Using LiDAR to Determine Vegetation Heights in a Rangeland Environment

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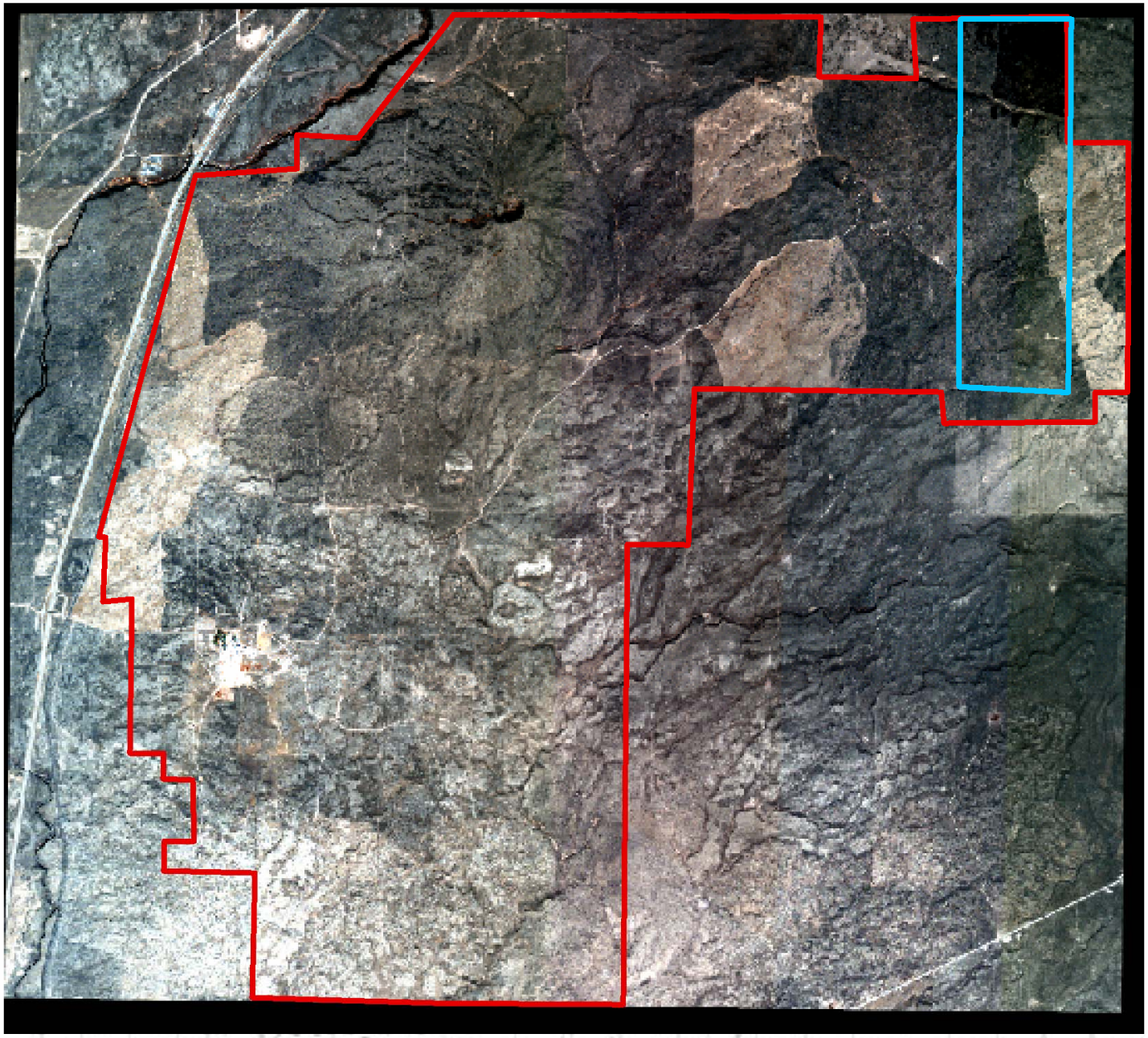
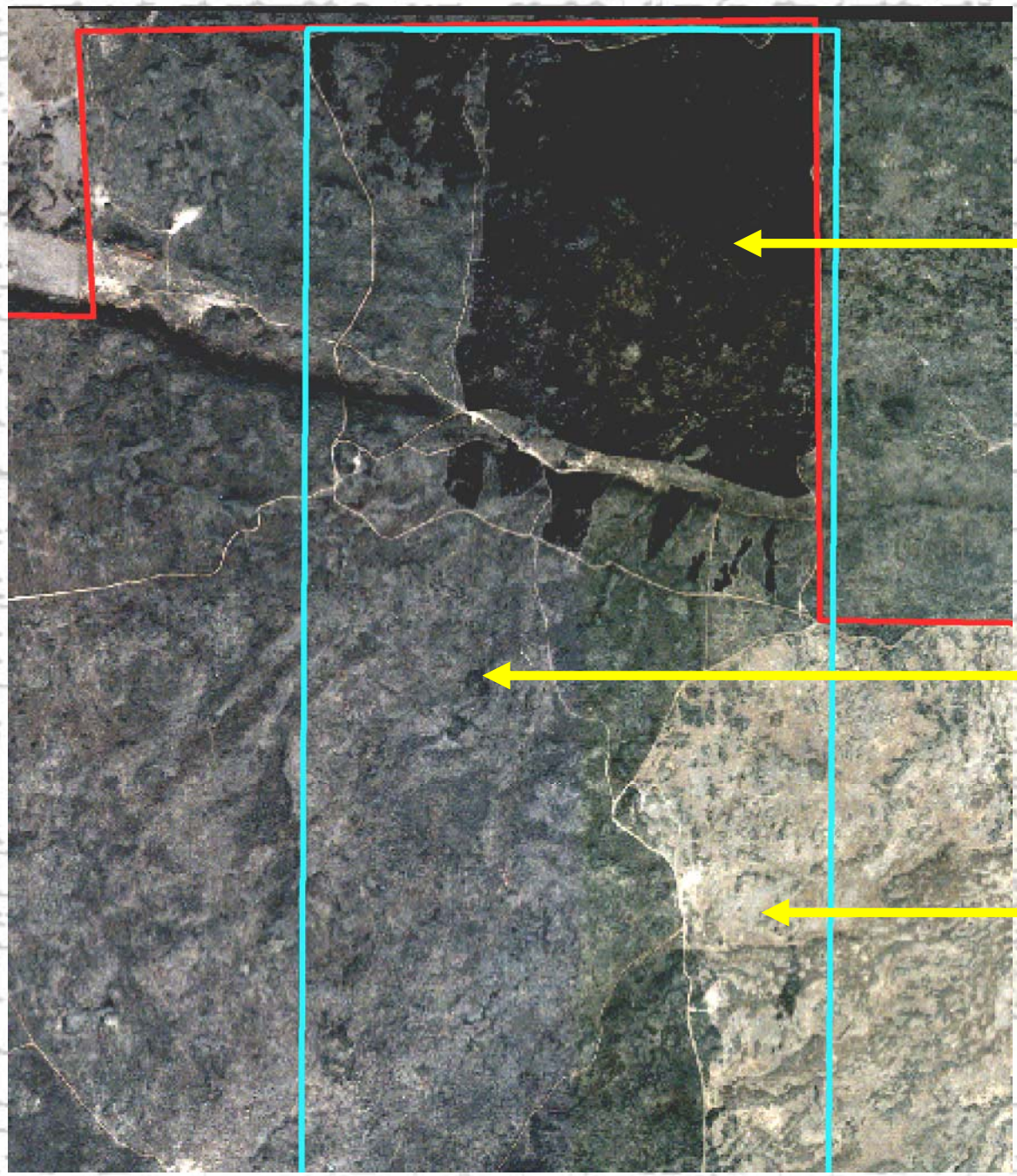
- Major Species
  - Mountain Sagebrush
  - Rabbitbrush, Horsebrush
  - Thickspike wheatgrass, Plains reedgrass, Idaho fescue

- Heights of 50 - 150 cm




2002 Burn
Unburned Sagebrush
1995 Burn

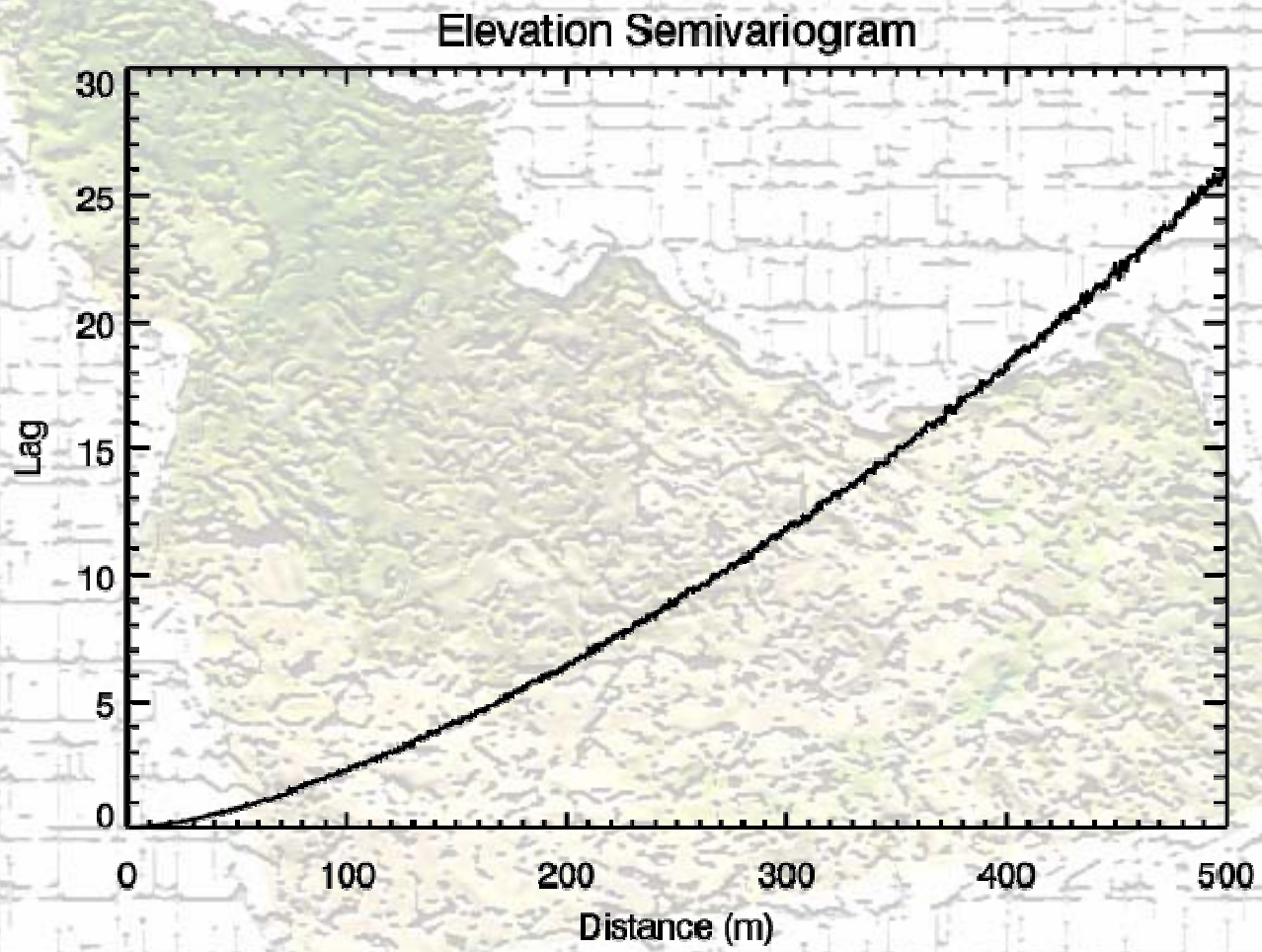
Goals of study

- **Use LiDAR to determine rangeland vegetation heights**
- **Distinguish between burned and unburned areas, brush and grasses**

