

Assessment of UAV photogrammetry and LiDAR for environmental inspection. Case study from landfill Radlák, Czechia

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Motivation

- Importance of environmental inspection and monitoring of landfill
- Changes, reclamation quality, environmental sensitivity
- Need for effective and accurate monitoring methods

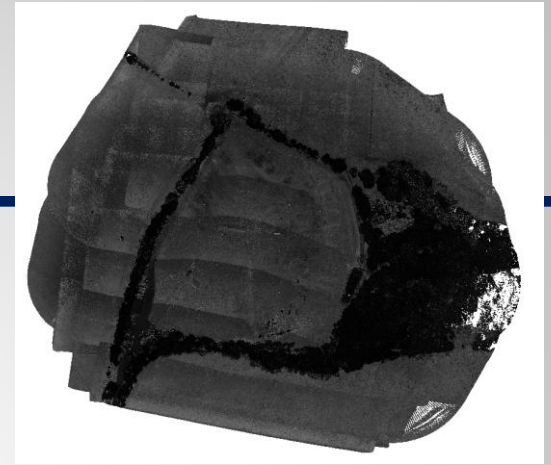
This work is a part of the project no. SS07010417
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Technology Agency of the Czech Republic.

The logo consists of a red square containing the letters T, A, Č, and R in white, arranged in a 2x2 grid.

T A
Č R

Objectives

- To compare UAV photogrammetry and LiDAR in the context of landfill monitoring
- To evaluate geometric accuracy, spatial coverage, and overall data quality
- To assess the influence of number ground control points on model accuracy
- To demonstrate the potential of both methods for monitoring reclaimed landfills



LiDAR (intensity)



UAV photogrammetry

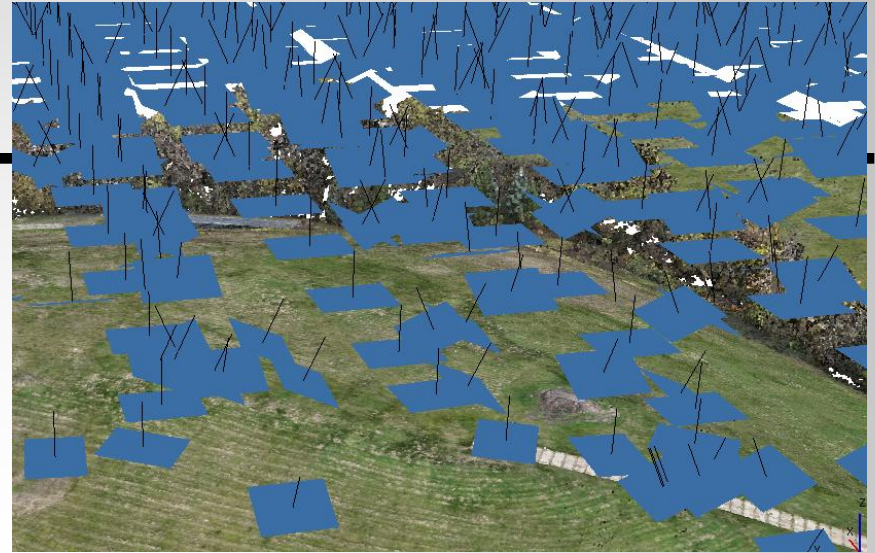
Landfill Radlík

- located in the Central Bohemian Region
- It is a controlled municipal solid landfill used to store mixed waste
- The landfill was in use since the 1990s; after temporary closure in 2004 due to non-compliance with newly introduced environmental regulations, the landfill was modernized and subsequently reopened in 2007.
- Final capacity filling and closure took place around 2016.
- Since 2010, technical and biological reclamation has been underway, including continuous monitoring of groundwater, landfill gas, and the surrounding environment.



