# HAPPY MONITORING

“When the unthinkable becomes achievable, happiness fills you.”

# 1

## The beginning of a new era

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# Who we are?

Swiss developed

HAPPY MONITORING is a Swiss development solution by researching and creating our algorithm.

We are a team of experts in real-time 3D monitoring, and we help governments and companies to prevent accidents. Through dialogue and partnerships, we look for solutions that allow real added value for all monitoring projects. Thus, we contribute to a safer planet for all.

Official foundation of the company

**2015**

Start of algorithm development

**2017**

First installation in Switzerland

**2018**

First installation outside Europe

**2019**

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# The new era of monitoring

New GNSS measurement technology exists for geodetic monitoring applications (updated situation 2022)

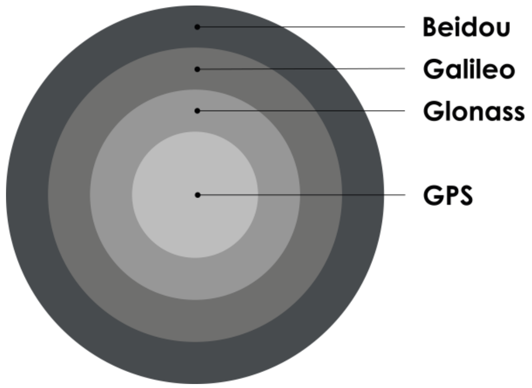
**GPS**
1991
31 SV
USA

**Glonass**
2002
24 SV
Russia

**Galileo**
2007
25 SV
Europe

**BeiDou**
2014
49 SV
China

**Standard sensors : NO GPS=NO FIX***

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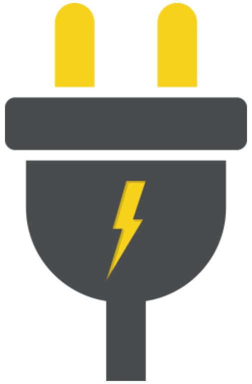
* In position fixing navigation, a position fix (PF) or simply a fix is a position derived from measuring in relation to external reference points.

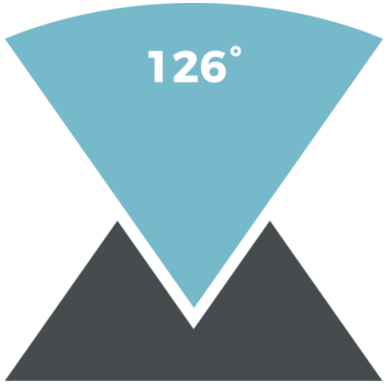
# Requirements

1. Power supply 12 V



2. 3G coverage


3. 70% open sky




4. Geologist

# How can we do that?

Only RTK-Coordinates used ( no raw-data registration )

Intelligent algorithm for Measurement corrections (incorrect values, etc.)

AI = Artificial Intelligence for continuously improvement of the algorithm by itself

High data transmission rate

**With the expansion of the four GNSS systems results will always get better**

# 2

## Project Hochvogel

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# Mt. Hochvogel 2592 m ü.M.

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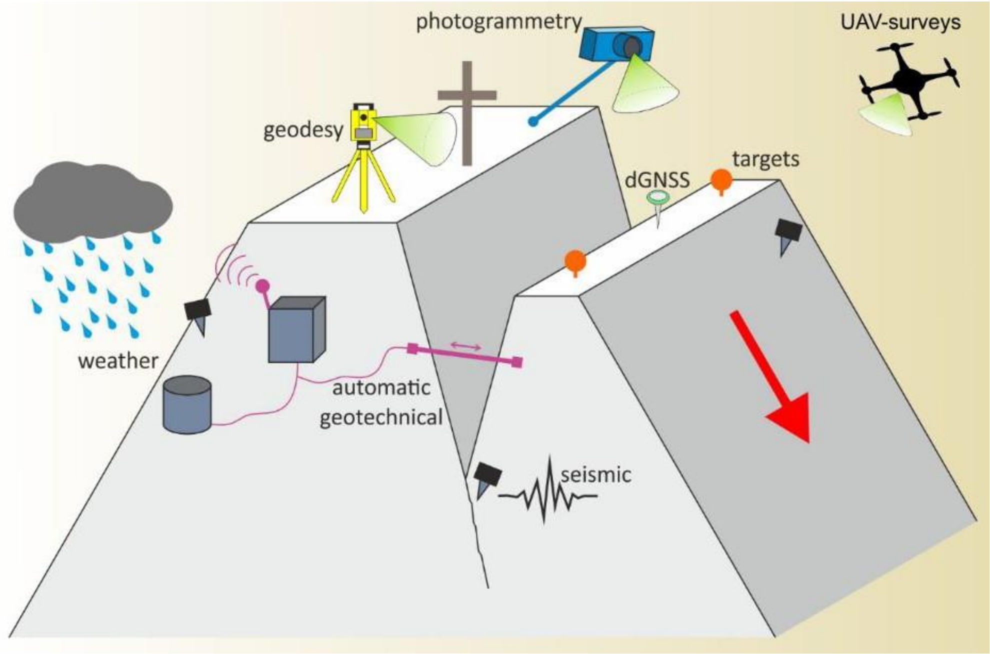
# Multi-Sensor System




