United States Army Corps of Engineers
Cold Regions Research & Engineering Laboratory
Remote Sensing and GIS Center of Expertise
Hanover, NH

SnowEx 2023 Terrestrial Laser Scanning Support

Final report

Overview

- Collection dates: 8 – 16 March 2023
- Location: Tanana Flats, southwest of Fairbanks, Alaska along the Tanana River
- Collection type: Terrestrial laser scanning
- Delivered on: 2023-04-28
- Point of contact: Adam L. LeWinter
- Spatial reference system: WGS84 UTM Zone 6N
    - Heights: NAVD88
    - Units: meters

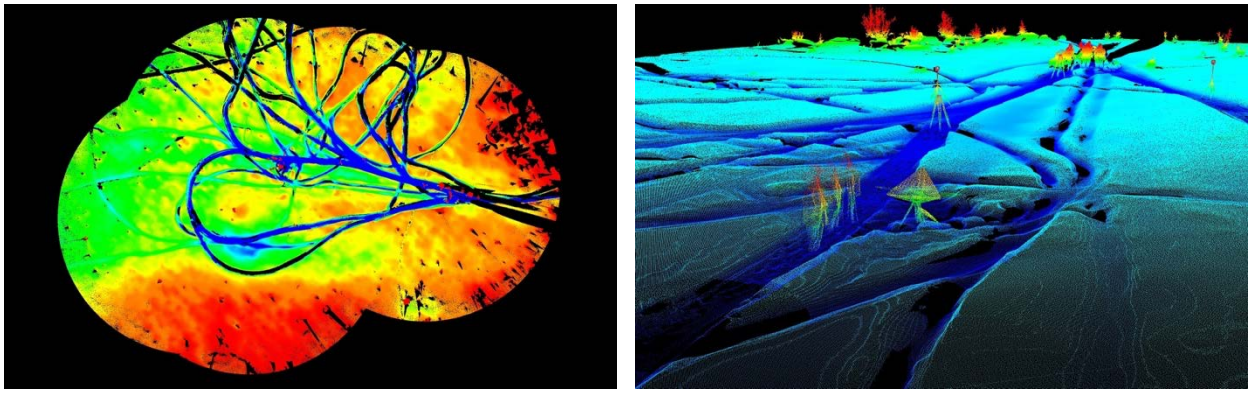

Figure 1: Left) Top view of lidar point cloud from CRE survey site, colored by height. Right) Oblique view of lidar point cloud from CRE survey site, colored by height, focused on the radar reflector (and TLS field crew).

Contents

Mission Description

From March 8 – 16, 2023, The US Army Corps of Engineers Cold Regions Research and Engineering Laboratory's Alaska Projects Office (AKRO) and Remote Sensing and GIS Center of Expertise (RSGIS CX) conducted field collection and processing of terrestrial laser scanning (TLS) data for NASA's SnowEx mission. With training and direction from RSGIS CX, AKRO personnel collected TLS and ground control data at 21 survey sites near the Tanana River southwest of Fairbanks, Alaska. RSGIS CX personnel processed these resulting data into classified point clouds (2-cm sub-sampled data) and 15-cm digital terrain models (DTM). To overcome line-of-sight obstructions caused by the dense ground vegetation at the survey sites, multiple scan positions were collected at each site to get a more complete survey of the areas. These individual scan positions were then combined into a single point cloud, from which the digital terrain model was derived. Figures 2 and 3 provide an overview of the survey site locations.

Figure 2: Overview map of the survey sites (red box, see Figure 3 for detailed view) in relation to Fairbanks, Alaska. The survey sites are located along the Tanana River roughly 30-kilometers to the southwest of Fairbanks.

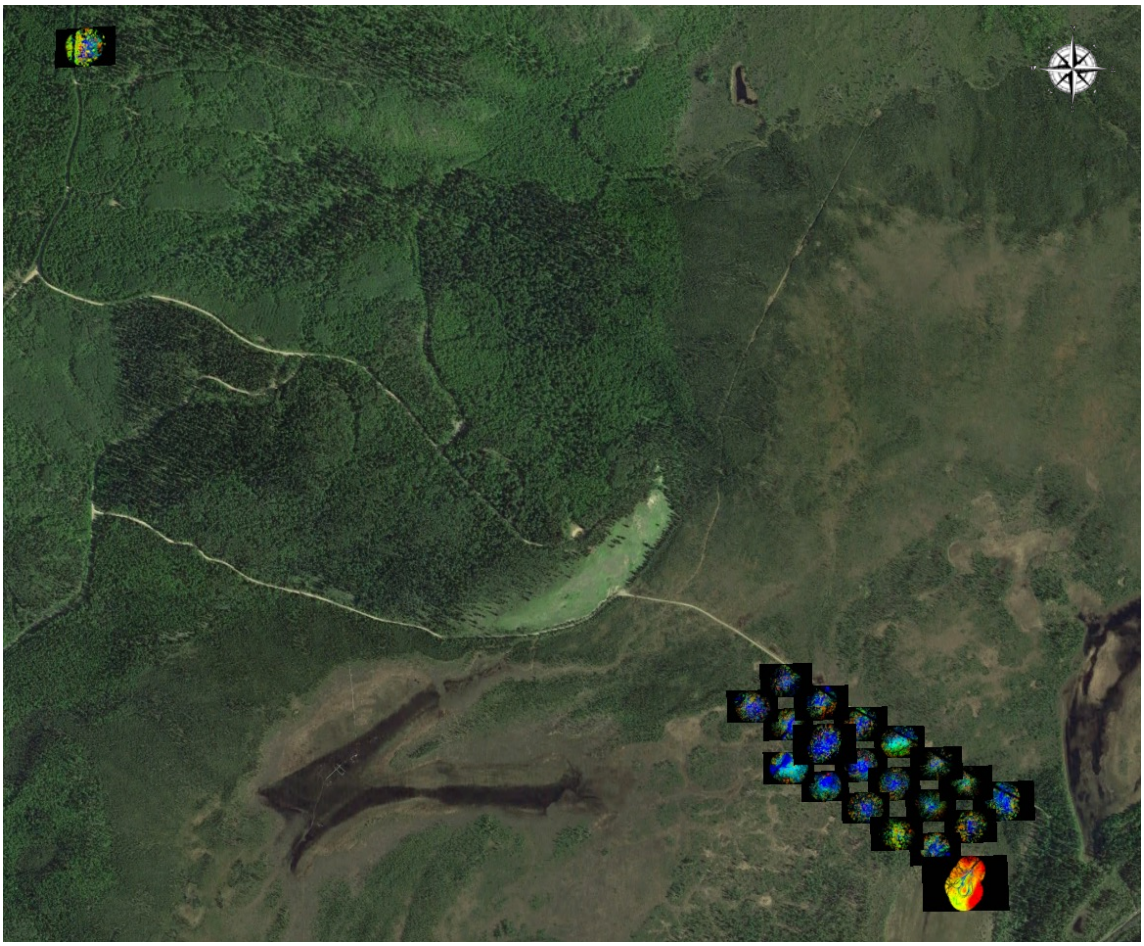

Figure 3: Detailed view of the 21 survey sites, with the resulting 2-cm octree filtered point clouds overlaid on satellite imagery.

Instrumentation

Parameter	Specification
Manufacturer	Riegl LMS GmbH
Model	VZ-400i
Laser Wavelength	1550 nm
Laser Pulse Repetition Rate (PRR) (peak)	1200 kHz
Maximum Measurement Range (90% reflective target)	250 m
Accuracy	5 mm
Precision	3 mm
Laser beam divergence	0.35 mrad
Vertical Field of View	100 deg
Horizontal Field of View	360 deg

Table 1: Riegl VZ-400i Terrestrial Laser Scanner Specifications

Control

A GNSS survey was conducted by AKRO to collect precise coordinates of the centroid of 10cm cylindrical reflectors deployed throughout each scan location. These reflectors were used to tie the TLS data to a global coordinate system (WGS84 UTM Zone 6N / NAVD88 height). The below coordinate list was provided to RSGIS CX by AKRO, and represent the horizontal and vertical center of each reflector deployed. The *Point_ID* naming convention refers to the 21 individual survey sites collected with the TLS system in October 2022.

