60 G&O Years

GREENHORNE & O'MARA

CONSULTING ENGINEERS

Inspired Solutions, Improving Lives

Floodplain Mapping & LiDAR: Can There be Too Much Data?

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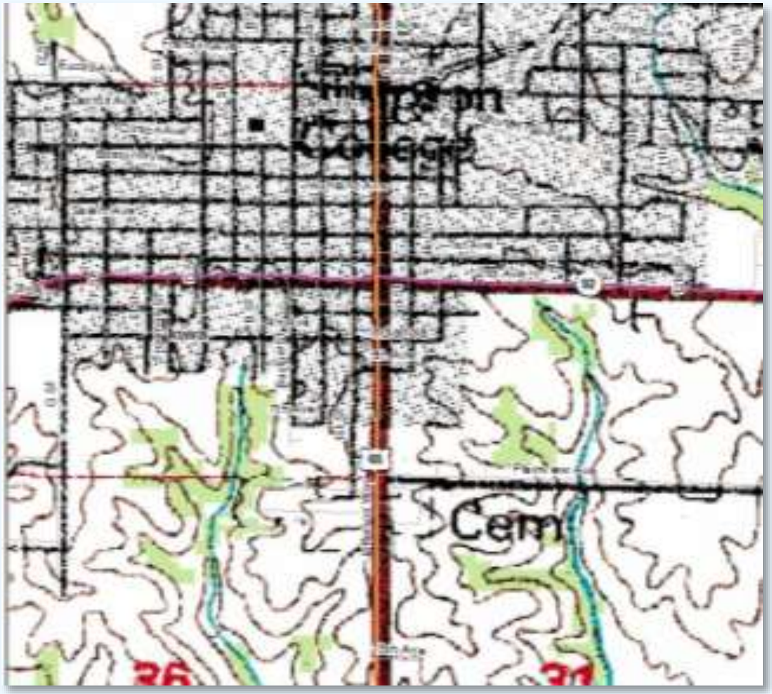
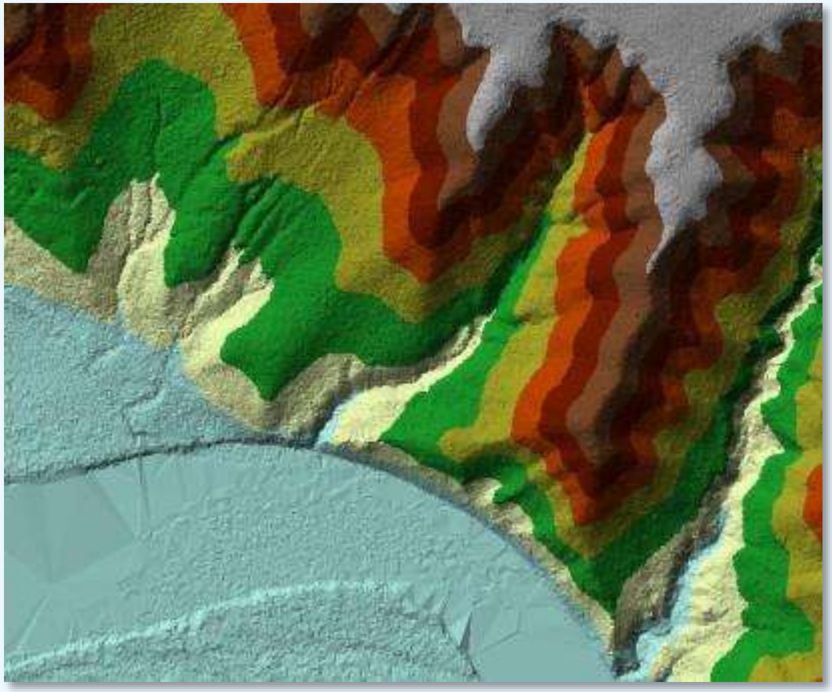
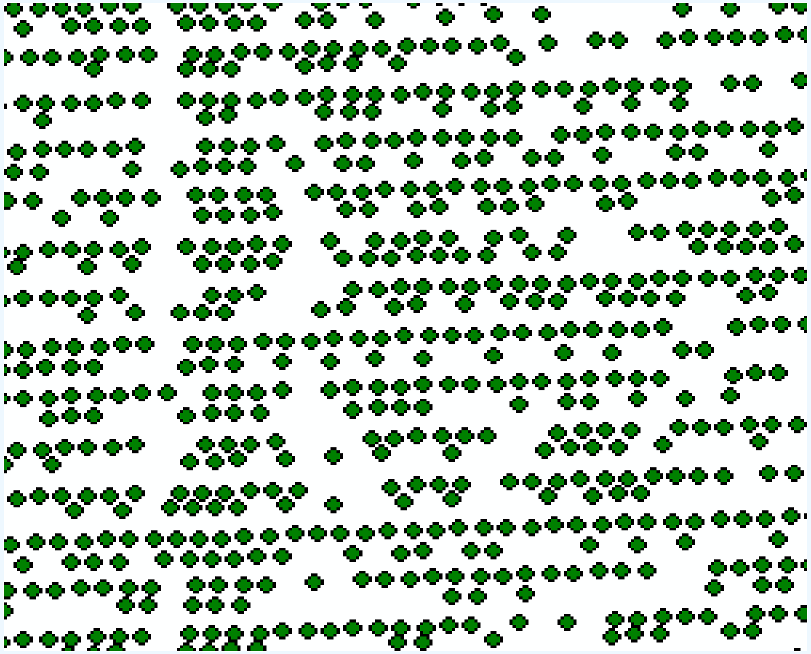
LiDAR – the Giant Step Forward