Dataset Characteristics

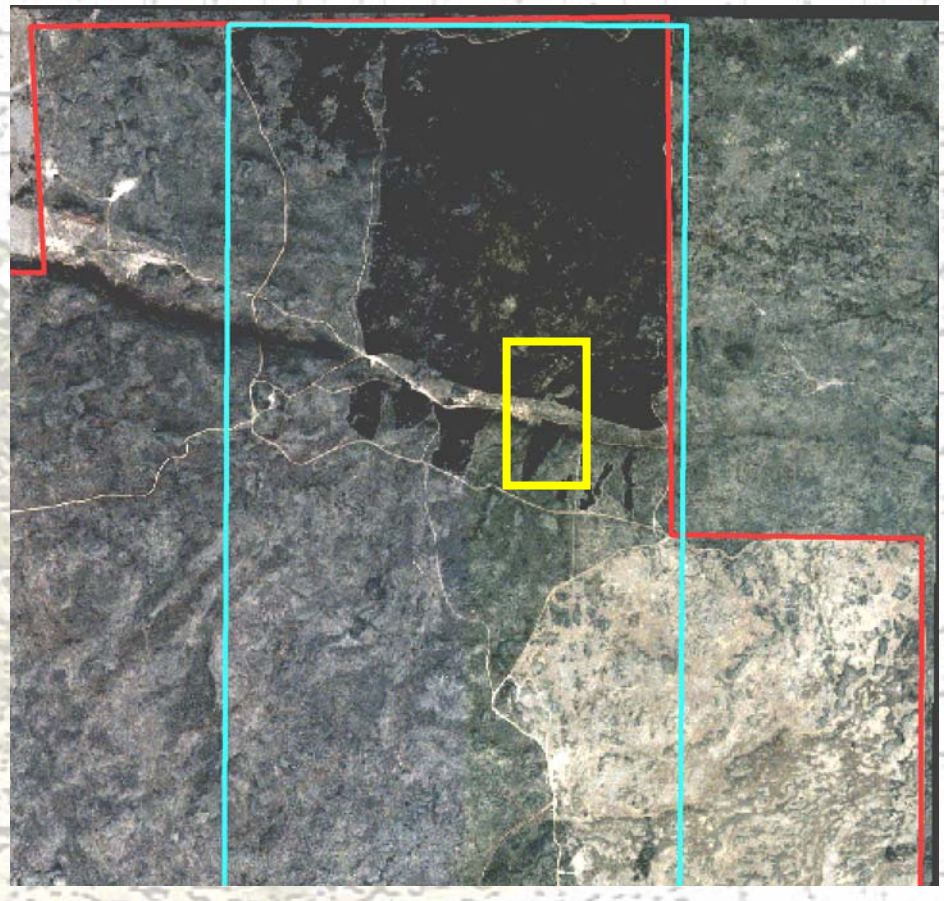
- Nine flightlines, each ~300 m wide
  - Flightline overlap of ~50%
- Total coverage of 6.9 km^2
- Over 8 million postings, each with first and last returns
  - Average spacing of < 1 m
  - Laser footprint diameter of 25 cm
- Elevation ranges over 90 m

