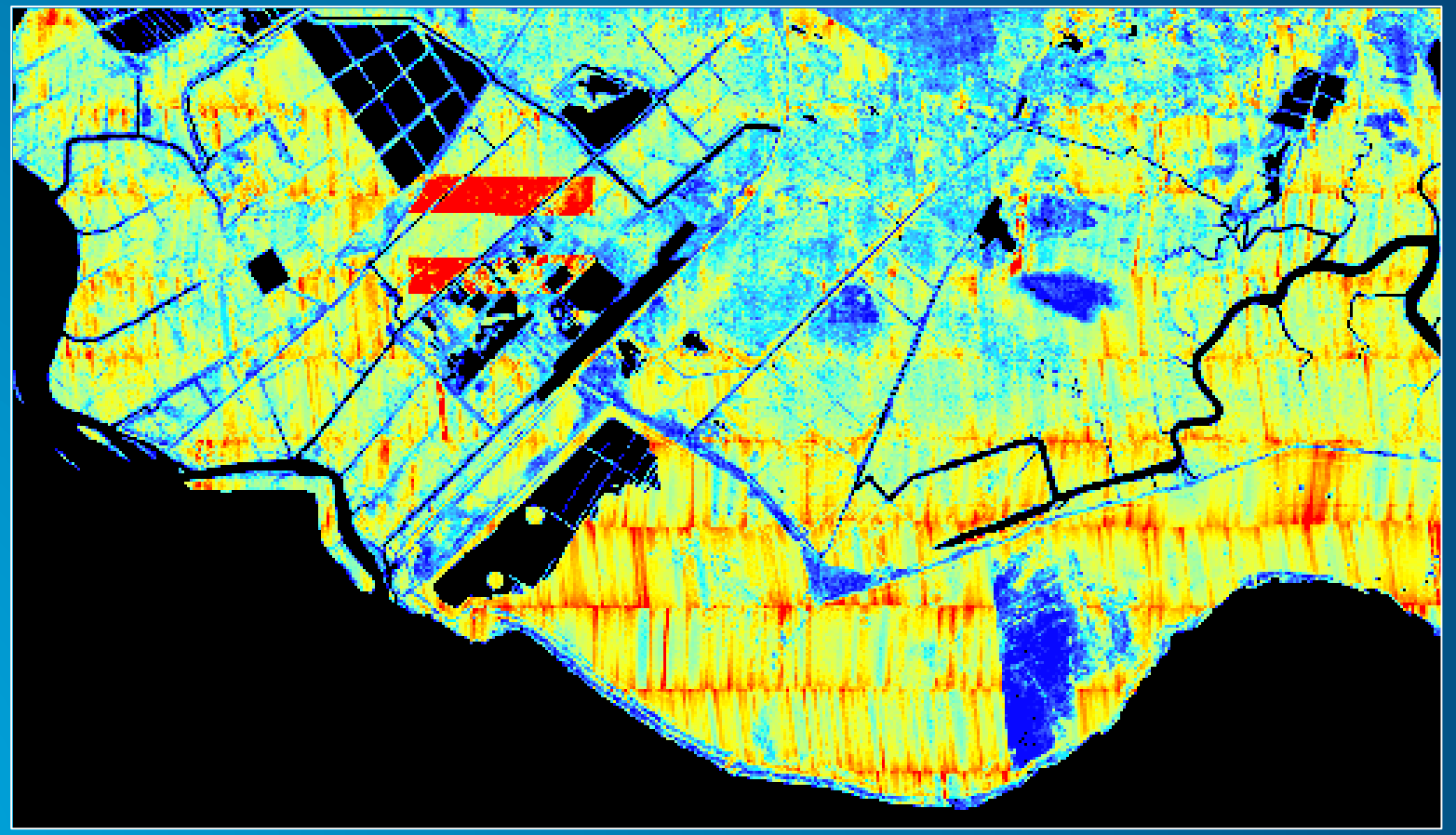


Point File Information Tool



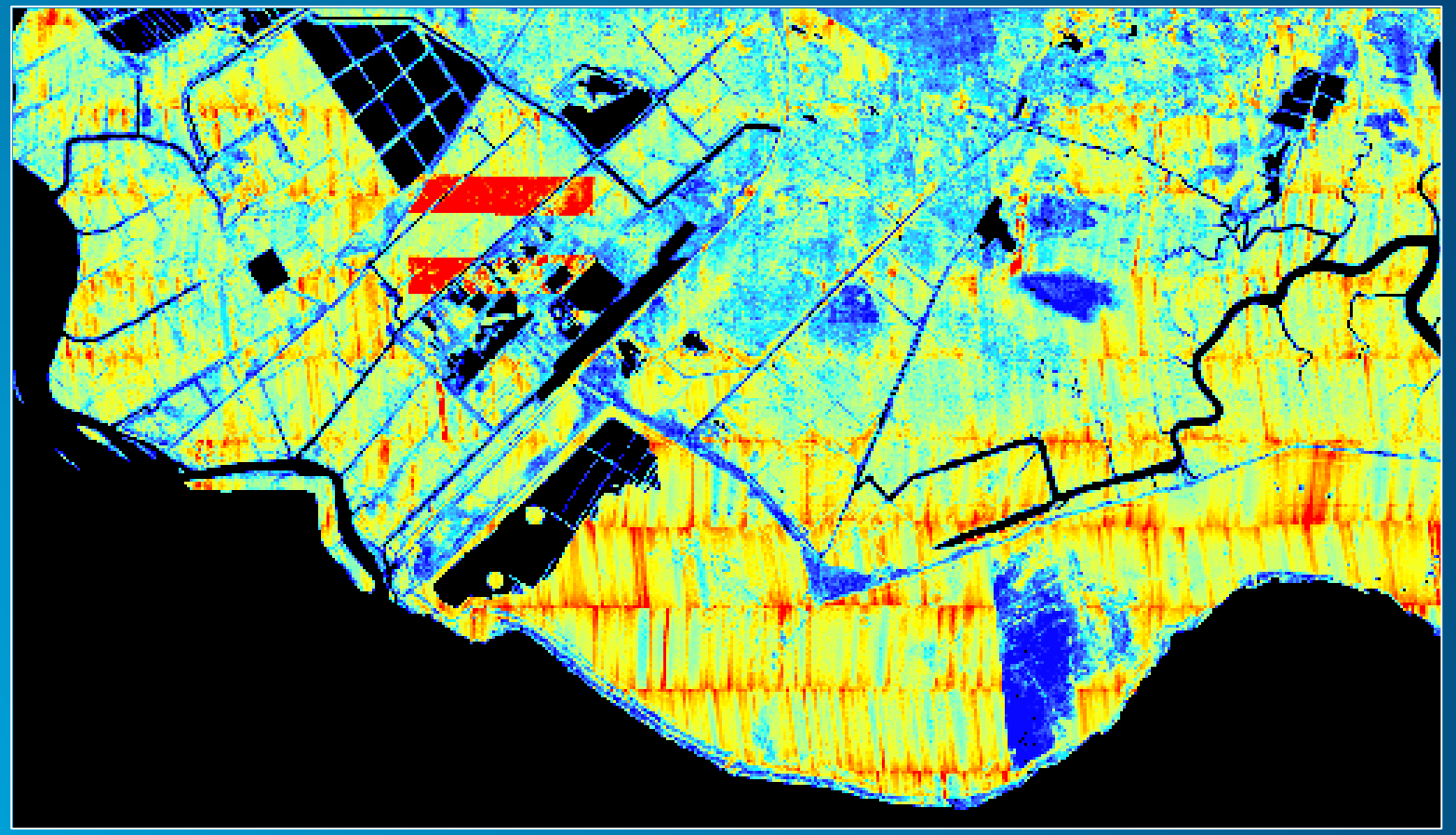
LAS Point Statistics As Raster Tool (10.1)

