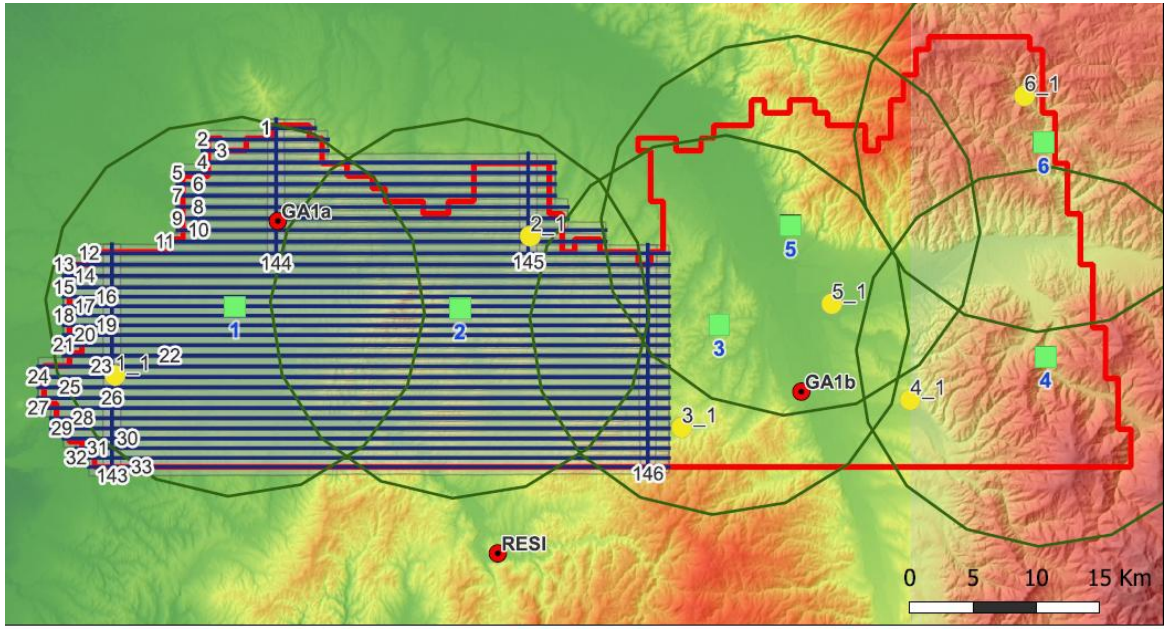
ANCPI
AGENȚIA NAȚIONALĂ DE CADASTRU ȘI PUBLICITATE IMOBILIARĂ

CNC
CENTRUL NAȚIONAL DE CARTOGRAFIE

Data quality for 3D geospatial products
Use cases for Romania

Iuliana PÂRVU - Head of Photogrammetry Department

1. About us
2. LAKI III project
   - ❑ about the project
   - ❑ quality control works
3. Other projects
4. Usage of LiDAR data
5. Conclusions



ABOUT ROMANIA

- surface: 238.000 sqkm
- population: 20.000.000 inhabitants
- heights: 0 m (Black Sea) to 2.544 (Carpathian Mountains)

BLACK SEA

CARPATHIAN MOUNTAINS

ABOUT CNC (1958-2025)

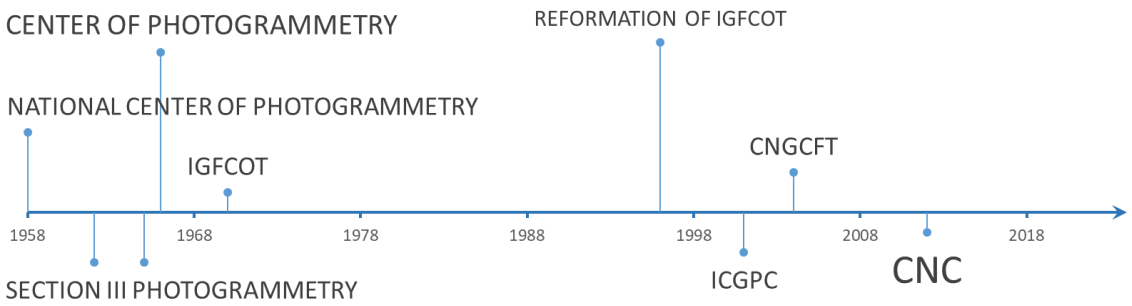
National Agency for Cadastre and Land Registration

- **National Center of Cartography**
- **42 Cadastre and Land Registration Offices**

The National Center of Cartography has a history of more than 65 years - was founded in 1958 – period over which it has undergone several changes of name and has constantly enriched its field of activity

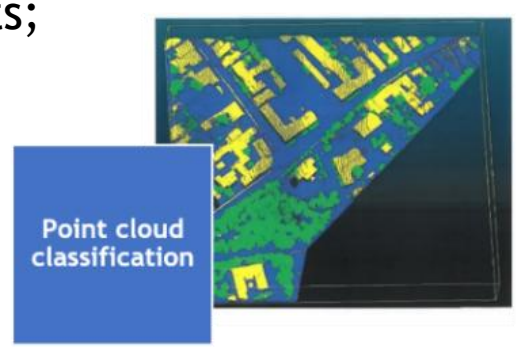
https://www.cartografie.ro

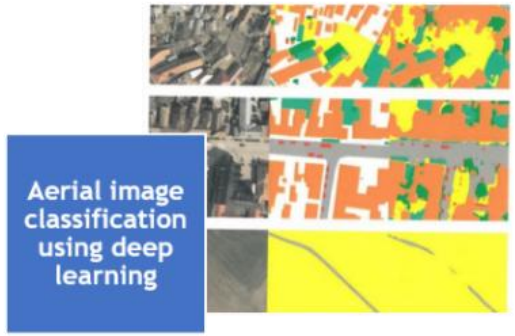
Romania is composed of 42 counties

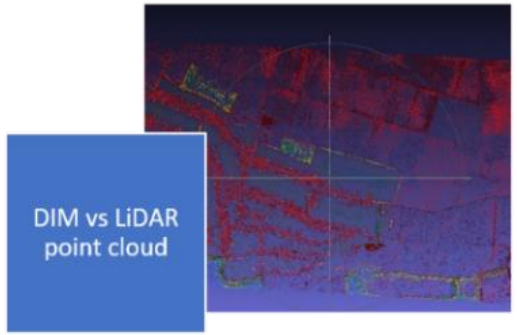


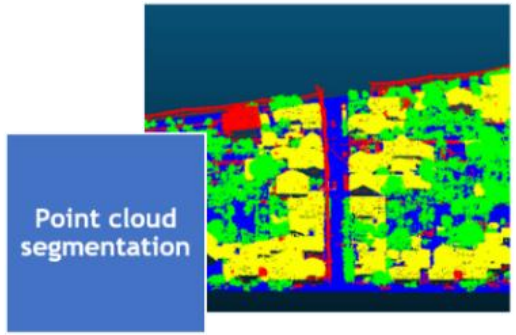
Main activities of the photogrammetry department

- ✓ developing, maintaining and updating the Digital Terrain Model (DTM) at national level, based on the CNCs' data or provided by third parties;
- ✓ developing photogrammetric products;
- ✓ participation in the development of national and international projects for the production of 2D and 3D datasets;
- ✓ **quality control for photogrammetric projects at national level**;
- ✓ developing and updating methodologies, technical specifications, norms, and technological standards in our field of activity.









