Getting *Thinner*
Creating Model Key Point Clouds from LiDAR Datasets - Effects on Digital Terrain Model Quality

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"Changes in Latitudes"

Background

- ***Rapidly*** *accumulating LiDAR datasets (FEMA-KYAPEP)*

- LiDAR ***standards*** continuously improving – more complex and rich datasets (LAS 1.4 and counting…)

- A diverse range of ***products*** delivered:

  - LiDAR "point clouds" :
    - *elevation* ("height") information
    - surface cover properties (intensity)
    - "*top of objects*"; "*interior*" vegetation ("canopy");
      "*bare earth*": "**Ground Point"| "Model Key Point**"
  - Derivatives:
    - *TINs*
    - *Hydro-flattening/hydro-enforcing breaklines*
    - *DEMs*
    - *DSMs*
    - *DTEMs*

Background (*cont.*)

- ***Watershed delineation*** (i.e. HUC boundaries): *new boundaries!*
- ***Hydrology****: where water goes*
- ***Hydraulics****: how fast water moves (up, down, sideways)*
- ***Precision resource management****: agriculture, forestry, engineering, etc.*
- ***Modeling****: DEMs are a NECESSARY input to HAZUS (FEMA)*
- ***Visualization****: terrain is substrate to spatial landscape elements (3-D, 4-D)*
- ***Terrain data*** *are the UNDERPINNING for the best basemaps*
  - *Risk maps*
  - *Communities*
  - *Resources*
  - *Assets*
  - *Disaster/hazard mapping*
  - *Etc. etc. etc.*

LAS Binary Data Format (v. 1.2)

(*Source*: ASPRS (http://www.asprs.org)

The LAS file : contains **LiDAR point data records**.

The Binary Data Format includes:

Point Data: X, Y, Z, Intensity, Scan Direction Flag, Edge of Flight Line, Classification, etc.

ASPRS Standard LIDAR Point Classes Classification Value

0	Created, never classified
1	**Unclassified**
2	**Ground**
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	**Low Point (noise)**
8	**Model Key-point**
9	**Water**
10	Reserved for ASPRS Definition
11	**Reserved for ASPRS Definition**
12	Overlap Points
13	- 31 Reserved for ASPRS Definition

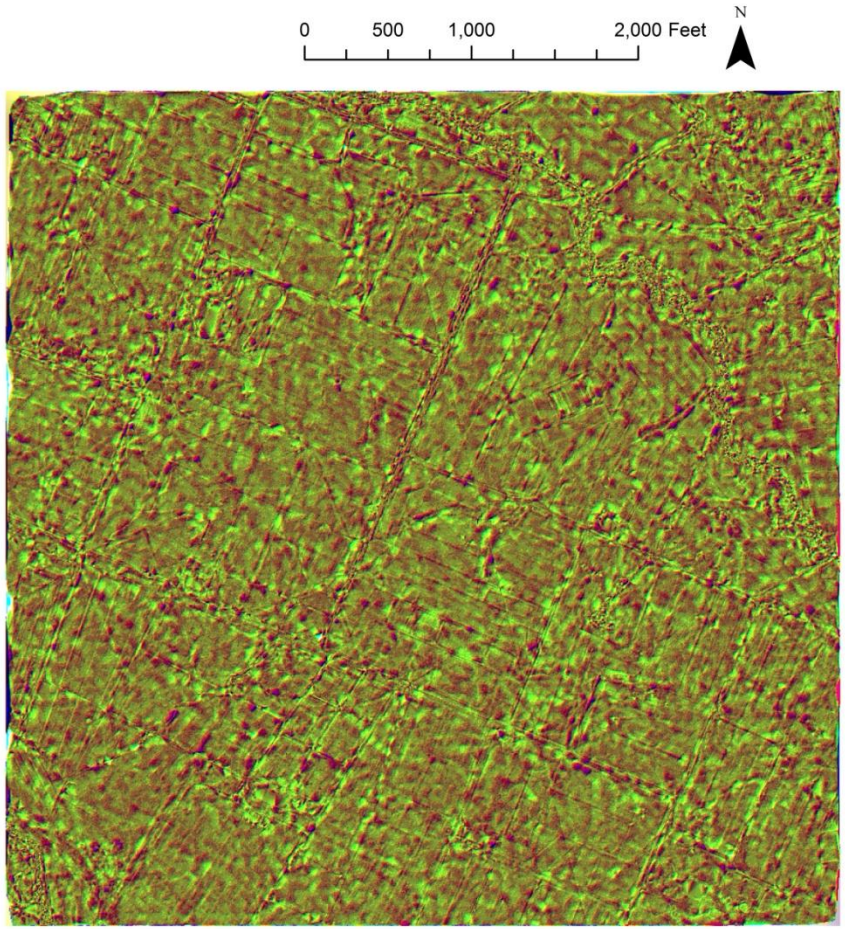
Model Key Points *(MKP)*:

A "thinned out" version of "Ground Points"

- "*Statistical filter*"
  - Model-based, numerical/probabilistic (gamble!)
  - Retains only "meaningful" points
  - Results in "engineering" quality contour lines
  - Gets rid of "noise"
  - Reduces storage requirements

