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GVL Geospatial Ventures Ltd

satsense

Artificial Intelligence for Land Planning

Final Presentation
15-Nov-2024

Paul Bhatia: GVL Managing Director
Chris Hill: GVL Chief Engineer

Agenda

- **Welcome**
  O. Smeyers, NAVISP PNT Competitiveness Engineer, ESA
- **Project Introduction**
  H. Sobreira, Technical Officer, ESA
- **Project Implementation and Results**
  P. Bhatia, Managing Director, GVL; C. Hill, Chief Engineer, GVL
- **Questions and Answers**
  Moderator H. Sobreira, Technical Officer, ESA
- **Outlook and Next Events**
  O. Smeyers, NAVISP PNT Competitiveness Engineer, ESA

Welcome

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Project Introduction

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Artificial Intelligence for Land Planning

Project Implementation and Results

Paul Bhatia: GVL Managing Director
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About GVL

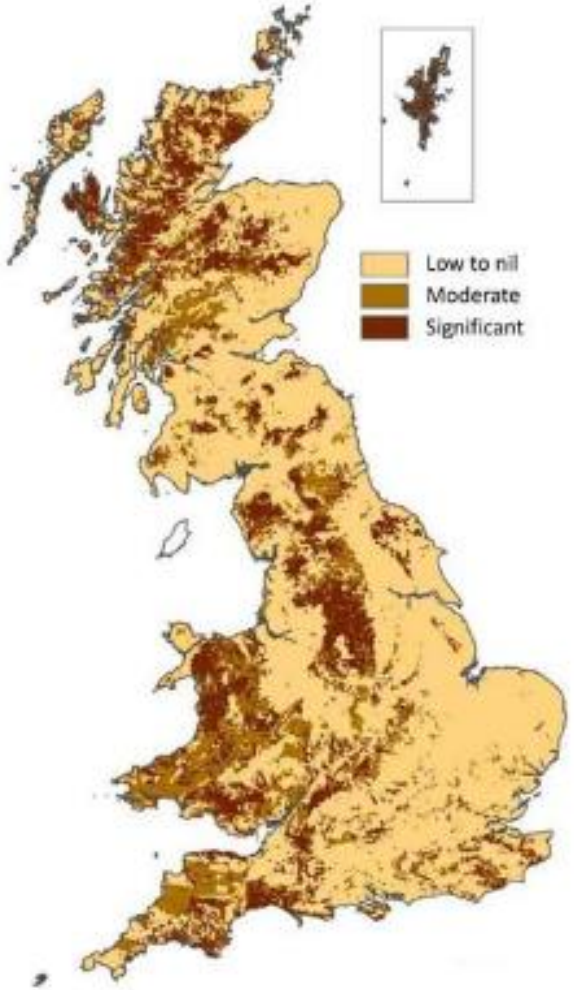
- We were formed in 2020 & we are based on the campus of the University of Nottingham
- We currently have a headcount of 9 and are growing year on year
- We use **geospatial technology** to solve r**eal-world** problems
- We are focused on developing and applying monitoring solutions for infrastructure and mobility
  - We use cost-effective high accuracy GNSS technology integrated with other sensors
  - We combine **GNSS** with **InSAR** to provide holistic **remote monitoring** services

We are based at the Sir Colin Campbell Building, University of Nottingham Innovation Park

Context and Rationale

Brownfield land planning & monitoring of new and ageing infrastructure as well as geohazards

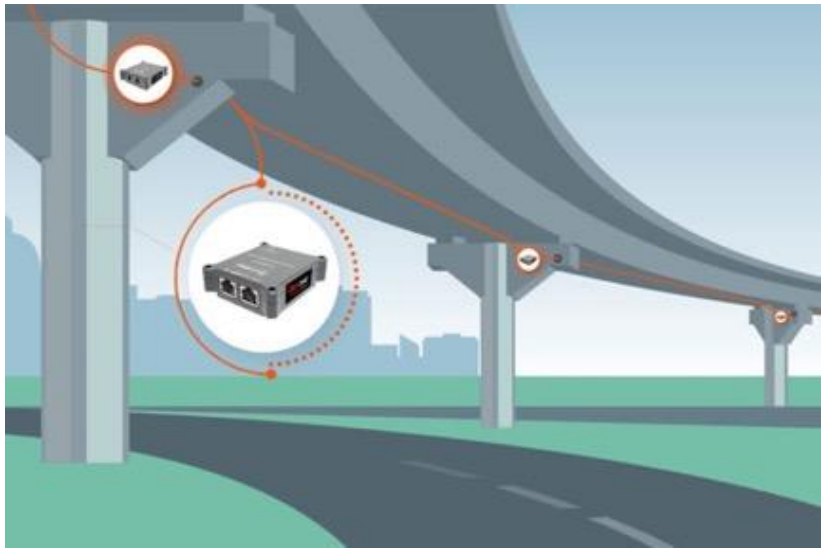
- 27,000 Ha of brownfield development land (CPRE)
- 97,000 km of roads
- 31,000 km of rail-track
- 86,458 bridges with 3,200 classified as substandard
- Landslides
- Earthquakes
- Peat Bogs



Landslide likelihood UK (BGS)
Office of Rail and Road UK

Context and Rationale

Artificial Intelligence for Land Planning



Structural Health and Condition Monitoring is required to:

- detect problems at an early stage
- enable a proactive response
- design cost-effective solutions
- optimise maintenance process
- avoid breakdowns
- boost the lifetime of structures
- improve design codes
- improve safety & save lives

Current systems are **expensive** and **in-appropriate** for most structures

Context and Rationale

AIPLAN combines a custom-built COTS-based GNSS receiver with InSAR technology, fine-tuned using AI and ML to deliver enhanced results – for Infrastructure and environmental monitoring.

- **Market Needs:**
  - Growing demand for accurate, cost-effective environmental and infrastructure monitoring
  - Mining, infrastructure, and agriculture
- **Technological Innovation:**
  - Leveraging GNSS and InSAR technologies, enhanced by AI and ML algorithms
  - High-accuracy monitoring that competes with more costly solutions, meeting industry standards for precision.
- **Strategic Advantage:**
  - All-terrain monitoring solution with scalability
  - Allows GVL to enter new markets and expand its product portfolio.
  - The integration of "GVL Tracking and Visualisation Platform" visualises data in real-time, offering clients actionable insights.

