Cartography M.Sc.

TECHNISCHE UNIVERSITÄT DRESDEN

Mapping the Relief of Mount Ushba (Georgia) as a Contribution to an Alpine Club Map

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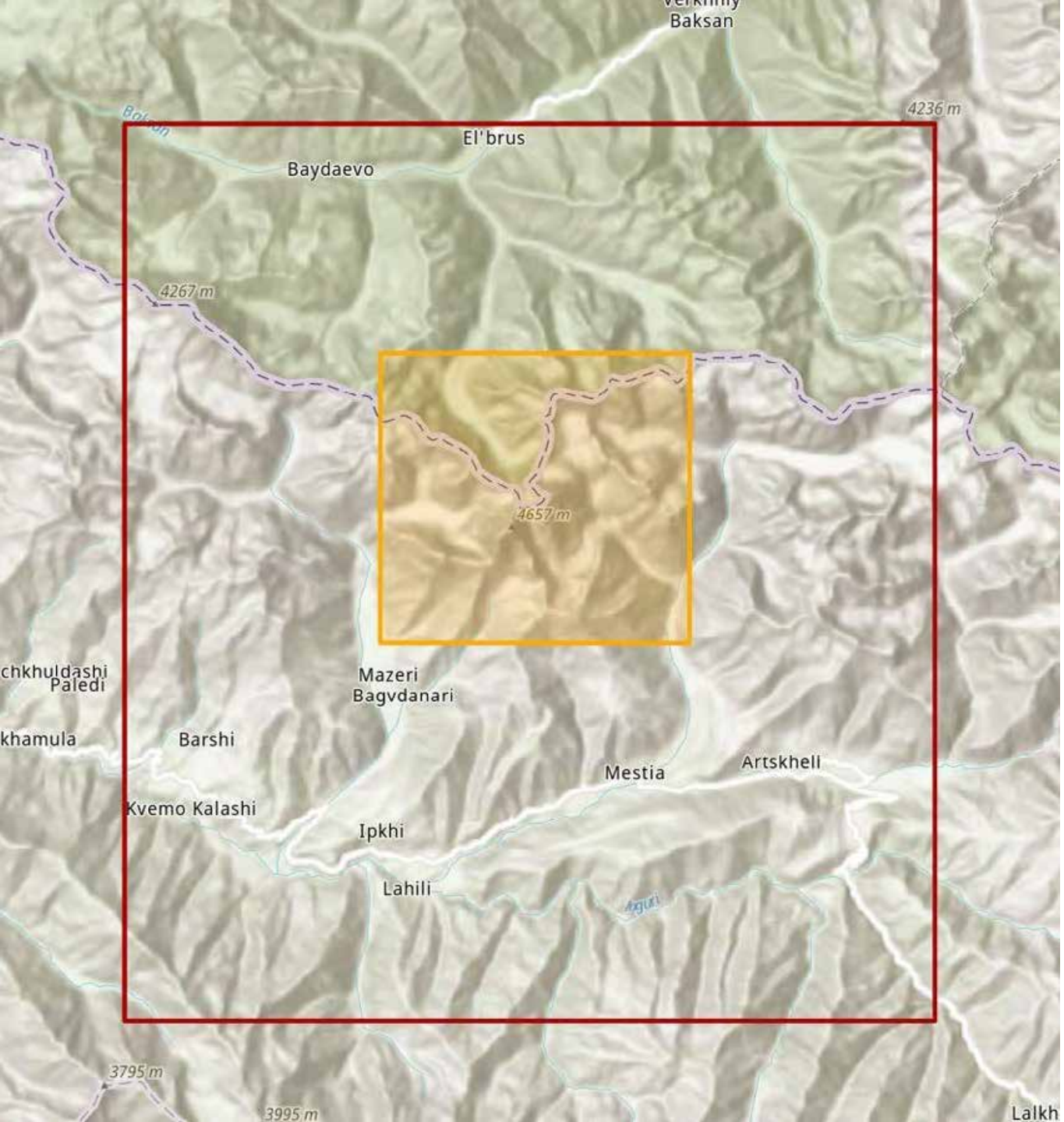
Content

Research Objective

To develop a detailed high-quality cartographic depiction of the alpine and nival zone of Mount Ushba, Georgia

The generation and evaluation of a Digital Elevation Model of the Mount Ushba region, Georgia, with the use of high-resolution PlanetScope Imagery.

