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Drone-based bathymetric measurements in the assessment of the Impounded Riverbed of Rautuvaara

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Uomari-project

Project duration

10/2023-03/2026

Budget

666 942 €

EU-funding

553 551 €

New drone-based measurement and imaging solutions for reducing environmental impacts and risks in mining industry and stream habitat restoration

LAPIN LIITTO GTK Kajaanin Yliopistokeskus OULUN YLIOPISTO Suomen ympäristökeskus Finlands miljöcentral Finnish Environment Institute MML PAIKKATIETOKESKUS FGI KAINUUN LIITTO

OTANMÄKI MINE Energiateollisuus MITTA Hannukainen Mining GEO-WORK radai

Abstract

The dammed riverbed of the Niesajoki River at the former Rautuvaara mine was investigated using a dual-wavelength laser scanner and ground-penetrating radar (GPR) adapted for drone deployment.

For reference measurements, an autonomous unmanned surface vehicle (USV) equipped with single-beam and side-scan sonar was used to generate a depth map of the channel.

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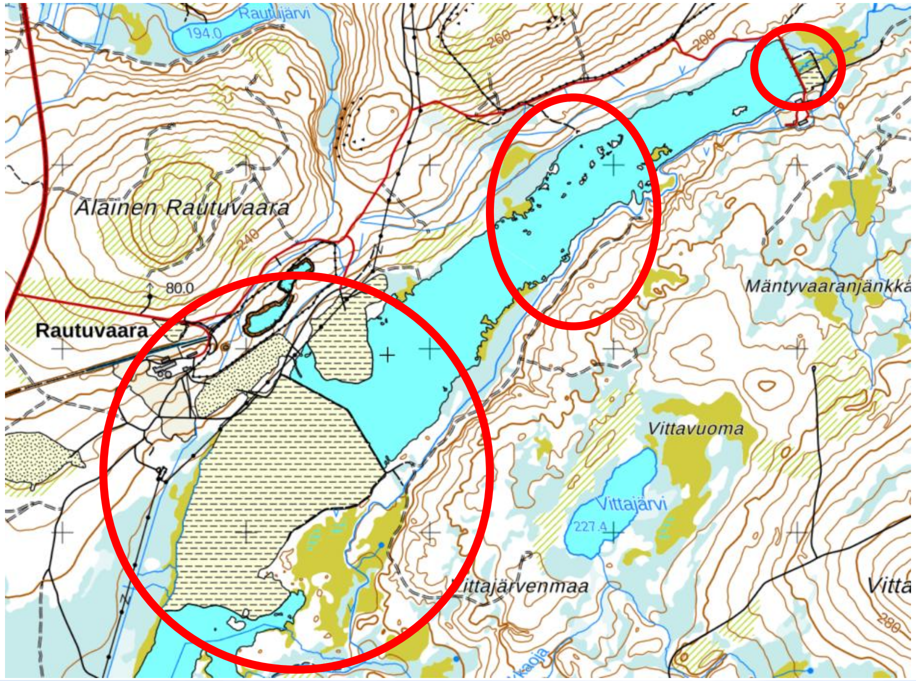
Rautuvaara

- Old iron mine in Kolari
  - Mining operations shut down in 1996
- Currently the old raw water basin is used for post clarification of purified municipal wastewater
  - New waster water treatment plant 2021
- New mining and water treatment related plans
- Challenging environment for bathymetric surveys



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Drone GPR

Drone:

DJI Matrice 350 RTK

- RTK (Real Time Kinematic) positioning
- Wide operating temperature range (-20… +50°C) and IP55 rating

GPR system:

GPR: Radar Systems Zond Aero LF

- Center frequency 100 MHz (also 150 and 300 MHz)
- Terrain Follow feature

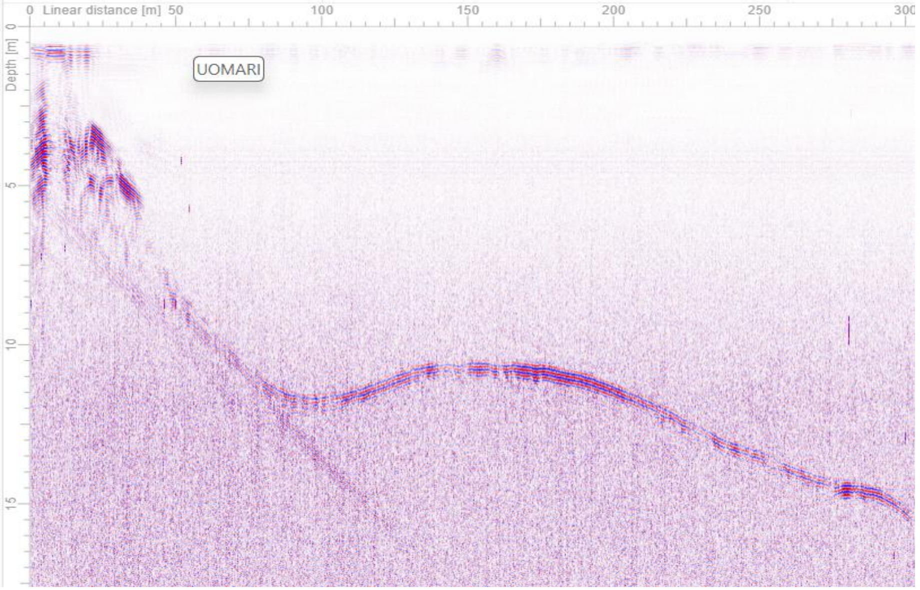
SkyHub data acquisition unit

- Real time sampling with hardware stacking

Terrain Follow feature

Safety equipment:

Automatic life jacket



Images: Veijo Sutinen, OY

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Dual-wavelength airborne bathymetric scanner (Fraunhofer IPM)

Laser

Dual-wavelength laser

Simultaneously emitting at 515 nm and 1030 nm wavelength

Laser pulse repetition rate: 35 000 Hz

Laser footprint (515 nm): 50 mm @ exit; 0.5 mrad divergence

Laser footprint (1030 nm): 50 mm @ exit; 2 mrad divergence

Detection and Storage

Full waveform acquisition, multi echo detection

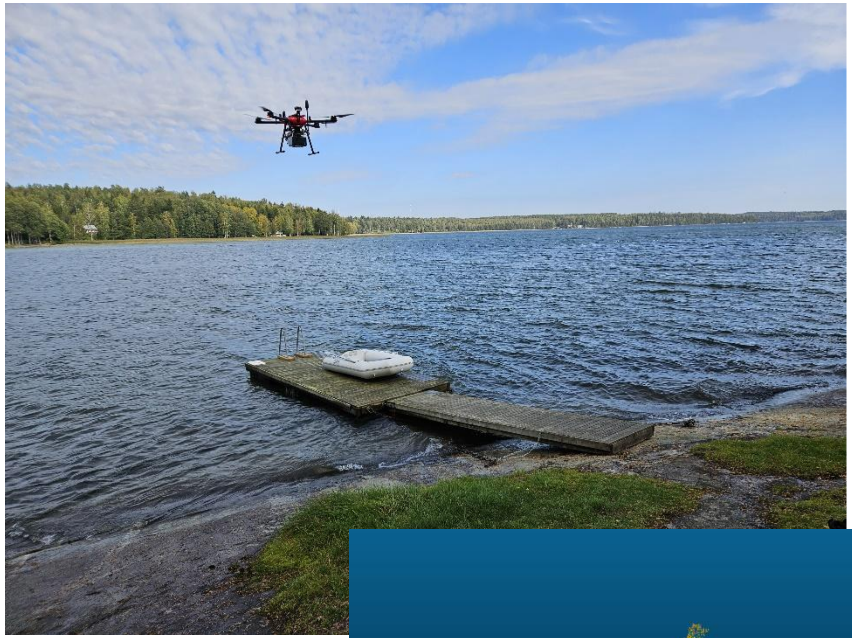
16 bit intensity information for each echo

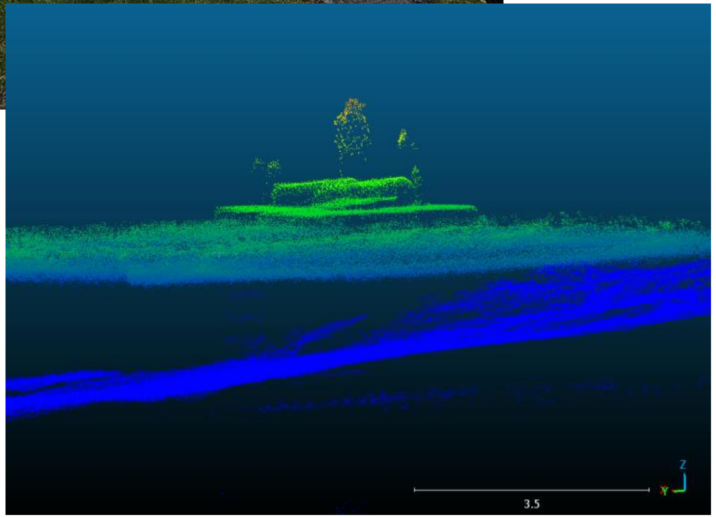
Synchronous multi-channel sampling at 4.95 Giga samples per second

