TECHNISCHE UNIVERSITÄT WIEN

Leveraging robotic total stations for highly accurate multibeam bathymetry in inland waters

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Introduction

- What?
  - Multibeam USV survey in mountain environment in Austria

- Position estimation of platform with robotic total station (RTS), not GNSS

→ Hardware-based approach

- Multi-sensor adjustment to estimate trajectory based on positions, IMU and multibeam data

→ Software-based approach

- We also collected bathymetric LiDAR data and compare it to the multibeam data

→ Not topic of talk / poster

Motivation

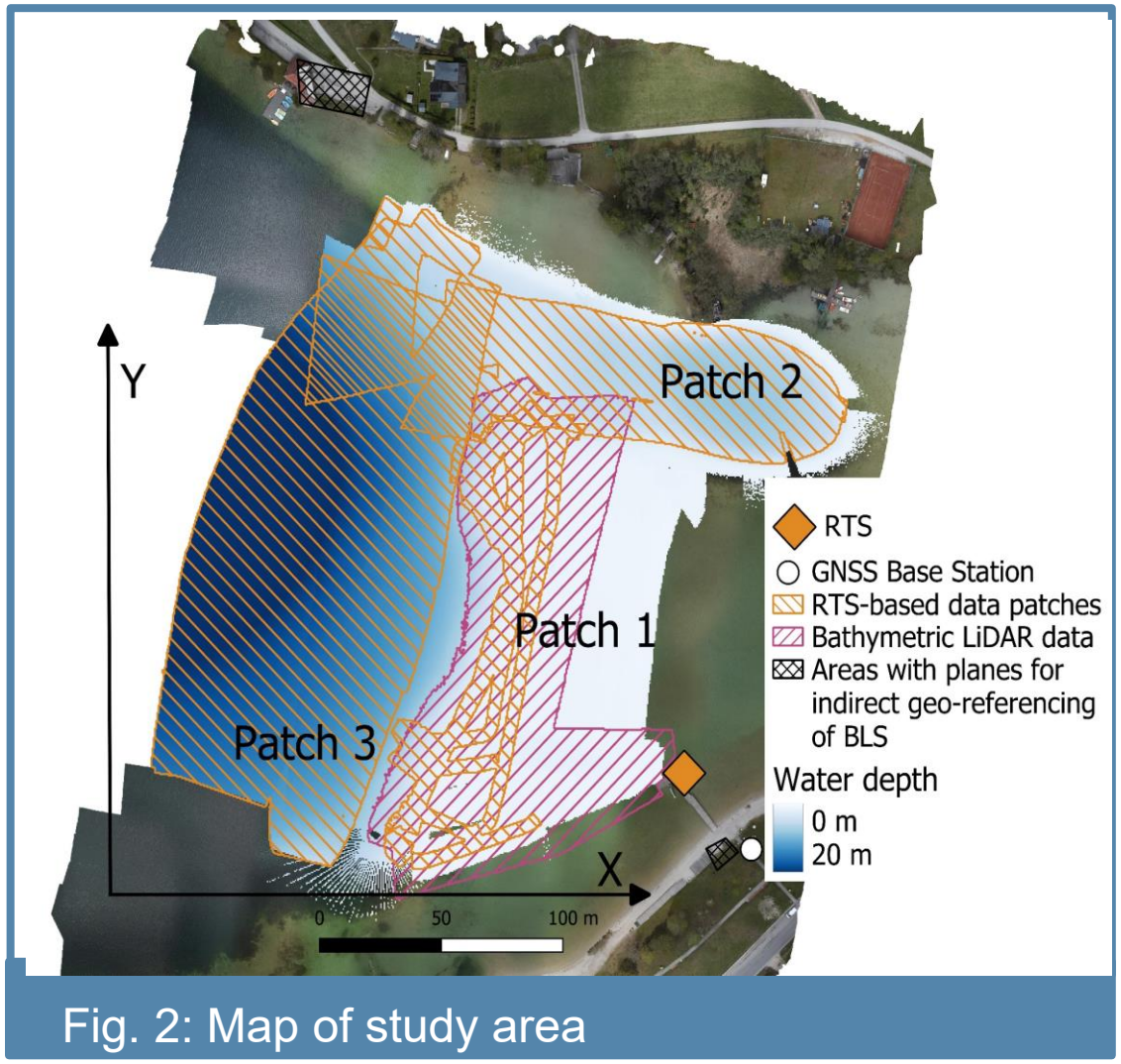


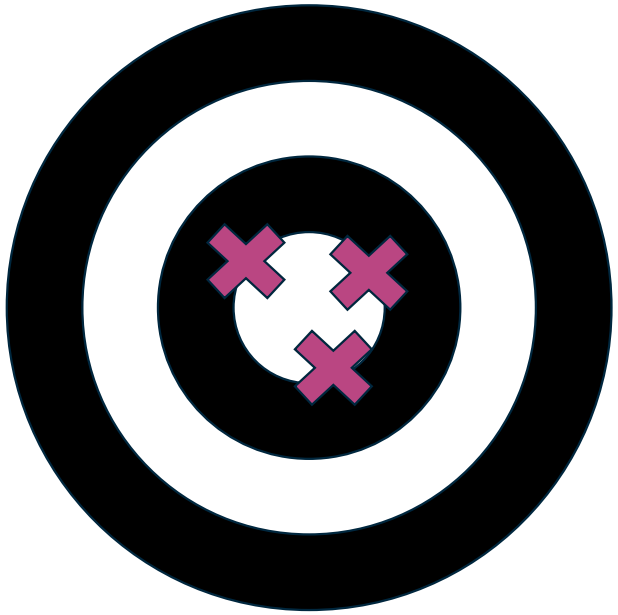
Fig. 2: Map of study area

- Why?
  - GNSS limits data accuracy and performs poorly in challenging environments
    - Especially in height
  - RTS outperform GNSS in terms of accuracy

- State-of-the-art trajectory estimation goes further than Kalman-Filtering
  - Multi-sensor adjustment makes use of all available data and delivers a precise / homogeneous data set

Accuracy & Precision

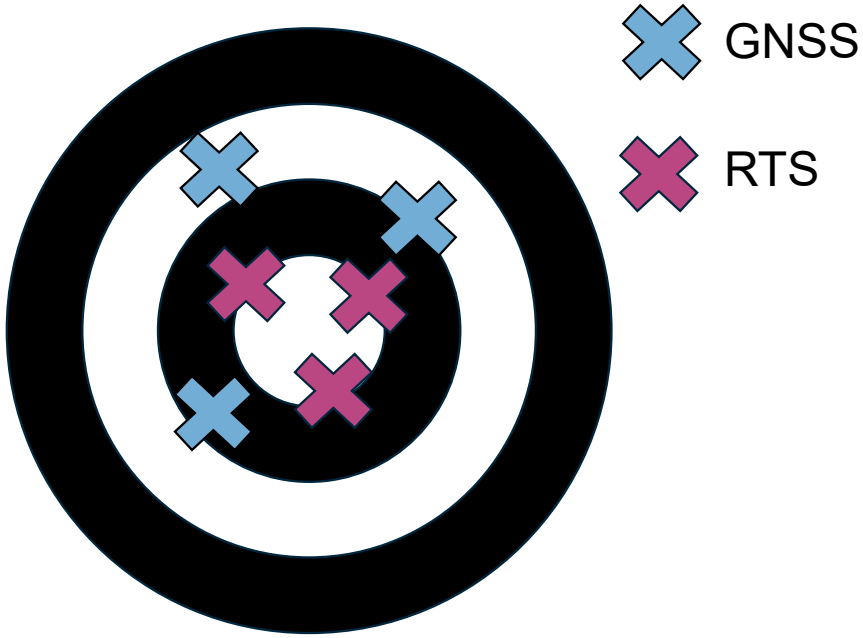
- Accuracy, i.e. deviation from true value