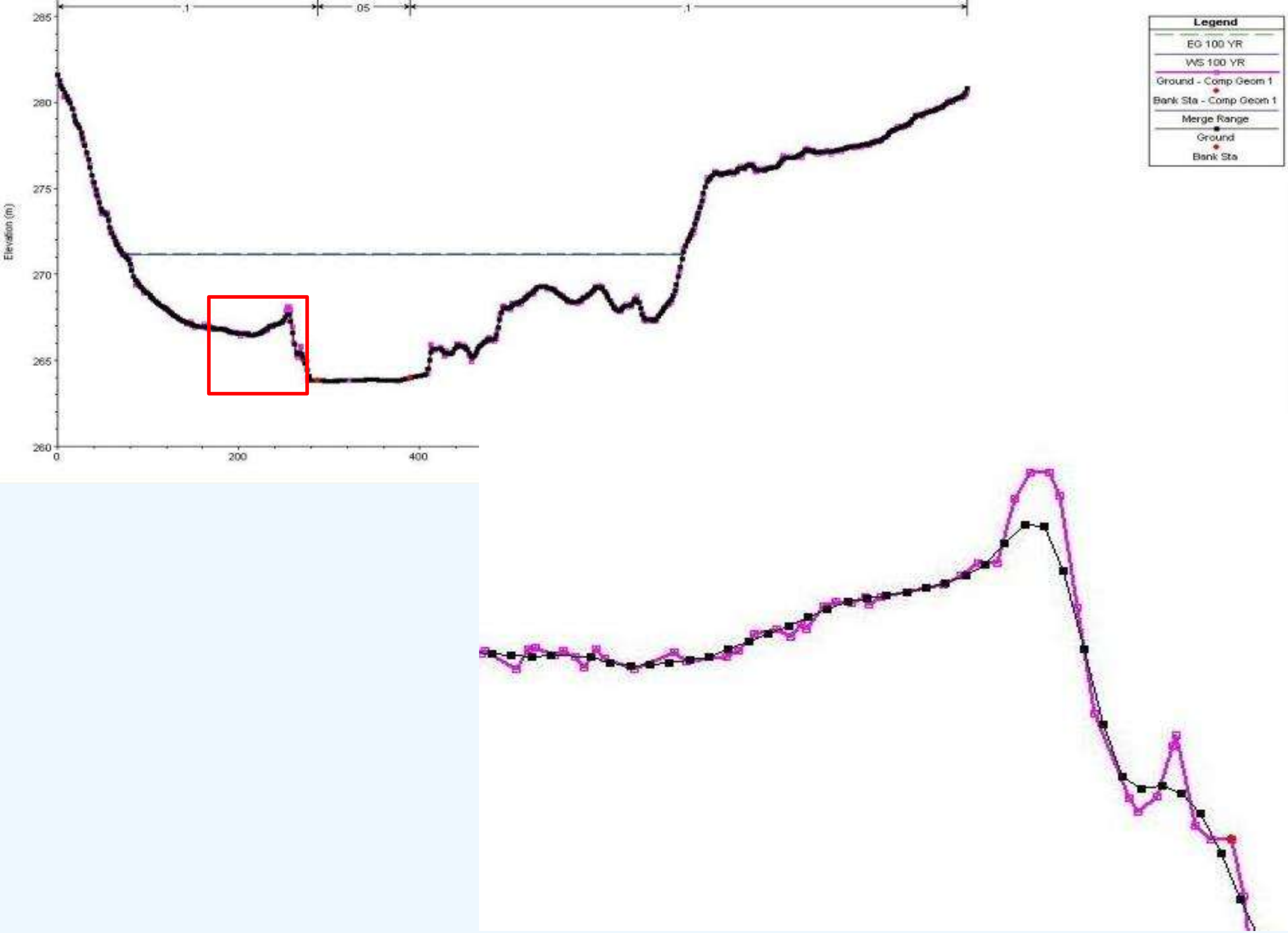


Can there be too many points?

100’x100’ LiDAR Grid
•File size 2 GB
•Frequently corrupted
•Long processing times
•Difficult to append more data if needed



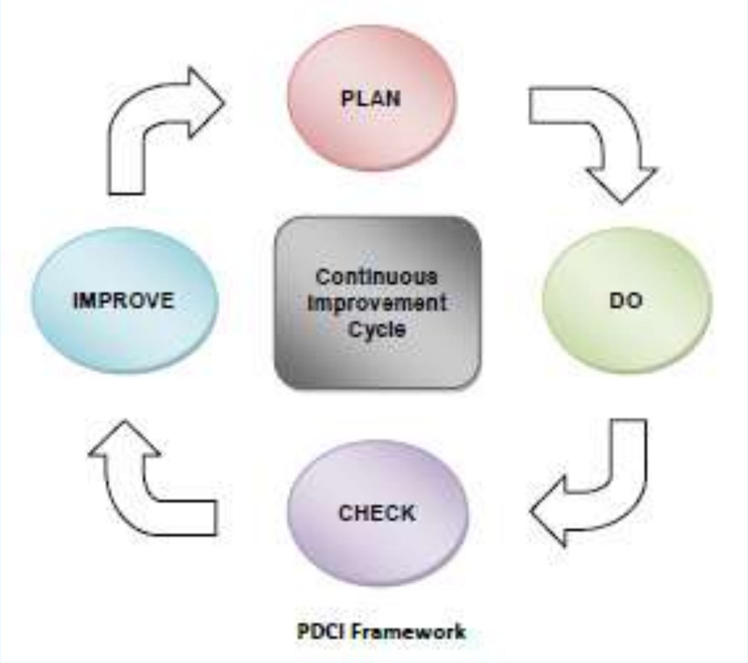
Bottom Line – Blown Budgets!