Context



Research Area

- Tourism Ushba region
- Steep mountainous terrain

- Alpine Club Map
- Mestia and Mount Ushba
- 1:33,000

Map extent Research Area

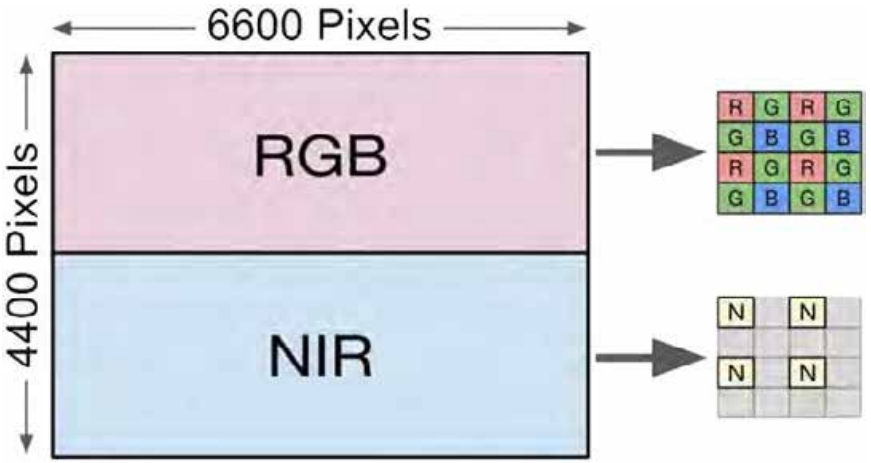
DEM Generation

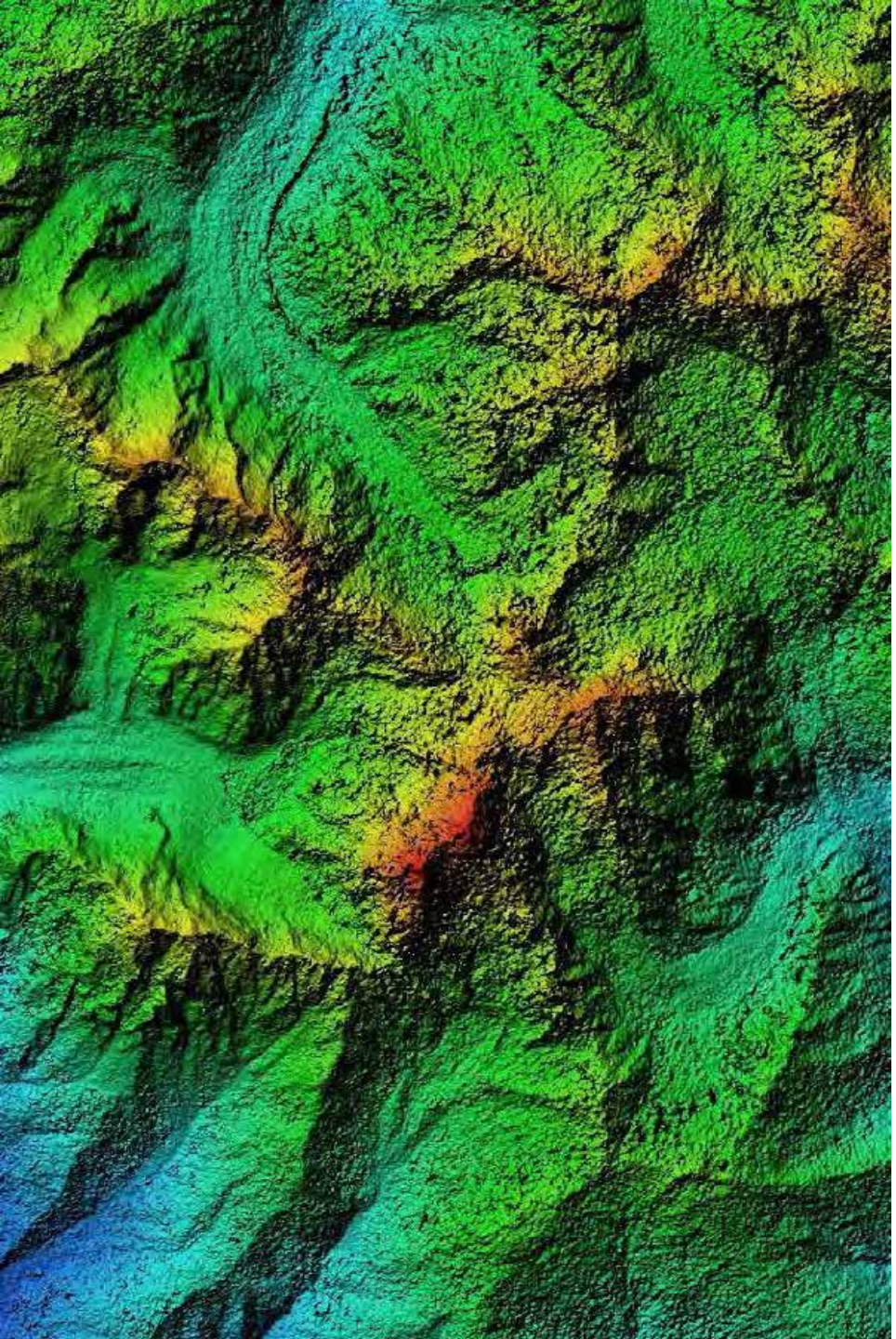
PlanetScope

- CubeSat 3U form factor satellites
- Dove-1
- 10cm x 10cm x 10cm, 1.33 kg

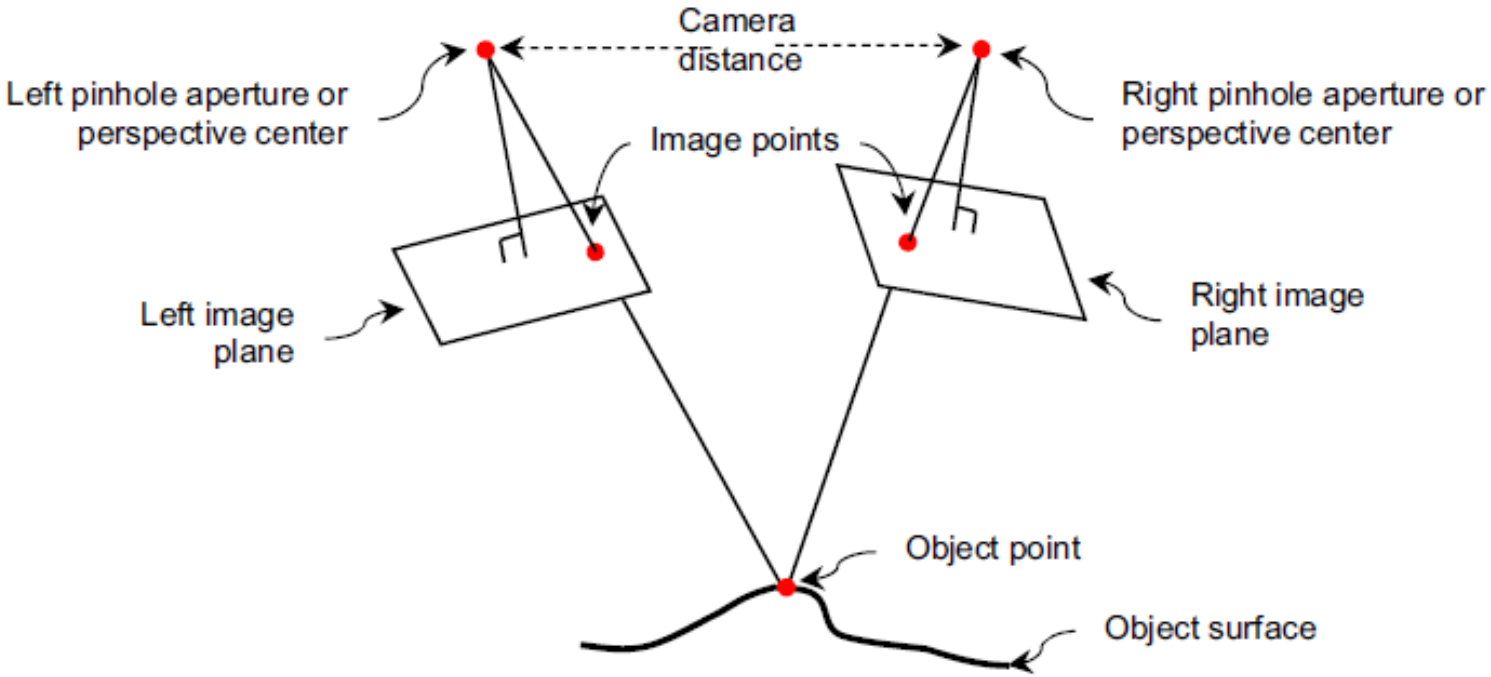
PlanetScope

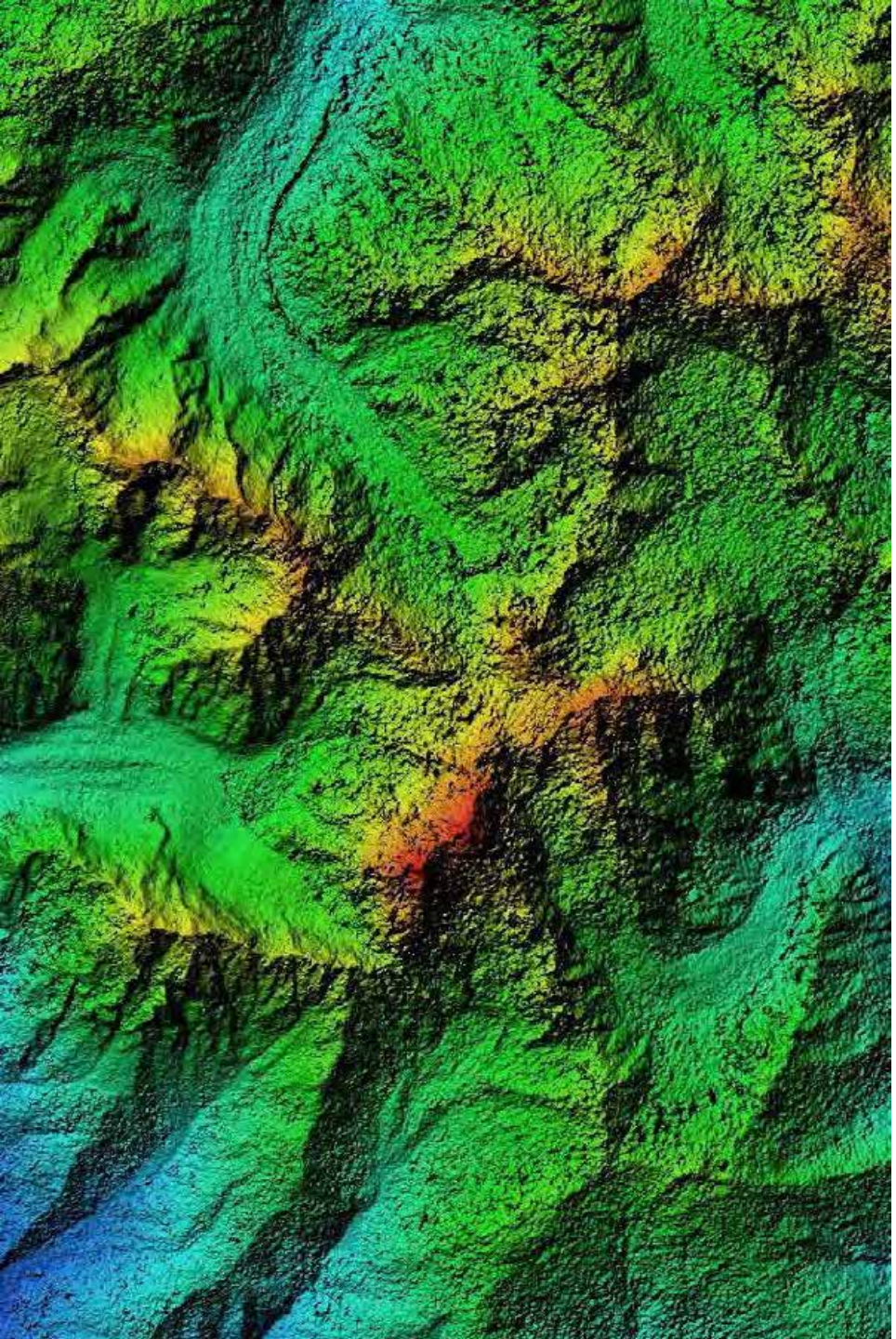
- Four spectral bands (RGB, NIR)
- Rational Polynomial Coefficients (RPC)
- 3.7-meter resolution
- B/H ratio < 1/10



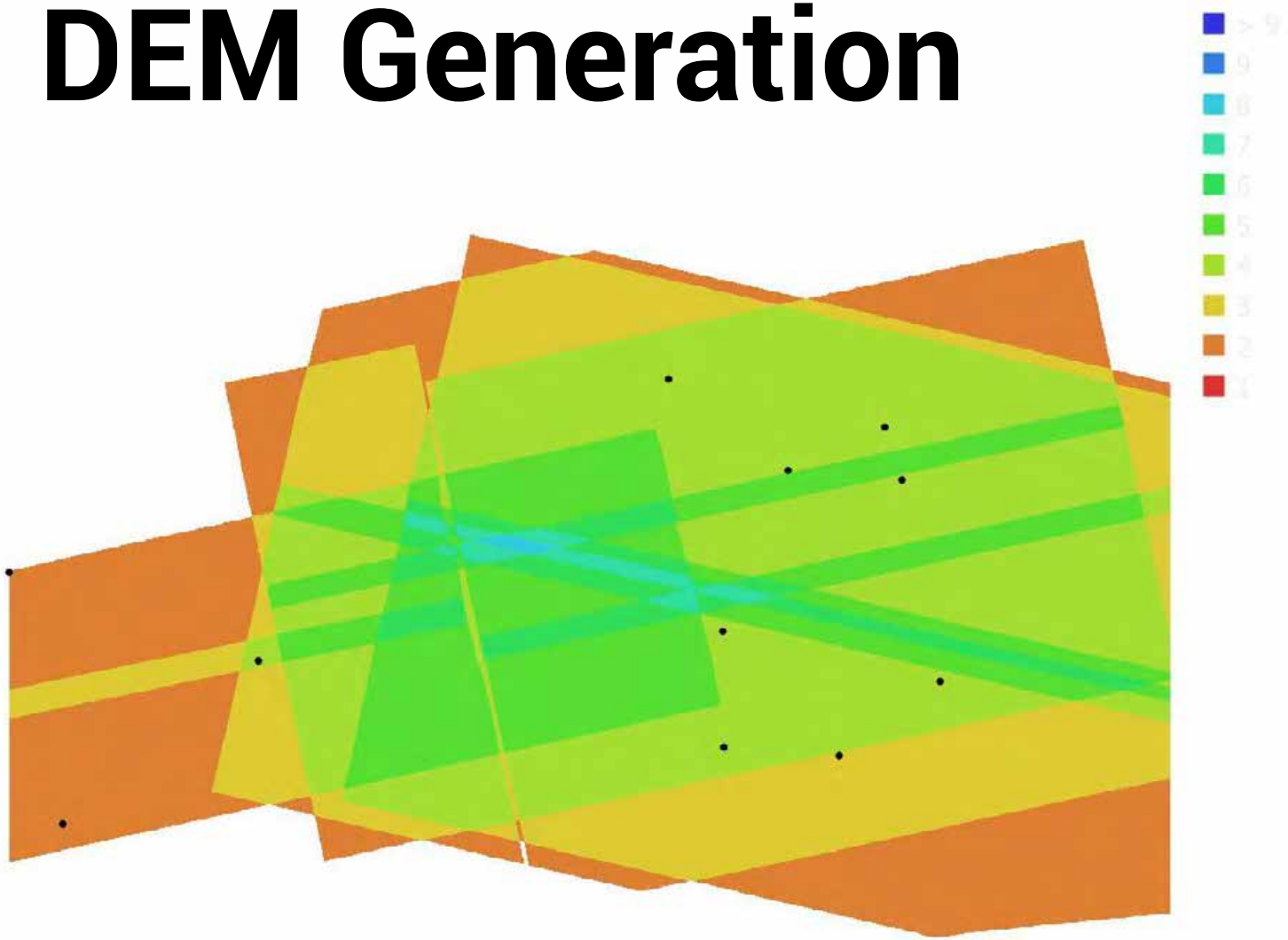


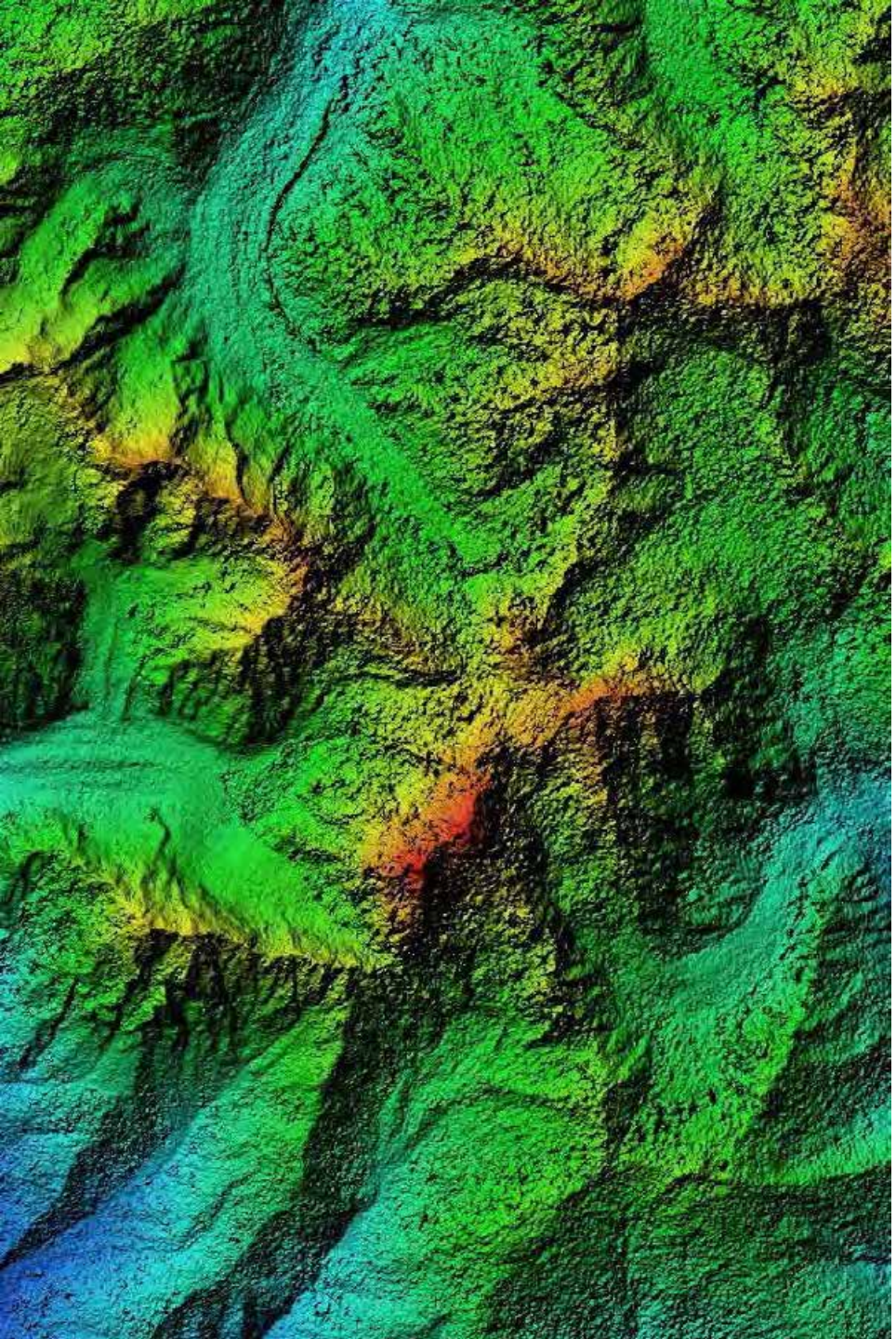
DEM Generation





DEM Generation

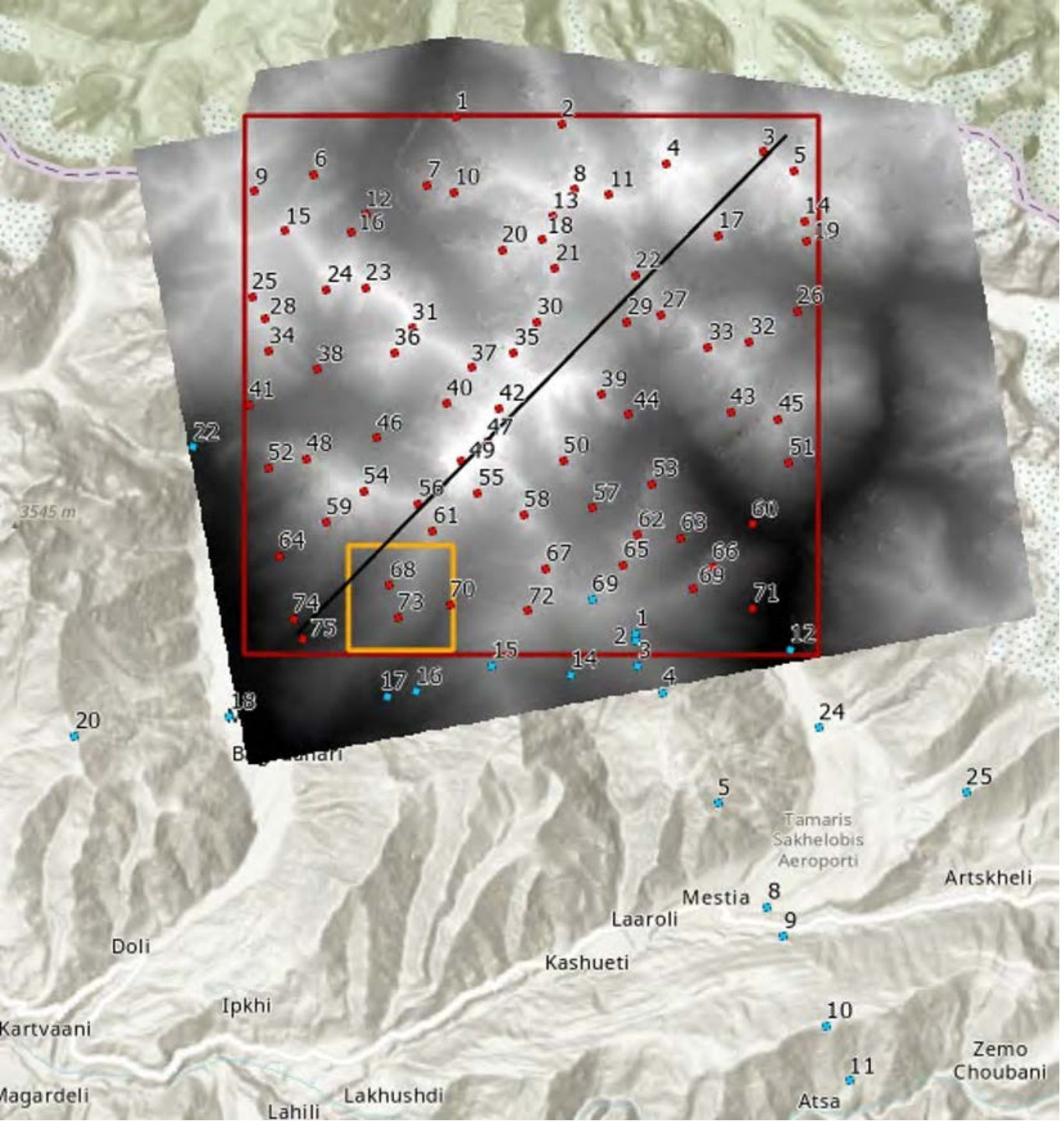




DEM Generation

- Camera Alignment
- Include RPC (Rational Polynomial Coefficients) information
- Apply selection on sparse point cloud
- Generate dense point cloud
- Build DEM
  - UTM zone 38N
  - WGS84 ellipsoidal heights
  - IDW (Inverse Distance Weighting)

DEM Evaluation



DEM Evaluation

- SRTM Data
- Map sheets
- Field measurements

SRTM Data

- Shuttle Radar Topography Mission (1994)
- Covers over 80% of the Earth's land surface, between 60° north and 56° south latitude