Pulse/sample density



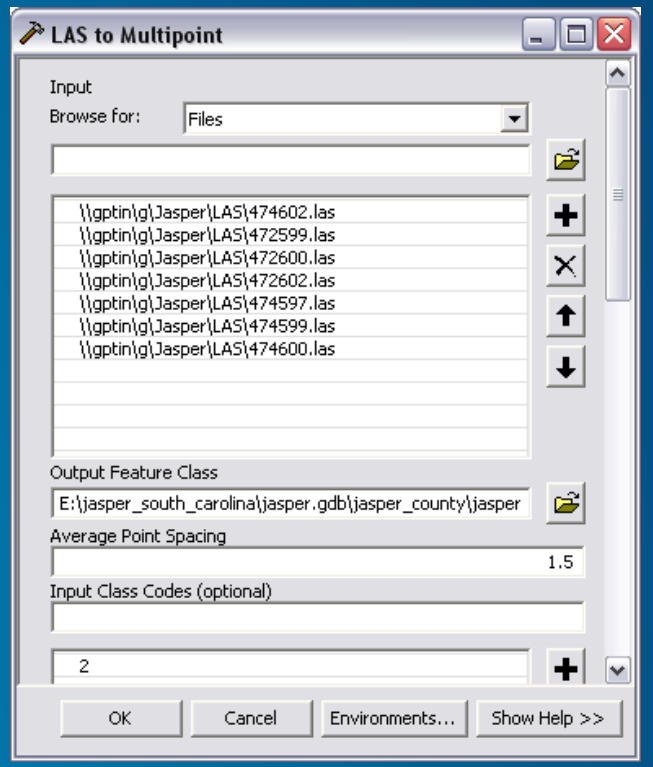
Point To Raster Tool

Pulse/sample density



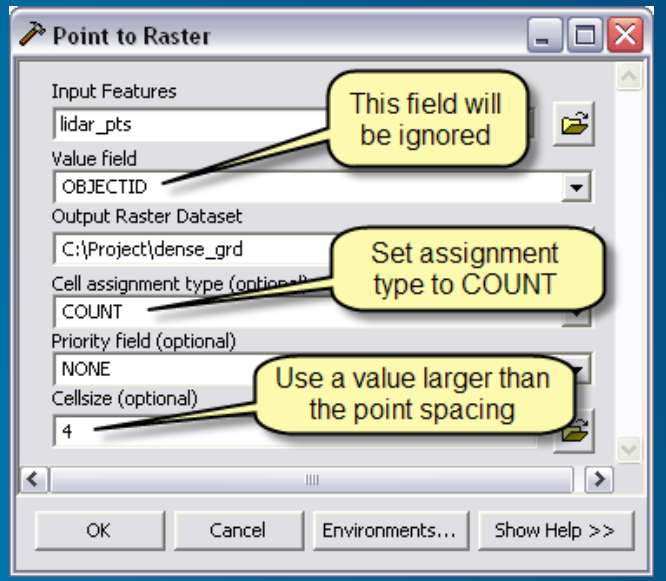
Loading Data: LAS To Multipoint Tool

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



Point to Raster Tool

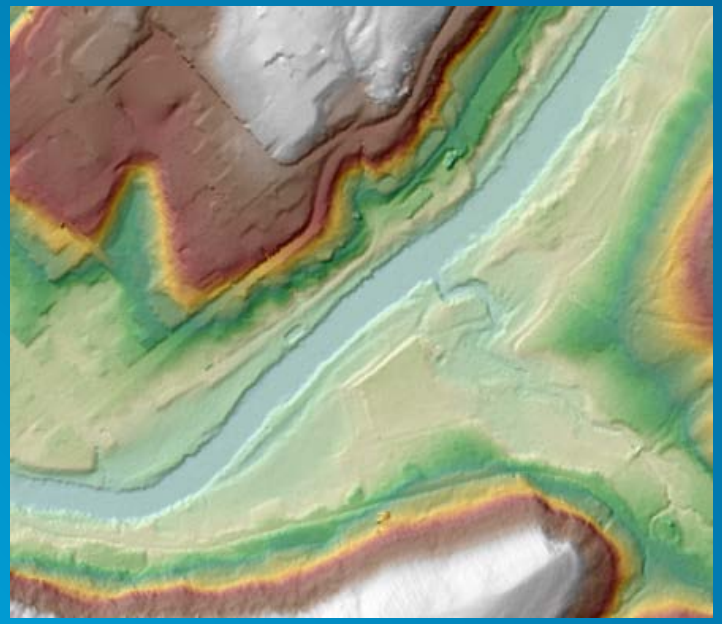
- Used after points are loaded into geodatabase
- More detailed assessment than Point File Information
- Based on actual points loaded (i.e., filtered by class code or return) rather summary of entire file.



Demo

Creating Raster DEMs and DSMs

Digital Elevation Model



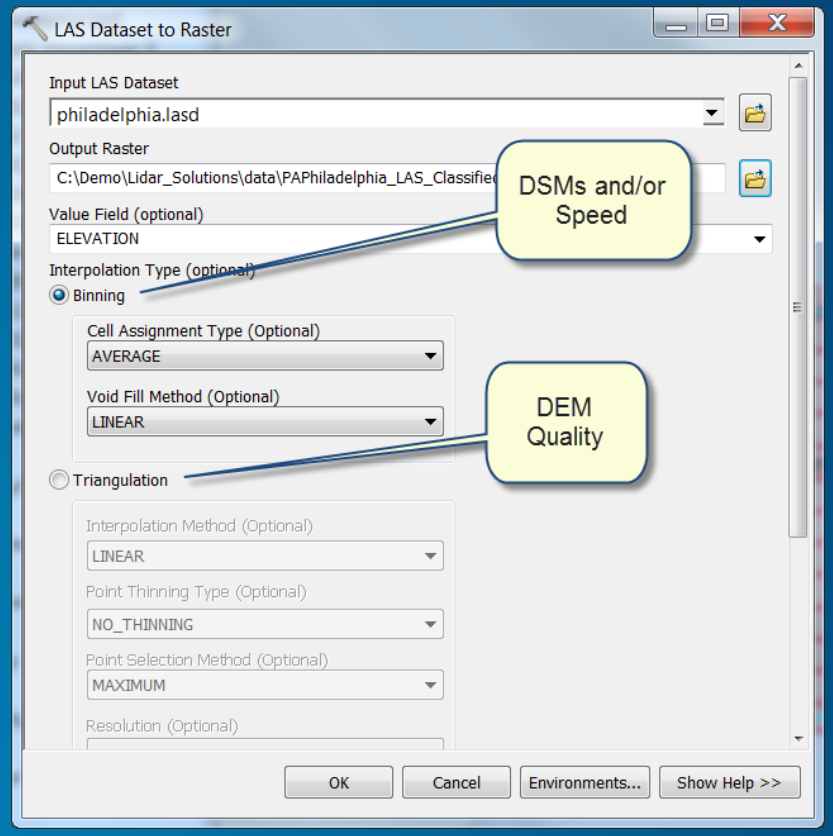
Bare earth surface made using only ground hits.

Digital Surface Model

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

LAS Dataset To Raster (10.1)