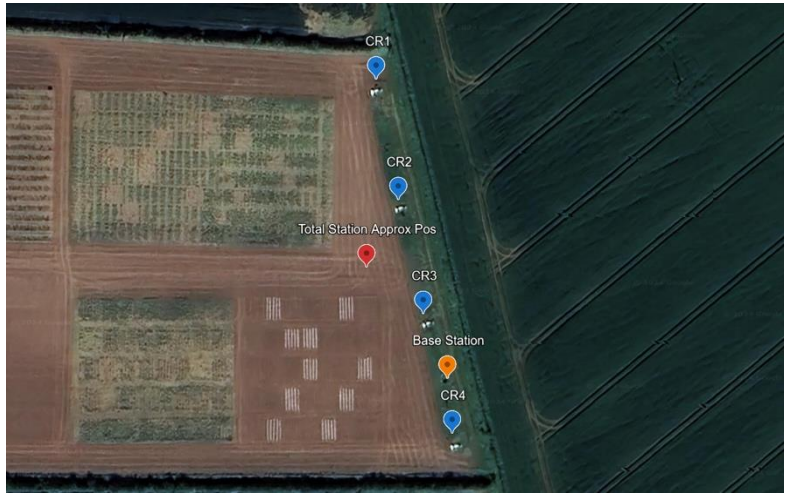
Developed under ESA's NAVISP program, the AIPLAN project enables GVL to apply space-based solutions to pressing earthbound challenges, aligning with ESA's vision of innovation and support for the European geospatial sector.

2-Project Outcome

Test and Development Sites

Leeds University ”Spen” Farm

- AIPLAN GNSS base-stations and rovers installed for test and calibration
- Dual InSAR corner reflectors installed for calibration
- Site surveyed regularly

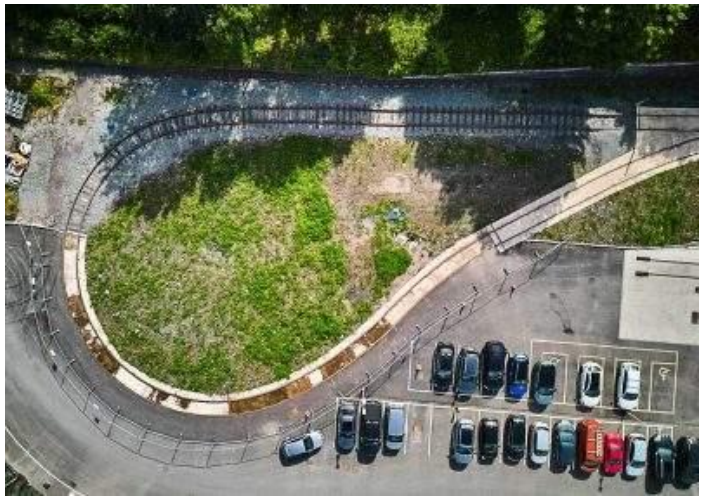


Snake Pass (A57)

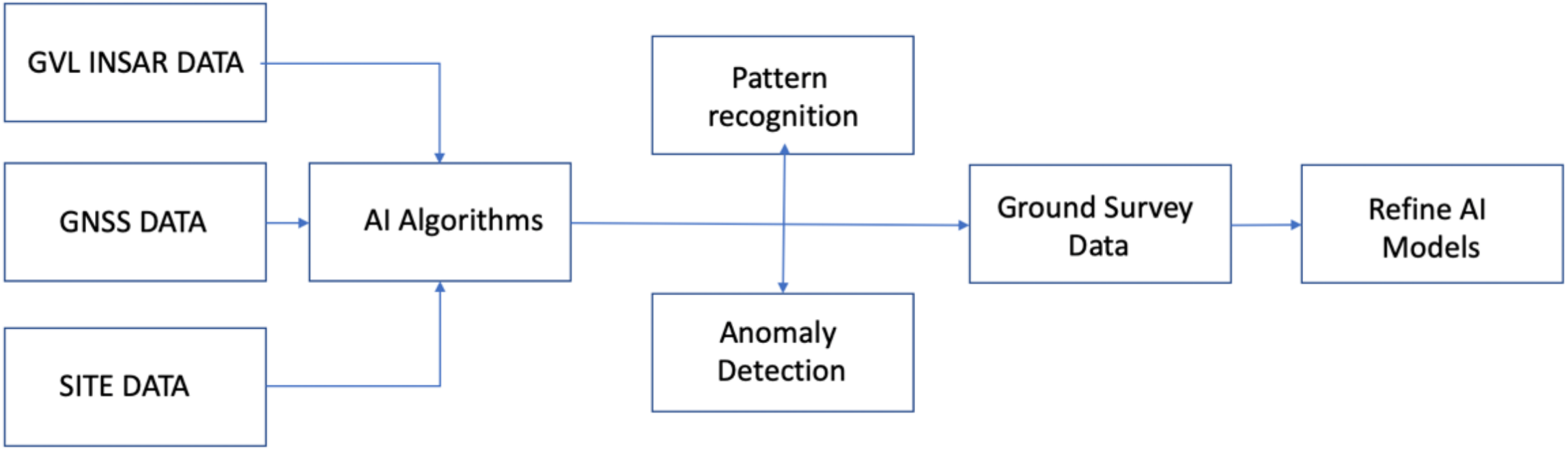
- AIPLAN GNSS base-stations and rovers installed for test and development
- Installation of InSAR Corner Reflectors
- Site surveyed regularly

Very Light Rail National Innovation Centre (VLRNIC)

- Client site for system trials
- New Infrastructure Development Site for Light Rail



System Architecture



- GNSS data collected via geodetic receivers & AIPLAN rovers
- Site data collected via traditional (theodolite/total station) surveys and site information data bases (known issues)
- InSAR point time-series collected via corner reflectors and natural reflectors
- All data is collected and input to the AIML system over the cloud for algorithm training
- Pattern recognition and anomaly detection are used to smooth errors in the data and provide algorithm training
- The AIML system(and AIPLAN subsystems) provide ground survey data

User and System Requirements

Hardware

- **Communication**: Devices must operate using cellular or Wifi.
- **Power**: Devices must function on battery power, recharge via solar power, with expected battery life of 24 hours.
- **Accuracy**: The system should achieve 1-5mm accuracy in plan, and 2-5mm in height.
- **Cost**: Low-cost GNSS modules must be used to keep hardware costs down.
- **Ruggedness**: Equipment must be waterproof and rugged to withstand challenging environments.
- **Daily Updates**: Devices must provide real-time updates with daily position reports.

