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Testing The Efficiency of Low-cost Dual-frequency GNSS Receivers for Real-time Positioning Vehicles in Mechanized Forestry

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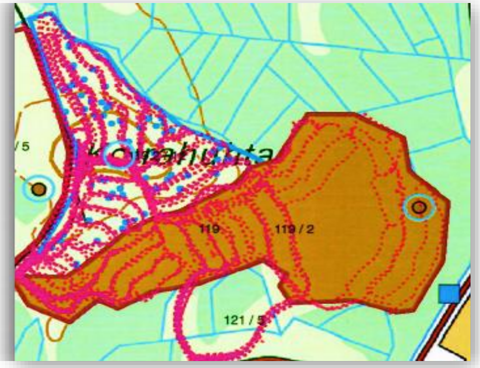
INTRODUCTION

- Accurate positioning as one of the main components of precision forestry
  - Creating tree maps after harvesting
  - Creating logging trail network
  - Following the paths designed prior to operations
  - Path the way to unmanned forest machines

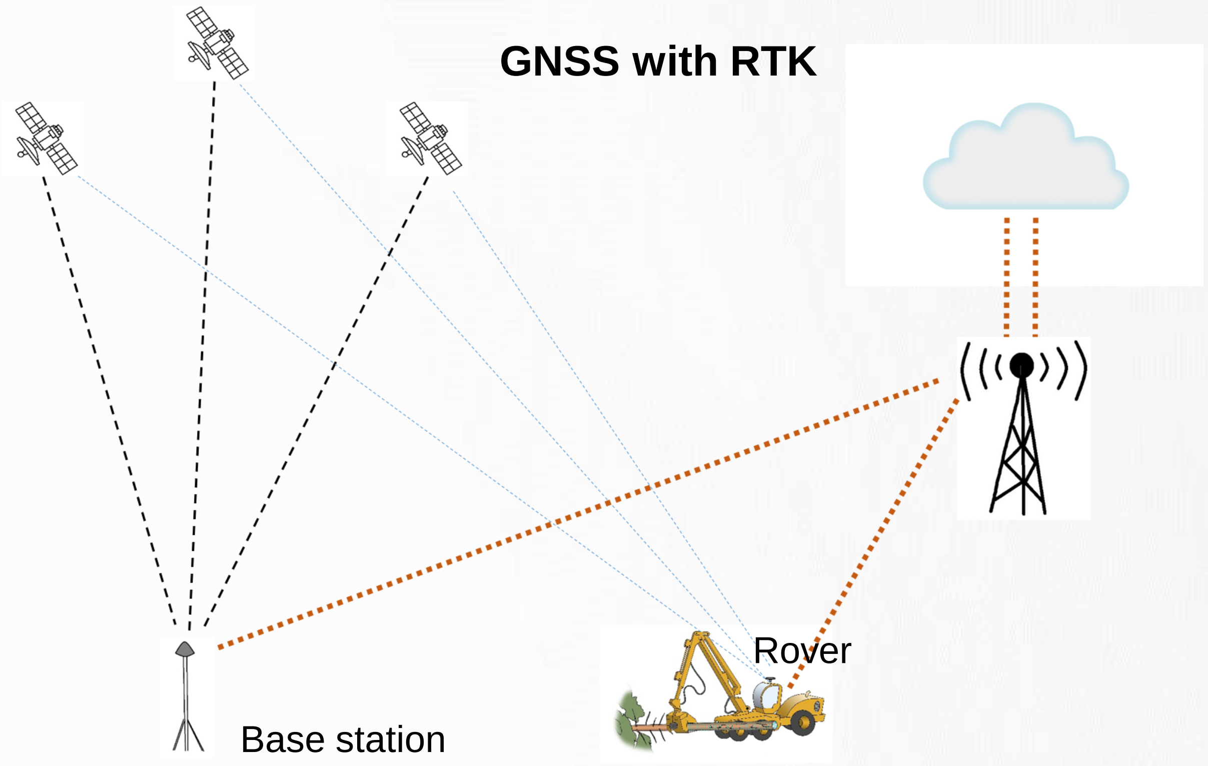


INTRODUCTION

- Good progress in GNSS positioning
- Most advanced GNSS receivers can interpret even 4 different constellations
  - The receiver needs four satellites to compute latitude, longitude, altitude and time
  - In most cases the number of available satellites exceeds 10
- Most satellite constellations will send two wavelengths in the future