- 1-arcsecond resolution (~30 meters)
- EGM96 geoid
- 16-meter vertical accuracy

SRTM Data

Legend

Difference DEMs

524 m

-524 m

Hill Shade

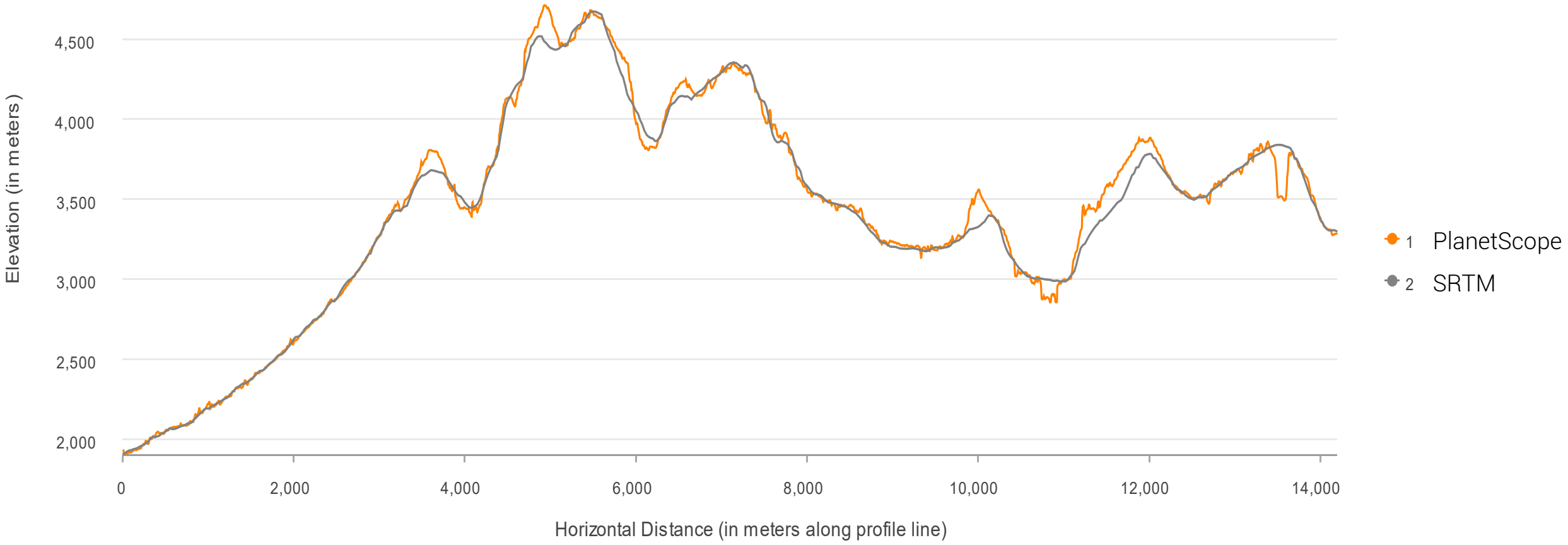
254

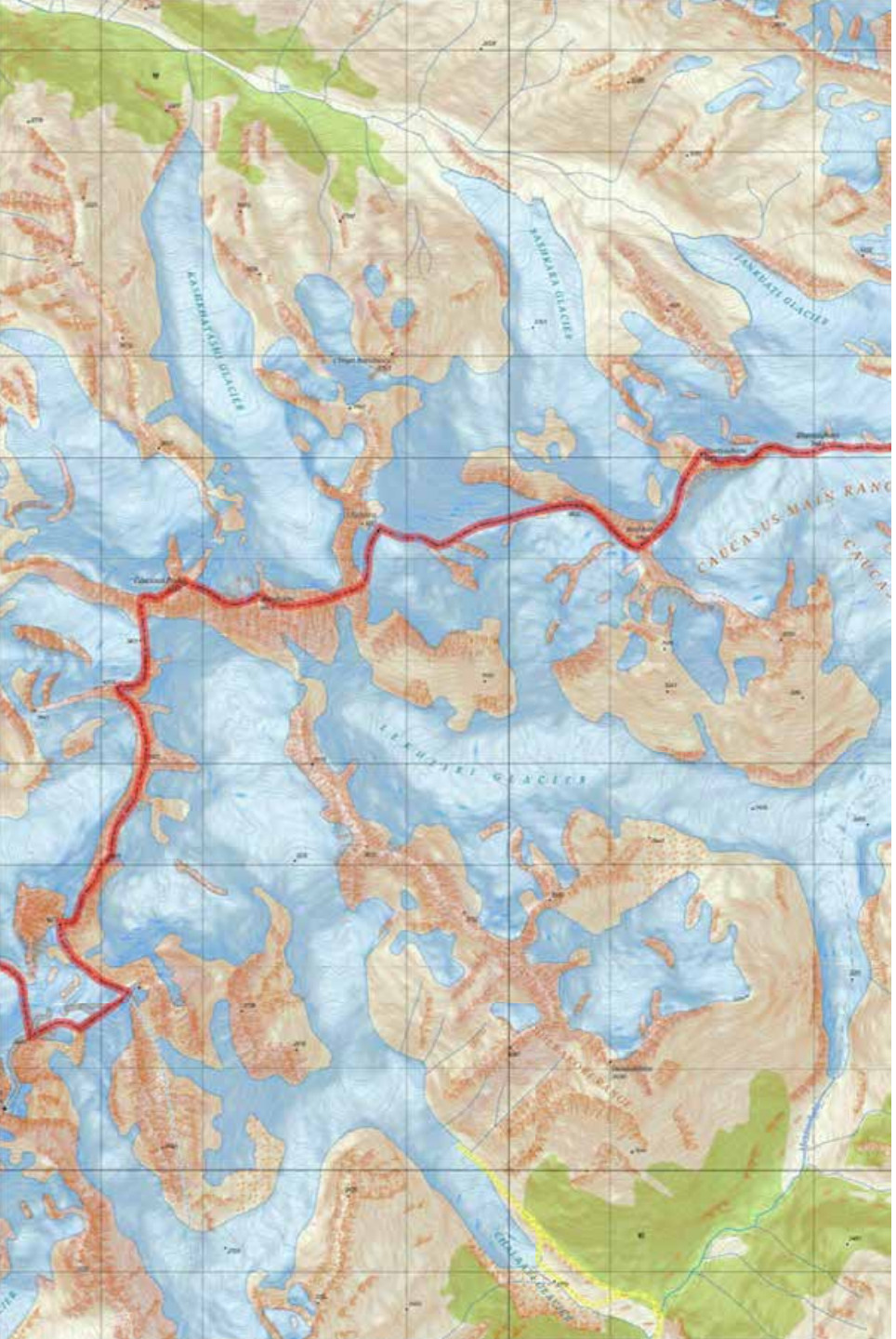
0

Average deviation: ~10 meter

RMSE: 46.9 meter

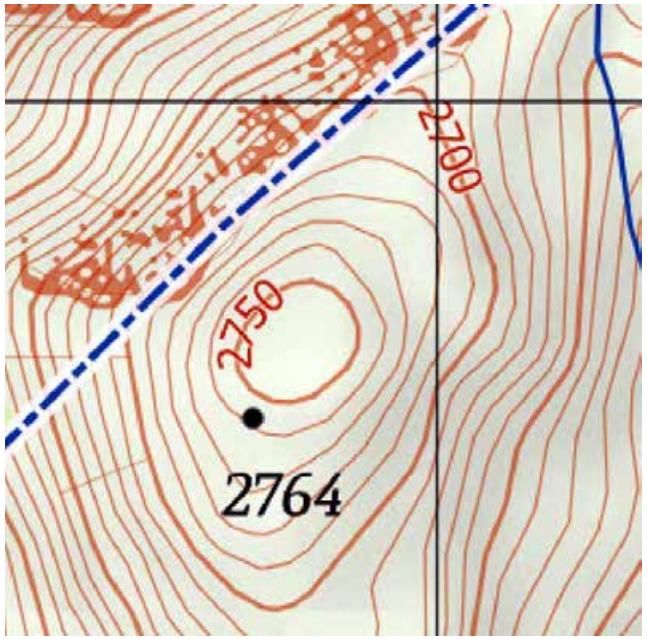
SRTM Data


4,500
4,000
3,500
3,000
2,500
2,000
Elevation (in meters)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Horizontal Distance (in meters along profile line)
1 PlanetScope
2 SRTM