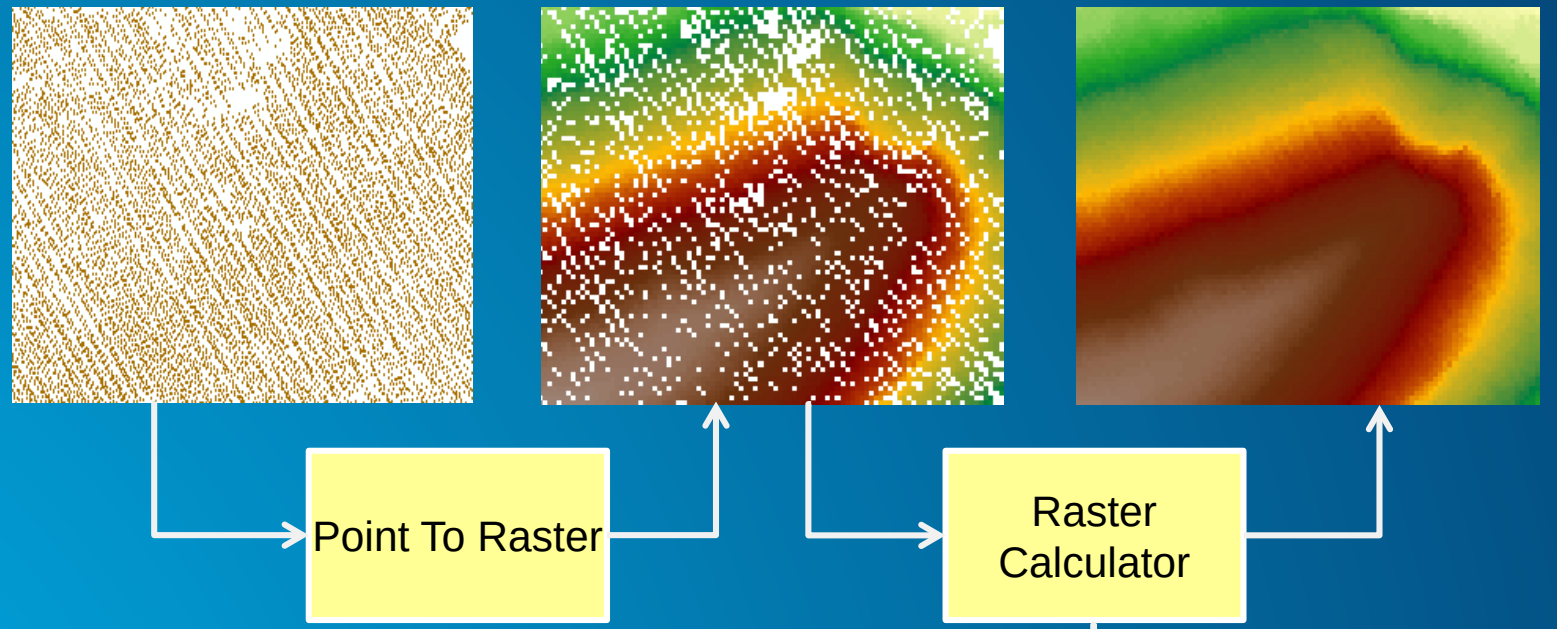
- **Binning**
  - **Fast**
  - **Reasonable for DSMs**
  - **Void filling options**
  - **Honors replace and clip constraint types**
- **Triangulation**
  - **True interpolation**
  - **Always fills voids**
  - **Appropriate for DEMs**
  - **Honors all constraint types**



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



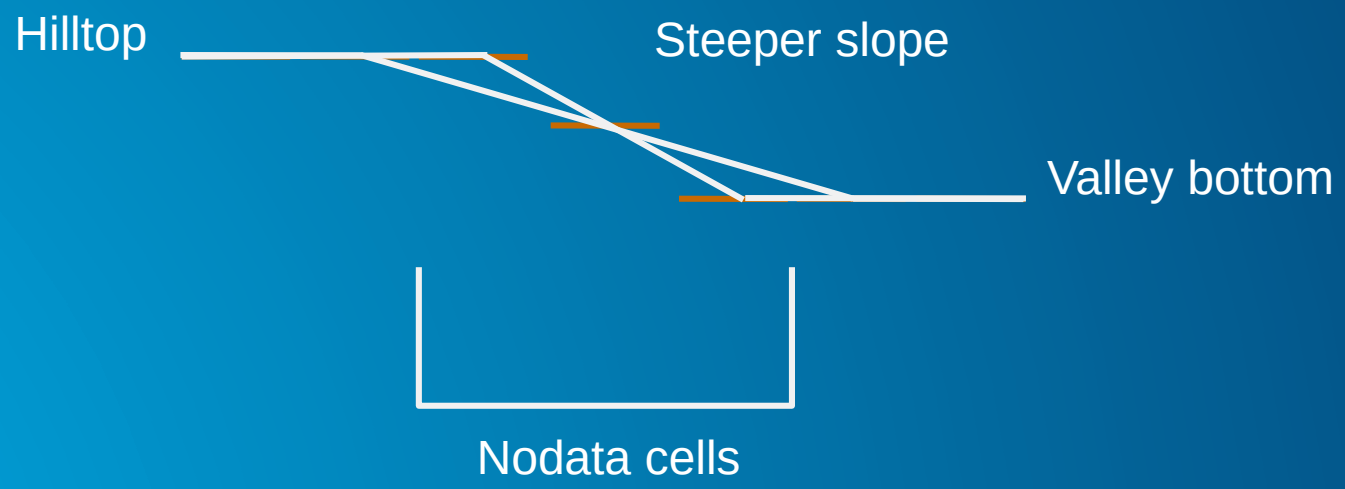
Con(IsNull("pt2ras"), FocalStatistics(“pt2ras", NbrRectangle(3, 3, "CELL"), "MEAN", "DATA"), "pt2ras") 10.0