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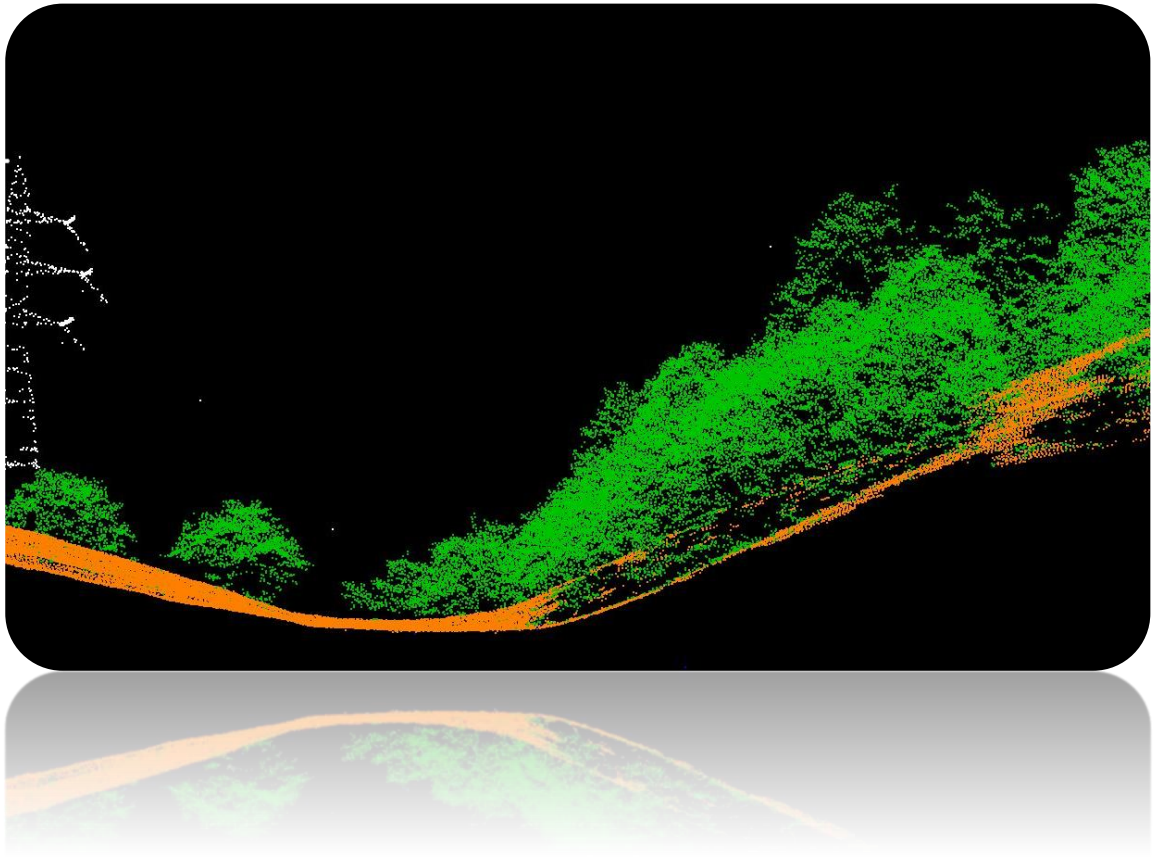
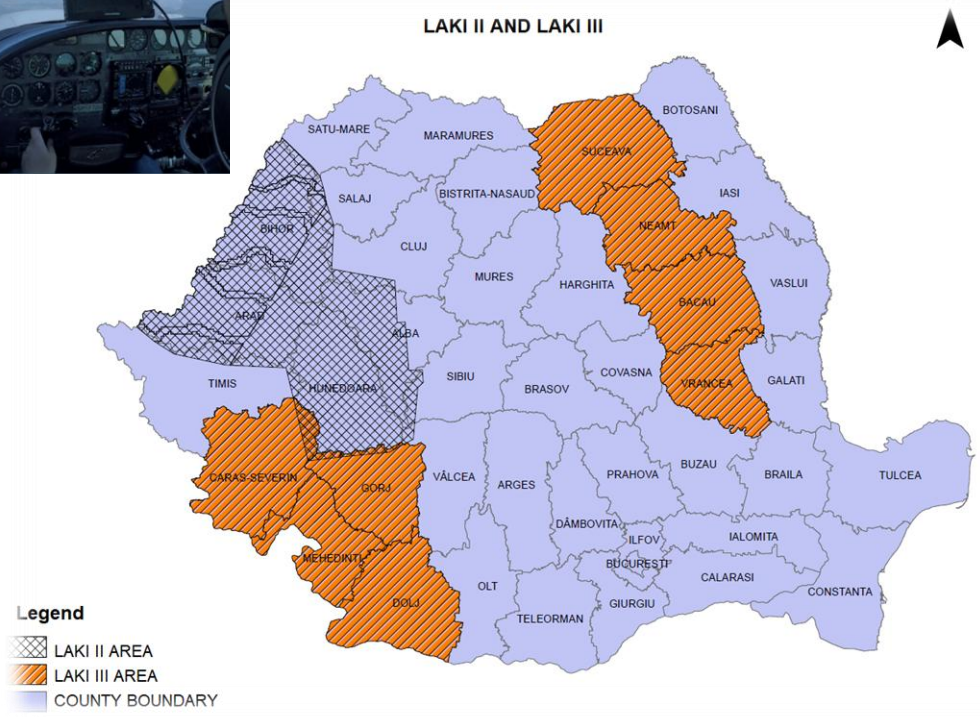


LAKI III - general data

- **Project name**: Land Administration Knowledge Improvement;
- **Project area**: 50.000 sqkm;
- **Project duration**: 2023 - ongoing;
- **Activities**: laser scanning flights for producing DTM and DSM;

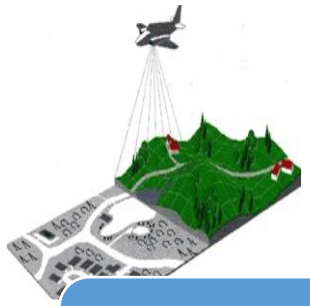


Point cloud density (p/m²)	Horizontal absolute accuracy* – point cloud (m)	Vertical absolute accuracy* – point cloud (m)
5	±0.40	±0.30

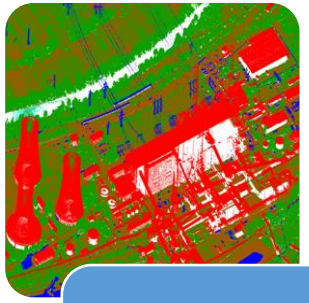
* National reference system: Krasovski 1940 ellipsoid, Projection Plan Stereographic 1970 (EPSG 3844) and Normal height system Black Sea 1975

DTM/DSM resolution (m)	Vertical absolute accuracy* DTM/DSM (m)
0.50	±0.40

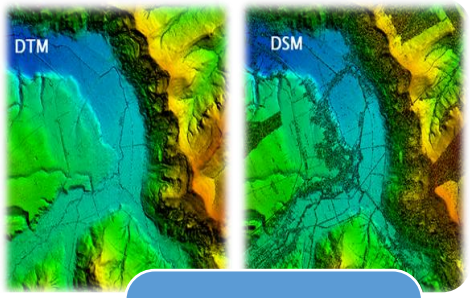
LAKI III - deliveries and status



Field measurements and laser scanning

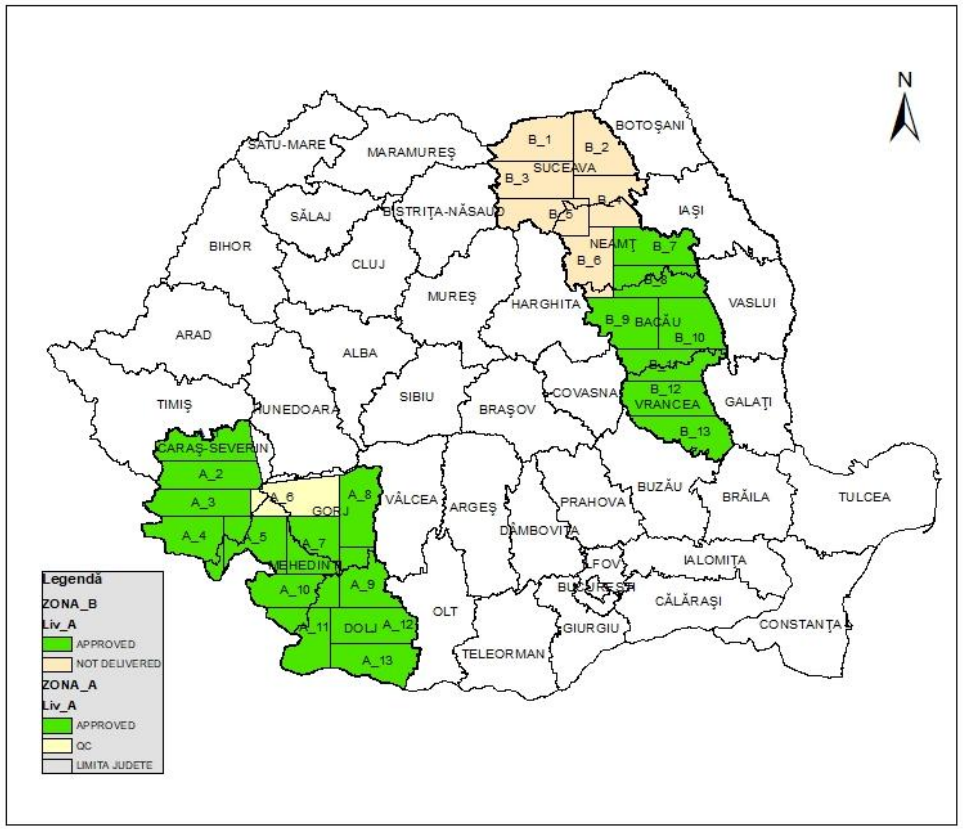


Point cloud processing



Generating digital models DTM / DSM

AREA	No. blocks		
	Approved	Not delivered	In QC works
A	12	0	1
B	7	6	0



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QC activities:

a. **point cloud density**

b. **point cloud classification**

c. **point cloud accuracy assessment**

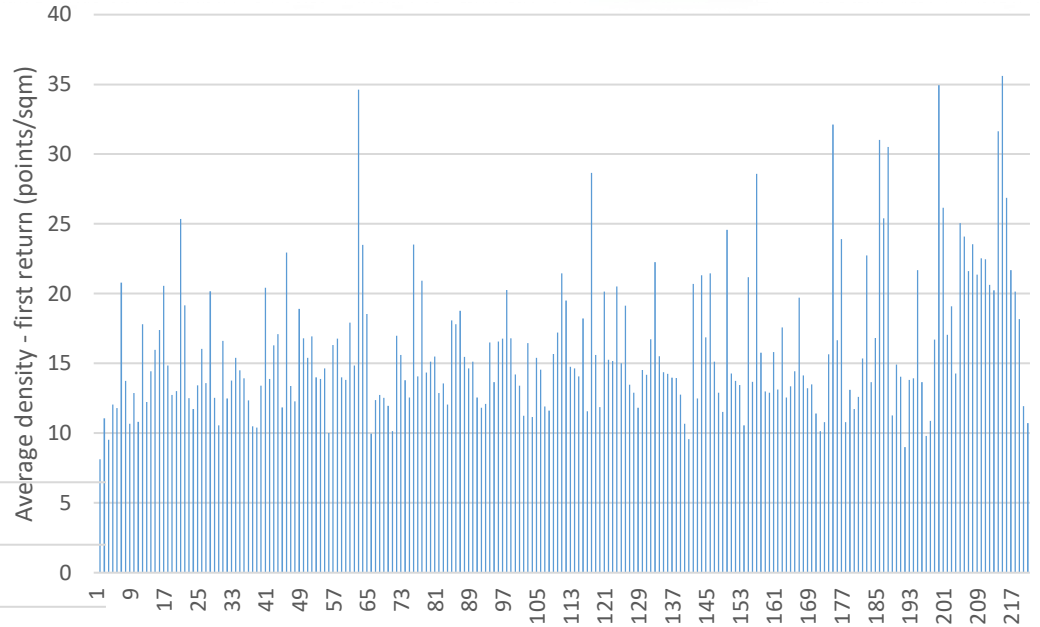
d. **DTM and DSM generation**

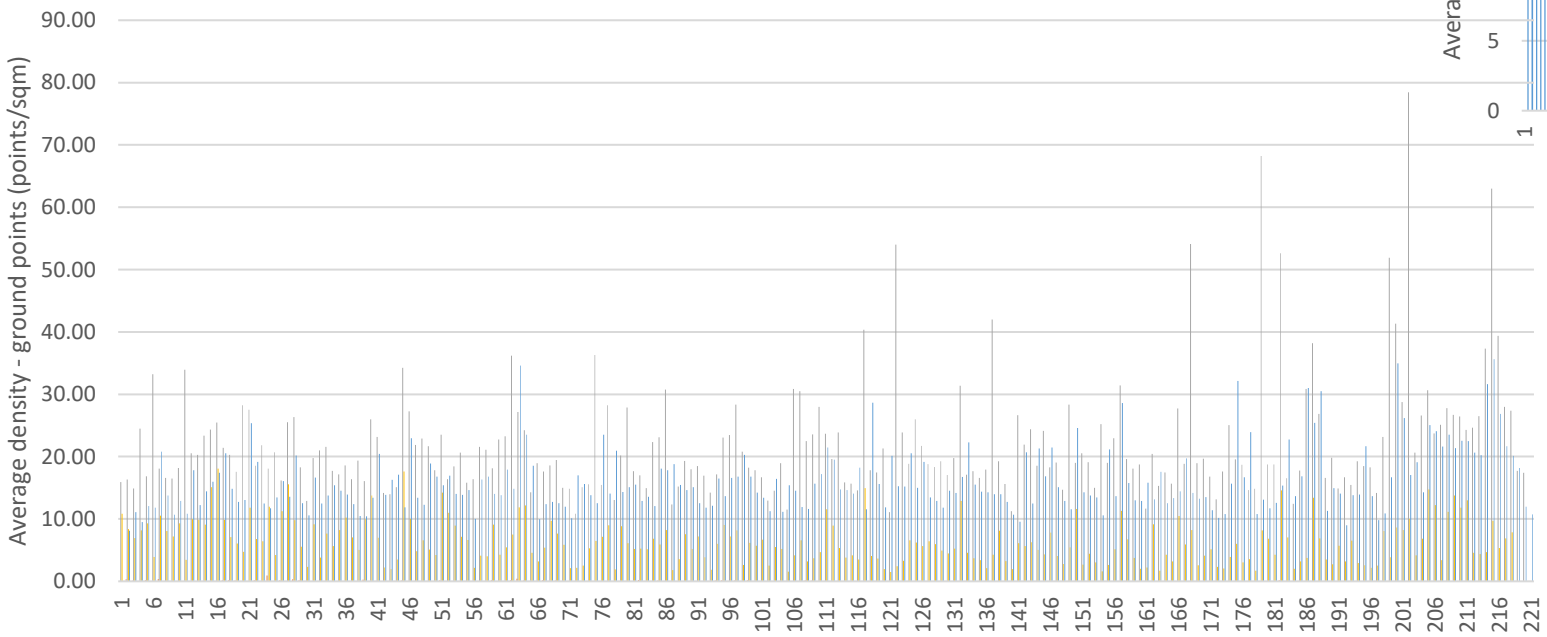
e. **DTM and DSM accuracy assessment**

LAKI III (QC works) - point cloud density

Based on the provided tiles, a grid of 10m x 10m was generated. The average point density for each cell was computed after removing the void areas, in two ways:

- based on first return points;
- based on bare-earth points.





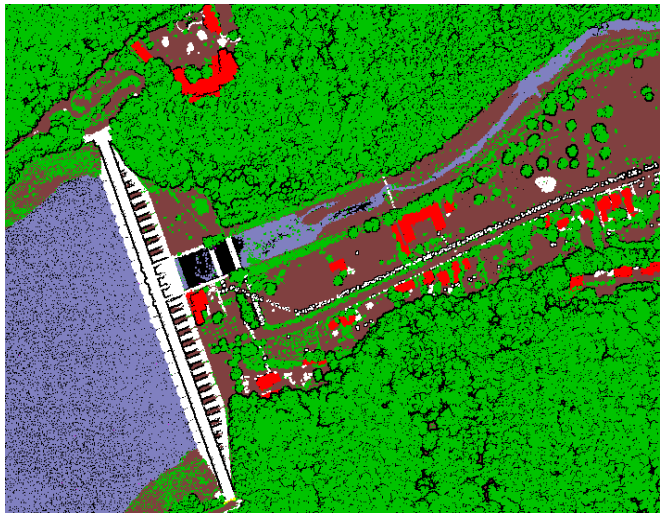
BLOCK ANALISYS – 100% tiles	
Minimum density (points/sqm)	7.00
Maximum density (points/sqm)	39.00
Average density (points/sqm)	14.53

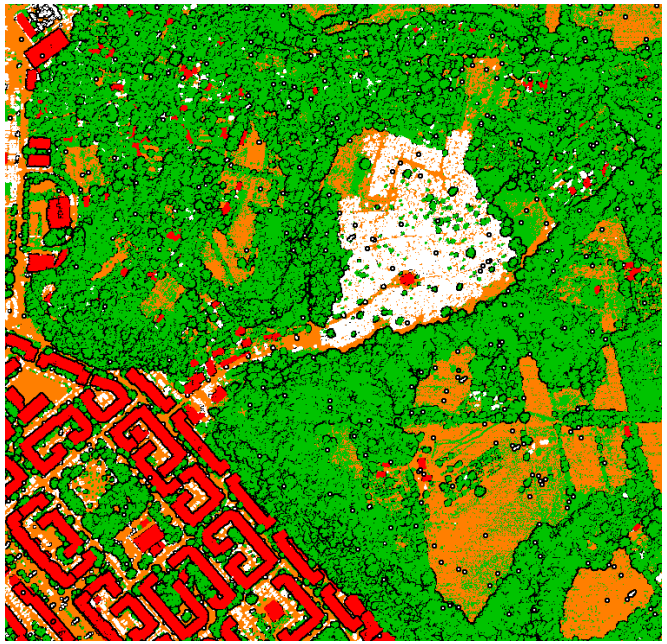
LAKI III (QC works) - point cloud classification

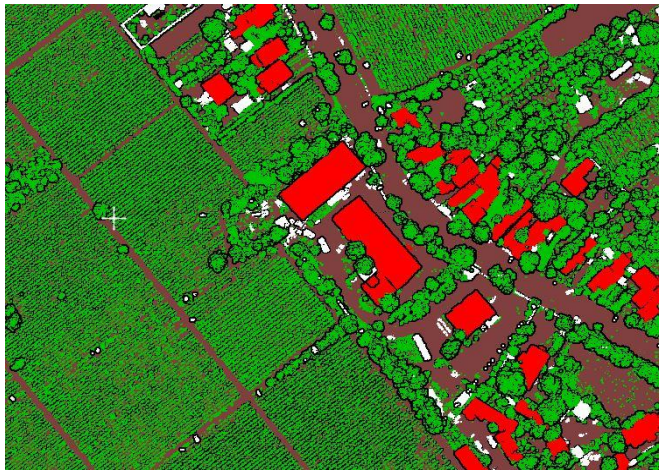
- point clouds are delivered on 1km x 1km tiles;
- accuracy assessment for the classification process:

  - 2% or 5% misclassified points for a class (depending on the class).