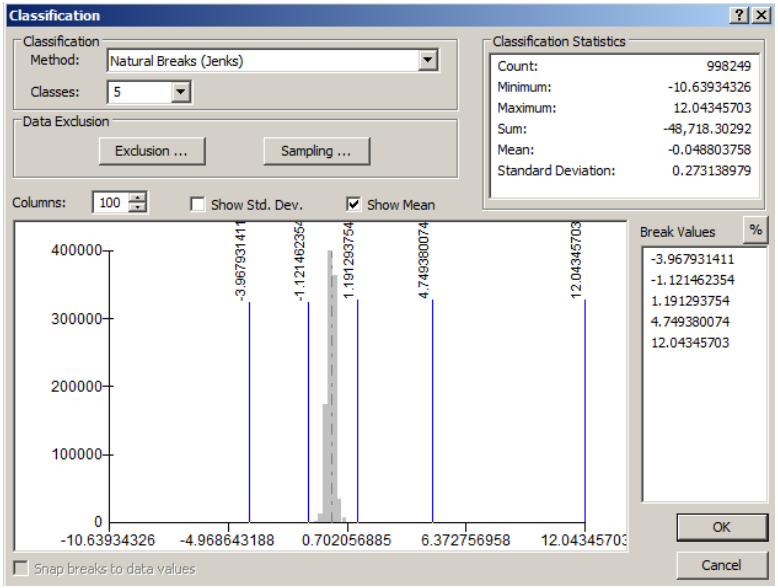
Model Key Points *(MKP)*:

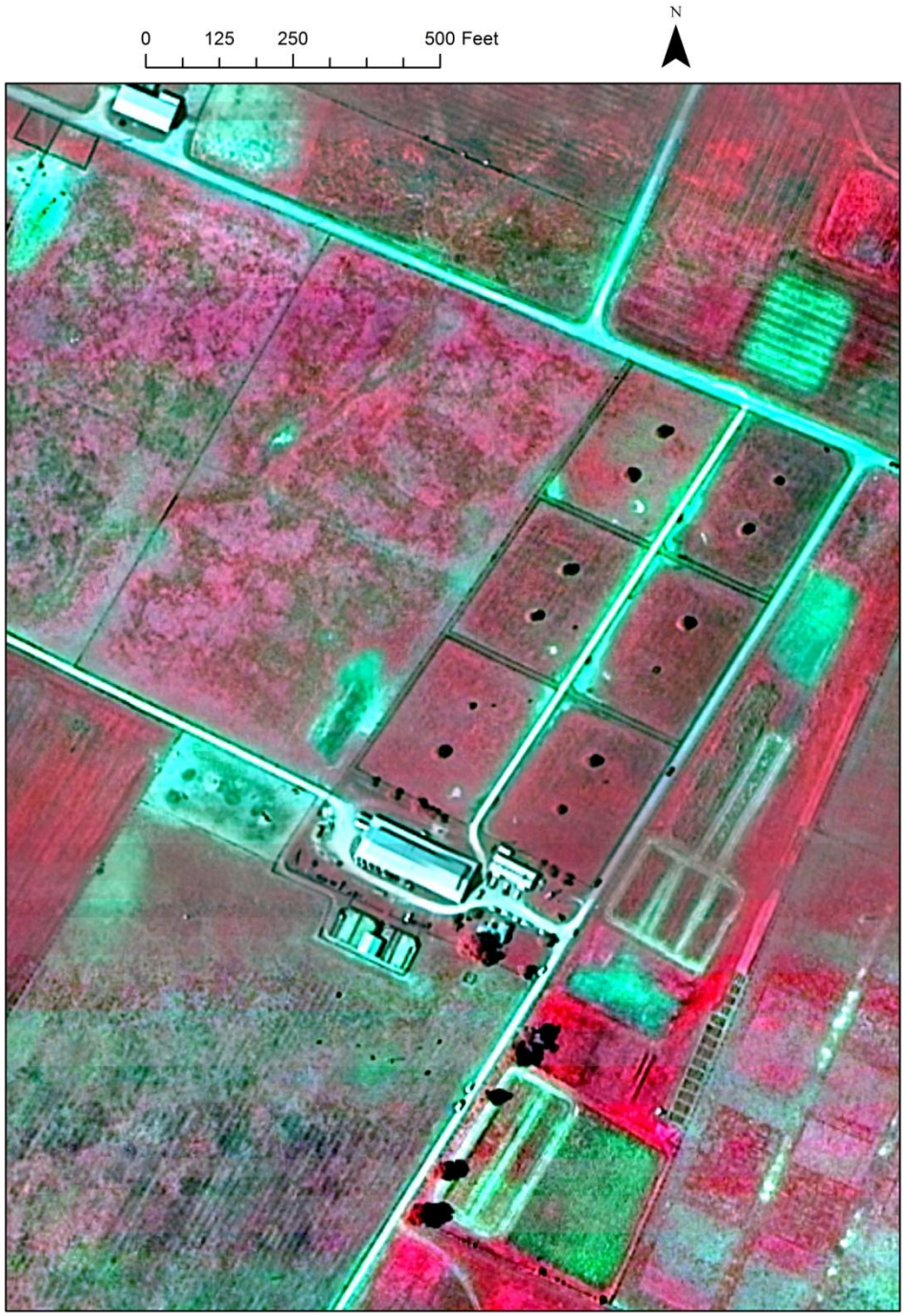
- *Information potentially "lost"*
  - Type/amount of plant (live/dead matter) cover
  - "Features" (e.g. archaeology, geology, agronomy)
  - Hydraulic information (breaklines?)
  - Micro-topography / micro-geomorphology



Min(d)ing the Difference!

(Ground Point Surface** minus **Model Key Point Surface)




0
125
250
500 Feet
N

Contour Lines:

(A vector manifestation of the DTEM/DEM/DSM)

- Source
  1. From “Ground Point” class TIN
  2. From “Model Key Point” class TIN

- MKP= “Engineering quality or grade”
  - Not aesthetically pleasing
  - Accurate:
    - Not necessarily *smooth*, but they follow surface irregularities (i.e. all bumps)

Contour quality
The contour tools produce engineering-quality contours, representing an exact interpretation of the raster surface. Overall contour accuracy depends on how well the data used to create the input raster represents the actual surface.

The size of the raster cells used affects the appearance of the output contours. A large cell size may result in coarse, blocky contours.

Occasionally, engineering-quality contours may cross, appear to intersect, or form an unclosed branching line. ***Crossing*** contours can occur in saddle regions that lie exactly on a contour interval. In other cases, the contours may pass so close to one another that they appear to intersect. ***Branching*** contours can occur in cases of intersecting ridges that fall exactly on a contour interval. These are all valid engineering-quality interpretations of the surface that cartographers typically modify for aesthetic purposes.