Point_ID	Easting	Northing	Reflector Centroid (m)
CRE-1	7175688.26	438889.4008	123.687
CRE-2	7175718.59	438950.6448	122.091
CRE-3	7175754.55	439011.0788	122.165
CRE-A	7175512.98	438650.7438	123.948
CRE-B	7175494.42	438644.0668	124.041
CRE-C	7175514.64	438637.6018	123.916
CRE-D	7175503.71	438617.3868	123.919
CRS01-A	7175654.57	438713.2598	124.988
CRS01-B	7175654.05	438726.7788	125.065
CRS01-C	7175667.39	438724.2088	125.362
CRS01-D	7175669.04	438714.3148	125.239
CRS02-A	7175705.96	438643.8778	125.489
CRS02-B	7175701.34	438642.9078	125.154
CRS02-C	7175698.63	438642.2958	125.228
CRS02-D	7175697.17	438643.4318	125.145
CRS03-A	7175746.31	438589.2118	125.022
CRS03-B	7175740.34	438589.5778	124.901
CRS03-C	7175737.53	438586.3048	124.896
CRS03-D	7175736.46	438582.1578	124.795
CRS04-A	7175781.73	438518.9778	125.299
CRS04-B	7175781.85	438511.0128	125.145
CRS04-C	7175781.41	438502.9338	125.107
CRS05-A	7175829.29	438437.7418	124.951
CRS05-B	7175824.45	438442.1758	124.872
CRS05-C	7175822.73	438433.7328	124.93
CRS05-D	7175812.65	438428.6388	124.858
CRS06-A	7175895.7	438344.5278	124.372
CRS06-B	7175886.68	438365.2828	124.6
CRS06-C	7175863.65	438356.9758	124.719
CRS06-D	7175855.19	438349.3258	124.85
CRS07-A	7175924.96	438285.6118	124.648
CRS07-B	7175917.95	438284.7108	124.656
CRS07-C	7175915.23	438282.2448	124.591
CRS07-D	7175909.5	438285.3978	124.504
CRS08-A	7175618.91	438656.0758	124.563
CRS08-B	7175619.83	438648.4238	124.666
CRS08-C	7175614.67	438640.7638	124.691
CRS08-D	7175604.34	438644.7468	124.446
CRS09-A	7175665.91	438567.8078	125.207
CRS09-B	7175658.95	438567.8298	125.165
CRS09-C	7175652.99	438573.1928	125.096
CRS09-D	7175653.47	438578.6718	125.256
CRS10-A	7175714.71	438505.6768	125.185
CRS10-B	7175707.63	438501.4128	125.06
CRS10-C	7175700.66	438499.8218	124.989
CRS10-D	7175692.69	438494.0308	125.213
CRS11-A	7175745.13	438429.6998	124.631
CRS11-B	7175738.26	438428.3138	124.438
CRS11-C	7175731.45	438430.6268	124.465

CRS11-D	7175744.09	438441.9318	124.68
CRS12-A	7175787.64	438367.9478	124.768
CRS12-A	7175787.64	438367.9478	124.768
CRS12-B	7175789.59	438363.0028	124.769
CRS12-B	7175789.59	438363.0028	124.769
CRS12-C	7175781.34	438365.8568	124.589
CRS12-C	7175781.34	438365.8568	124.589
CRS12-D	7175774.38	438356.0298	124.539
CRS12-D	7175774.38	438356.0298	124.539
CRS13-A	7175817.17	438289.1538	123.963
CRS13-B	7175824.38	438290.4138	124.095
CRS13-C	7175828.39	438292.9708	124.175
CRS13-D	7175824.09	438284.4448	124.254
CRS14-A	7175857.33	438226.3878	124.708
CRS14-B	7175858.67	438218.0028	124.597
CRS14-C	7175864.2	438212.5228	124.608
CRS14-D	7175866.75	438204.4078	124.52
CRS16-A	7175566.98	438575.2258	124.459
CRS16-B	7175562.99	438584.7178	124.376
CRS16-C	7175568.76	438586.6288	124.406
CRS16-D	7175572.6	438574.9588	124.436
CRS17-A	7175595.81	438508.1148	124.596
CRS17-B	7175599.35	438501.9798	124.435
CRS17-C	7175601.15	438502.4528	124.476
CRS17-D	7175602.91	438498.6538	124.402
CRS18-A	7175652	438443.3288	125.2
CRS18-B	7175648.11	438438.4458	125.116
CRS18-C	7175658.35	438434.4908	125.026
CRS18-D	7175653.25	438440.8458	125.109
CRS19-A	7175701.16	438372.1018	124.024
CRS19-B	7175698.6	438367.8268	124.053
CRS19-C	7175703.45	438359.0058	124.097
CRS19-D	7175702.61	438356.5048	124.108
CRS20-A	7175746.84	438277.5018	124.177
CRS20-B	7175738.88	438284.1388	124.112
CRS20-C	7175738.3	438288.4168	124.288
CRS20-D	7175733.31	438287.3078	124.332
TLS2Snow-A	7177218.53	436876.4569	233.417
TLS2Snow-B	7177213.83	436883.7809	233.8
TLS2Snow-C	7177218.41	436894.3109	234.335
TLS2Snow-D	7177221.63	436891.9179	236.723
TLS2Snow-E	7177226.33	436881.9689	234.081

Table 2: 10-cm reflector cylinder coordinates, in WGS84 UTM Zone 6N / NAVD88 (meters). These coordinates were used to tie the TLS data to a global coordinate system.

Post Processing

The post processing for these data consisted of the following steps. Post processing was conducted using Riegl's RiSCAN Pro software and the Point Data Abstraction Library (PDAL):

1. Import 10-cm reflector cylinder control points (RiSCAN Pro)
2. Register individual scans (multiple scan positions collected at each site to provide complete coverage) using reflector registration (RiSCAN Pro)
3. Filter and combine scan data from each survey site (RiSCAN Pro)
    a. Filter data using the following parameters:
        i. Deviation: < / = 9
        ii. Reflectance: > -25 dB
        iii. Range: 1.5 – 30 m
    b. Combine individual scan positions and apply 2-cm octree filter
4. Export LAZ 1.4 point cloud for each survey site (RiSCAN Pro)
5. Classify point cloud data to extract ground points using a Simple Morphological Filter (https://pdal.io/en/latest/stages/filters.smrf.html), export classified LAZ 1.4 point cloud, create 15-cm DTM. See Appendix B for the *smrf.json* PDAL processing pipeline (PDAL)

Deliverables

1. Point clouds:
    a. Individual point clouds for each survey site (quantity 10)
    b. Naming convention:
        i. YYYY-MM-DD_(survey site name).laz
        ii. Example: *2023-03-08-BCEF_tls_crs11.laz*
    c. LAZ 1.4 format
    d. 2-cm octree filtered: The octree filter takes all scan data from each scan position at each site and reduces the data to 2-cm cubes, choosing the closest "real" point in cube to the center of gravity
    e. Point classifications: 0 = never classified, 1 = unassigned, 2 = ground
2. Digital Terrain Models (DTM):
    a. Individual DTMs for each survey site (quantity 10)
    b. Naming convention:
        i. YYYY-MM-DD_(survey site name)-15cm-DTM.tif
        ii. Example: *2023-03-08-BCEF_tls_crs11-15cm-DTM.tif*
    c. GeoTIFF format
    d. 15-cm raster

Appendix A: Figures

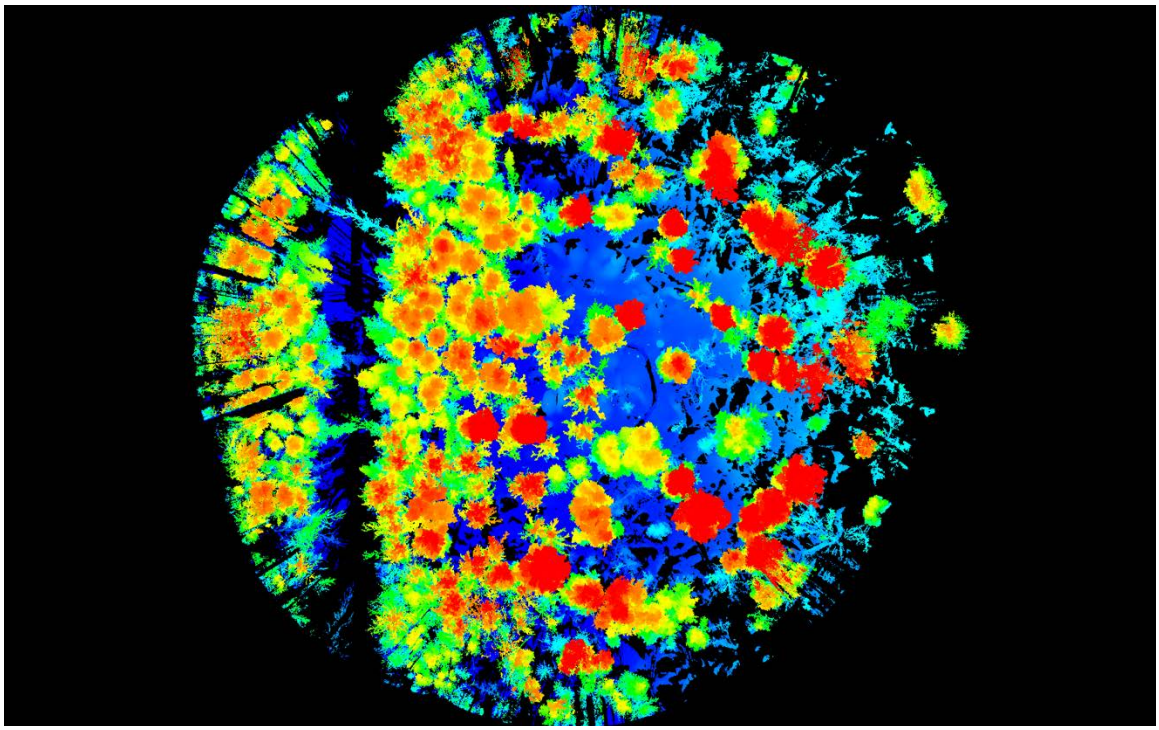

Figure 4: Top view of 2-cm octree filtered point cloud, colored by height, for the TLS-2 Snow site.