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

9.3

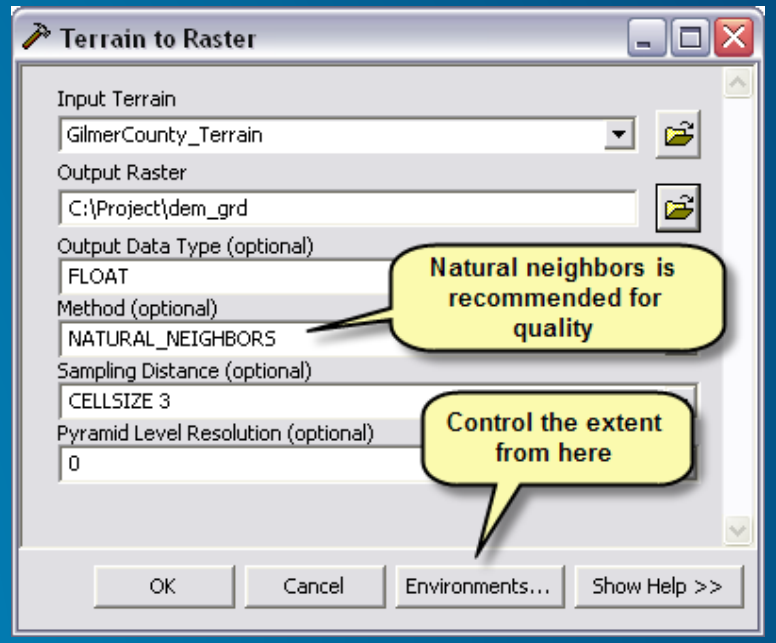
Don’t Abuse Con

- **Introduces anomalies if used repeatedly**



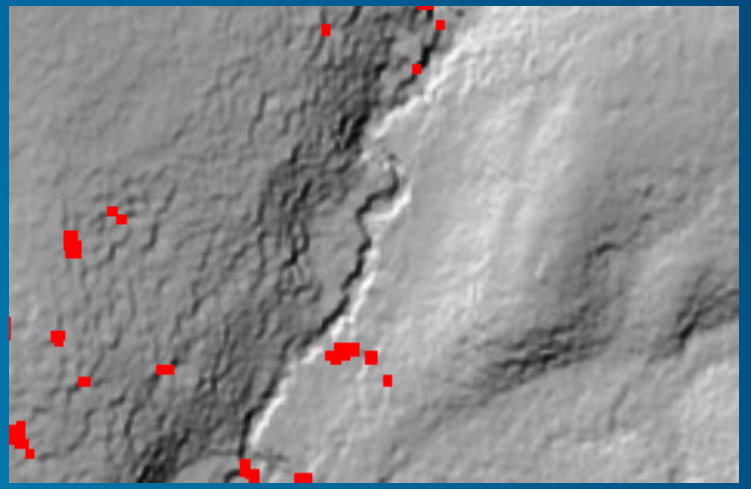
Terrain to Raster

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



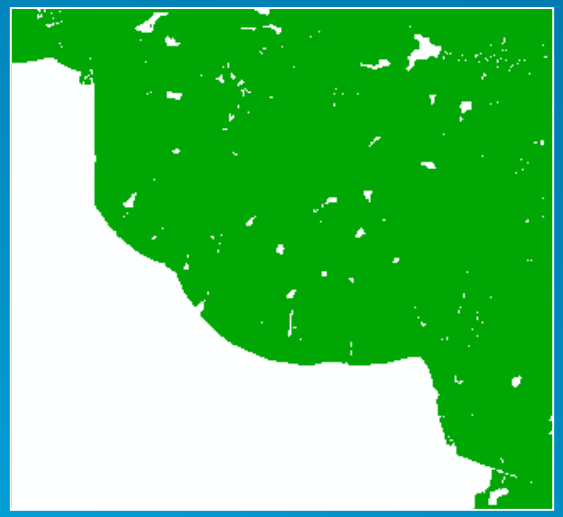
Comparison

Interpolation

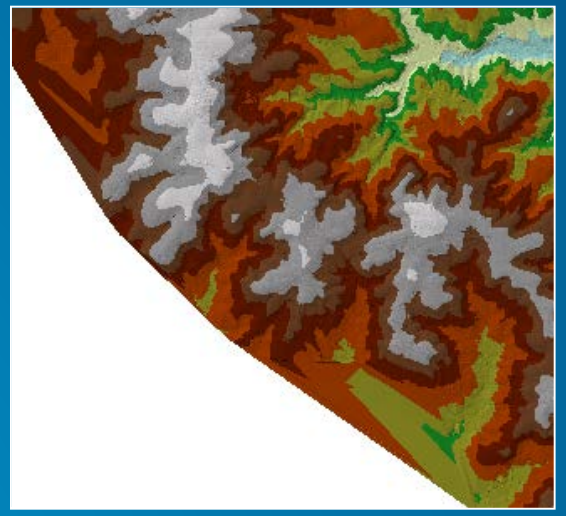


Binning

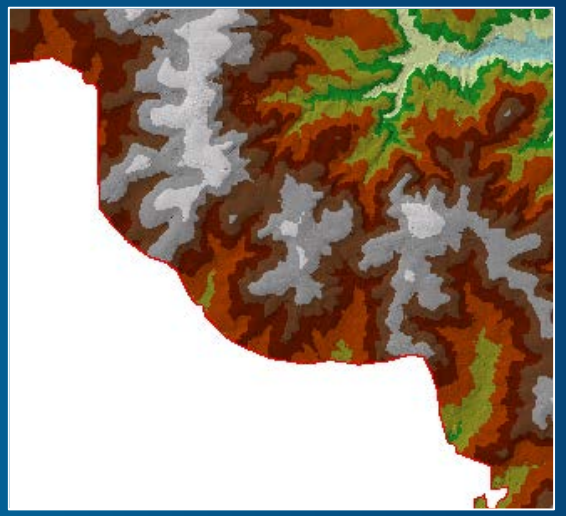
Data Area Delineation



Dense collection of source measurement points (green)