User and System Requirements

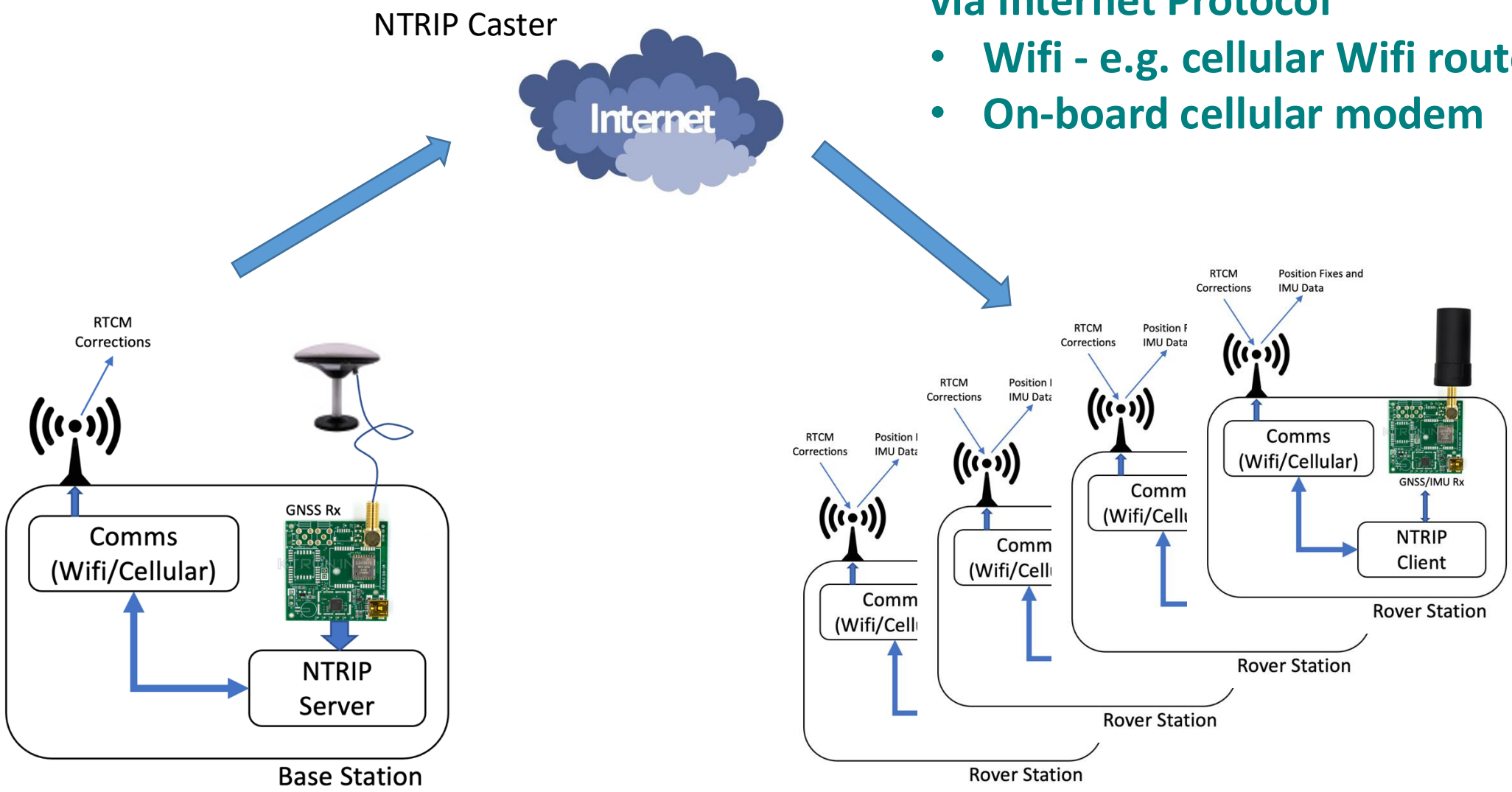
Software

- **Easy Configuration**: User-friendly, configure devices via mobile phones or laptop.
- **Autonomous Operation**: Devices must store configuration, reboot automatically without user intervention.
- **Remote Configuration**: Remote configuration using MQTT (Message Queuing Telemetry Transport).
- **Real-Time Reporting**: 1Hz position updates using MQTT for real-time tracking.
- **RTK and NTRIP Support**: The system must support RTK (Real-time Kinematic) positioning, with the firmware supporting NTRIP protocols for base stations (servers) and rover receivers (clients).
- **Data Storage and Visualisation**: A data pipeline connected to a MySQL database. Visualise receiver positions and status on a real-time web map, retrieve data for specified periods.

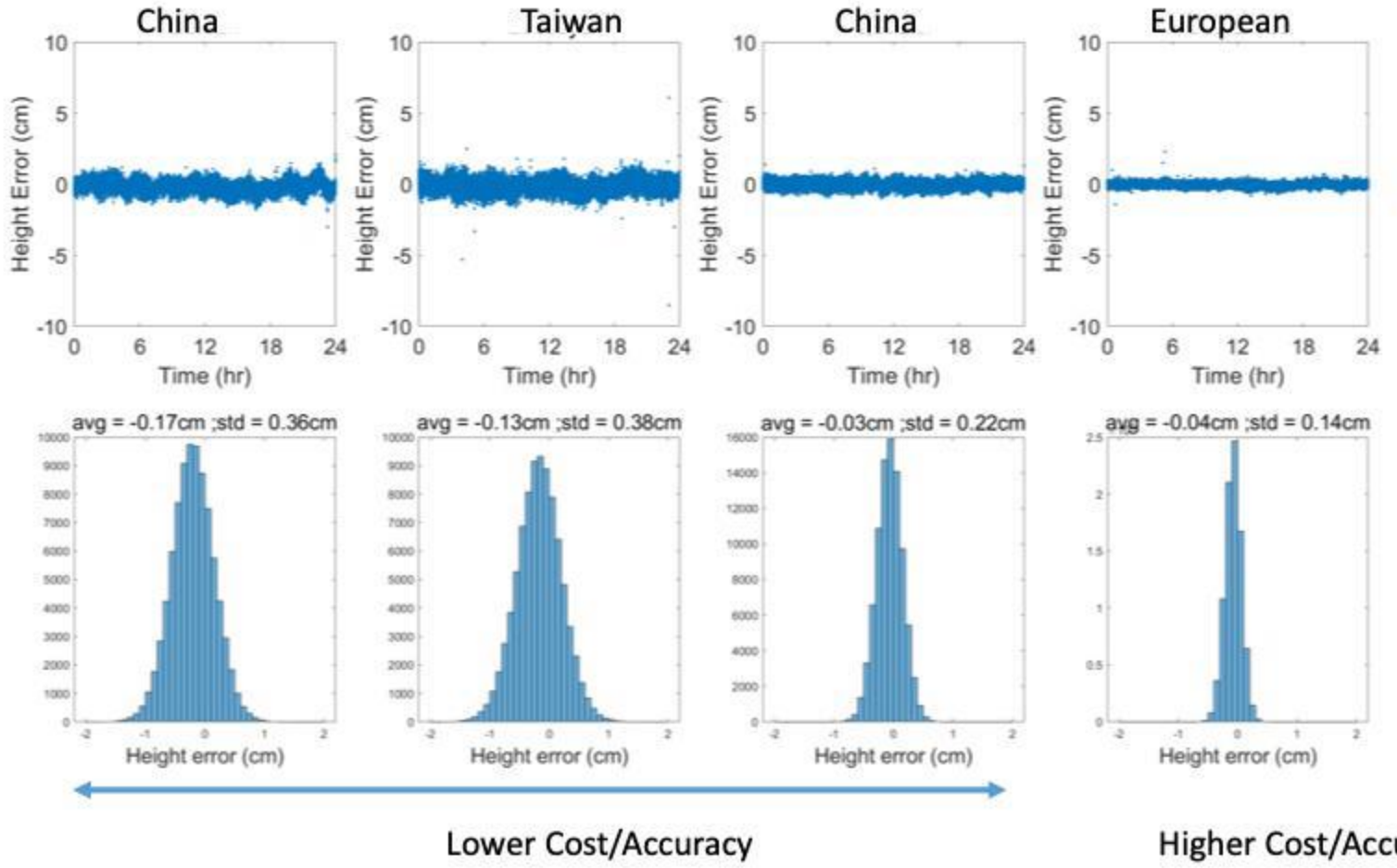
RTK Set-up

NTRIP: Networked Transport of RTCM via Internet Protocol

- Wifi - e.g. cellular Wifi router
- On-board cellular modem



GNSS Module Bench Testing



All modules L1/L5
Zero Baseline testing of raw data quality and positioning performance