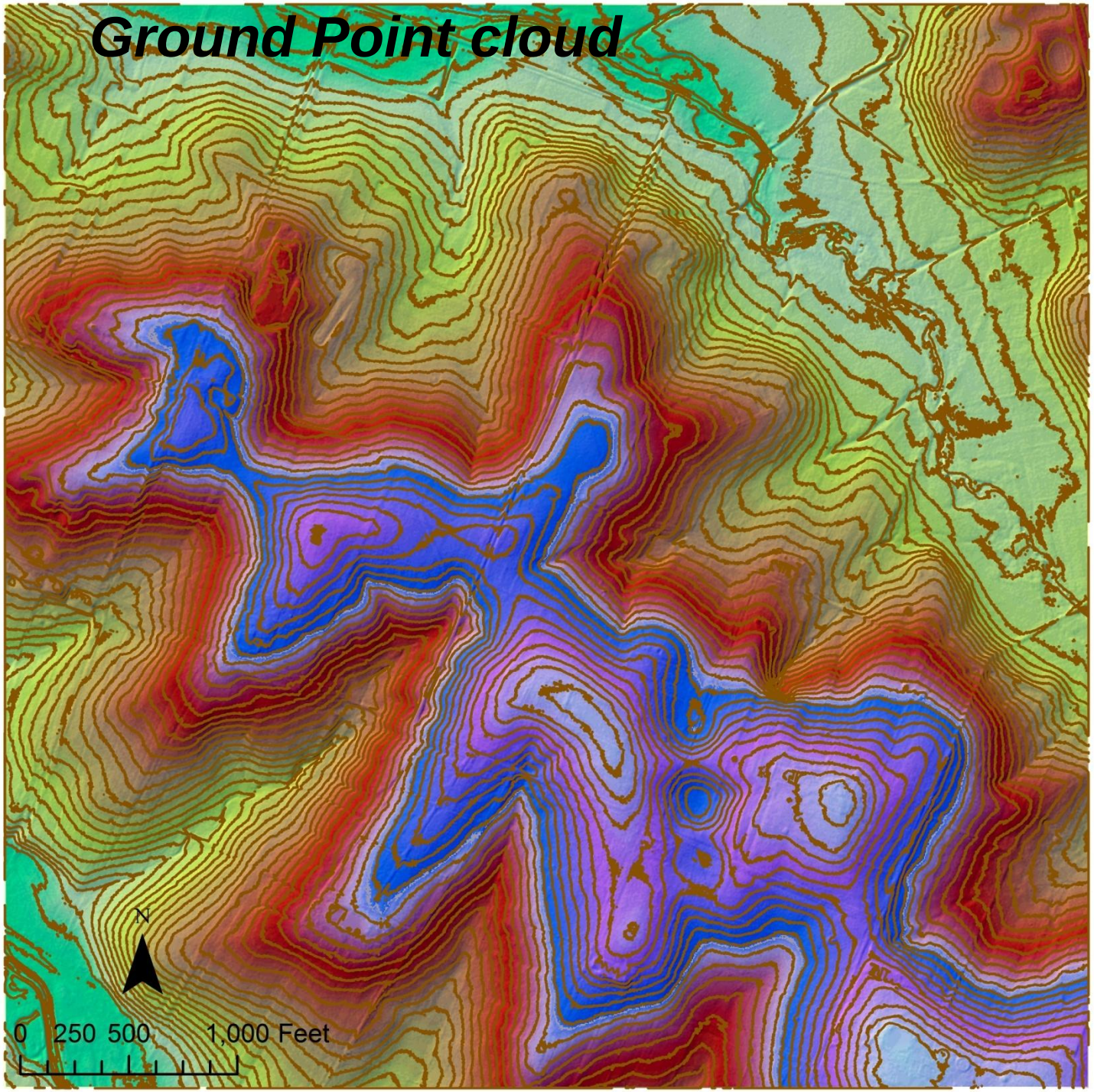
Esri ArcGIS 10.1 Help, 2012

MK Filter

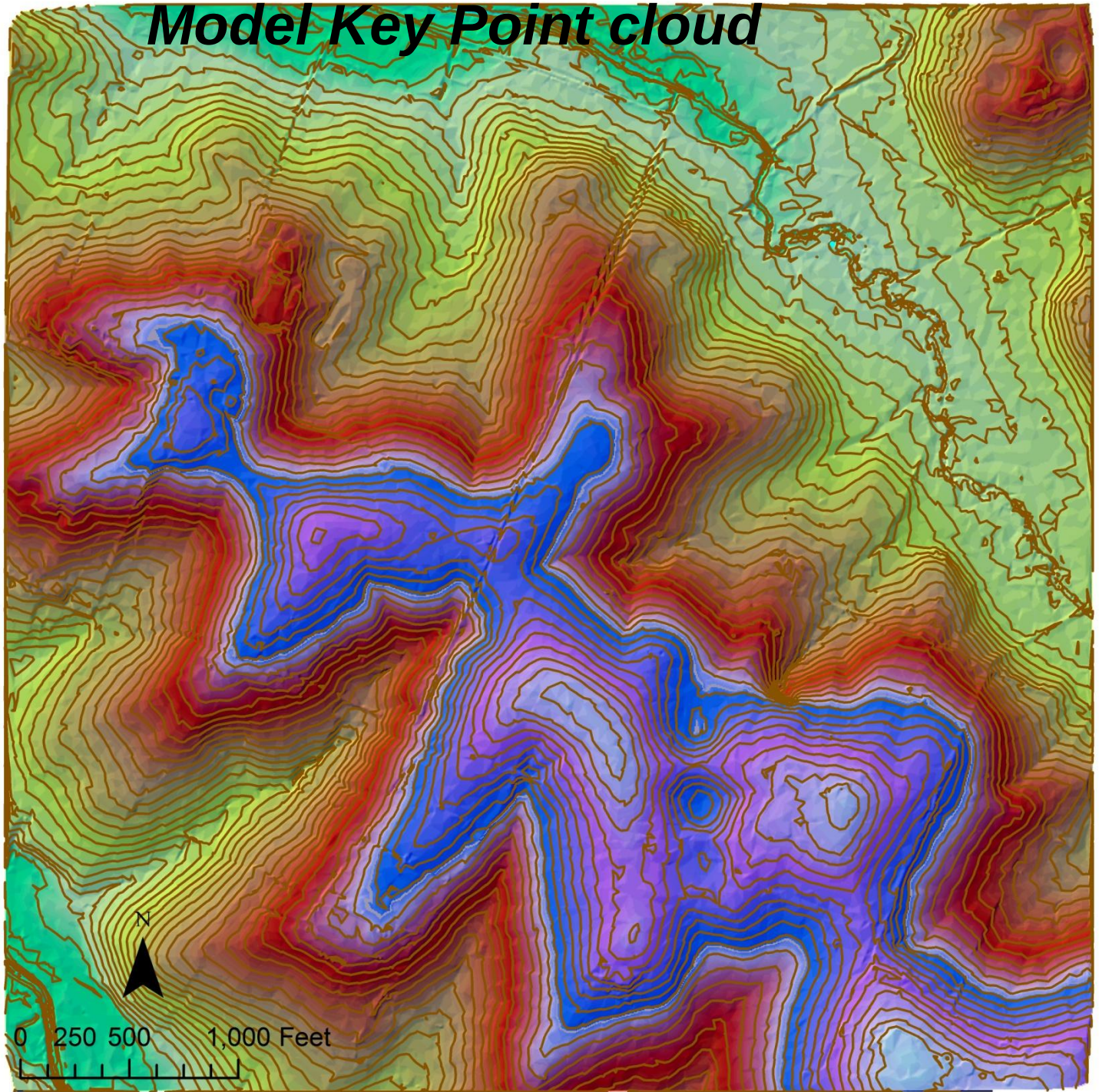
(LP360 v. 2012.1.22.0 by Qcoherent | GeoCue)

Algorithm – how does it work?

- Iterative
- Settings
  - Maximum positive/negative deviation from surface in feet
  - Minimum sampling distance (granularity)
  - TIN based
- Ground points are labeled MKP (or not)
- MKP a subset of GP class