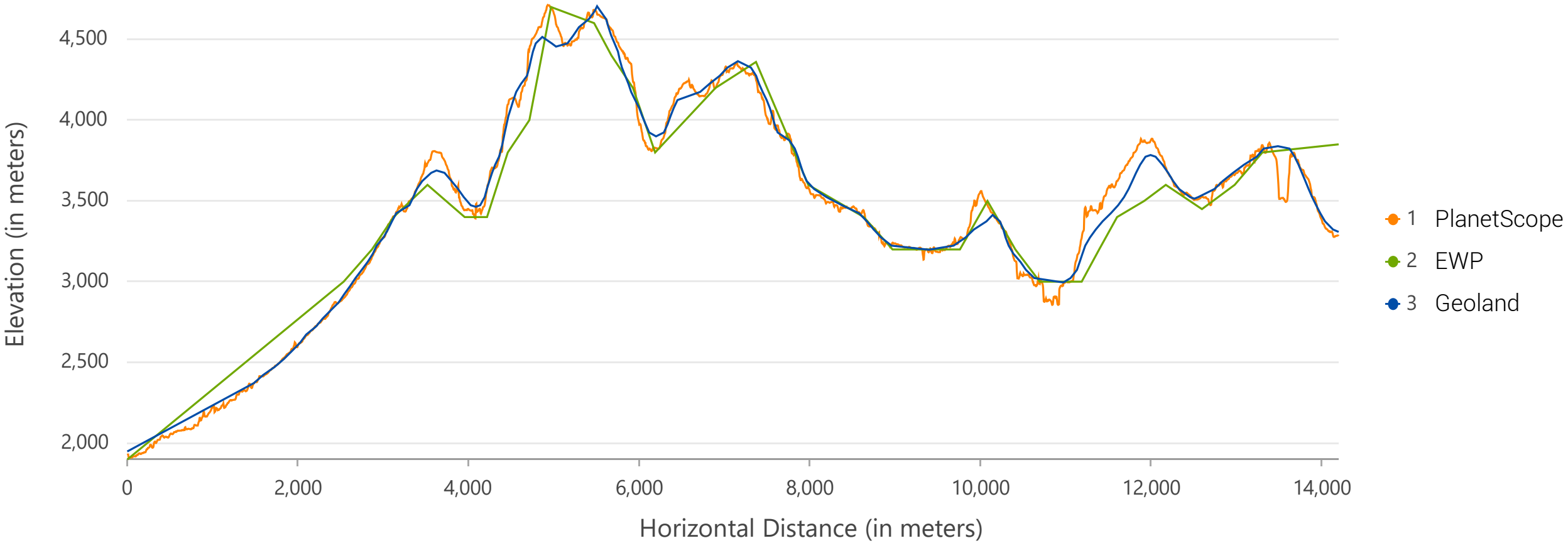
Map sheets

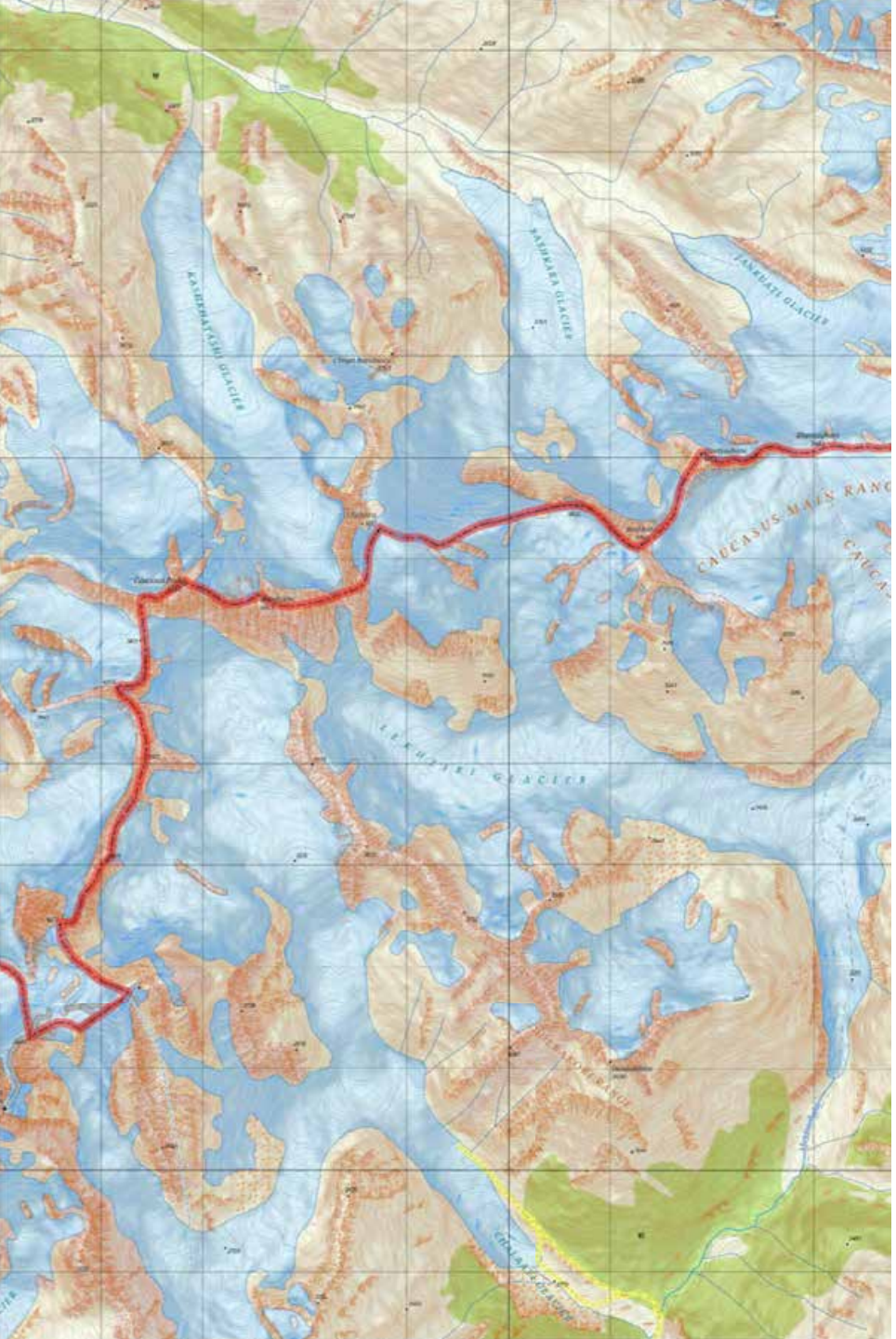
- Geoland, 2020
- 1:25,000

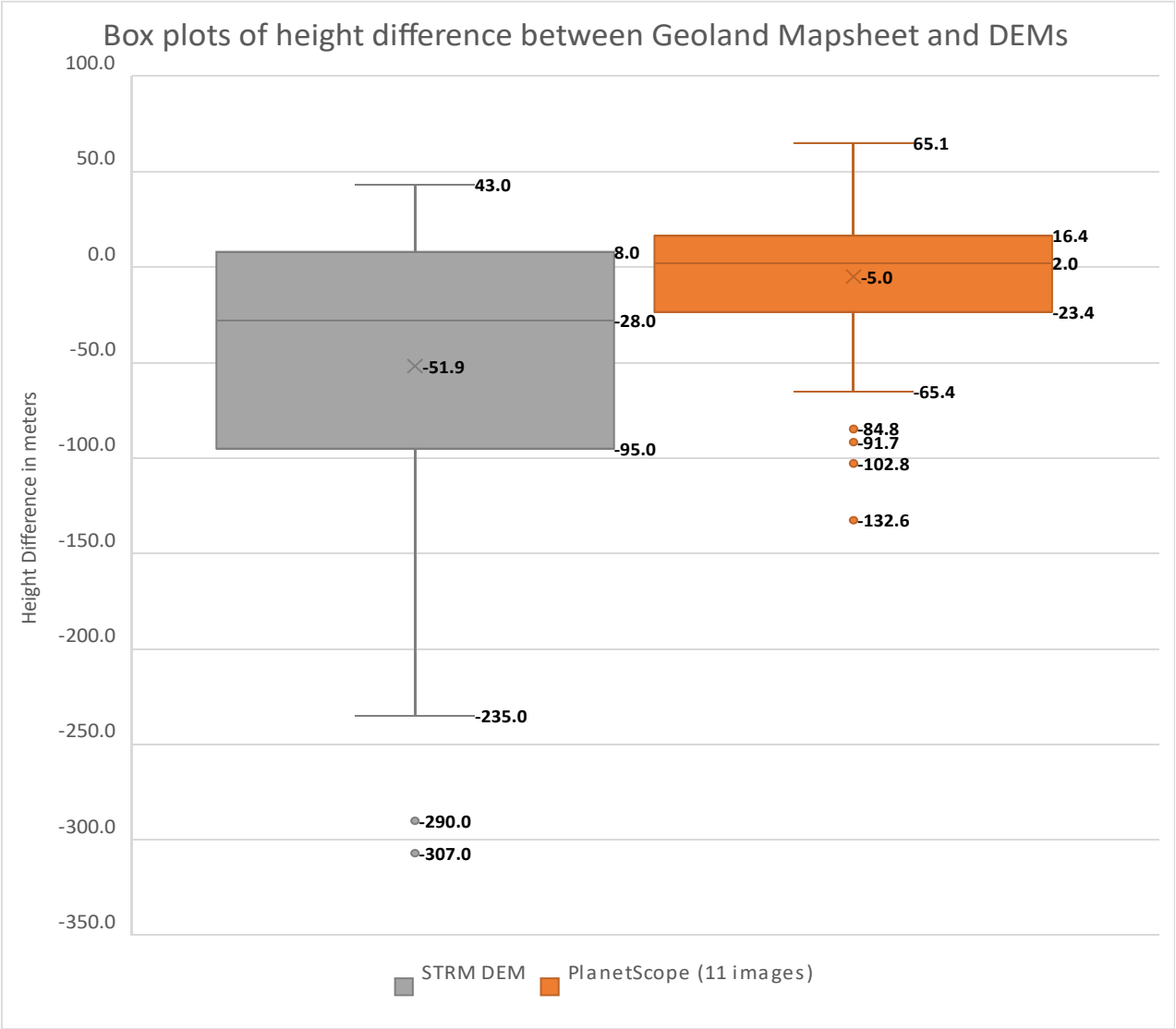


- EWP, 2007
- 1:50,000

Map sheets


4,500
4,000
3,500
3,000
2,500
2,000
Elevation (in meters)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Horizontal Distance (in meters)
1 PlanetScope
2 EWP
3 Geoland



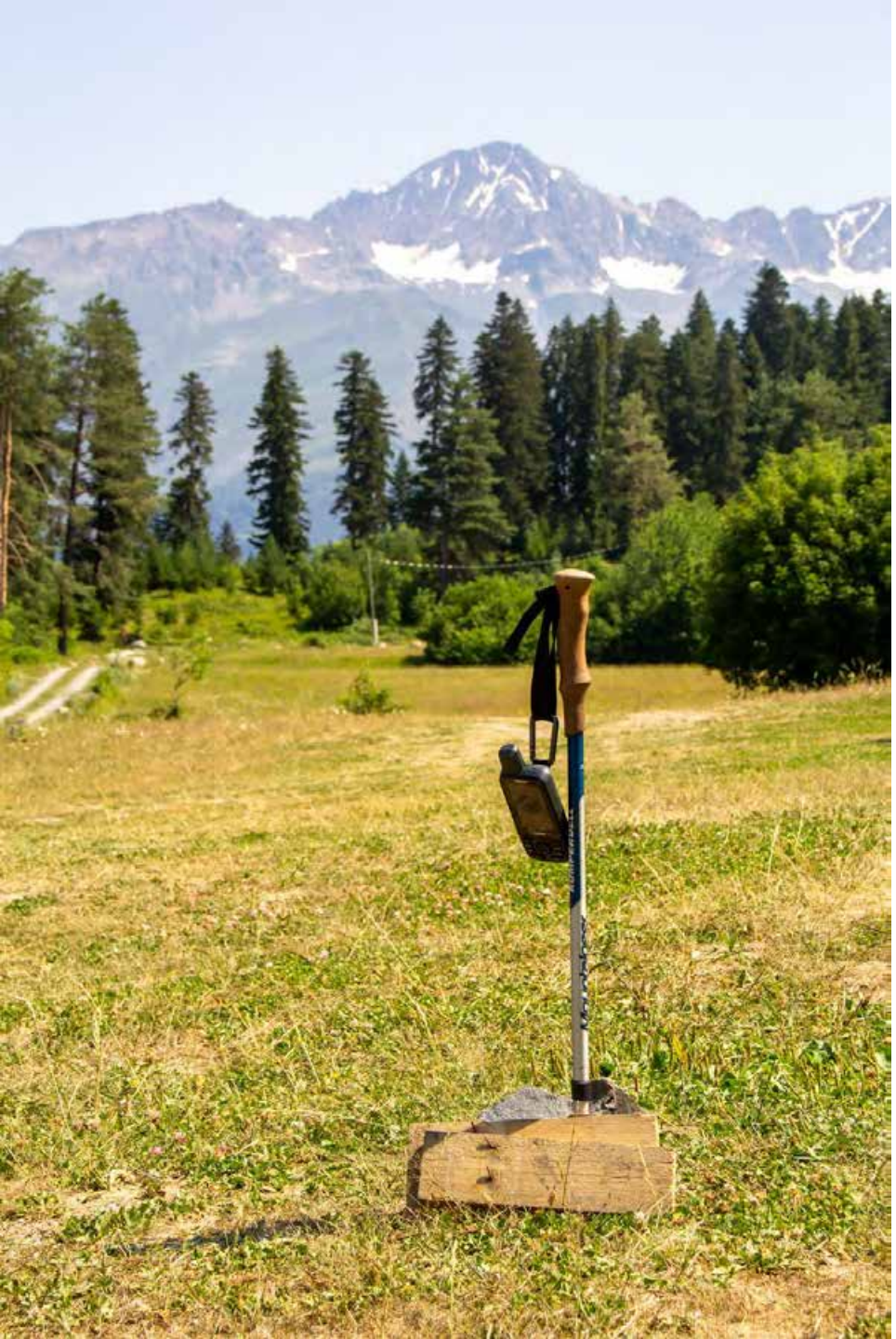


	STRM DEM	PlanetScope
Mean Error	-51.9	-5.0
RMSE	94.1	36.8

Field work

- Mapping Campaign July 2021
- Mestia, Georgia

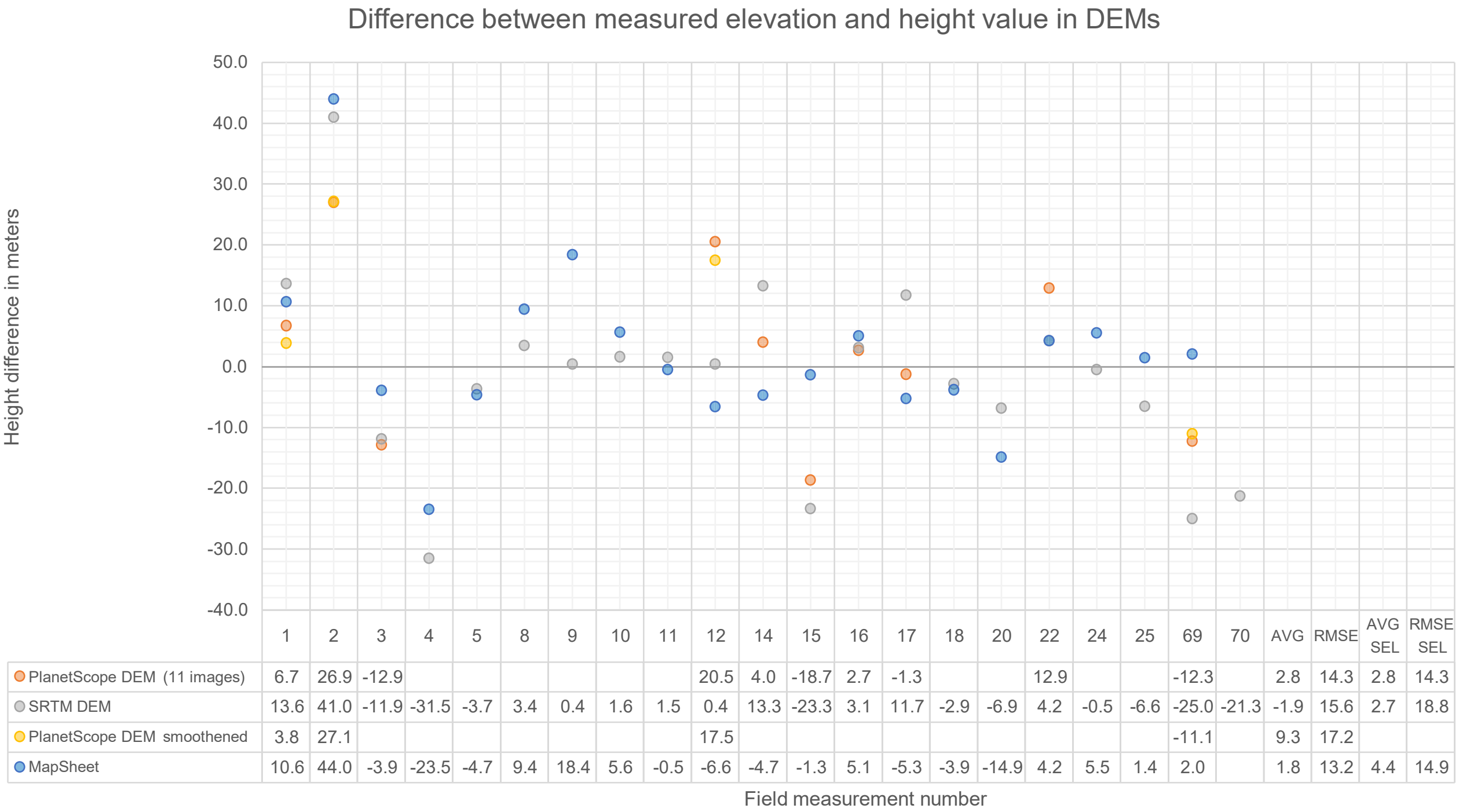
- 21 elevation measurements



Field measurements

- Garmin GPSMAP 66sr
- RINEX files
- WAPPP

- Extract elevation values at measurement locations from DEMs and maps.



	1	2	3	4	5	8	9	10	11	12	14	15	16	17	18	20	22	24	25	69	70	AVG	RMSE	AVG SEL	RMSE SEL
PlanetScope DEM (11 images)	6.7	26.9	-12.9							20.5	4.0	-18.7	2.7	-1.3			12.9			-12.3		2.8	14.3	2.8	14.3
SRTM DEM	13.6	41.0	-11.9	-31.5	-3.7	3.4	0.4	1.6	1.5	0.4	13.3	-23.3	3.1	11.7	-2.9	-6.9	4.2	-0.5	-6.6	-25.0	-21.3	-1.9	15.6	2.7	18.8
PlanetScope DEM smoothened	3.8	27.1								17.5										-11.1		9.3	17.2		
MapSheet	10.6	44.0	-3.9	-23.5	-4.7	9.4	18.4	5.6	-0.5	-6.6	-4.7	-1.3	5.1	-5.3	-3.9	-14.9	4.2	5.5	1.4	2.0		1.8	13.2	4.4	14.9

The creation of a large-scale relief depiction based on the cartographic depiction of the Alpine Club.