Assessment also included feature comparison (e.g. configuration options)

On-Site Hardware

Hardware iteration

Internal battery: 5000mAh @ 3.7V

18Wh per 24 hrs using Wifi

Approx 2x energy when using cellular

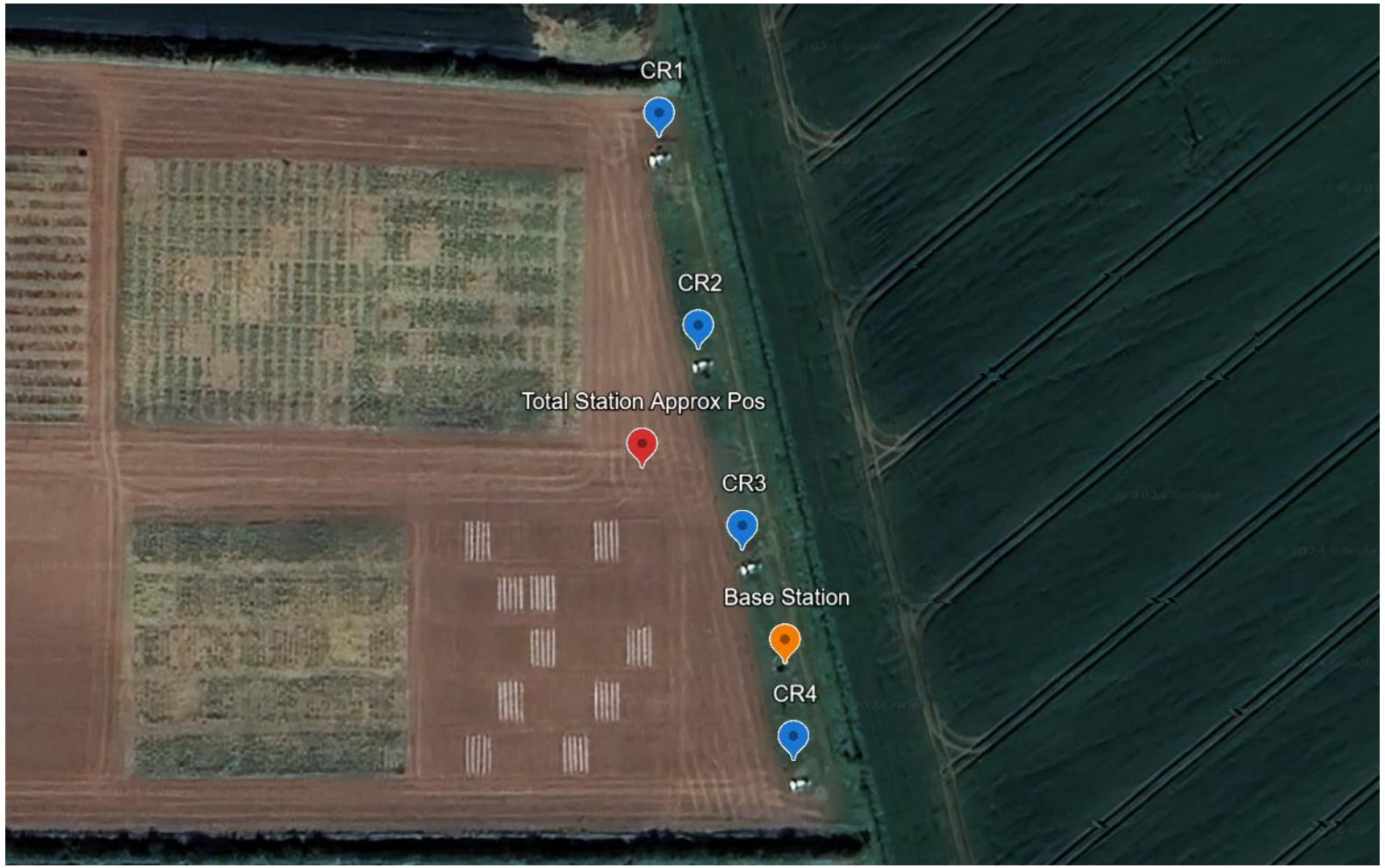
12V 6Ah LiFePO4 cells