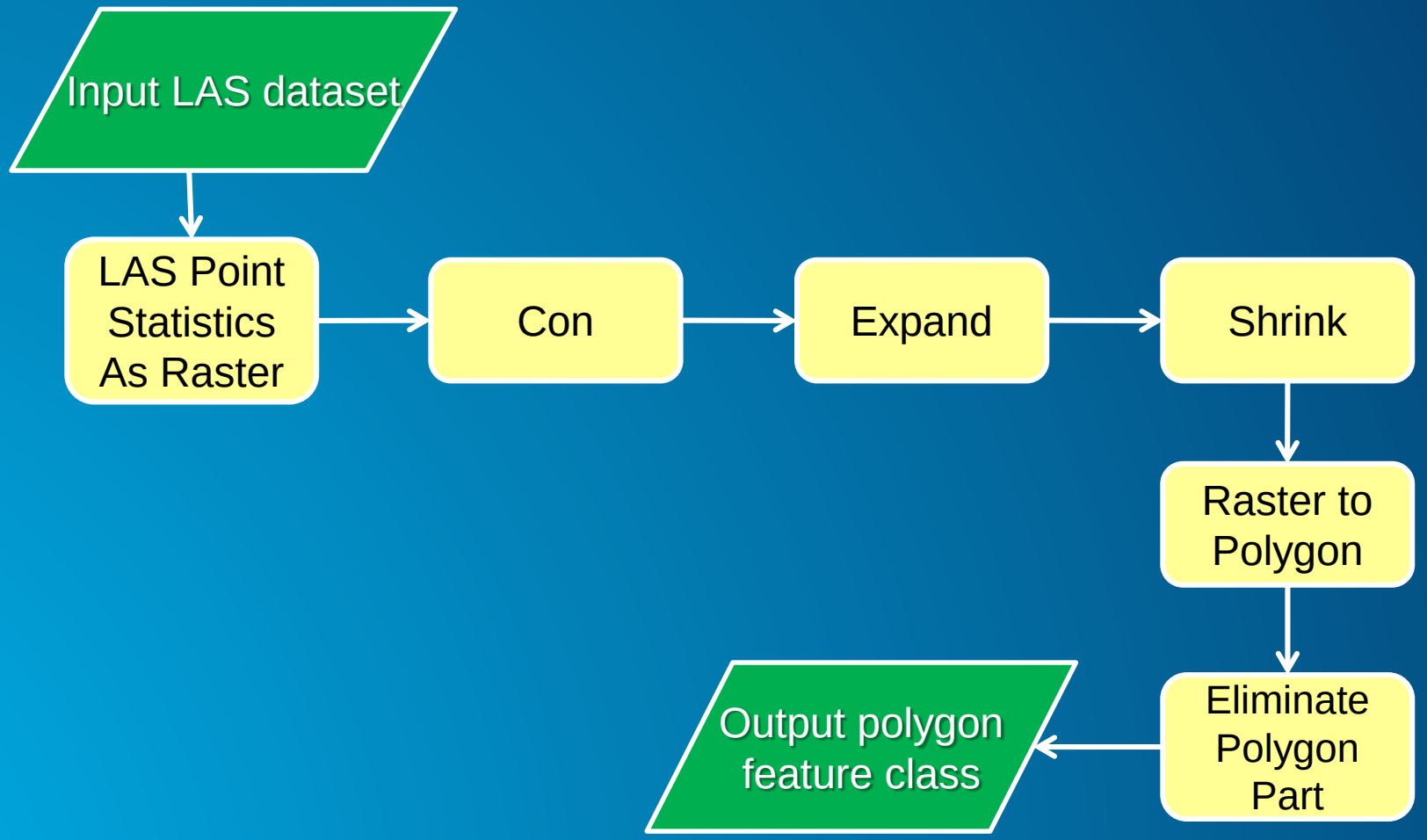


Triangulation of those points without a boundary constraint

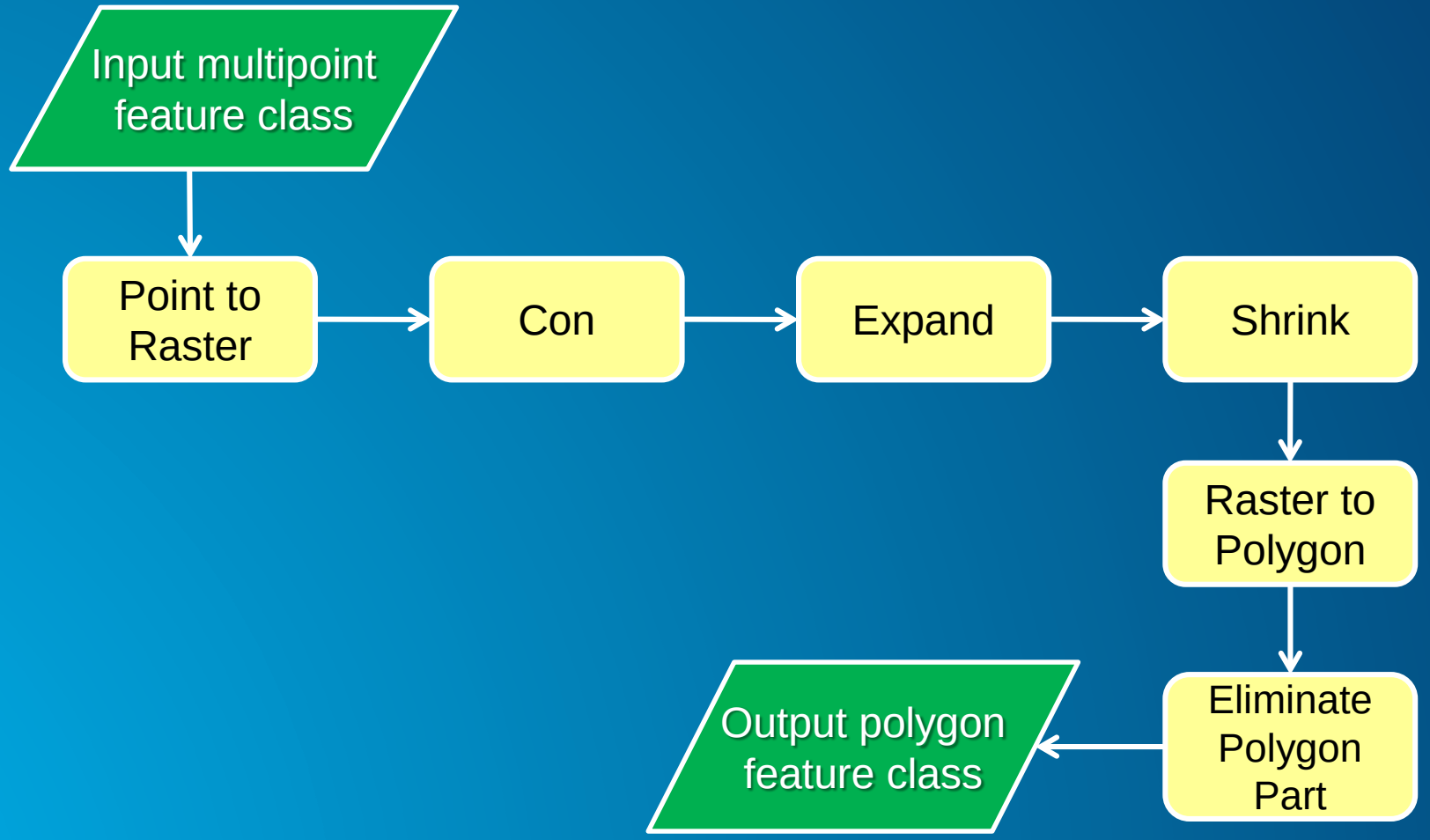


Constraint applied

Workflow to Calculate a Data Area Polygon (10.1)

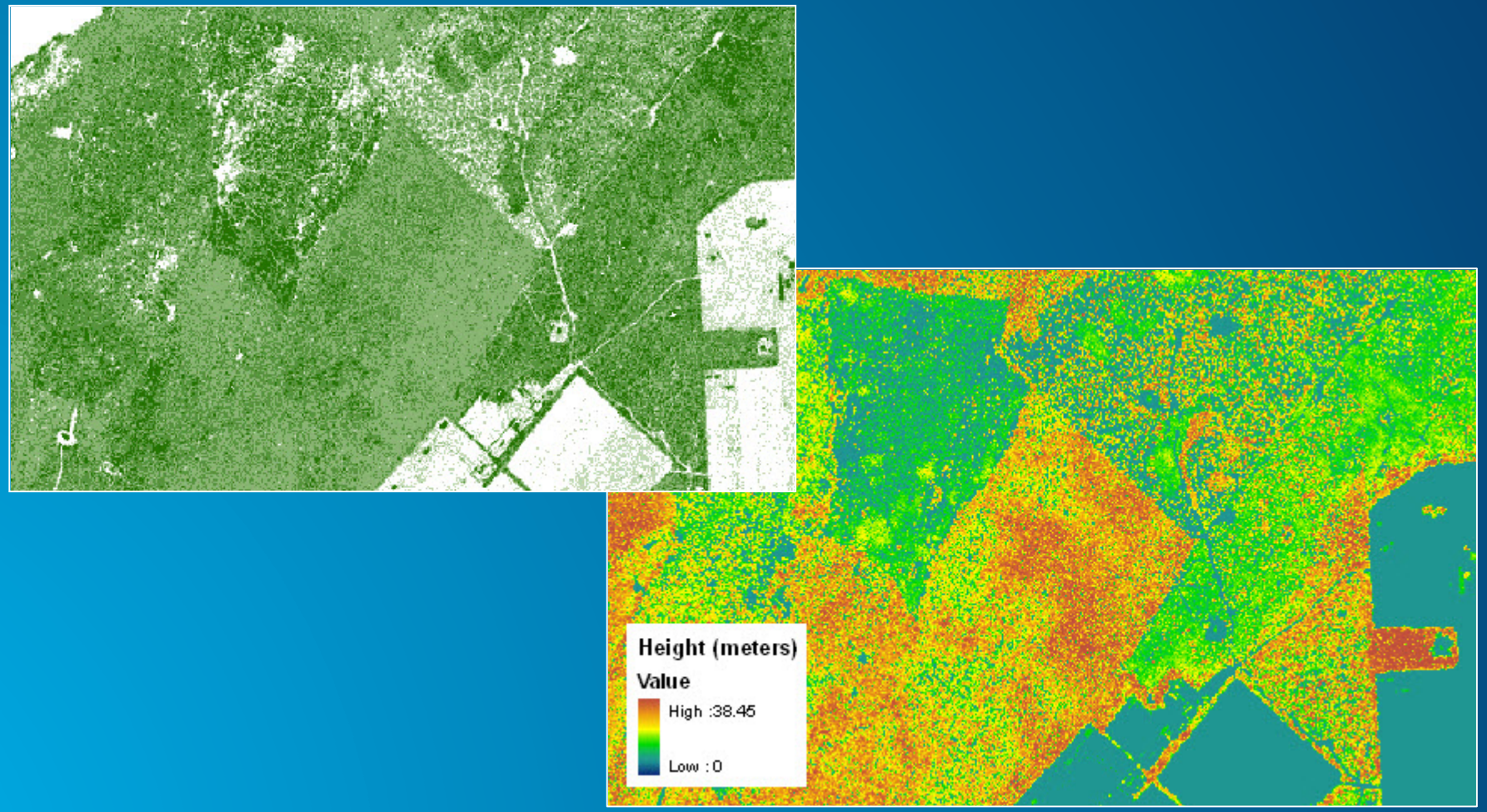


Workflow to Calculate a Data Area Polygon



Demo

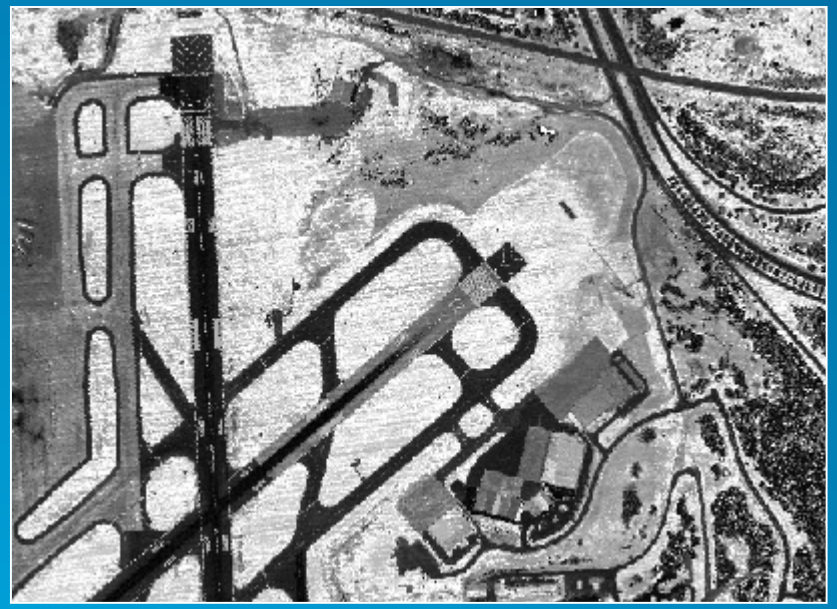
Estimating Forest Canopy Density and Height