Relief Depiction

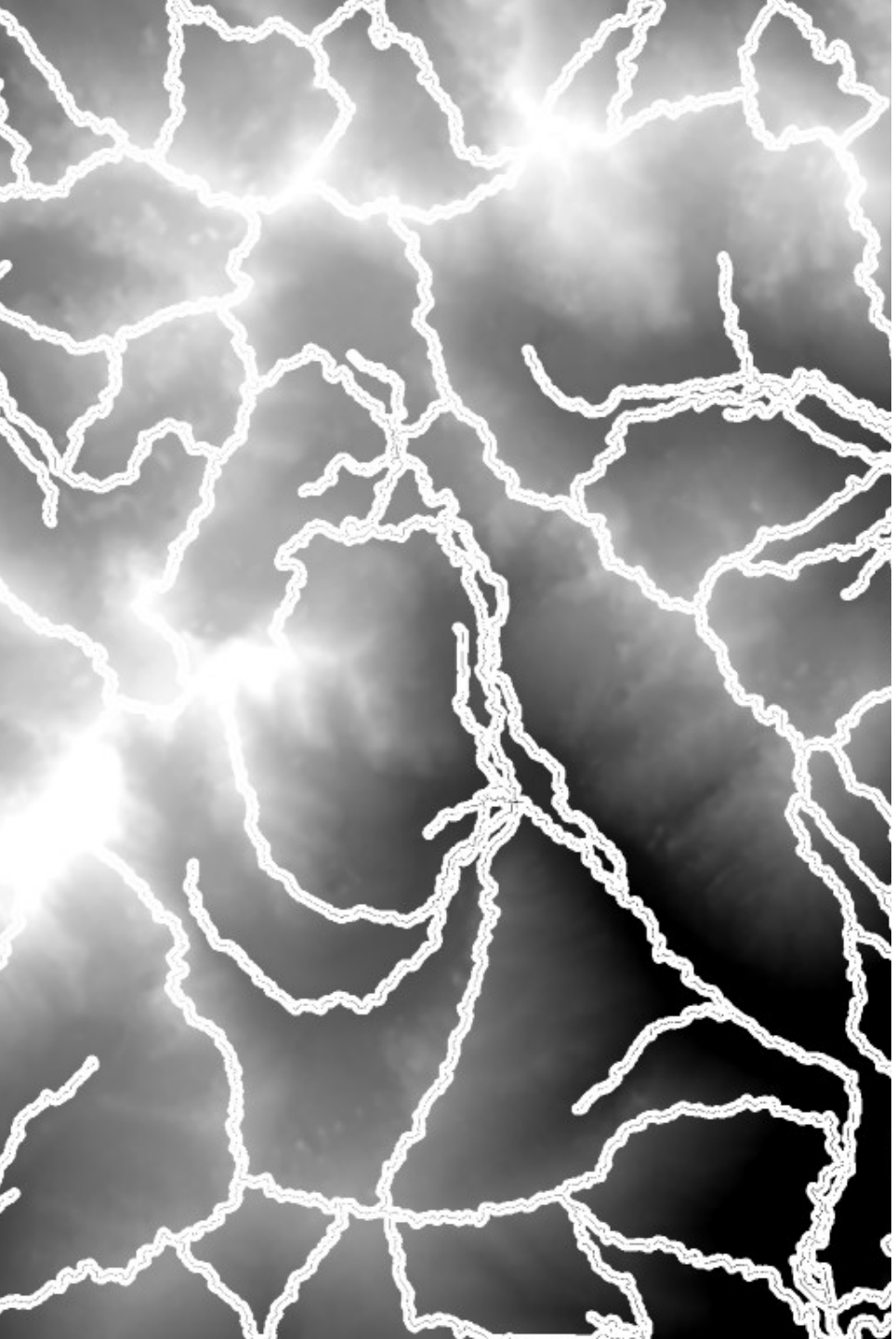
Smoothen DEM

- A lot of unnecessary detail
- Bumps and sinks in terrain

Smoothen DEM

- Fill sinks
- Calculate flow accumulation
- Determine pour points
- Create watersheds

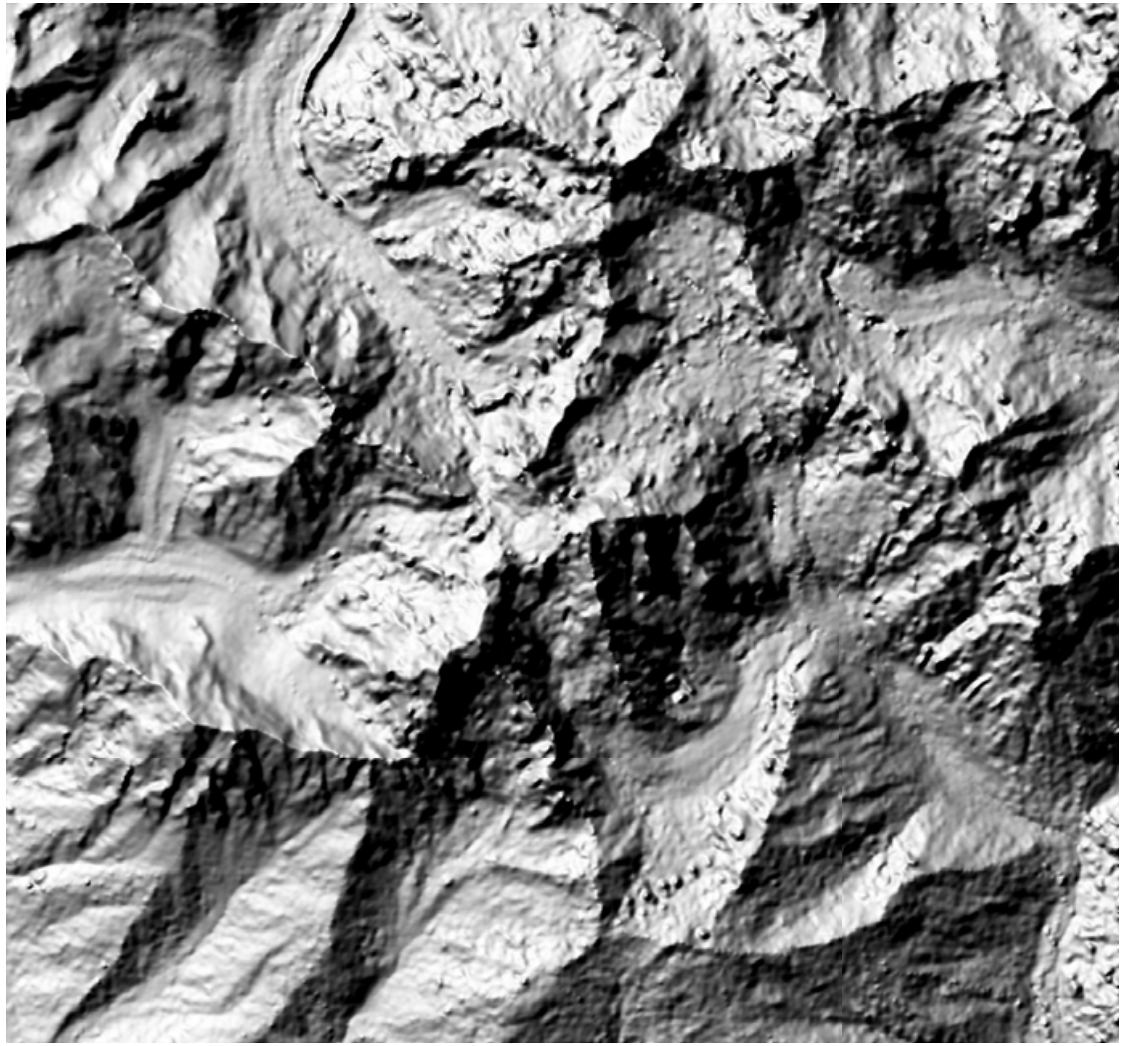
- Outlines represent ridgelines
- Extract drainage lines → valleys