INTRODUCTION

- Factors affecting the signal from the satellites to earth (19-23 km):
  - Signal blockage and multipath errors result from site-specific conditions (e.g., trees' occlusion or terrain conditions)
  - Atmospheric conditions (space weather); e.g geomagnetic storms



- Comprise a base station with known location, a rover and a real time connection with these two parts
- GNSS receivers linked with the RTK systems have proven to be efficient and reliable, but most mapping-grade or geodetic-grade devices are rather expensive

WHY LOW-COST?

- The cost of establishment a traditional RTK-related receiver, e.g., a geodetic-grade receiver, is approximately 10 times higher than a low-cost RTK receiver (cost-sensitive for small size applications in forestry or agriculture applications)

The ZED-F9P is a low cost (~U$ 200-300) positioning module especially designed for moving machines (UAVs)

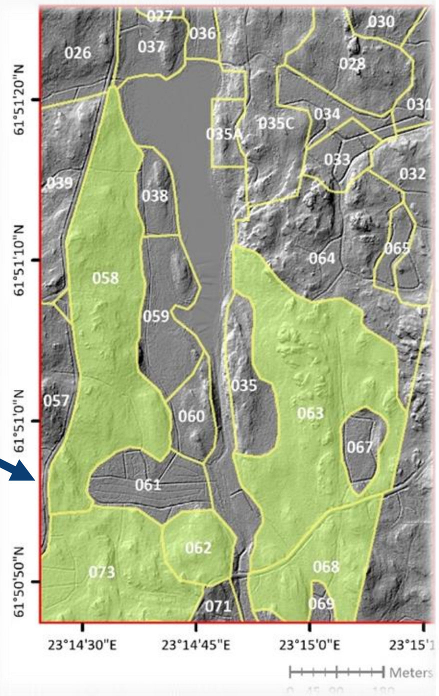
OBJECTIVES

- Testing the efficiency of low-cost dual-frequency GNSS receiver in positioning **a vehicle moving in forest** (e.g., boreal forest canopy above)
  - Accuracy of the positioning (in centimeters)
  - Factors affecting the accuracy

ANN-MB series L1/L2 multi-band, high precision GNSS antennas (~U$ 40-60)