Data sources

- Ground Control Points
- Check points
- UAV Photogrammetry
- LiDAR



Ground control points

- Trimble R12i + RTK
- 78 points were measured
- Vertical accuracy $Z = 3\text{cm}$
- Horizontal accuracy $XY = 2\text{ cm}$
- Standard black and white targets and (green) cross-shaped markers on solid surfaces
- The points were measured twice within a period of approximately 3 hours (at the beginning and end of imaging /scanning)
- ETRS89/UTM zone 33N



Check points

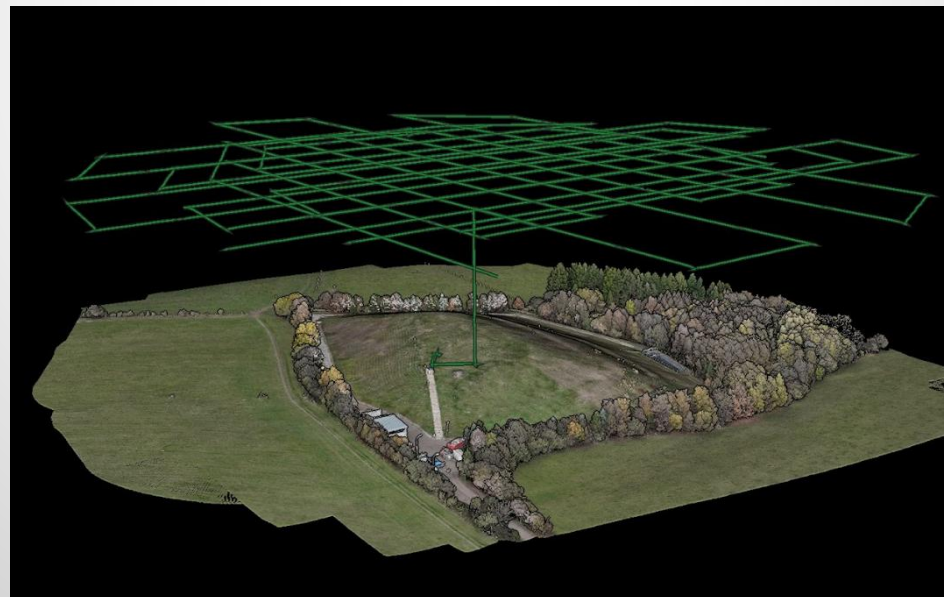
- Trimble R12i + RTK
- 591 points were measured
- Vertical accuracy
 $Z = 3\text{cm}$
- Horizontal accuracy
 $XY = 2\text{cm}$
- ETRS89/UTM zone 33N



LiDAR



- DJI matrice 300RTK, Zenmuse L2
- Two orthogonal flights, height 74.5 m, mapping area 48411.4 m², point density 500 points/m²
- Processing -> DJI Terra -> point cloud 22 237 237 points



UAV photogrammetry

- Dron DJI Mavic 3 (M3M), RTK modul
- Mapping area about 48 000 m²
- RGB images from two heights, ortho and obliq (for better capture of slopes)

Flight height	Forward Overlap	Side Overlap	GSD/oblique GSD	Images
40 m	85%	85%	1.0 cm/1.2 cm	2041
90 m	85%	85%	2.5 cm/2.8 cm	619



UAV photogrammetry

- Image processing – Agisoft Metashape
- Georeferenced point clouds (for 40 m and 90 m)
- Various number of GCP

Flight height 40 m	GCP/error [m]	CP/error [m]
	0 / -	78/0.065
	1 / 0	77/0.040
	5/0.007	73/0.037
	9/0.005	69/0.037
	78/0.010	0/-