**Evaluation of the achievable reliability and measurement accuracy of deformations**

**Periodic**
- GNSS
- Tacheometry
- 3d Laser scanning
- Photogrammetry (terrestrial & airborne)
- Gravimetry

**Continuous**
- GNSS HAPPY MONITORING
- Crackmeters
- Laser range finder
- Seismometers
- Meteorology

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# GNSS Monitoring


- Permanent monitoring system based on RTK-GNSS
- Quasi real-time capable
- Improved accuracy by smoothing over a specified time interval
- Adaptive smoothing algorithm to determine a more precise weighted, filtered mean value

**What accuracy can be achieved?**

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Chair of Engineering Geodesy
TUM School of Engineering and Design
Technical University of Munich

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# Genauigkeitsuntersuchung eines neuartigen GNSS-Monitoringsystems für das Geomonitoring am Hochvogel

Lukas Raffl

René Schnider

Christoph Holst

**Technical University of Munich**

TUM School of Engineering and Design

Chair of Engineering Geodesy

3rd March 2022

# Accuracy evaluation

## What accuracy can be achieved?

a. Achievable coordinate precision of stationary rovers
b. Absolute distance accuracy between two rovers
c. Achievable measurement accuracy of deformations

## Dependency on the

- Baseline length
- Length of the evaluation window

## Various measurement series to evaluate a, b, c

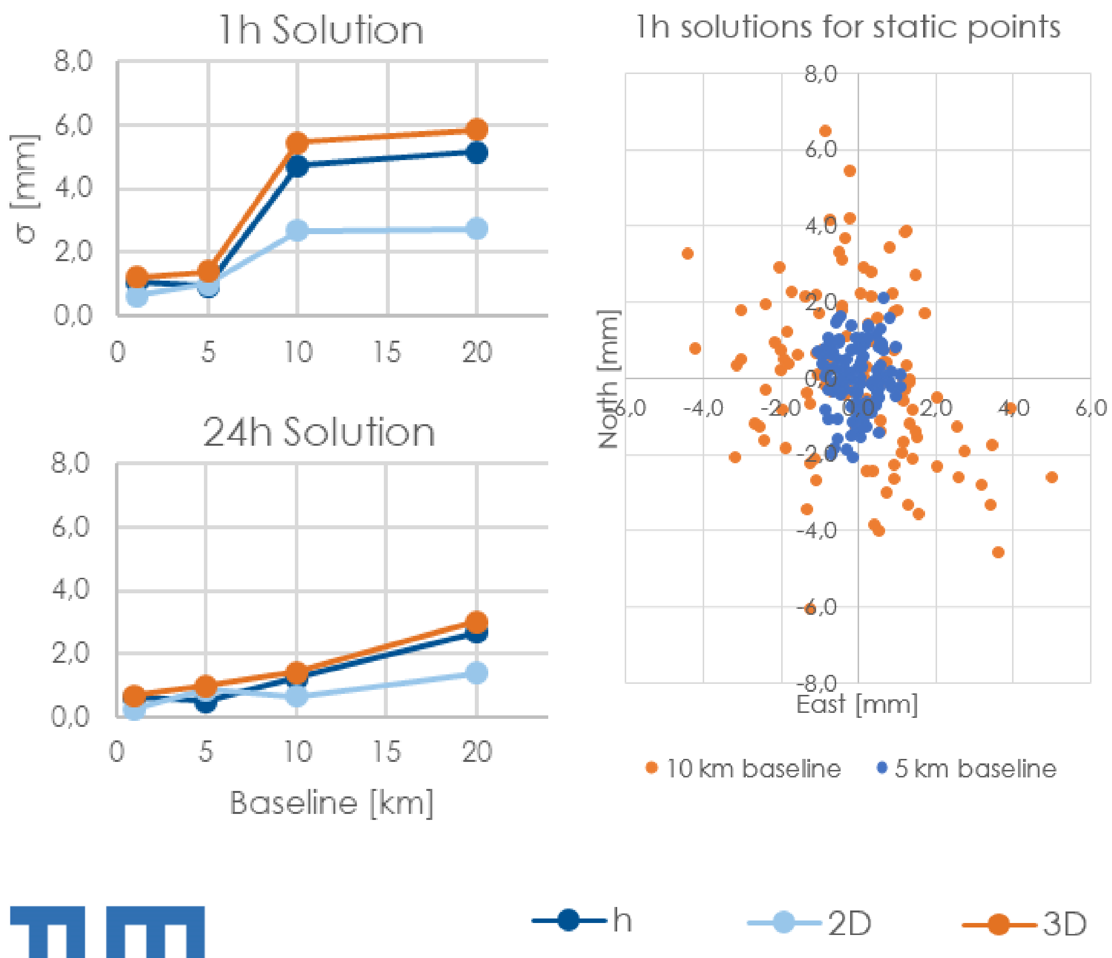
- Nov. 2020 – Feb. 2021
- Cold temperatures
- 1 base station, 2 rovers
- Ideal environment: free line of sight