STUDY SITE

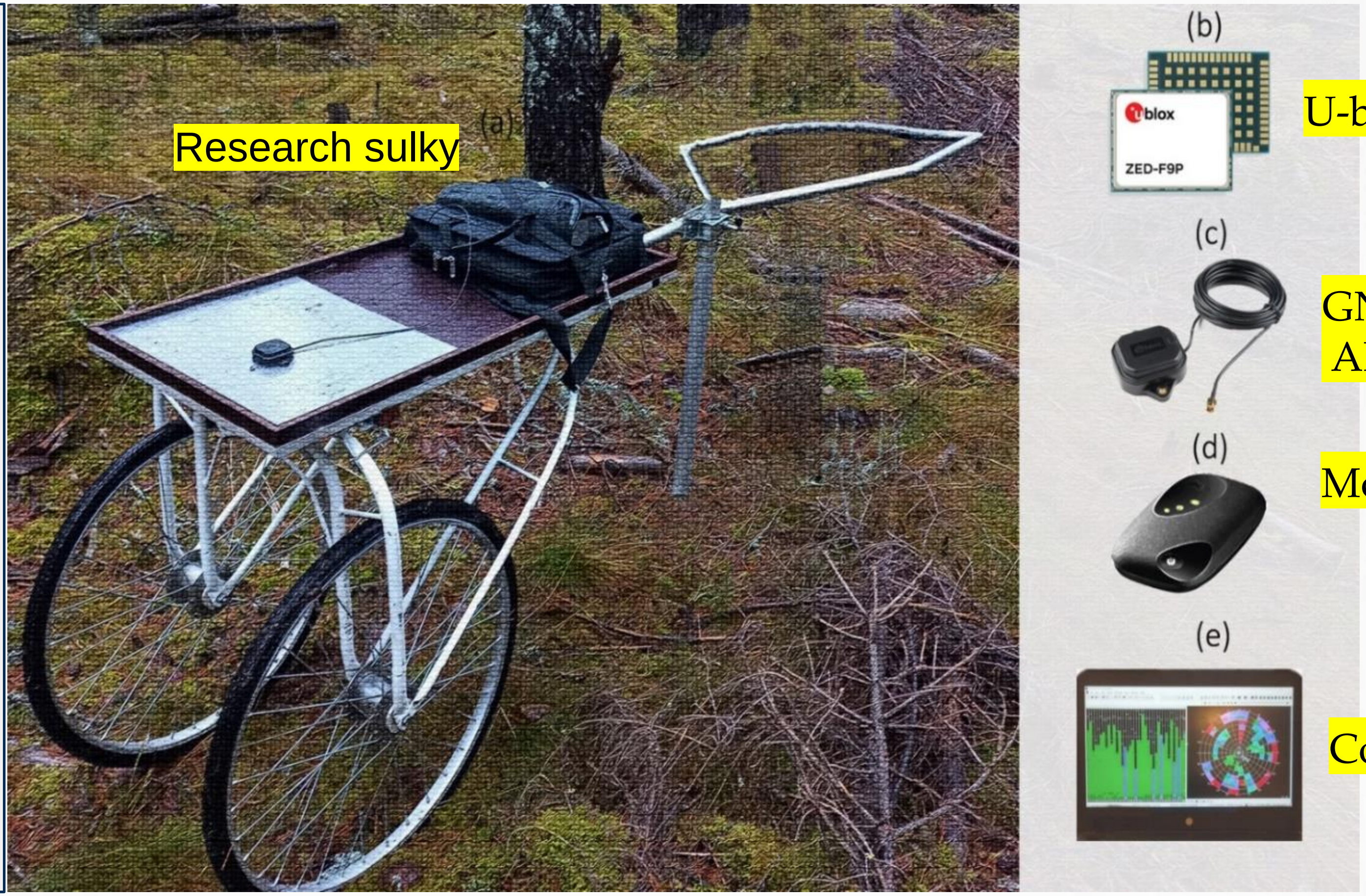
- The study site was located in the municipality of Ikaalinen in Southern Finland
- The forest trail passed four different stands
- Roughly 50-60 years old - mixed forest; recently thinned
- Volume averaging between 180-250 m3/ha (tree height 17-18 m)



U-BLOX AND COMPARTMENTS

U-blox ZED-F9P

- Multi-band GNSS receiver (L1, L2/E5b/B21)
- GPS, Galileo, BeiDou, and GLONASS
- High integrity and continuity of positioning
- Centimetre-level accuracy
- Low cost
- User friendly
- Working in different modes
- Working in different weather conditions (–40° to +85° C)