- Precision, i.e. spread of data around mean

Accuracy & Precision

- Accuracy

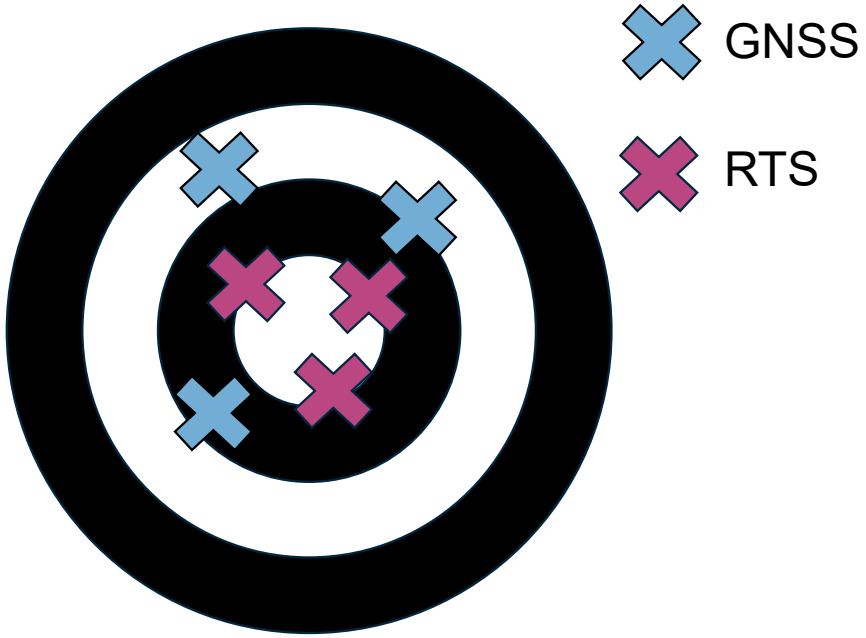


- Precision

→Hardware-based approach

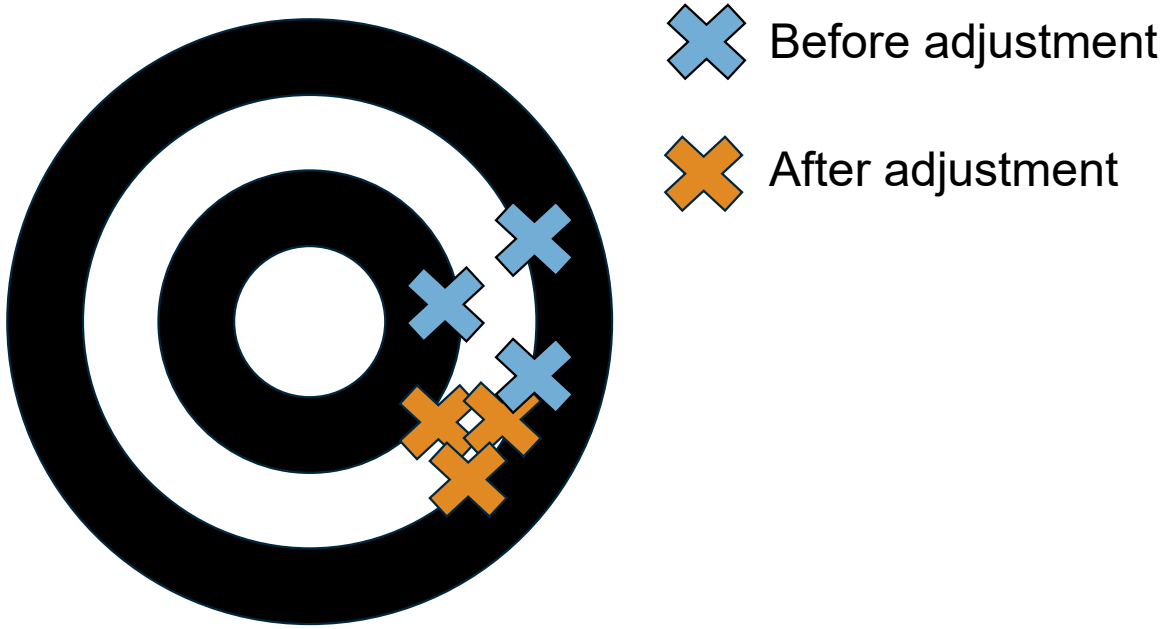
Accuracy & Precision

- Accuracy



→Hardware-based approach

- Precision



→ Software-based approach

Details

- Hardware-based approach
  - RTS measure position with 20 Hz
  - Expected accuracy is < 1 cm for ranges < 400 m
  - Limited to ~ 800 m distance
  - Requires line-of-sight