# a. Achievable coordinate precision of stationary rovers

- Rover is mounted stationary on a fixed point
- Different baseline lengths
- Observation time: 6 to 23 days
- Variation of the evaluation window
- Precision = standard deviation (1**σ**) of the mean

| Baseline (km) | | | |
|---|---|---|---|
| 1 | 5 | 10 | 20 |

| Evaluation window (h) | | | | |
|---|---|---|---|---|
| 1 | 3 | 6 | 12 | 24 |

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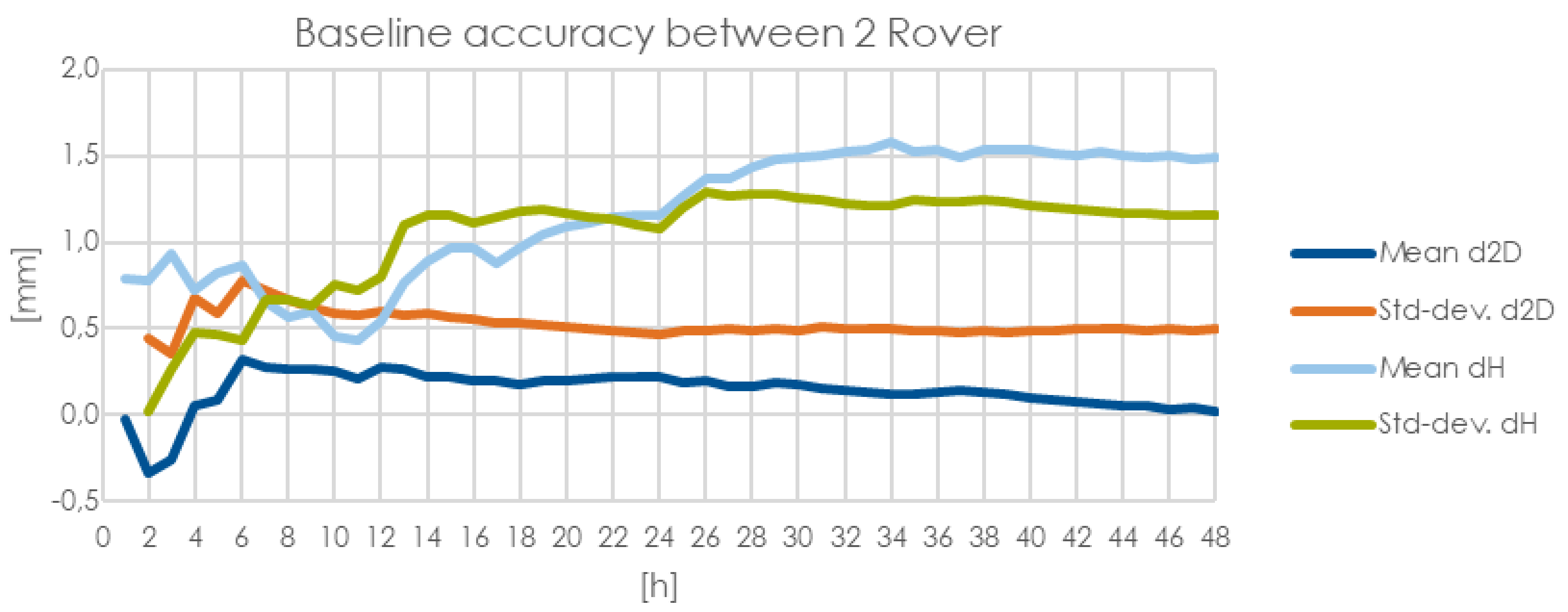
# b. Distance accuracy between two rovers

- Measurement on a known reference line
- 2 stationary rovers
- Distance to the base station: 1 km
- 38 days

| Reference | Nominal value | Std.-Dev. σ |
|---|---|---|
| Horiz. Dist. | 101.2373 m | 0.0001 m |
| Height Diff. | - 0.0068 m | 0.0005 m |

# b. Distance accuracy between two rovers

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# b. Distance accuracy between two rovers

| Base 1 km | Nominal value | Measured value | Difference | Std.-Dev. σ |
|---|---|---|---|---|
| Horiz. Dist. | 101.2373 m | 101.2372 m | 0.0001 m | 0.0002 m |
| Height Diff. | - 0.0068 m | -0.0079 m | 0.0011 m | 0.0007 m |

| Base 10 km | Nominal value | Measured value | Difference | Std.-Dev. σ |
|---|---|---|---|---|
| Horiz. Dist. | 101.2373 m | 101.2351 m | 0.0022 m | 0.0008 m |
| Height Diff. | - 0.0068 m | -0.0058 m | - 0.0010 m | 0.0021 m |

# c. Achievable measurement accuracy of deformations

- Base station is moved using a compound slide and a height screw
- Nominal displacements can be adjusted with an accuracy < 0.1 mm
- Same displacement should be measured at both rovers
- Measurement of the nominal displacement direction