Class name	Description	Tolerance
Unclassified	Processed points, but not classified in the other classes	2%
Ground	All ground points. Channel must be trated as ground.	2%
Vegetation	-	5%
Buildings	Buildings with an area > 50 sqm	5%
Low Noise	-	2%
Water	Points situated on water surface. The points situated upper than the water level must be classified on the corresponding class	2%
Bridge Deck	Bridges with an area > 10 sqm	2%
High Noise	-	2%



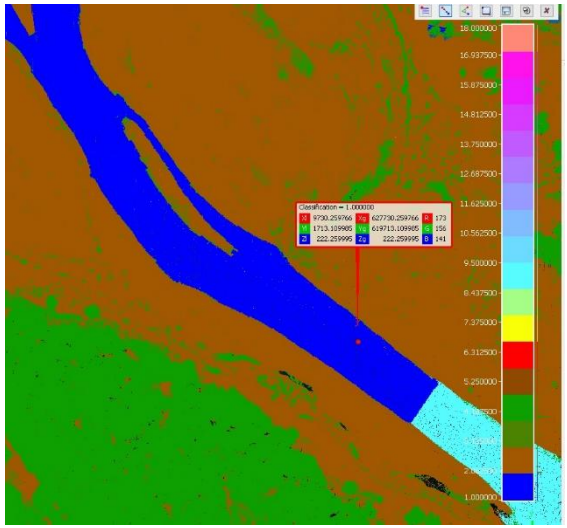




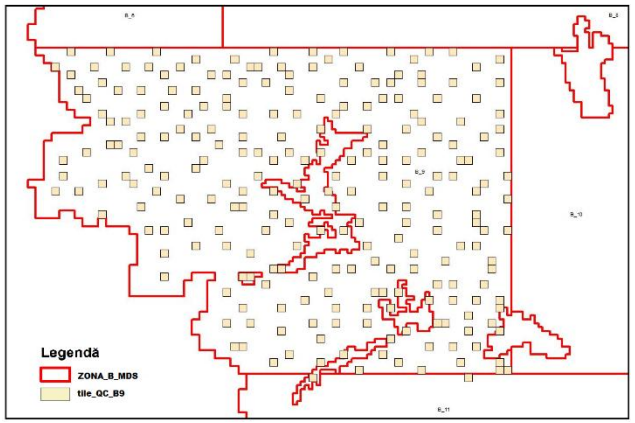
LAKI III (QC works) - point cloud classification

- extracting statistics and manual filtering of misclassified points - 10% of point cloud files
- computing the confusion matrix and the percentage of misclassified points
- common errors:
  - buildings with an area smaller than 50 sqm – classified as buildings;
  - industrial facilities classified as buildings;
  - vegetation on water surface classified as unclassified;
  - bridge points classified as ground;
  - water classified as ground.

	Unclassified	Ground	Vegetation	Buildings	Noise	Water	Bridge Deck	TOTAL	Misclassified points (%)
Unclassified	3519589			2631				3522220	**0.1**
Ground		1158113417					610	1158114027	**0.0**
Vegetation			4786001024					4786001024	**0.0**
Buildings	592778	1000		12454972				13048750	**4.6**
Noise					443369			443369	**0.0**
Water						1378897		1378897	**0.0**
Bridge Deck							115509	115509	**0.0**
TOTAL	4112367	1158114417	4786001024	12457603	443369	1378897	116119	5962623796	



UNCLASSIFIED - dark blue
RED - buildings
WATER - light blue



LAKI III (QC works) - point cloud accuracy assessment

- **Relative Vertical Accuracy** - is statistically summarized using difference raster and computing the root mean square difference in the z direction (RMSDz).
  - **Inter-swath Accuracy** (smooth surface) - Assessment is made on hard surfaced areas containing only single return LiDAR points. Sample areas for assessment of precision will be approximately 100 pixels and must be distributed to cover the full width of the overlap.
  - **Inter-swath (Overlap) Consistency** - Assessment is done at multiple locations within overlap in non-vegetated areas of only single returns and with slopes of less than 10^0.
- **Absolute Horizontal Accuracy** - using the control profiles.
- **Absolute Vertical Accuracy** - based on all GCP cluster points.

Relative vertical accuracy		Absolute vertical accuracy (RMSE)	Absolute horizontal accuracy (RMSE)
Inter-swath Accuracy	Inter-swath (Overlap) Consistency		
≤0.06 m	≤0.08 m	≤0.30 m	≤0.40 m

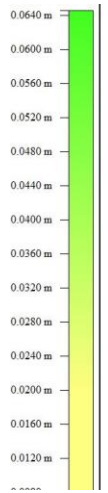
LAKI III (QC works) - point cloud accuracy assessment

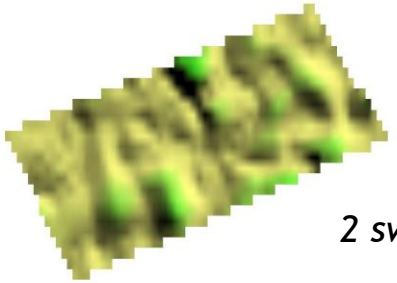
Relative Vertical Accuracy

Inter-swath Accuracy

(between 2 adjacent, overlapping parallel swaths)

Tile name	Maximum H difference (m)
489_642	0.064
493_642	0.064
481_636	0.042
477_636	0.076
479_676	0.060
474_676	0.052
$RMSD_z$	0.061

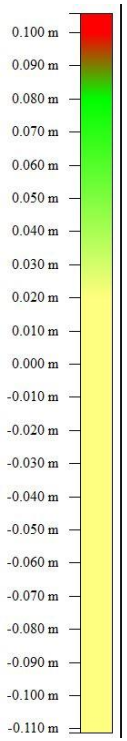


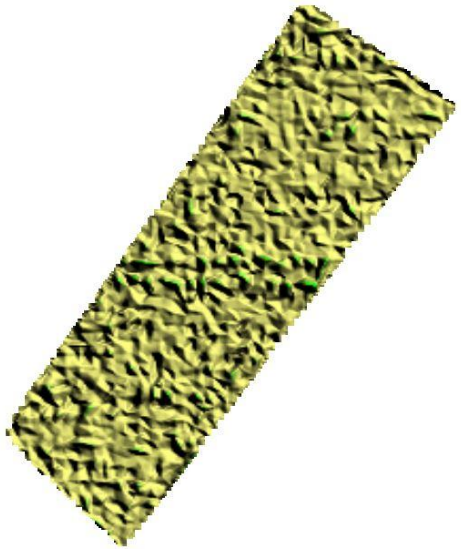


2 swaths (1015-1016)

Inter-swath (Overlap) Consistency

(between 3 swaths, including the cross-swath)



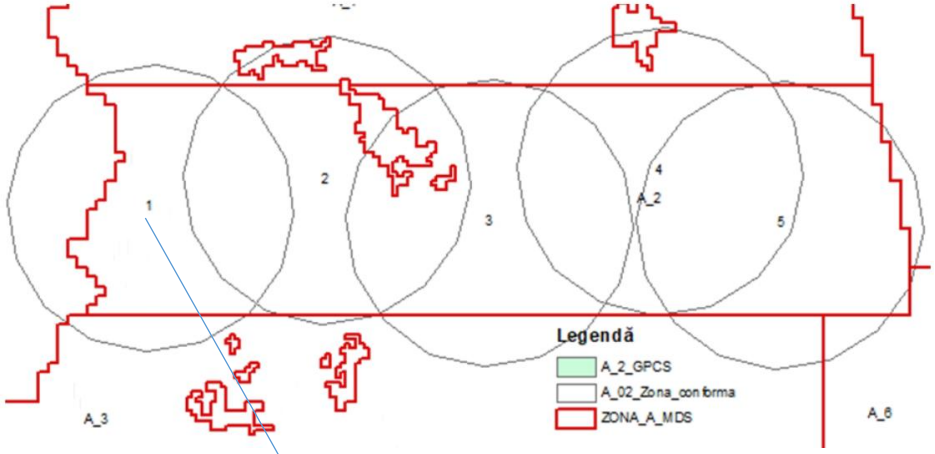


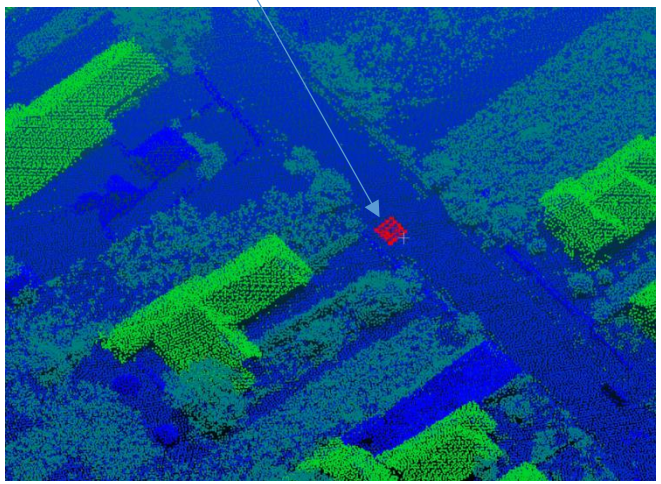
3 swaths (1015-1016-1061)

LAKI III (QC works) - point cloud accuracy assessment

Absolute Vertical Accuracy - based on ground control points

Point name	X_ground (m)	Y_ground (m)	H_ground (m)	H_point_cloud (m)	ΔH (m)
G_1	635385.588	490746.052	418.127	418.100	-0.027
G_2	635386.260	490746.419	418.080	418.040	-0.040
G_3	635386.620	490746.656	418.036	418.078	0.042
G_4	635387.241	490746.931	418.060	418.060	0.000
G_5	635387.790	490747.245	418.092	418.058	-0.034
G_6	635387.467	490747.858	418.068	418.060	-0.008
G_7	635386.848	490747.550	418.041	418.069	0.028
G_8	635386.377	490747.210	418.049	418.059	0.010
G_9	635385.817	490746.930	418.084	418.063	-0.021
			.....		
G_116	613849.856	482855.273	1104.830	1104.745	-0.085
G_117	613849.245	482855.397	1104.898	1104.828	-0.070
G_118	613849.465	482856.013	1104.990	1104.874	-0.116
G_120	613849.668	482857.131	1104.996	1104.877	-0.119
G_121	613849.820	482857.820	1105.072	1104.931	-0.141
G_123	613849.012	482857.308	1105.085	1104.943	-0.142
G_124	613848.848	482856.690	1105.101	1104.977	-0.124
G_125	613848.719	482856.078	1105.087	1104.968	-0.119
G_126	613848.593	482855.537	1105.046	1104.925	-0.121
			RMSE_H (m)		0.057