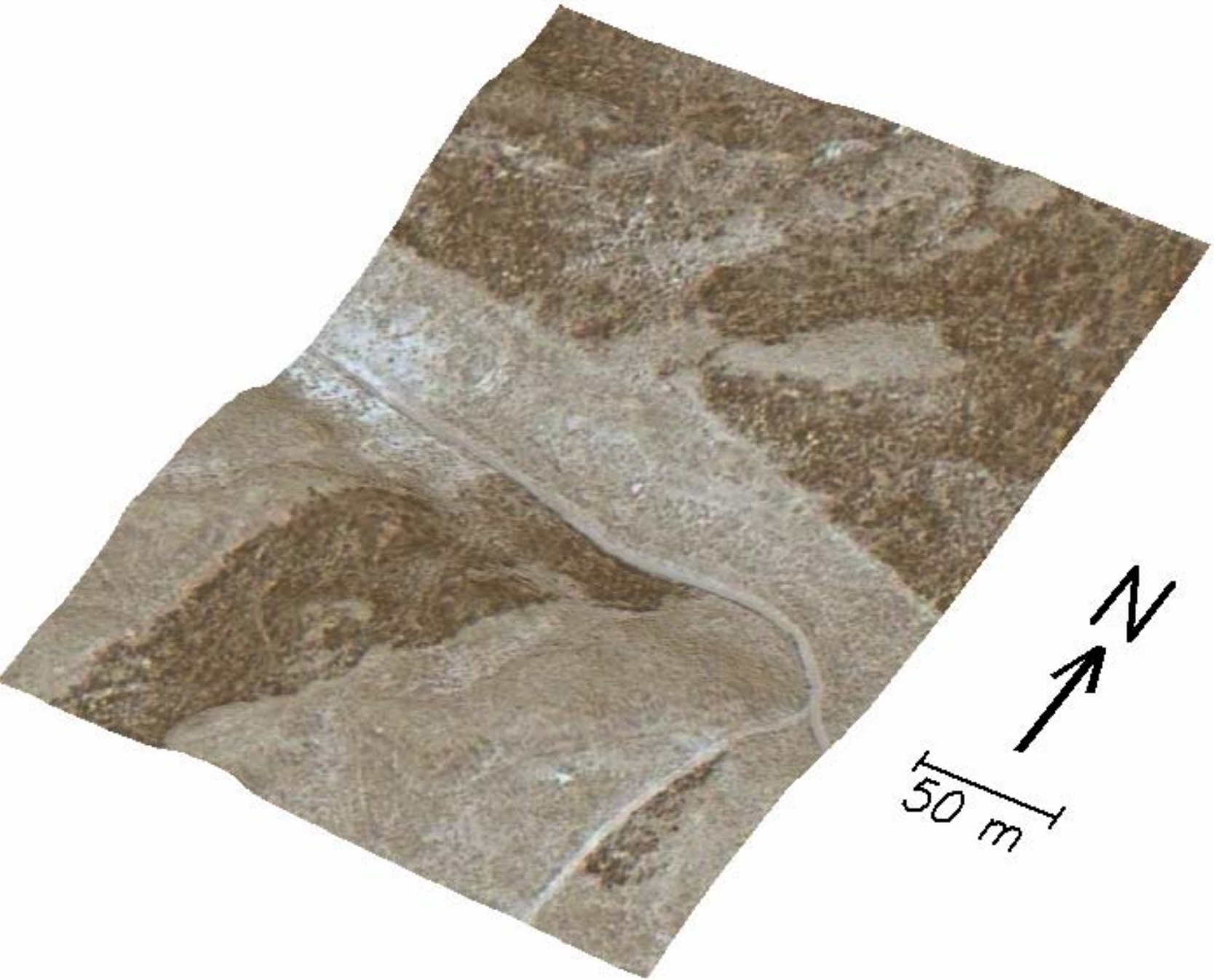
Semivariogram

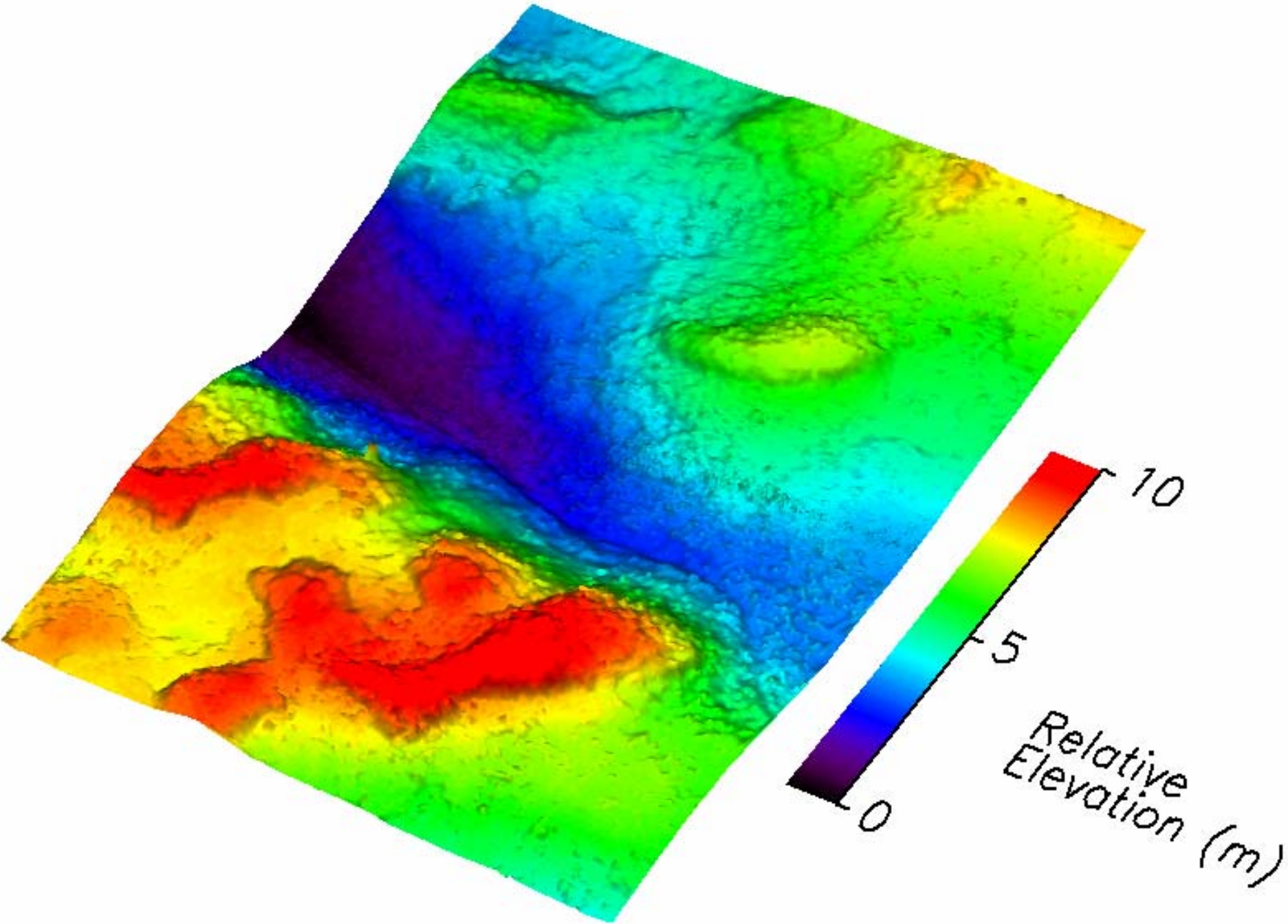


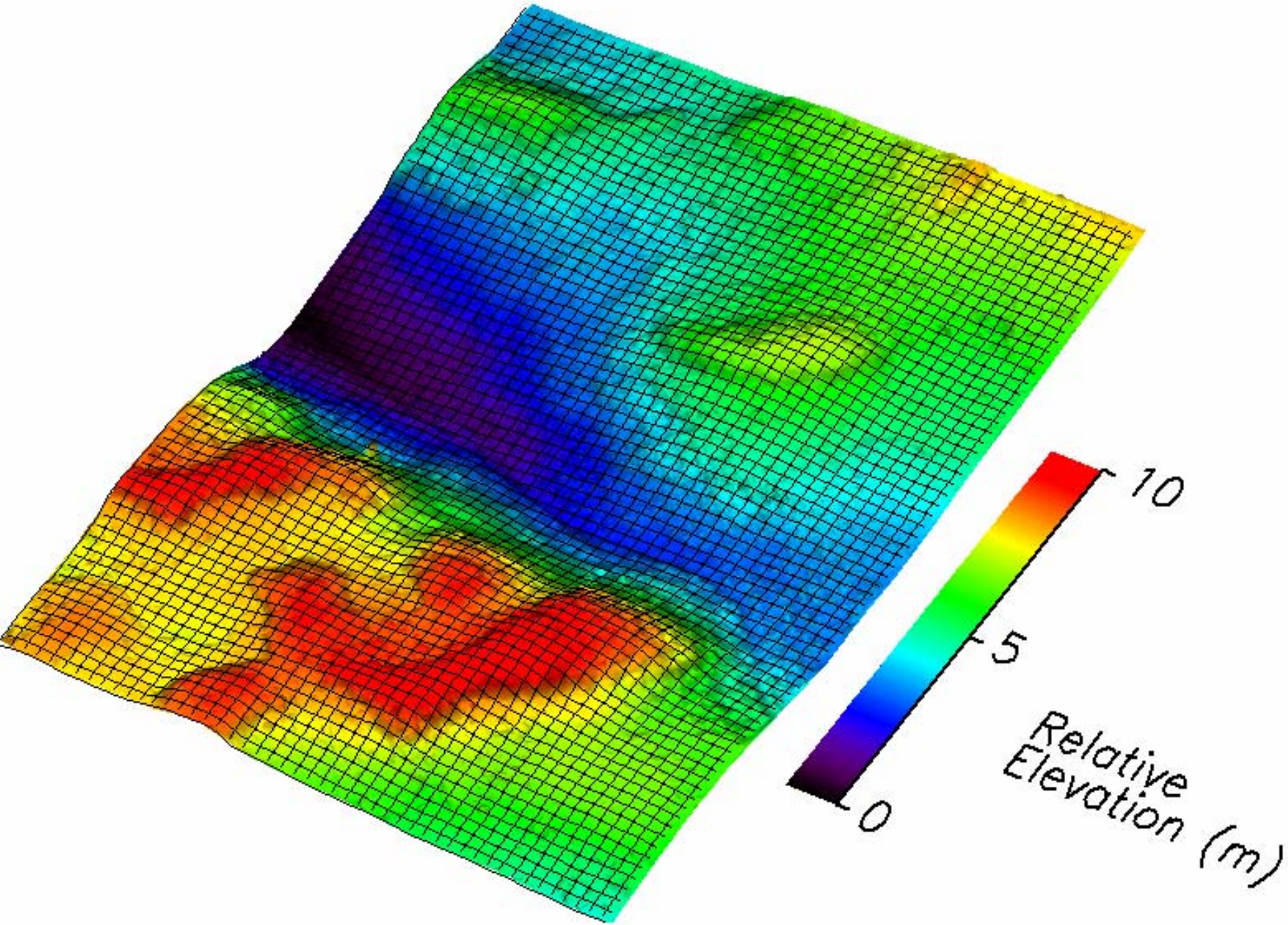
Relative Vertical Accuracy

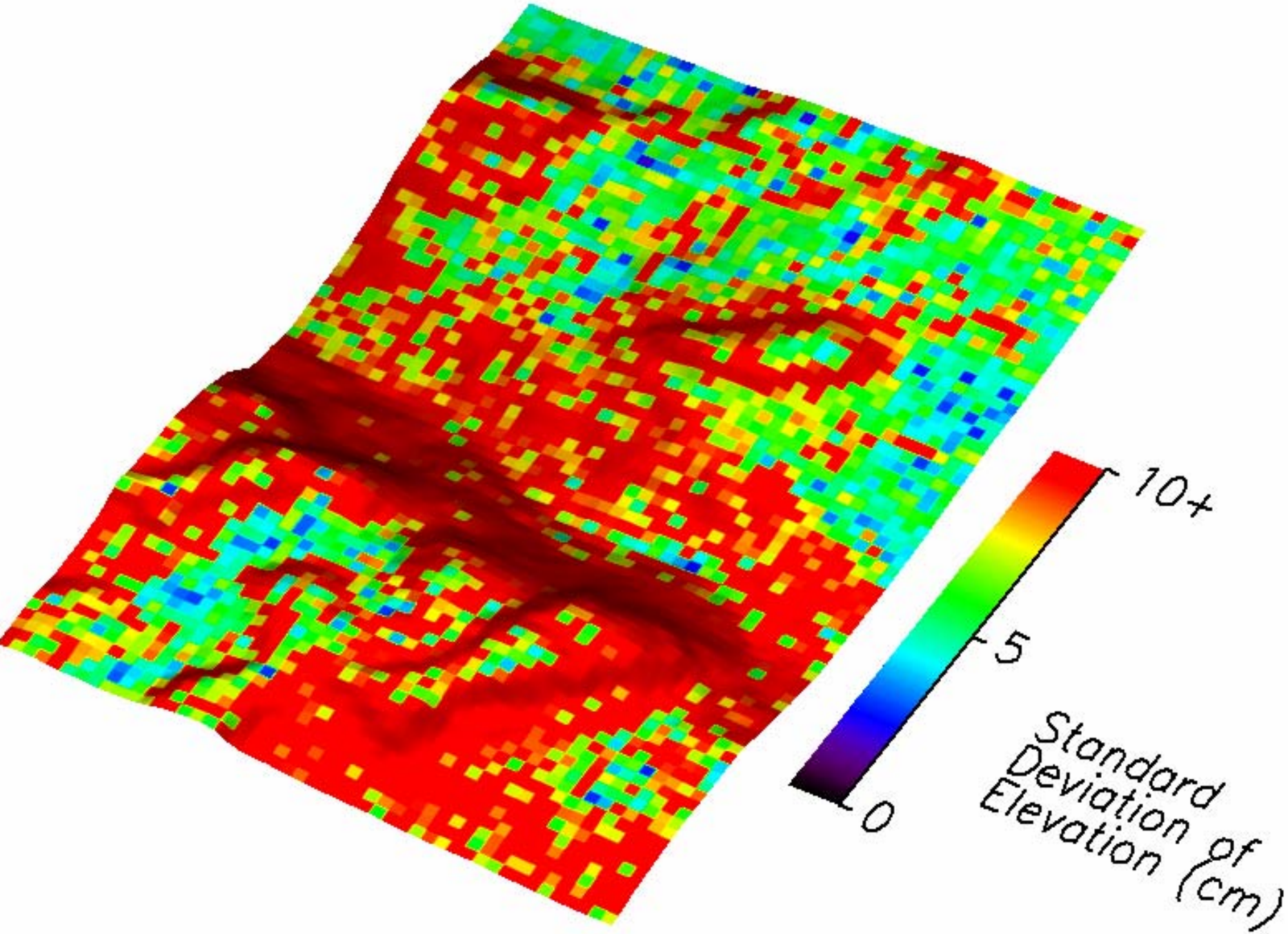
- Find flat areas
- Measure standard deviation of elevation across area
- Vertical accuracy cannot be worse than the standard deviation




N
50 m

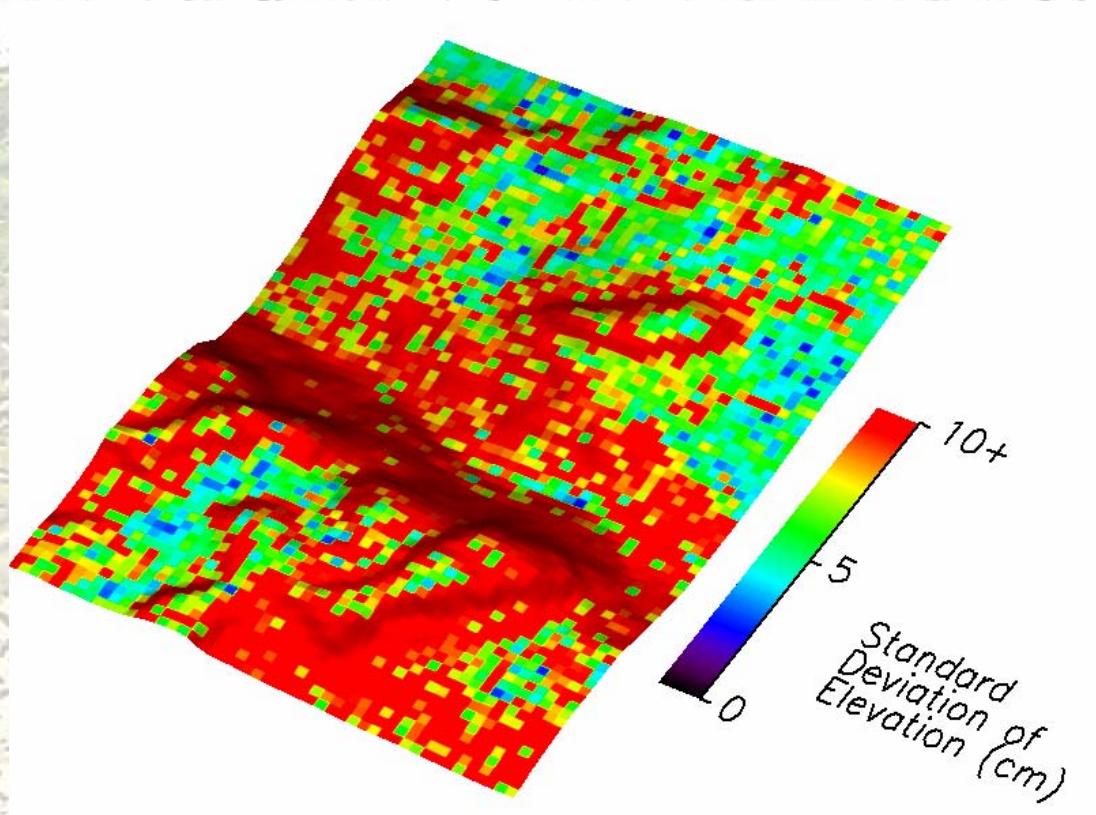

10
5
0
Relative Elevation (m)


10
5
0
Relative Elevation (m)


10+
5
0
Standard Deviation of Elevation (cm)