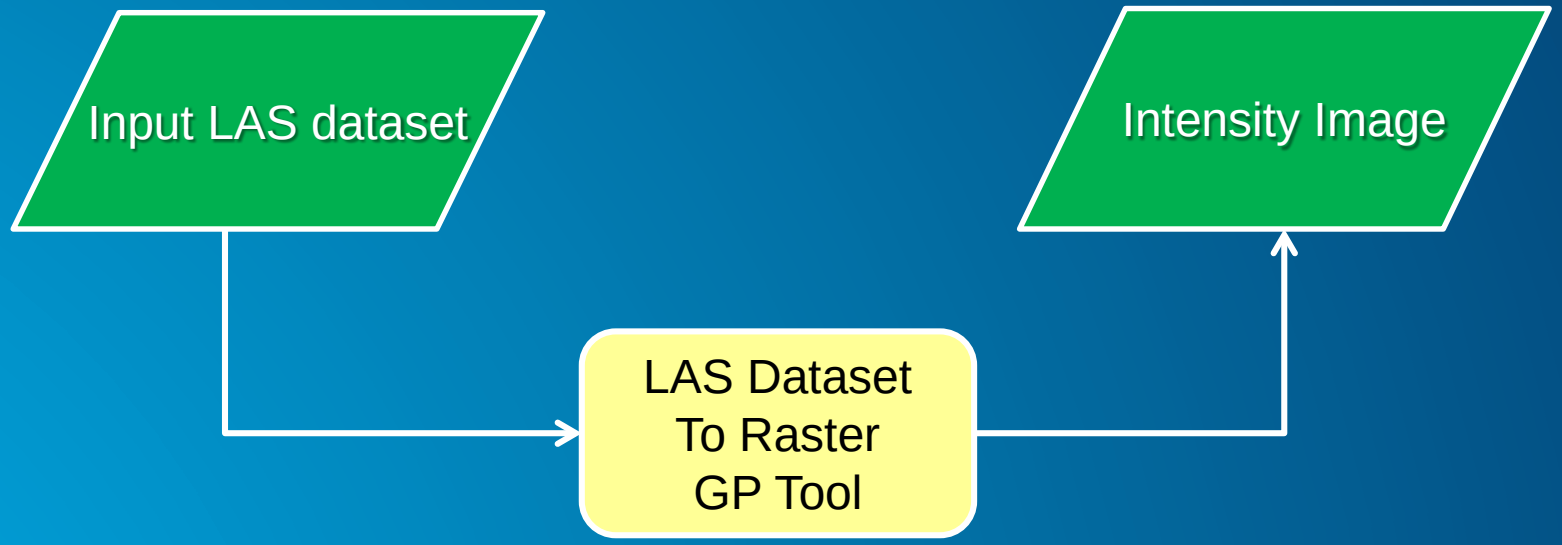
Canopy Density and Height

- 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.
  - 10.1 or later can use LAS Point Statistics As 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.

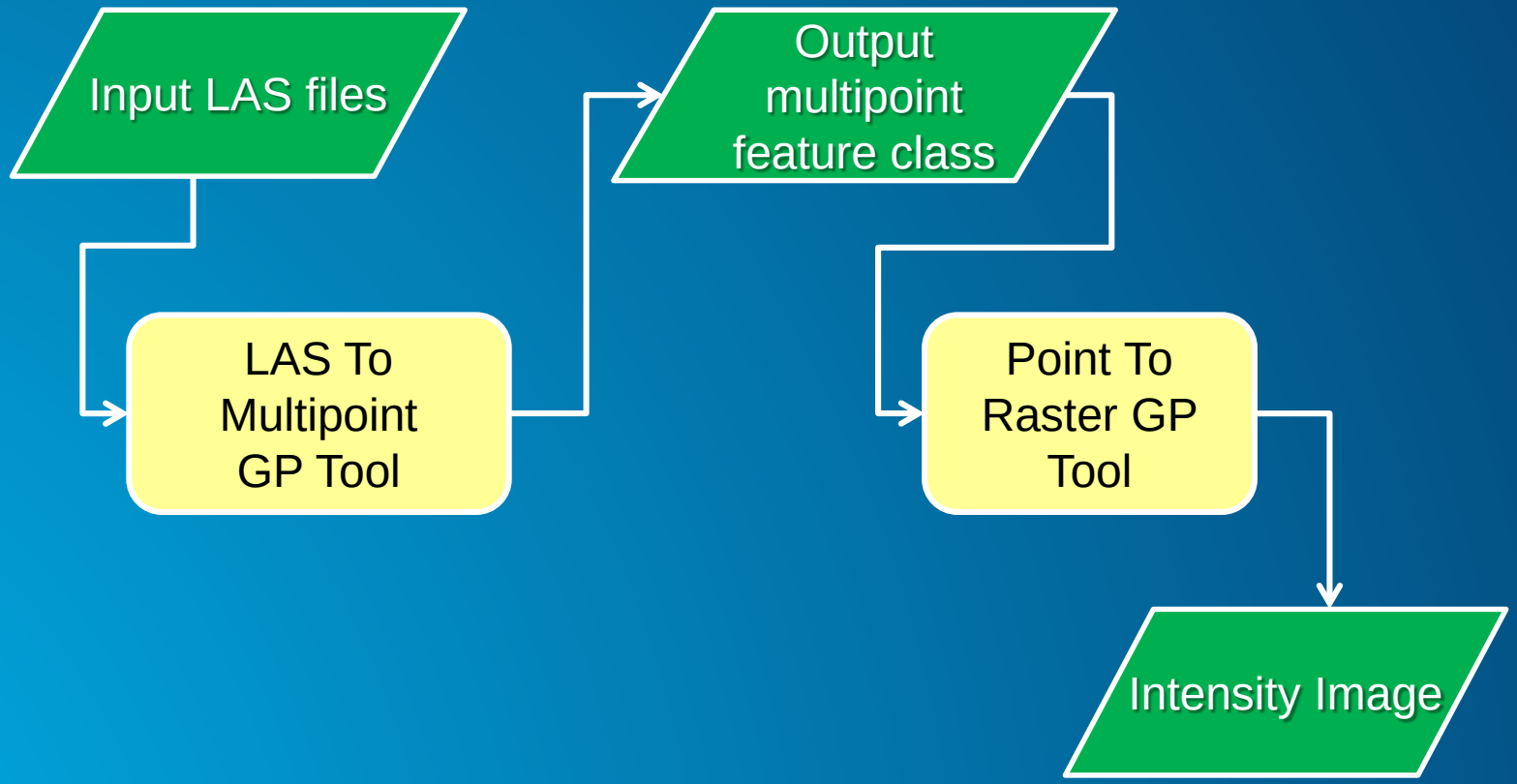
Creating Intensity Images



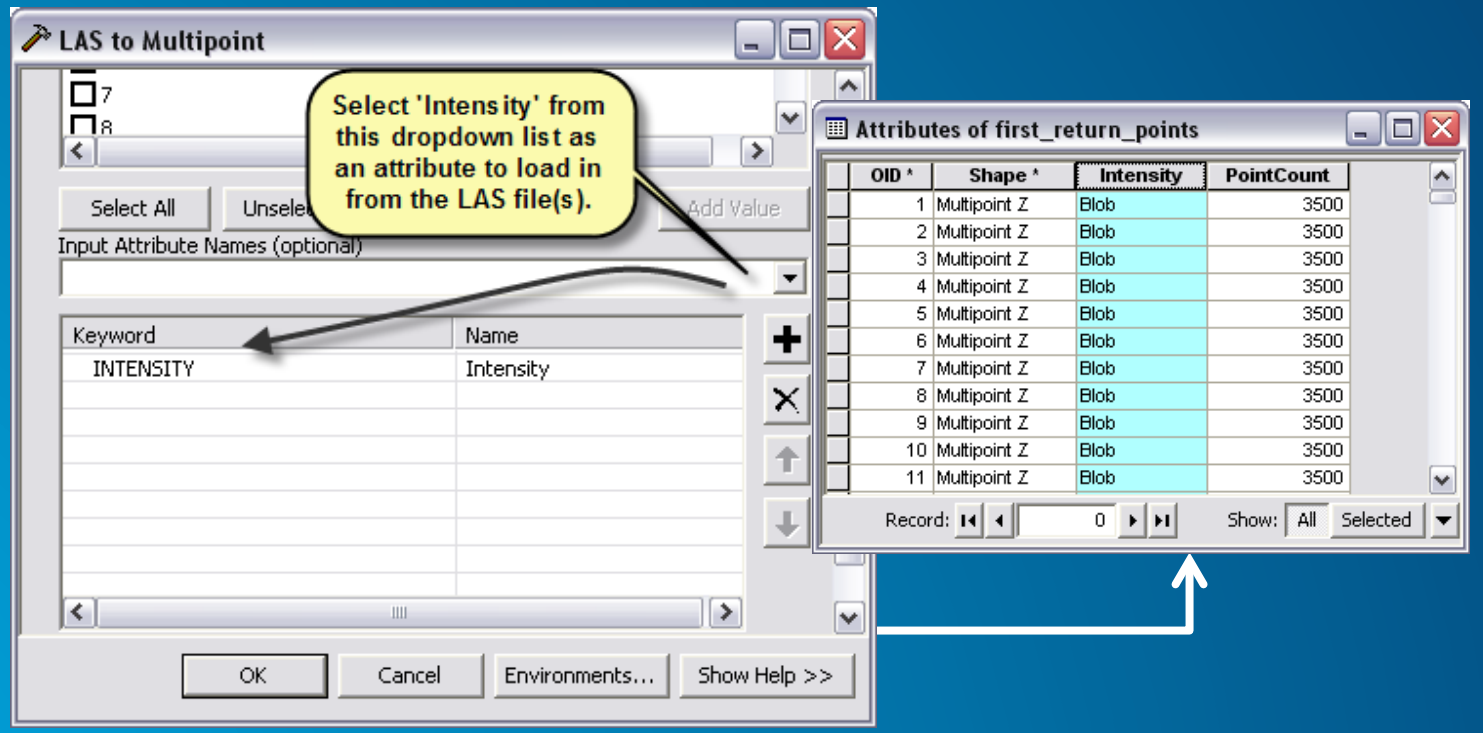
Intensity Image Workflow (10.1)