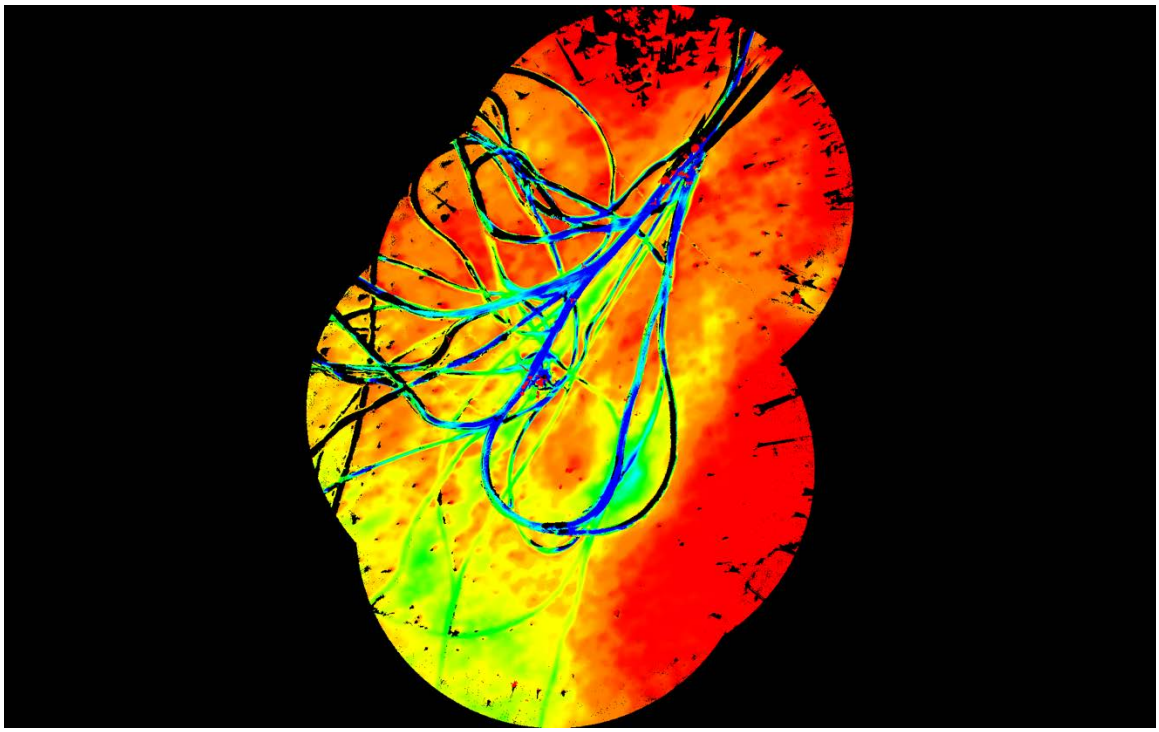

Figure 5: Top view of 2-cm octree filtered point cloud, colored by height, for the TLS-CRE site.

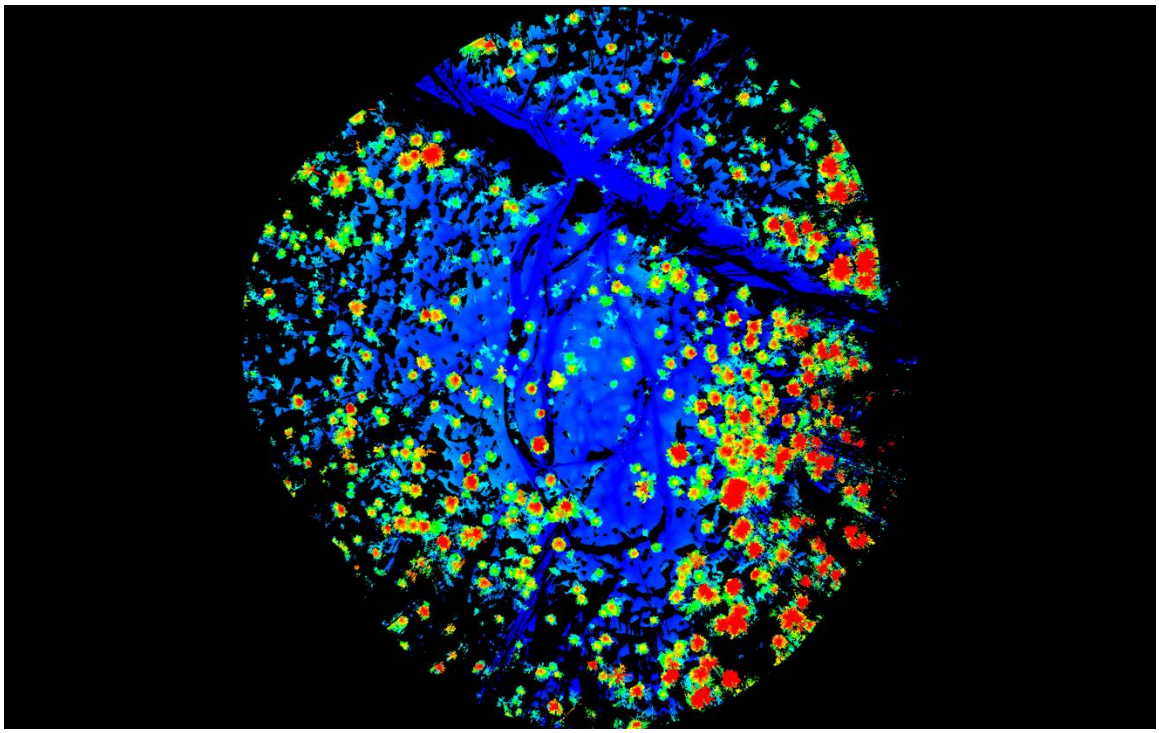

Figure 6: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-1 site.

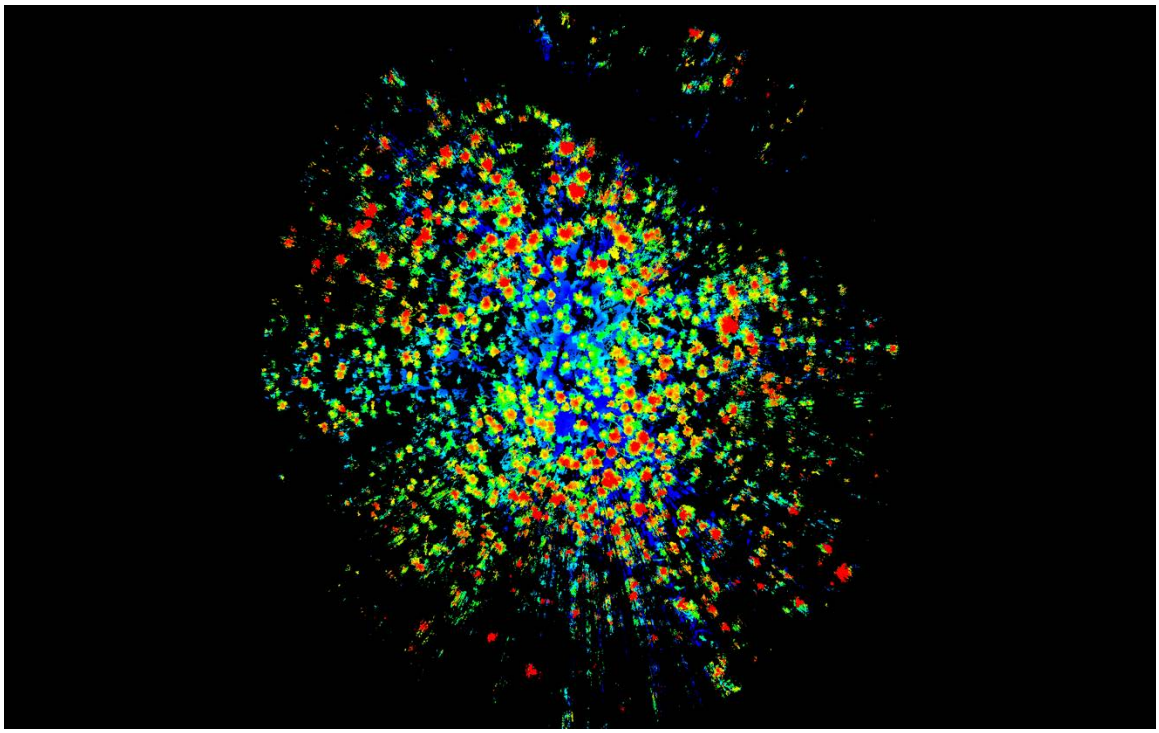

Figure 7: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-2 site.

