Managing Lidar
(and other point cloud) Data

Lindsay Weitz
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Presentation Context

- What is lidar, and how does it work? → Not this presentation!
- What can you do with lidar in ArcGIS?
- What does Esri recommend as best practices for processing and managing lidar data?
- What about other point clouds (from photogrammetry)?
Presentation Outline

• Data structures
  - LAS and zLAS formats
  - LAS Dataset – for lidar & surface constraints
  - Terrain Dataset – for lidar & surface constraints
  - Mosaic Dataset – for lidar & raster data management

• Data management
  - QC & Derived products
  - Automation & Sharing
Data Structures for Lidar support in ArcGIS

Multiple files/folders

File01.las
File02.las
...
File99.las

Tiled/overlapping extents (location/time)

Analyze and update

LAS dataset
Terrain dataset

LAS dataset / Terrain dataset

Manage, serve, share

Mosaic dataset

Managing Lidar
Application Fusion: ArcGIS Pro

ArcMap

ArcCatalog

ArcGlobe / ArcScene
Lidar in ArcGIS Pro
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Lidar data storage – LAS files

- Binary file format developed by ASPRS
- Metadata in a header block
- Individual record for each laser pulse recorded
- Directly readable by ArcGIS
- Most common format for lidar and other point clouds (e.g. from photogrammetry), but designed as an exchange/archive format, not optimized for operational use…
Lidar data storage – zLAS

- Introduced January 2014
- Compression, sorting, and indexing
- Direct read
  - Parallel decompression added to ArcGIS apps in 10.3
- Features & Benefits
  - Re-sequence points w/ geospatial index
  - Optimized for random access
  - Lossless compression
  - Transparent integration with LAS dataset
zLAS

- Free!! Does not require ArcGIS
- Support added in 10.2.1
- Standalone application “EzLAS” on Resource Center
  - http://esriurl.com/zLAS
- API available for developers
  - https://github.com/Esri/esri-zlas-io-library
- For more info:
  - http://www.lidarnews.com/content/view/10214/2/
Rearranging Point Records

Spatial distribution of points

Physical location in file
Rearranging Point Records

Spatial distribution of points

Physical location in file
LAS dataset
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Lidar data with a LAS dataset

- Direct read of LAS or zLAS format lidar
- File based
- QA/QC tools
- Stores references to LAS/zLAS files on disk
- Optionally reference breakline and control point data
- Treats a collection of LAS/zLAS files as one logical dataset ("Project")
Create a LAS dataset

- Interactively through ArcCatalog
  - Use the file folder context menu

- Using scripts and models with geoprocessing tools
QA\QC: LAS file based statistics

- LAS Dataset Properties: LAS File Statistics
QA\QC: LAS dataset based statistics

- LAS Dataset Properties: LAS Dataset Statistics
Edit classification codes

- **Interactive**
  - Fixing data anomalies and misclassifications via point profile window

- **Automated (GP tools)**
  - Classify relative to feature data
  - Reclassify to standard LAS specification
LAS dataset demo
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Lidar Related Analysis Tools
LAS Point Statistics By Area
Classify LAS by Height

<table>
<thead>
<tr>
<th>Class</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
</tr>
</tbody>
</table>

- Use just model key points for ground (optional)
- Model key type (optional): Code based
- Reclass points below ground to noise (optional)
- Reclass points above max height to noise (optional)
- Classify within processing extent only (optional)
- Calculate statistics (optional)

Profile View
Locate LAS Points By Proximity

Data courtesy of PhotoScience
Locate LAS Points By Proximity
Lidar/3D Sample Tools

- Available in ArcGIS 10.2 and 10.3
- Sample geoprocessing tools
  - Esri 3D Resource Center
  - http://links.esri.com/3dSamples
Best Practices

- Tiled LAS, v1.1 or higher
- Projected, rearranged, indexed
  - zLAS
- File size: 1 – 2 GB or less (<500 MB if not rearranged)
- Keep file I/O local, avoid network
- Study area boundary included as constraint
- Airborne lidar
  - Classified (bare earth, non-ground)
  - Breaklines for hydro enforcement
- Terrestrial lidar
  - RGB & intensity values, classified

* Also applies to photogrammetric point clouds
Terrain dataset
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Managing lidar data in a terrain dataset

- A Terrain dataset is a multi-resolution surface created from measurements stored in feature classes.

- Typical applications:
  - Topographic mapping
  - Bathymetric mapping

- Typical data sources:
  - Photogrammetric data
  - Lidar
  - Sonar
Multiresolution surface model

Points and breaklines

Terrain Pyramids

Thinned lidar point set

Full resolution lidar point set

Multiresolution terrain dataset (TIN structure)
Terrain dataset advantages

Scalability
Large collections of mass point data (e.g. LIDAR) have been a problem

Data integration
Need surface to live with source data

Data management
Database tools
Editing/update
Multi-user
Terrain dataset editing

• Updating via editing of source measurements
  - Appending, removing, replacing mass points by area
  - Standard and custom edit tools for modifying polylines, polygons, spot heights
  - Terrain rebuild based on dirty areas

• Support for versioning in SDE
Creating a terrain dataset

Managing Lidar
Analysis capabilities for terrain datasets

- QA/QC data
- DTM, DSM
- Slope
- Aspect
- Contours
- Surface differencing
- Intensity image
- Forest canopy estimation
- Data area delineation
- Thinning, reducing noise
- Spot interpolation
- Profiling
Mosaic Dataset
Cody Benkelman
Introduction / Review