Internal data storage: M.2-NVME-SSD (standard 1 TB)

Performance

Water penetration up to 1.75 Secchi





Images: Joonas Kousa, FGI

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USV setup

- Syke built custom system
  - 2 m x 1 m, +80 kg payload capacity
  - 8 h+ operation time
  - Torqeedo 3 hp electric motor
  - Humminbird Helix 9 sonar
  - Ardupilot (Cube Orange) + MissionPlanner

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Survey

- Impossible to plan regular grid lines
  - Floating peat islands
  - Trees
  - Ice
- First manual survey ”lines” with the USV
- GPR flights at 1 m altitude trying to match the USV tracks
- Lidar test flights at 30, 60 m altitudes
  - Too high turbidity, bottom not visible

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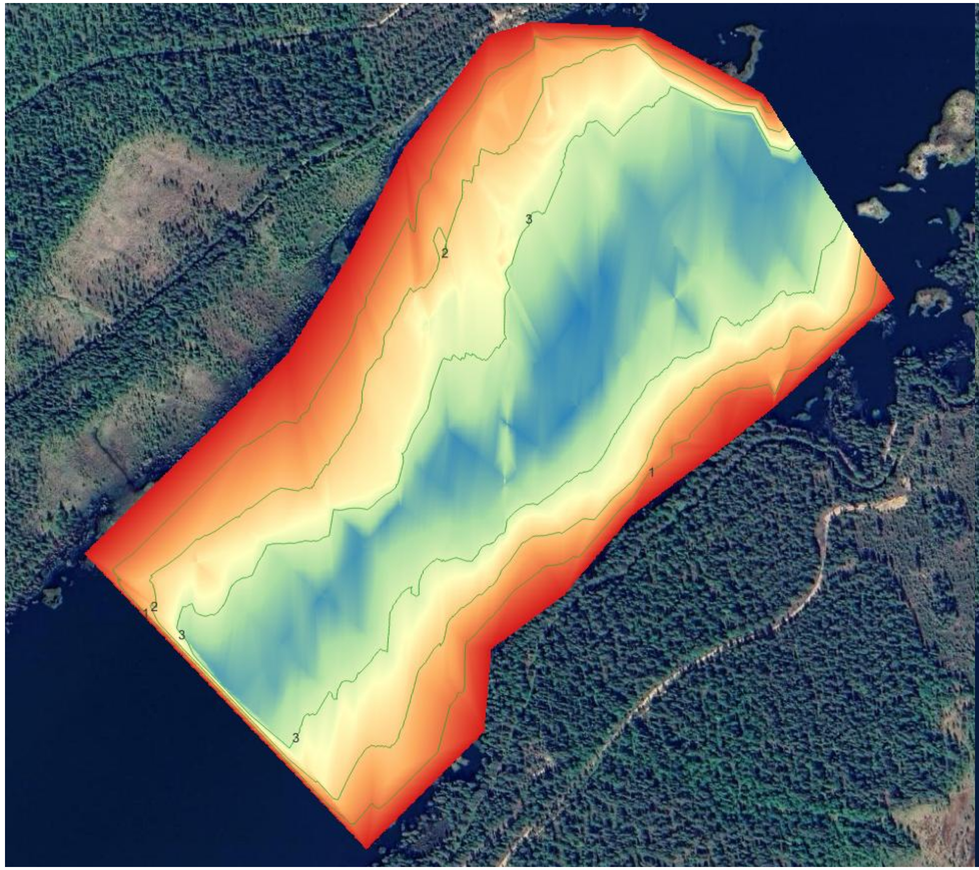
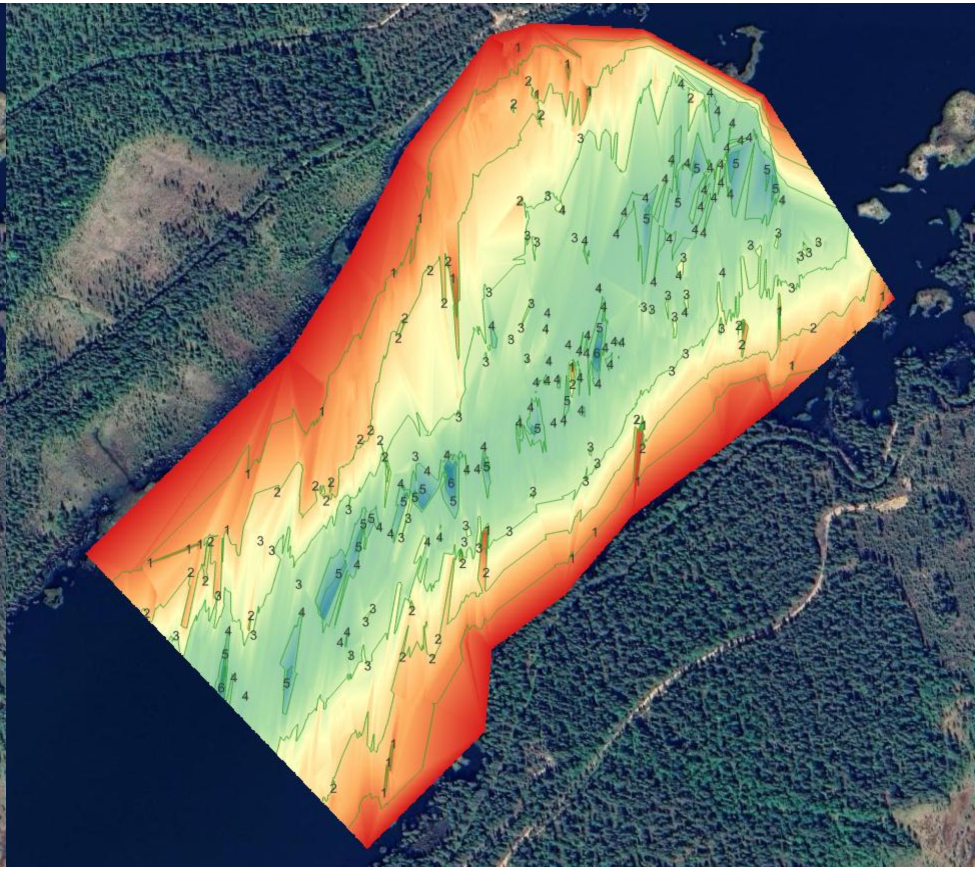
Qgis interpolated depth charts & contours



