POINT CLOUDS FOR TERRAIN MONITORING IN VEGETATED AREAS

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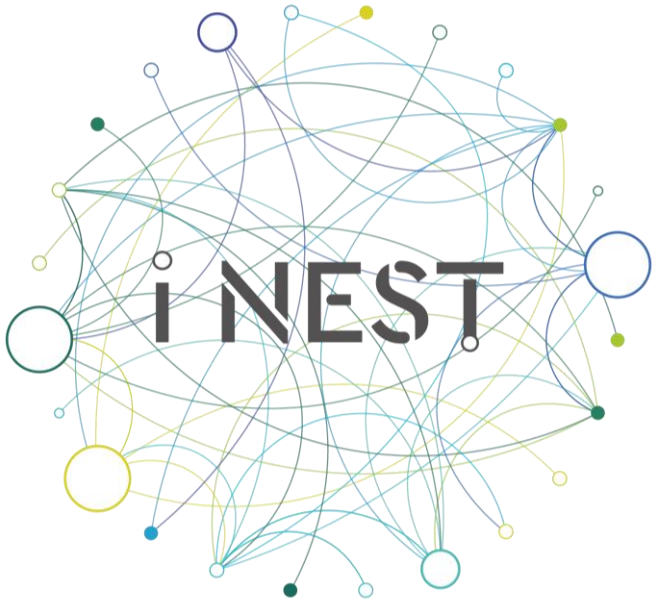
iNEST
Interconnected Nord-Est Innovation Ecosystem

INTRODUCTION

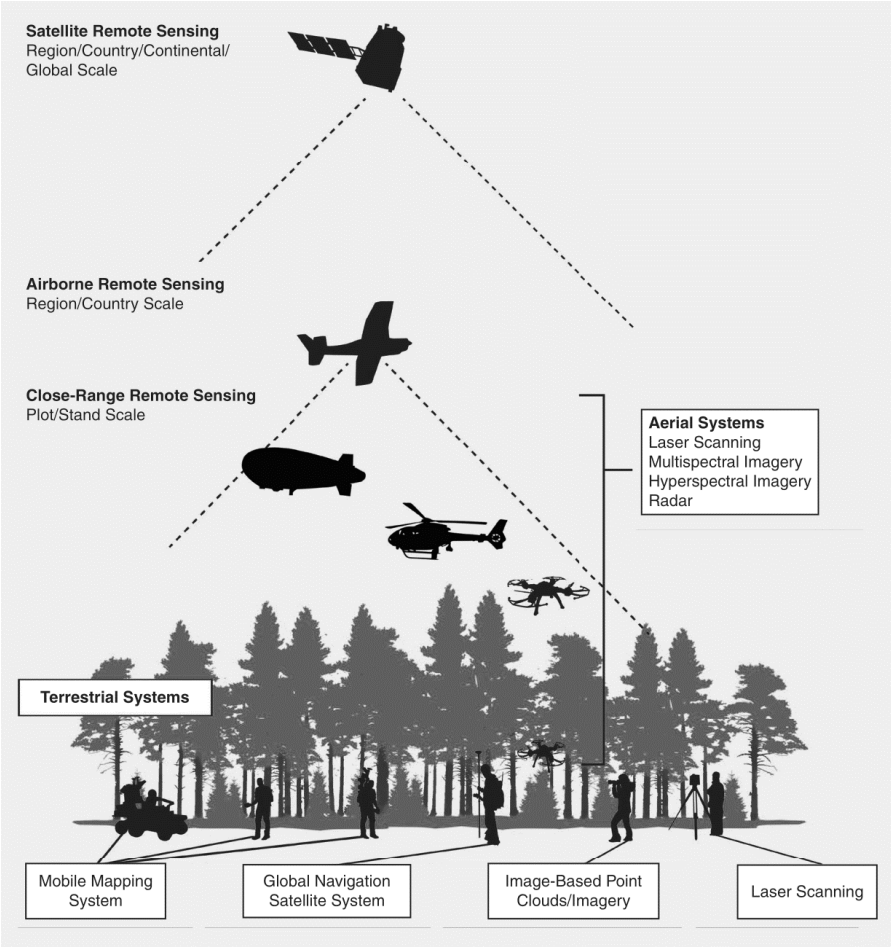
- The Interconnected Nord-Est Innovation Ecosystem (iNEST) project aims to extend the advantages of digitalization to the main specialization areas of Northeast Italy.
- Research focused on improving the resilience of mountain areas to the risks of climate change and geo-hydrological hazards.
- Activities employ current and legacy cartographic data to monitor the evolution of torrents and sediment-related phenomena at a regional scale, and high-resolution topographic surveys to locally assess the interaction between sediment dynamics and channel control works.
- The goal is to define best practices for remote sensing surveys, also applicable by practitioners and local authorities.