Intensity Image Workflow

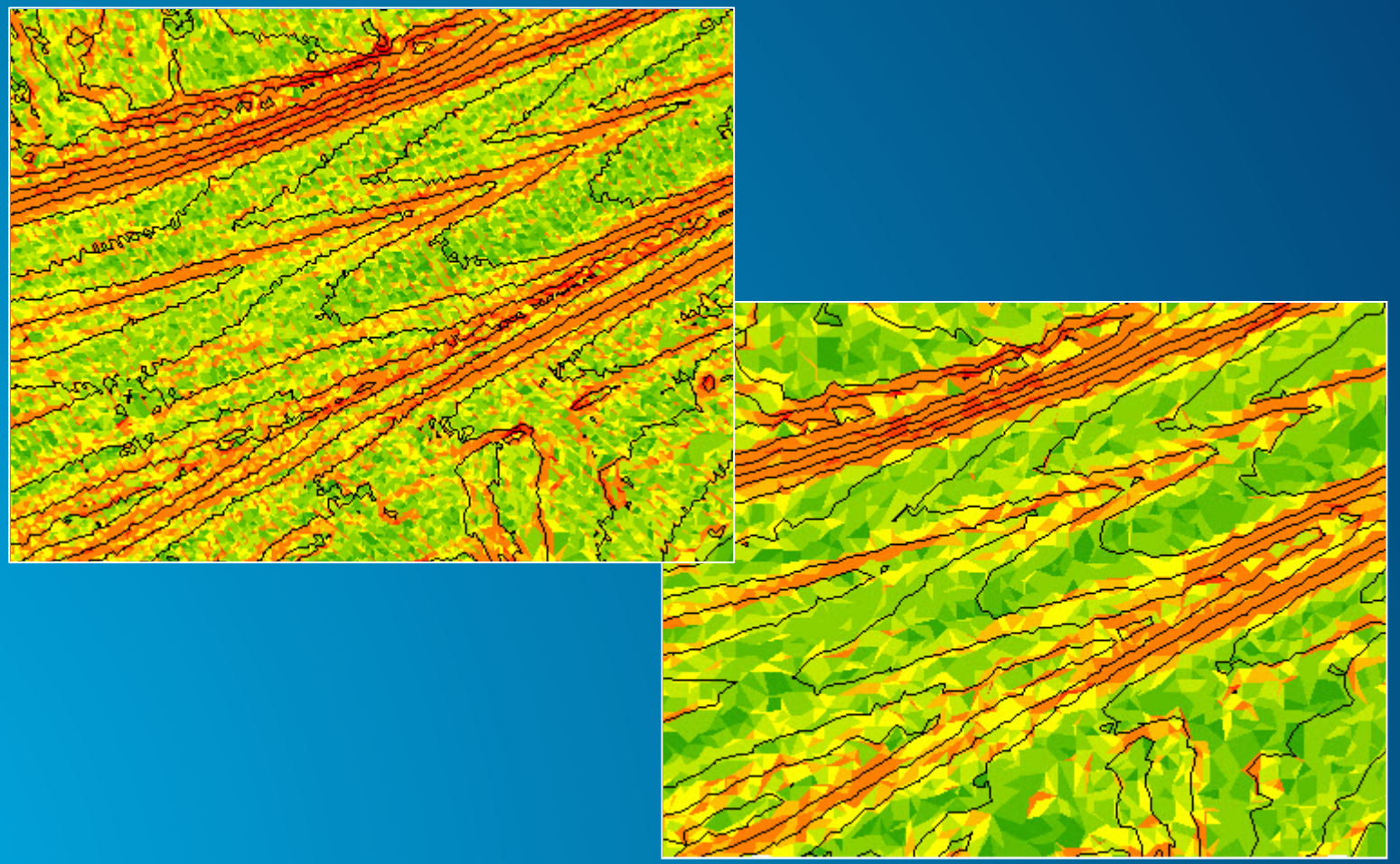


BLOB Based Storage of Intensity



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.