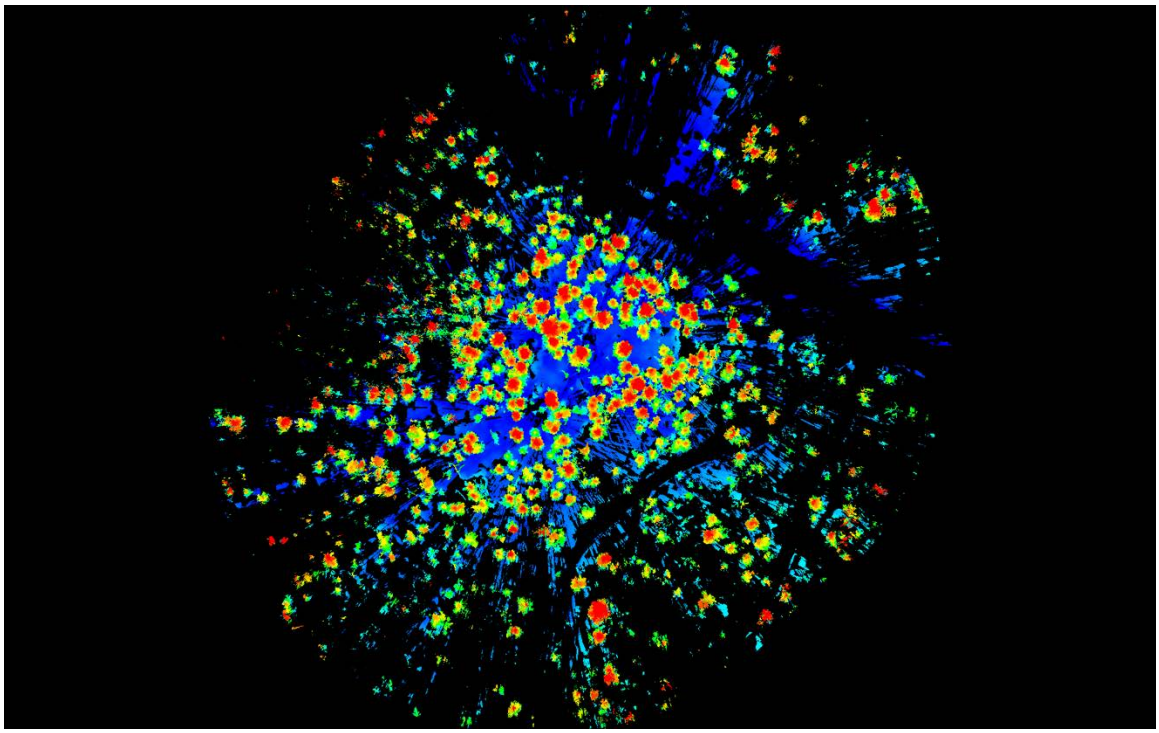

Figure 7: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-3 site.

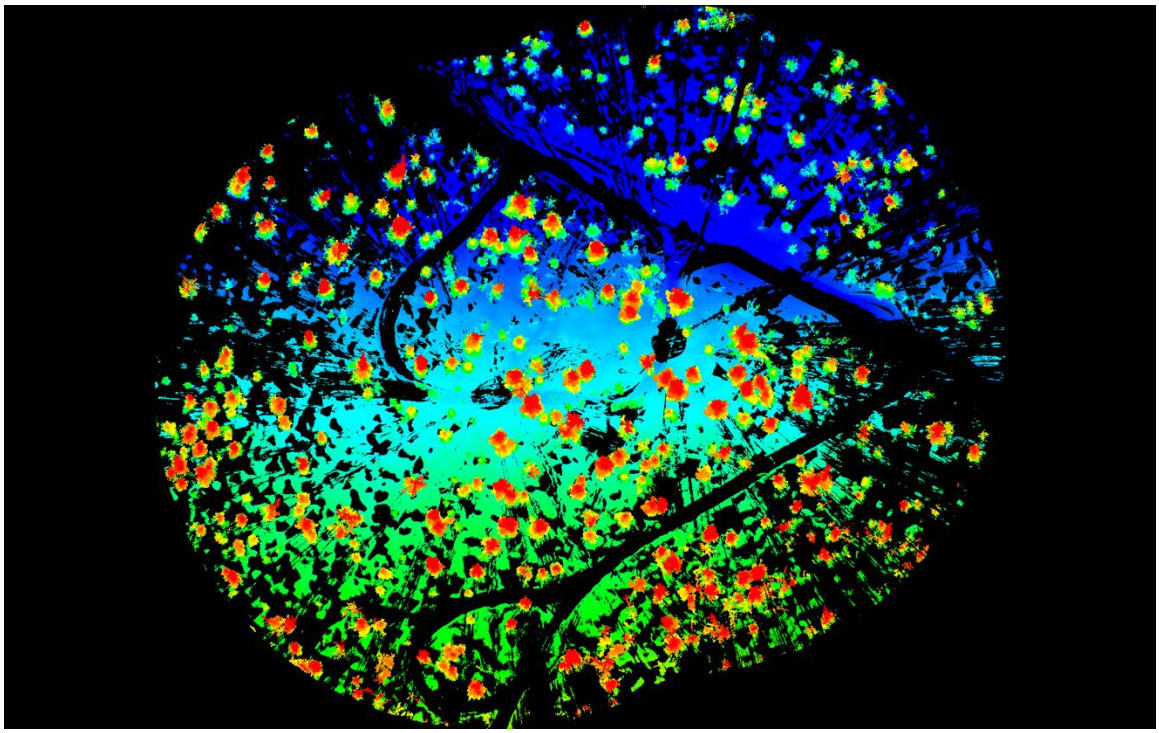

Figure 8: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-4 site.

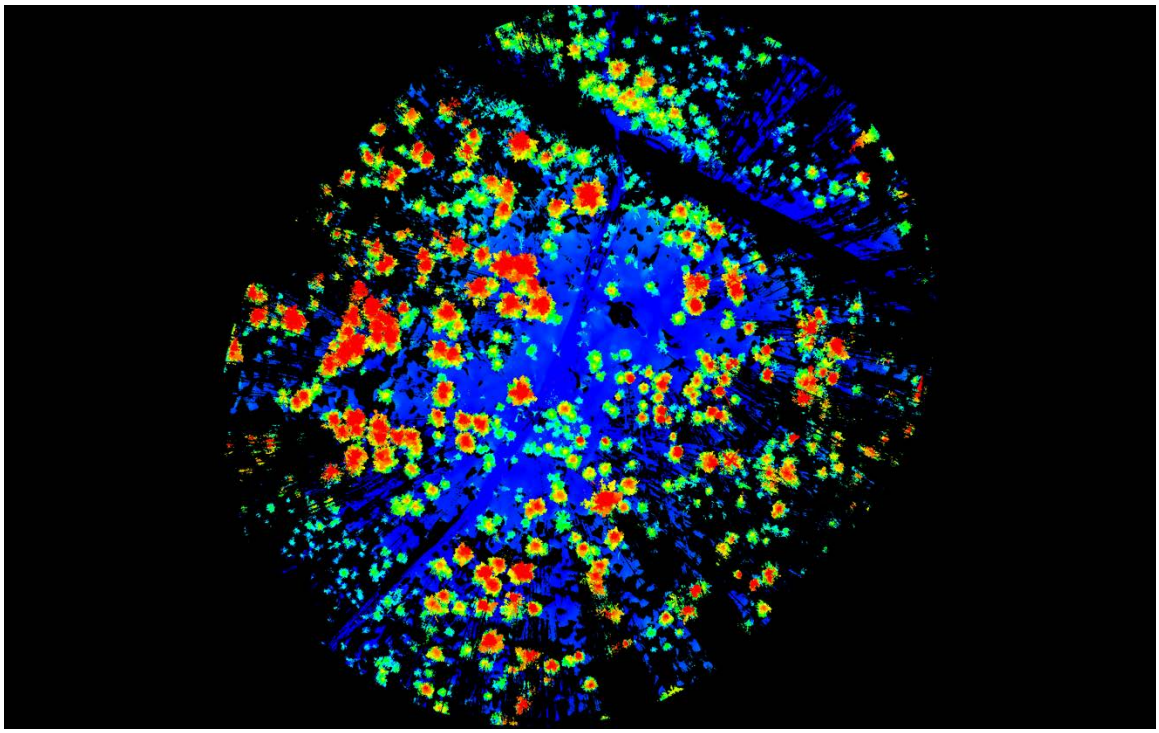

Figure 9: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-5 site.

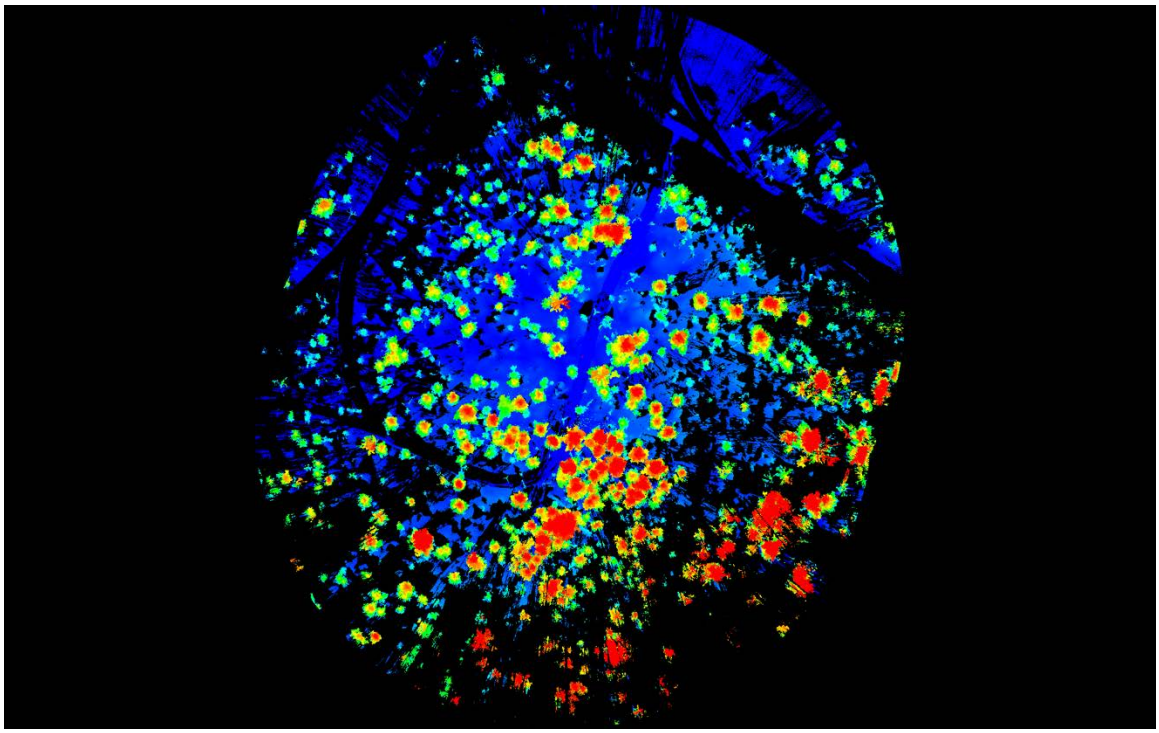

Figure 10: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-6 site.