REMOTE SENSING TECHNIQUES: UAV PHOTOGRAMMETRY AND LASER SCANNING

REMOTE SENSING TECHNIQUES

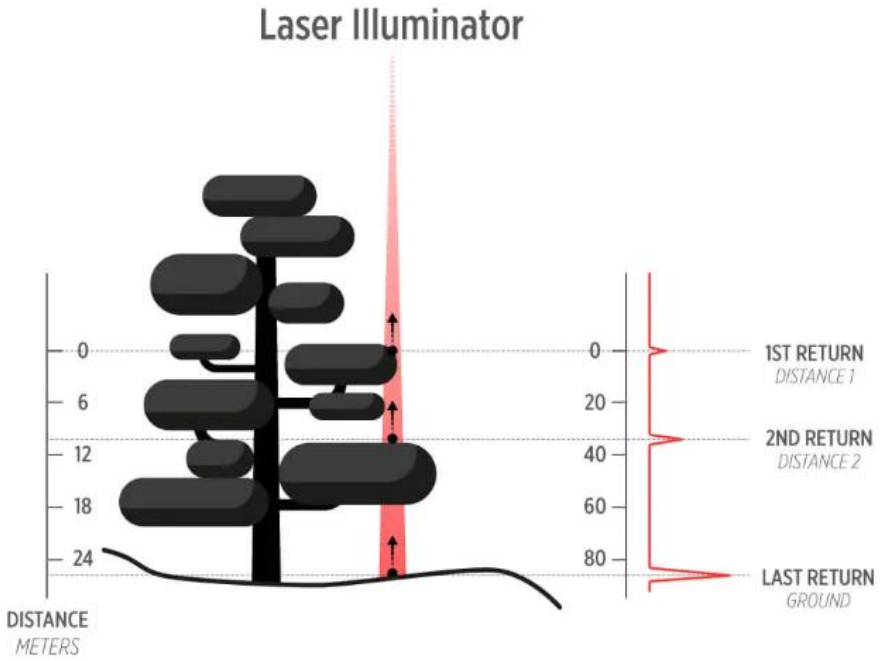
- Platforms and data sources are proliferating at an unprecedent speed.
- Unmanned aerial vehicles (UAVs) are the dominant platform among low-altitude airships, allowing extensive, high-detailed and repeated surveys.
- UAVs are mainly equipped with low-cost and easy-access cameras to acquire images, processed via Structure from Motion (SfM) to obtain 3D point clouds.
- Photogrammetry cannot see beneath the vegetation that often covers the area of interest.



Liang et al. (2022). Close-range remote sensing of forests, *IEEE GEOSCIENCE AND REMOTE SENSING MAGAZINE*, 10.1109/mgrs.2022.3168135

LASER SCANNING

- Laser scanning (or LiDAR – Light Detection and Ranging) offers a suitable solution to model the bare terrain surface.
- Active system that emits infrared signals able to penetrate through gaps in the forest canopy, measuring points on the ground.
- LiDAR sensors increasingly used as UAV payload (ULS – UAV-borne Laser Scanning).
- Need for understanding accuracy and precision provided by ULS and its ability to effectively penetrate vegetation and provide high detailed Digital Terrain Models (DTMs).



https://precisioncroptech.com/phoenix-lidar/

LITERATURE REVIEW

- Most of the articles are related to forest inventory: ULS point clouds are mainly employed for crown structure metrics assessment.
- The canopy penetration ability is strongly affected by scanner settings and flight properties:
  - pulse repetition rate
  - number of returns recorded
  - scan angle (field of view)
  - number of flight directions
  - leaf-on/leaf-off conditions
- Dense vegetation can negatively influence the accuracy of the DTM.
- Occlusions at the bottom of the canopy cannot be easily overcome with ULS.