  - Works at water dams, below bridges, under vegetation and even indoors
  - Requires synchronization to IMU & multibeam (e.g. using PPS of GNSS)

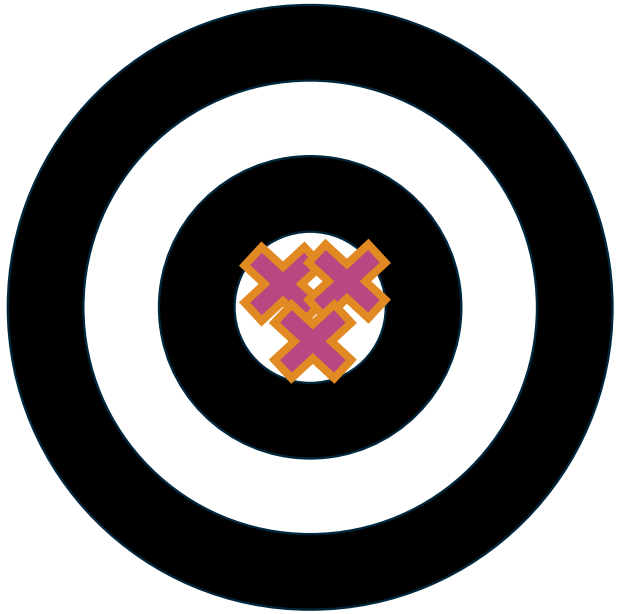
  → Accuracy

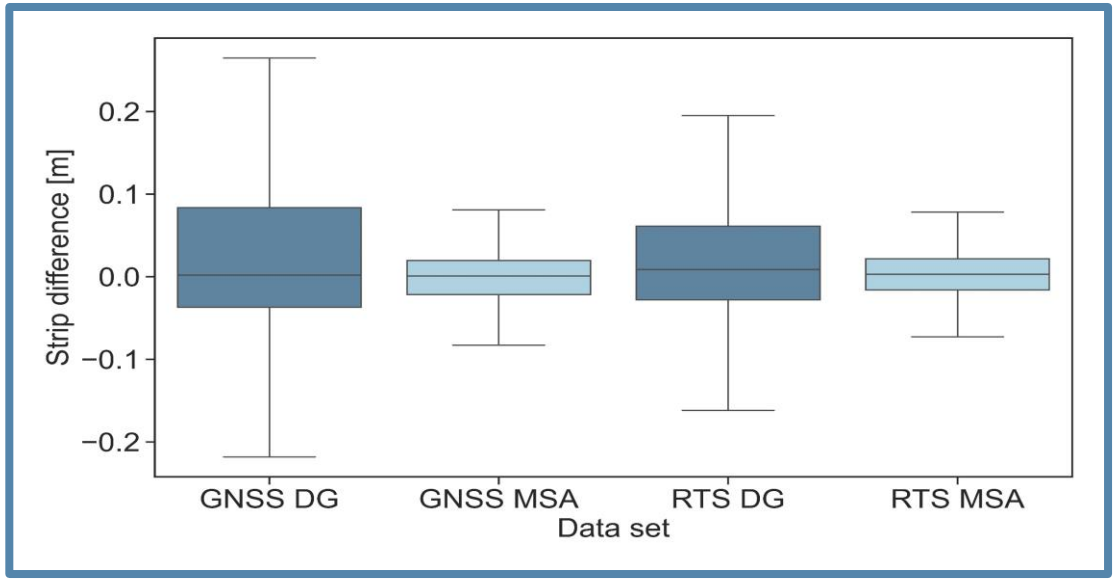
- Software-based approach
  - Adapted from airborne LiDAR
    - (Pöppl et al., 2024 & 2025)
  - Makes use of planar correspondences in overlapping point cloud data
  - Weighted consideration of…
    - Positions (from RTS, or GNSS)
    - IMU data
    - Multibeam data (or LiDAR data)