MPPT Solar charge controllers with data logging

Solar Power + Waterproof Enclosure

30W solar panel

Trial Site – Spen Farm, Tadcaster, UK



Trial Site – Spen Farm, Tadcaster, UK

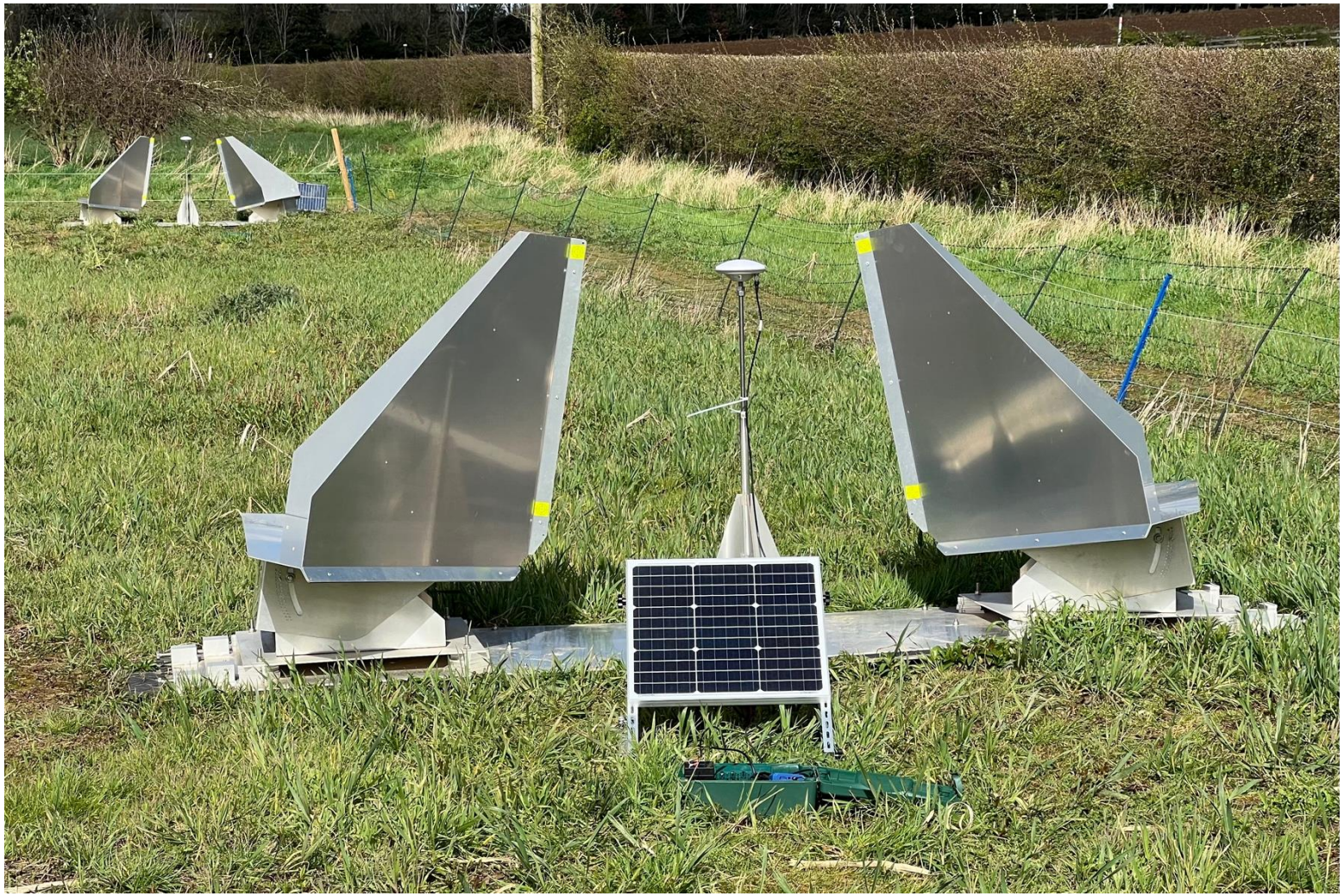
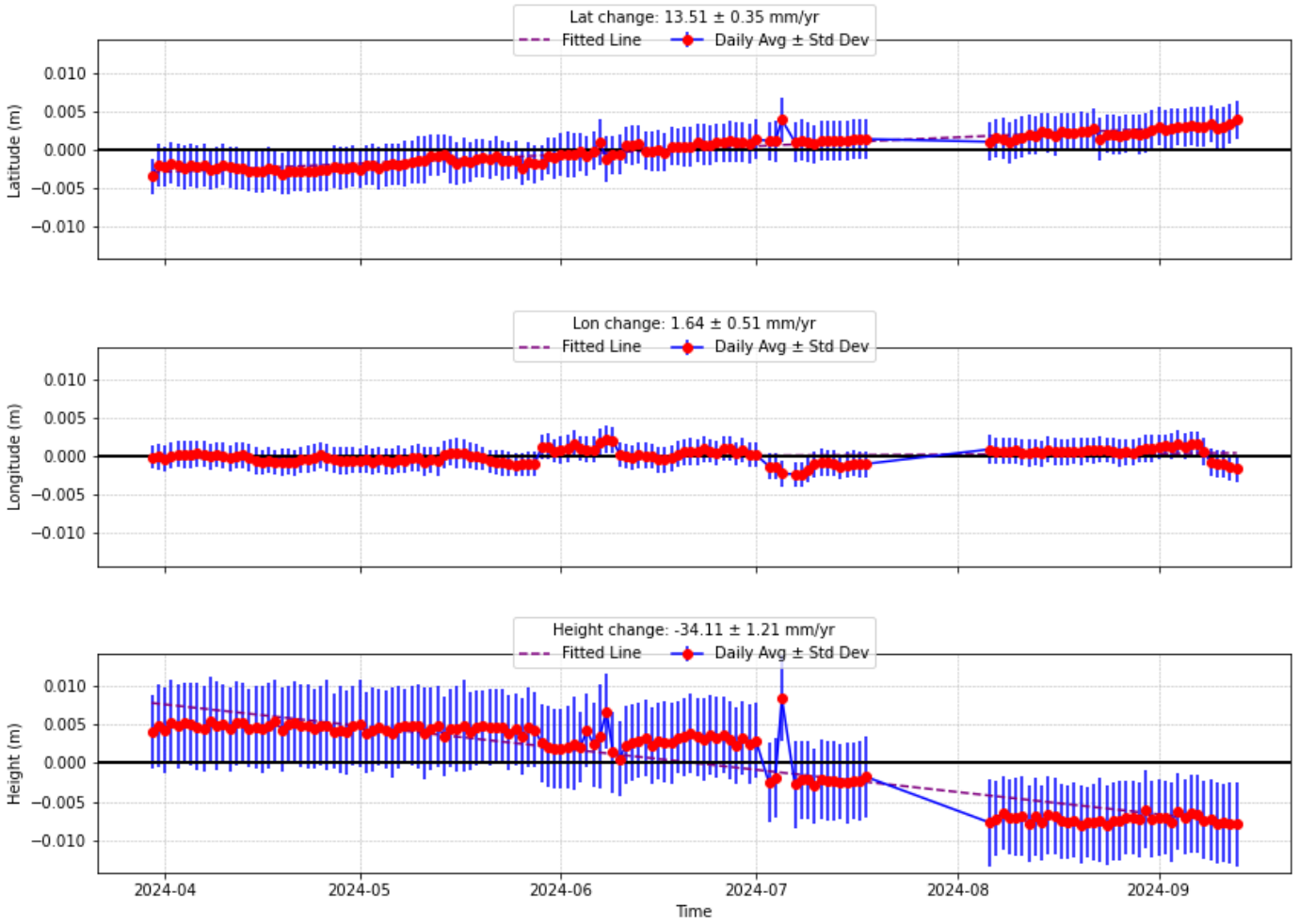