- LAS Datasets
  - For individual projects; support access to 3D points, w/ filtering, toward analysis
- Terrain datasets
  - For organizations creating, editing, & maintaining authoritative DTM
- For managing multiple projects, and accessing 3D surfaces (DTM, DSM), Mosaic Dataset is recommended
  - Post QC, organized by project via LAS Datasets *or*
  - Managed within a Terrain Dataset
Image Management Workflow Using Mosaic Datasets
Highly Scalable, From Small to Massive Volumes of Imagery

Create Catalog of Imagery
- Reference Sources
- Ingest & Define Metadata
- Define Processing to be Applied

Apply:
- On-the-fly Processing
- Dynamic Mosaicking

Access as Image or Catalog
Image Dissemination
Integrating with / and in The Cloud

• Dynamic Image Services
  • Processing & Analysis
  • Catalog of Metadata
• Geoprocessing Services
  • Processing Tasks
Image Dissemination ArcGIS Online
Integrating with / and in The Cloud

- Massive Accessibility
- Content Management
- Register With ArcGIS Online

ArcGIS Online

ArcGIS Server on Premise or in the Cloud

Portal

Desktop

Mosaic Dataset

Large Image Collections

Desktop, Web & Mobile Users
Adding lidar data to a mosaic dataset (Method 1)

- Advantages
  - Fastest method to begin using & sharing raster surfaces
  - Filter to create custom surfaces (e.g. buildings & DTM, remove vegetation)
Adding lidar-derived data to a mosaic dataset (Method 2)

- Advantages
  - Most scalable
  - Best performance

Export

- DSM raster tiles
- DTM raster tiles

Project LAS/zLAS Files

LASD

QC

EDIT

DSM Mosaic Dataset

DTM Mosaic Dataset
Lidar data management using Mosaic Datasets

- **Design**
  - Begin with Elevation data management
    - In most organizations, DTM & DSM supports the majority of users
  - Support download for 3D point data users

- **Build & Maintain**
  - Automation (see *Image Management Workflows*)

- **Share**
  - Within an organization
  - With external users
Elevation data management using Mosaic Datasets

- Manage each project separately (LASD)
- Create tiled DTM and DSM for ingestion into Mosaic Dataset
- Combine multiple projects into single repository
- Manage DTM and DSM as base data, provide other products on demand
  - hillshade, slope, ellipsoidal height, etc.
- For users needing source 3D points (lidar/photogrammetry), allow data download
Manage each project separately
Source Data

USGS NED

SRTM

LAS project #N

Source Mosaic Datasets

Derived Mosaic Dataset (DTM or DSM)

Raster Type = Table

Link projects into single repository

Managing Lidar
Link projects into single repository
Source Data

USGS NED

SRTM

LAS project #N

New lidar project

Source Mosaic Datasets

Derived Mosaic Dataset (DTM or DSM)

Referenced Mosaic Datasets

Orthometric Height

Hillshade

Slope

Aspect

Slope Map

Managing Lidar
Source Data

- USGS NED
- SRTM
- LAS project #N
- New lidar project

Source Mosaic Datasets

Derived Mosaic Dataset (DTM or DSM)

Alternative: Raster Function Templates (RFTs) allow client app to select & control functions on a single service

Referenced Mosaic Datasets

- Orthometric Height
- Hillshade
- Slope
- Aspect
- Ellipsoidal Height

Managing Lidar
Multiresolution Elevation Data
Advantages/Objectives of Automation

• Productivity
  - Repeatability, Scalability, Maintainability
  - System Documentation → to facilitate QA & QC, Design Review

• Training/Examples
  - Encapsulate best practices
  - Reusable templates

• Simplicity

• Options for creating Mosaic Datasets:
  - Manual
  - ModelBuilder
  - Python
Create Simple Mosaic Dataset - ModelBuilder
Comparing Models
Python example tools - *Mosaic Dataset Configuration Script (MDCS)*

- Calling standard Geoprocessing tools from a single script
- Input configuration file contains complete information to:
  - Create,
  - Populate, and
  - Configure one mosaic dataset
- Also generates detailed log files
Advantages of MDCS

- Configuration file encapsulates “Best practices” (mosaic dataset properties) based on image type
- “Self Documenting” –
  - Template is reusable for different image types, or multiple mosaic datasets within a more complex system
  - Compare versions (difficult with ModelBuilder)
- Automated Log files – Simple Review
- Based on 10.2, but compatible with upcoming ArcGIS Pro App
Configuration file contents

- Input Data Paths
- GP tools necessary for the workflow
- Raster Types & Raster Functions
- Mosaic Dataset properties
Configuration file contents

“BEST PRACTICES”

- Input Data Paths
- GP tools necessary for the workflow
- Raster Types & Raster Functions
- Mosaic Dataset properties
Demo - Automation

Adding Lidar to World Elevation

*If you want to follow on a mobile device:*

http://esriurl.com/AddLidar
Finding MDCS and related resources
http://resources.arcgis.com/en/communities/imagery

Imagery Community on the ArcGIS Resource Center
Finding MDCS and related resources

...to the Landing page on Resource Center
Finding MDCS and related resources

Image Management Guidebook in ArcGIS Help System for detailed advice

General workflow, Elevation workflow, & Lidar workflow
ArcGIS Online (AGOL) group

- Downloadable examples
- More workflows/templates to be added over time
Resources: “Imagery Management Workflows”

• Imagery Resource Center: http://esriurl.com/6005
• Image Management Workflows: http://esriurl.com/6550
• Guidebook in ArcGIS Help: http://esriurl.com/6007
• ArcGIS Online Group: http://esriurl.com/6539

• Recorded Webinar on lidar data management: http://esriurl.com/LTSLidarMgmt
• Optimized LAS tool: http://esriurl.com/zlas
• Tools from 3D Team: http://links.esri.com/3dSamples

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Understanding our world.

Managing Lidar