.1
.05
.1
Legend
EG 100 YR
WS 100 YR
Ground - Comp Geom 1
Bank Sta - Comp Geom 1
Merge Range
Ground
Bank Sta
Elevation (m)
285
280
275
270
265
260
0
200
400

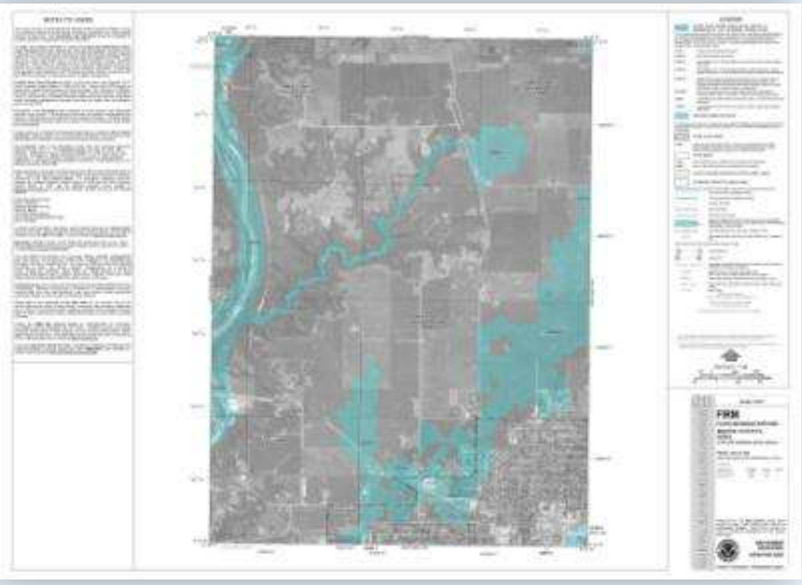
Finding a Solution

- Tasked Jason with finding a better way
  - No loss in profile accuracy
  - Floodplain lines must pass checks
  - Overlay solution on full LiDAR products for comparison
  - Fully document the process for all users
  - Process can be improved as needed



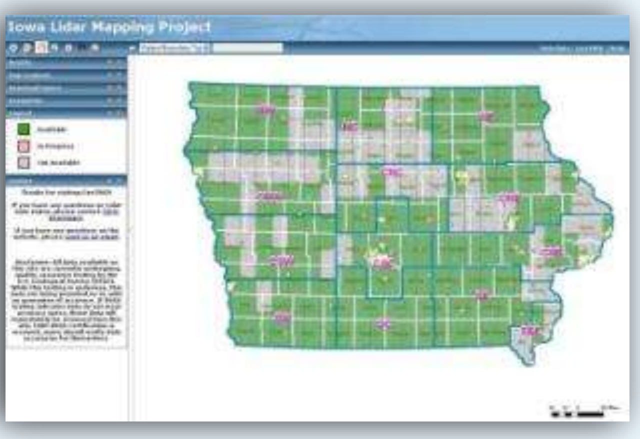
Inspiration/Problem Identification

- Map Production
  - Panning/Zooming draw times
    - Several second refresh rates
    - Large vector datasets with excessive detail
  - Printing
    - Larger files with longer print processing
- Storage/Serving
  - Large vector datasets
  - LiDAR
  - OrthoImagery



Inspiration/Problem Identification

- Surface processing
  - Buffer waterways to generate "domain"
  - Extract LiDAR groundshot from domain
    - May not have enough coverage
  - Construct TIN ground surface for flood extraction
- Studies in FEMA Region 7 – Iowa
  - High-resolution LiDAR point files (LAS and XYZI) available from the GeoTREE Iowa LiDAR Mapping Project
    http://geotree2.geog.uni.edu/lidar/



Region 7 – Iowa LiDAR (Boone County)

- Voluminous data
  - 1.4m avg. point spacing
  - 2.5 Mil groundshot points per 4.0 Mil m^2 (approx. 1.5 sq. mi.)
  - 400 tiles in county
  - Approx. 1 Bil groundshot points in county
- Extremely difficult to process seamless TIN surfaces for larger domains

Goals

- Improve speed
- Storage savings
- Network performance
- Time savings
  - Dedicated to QA/QC
- Effective products
  - Information that is optimized for target scale
  - More representative of real-world features

Optimization

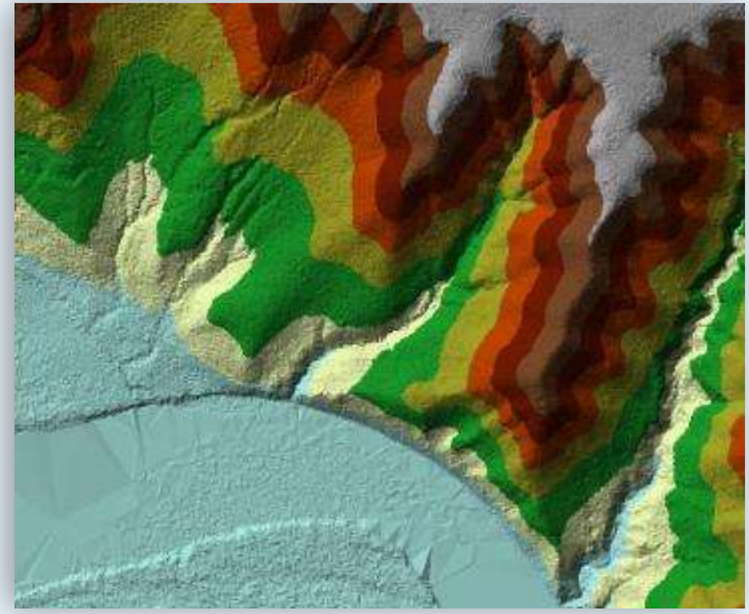
- "Less Is More"
- "Sweet-spotting"
- Improve performance/efficiency of existing and future processes through generalization of mapping inputs/outputs
- "Sweetspot" source data to produce most effective information with least effort

Proposed Solutions

- Generalize Product (vector)
  - Smoothing/Simplifying lines
    - Must meet FEMA DFIRM mapping standards (FBS Audit)
    - Still requires TIN generation
    - TIN extraction not uniform so process is more difficult
- LiDAR Thinning
  - Iowa possesses little relief
    - Still requires more processing/storage to generate TIN
    - Eliminating detail from Raw data
- Raster Elevation Surface
  - Generate GRID(s) (2m cellsize) from raw groundshot
    - Applies point mean to each cell
    - Easy to control generalization
    - Smaller file size
    - County-wide surface