  → Precision

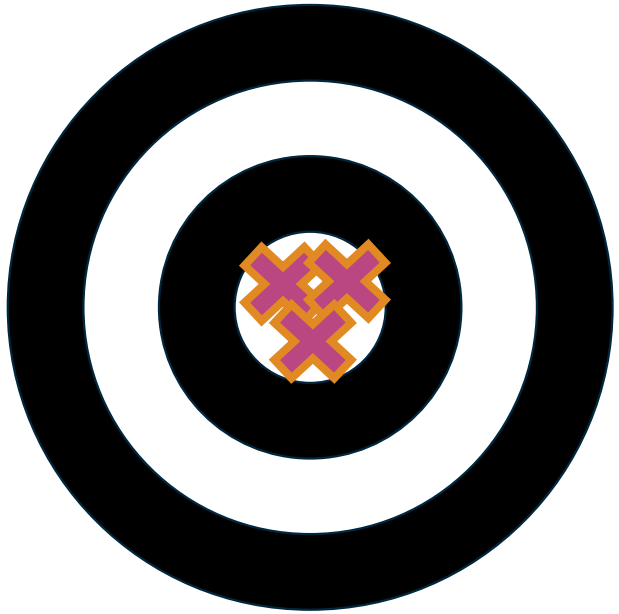
Results

- How to evaluate accuracy and precision?
  - Accuracy assessment relies on independent reference data
    - For our study not possible
    - We must rely on theoretical knowledge and simulations
  - Precision can be estimated by height differences in overlapping data
    - Without consideration of multibeam data
      - RTS shows an interquartile range of 8 cm compared to 12 cm shown by analogue GNSS processing
    - With consideration of multibeam data interquartile range is reduced to 4 cm





Results



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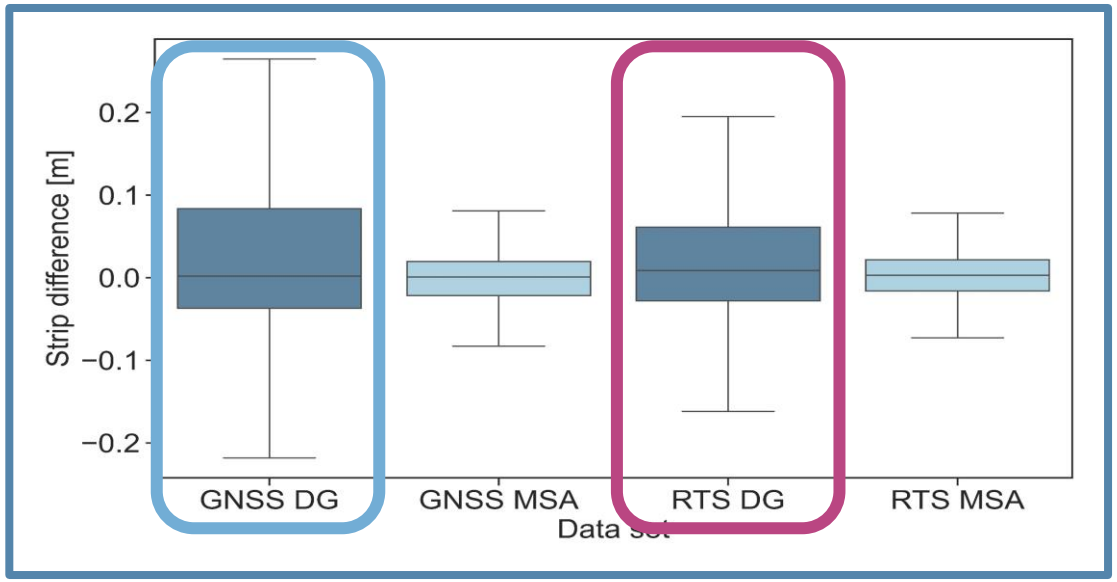