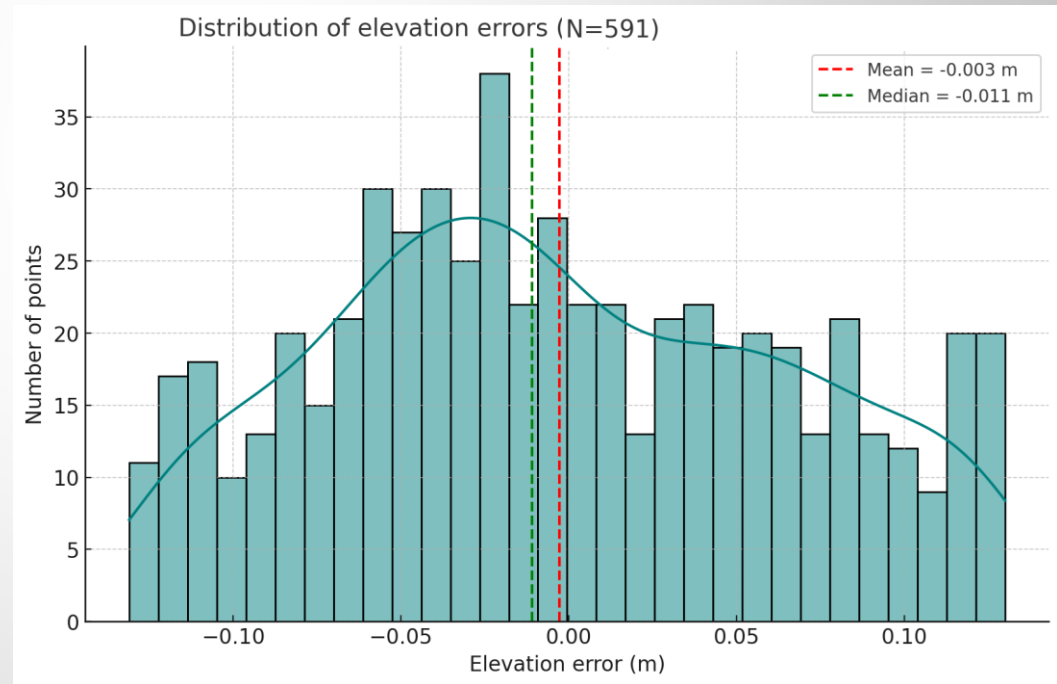
Flight height 90 m	GCP/error [m]	CP/error [m]
	0 / -	78/0.092
	1/0	77/0.108
	5/0.01	73/0.098
	9/0.008	69/0.111
	78/0.013	0/-



CP vs photogrammetry (40m)

- the heights of control points were compared with the heights of point clouds from photogrammetry (40m)
- 591 CP were compared

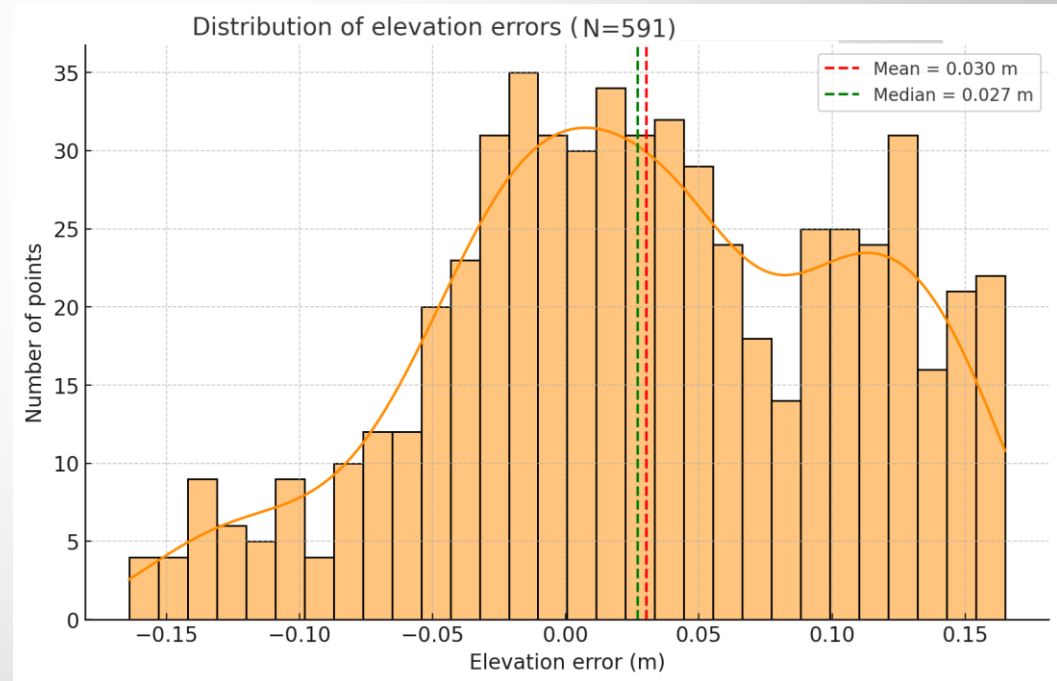
RMSE = 0.069 m
Standard dev = 0.069 m
Mean error = +0.003 m
Median = 0.011m
Min error = -0.131 m
Max error = +0.130 m