**Hight screw**

**Compound slide**


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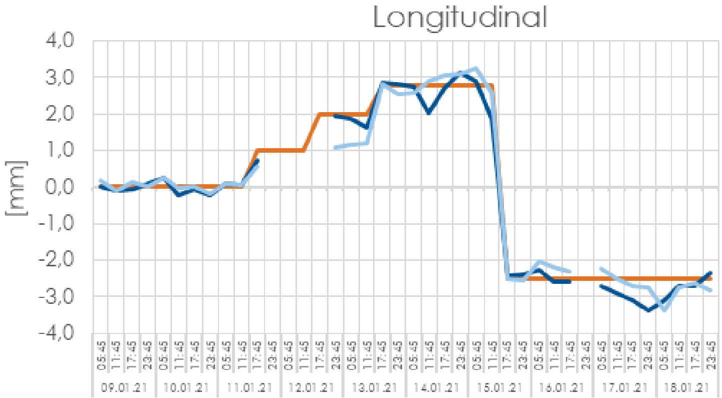
# c. Achievable measurement accuracy of deformations

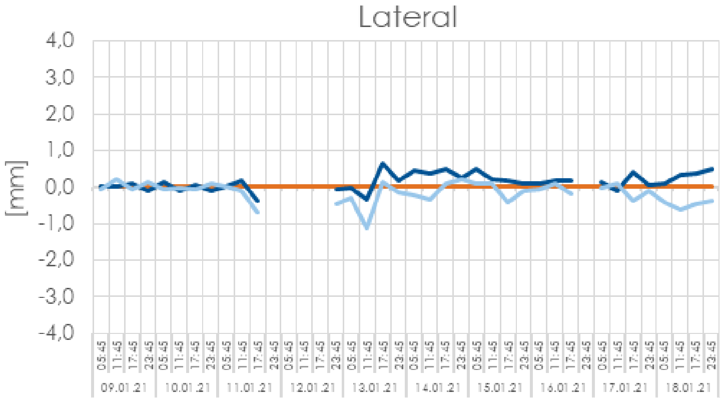
- For 3 days: ever 24 h move 1 mm in plane and 1 mm in height
- 1 day rest
- 5th day: move in opposite direction by 5.5 mm in plane and 5 mm in height
- Measurement failure at the base between 11.01.21 and 12.01.21
- 6 h solutions

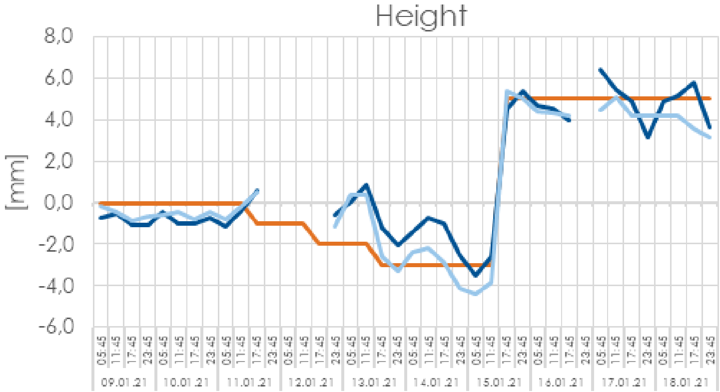
**Average residuals**

Plane: 0,3 mm ± 0,3 mm

Height: 0,9 mm ± 0,6 mm

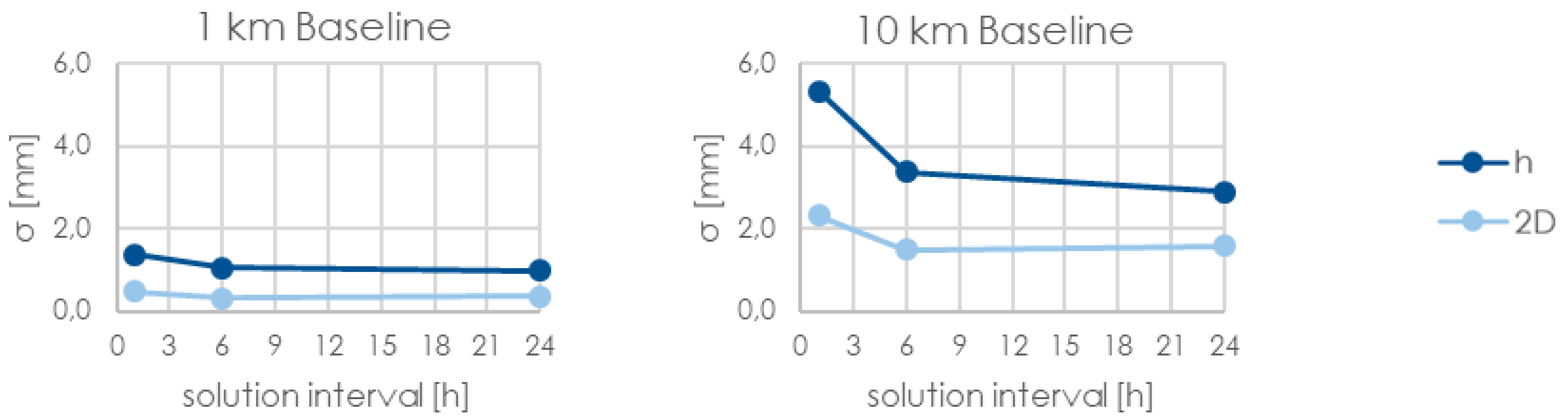



Reference
Rover 1
Rover 2

# c. Achievable measurement accuracy of deformations

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# Application on Mt. Hochvogel