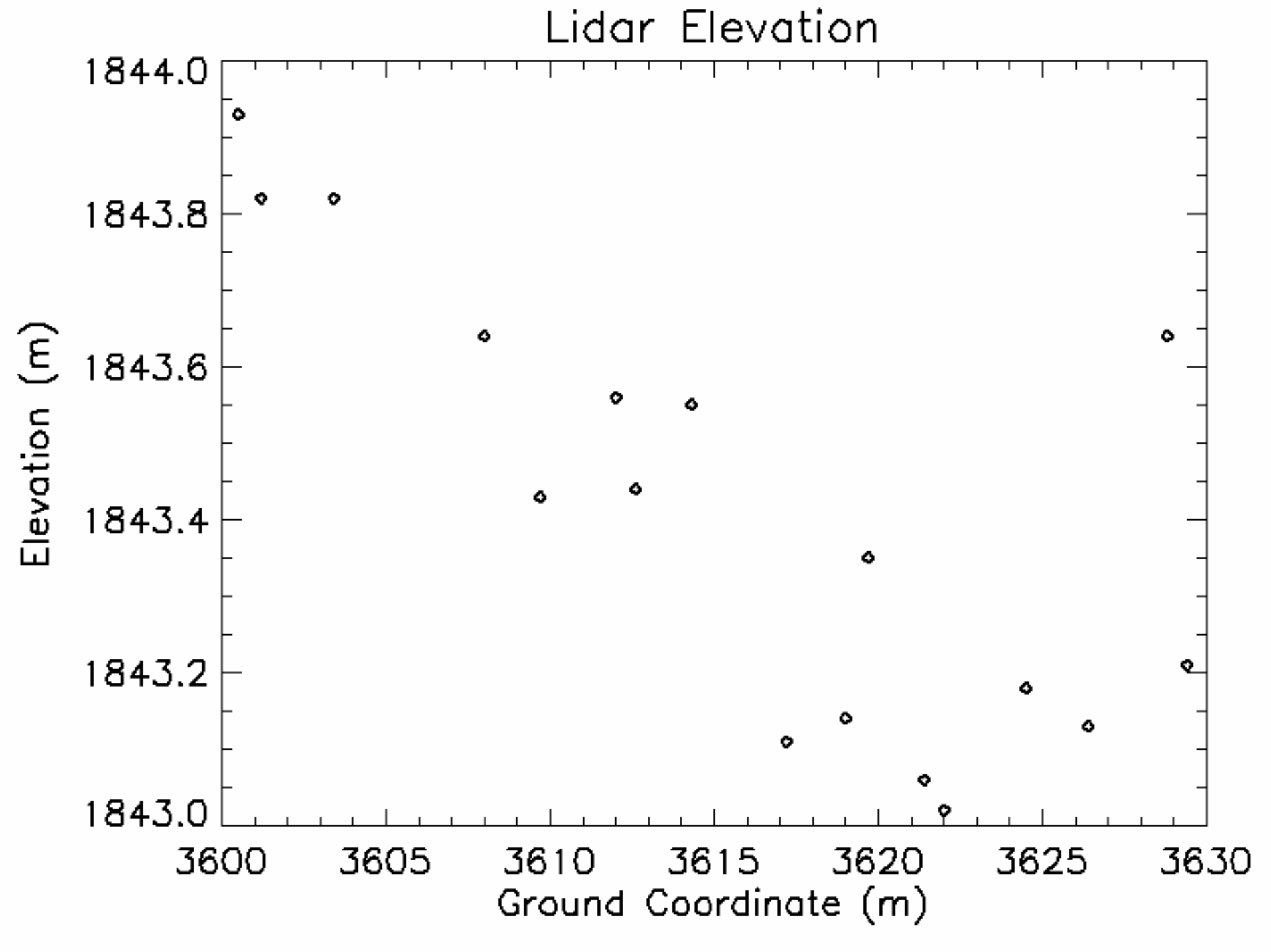
Relative Vertical Accuracy

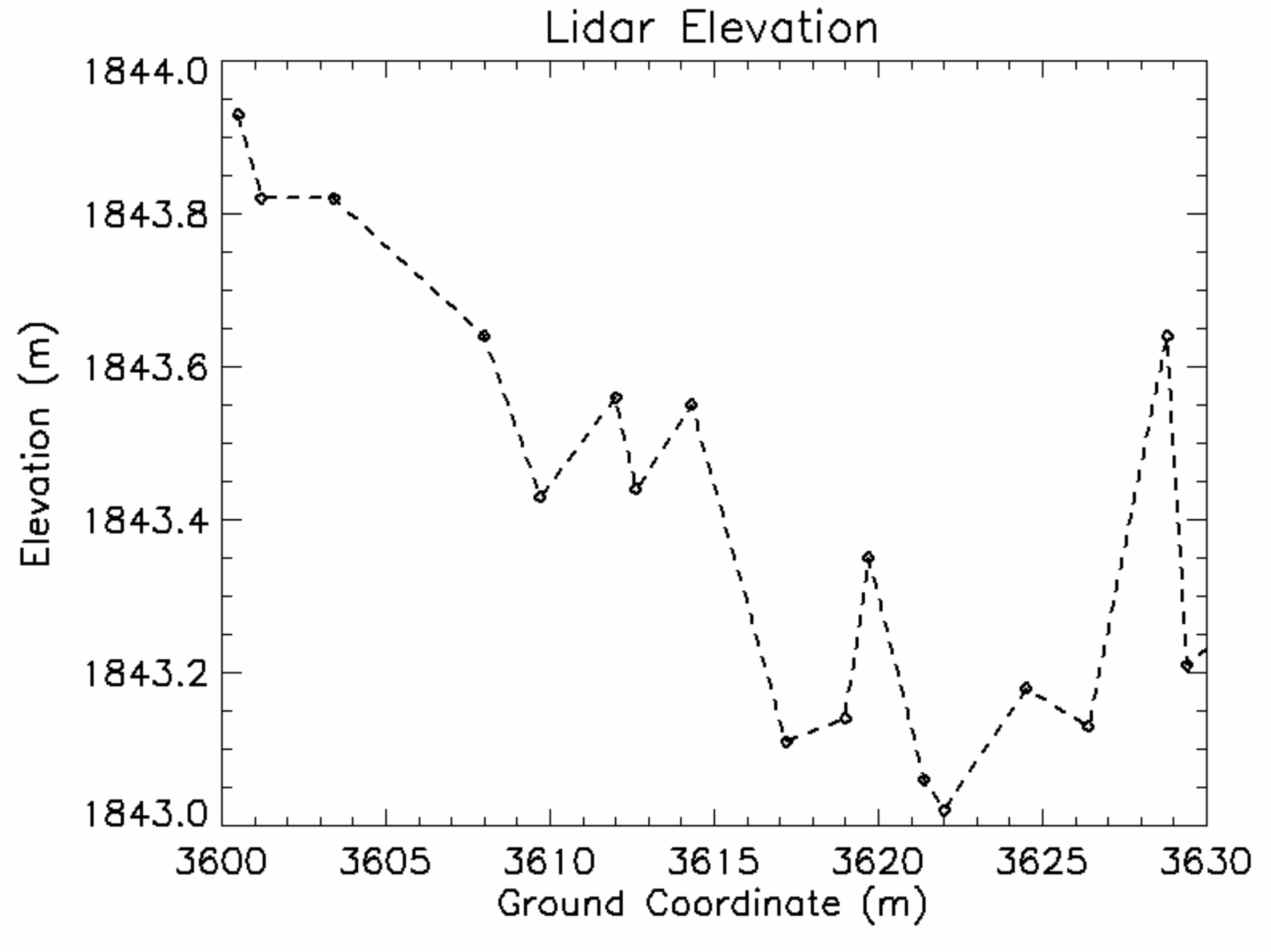
- For overlapping flightlines, relative accuracy is ~25 cm
- For individual flightlines, relative accuracy of ~5 cm can be achieved
- To maintain high accuracy, processing is performed on individual flightlines



Height Calculation

- Assumes open canopy
- Uses only last pulse data
- Lowest elevations over a 5 m grid assumed to be “ground”
- Use “ground” points to interpolate a “ground surface”
- Vegetation height calculated as difference between LiDAR height and ground surface
- Negative heights are reclassified as “ground”
- Process is iterated until convergence


Lidar Elevation
1844.0
1843.8
1843.6
1843.4
1843.2
1843.0
Elevation (m)
3600
3605
3610
3615
3620
3625
3630
Ground Coordinate (m)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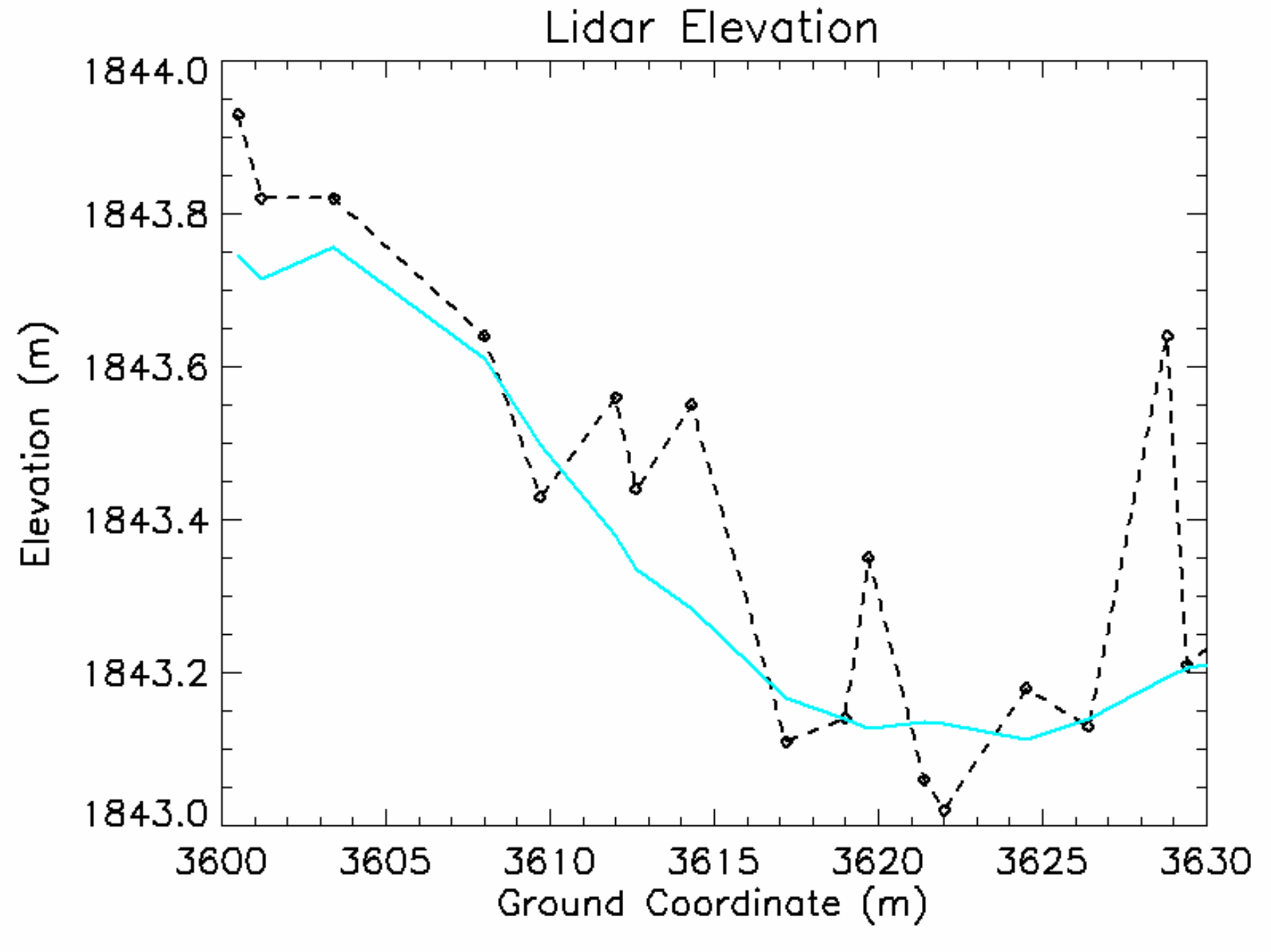
Lidar Elevation
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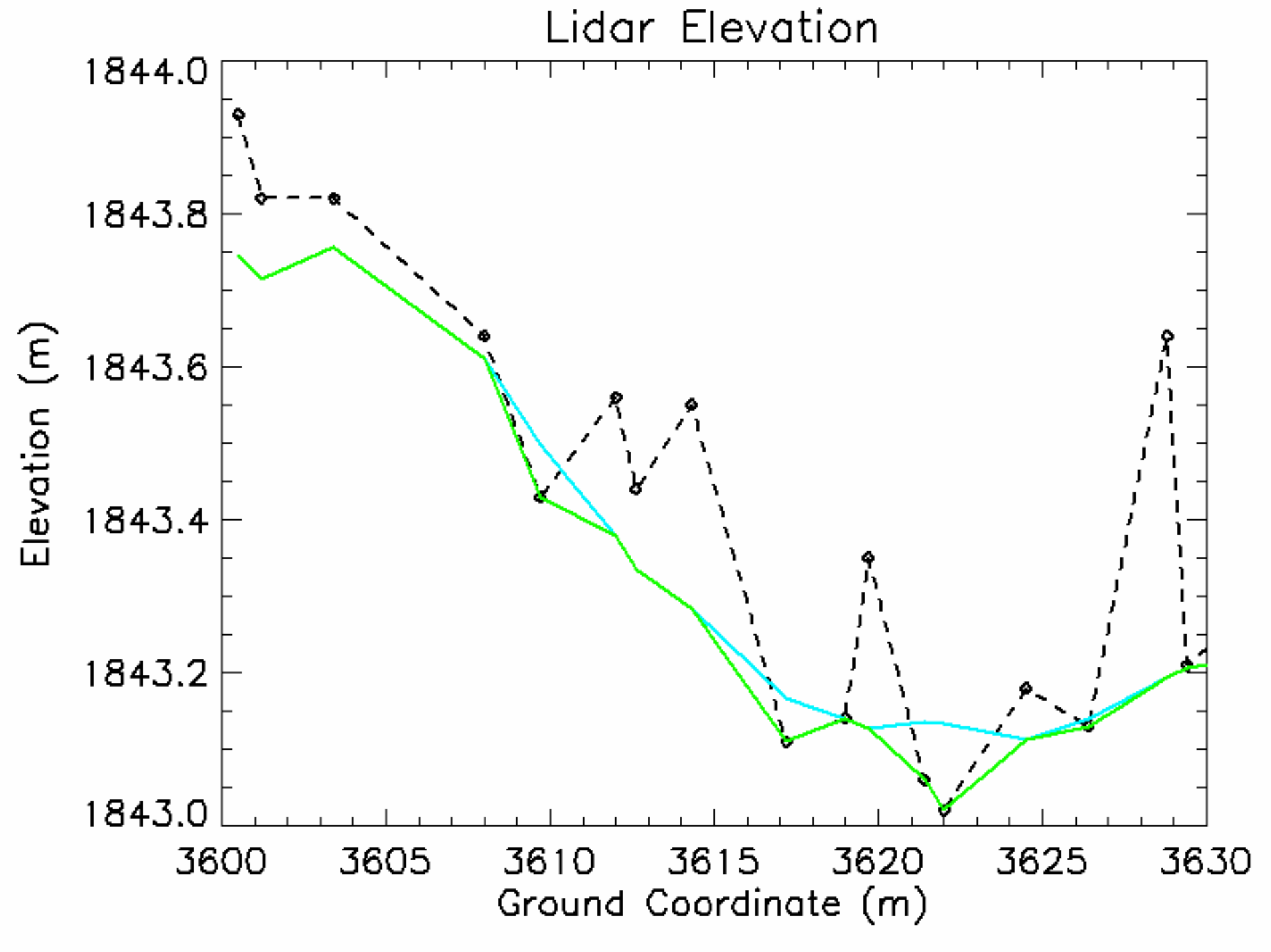
1843.8
1843.6
1843.4
1843.2
1843.0
Elevation (m)
3600
3605
3610
3615
3620
3625
3630
Ground Coordinate (m)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Elevation (m)
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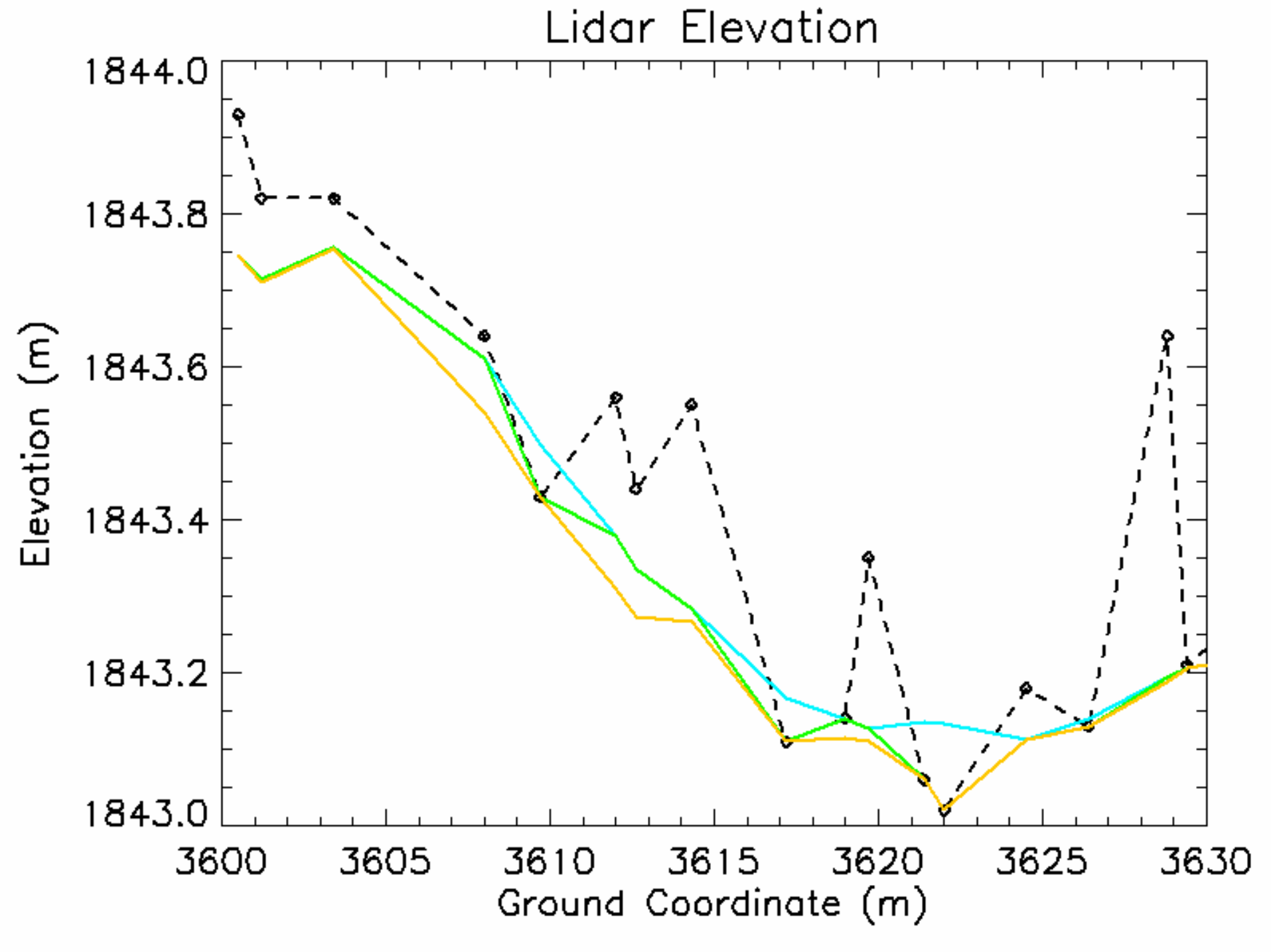
3625
3630
Ground Coordinate (m)