CP vs photogrammetry (90m)

- the heights of control points were compared with the heights of point clouds from photogrammetry (90m)
- 591 CP were compared

RMSE = 0.083 m
Standard dev. = 0.077 m
Mean error = +0.030 m
Median = 0.027 m
Min error = -0.164 m
Max error = +0.165 m



CP vs LiDAR

- the heights of control points were compared with the heights of point clouds from LiDAR
- 591 CP were compared

RMSE = 0.058 m

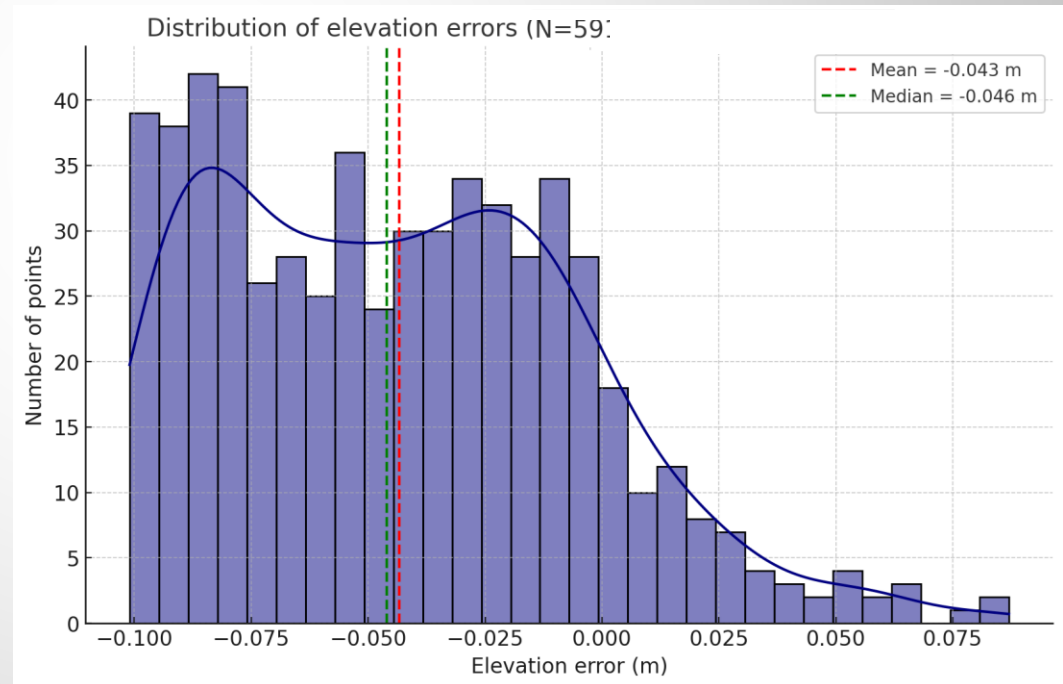
Standard dev. = 0.039 m

Mean error = -0.043 m

Median = -0.046 m

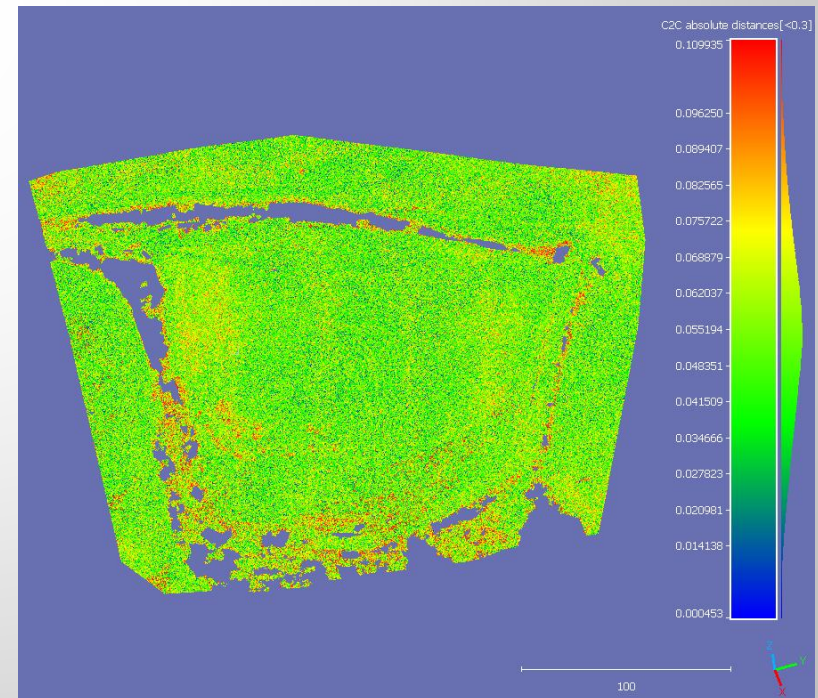
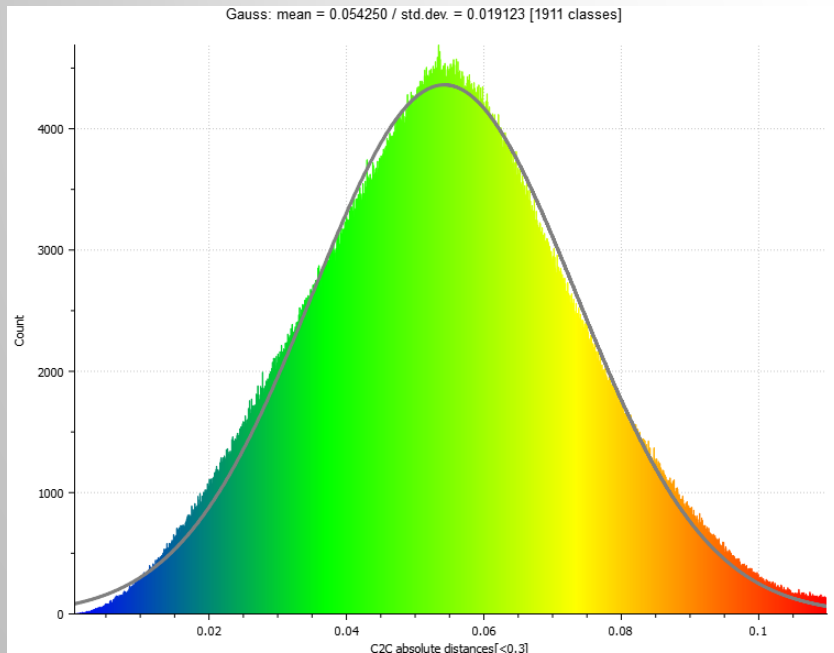
Min error = -0.101 m