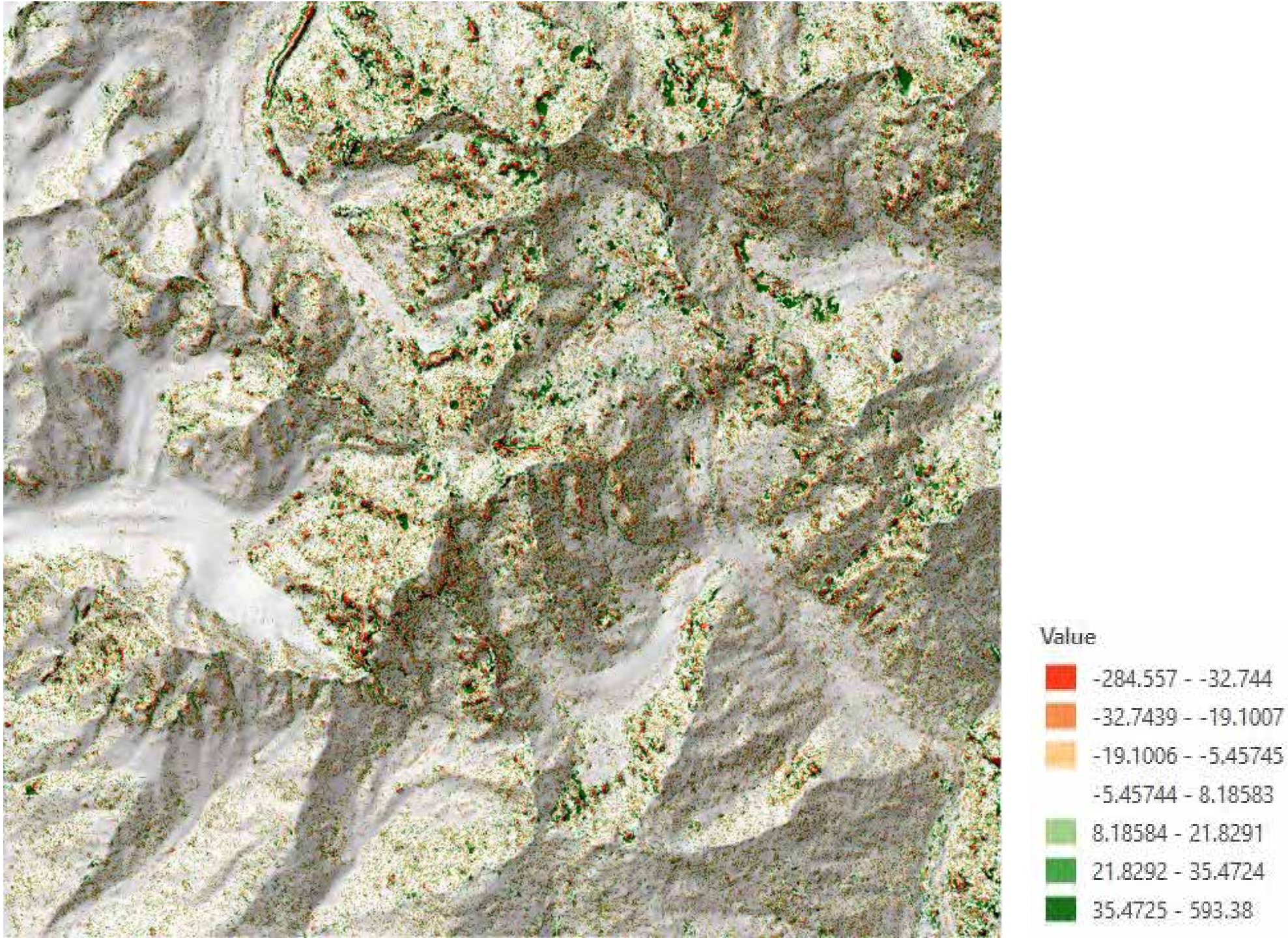


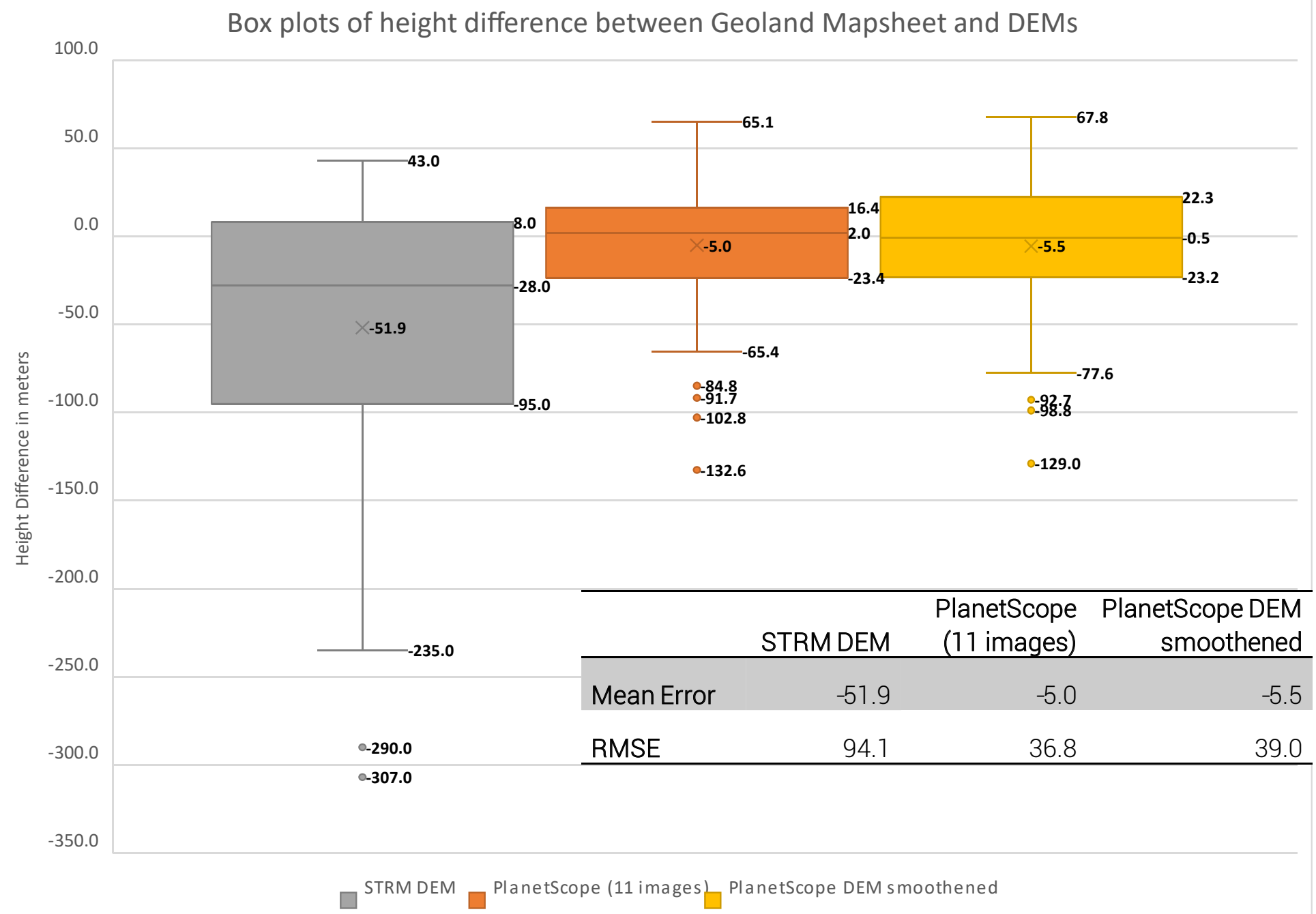
Smoothen DEM

- Apply low-pass filter
- Clip DEM with ridges and valleys + buffer

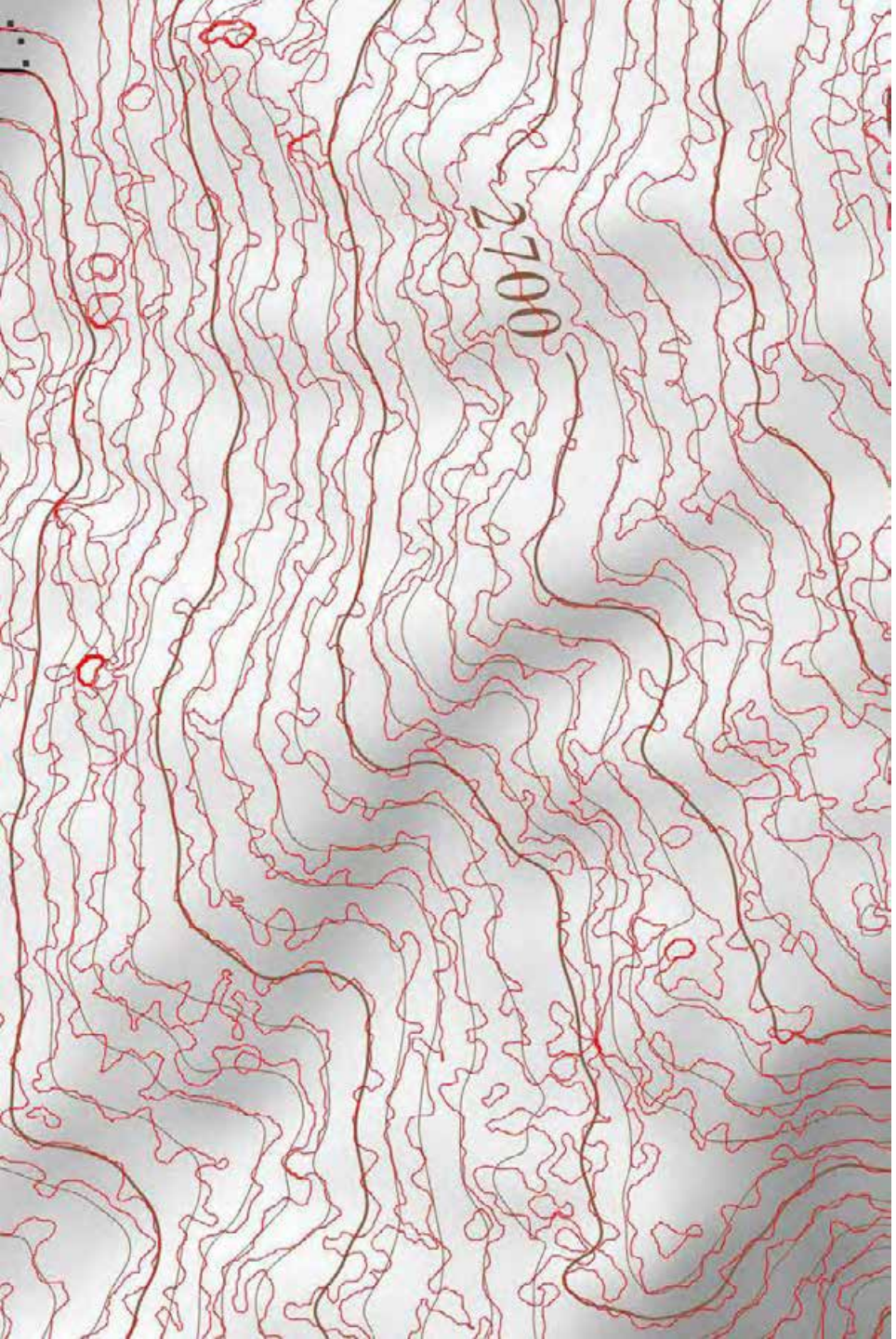
- Merge smoothened DEM and ridge and valley lines with original values
- Connect both with spline interpolation




Value
-284.557 - -32.744
-32.7439 - -19.1007
-19.1006 - -5.45745
-5.45744 - 8.18583
8.18584 - 21.8291
21.8292 - 35.4724
35.4725 - 593.38



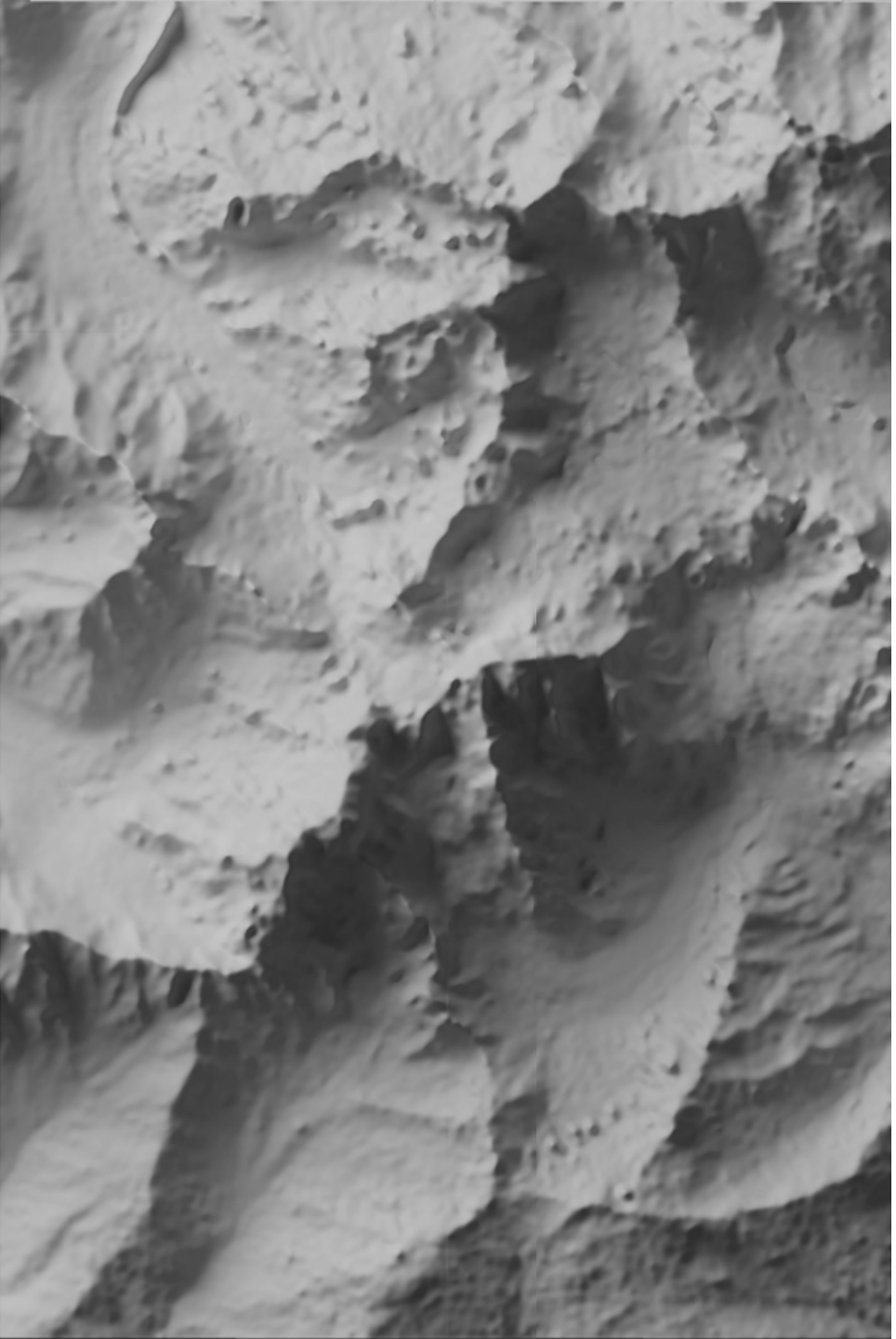
	STRM DEM	PlanetScope (11 images)	PlanetScope DEM smoothened
Mean Error	-51.9	-5.0	-5.5
RMSE	94.1	36.8	39.0



Contour Lines

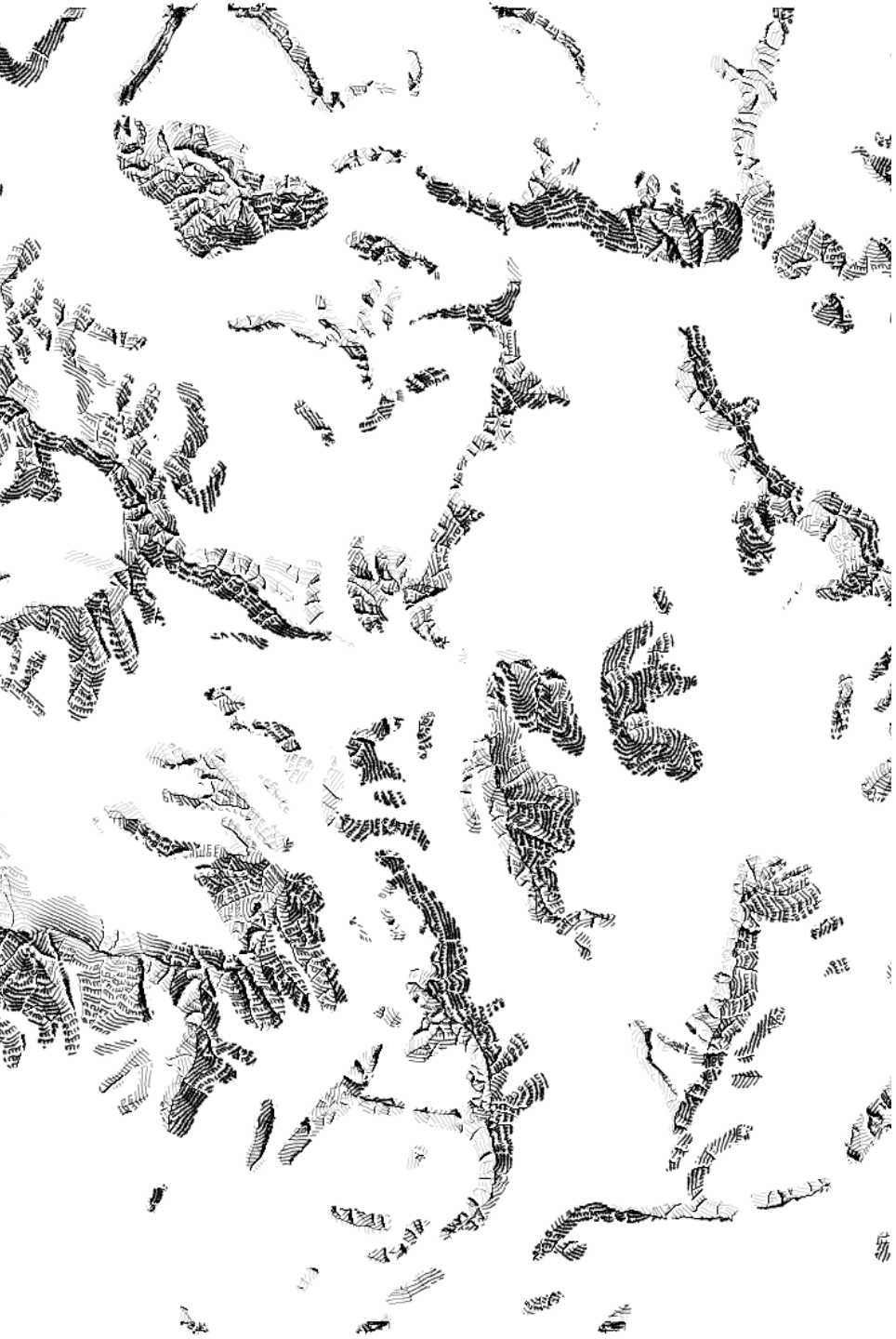
- Equidistance of 20 meters
- Index lines every 100 meters
- Line color based on terrain