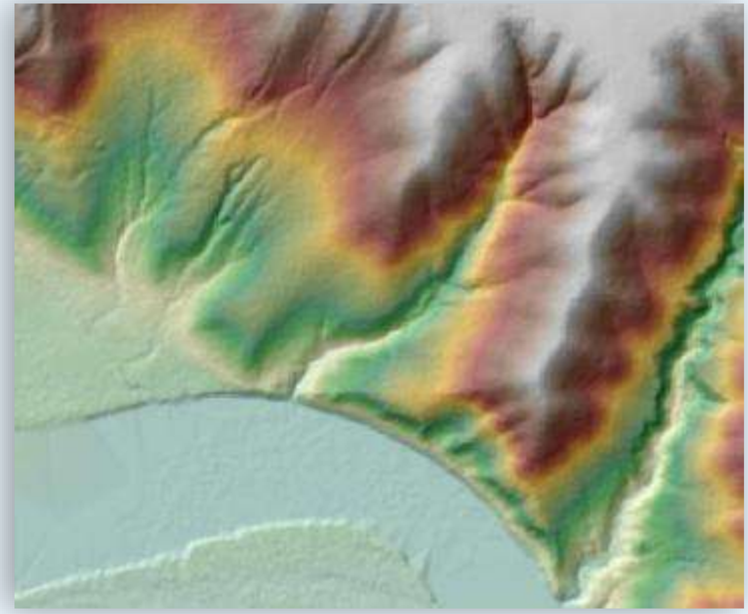
TIN vs. GRID

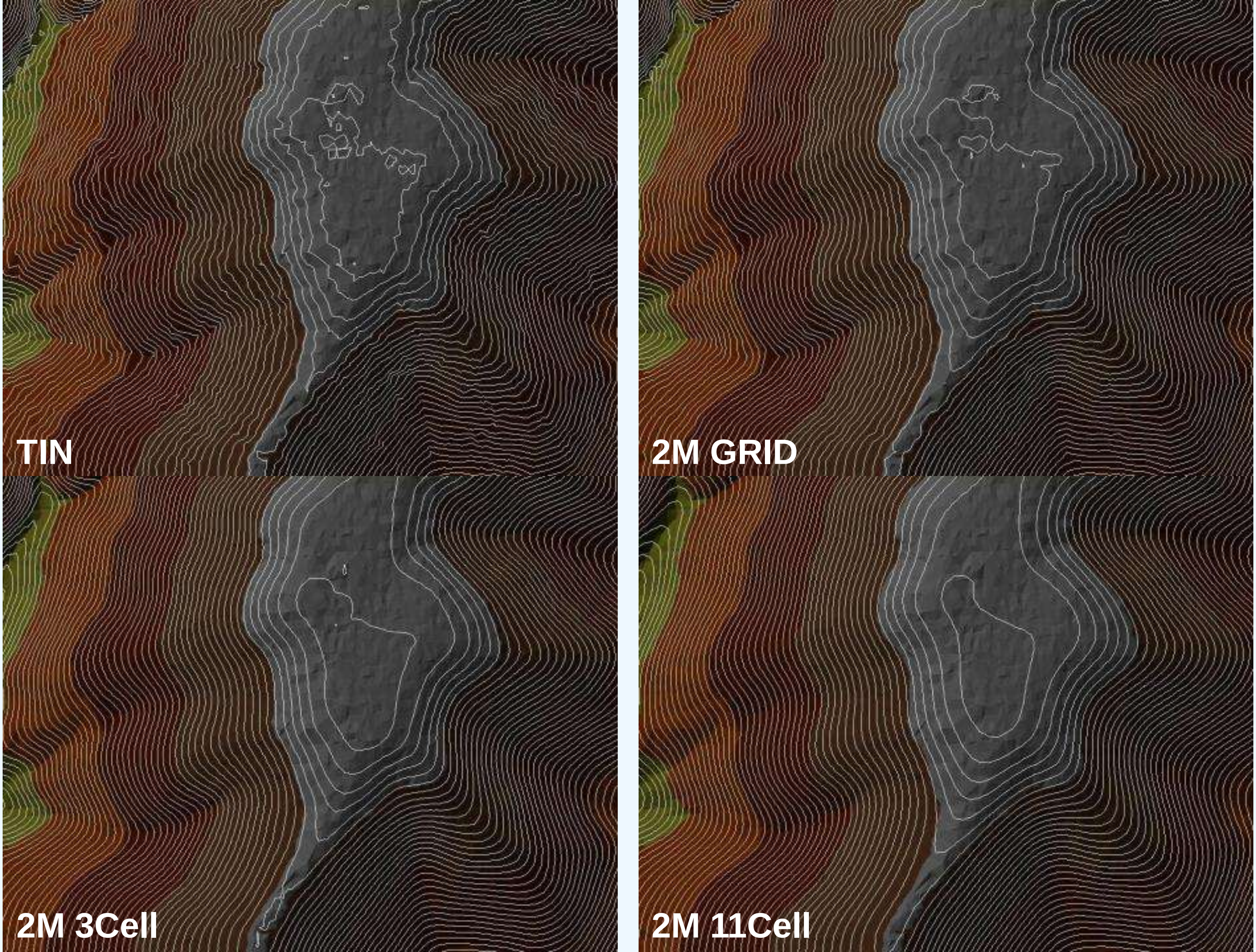
- Difference in level of detail, or just a difference in interpolation?
- TIN
  - Elevation of each point is preserved
    - Vertical error (+/-7”) also preserved
    - Eliminates area from laser pulse (0.5m – 1m)
  - Slope/Aspect determined by triangulating three adjacent points
  - Vertices of extraction non-uniform due to varying triangulations
    - Harder to select generalization tolerances
  - Greater uncertainty in sample voids