Brede et al. (2022). Peering through the thicket: effects of UAV LiDAR scanner settings and flight planning on canopy volume discovery. *International Journal of Applied Earth Observation and Geoinformation*, 10.1016/j.jag.2022.103056

CASE STUDIES: ULS FOR 3D TERRAIN MAPPING

ULS SYSTEM AND DATA COLLECTION

DJI Matrice 300 RTK

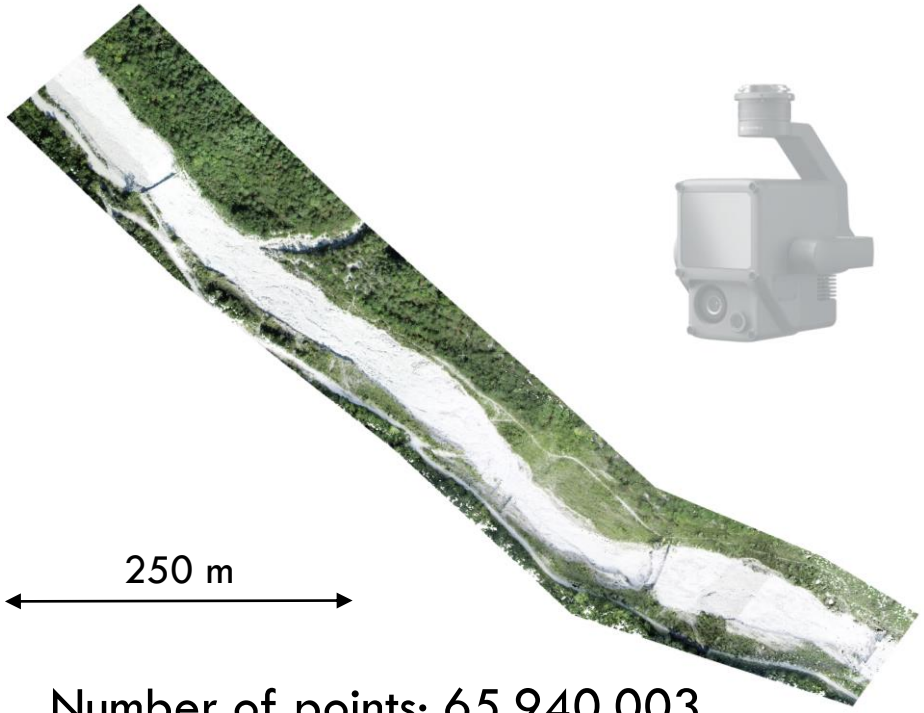
- Weight: 6.3 kg
- Max payload: 2.7 kg
- Flight time: 55 minutes