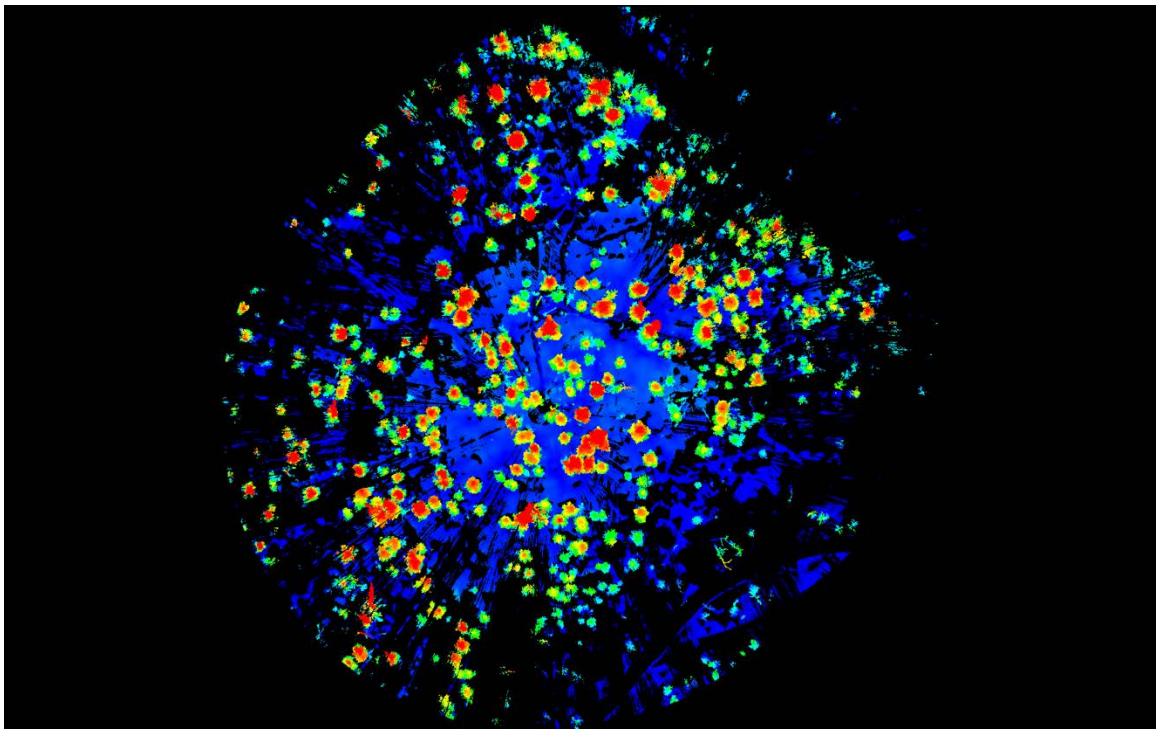

Figure 11: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-7 site.

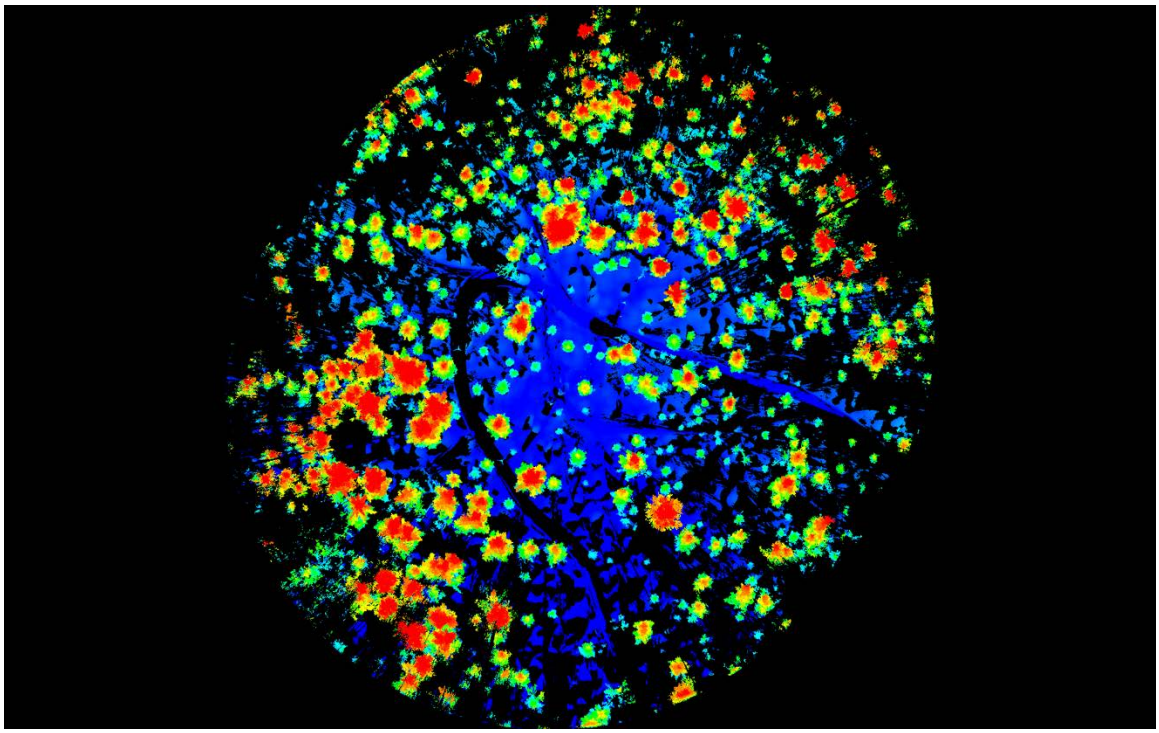

Figure 12: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-8 site.

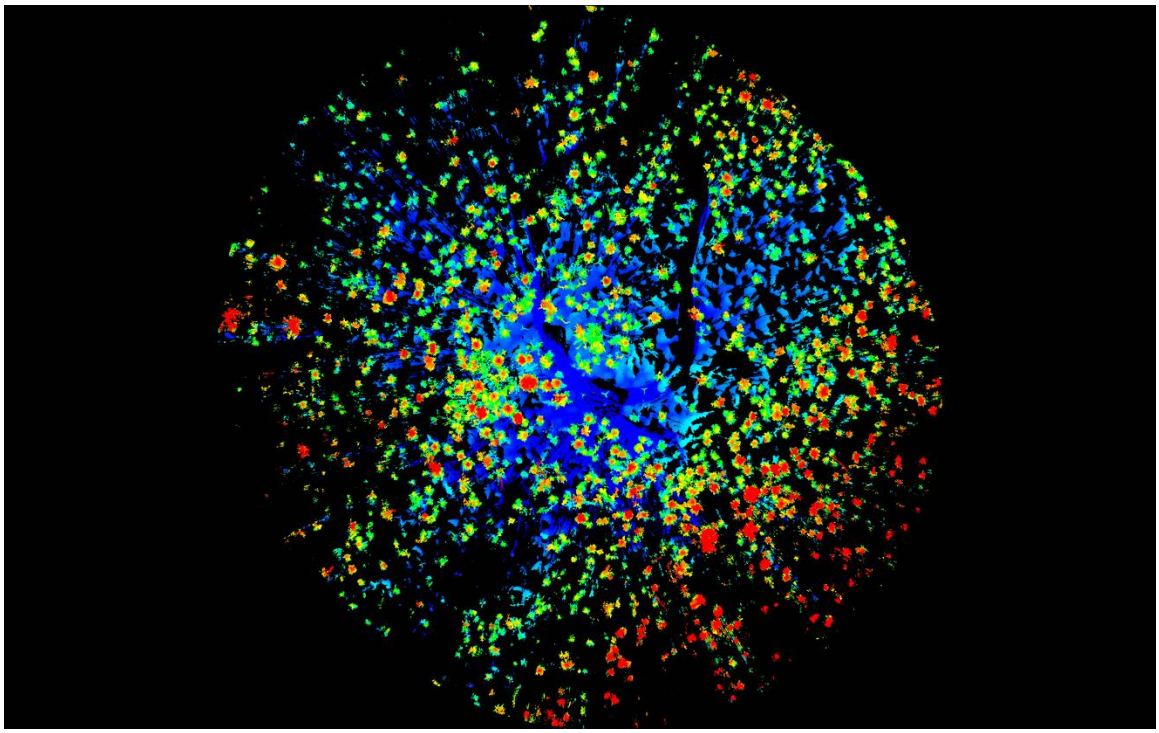

Figure 13: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-9 site.