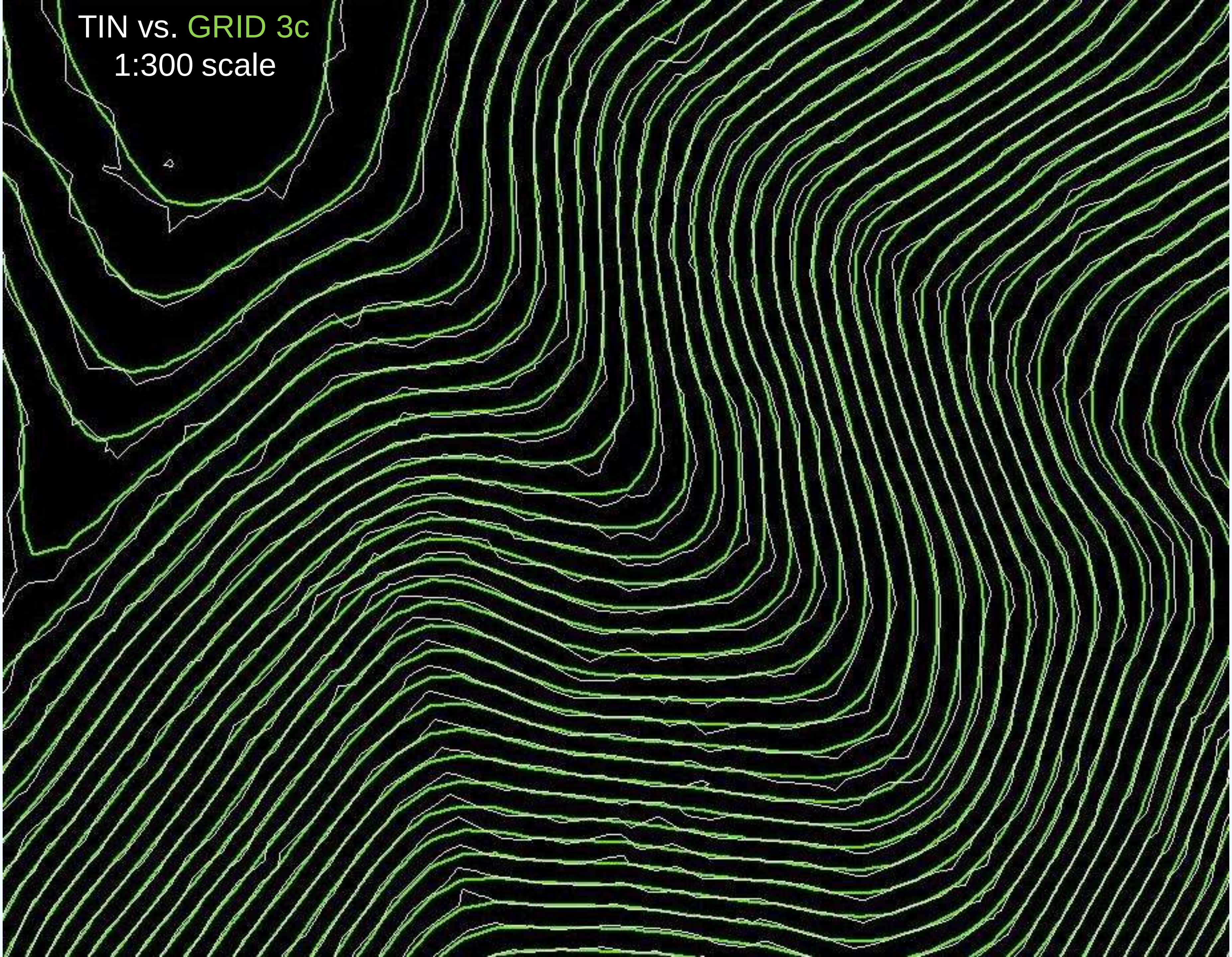


TIN vs. GRID

- GRID
  - Elevation points are "leveled" through cell averaging
    - Vertical error also leveled
  - Applies elevation values to an area rather than specific x/y coordinate
  - Vertices of extraction are more uniform due to equal cell size
    - Easier to select generalization tolerance
  - Interpolation considers more information in void areas