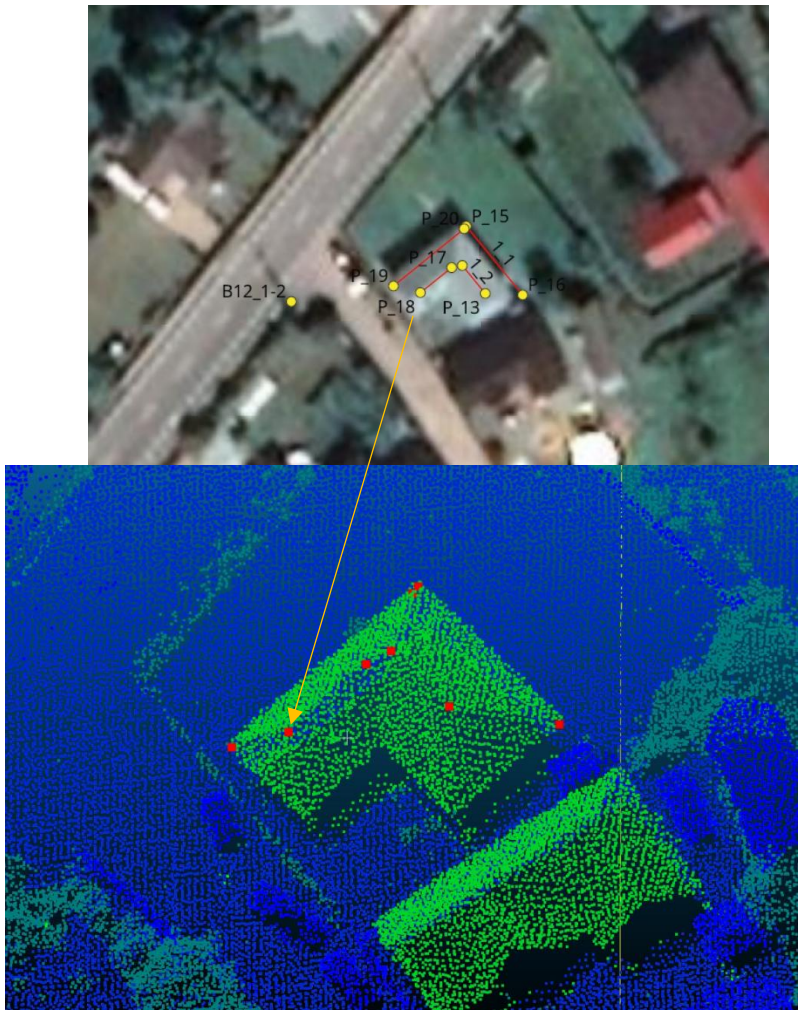




LAKI III (QC works) - point cloud accuracy assessment

Absolute Horizontal Accuracy - based on profile points

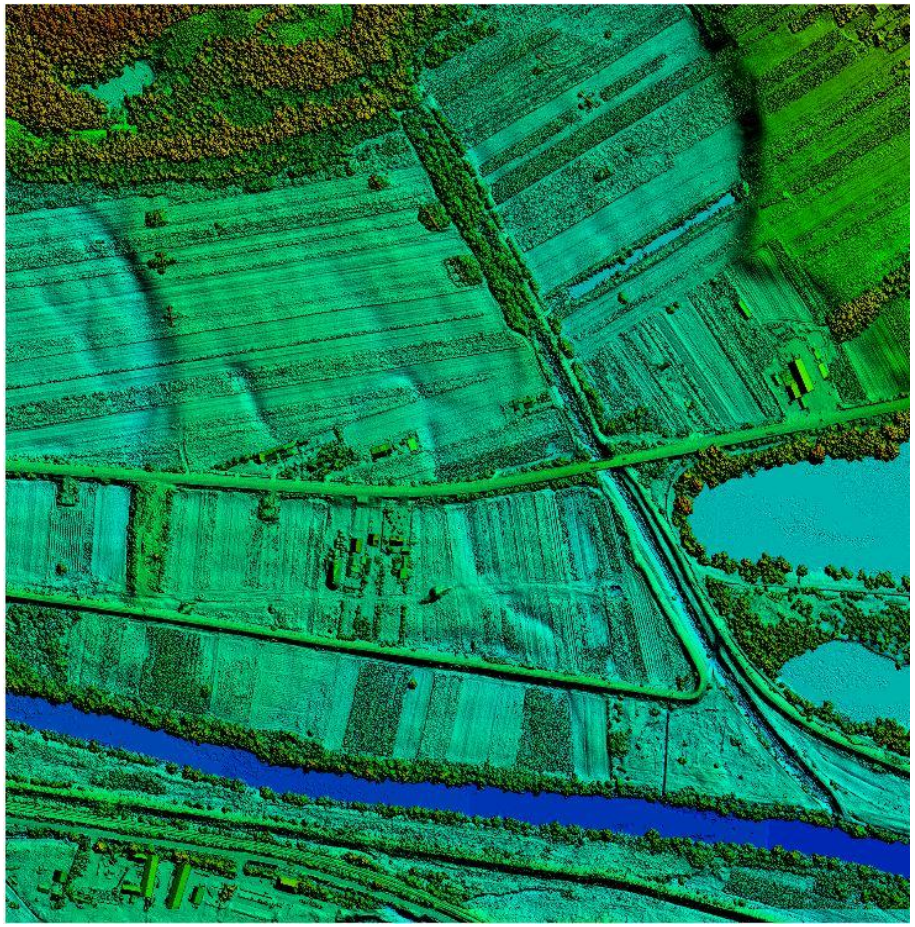
Point name	X_ground (m)	Y_ground (m)	X_point_cloud (m)	Y_point_cloud (m)	ΔX (m)	ΔY (m)
P_16	616001.714	495374.749	616001.625	495374.750	0.089	-0.001
P_13	615996.379	495374.966	615996.437	495374.812	-0.058	0.154
P_14	615993.107	495378.953	615993.250	495378.875	-0.143	0.078
P_15	615993.664	495384.567	615993.750	495384.375	-0.086	0.192
P_17	615991.585	495378.658	615991.562	495378.594	0.023	0.064
.....						
P_106	666085.457	494354.983	666085.562	494355.281	-0.105	-0.298
P_107	666090.207	494356.244	666090.000	494356.437	0.207	-0.193
P_108	666086.456	494347.347	666086.187	494347.437	0.269	-0.090
RMSE X		0.134				
RMSE Y		0.164				
RMSE 2D		0.211				



LAKI III – DTM and DSM generation

Digital terrain models (DTMs):

- must only contain points classified as bare-earth;
- must be hydro-flattened using the breaklines;
- it must not contain bridge decks;
- there must be no large differences in height between the tiles on the connection area.



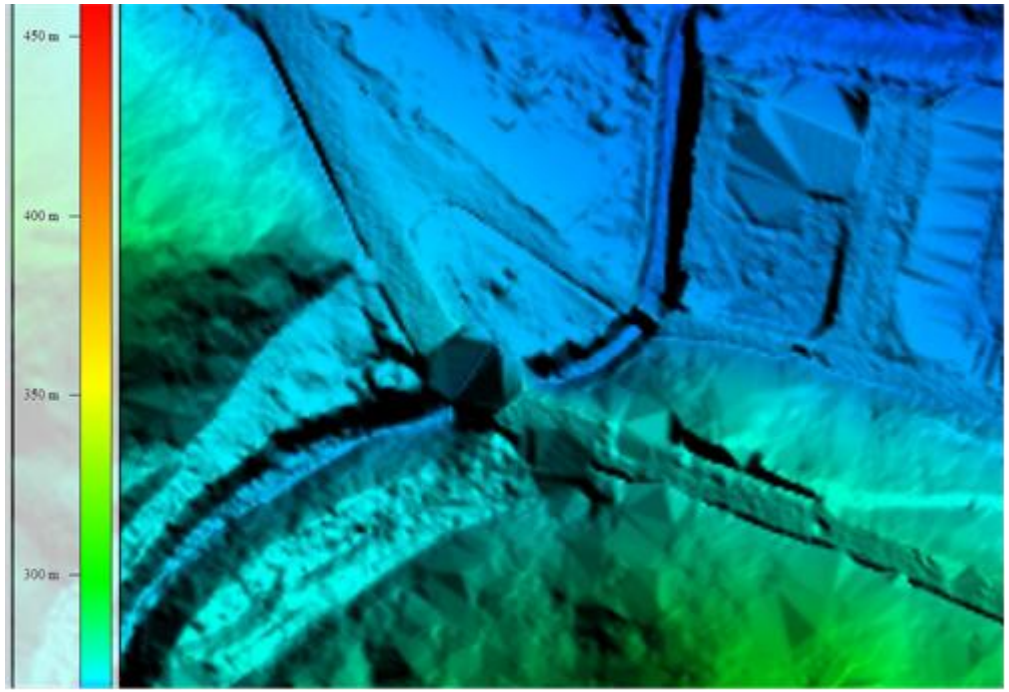
Digital surface models (DSMs):