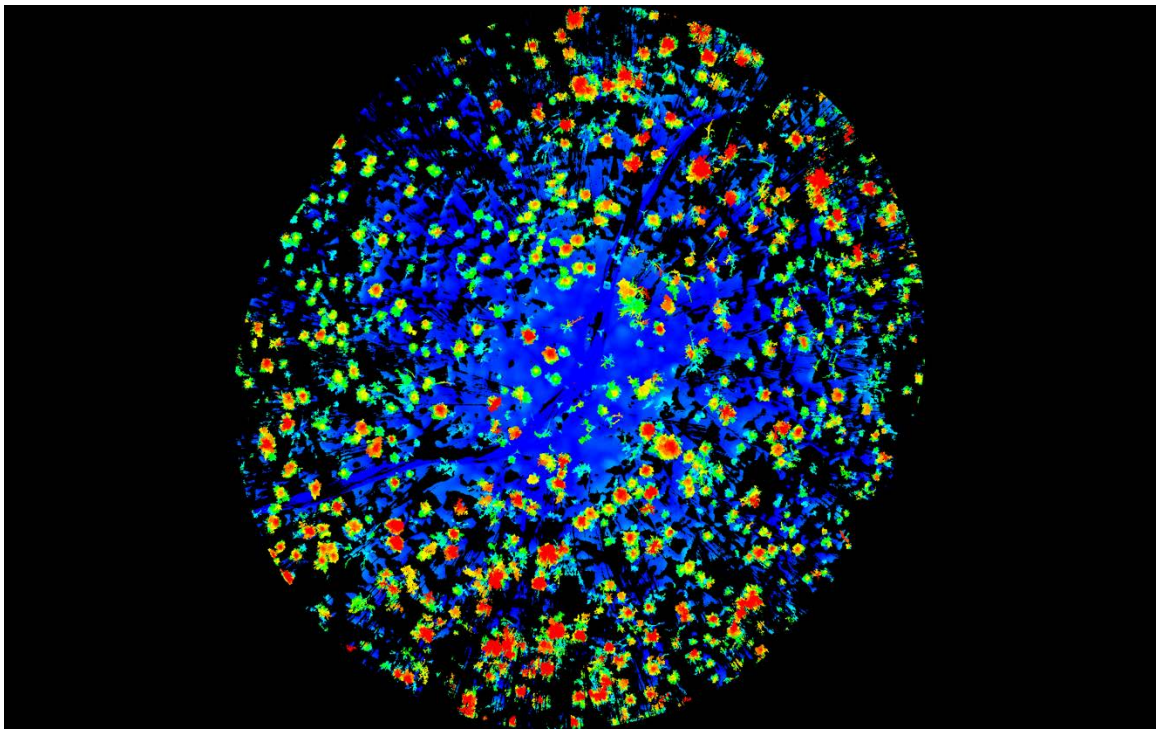

Figure 14: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-10 site.

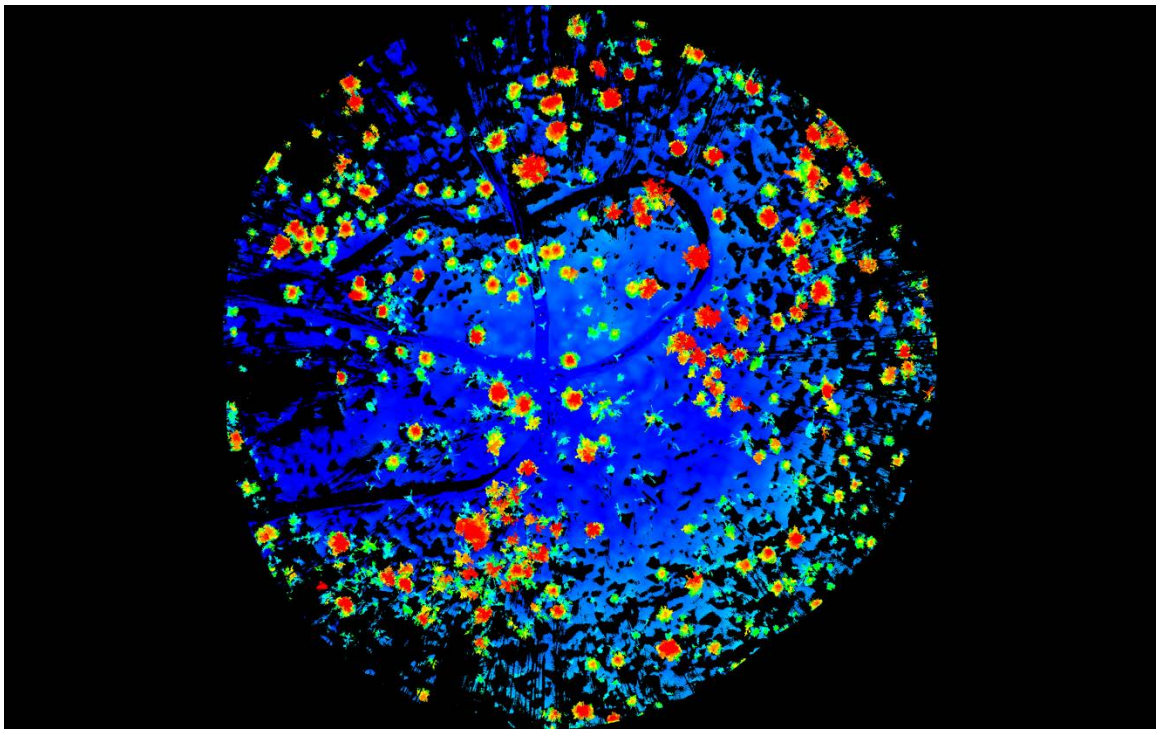

Figure 15: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-11 site.

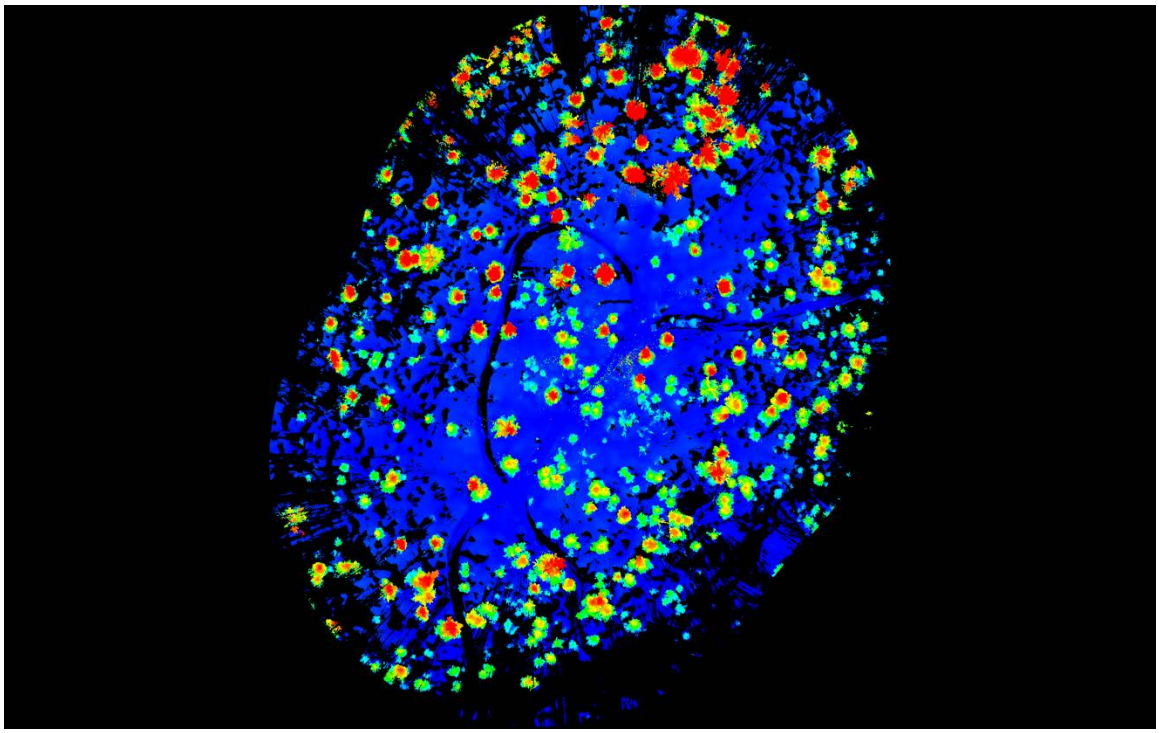

Figure 16: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-12 site.