Drone GPR



USV sonar

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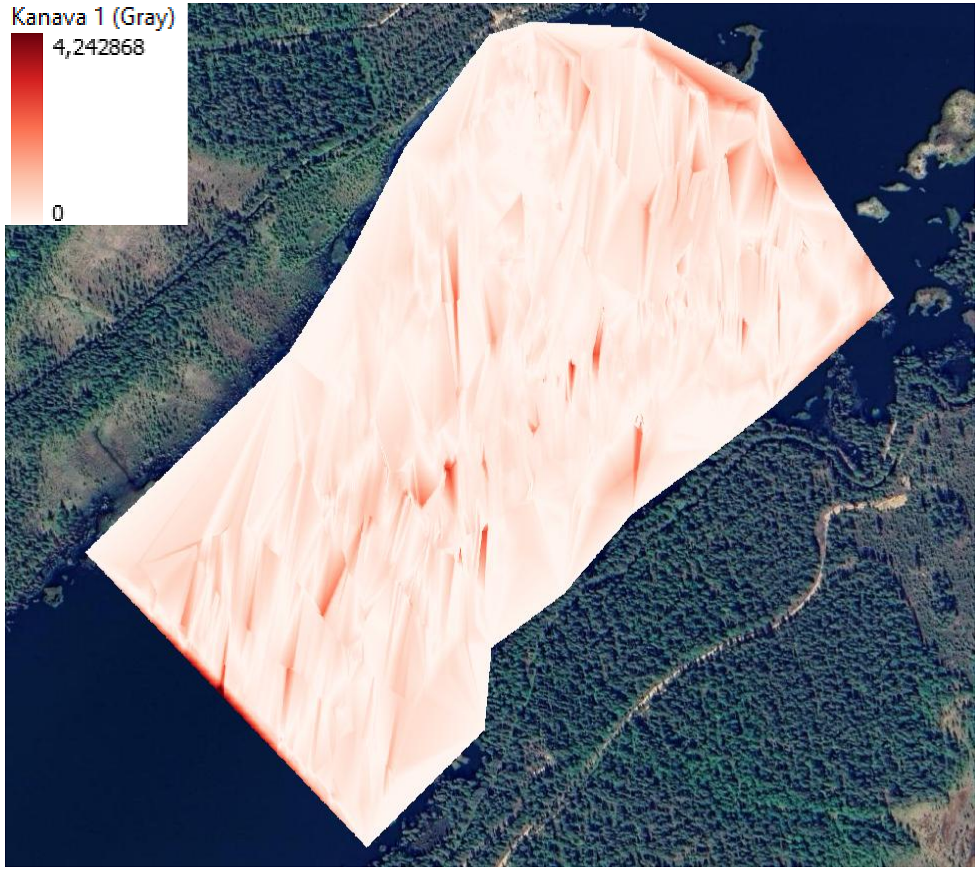
Depth chart differences