DJI Zenmuse L1

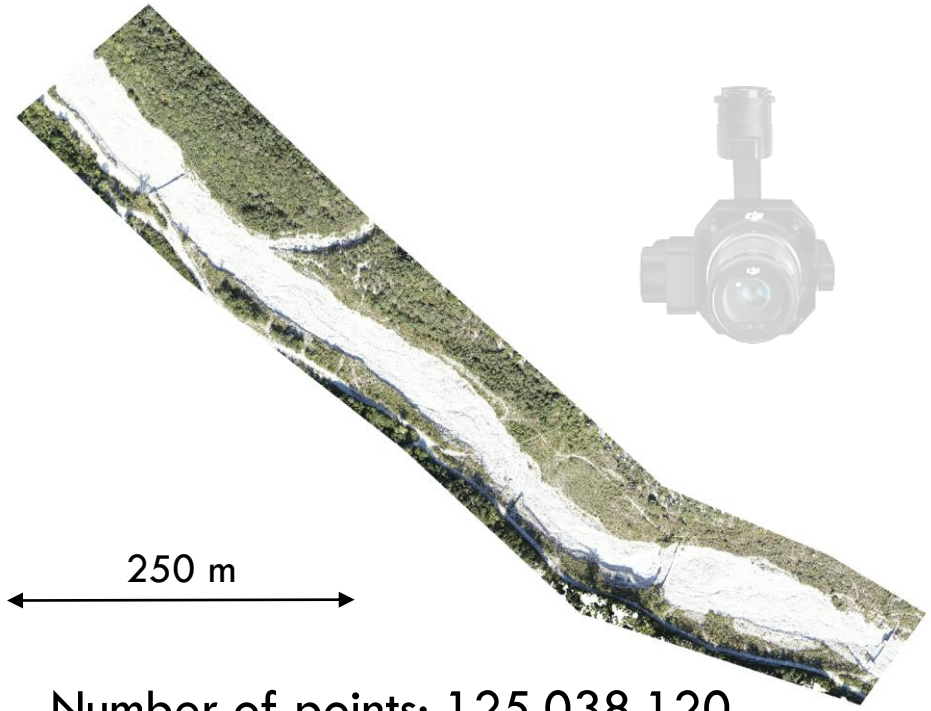
- System accuracy: 5 – 10 cm @ 50 m
- Ranging accuracy: 3 cm @ 100 m
- Number of returns: up to 3
- Point rate: 480,000 pts/s
- Real-time point cloud coloring

DATASET 1 – THE VEGLIATO TORRENT

Area of 80,000 m^2, river banks and fluvial terraces, medium to high vegetation on the sides.



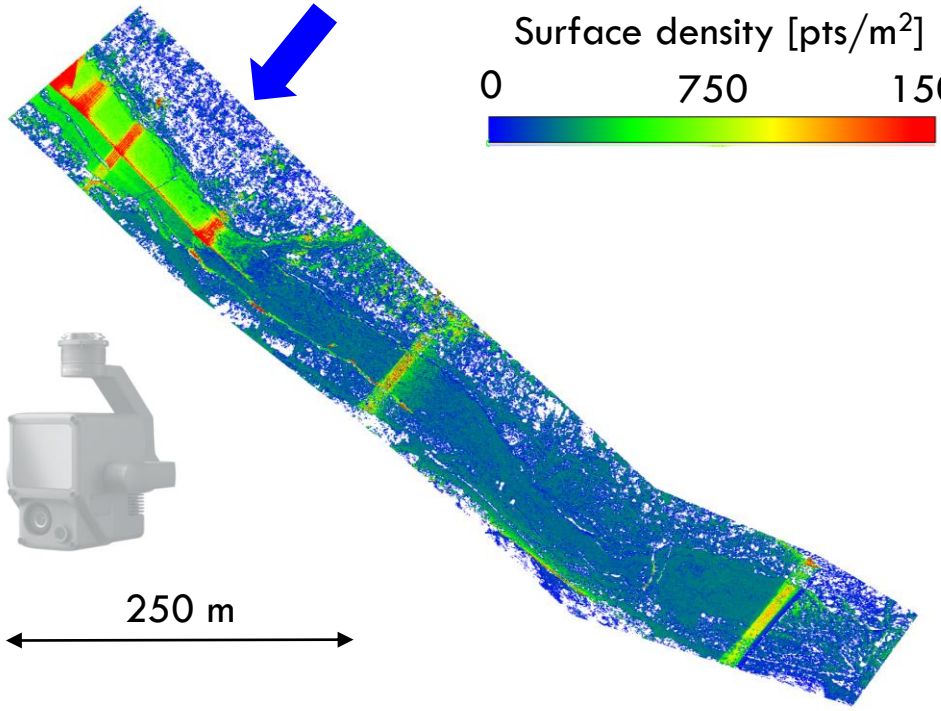
- Number of points: 65,940,003
- Post-processing time: ~10 min
- Flight altitude: 80 m agl