Lidar Elevation
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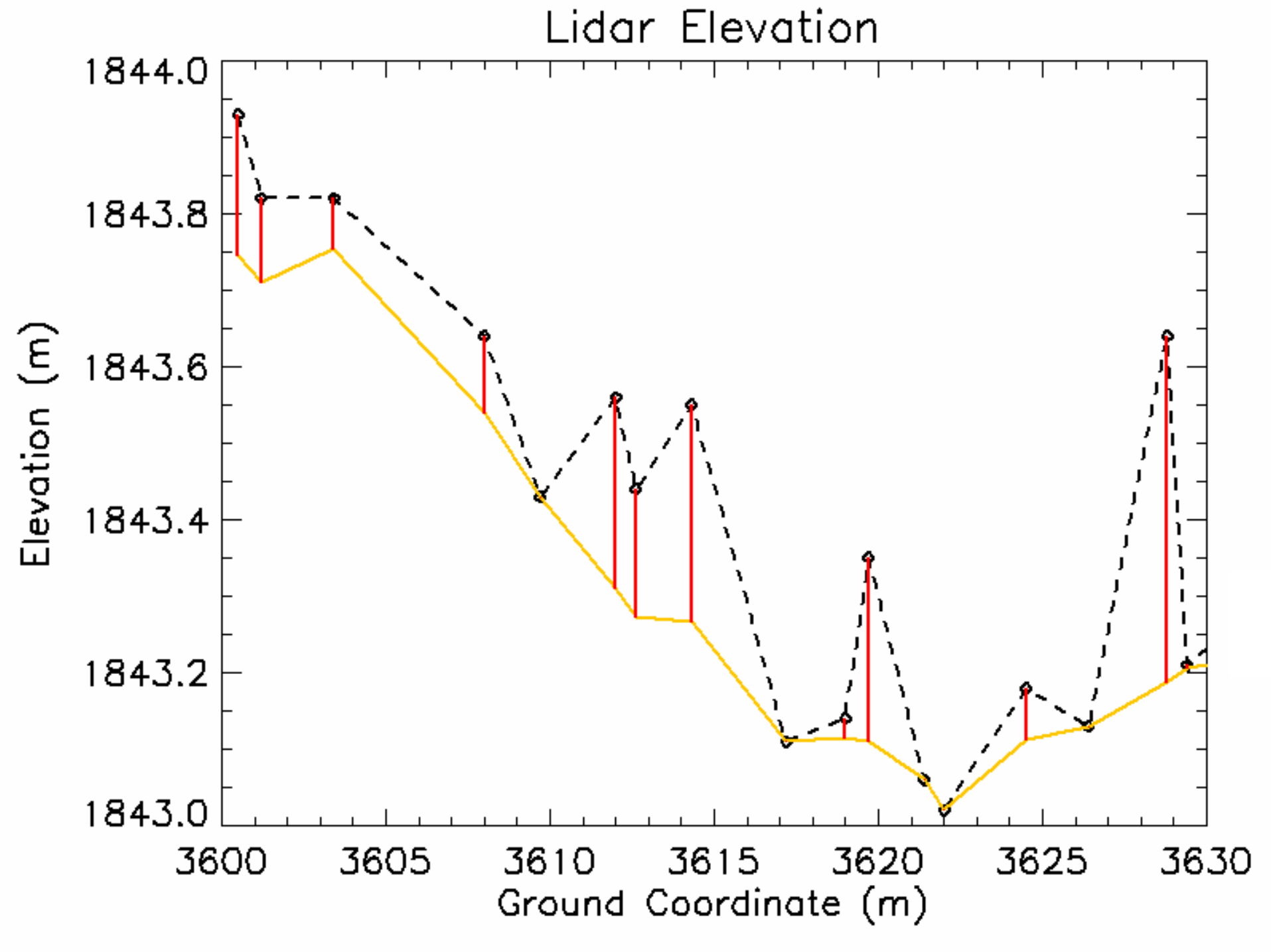
1843.8
1843.6
1843.4
1843.2
1843.0
Elevation (m)
3600
3605
3610
3615
3620
3625
3630
Ground Coordinate (m)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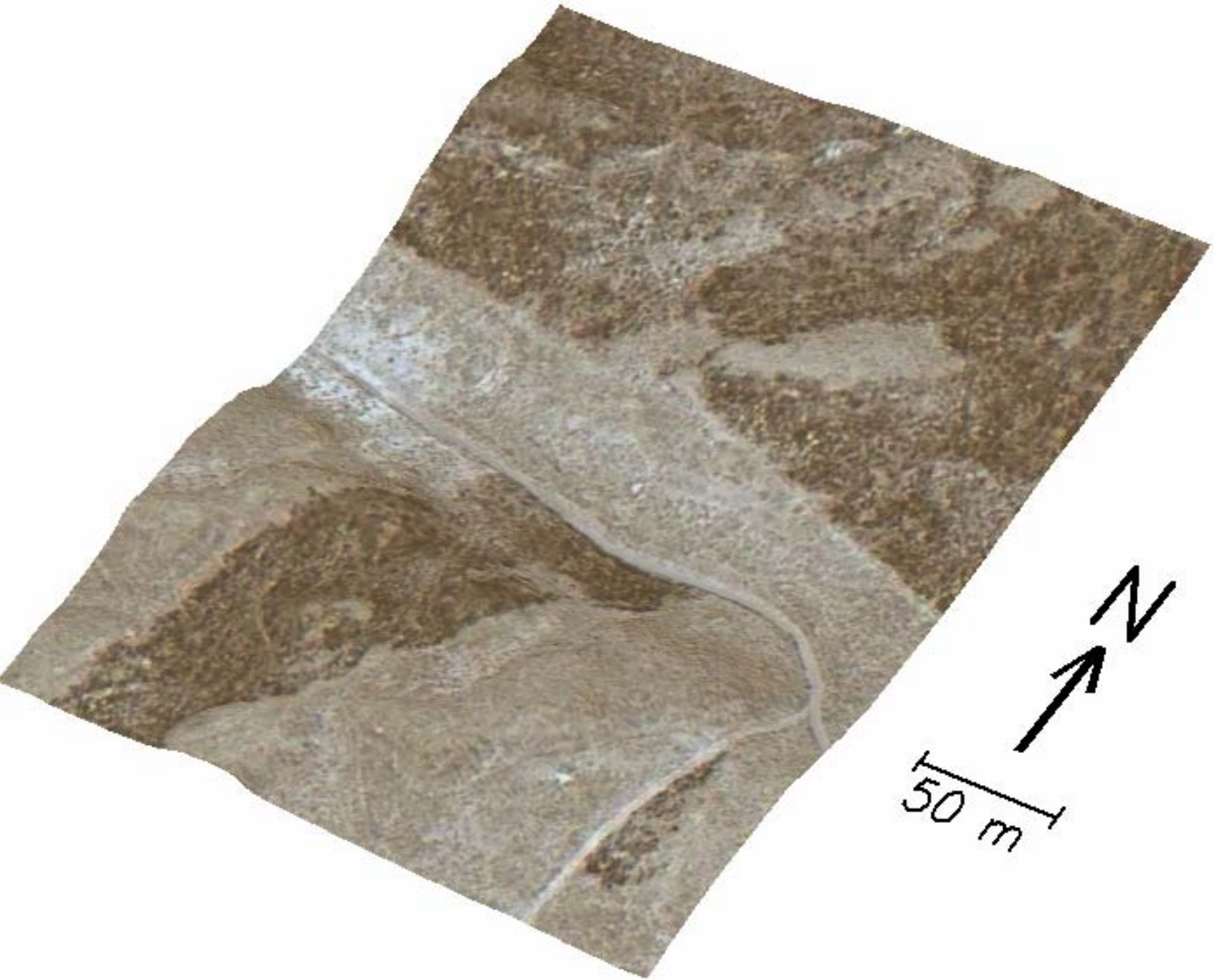
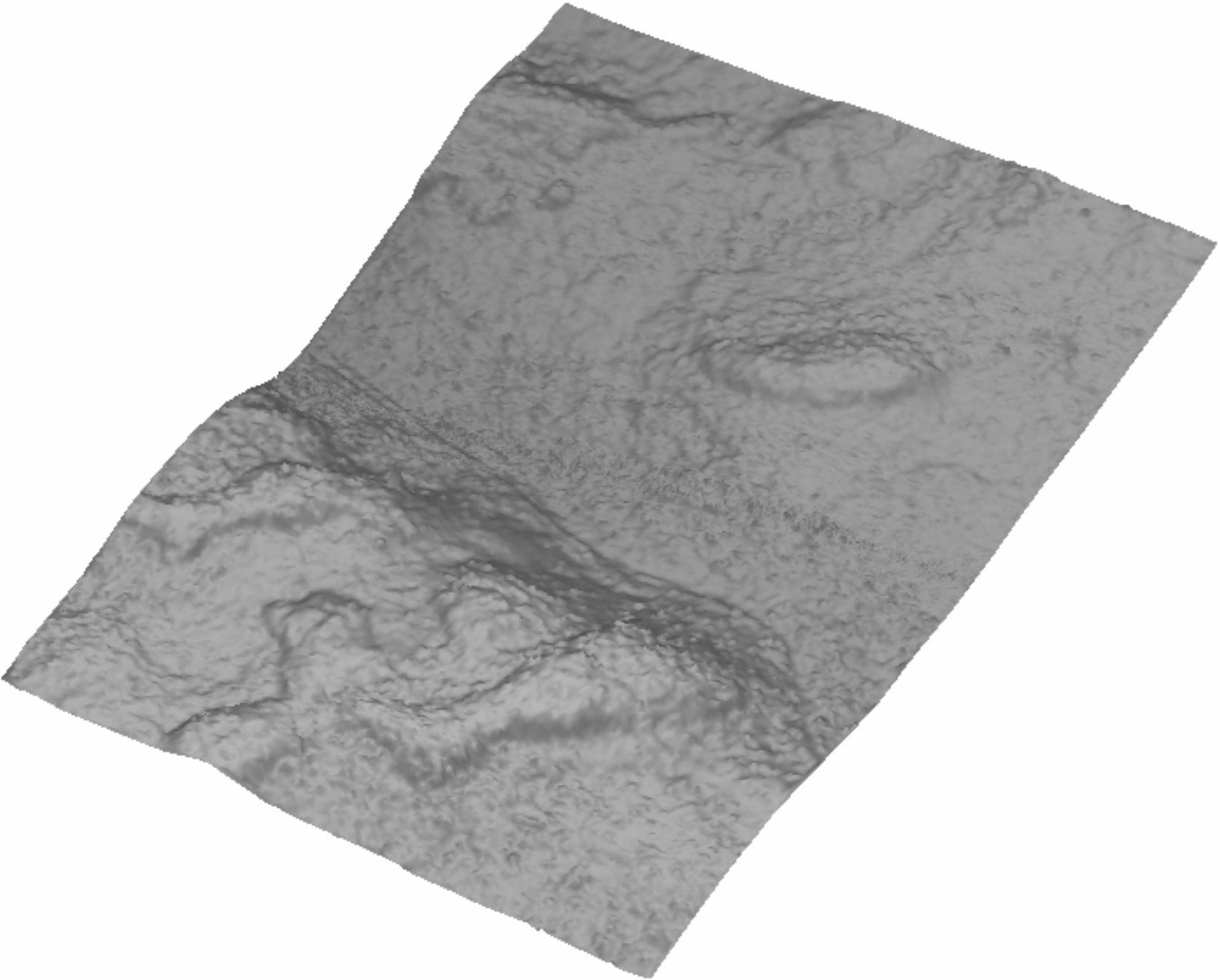
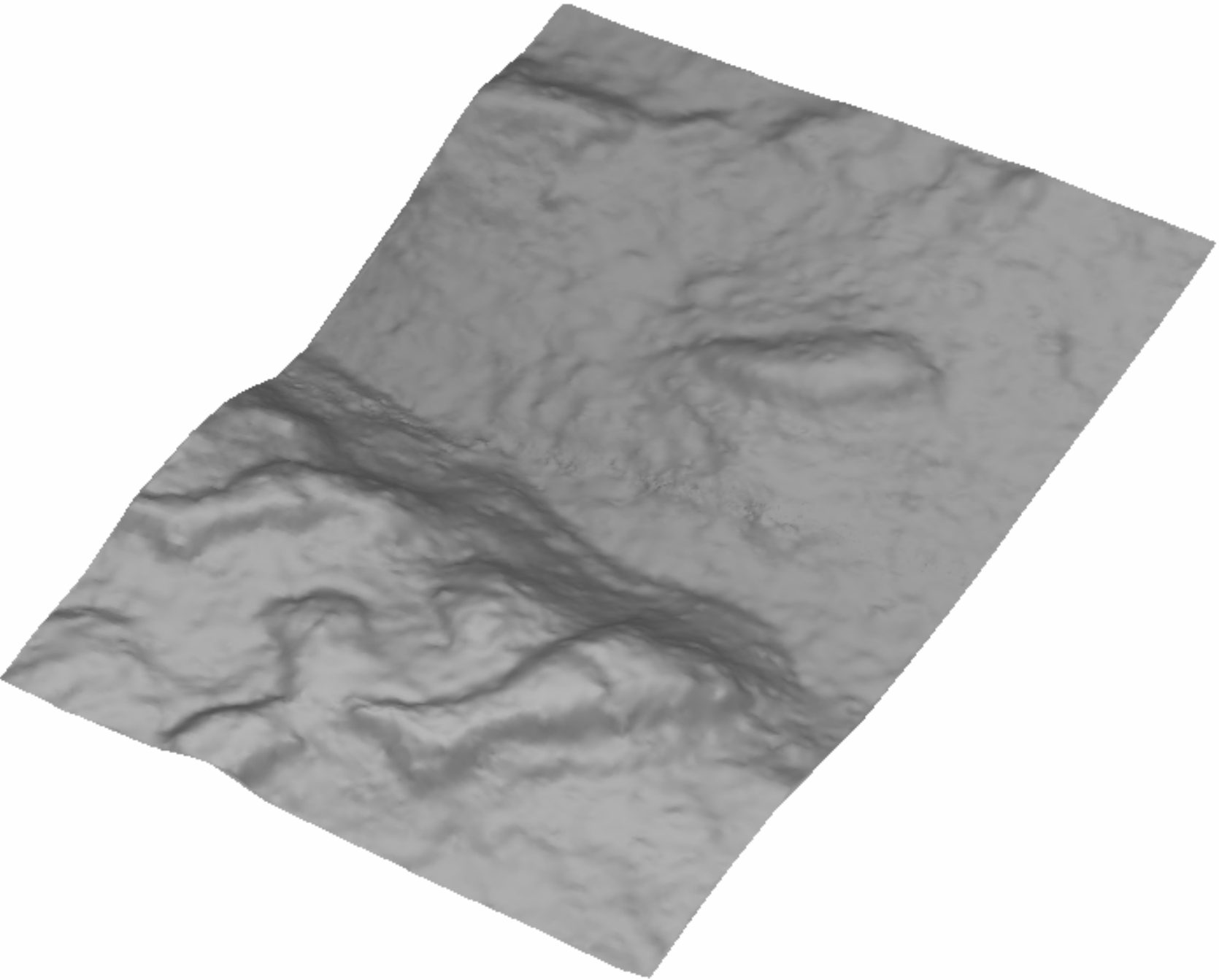
1843.8
1843.6
1843.4
1843.2
1843.0
Elevation (m)
3600
3605
3610
3615
3620
3625
3630
Ground Coordinate (m)