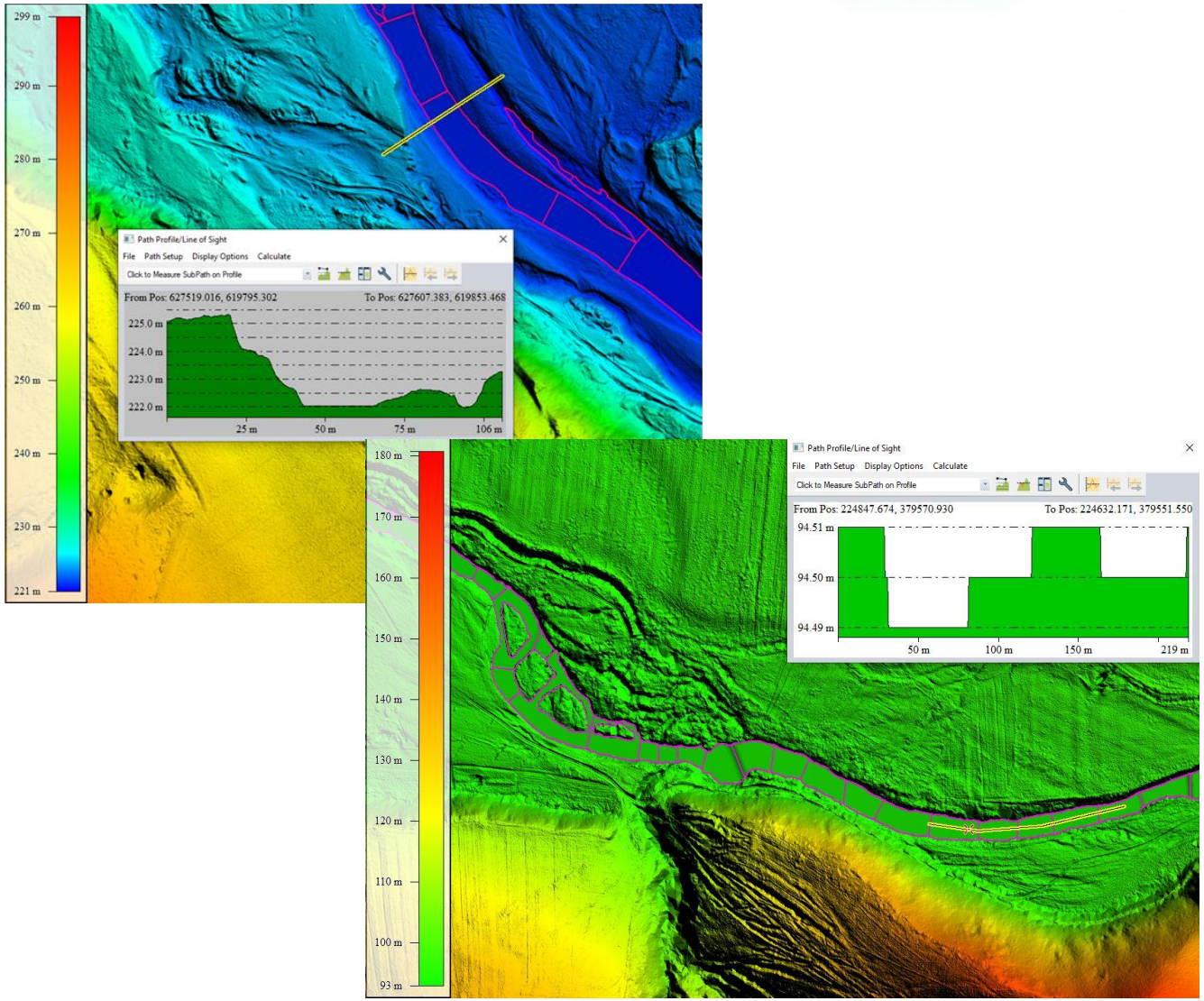
- must contain first-return points from classes 1, 2, 4, 6, 9, 17;
- must be hydro-flattened using the breaklines;
- the artifacts must be removed from DSM tiles;
- there must be no large differences in height between the tiles on the connection area.

LAKI III – DTM and DSM generation

QC checks:

- evaluation of breakline extraction;
- identification of bridges in DTM;
- identification of artefacts in DSM.

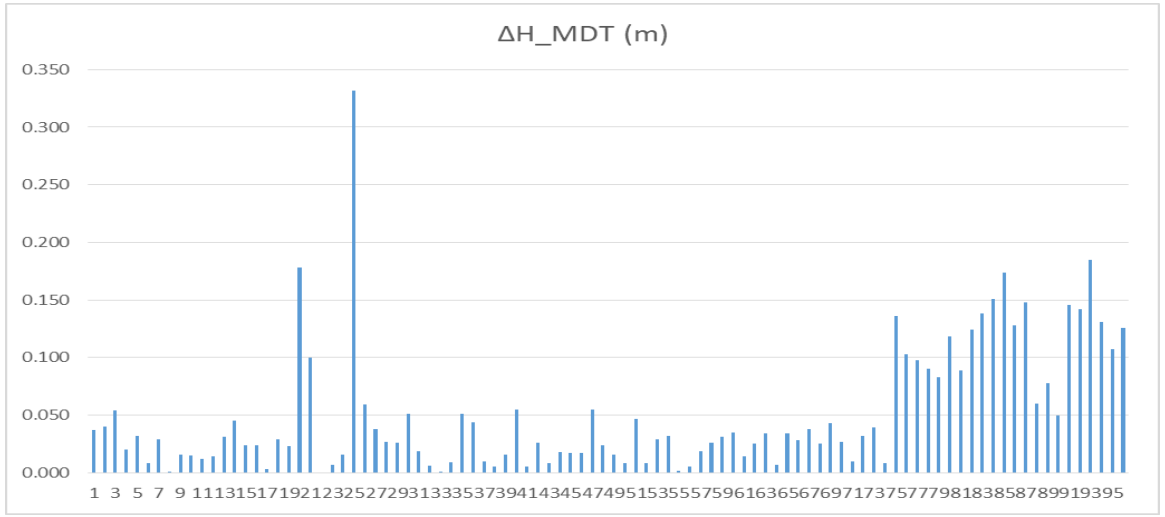




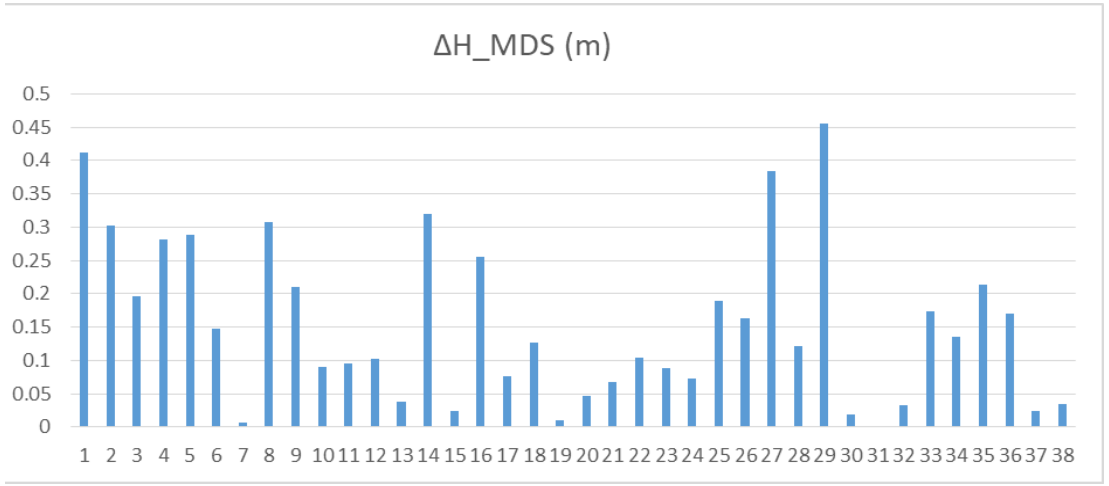
LAKI III (QC works) - Accuracy assessment for DTM and DSM

DTM/DSM resolution (m)	Vertical absolute accuracy DTM/DSM (m)
0.50	±0.40

The absolute vertical accuracy is computed using the RMSE based on points with known coordinates (measured in the field, or from this project, or from other projects, with similar specifications).