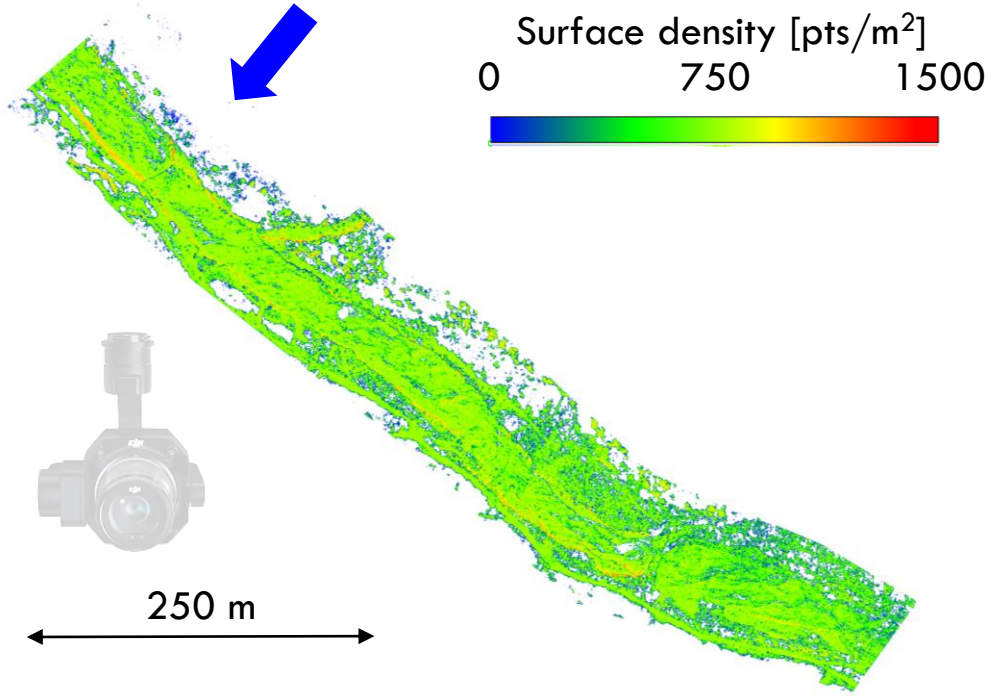
- Number of points: 125,038,120
- Post-processing time: ~ 4.5 hours
- Flight altitude: 80 m agl
- GSD: 1.8 cm/pixel

DATASET 1 – THE VEGLIATO TORRENT

Point clouds automatically filtered to extract ground points.



- Bare ground completely covered.

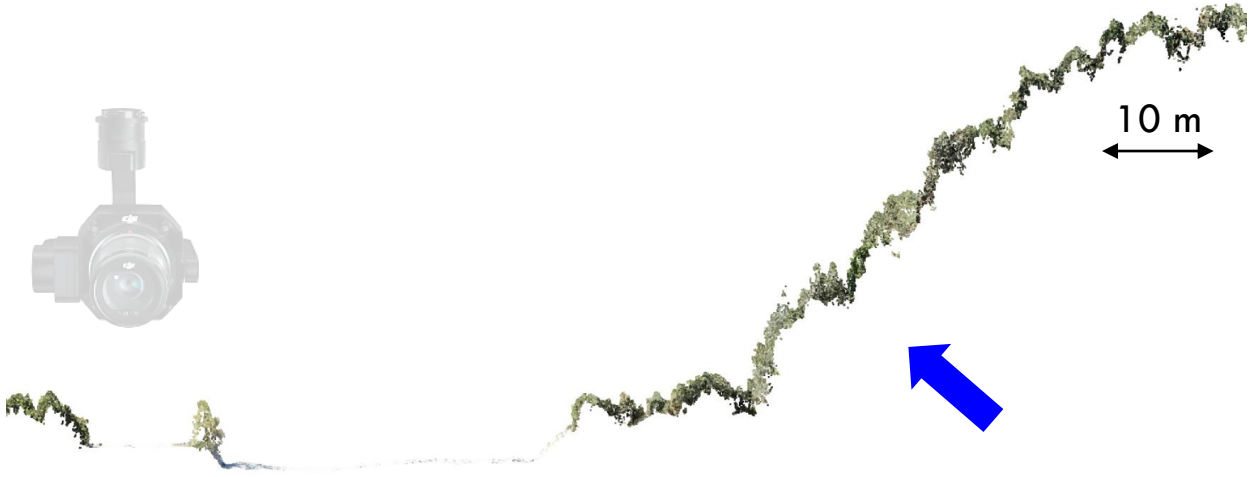


- Occlusions caused by vegetation did not allow to reach the bare ground in some areas.