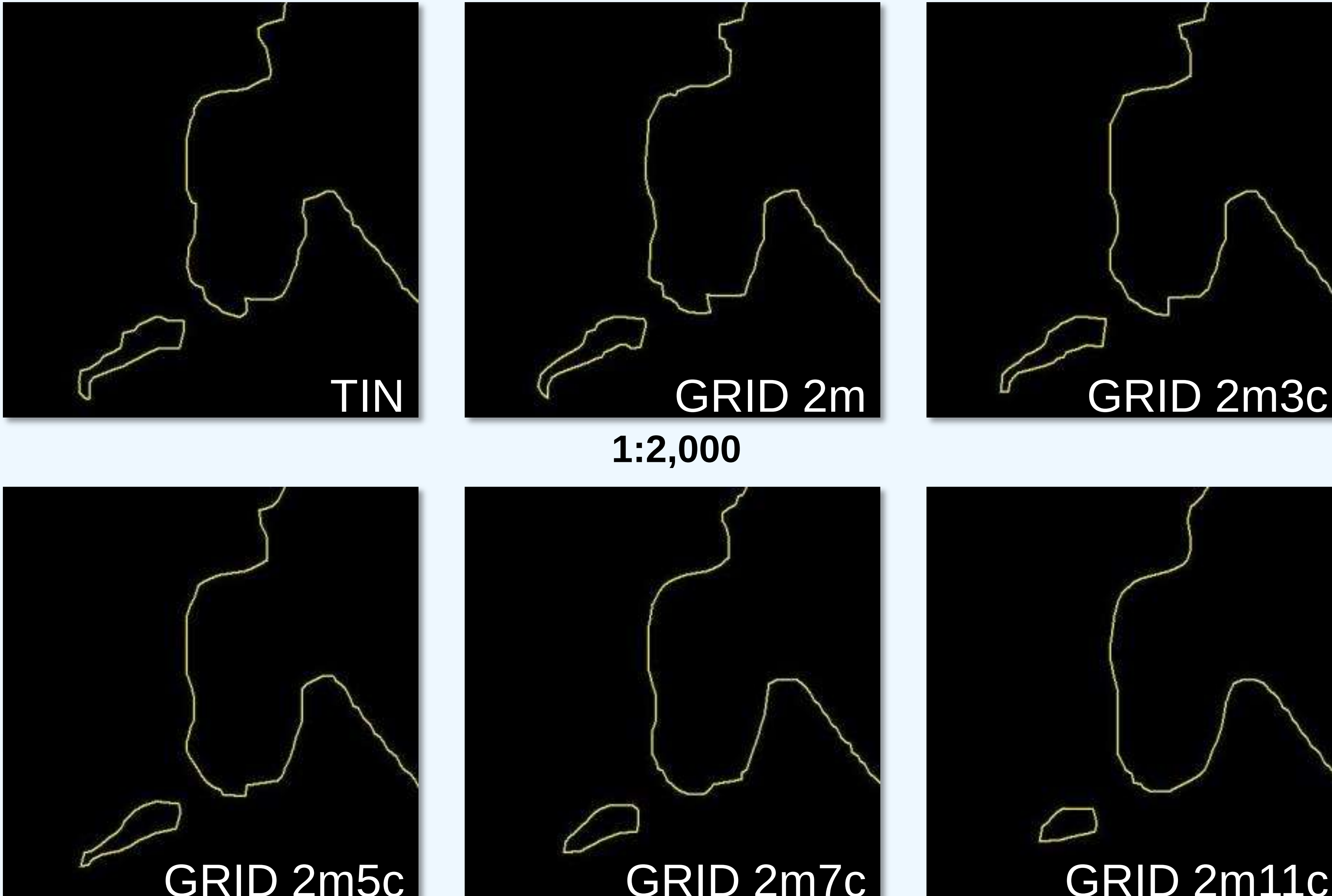



TIN
2M GRID
2M 3Cell
2M 11Cell


TIN vs. GRID 3c
1:300 scale

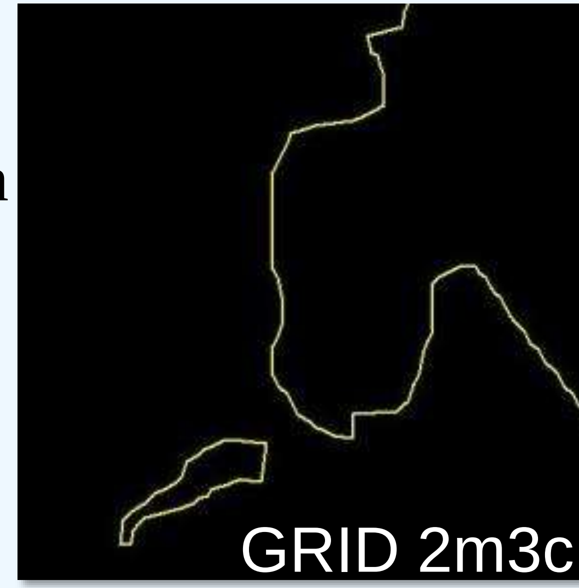
Surface Tests

- TIN from raw LAS extraction (groundshot)
- GRID (2m cellsize)
- GRID Re-sampled (Mean Neighborhood-square)
  - 3 cells
  - 5 cells
  - 7 cells
  - 11 cells
- 3 Water features
  - Des Moines River (large), North River (med.), and Butcher Creek (small)


TIN
GRID 2m
GRID 2m3c
1:2,000
GRID 2m5c
GRID 2m7c
GRID 2m11c

Surface Selection

- 3cell Re-sampled GRID surface
  - Smooth, cartographic quality delineation
  - "Clean" at 1:6,000 scale
  - Upheld accuracy standards
- FBS Audit
  - Two pass test
    - Pass 1 - Line position compared to source models (<= 1')
    - Pass 2 - Line must fall within 38' of the elevation match



FBS Audit results - Des Moines River

Source Surface	Audit Surface	Water Surface	Sample Size	Max/ Average Difference	Pass 1 - %	Pass 2 - % (38ft)	Pass 3 - % (25ft)	Pass 4 - % (5ft)
TIN	TIN	TIN	491	4.54'/0.80'	68.64%	100%	100%	96.33%
GRID 2m	GRID 2m	GRID 2m	491	3.72'/0.43'	88.80%	100%	100%	98.98%
GRID 2m 3c	**GRID 2m**	**GRID 2m**	**439**	**2.59'/0.44'**	**89.29%**	**100%**	**100%**	**99.09%**
GRID 2m 5c	GRID 2m	GRID 2m	412	3.99'/0.70'	74.03%	100%	100%	93.20%
GRID 2m 7c	GRID 2m	GRID 2m	387	4.91'/0.91'	65.63%	100%	100%	87.08%
GRID 2m 11c	GRID 2m	GRID 2m	336	9.02'/1.40'	51.79%	100%	99.70%	70.83%
GRID 2m 3c	**TIN**	**TIN**	**439**	**2.77'/0.51'**	**86.10%**	**100%**	**100%**	**97.69%**

FBS Audit results - North River

Source Surface	Audit Surface	Water Surface	Sample Size	Max/ Average Difference	Pass 1 - %	Pass 2 - % (38ft)	Pass 3 - % (25ft)	Pass 4 - % (5ft)
TIN	TIN	TIN	1084	11.55'/1.12'	66.88%	100%	99.72%	83.39%
GRID 2m	GRID 2m	GRID 2m	1068	4.02'/0.36'	91.57%	100%	100%	98.13%
GRID 2m 3c	**GRID 2m**	**GRID 2m**	**991**	**5.39'/0.41'**	**88.80%**	**100%**	**100%**	**96.57%**
GRID 2m 5c	GRID 2m	GRID 2m	913	4.85'/0.54'	83.46%	100%	100%	93.10%
GRID 2m 7c	GRID 2m	GRID 2m	782	7.28'/0.67'	79.67%	100%	100%	87.98%
GRID 2m 11c	GRID 2m	GRID 2m	604	5.46'/0.99'	65.07%	99.17%	99.01%	70.53%
GRID 2m 3c	**TIN**	**TIN**	**991**	**6.34'/0.46'**	**85.77%**	**100%**	**100%**	**96.37%**