- Improved legibility



Shaded relief

- Blender
- Realistic lighting

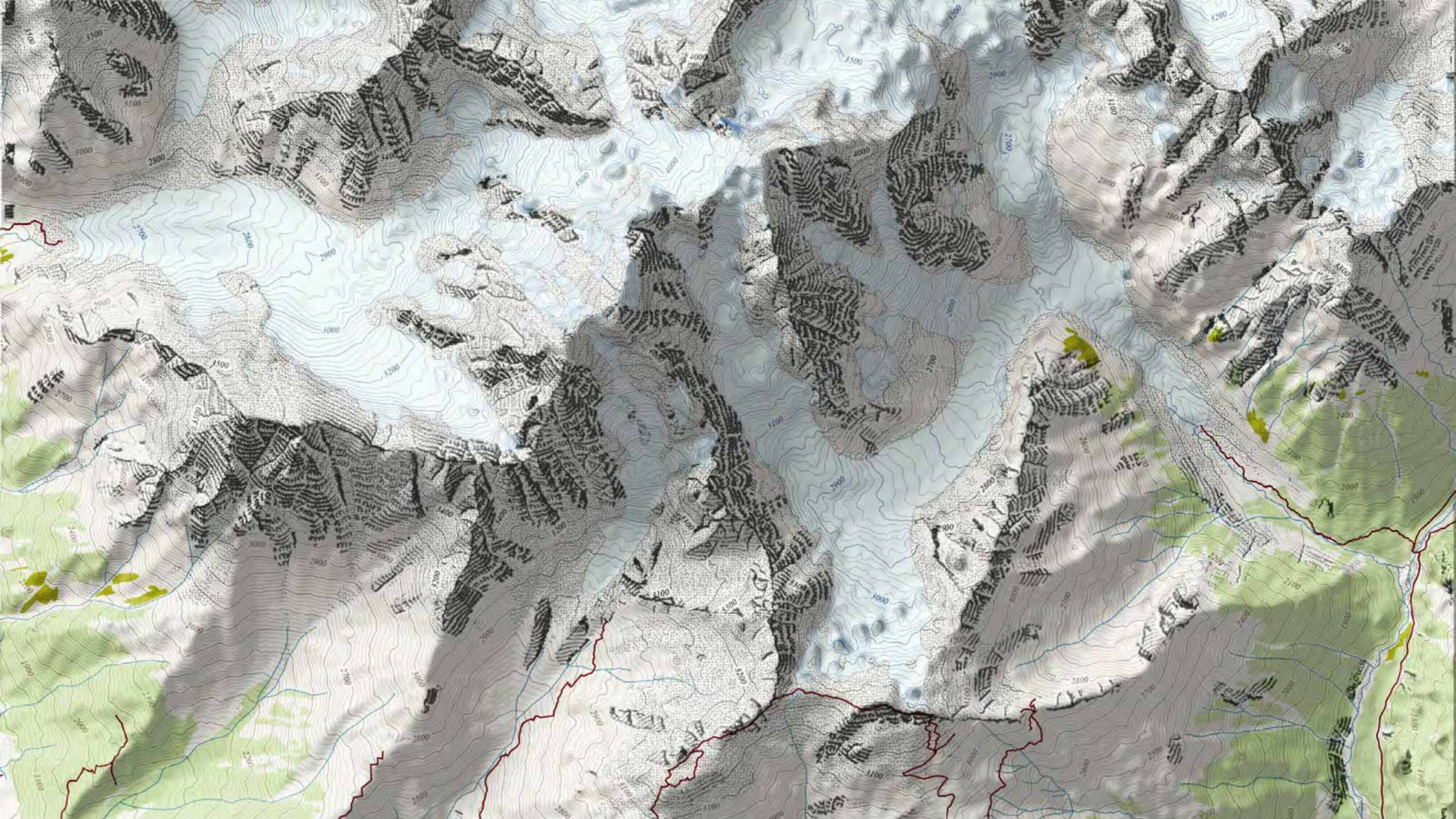


Rock Depiction

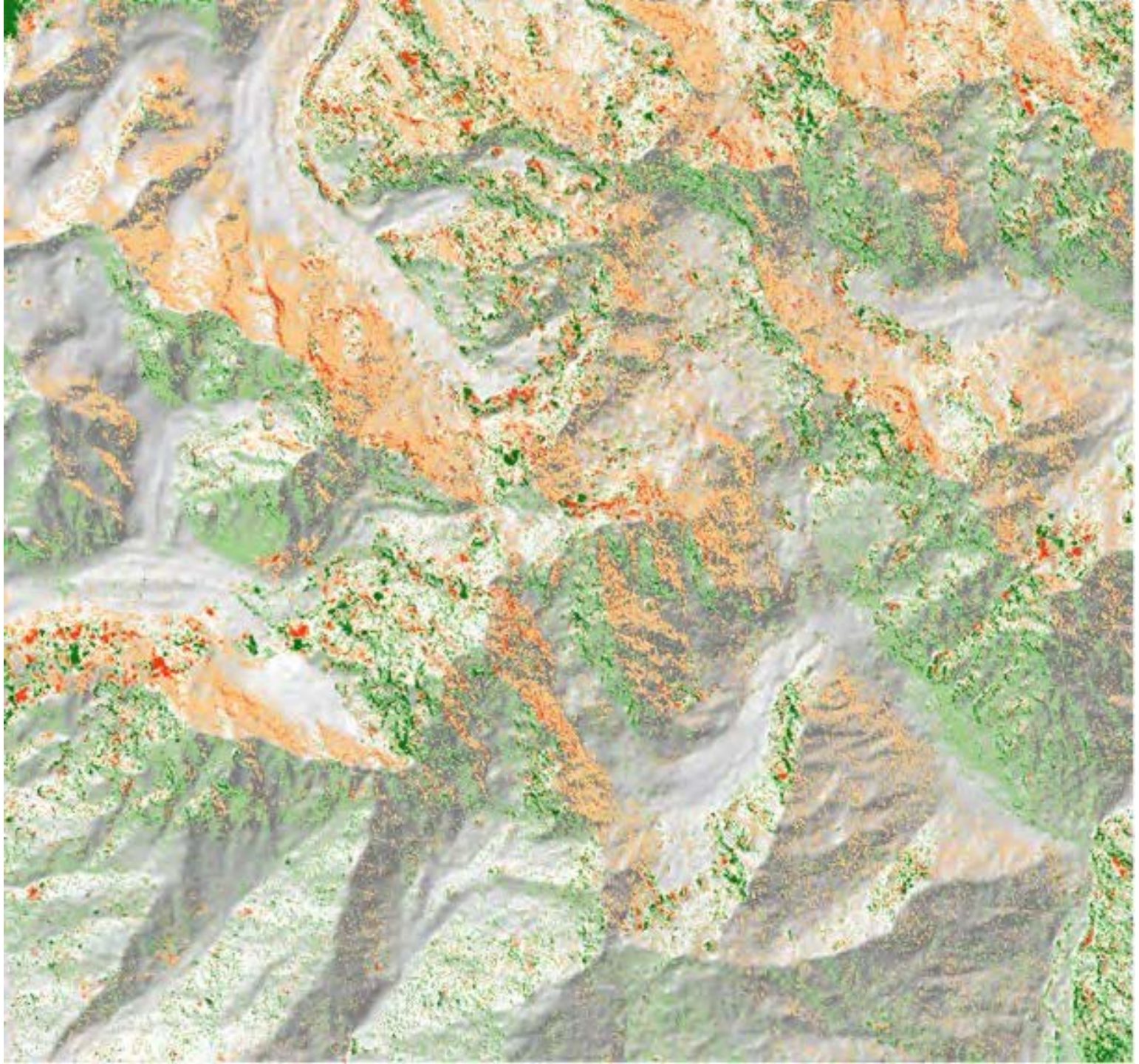
- Rock areas detected by Schröder (2020)
- Bedrock detected in map sheets

- Piotr software (Geisthövel, 2017)
- Swiss Rock depiction
- Horizontal & vertical hachures

Results



Discussion


Value
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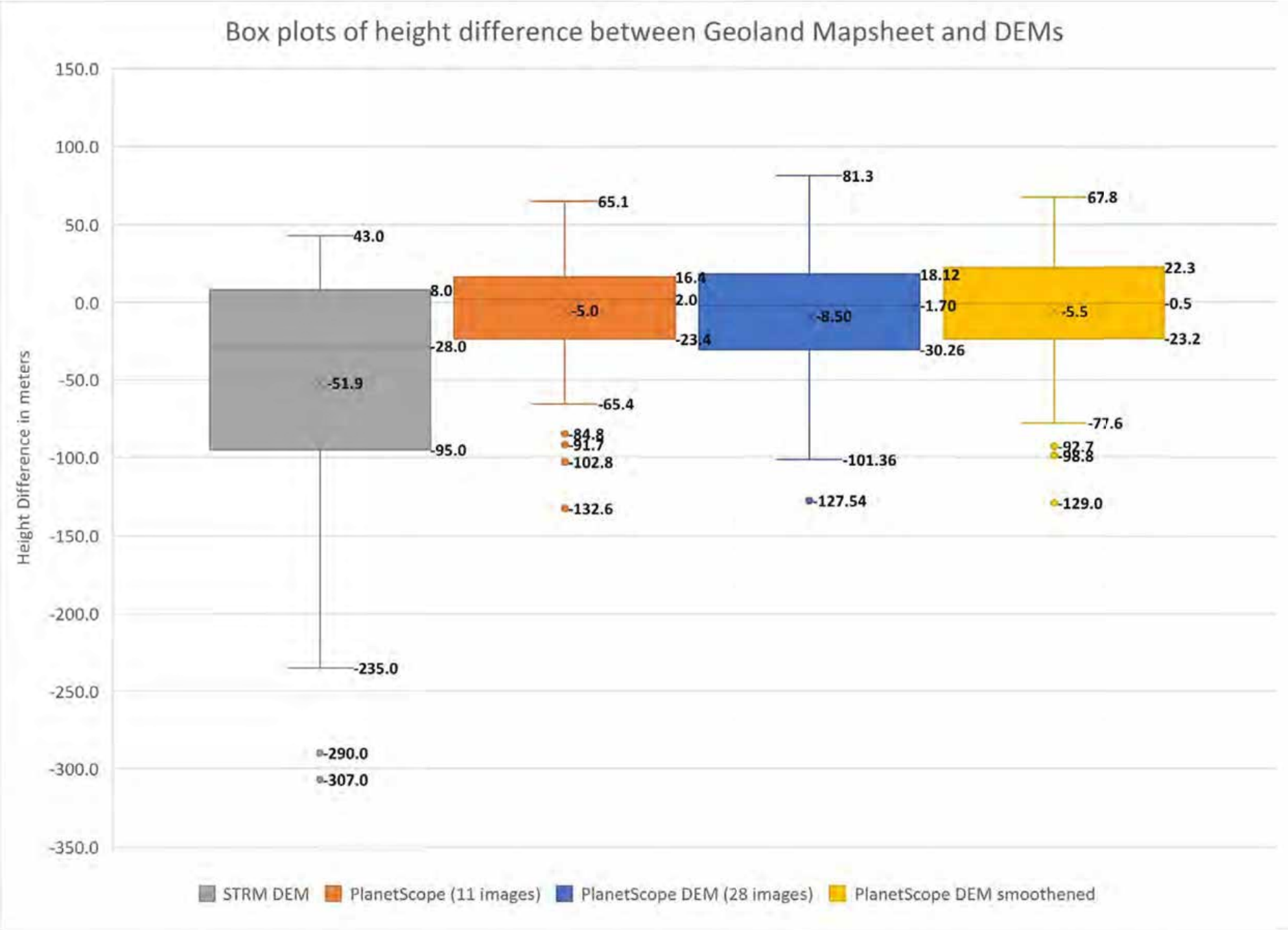
-49.0836 - -29.4502
-29.4501 - -9.81669
-9.81668 - 9.81683
9.81684 - 29.4503
29.4504 - 49.0839
49.084 - 979.852


Box plots of height difference between Geoland Mapsheet and DEMs
Height Difference in meters
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
43.0
8.0
-51.9
-28.0
-95.0
-235.0
-290.0
-307.0
65.1
16.4
2.0
-5.0
-23.4
-65.4
-84.8
-91.7
-102.8
-132.6
81.3
18.12
-1.70
-8.50
-30.26
-101.36
-127.54
67.8
22.3
0.5
-5.5
-23.2
-77.6
-97.7
-98.8
-129.0
STRM DEM
PlanetScope (11 images)
PlanetScope DEM (28 images)
PlanetScope DEM smoothened

Conclusion

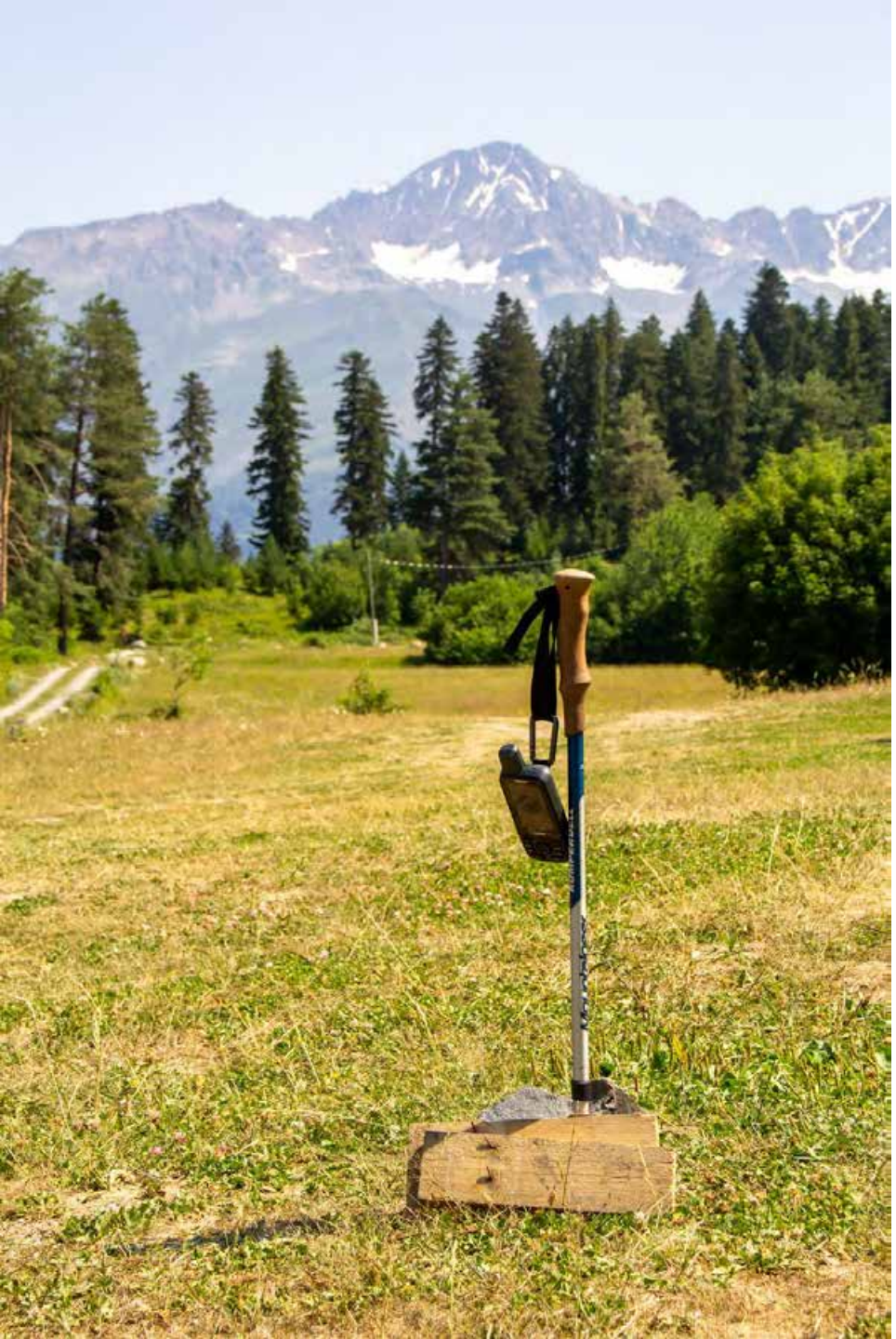
Conclusion

- Digital Elevation Model
  - Sufficient quality
  - Performs better than SRTM
  - Larger area for improved evaluation
- Relief Depiction
  - Legible contour lines
  - Realistic shaded relief with Blender
  - Rock depiction in Alpine Club style

Questions?