Photo shows CR2: Height adjustable via 5mm shims

GNSS Results @ Adjustable CR



Trial Site – Snake Pass, Derbyshire, UK

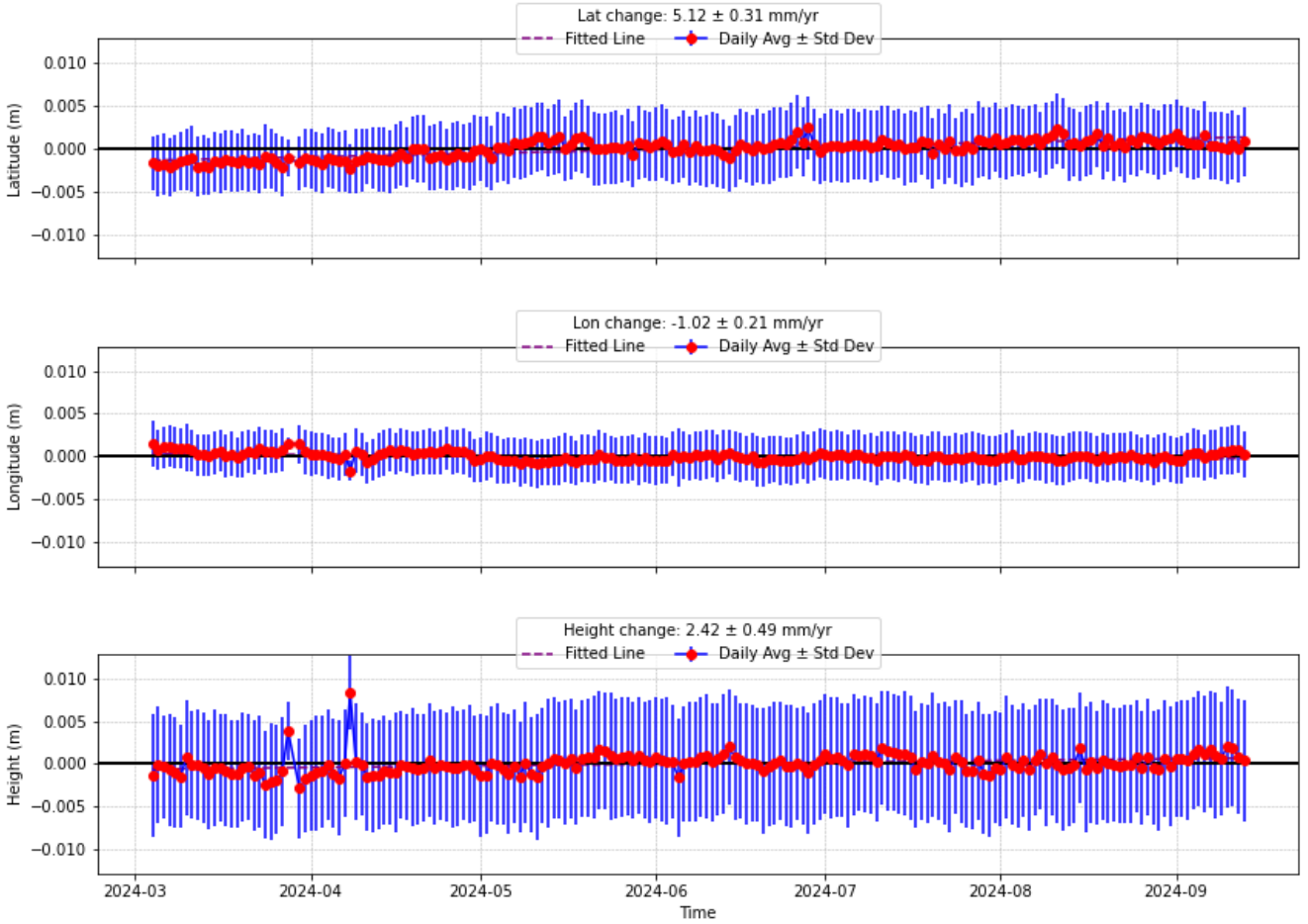
Interesting site due to continuous land movement
No stable point for Base Station - base and rovers expected to move

Snake Pass Hazards

Test Site – BCIMO, Dudley, UK

Trackside rovers monitoring possible movement of novel tram base

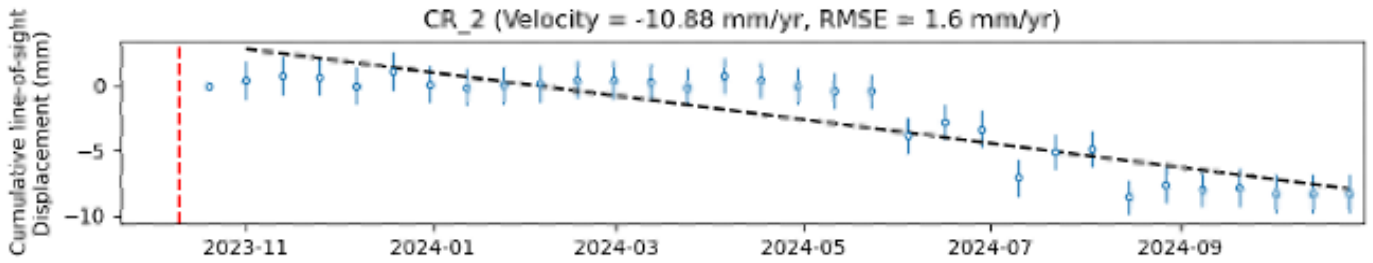
Test Site – BCIMO, Dudley, UK



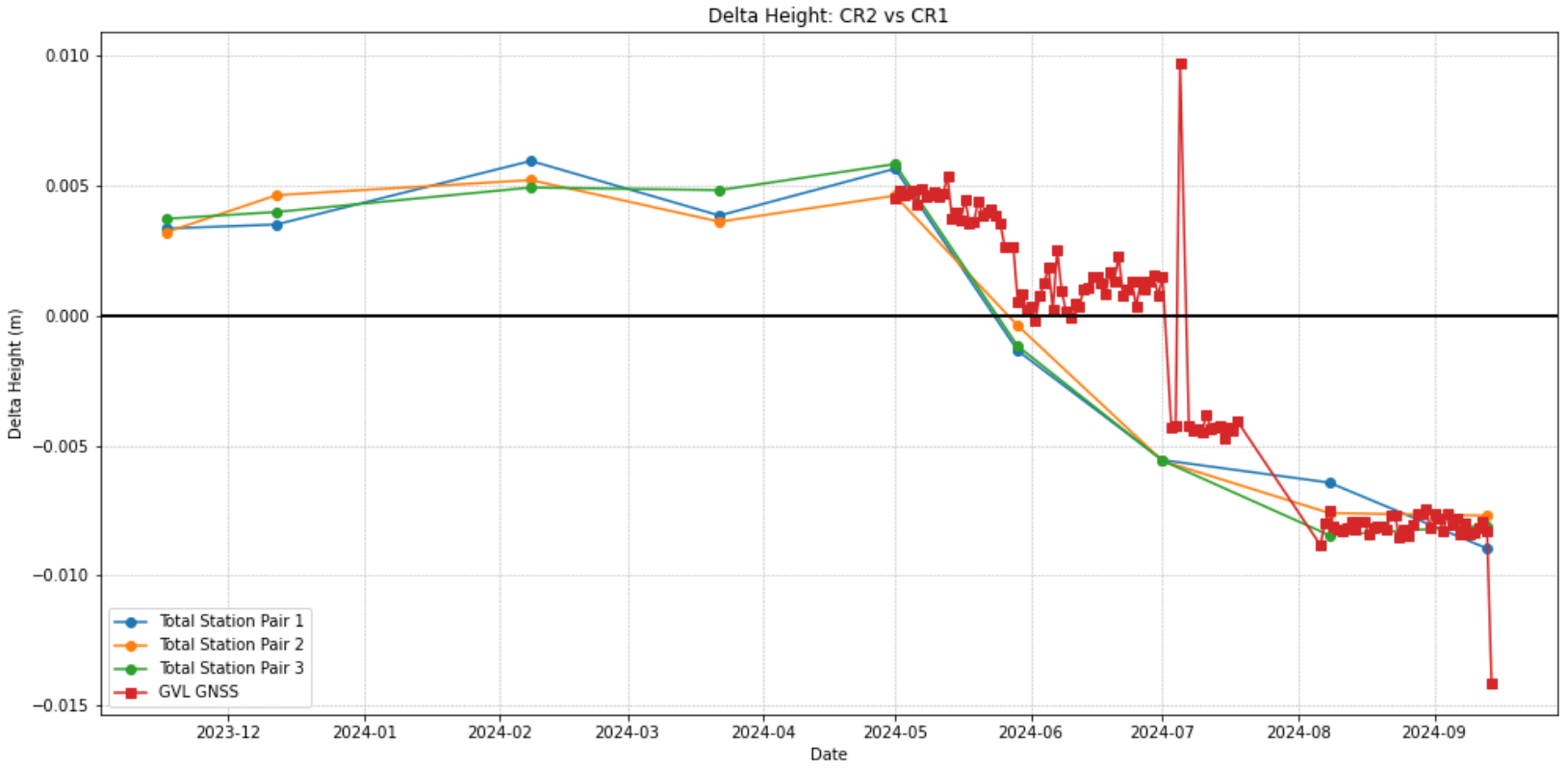
Comparison of GNSS, InSAR and Survey

Spen Farm, CR2 (adjustable)