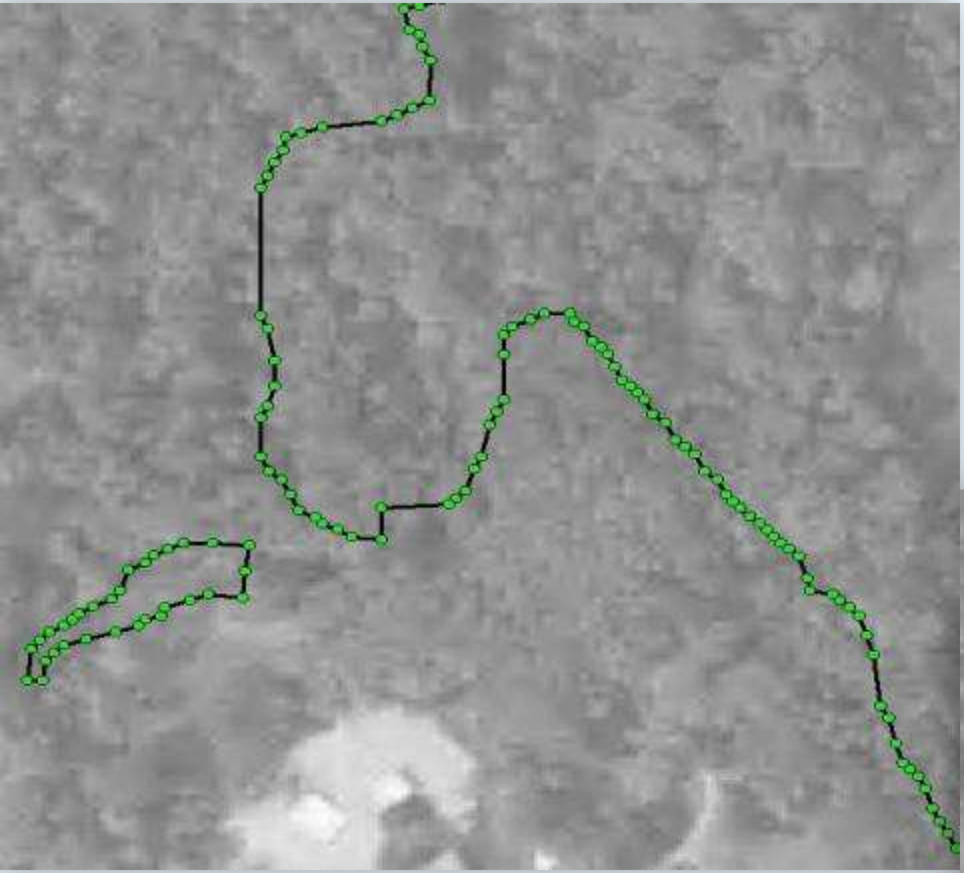
FBS Audit results - Butcher Creek

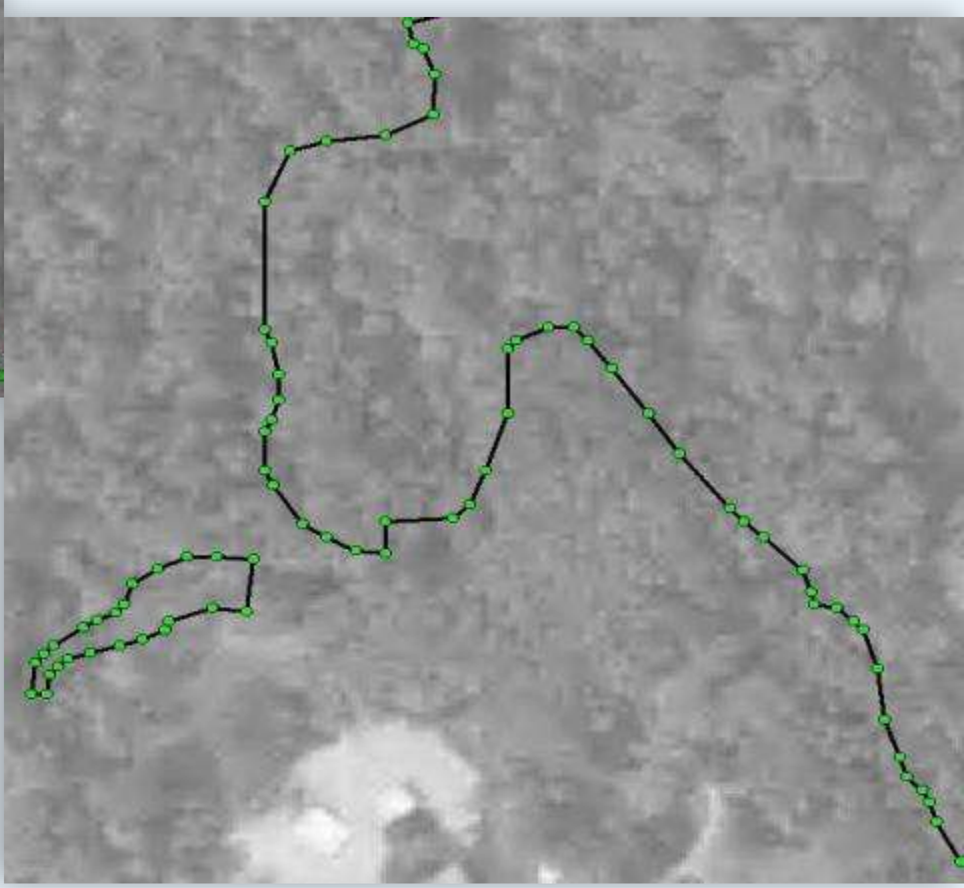
Source Surface	Audit Surface	Water Surface	Sample Size	Max/ Average Difference	Pass 1 - %	Pass 2 - % (38ft)	Pass 3 - % (25ft)	Pass 4 - % (5ft)
TIN	TIN	TIN	521	4.75'/0.29'	95.20%	99.81%	99.42%	98.08%
GRID 2m	GRID 2m	GRID 2m	484	4.33'/0.37'	90.91%	99.59%	99.17%	95.45%
GRID 2m 3c	**GRID 2m**	**GRID 2m**	**441**	**4.27'/0.43'**	**87.53%**	**99.77%**	**98.87%**	**95.69%**
GRID 2m 5c	GRID 2m	GRID 2m	409	4.79'/0.51'	86.06%	99.76%	99.27%	91.93%
GRID 2m 7c	GRID 2m	GRID 2m	386	6.00'/0.6'8	78.76%	99.74%	99.48%	85.23%
GRID 2m 11c	GRID 2m	GRID 2m	370	7.07'/0.99'	67.30%	98.92%	97.57%	70.27%
GRID 2m 3c	**TIN**	**TIN**	**441**	**4.69'/0.50'**	**86.85%**	**99.77%**	**99.32%**	**95.01%**