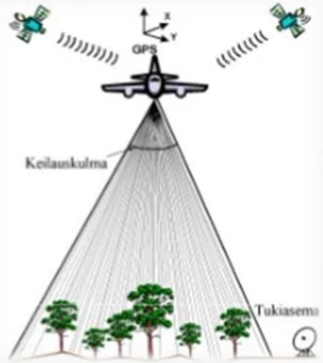
U-blox ZED-F9P

GNSS antenna ANN-MB-00

Modem

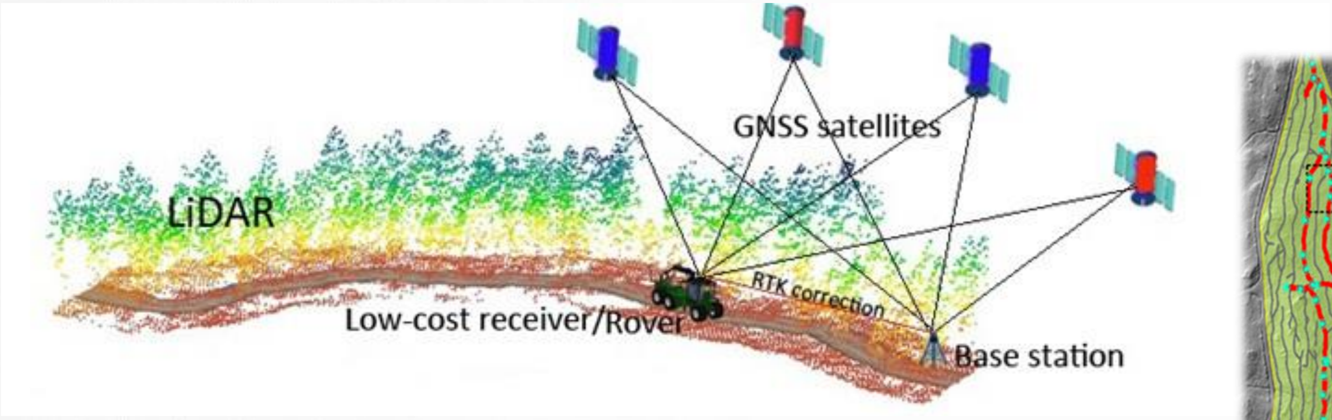
Computer system

METHODOLOGY

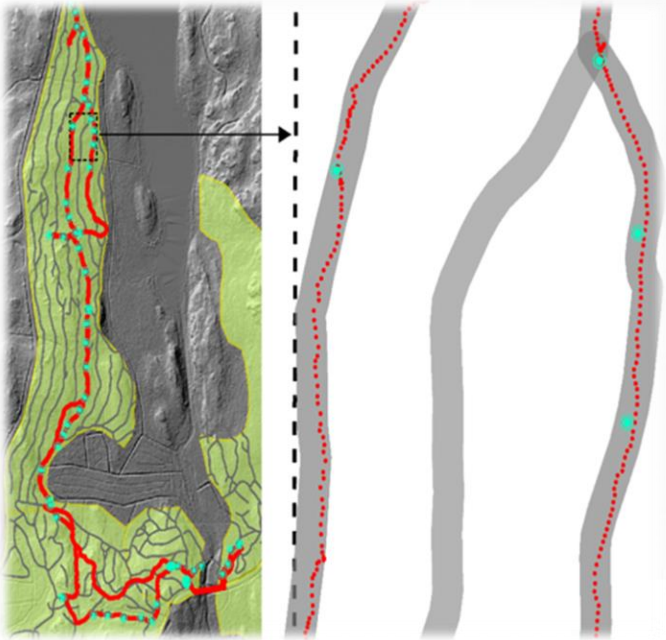


HD ALS data available (5 points/m2)

- Position observations from the moving vehicle (research sulky) were compared to
  - Center of the logging trail detected from the HD ALS data
  - Reference points measured with a surveying grade Trimble R2 with RTK correction