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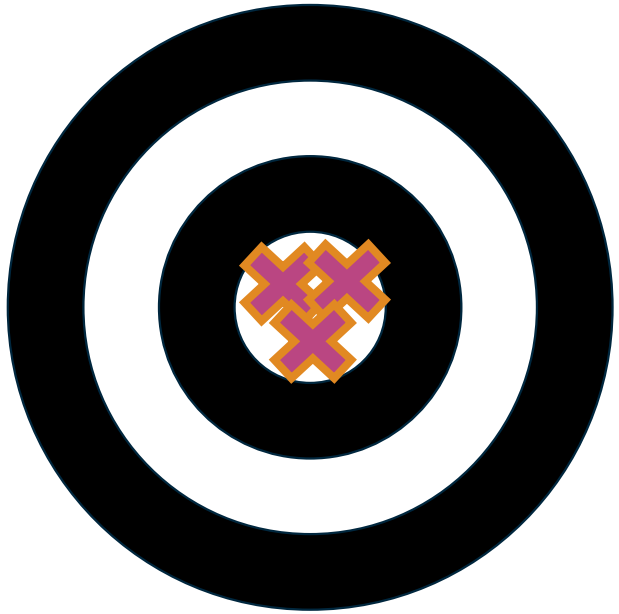

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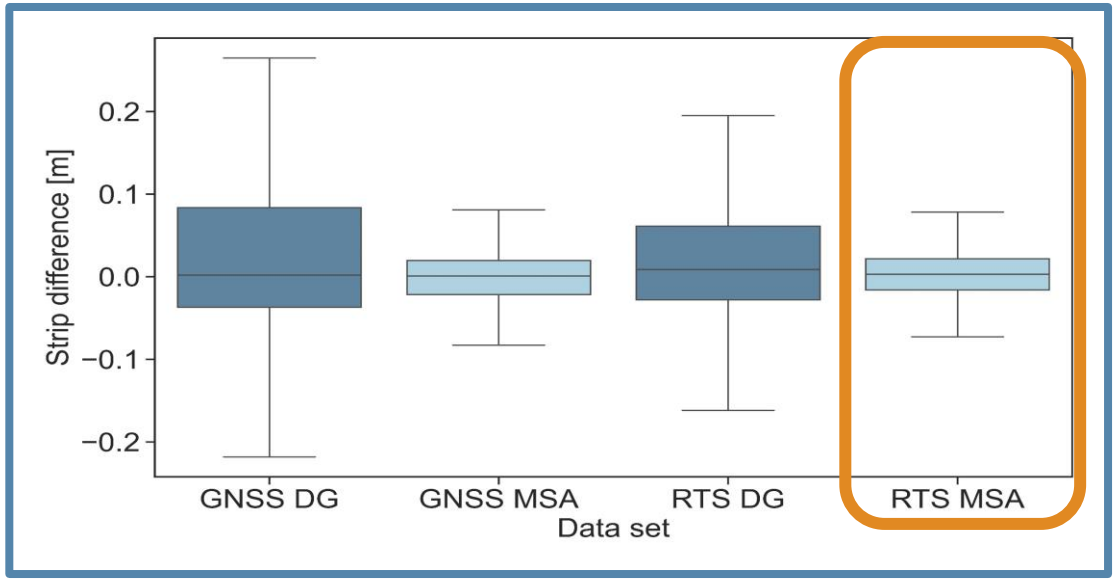

Outlook

- What about the comparison with bathymetric LiDAR?

→ Analyzed in corresponding paper (IHR, November 2025 Edition)

Future work:

- Perform a study with proper reference data to empirically assess accuracy
- Multi-sensor adjustment to combine MBES & LiDAR data

Thank you very much for your attention.

Contact information

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