Eg. RMSE_H_DTM = 0.075 m



Eg. RMSE_H_DSM = 0.188 m

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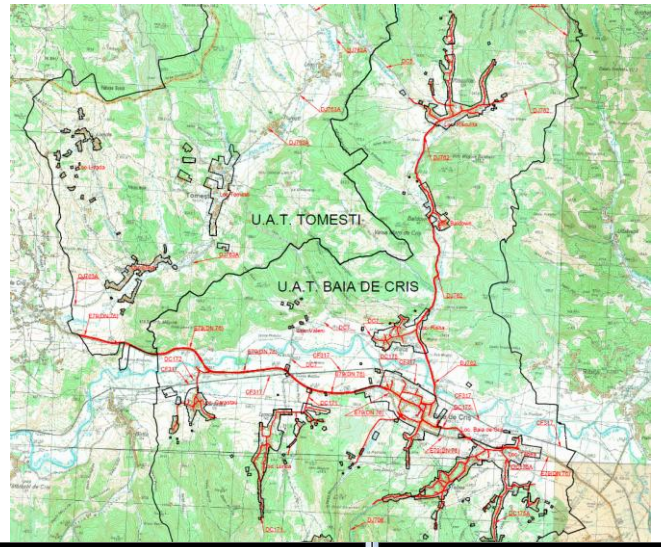
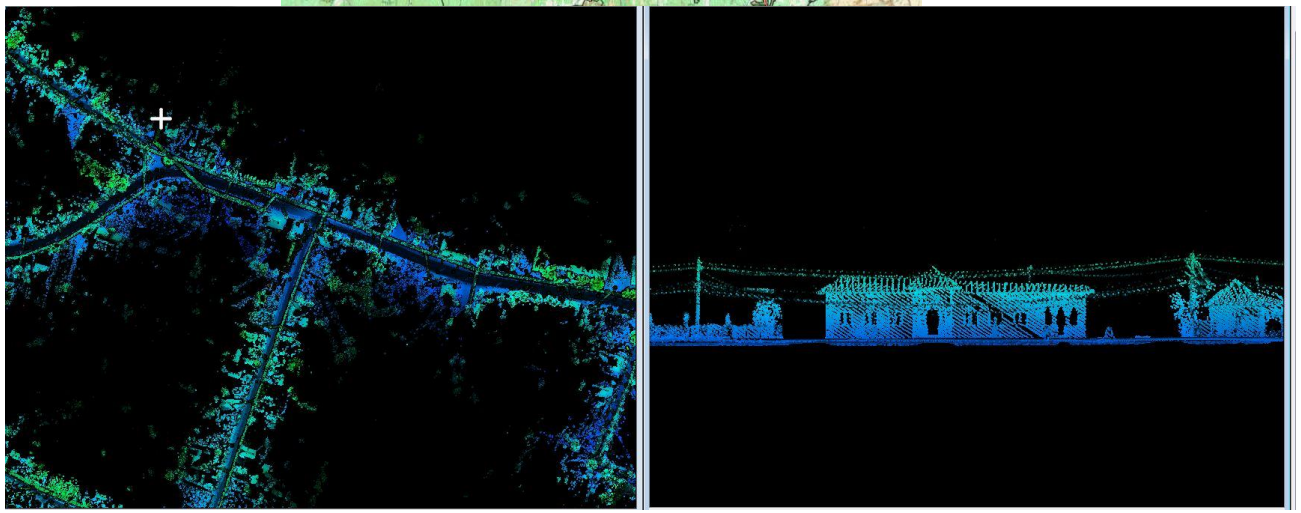
Quality control of photogrammetric and cartographic projects done by third parties in Romania

1. Broadband internet network Orange – Mehedinți county

- objective: to develop broadband internet infrastructure in the areas of Mehedinți county;
- **technology: MLS** Trimble SLM-250;
- quality controlled data: mobile point clouds and topographic maps at scale 1:500.

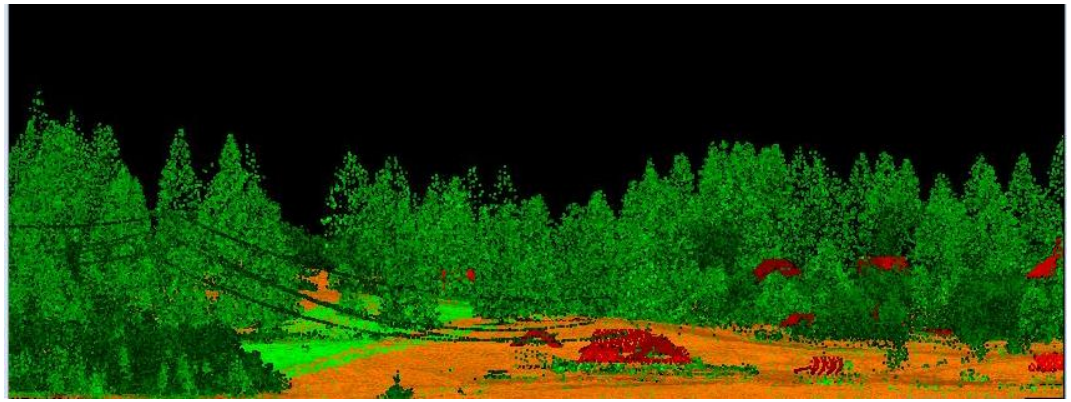


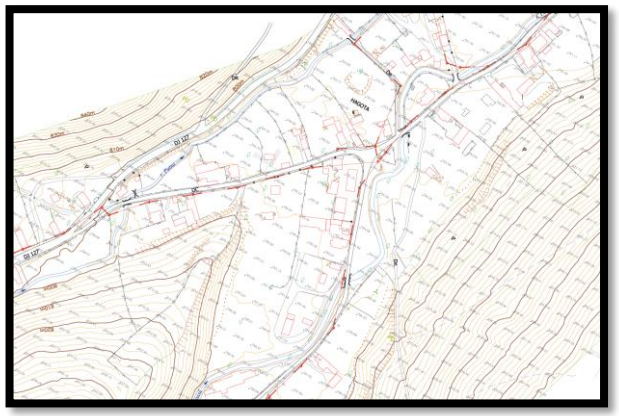


Quality control of photogrammetric and cartographic projects done by third parties in Romania

2. Mapping the proposed area for UNIREA Highway

- objective: to map the proposed area for UNIREA highway between Târgu Mureș and Târgu Neamț cities;
- technology used:
  - **airborne LiDAR**: RIEGL Q780 scanner;
  - **aerial photogrammetry**: UltraCam Eagle M2;
- quality controlled data: LiDAR point clouds, aerial images, DTM, and topographic 2D and 3D maps.

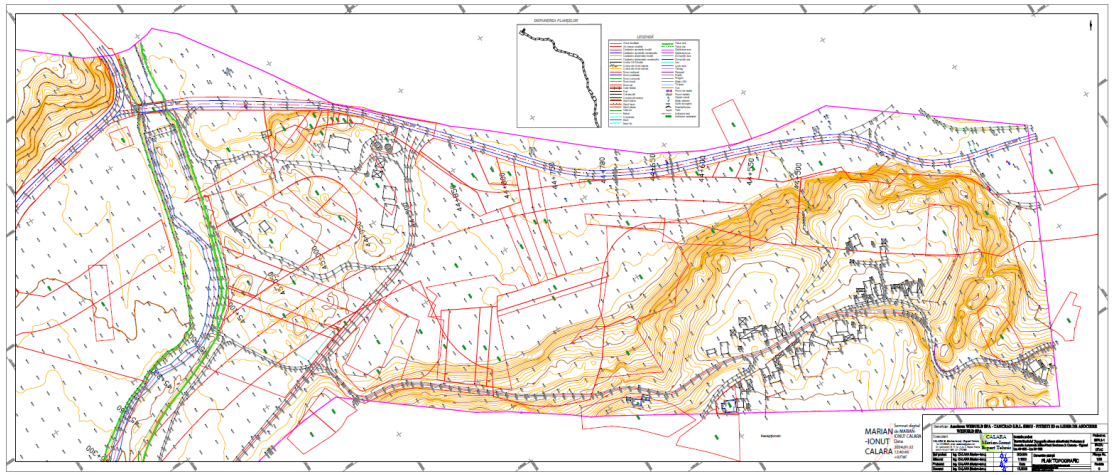




Quality control of photogrammetric and cartographic projects done by third parties in Romania

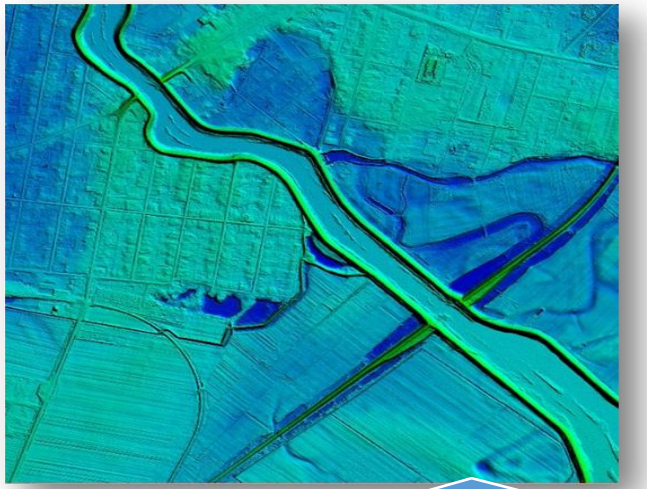
3. Mapping the proposed area for A1 Highway

- objective: to map the proposed area for A1 highway between Tigveni and Cornetu cities;
- technology used: **UAV LiDAR** - Velodyne Puck Hi Res VLP-16 Hi-Res mounted on DJI Matrice 300 RTK;
- quality controlled data: LiDAR point clouds, DTM, and topographic 2D maps at scale 1: 1.000.



1. About us
2. LAKI III project
   - ❑ about the project
   - ❑ quality control works
3. Other projects
4. Usage of LiDAR data
5. Conclusions

New products at CNC based on the LiDAR datasets



DIGITAL TERRAIN MODEL – FOR UPDATING THE NATIONAL DATASET AVAILABLE ON https://geoportal.ancpi.ro/portal/

3D CITY MODEL – USING PRECISE HEIGHT DATA

Applications using 3D buildings' models:

- estimating the effect of solar radiation on buildings;
- estimating urban areas with the potential for damage in case of floods;
- analysis of visibility in the urban environment;
- estimating noise propagation.

New research projects based on the LiDAR datasets
Canopy Height-Based Biomass Estimation

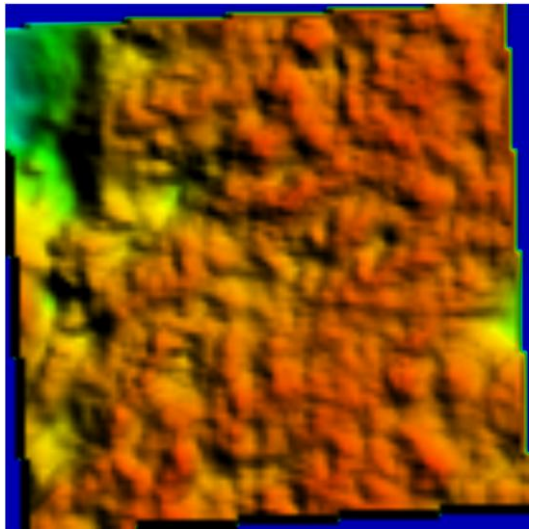
A global canopy height model, CHM-Global, was transferred and adapted for canopy estimation in Romanian forest sites CHM-Ro.