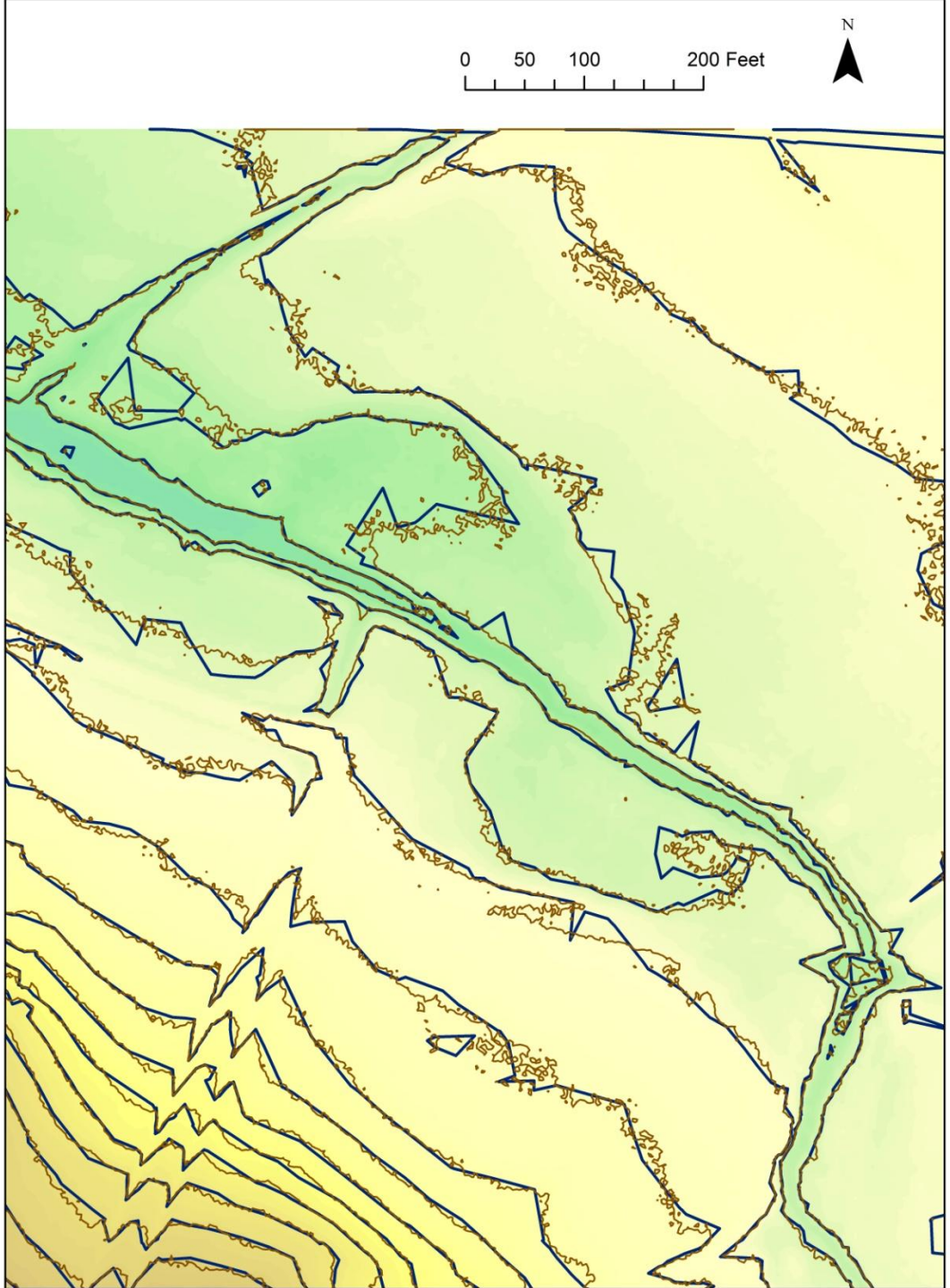

Ground Point cloud
N
0 250 500 1,000 Feet

Model Key Point cloud



2-foot contours

GP vs. MKP

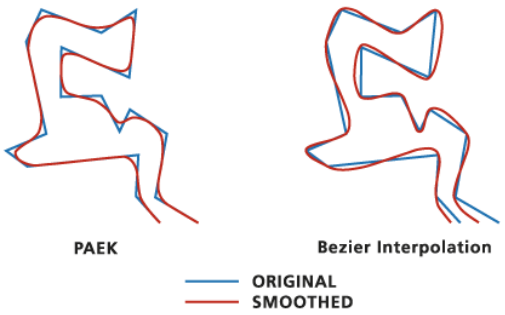


2-foot contours

GP vs. MKP

Cartography to LiDAR's rescue!

– "Cartographic quality or grade"
  - Aesthetically pleasing
  - Not *necessarily* accurate
  - Created by using thinning/smoothing algorithms:



» ***Simplify + Smooth GP***: Point removal (Douglas and Peucker, 1973) or Bend/Simplify (Wang, 1996)