Surface Processing Comparison

Surface	Spatial Extent	Overall Time	Direct Labor Time	File Size (rounded)	MB/sq.mi.	Comments
TIN	North River (4 sq. mi.)	12 hours	9 hours	400 MB	100 MB	• Large footprint •Extensive staff time
GRID 2m (and 4 versions)	Warren County (715 sq. mi.)	4 hours	1 hour	1800 MB	2.5 MB	•Smaller footprint •Simple processing

Line Generalization

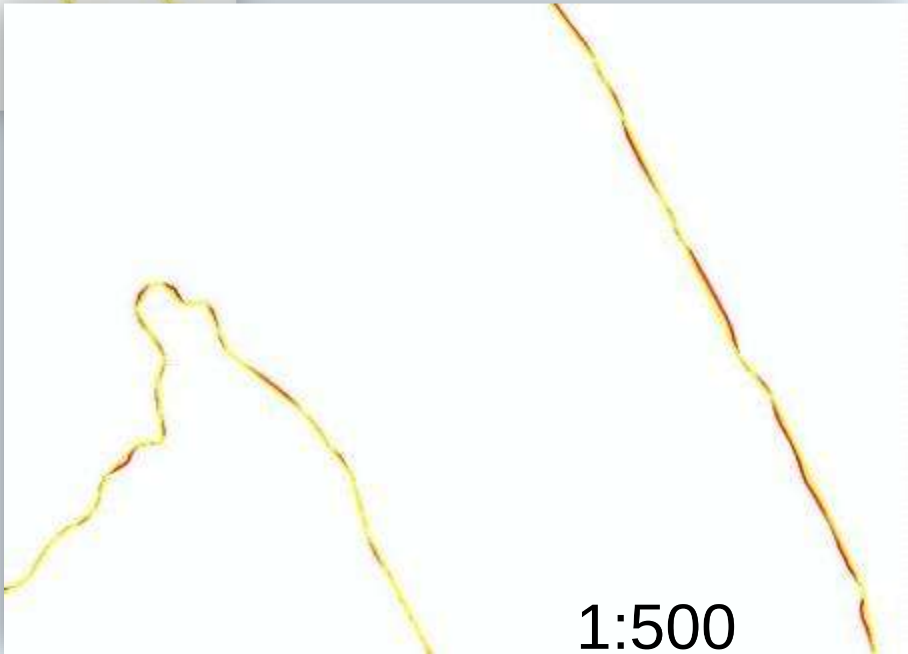




Line Generalization Results

Location	Line Length Pre-Simp	# of Vertices Pre-Simp	Line Length Post-Simp	# of Vertices Post-Simp	Line Length Reduction %	Vertex Reduction %
North River	35,118 m/ 115,217 ft	3,763	34,440 m/ 112,992 ft	2,482	**2%**	**> 34%**
Des Moines River	14,786 m/ 48,510 ft	2,884	14,611 m/ 47,936 ft	1418	**1%**	**> 51%**
Butcher Creek	14,935 m/ 48,999 ft	2,385	14,461 m/ 47,445 ft	1,547	**3%**	**> 35%**

- TINs used for re-delineated flooding
- Flooding produced 1,280,003 vertices
- Simplified by 1m = 177,311 vertices
- Poly size 39.1MB vs. 5.5MB



Generalized FBS Audit results

Location	Sample Size	Average Difference	Pass 1 - %	Pass 2 - % (38ft)	Pass 2 - % (25ft)	Pass 2 - % (5ft)
North River (Pre-Simp)	991	5.39’/0.41’	88.80%	100%	100%	96.57%
North River (Post-Simp)	**989**	**5.39’/0.41’**	**88.88%**	**100%**	**100%**	**96.26%**
Des Moines River (Pre-Simp)	439	2.59’/0.44’	89.29%	100%	100%	99.09%
Des Moines River (Post-Simp)	**432**	**2.68/0.50’**	**86.11%**	**100%**	**100%**	**98.38%**
Butcher Creek (Pre-Simp)	441	4.27’/0.43’	87.53%	99.77%	98.87%	95.69%
Butcher Creek (Post-Simp)	**425**	**4.11’/0.44’**	**88.71%**	**99.76%**	**99.53%**	**95.06%**

Conclusions

- LiDAR elevation data for Iowa could afford generalization
- Time savings allows for more time dedicated to QA/QC
- Produce quality product more efficiently
- TINs are not necessarily more accurate than Rasters when interpolating surfaces
- Capable of meeting FEMA DFIRM mapping specifications

Benefits Realized

- Surface generation was completed in 1/3rd of the time it takes to produce TIN surfaces
- Estimated 97% storage savings
- Linework more smooth, representative of real world phenomena, and streamlined map production

Comments/Questions?

- Acknowledgements

  - Aurore Larson, P.E., CFM – Greenhorne & O'Mara – Water Resources Services
  - Carmen Burducea, CFM – Greenhorne & O'Mara – Water Resources Services
  - Zachary J. Baccala, Senior GIS Analyst – PBS&J – Floodplain Management Division

- References

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