Max error = +0.087 m



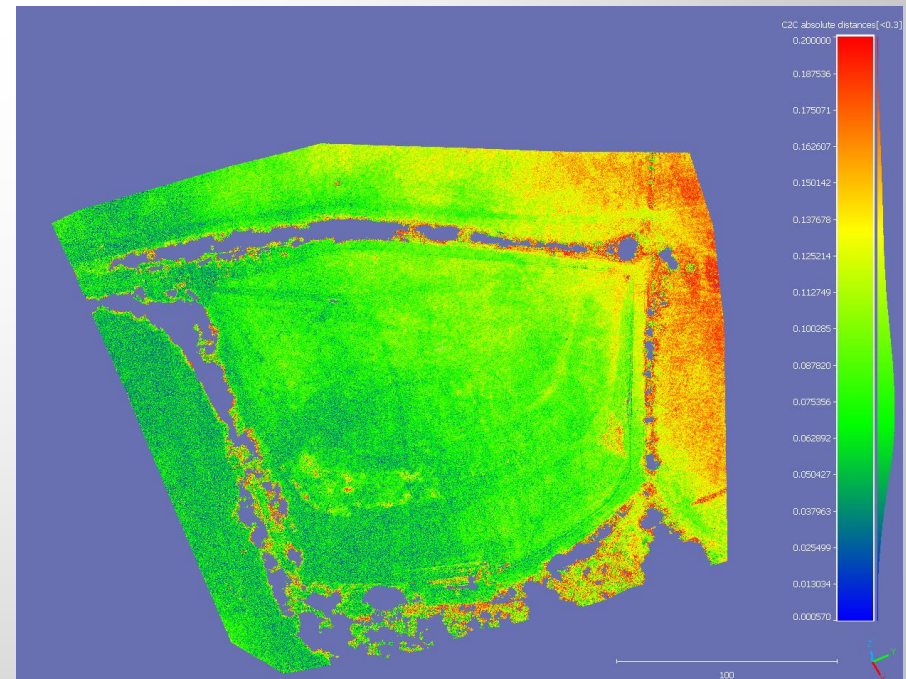
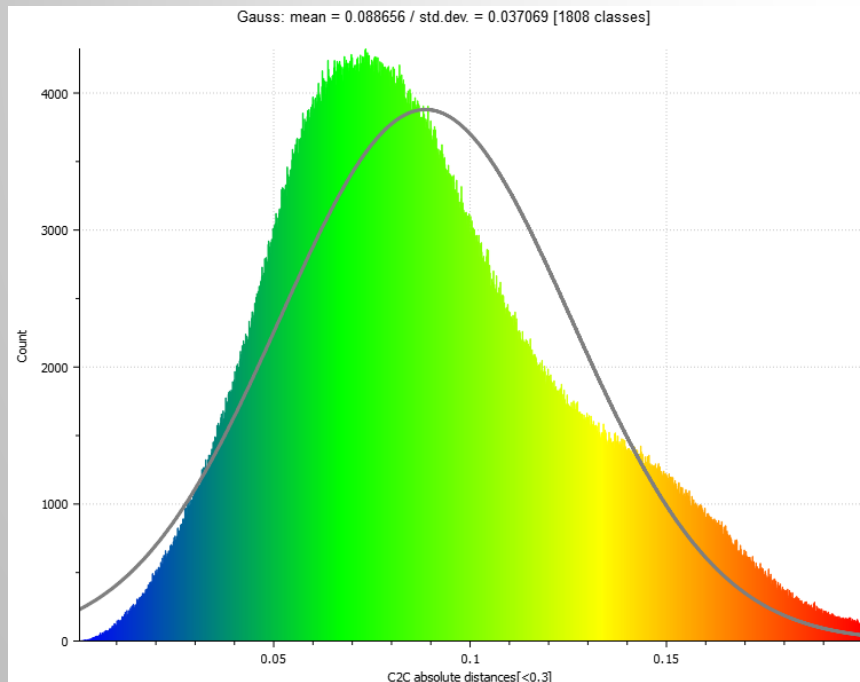
LiDAR vs photogrammetry(40m)

- Comparison revealed a high level of agreement between the two point clouds.
- The majority of points fall within the range = ± 6 cm, with an overall mean absolute deviation = 0.054 m and a standard deviation = 0.019 m.



LiDAR vs photogrammetry(90m)

- The second dataset shows larger deviations compared to the previous case. The mean absolute distance = 0.089 m with a standard deviation = 0.037 m, indicating a lower overall accuracy and a wider spread of errors. The histogram of distances is slightly skewed



Result summary

Dataset	Mean error (m)	Median error (m)	Std. dev. (m)	Min (m)	Max (m)	RMSE (m)
PM (40m)	-0.003	-0.011	0.069	-0.131	+0.130	0.069
PM (90m)	+0.030	+0.027	0.077	-0.164	+0.165	0.083
LiDAR	-0.043	-0.046	0.039	-0.101	+0.087	0.058

- LiDAR remains the most precise method.
- Photogrammetry (40m) offers the most balanced and unbiased results.
- Photogrammetry (90m) tends to shift elevations upward but still provides reliable accuracy.

Conclusion

Applicability for environmental inspection

- LiDAR advantageous in vegetated or complex areas,
- photogrammetry offers cost-effective and sufficiently accurate results in most monitoring tasks.

Simplicity and speed

- LiDAR acquisition rapid and robust, but requires more expensive and specialized equipment,
- photogrammetry is easy to deploy, affordable, and fast to process.

Conclusion

Overall contribution

- Both methods enable reliable detection of morphological changes, verification of reclamation works, and efficient periodic inspections. UAV-based approaches significantly accelerate landfill monitoring compared to traditional surveying, while maintaining acceptable accuracy.

Thank You for Your Attention

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