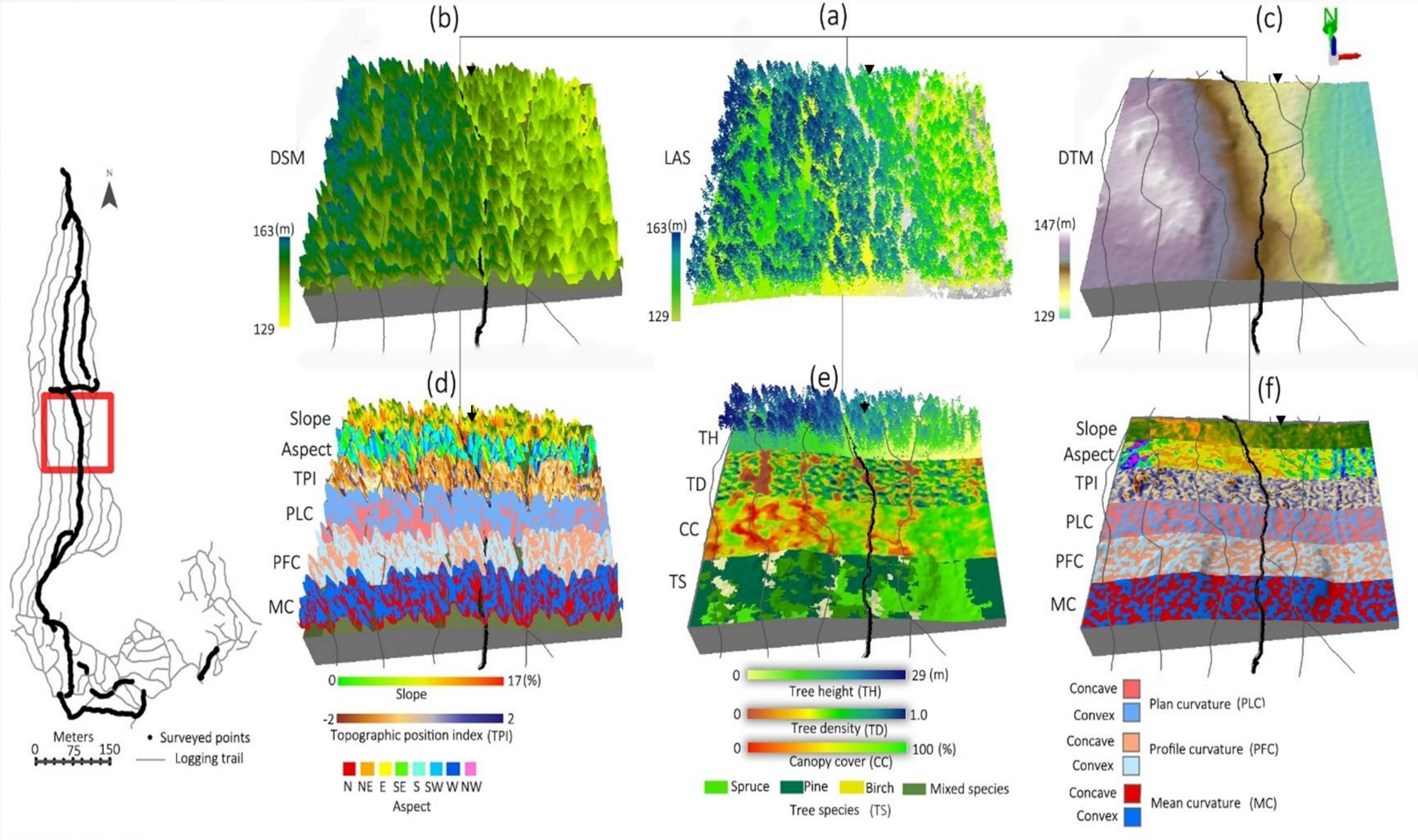
Trails along the forest where detected prior to test with the Logging trail detection system developed by Abdi et al (2021) – Presentation on Thursday