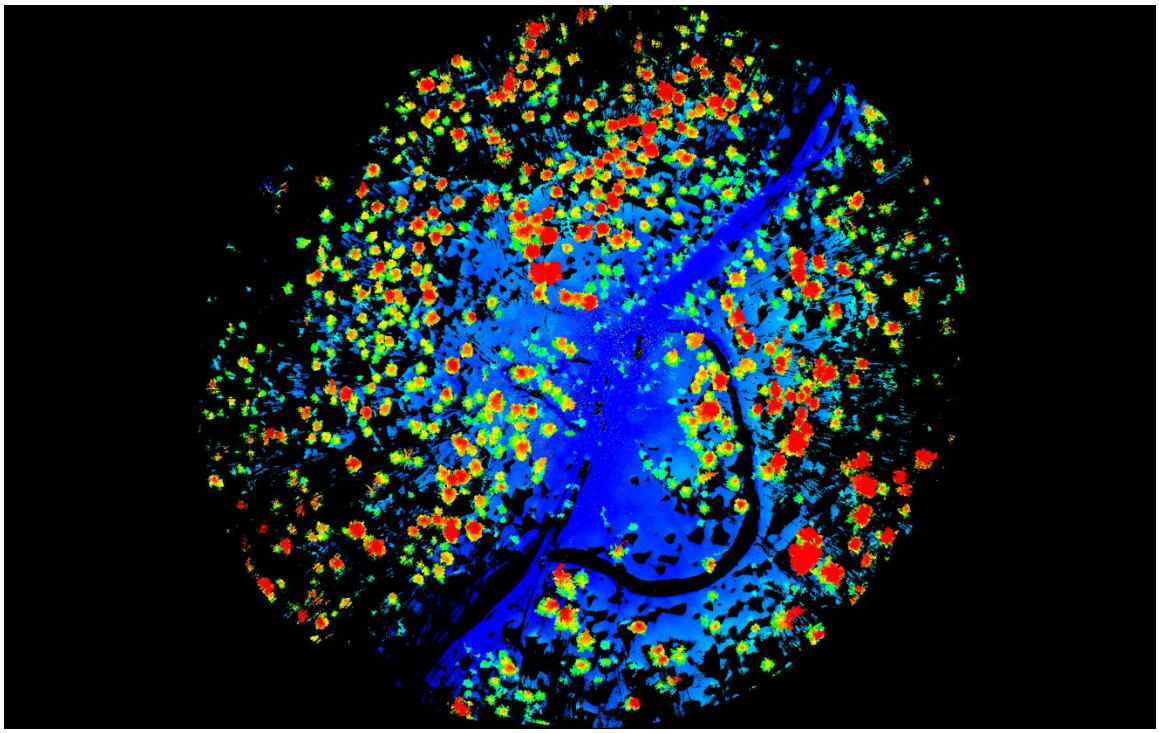

Figure 17: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-13 site.

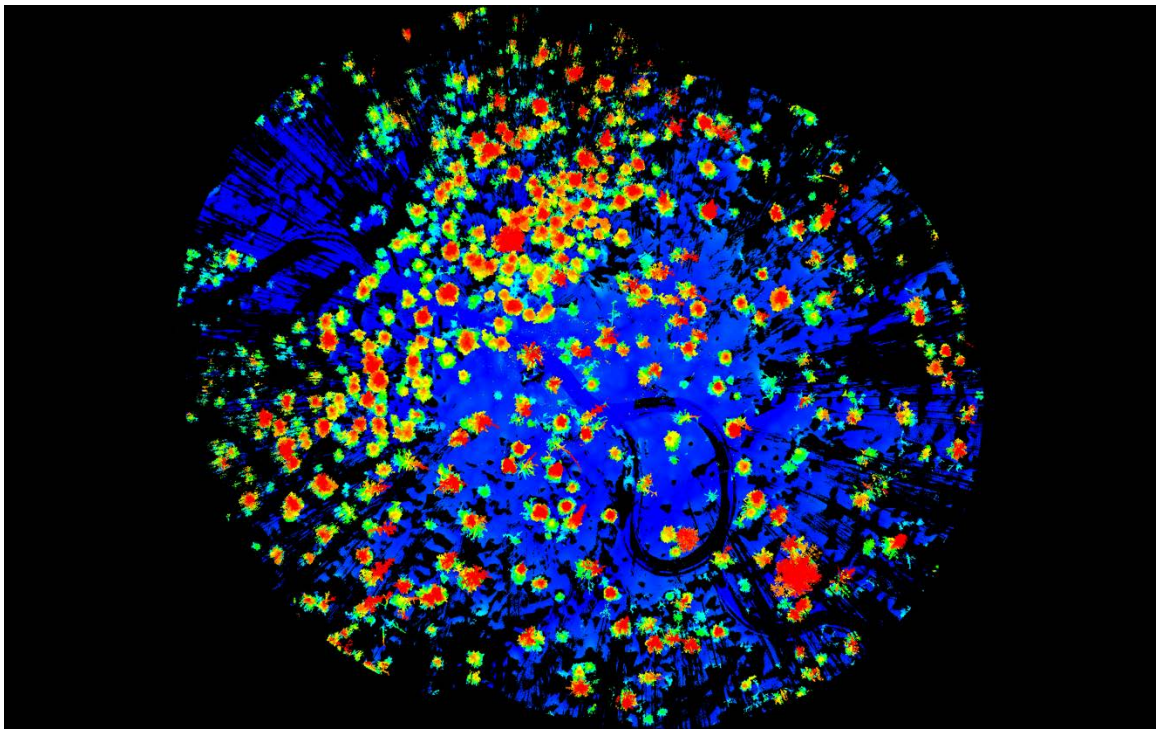

Figure 18: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-14 site.

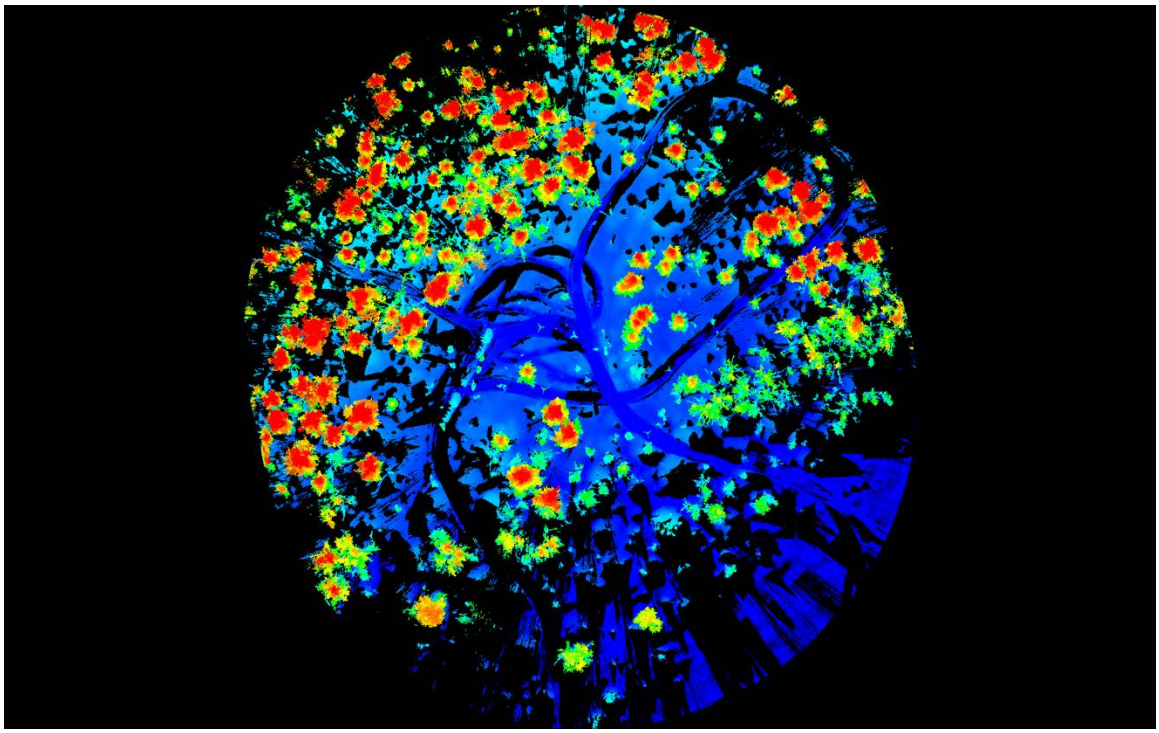

Figure 19: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-16 site.

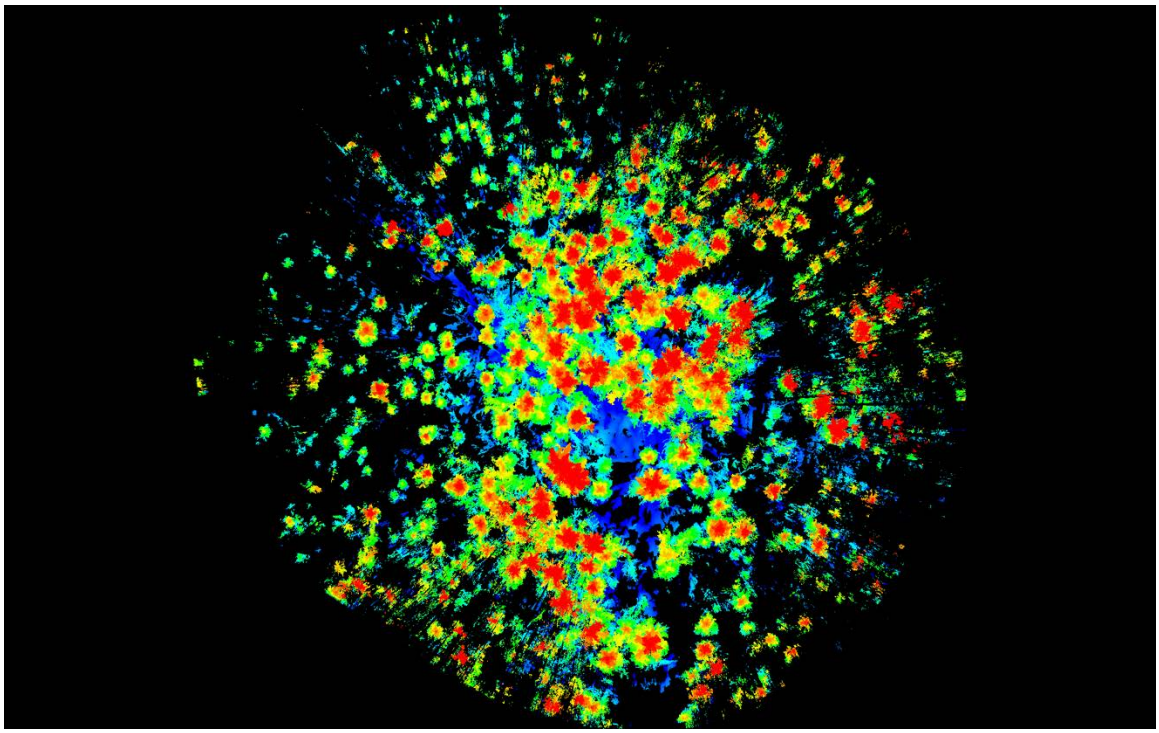

Figure 20: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-17 site.