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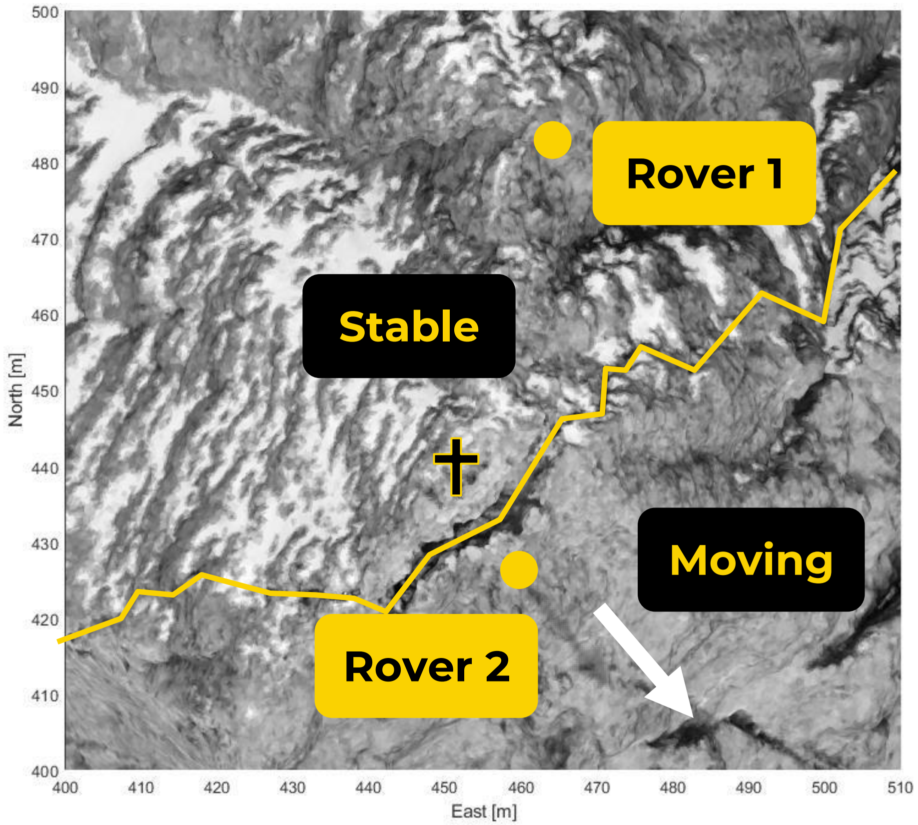
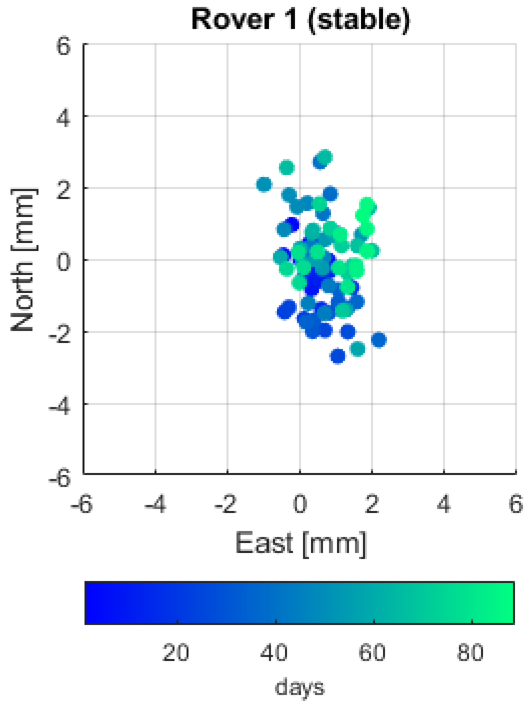
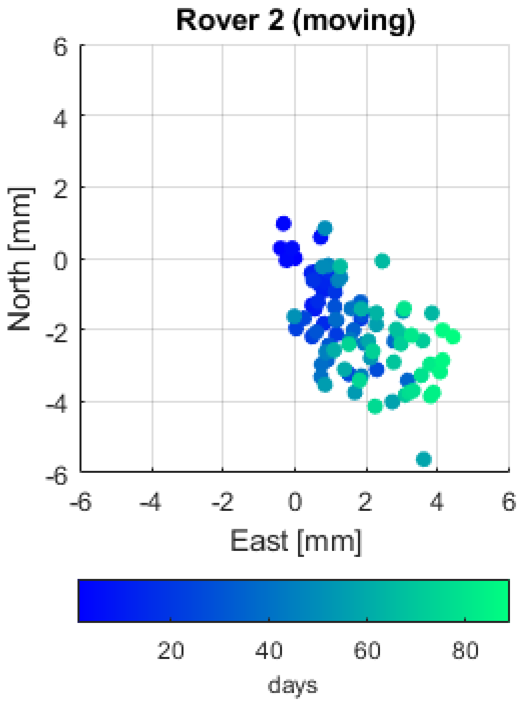
# Landslide monitoring at Hochvogel