- 10 000 sonar points, 130 000 GPR points
- |USV-Drone|
- Drone data smoother, but missing the deepest points
    - Sonar 6.83 m, GPR 3.85 m
    - Organic material layer on top of the hard bottom in some parts complicates the interpretation of depth



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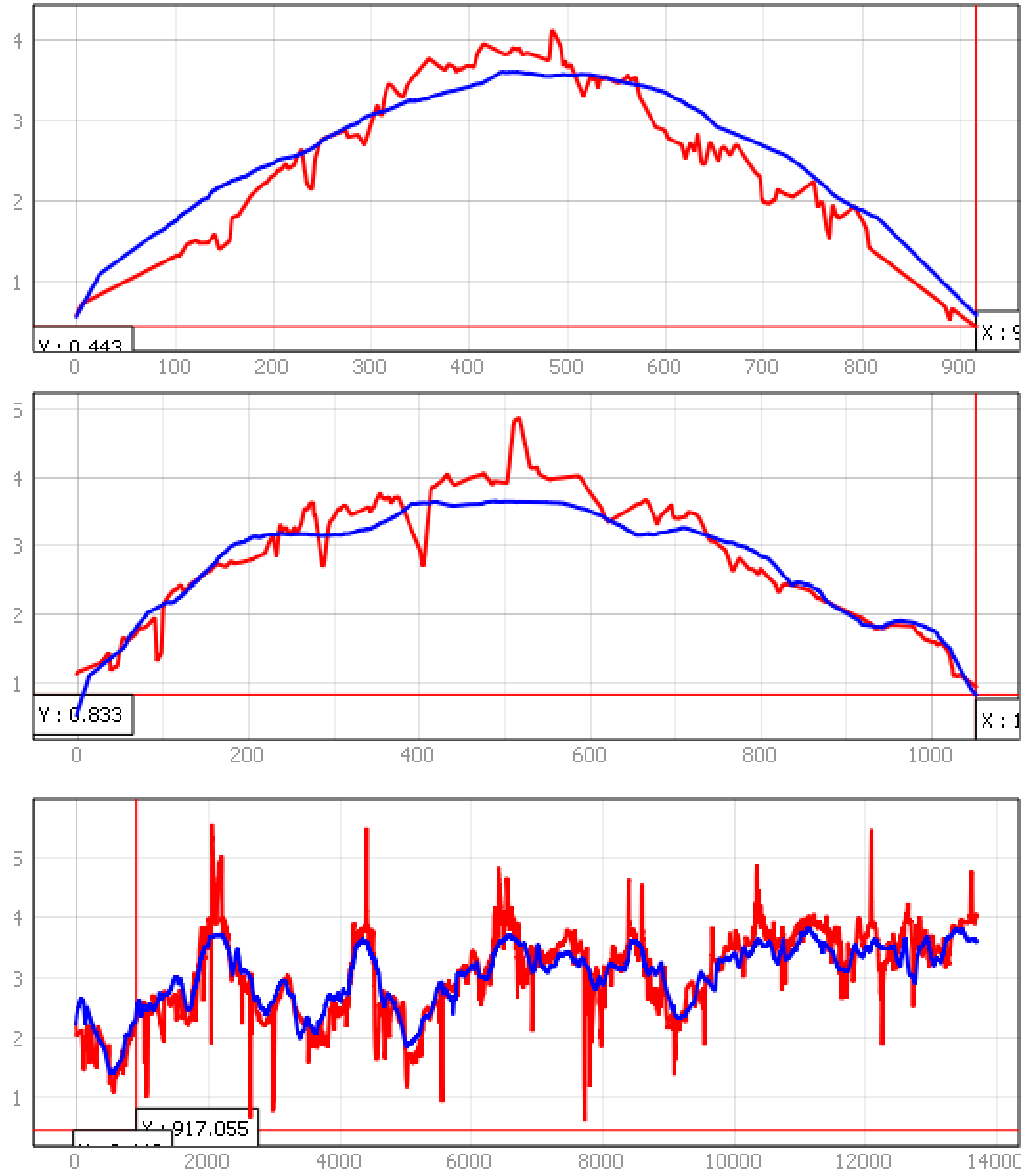
Cross sections