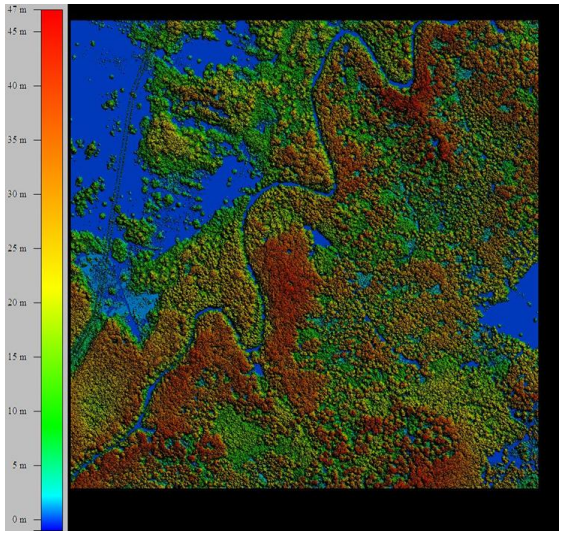
CHM-Ro model is based on the Xception architecture, with spatial and channel-wise depth-wise separable convolutions.

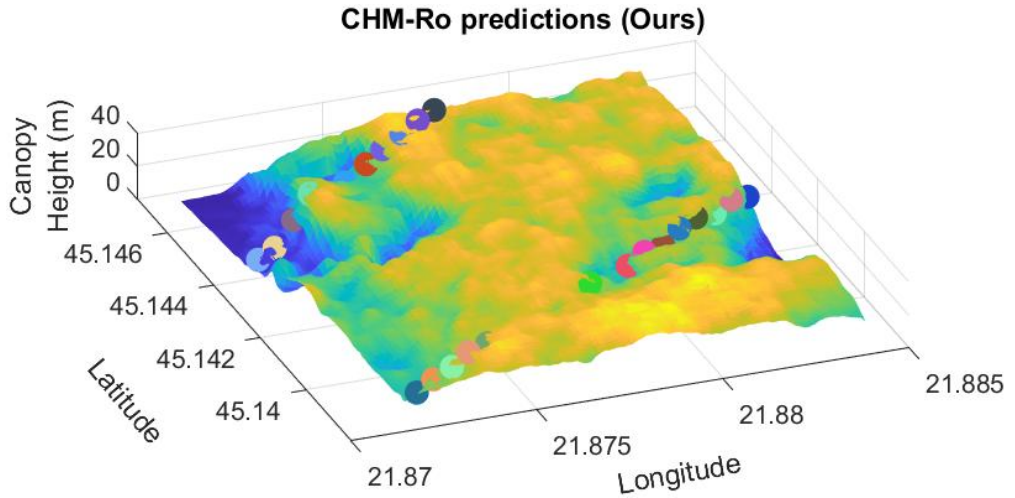
Input data:

- satellite imagery Sentinel 2A (27.09.2024) – spatial resolution 10 m, spectral resolution – 12 bands;
- LiDAR data GEDI L2A (28.09.2024) – resolution 25 m.

For quality evaluation – nDSM derived from ALS data was used (20.06.2024) – resolution 1 m.

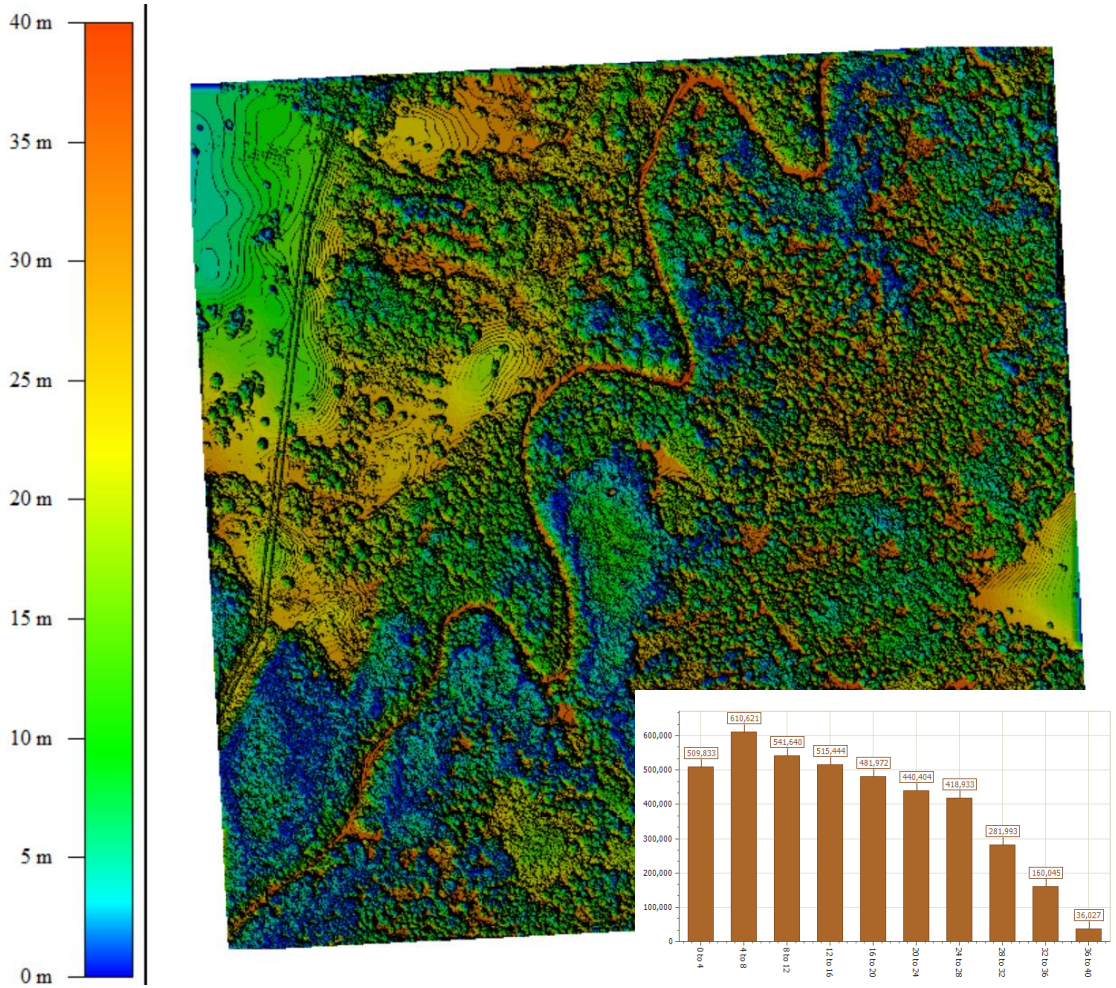


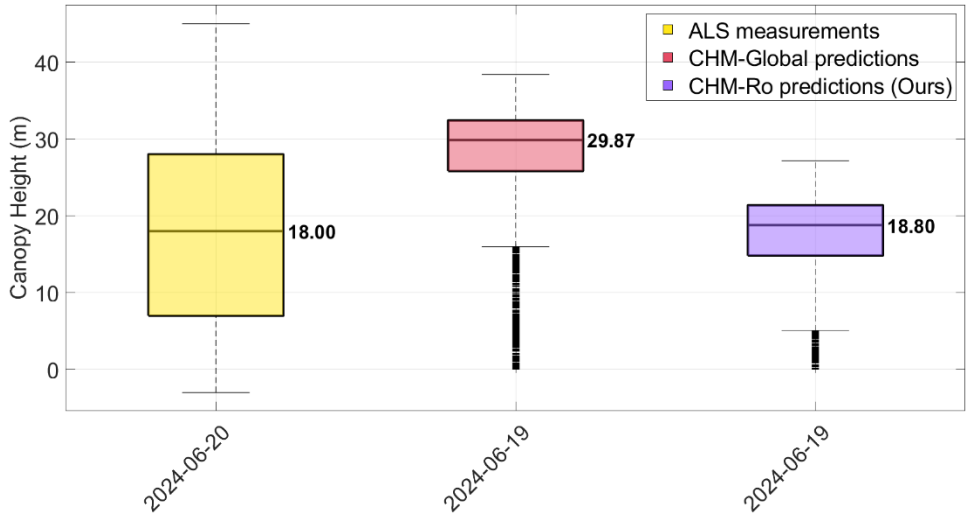




New research projects based on the LiDAR datasets
Canopy Height-Based Biomass Estimation

$nDSM_{CHM\text{-}Ro}$ - $nDSM_{LAKI\ III}$





- Better results for CHM-Ro – mean value of 18.8 m (CHM-Ro) compared to 18 m for ALS
- CHM-Global overestimates – mean value of 29.9 m

Conclusions

- **Quality control is an important stage in a project and carrying out the activity with professionalism and rigor provides the premises for a successful project;**
- **Quality control ensures consistency, reliability and regulatory compliance for the data;**
- The use of precise geospatial data by local and central administrations is essential in decision-making;
- Data quality must be imposed considering the purpose of the project;
- The usefulness of 3D modeling of buildings for analysis and urban planning is obvious and Romania must align itself with European countries and migrate from 2D to 3D.

Thank you!

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