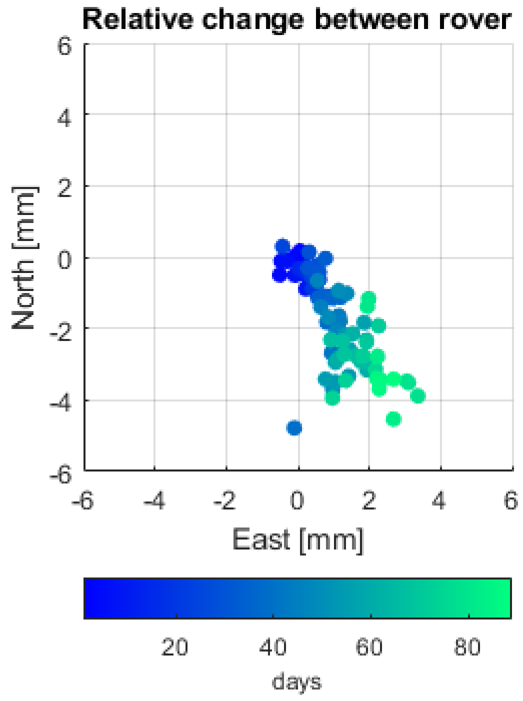
D = 5370m
Δh = 1425m



# Rover Positions (2d) – 48 h solutions

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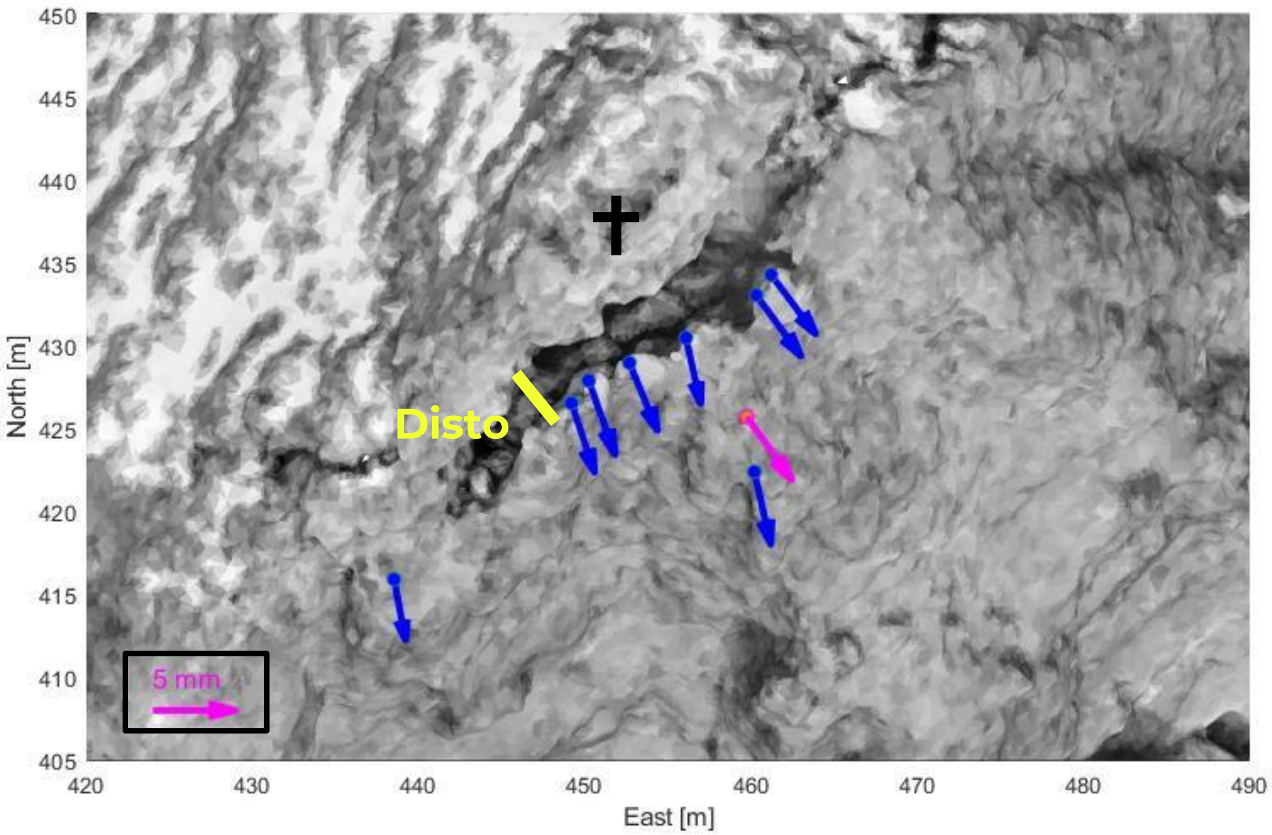
23.07.2021 – 18.10.2021 (89 days)