DATASET 1 – THE VEGLIATO TORRENT

- ULS was able to reconstruct both the upper part of the tree crowns and the bare ground

- No ground points measured under the canopy by photogrammetry



DATASET 2 – THE MOSCARDO TORRENT

Area of 7,500 m^2, river banks covered by brushes and low vegetation.

- Number of points: 2,201,544
- Flight altitude: 120 m agl

- Number of points: 49,732,683
- Flight altitude: 35 m agl
- GSD: 0.9 cm/pixel

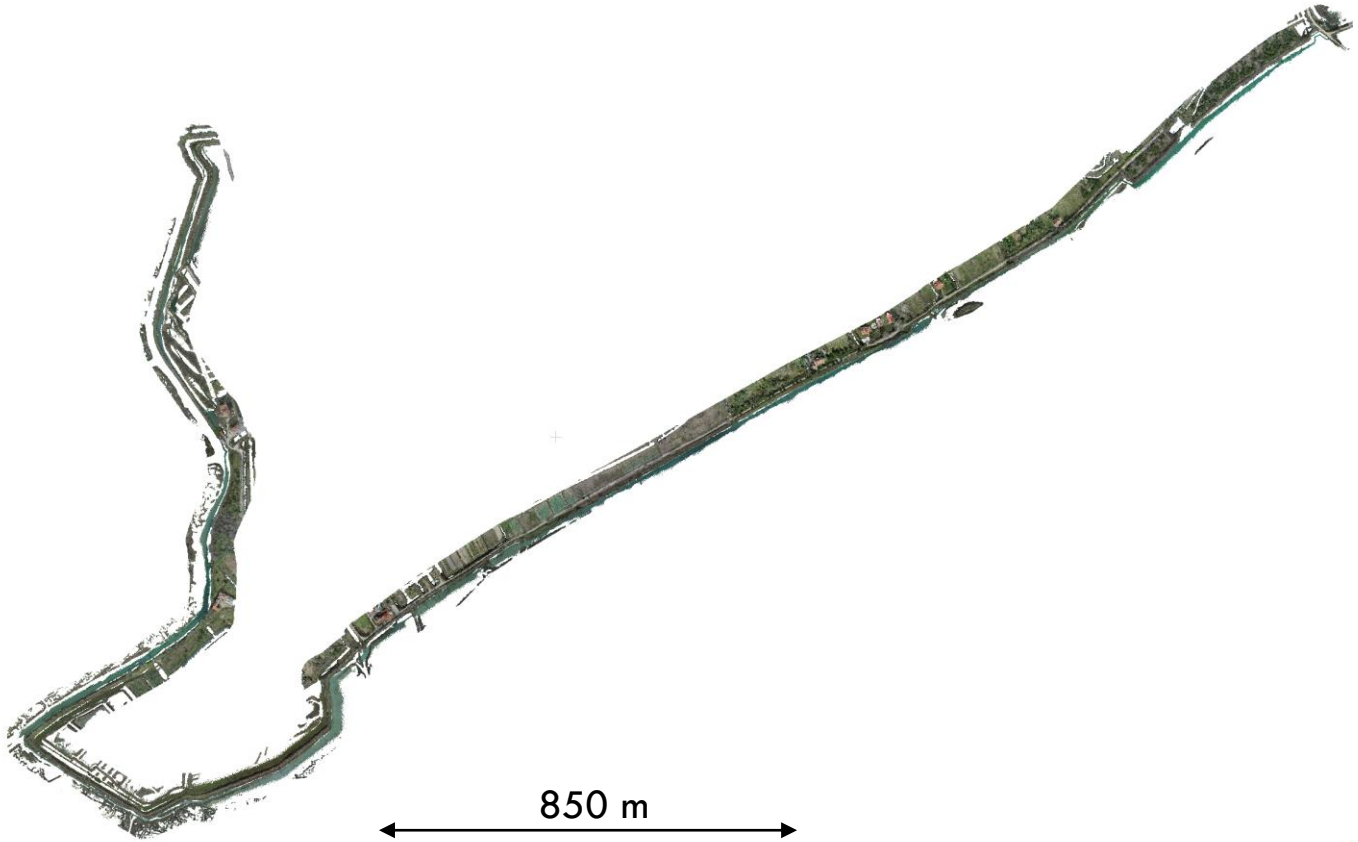
DATASET 2 – THE MOSCARDO TORRENT

- ULS detected few points on the ground beneath the low vegetation

- Higher point density and level of detail in the photogrammetric cloud

DATASET 3 – THE LAGOON IN LIO MAGGIORE

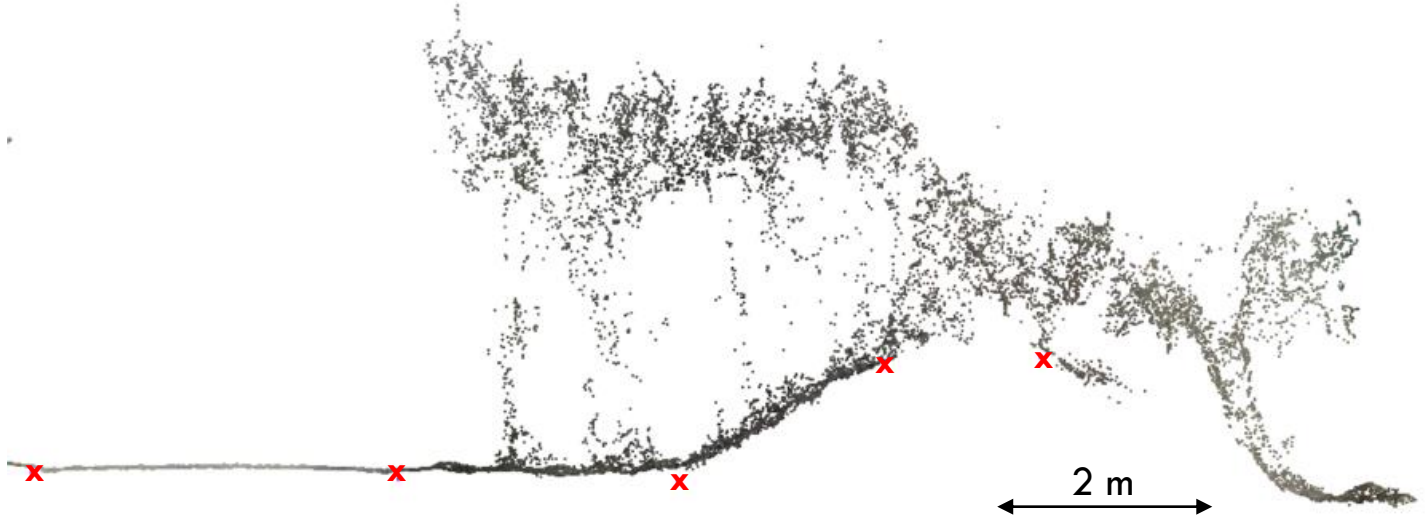
4.5 km of river banks covered by low vegetation.



- 202 points measured with high-precision GNSS receiver
- Mean error on the DTM: +0.179 m (+/- 0.157 m)

DATASET 3 – THE LAGOON IN LIO MAGGIORE

- Ground accurately mapped below the trees



- Brushes and dense riparian vegetation prevents the laser pulse from reaching the bare ground

CONCLUSIONS

- This work is part of an ongoing research that aims at defining best practices for terrain monitoring in vegetated areas.
- Although laser scanning guarantees higher canopy penetrability than photogrammetry, several limits still exist in the presence of low vegetation.
- Results are affected by flight parameters: best practices must be established to guide the choice of sensor and flight settings.
- Data fusion and the integration of terrestrial topographic techniques could be useful to obtain a complete and accurate DTM.

THANK YOU FOR THE ATTENTION!

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