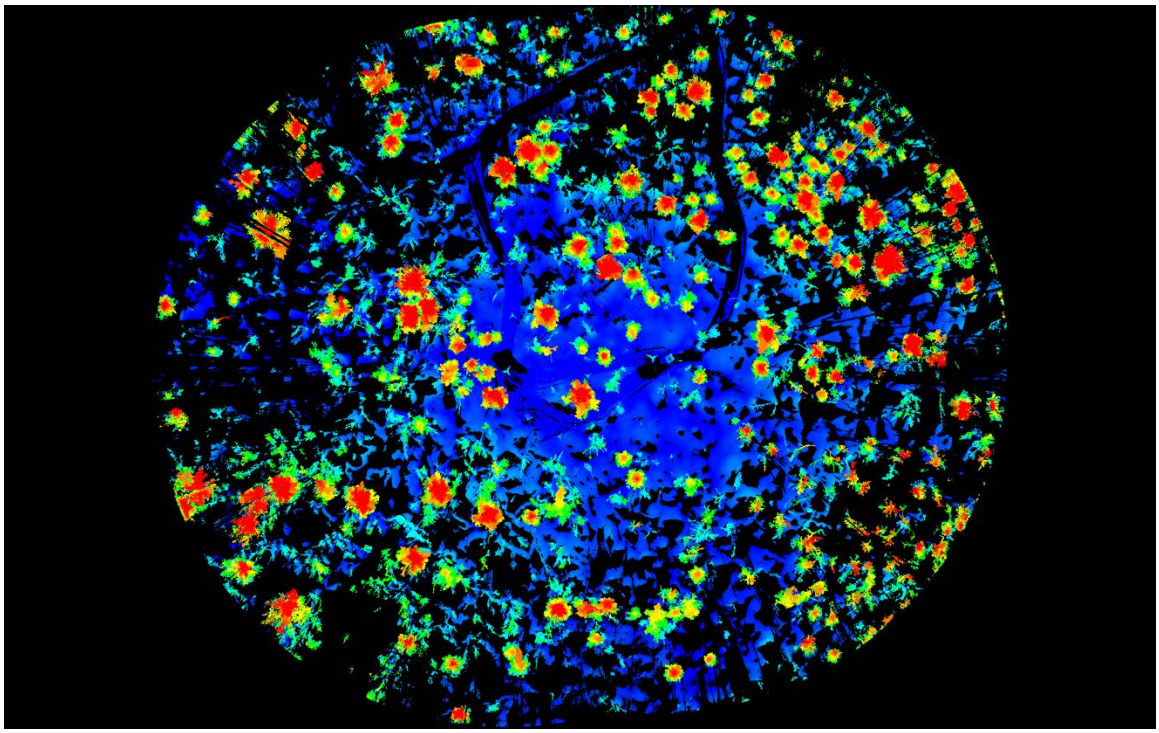

Figure 21: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-18 site.

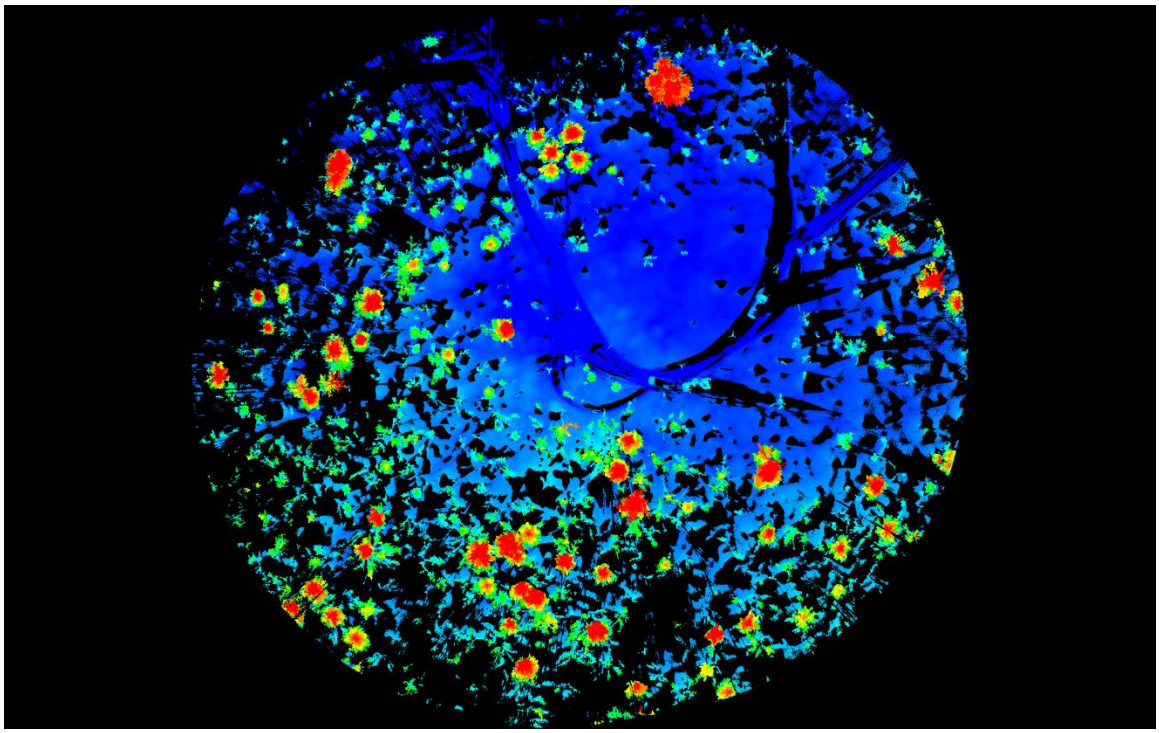

Figure 22: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-19 site.

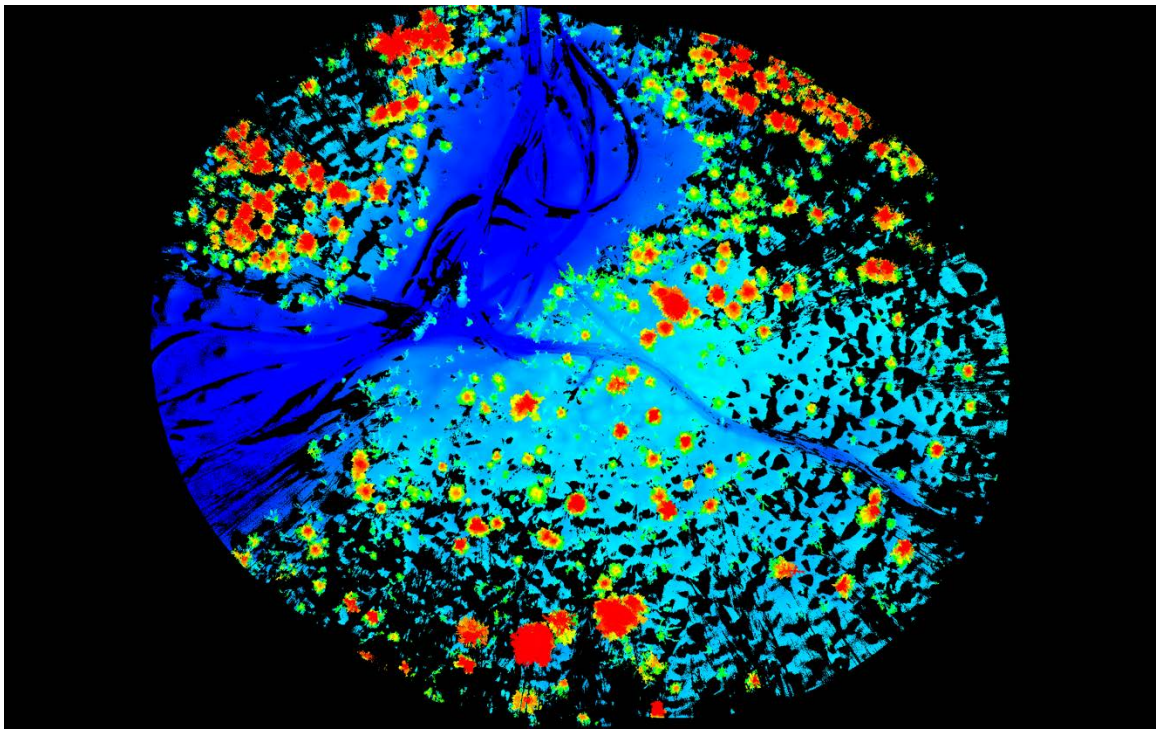

Figure 23: Top view of 2-cm octree filtered point cloud, colored by height, for the CRS-20 site.

Appendix B: PDAL Processing Pipeline

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