# Comparison to network measurements

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# Conclusion and Outlook

RTK-based permanent monitoring system

Increasing accuracy by averaging within evaluation window

Accuracy depending on length of baseline and length of evaluation window

For short baselines (1-2 km) and an evaluation window of 1 day coordinate accuracies below 1 mm could be reached. This was achieved for both, the static and the non-static (displacements) case

Also usable in challenging environments like Mt. Hochvogel

Longer time series on Mt. Hochvogel should allow more analyses on the precision and accuracy

# 3

## Some cases of interest

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# Landslide monitoring in Zermatt

**Zermatt:** Various landslides around Zermatt


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# Landslide monitoring in Zermatt

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# Landslide monitoring in Zermatt

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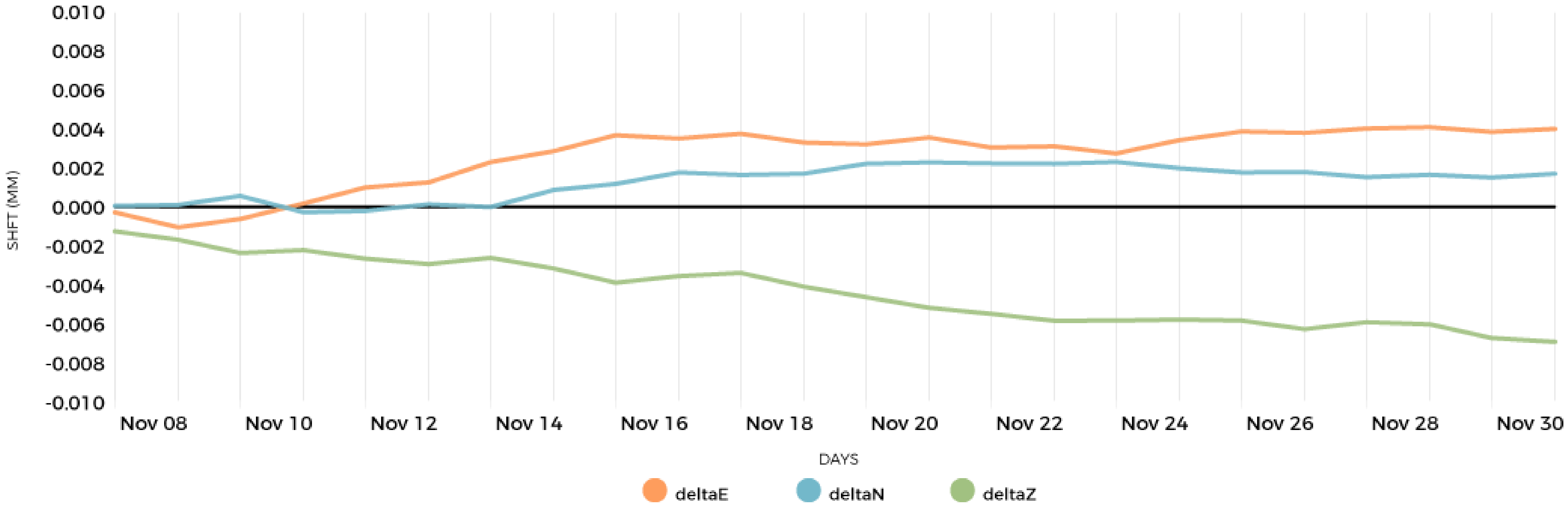
# Zermatt, graphic analysis

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# Aurachbrücke bridge monitoring


**Aurachbrücke:** A bridge needs to be renovated!

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# Aurachbrücke bridge monitoring