InSAR LoS



Survey and GNSS height

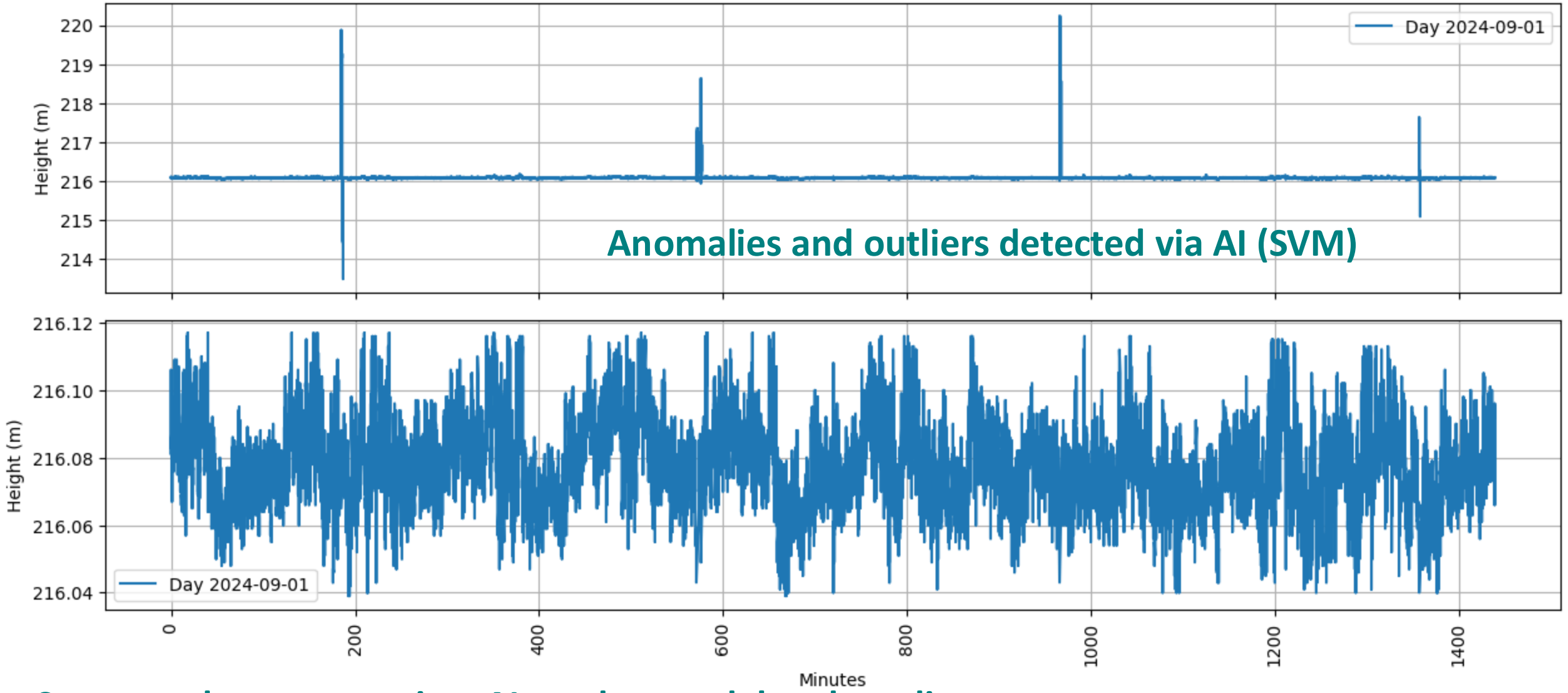


AI/ML Objective wrt GNSS

- AIPLAN trials data collected at 1Hz 24/7
- Multipath errors of ~4cm average to near-zero in 24 hours
    - daily repeatability ~2mm
- Averaging over shorter periods leaves a variable bias because satellite geometry with 4 constellations is complex

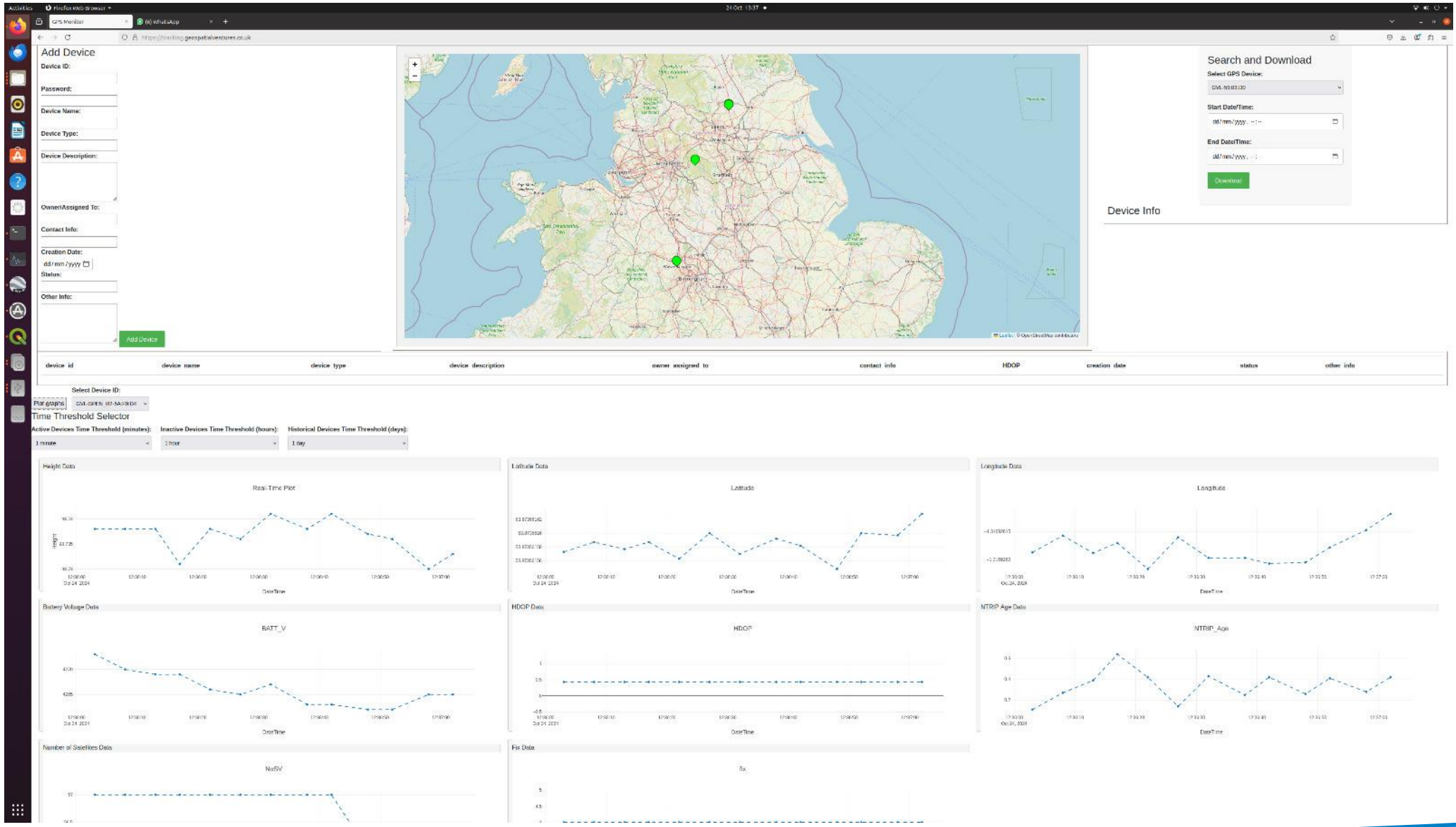
- Can we achieve equivalent performance with a reduced duty cycle?
    - e.g.
        - 50% (9WH) : 12hrs on/12hrs off
        - 25% (4.5Wh) : 6hrs on/18 hrs off
    - To allow smaller solar panel, smaller battery etc