» ***Smooth MKP***: PAEK (Bodansky et al., 2002) or Bezier Interpolation (Farin, 1997)

Contour quality

… cartographers typically modify for aesthetic purposes.

Esri ArcGIS 10.1 Help, 2012

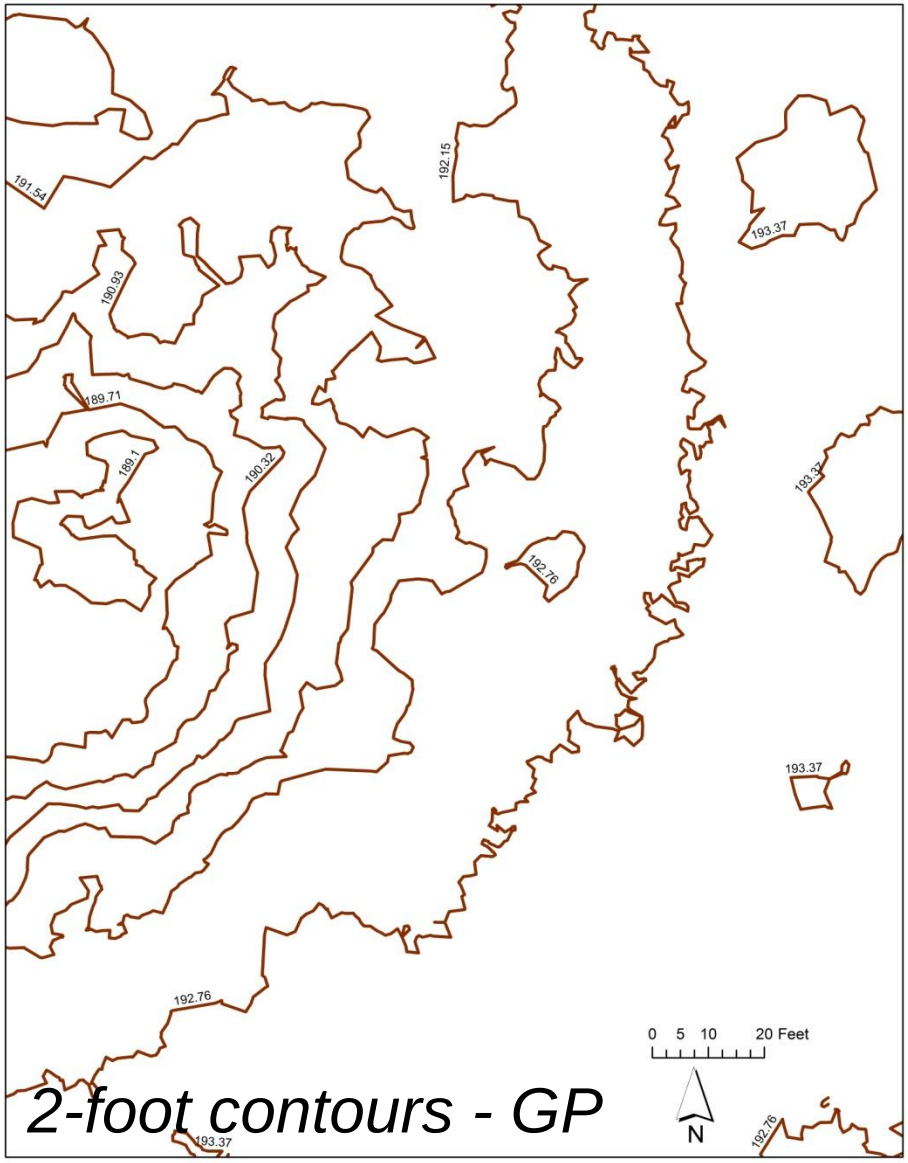
Workflow Using *Contour* ***Lines***

- ArcGIS 10.1 – Cartography Toolbox – Generalization Tools
- Smoothing **not Thinning** (MKP already contains all information we need – don't want to loose any!)
- P(olynomial) A(pproximation with)E(xponential)K(ernel) method: ***PAEK*** (Bodansky et al., 2002)