METHODOLOGY

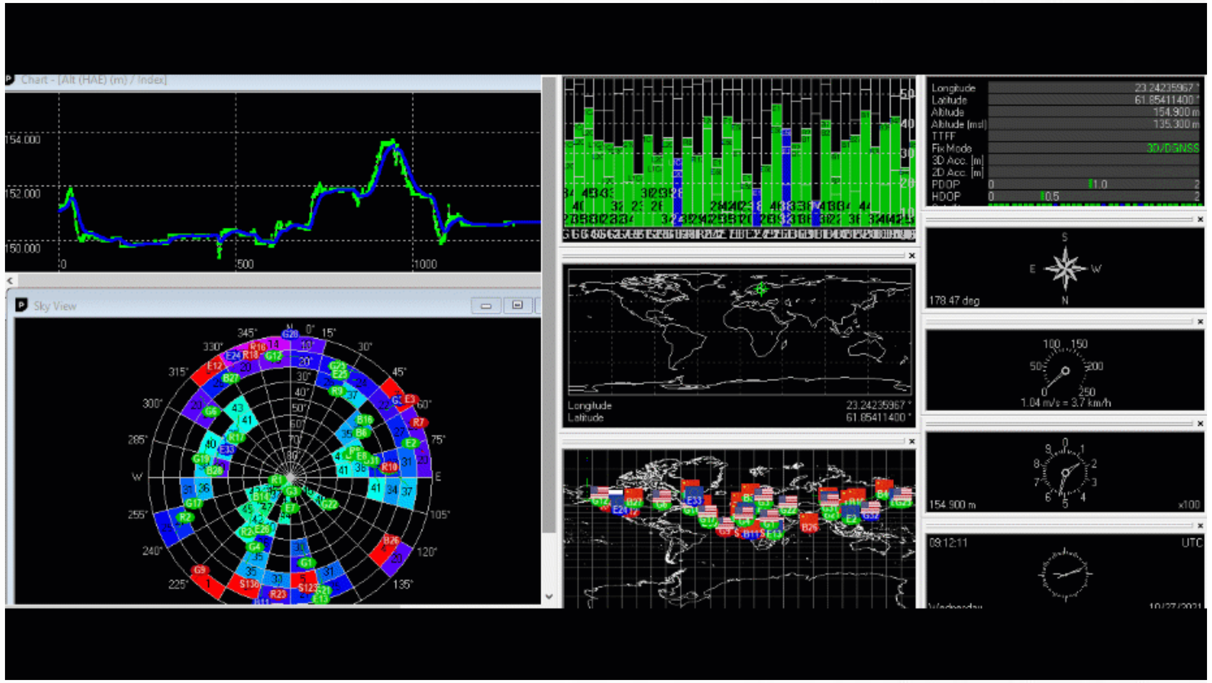
Forest attributes were detected from the RS data (laser scanning + orthophotos)

- Tree characteristics /topography features



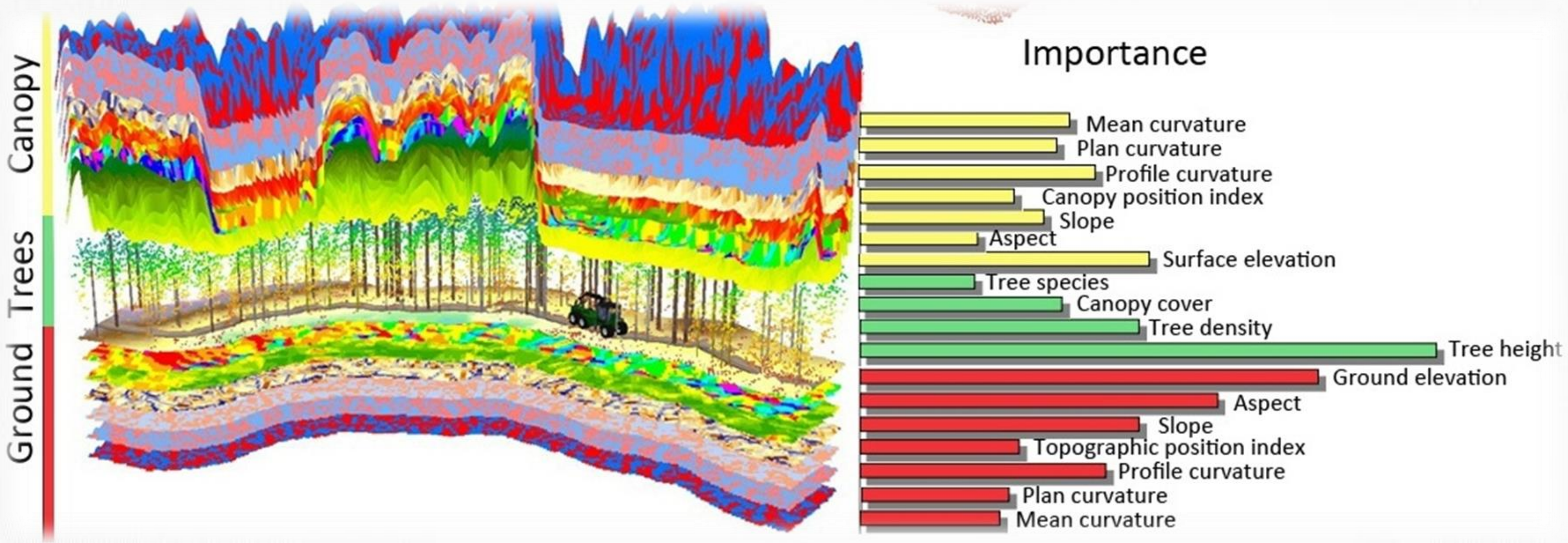
RESULTS
(THE ACCURACY OF POSITIONS)