AI/ML

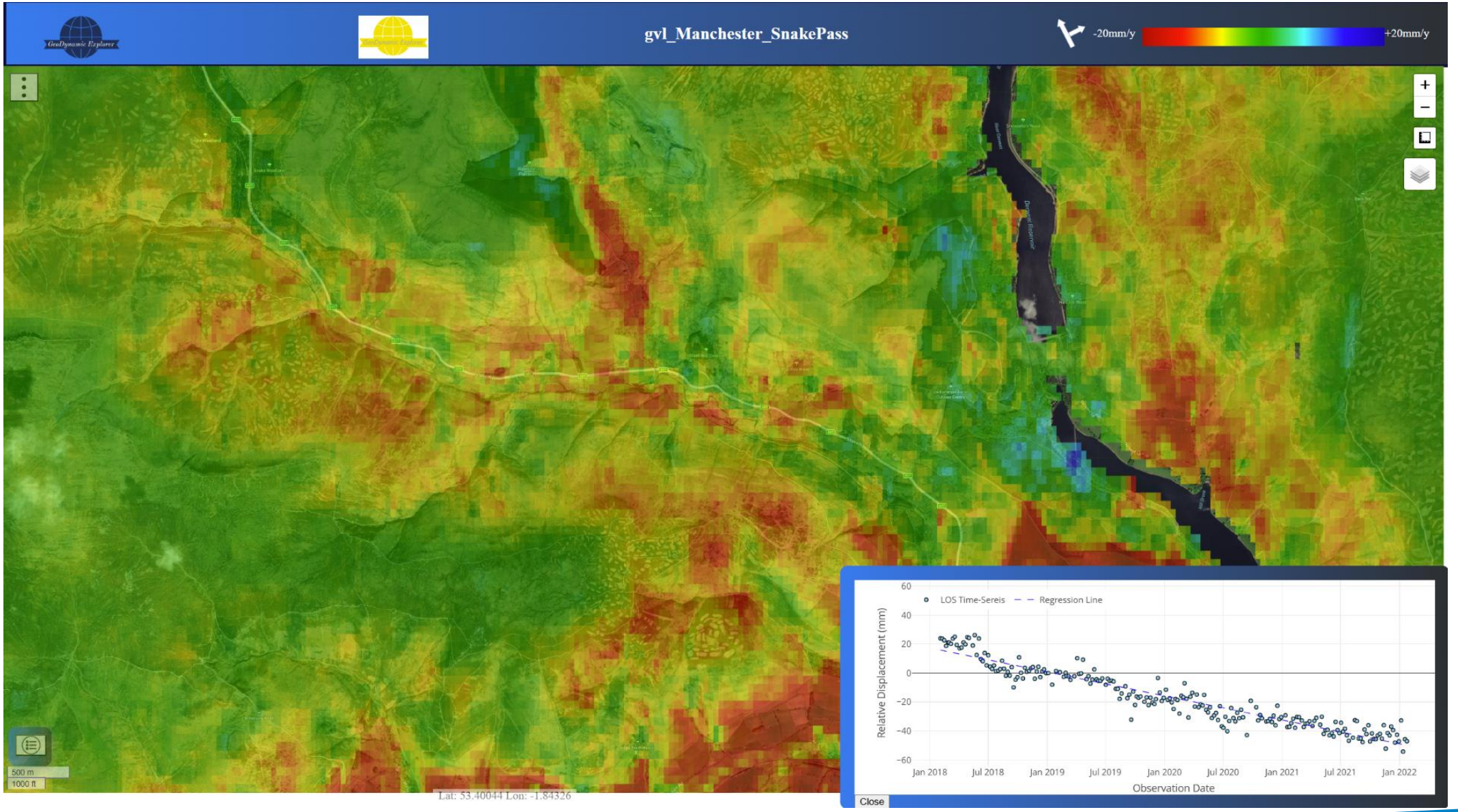


Structured errors remain – AI used to model and predict errors

GVL Tracking and Visualisation Platform



Correlated Time-Series Data



Conclusions

- A complete GNSS receiver setup has been developed and evaluated
  - based on COTS dual-frequency GNSS chipsets & associated componentry
  - PCB with bespoke firmware
  - bespoke Corner Reflector and combined GNSS antenna
- The system has been trained with live data collected in challenging and potentially hazardous scenarios & over many months
- The results show showed high accuracy (3-4mm) in both horizontal and vertical measurements
- The data can be correlated with site-specific data & can provide valuable insights
- The prototyped visualisation suite provides valuable time-series data for the monitoring points

Next Steps

- Continued trials on sites of interest
- Continued data collection to train and refine data sets
- Further R&D required:
  - For enhanced sensor integration
  - For improved GNSS performance
  - For enhanced GNSS and InSAR integration
- Further development required to improve visualisation
- Further investment required in order to bring products to the market and to commercialise

Benefits of working with ESA

- Invaluable support in technical and strategic aspects
- ESA's role in validating and endorsing GVL's technology
- Enhancing its credibility in the marketplace
- Facilitating partnerships with industry stakeholders.

Q&A

Moderator:
H. Sobreira, Technical Officer, ESA

Outlook and Next Events

O. Smeyers, NAVISP PNT
Competitiveness Engineer, ESA