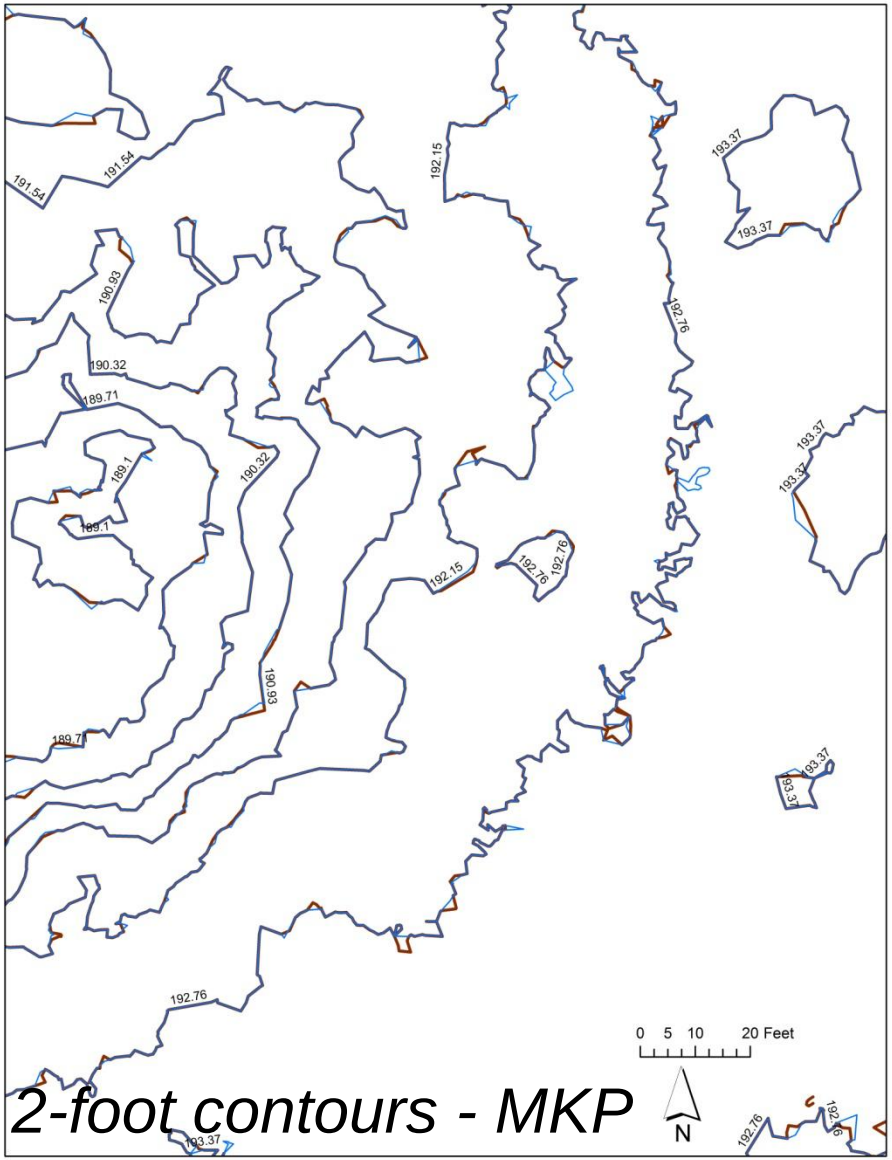
Workflow Using *Raster* **Surface**

- Smoothing the surface data with Focal Statistics (mean), or other methods.
- Extract new contour lines