- The absolute errors are distributed between 1.5 cm to 1.8 m
- The mean of absolute errors of positions between those measured by u-blox ZED-F9P and control points was obtained as about 43 cm

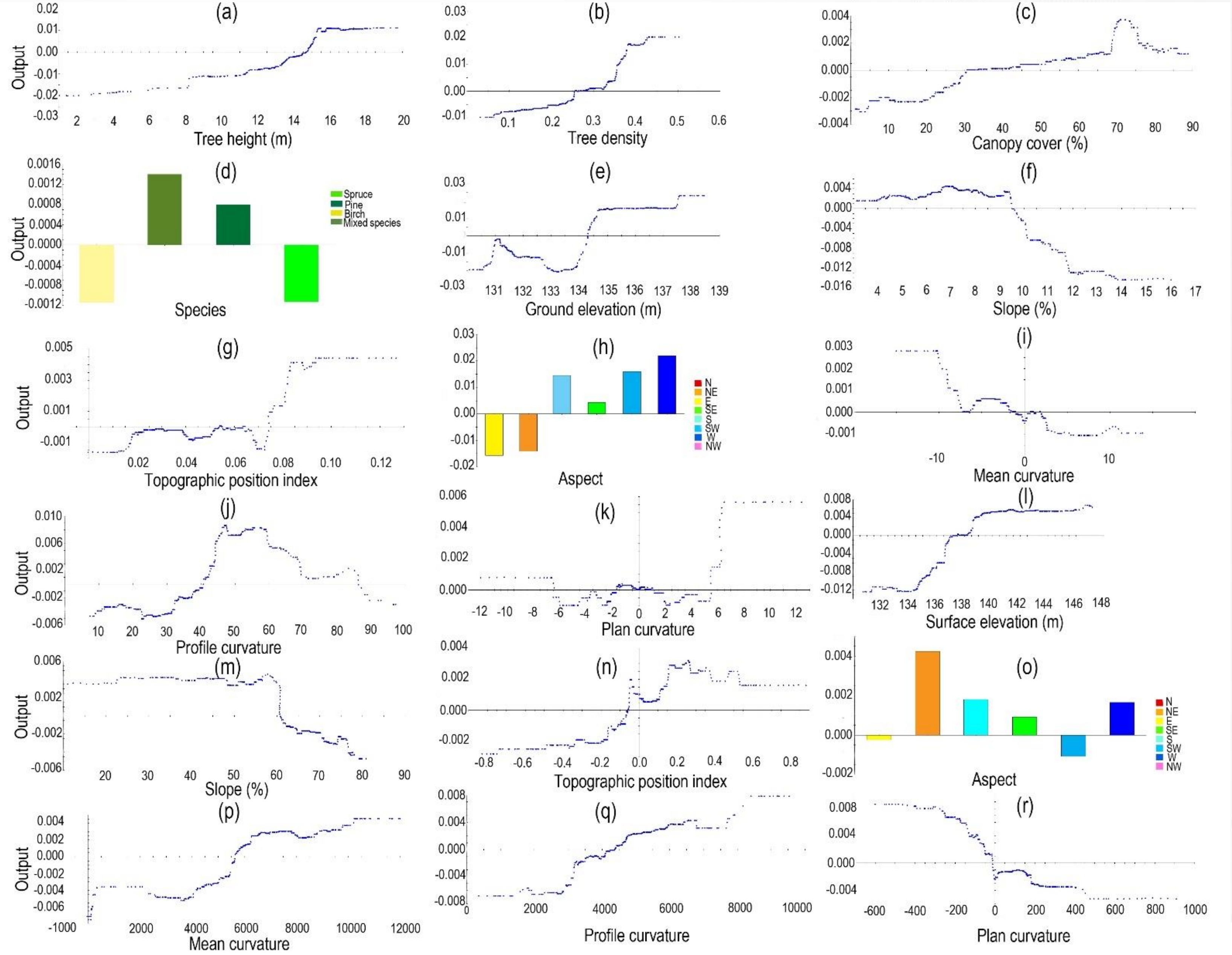


RESULTS
(EFFECTIVE FEATURES)

- The most important features, determining positioning accuracy, were **tree height**, **elevation** and **slope direction**
- A combination of features increased the positioning errors of the low-cost receiver

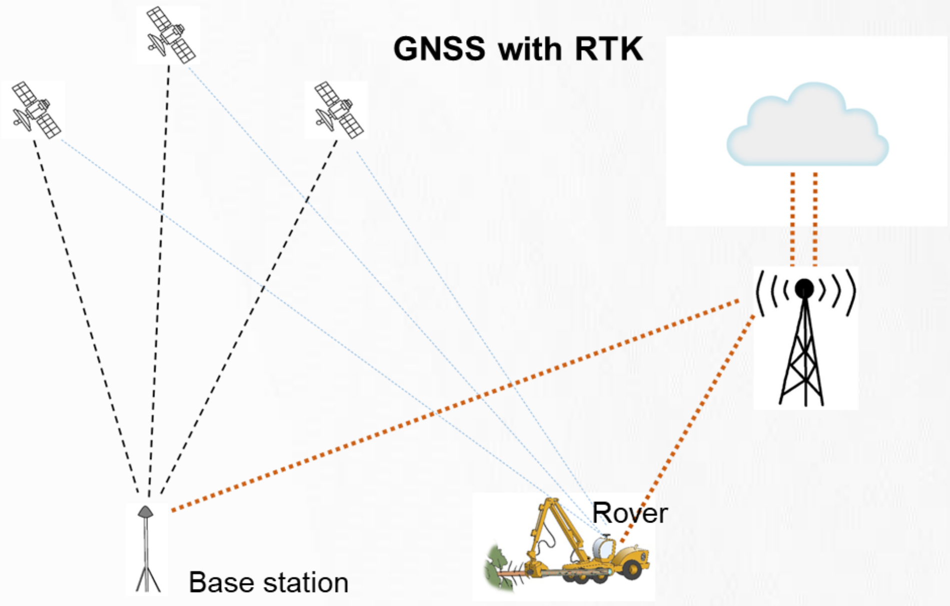


PD plots for features affecting the positioning accuracy of the u-blox



DISCUSION

- U-blox GNSS receiver showed reliable positioning accuracy (error= 43 cm)
- We did not have any problems with the satellite connections – however due to mobile connection problems RTK correction systems dropped out couple of times
- Our recent experiences from this summer confirms this – mobile connection problems seems to be the most vulnerable reason for precise positioning



DISCUSSION/CONCLUSIONS

- Our study site was not the most demanding environment for positioning – more tests is needed
- Testing the efficiency of other types of antennas is required to improve the positioning accuracy in the forest environment
- Forest vehicle robotization cannot entirely rely on GNSS systems – Fusing of data from other sources is required

Abdi, O.; Uusitalo, J.; Pietarinen, J.; Lajunen, A. Evaluation of Forest Features Determining GNSS Positioning Accuracy of a Novel Low-Cost, Mobile RTK System Using LiDAR and TreeNet. Remote Sens. 2022, 14, 2856.