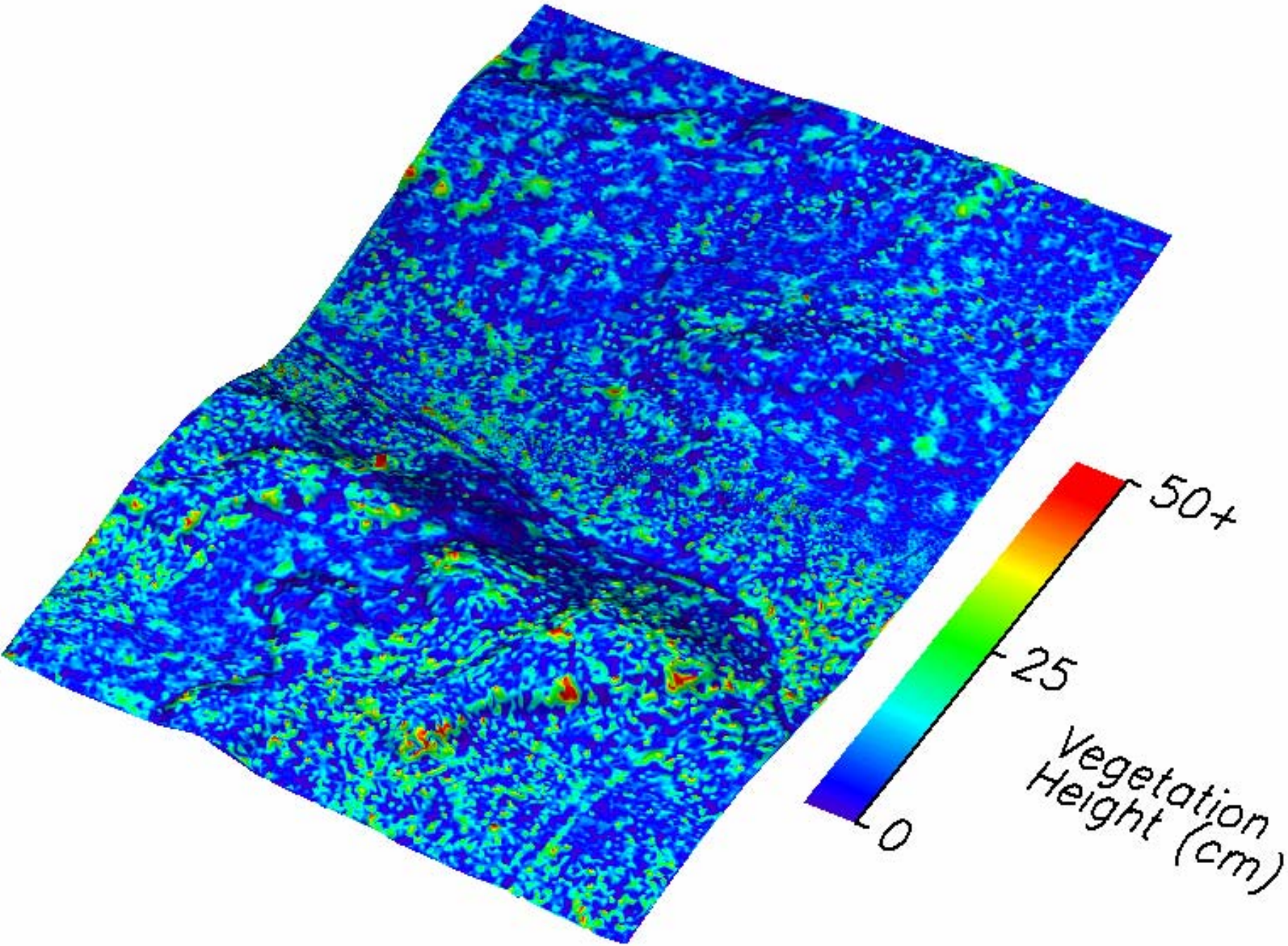
Vegetation Roughness

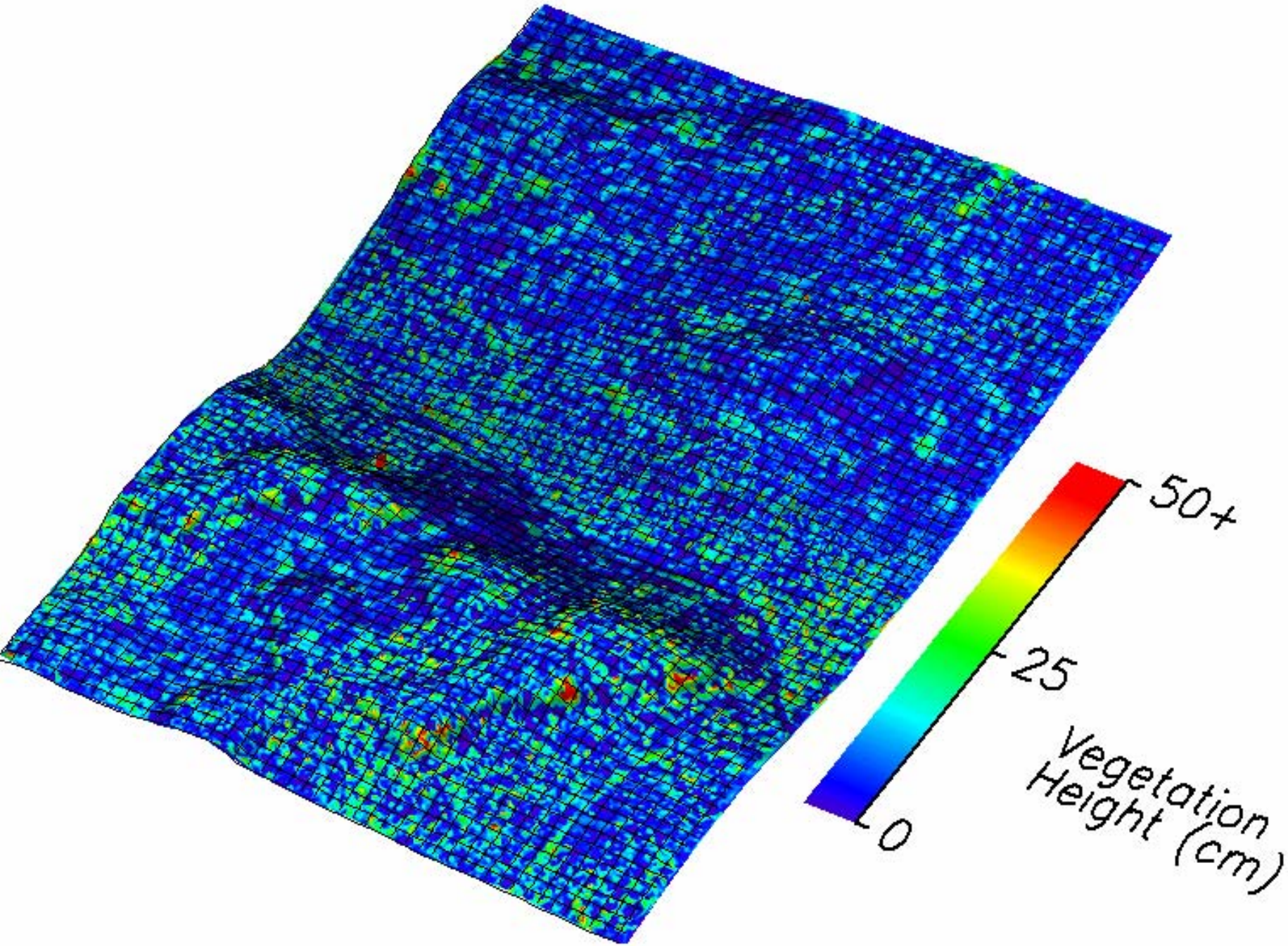
- Vegetation heights are separated into 5 m grid cells
- Vegetation roughness is calculated for each grid cell/pixel as standard deviation of all heights within the grid cell
- Statistical measure of vegetation structure