Little River (USDA-NRCS) - Example



2-foot contours - GP

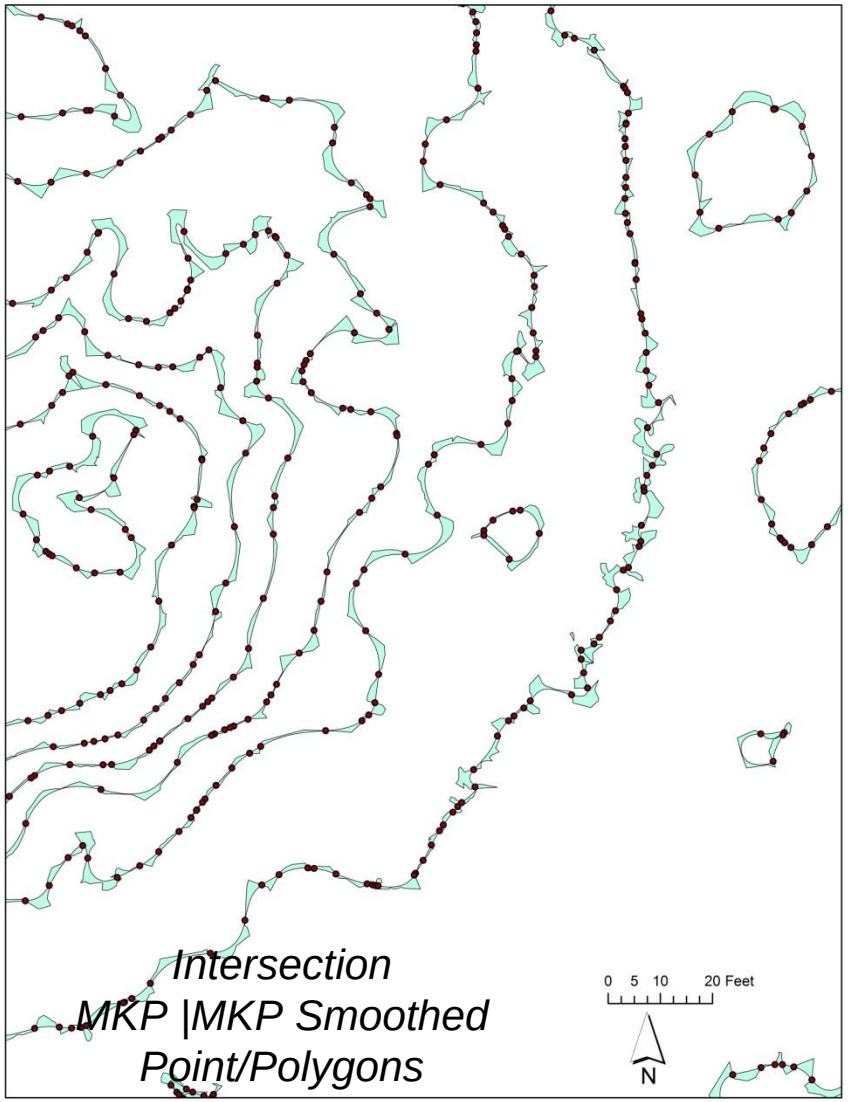


2-foot contours - MKP

Cartographic cosmetics…

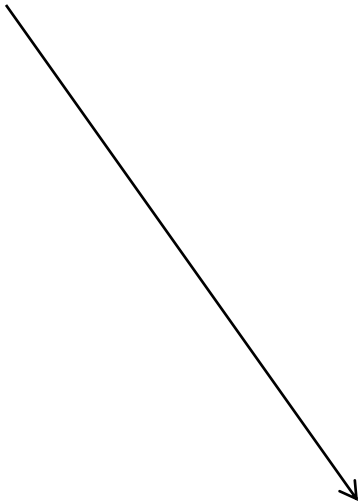
Little River (USDA-NRCS) - Example

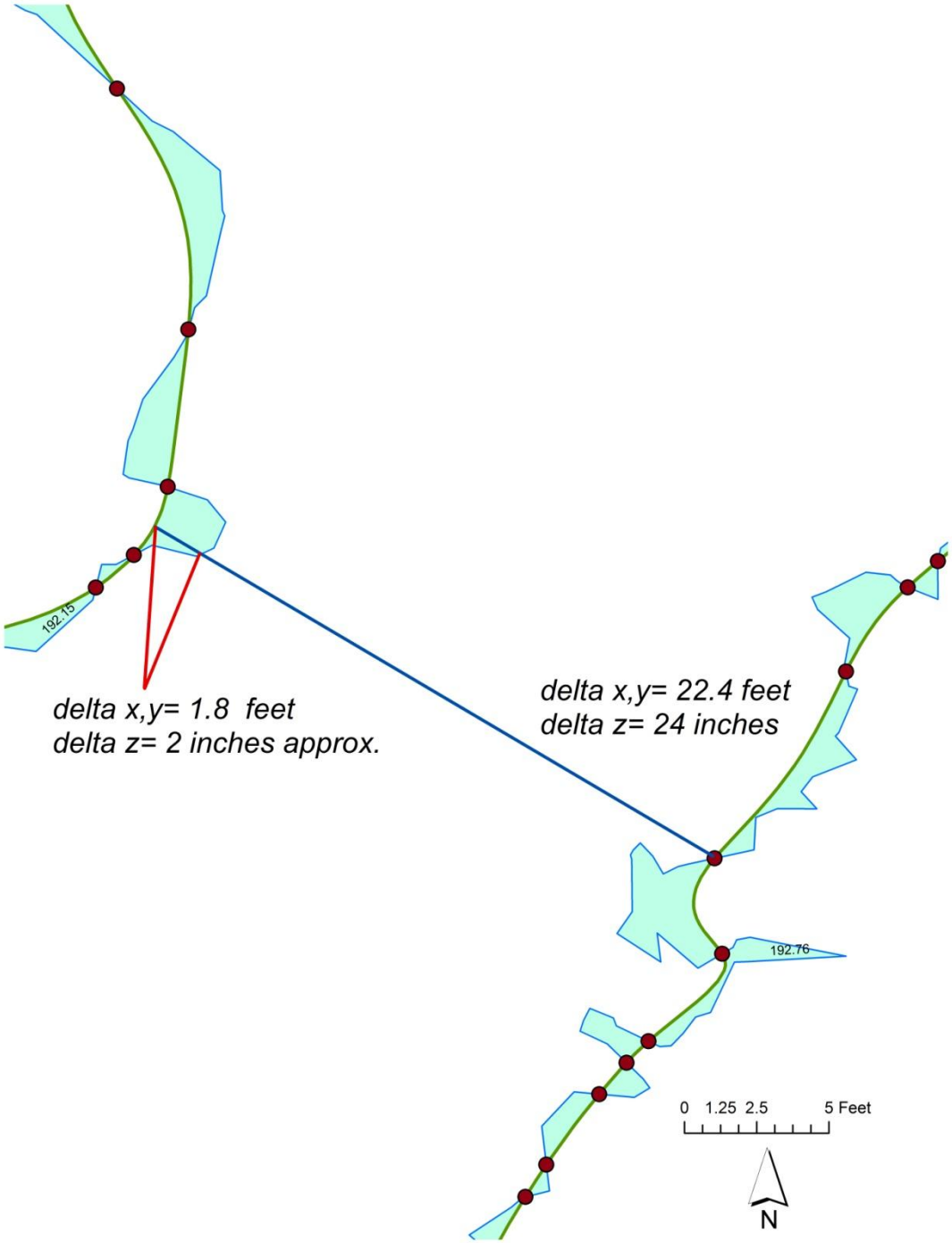
MKP Smoothed
(2 runs of PAEK)