Horizontal & Vertical Datum

	Resolution	Horizontal datum	Vertical datum
SRTM DEM	30 meters	WGS84 / UTM 38N	Geoid | EGM96
PlanetScope DEM	3.6 meters	WGS84 / UTM 38N	Ellipsoid | WGS84
Map sheets		WGS84 / UTM 38N	WGS84 / EGM96
Field measurements		WGS84 / UTM 38N	Ellipsoid | WGS84

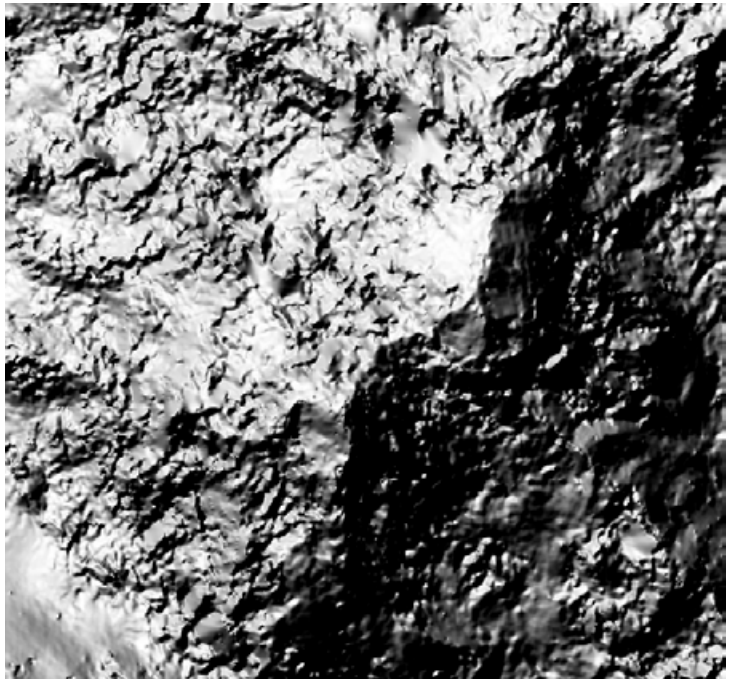


Field measurements

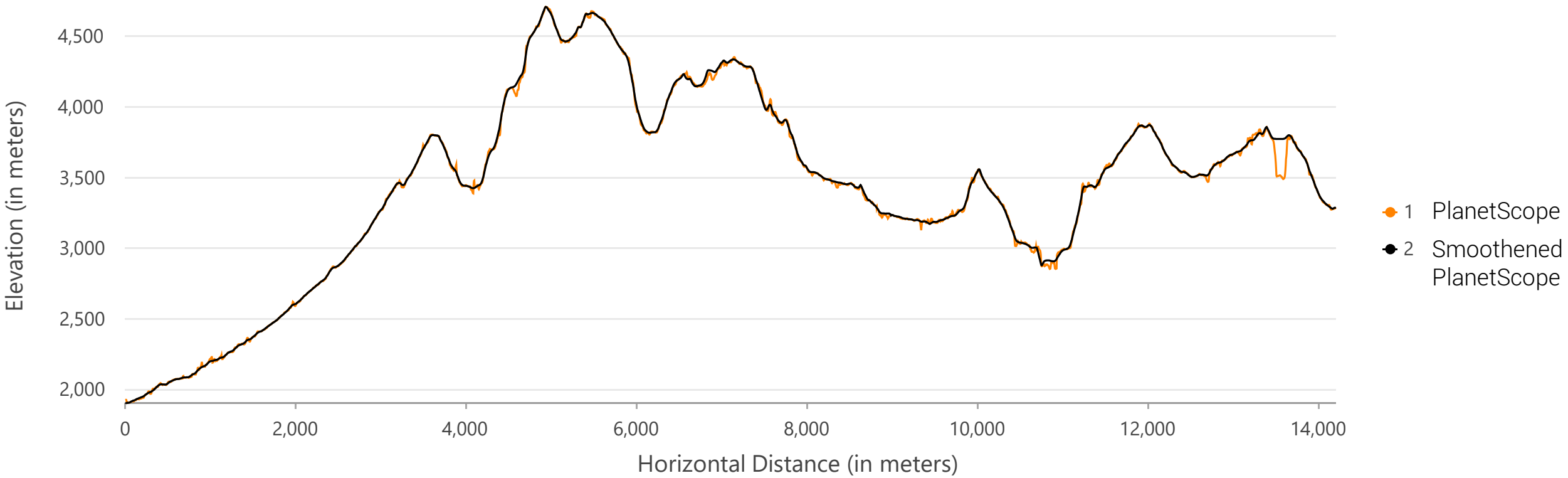
	Average deviation	RMSE
PlanetScope DEM	2.8m	14.3m
SRTM	2.7m	18.8m
Map sheet	4.4m	14.9m

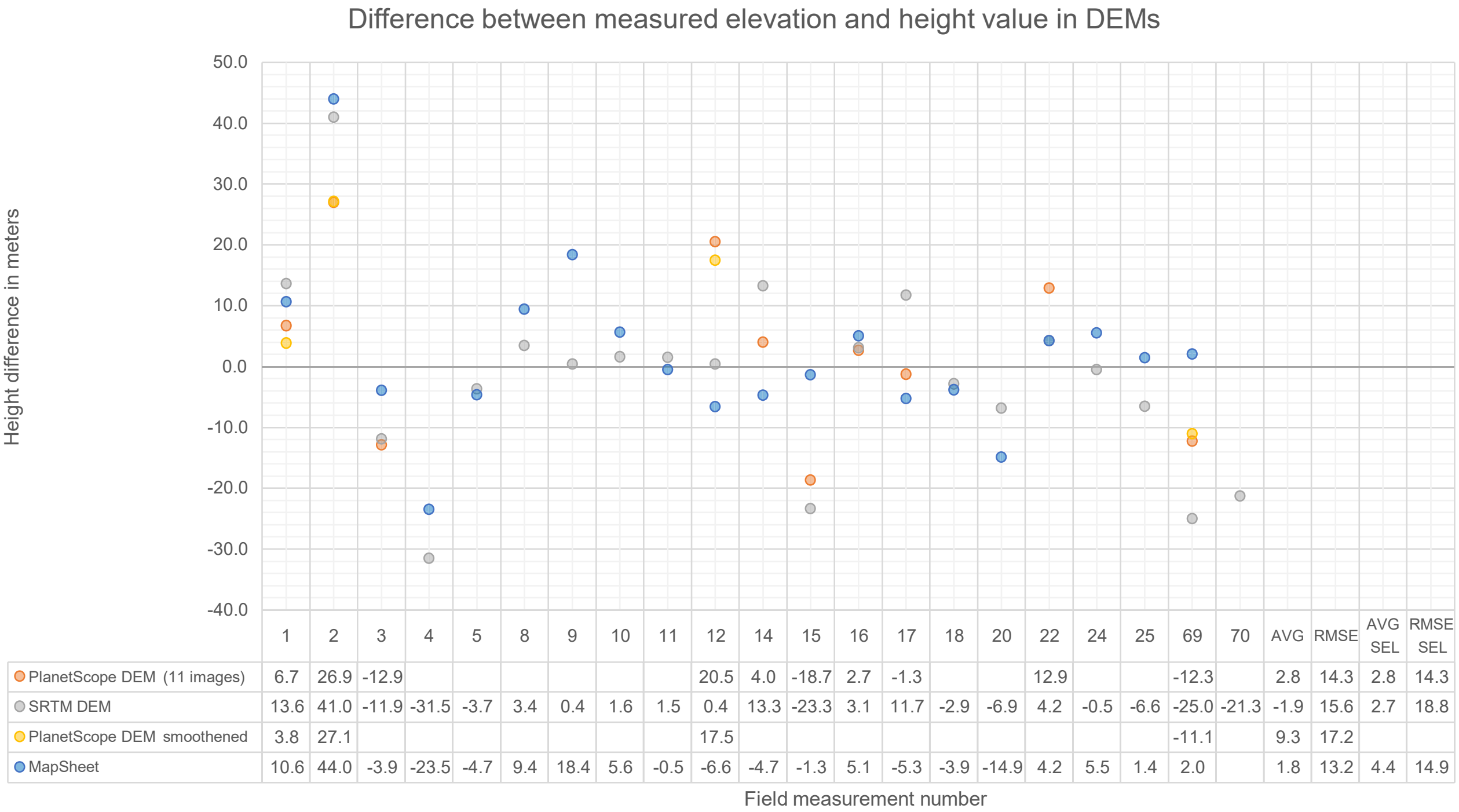
Smoothen DEM

- Low-pass filter
- Feature-preserving DEM smoothing

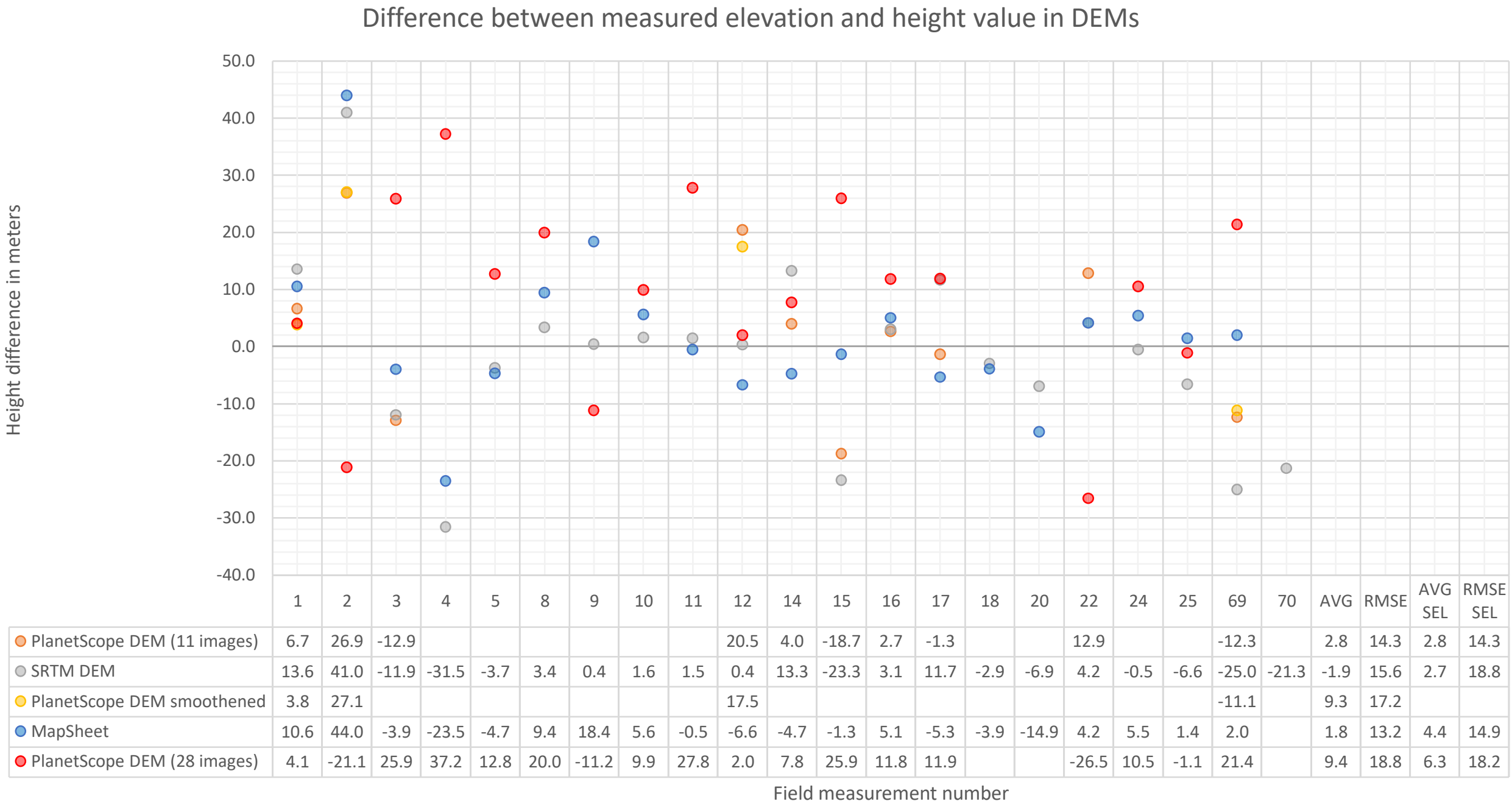


Smoothen DEM





	1	2	3	4	5	8	9	10	11	12	14	15	16	17	18	20	22	24	25	69	70	AVG	RMSE	AVG SEL	RMSE SEL
PlanetScope DEM (11 images)	6.7	26.9	-12.9							20.5	4.0	-18.7	2.7	-1.3			12.9			-12.3		2.8	14.3	2.8	14.3
SRTM DEM	13.6	41.0	-11.9	-31.5	-3.7	3.4	0.4	1.6	1.5	0.4	13.3	-23.3	3.1	11.7	-2.9	-6.9	4.2	-0.5	-6.6	-25.0	-21.3	-1.9	15.6	2.7	18.8
PlanetScope DEM smoothened	3.8	27.1								17.5										-11.1		9.3	17.2		
MapSheet	10.6	44.0	-3.9	-23.5	-4.7	9.4	18.4	5.6	-0.5	-6.6	-4.7	-1.3	5.1	-5.3	-3.9	-14.9	4.2	5.5	1.4	2.0		1.8	13.2	4.4	14.9



	1	2	3	4	5	8	9	10	11	12	14	15	16	17	18	20	22	24	25	69	70	AVG	RMSE	AVG SEL	RMSE SEL
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SRTM DEM	13.6	41.0	-11.9	-31.5	-3.7	3.4	0.4	1.6	1.5	0.4	13.3	-23.3	3.1	11.7	-2.9	-6.9	4.2	-0.5	-6.6	-25.0	-21.3	-1.9	15.6	2.7	18.8
PlanetScope DEM smoothened	3.8	27.1								17.5										-11.1		9.3	17.2		
MapSheet	10.6	44.0	-3.9	-23.5	-4.7	9.4	18.4	5.6	-0.5	-6.6	-4.7	-1.3	5.1	-5.3	-3.9	-14.9	4.2	5.5	1.4	2.0		1.8	13.2	4.4	14.9
PlanetScope DEM (28 images)	4.1	-21.1	25.9	37.2	12.8	20.0	-11.2	9.9	27.8	2.0	7.8	25.9	11.8	11.9			-26.5	10.5	-1.1	21.4		9.4	18.8	6.3	18.2