- Similar results
    - Challenging environment
    - Organic material
- Drone GPR smoother, more noise in sonar data
- Average difference from 4 cross sections 14 cm (33 cm absolute)
- Area between graphs 5.4 %
- Difference in calculated volume 0.6 %



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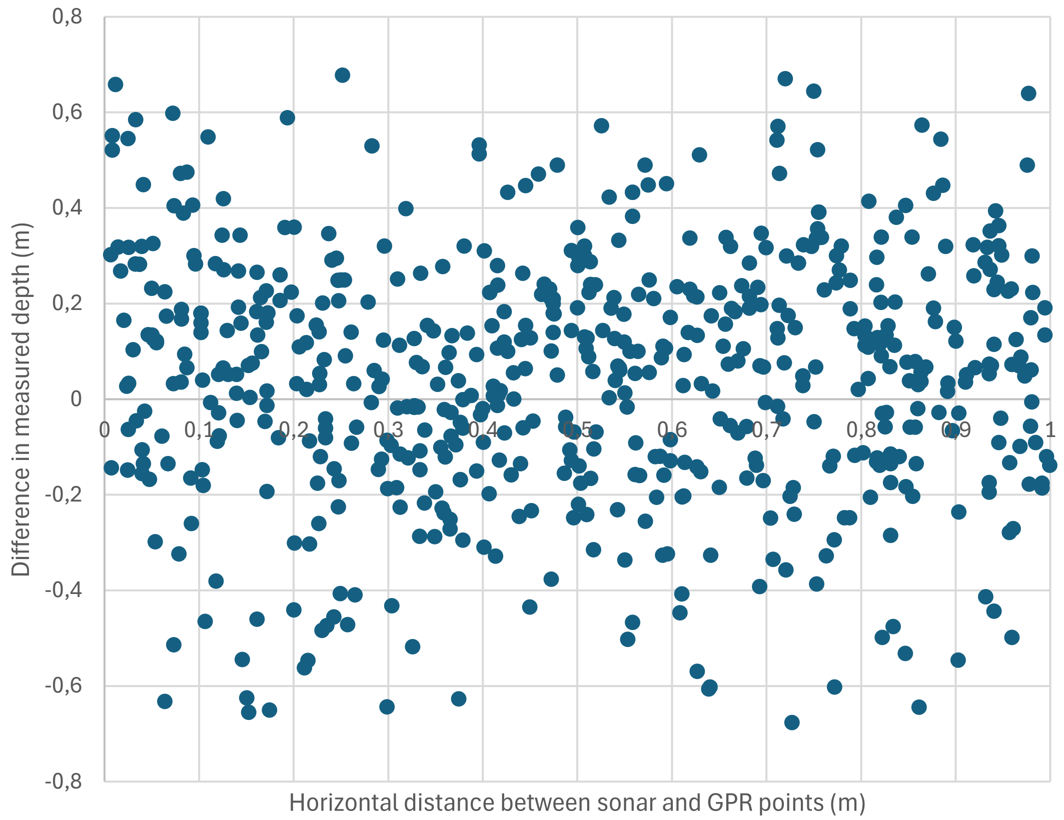
Point comparison

- 601 points with less than 1 m horizontal distance
  - 14 outliers (> 5 s) removed
- 4.5 cm difference in means
- Still statistically significant difference between the two methods
  - t-Test: Paired Two Sample for Means



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Conclusions

- Two wavelenght lidar not suitable for turbid waters (as expected)
    - Great in other sites with clear water
- Drone GPR was easier to operate compared to USV
- Irregular USV sonar data from this site does not interpolate neatly
- Only minor difference between GPR / sonar data in practical applications even with double bottom in some areas

- Uomari final seminar 24.3. Kajaani & Online

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Thank you!

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