Intersection
MKP |MKP Smoothed
Point/Polygons

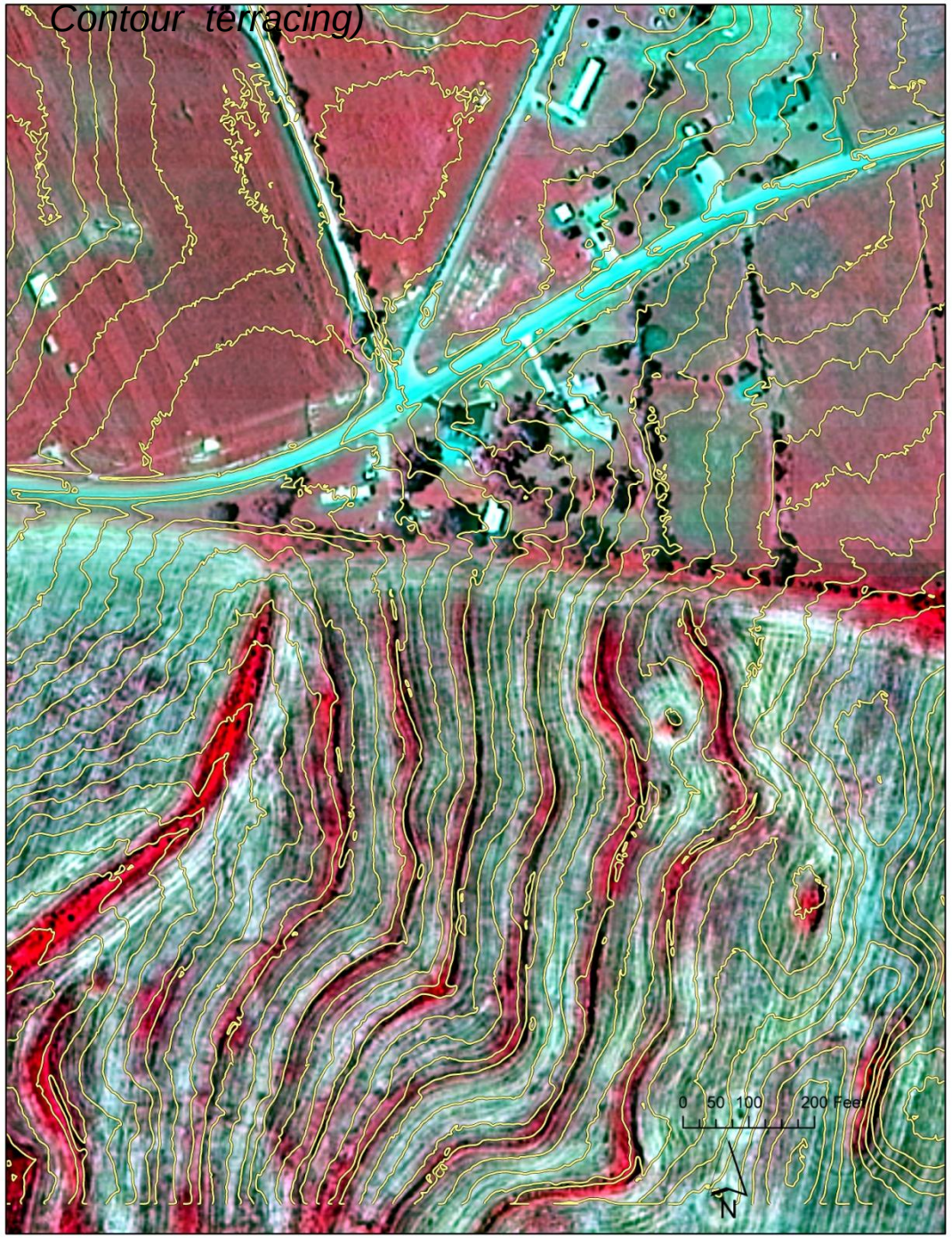
- **Photogrammetry**
  - **LiDARgrammetry**
    - **GIS user base**





A new item in our vertical accuracy budget?

Usable?


Contour terracing)
0 50 100 200 Feet
N

Summary/Conclusions

- Understanding what Model Key Point filtering does/how it works
- Interplay between *surface* and *contour line*
- Loosing information or loosing “noise”?
- ***A***esthetics vs. ***A***ccuracy => a choice (balance) to make (achieve)
- New type of accuracy assessment needed?
- Rethinking accuracy budget?
- LiDAR= new **type of datasets** with new **challenges (opportunities!)**

Contact Information

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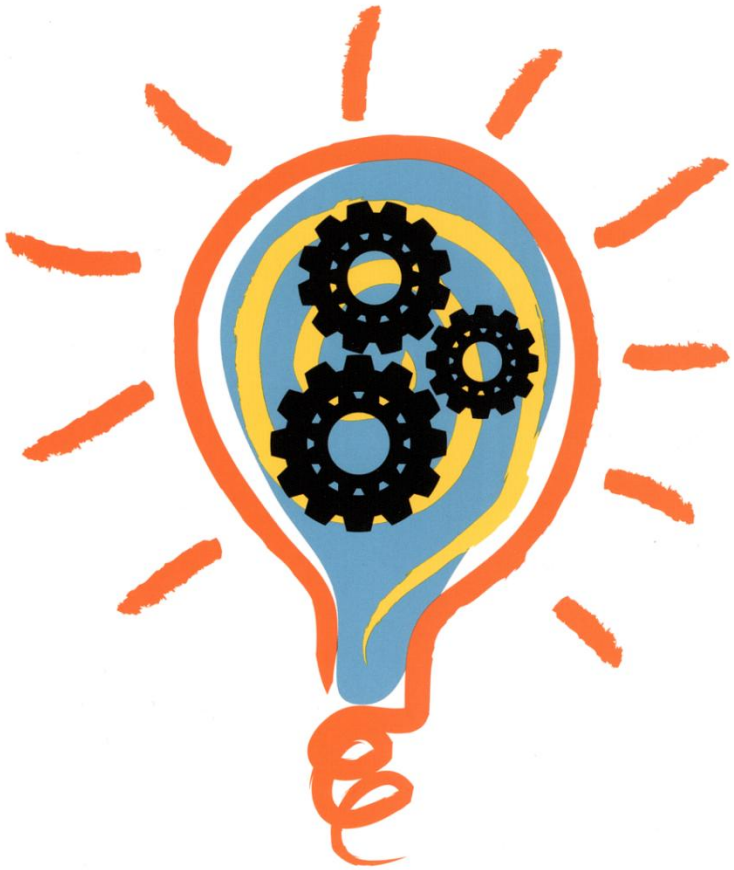

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