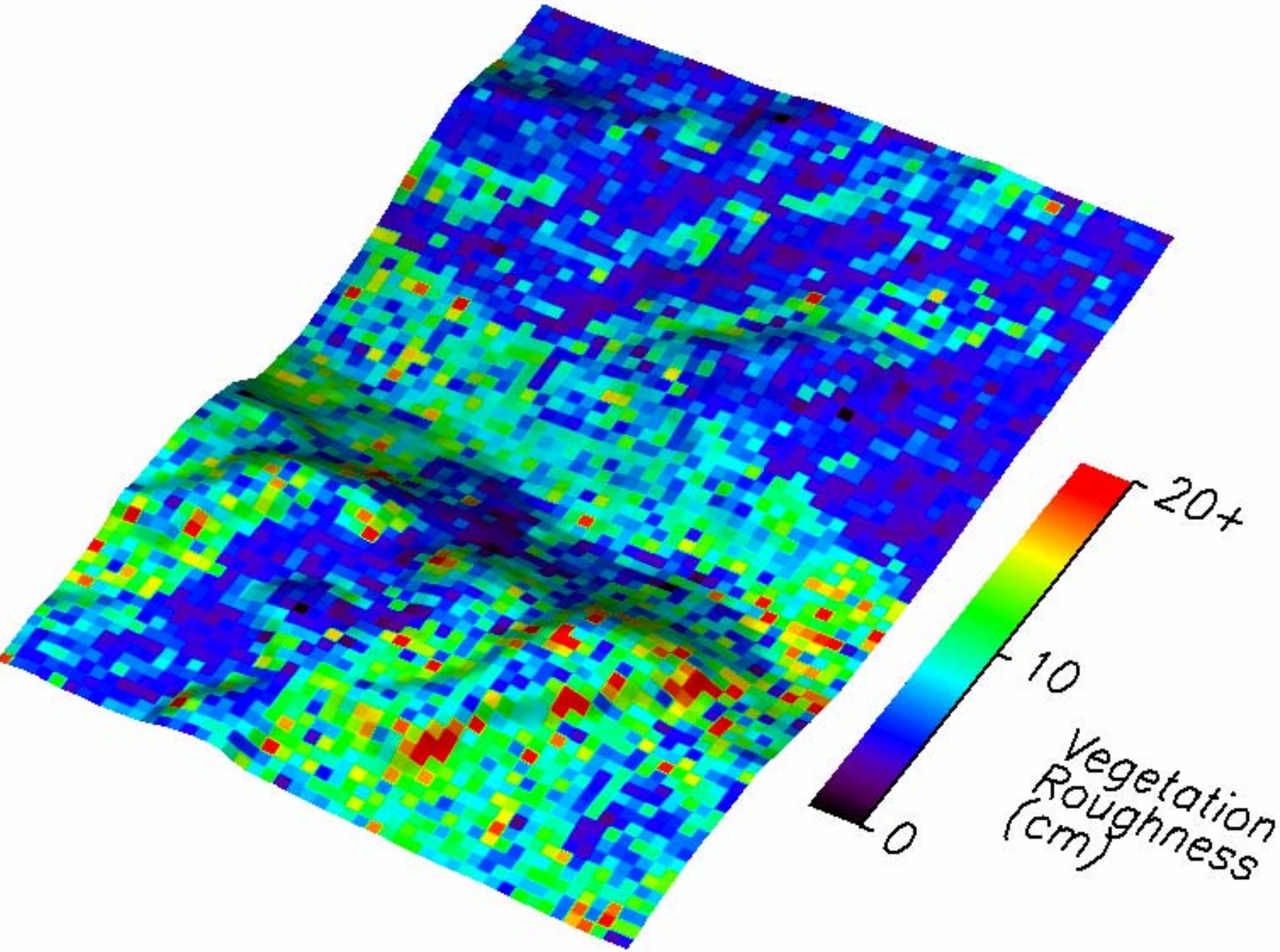

N
50 m

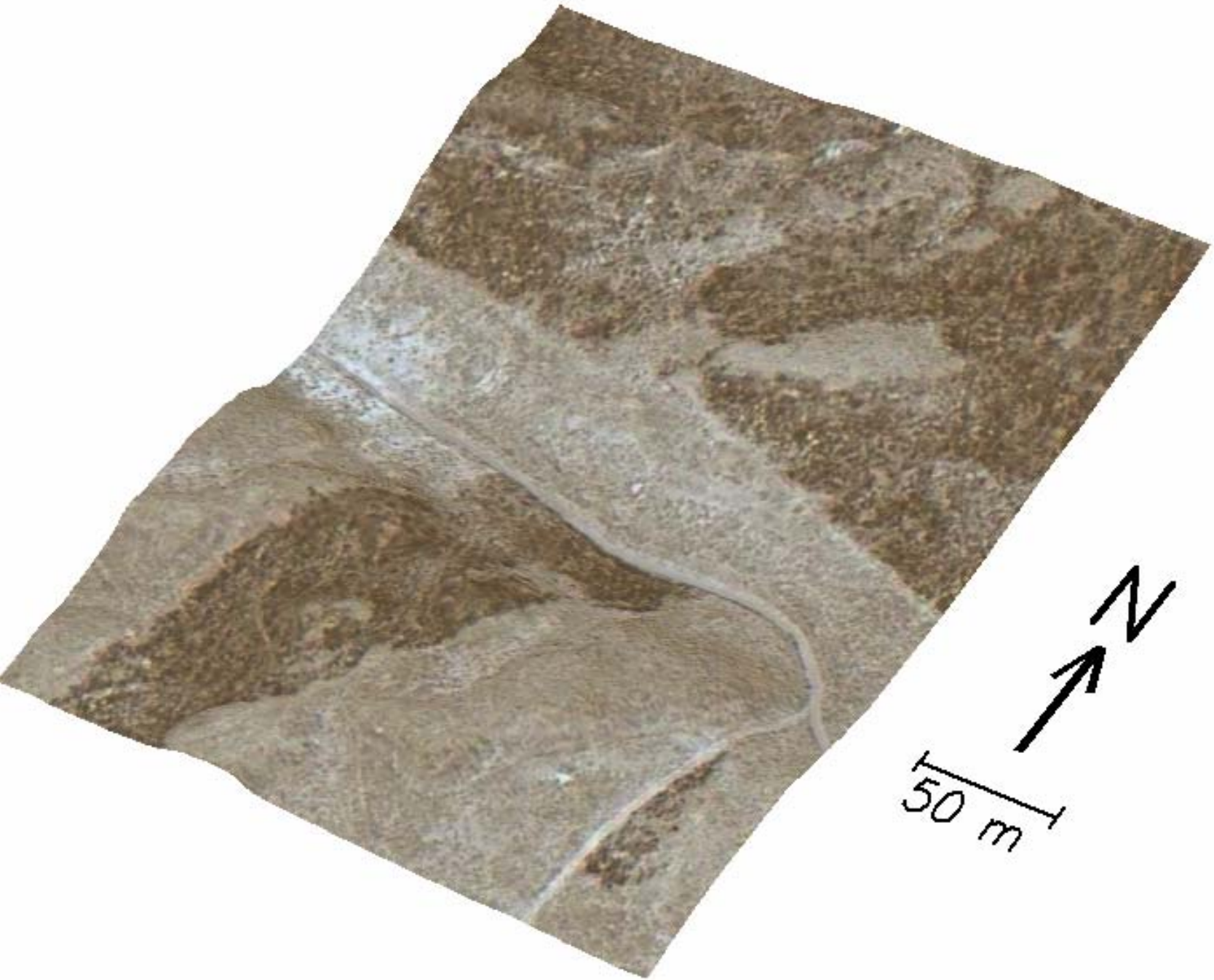




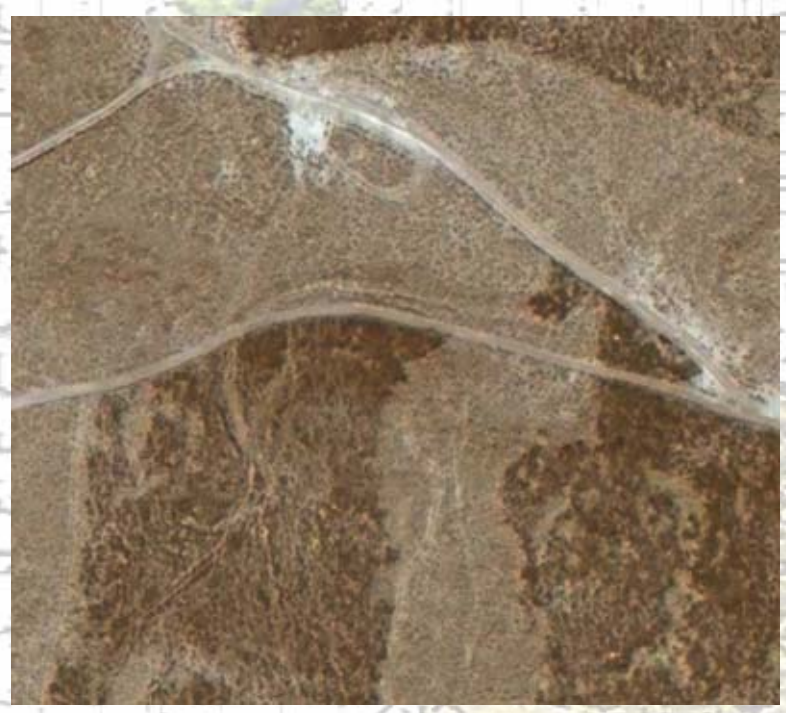

50+
25
0
Vegetation
Height (cm)

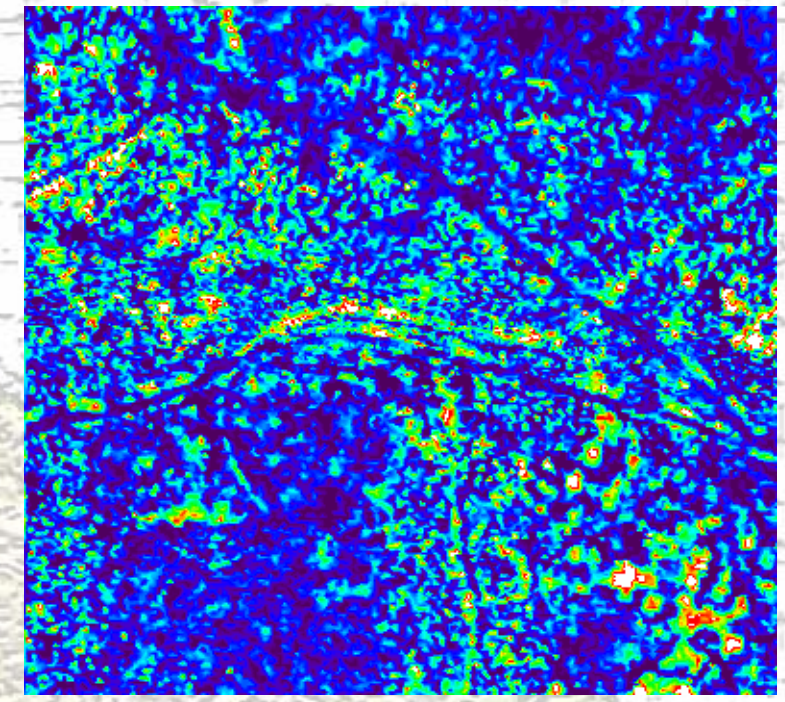

50+
25
0
Vegetation
Height (cm)


20+
10
0
Vegetation
Roughness
(cm)


N
50 m

Geocorrection



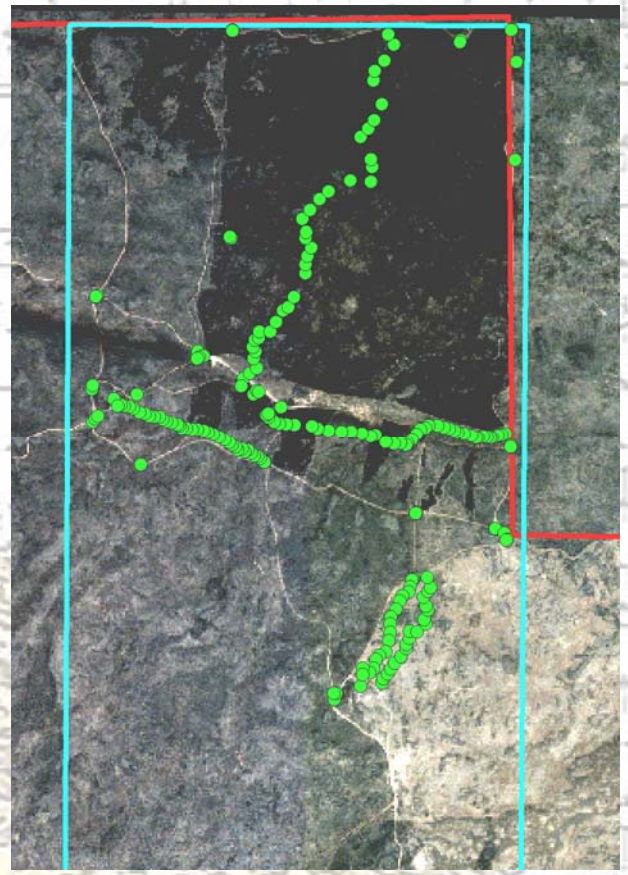


- 45 differentially corrected Ground Control Points collected at road intersections and other identifiable features