Reducing Noise for Contouring and Slope Analysis



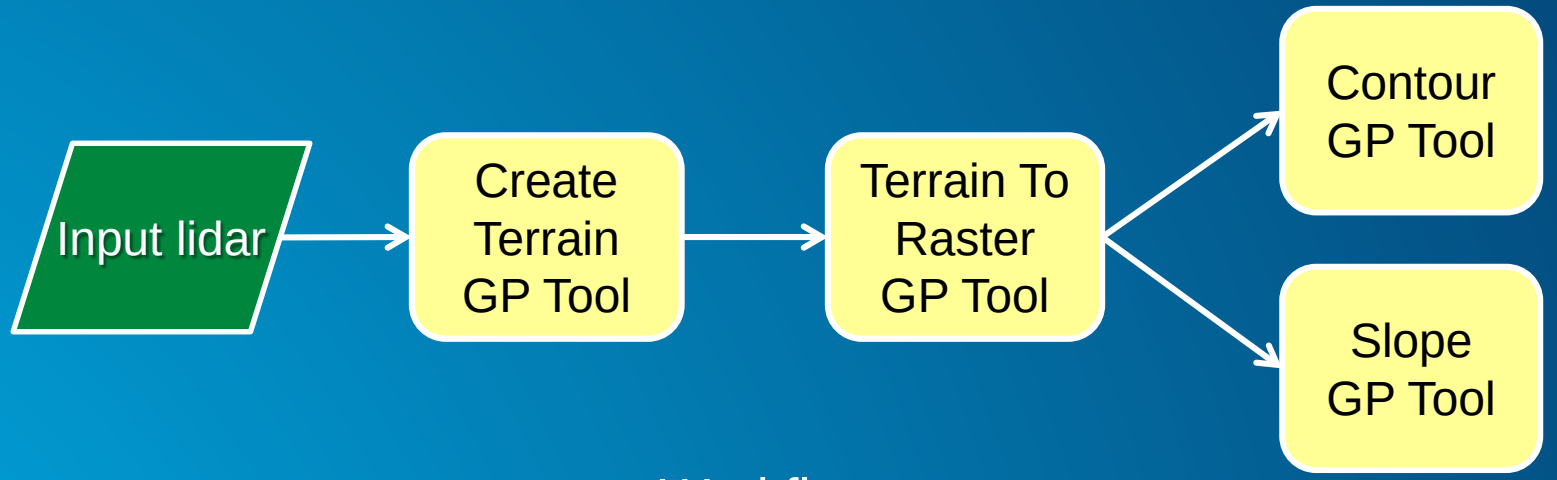
Lidar Is Noisy

- 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

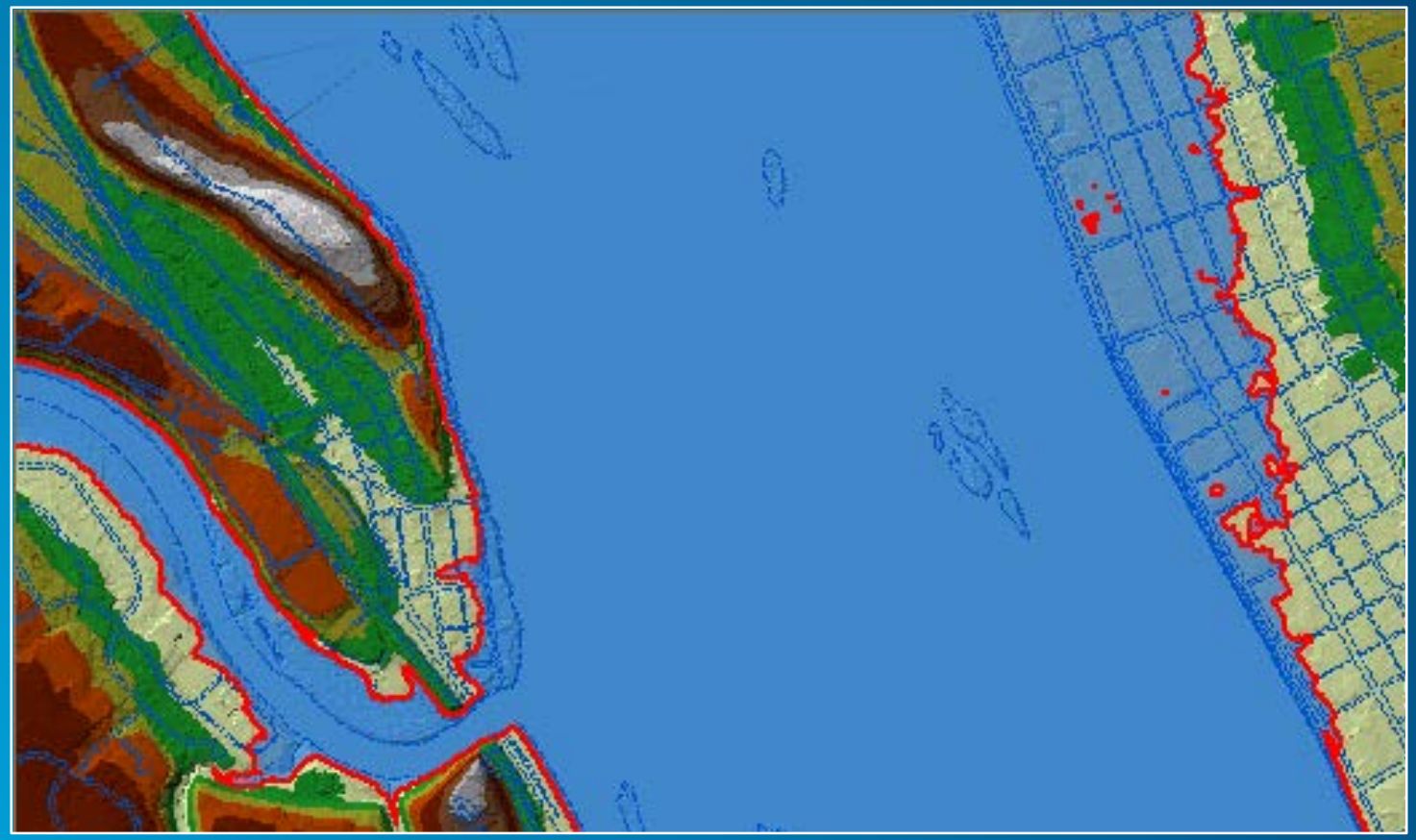
- Use only those points necessary
- Some applications refer to points selected for use in making contours as ‘model key’ points
- Terrain pyramids
  - Original points filtered into different levels of detail
  - Can specify which pyramid level to use when interpolating to raster or extracting TIN
- Natural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

Point Thinning, Interpolation, and Rasterization



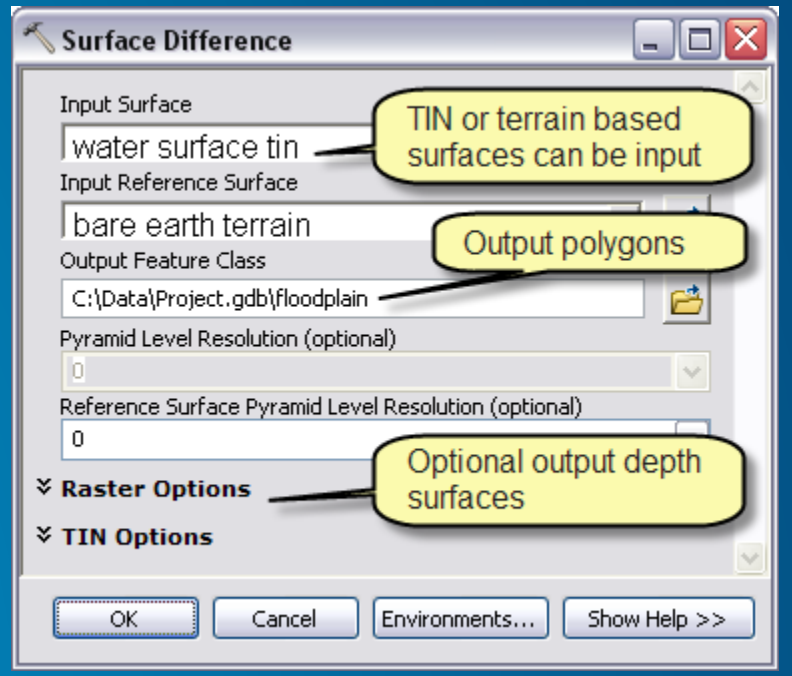
Workflow

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)



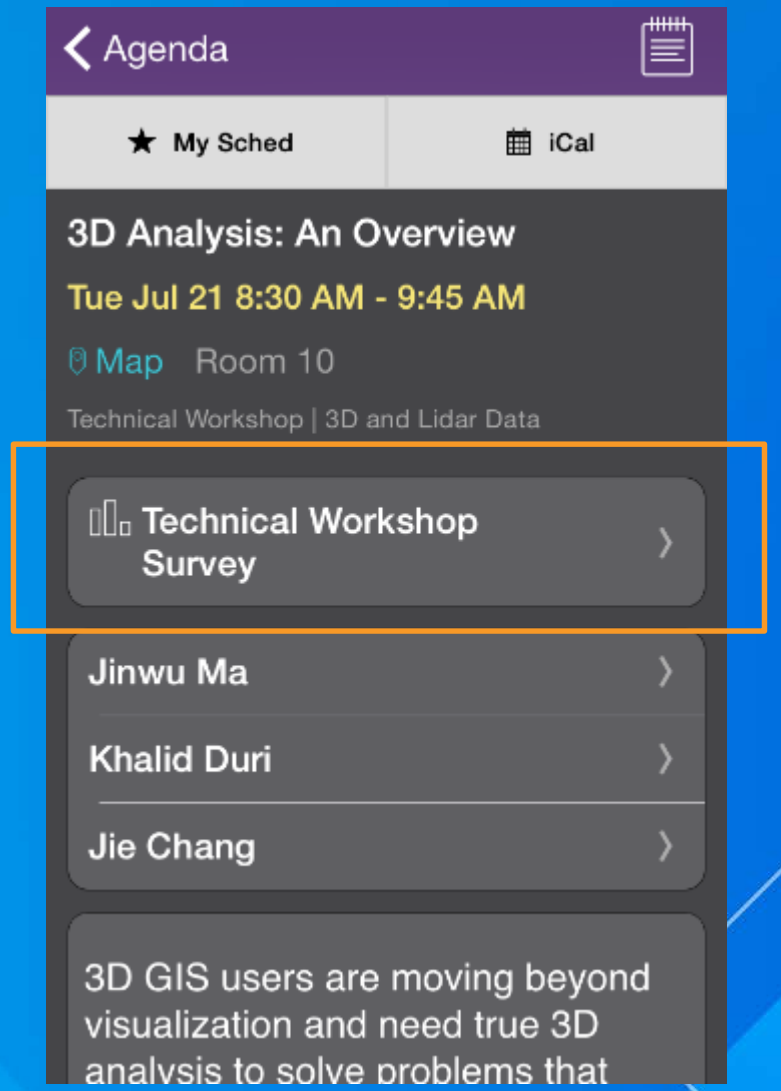
Demo

For those wanting models:

Email: ccrawford@esri.com

Thank you…

- Please fill out the session survey in your mobile app
- Select ‘Lidar and GIS: Applications and Examples’ in the Mobile App
  - Use the Search Feature to quickly find this title
- Click “Technical Workshop Survey”
- Answer a few short questions and enter any comments



Understanding our world.