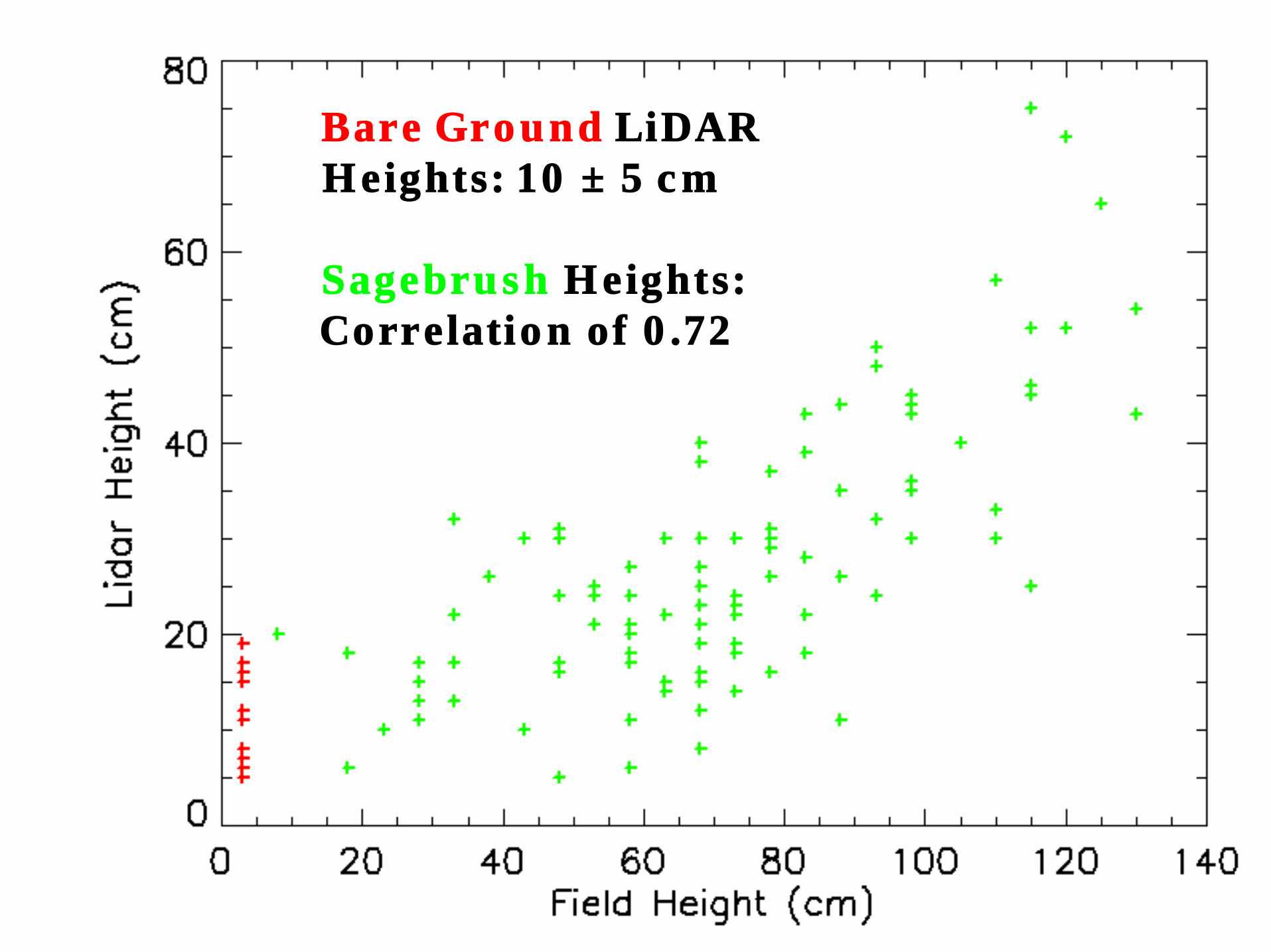
- RMS error of 0.8 m
- Two-sigma accuracy of 1.5 m

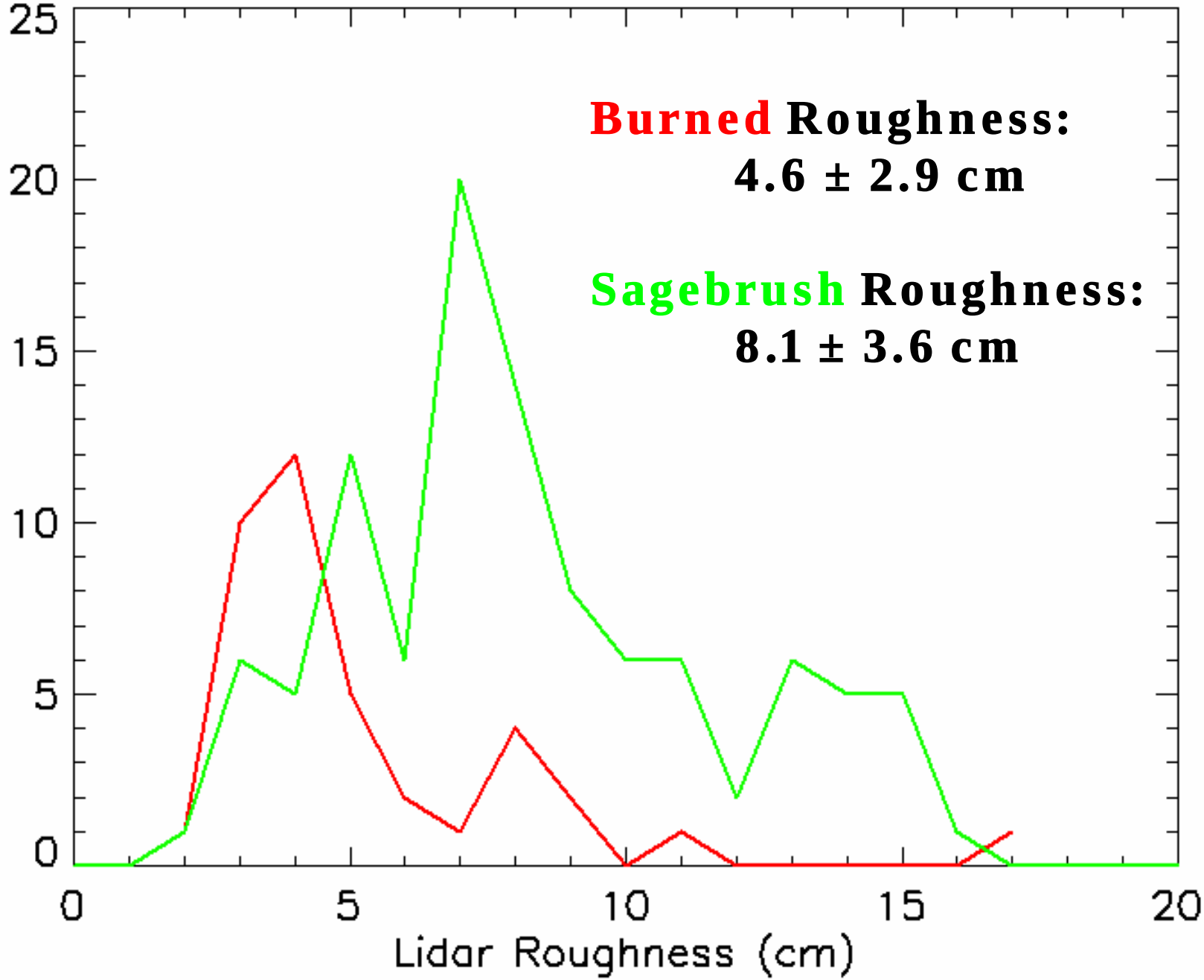
Validation

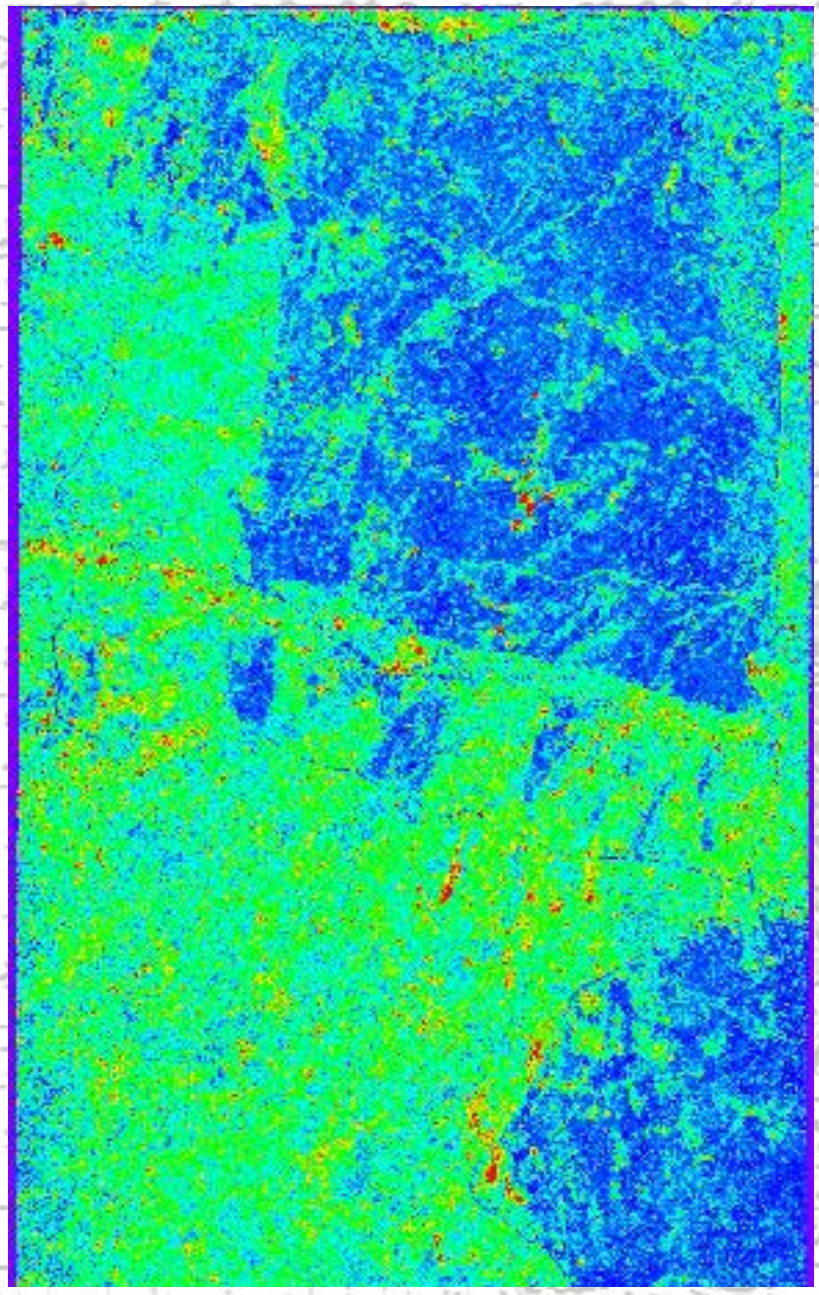
- 168 field validation points
  - Measured vegetation heights to accuracy of ~10 cm
  - Compared with lidar heights using buffer of 1.5 m



- Qualitative comparison to Quickbird imagery


Bare Ground LiDAR
Heights: 10 ± 5 cm
Sagebrush Heights:
Correlation of 0.72
Lidar Height (cm)
Field Height (cm)
0
20
40
60
80
0
20
40
60
80
100
120
140


Burned Roughness:
4.6 ± 2.9 cm
Sagebrush Roughness:
8.1 ± 3.6 cm
25
20
15
10
5
0
0
5
10
15
20
Lidar Roughness (cm)



Possible Sources of Error

- Incomplete LiDAR coverage
- Inability to precisely locate LiDAR postings in the field
- Penetration of laser pulse into vegetation
- Imprecision of field height measurement
- Inaccuracy of LiDAR height determination

Conclusions

- **LiDAR can be used with moderate success to determine rangeland vegetation heights**
  - **Scaling factor of two may be necessary**
- **LiDAR derived vegetation roughness may be useful in mapping rangeland vegetation characteristics**

Acknowledgements

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Questions?