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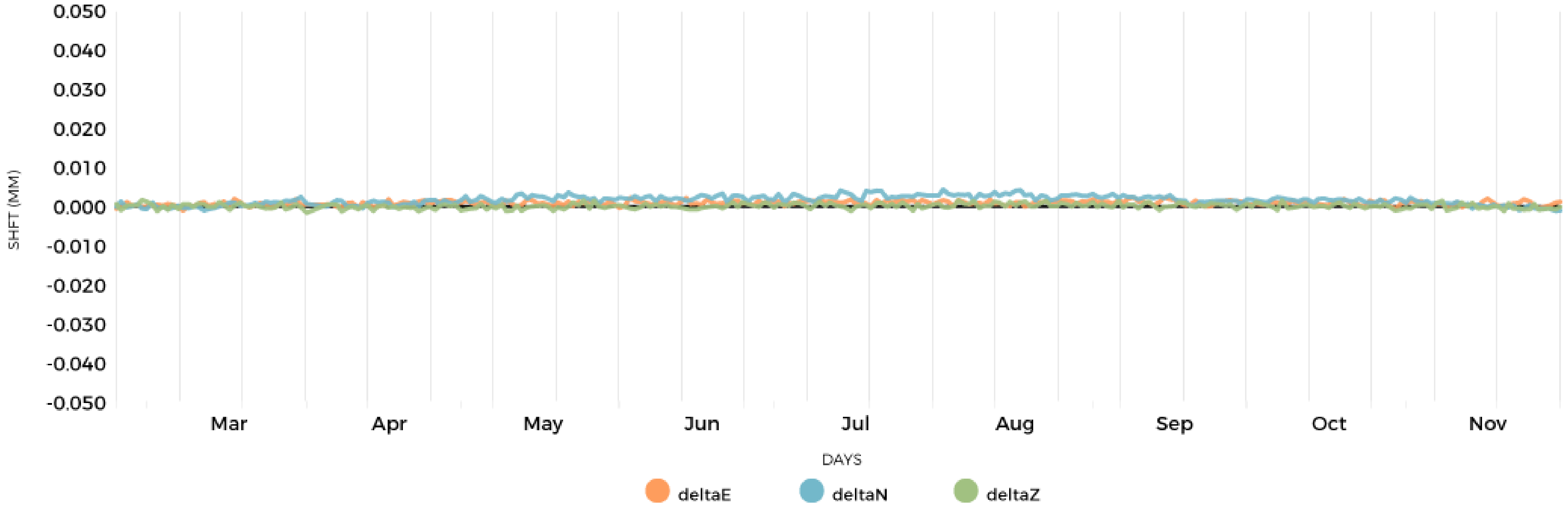
# Aurachbrücke, graphic analysis

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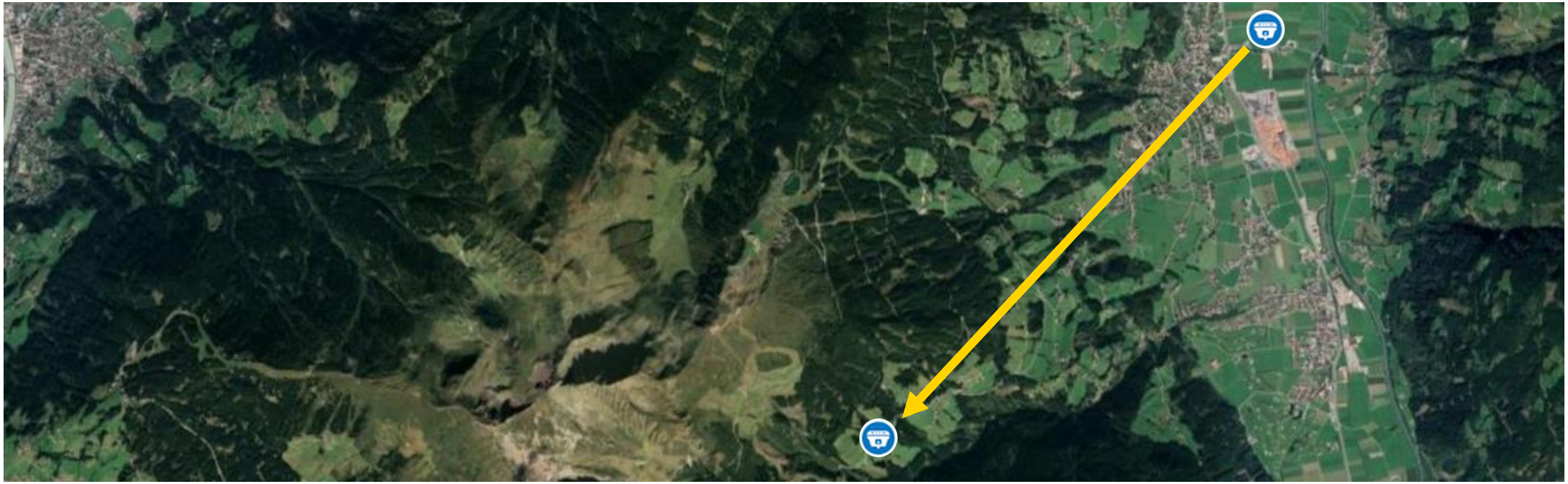
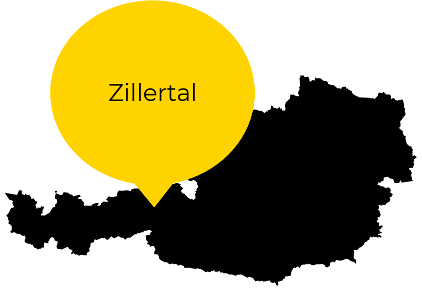
# Dam monitoring in Zillertal



**Zillertal:** How do you measure deformations on creek dams in a narrow valley?



# Dam monitoring in Zillertal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# Subsidence monitoring in Jakarta

**Jakarta:** The difficulty is the distance from the control point to the coast: up to 50km, the accuracy in height is approx. +/- 1.5mm with 48h evaluations


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# Subsidence monitoring in Jakarta

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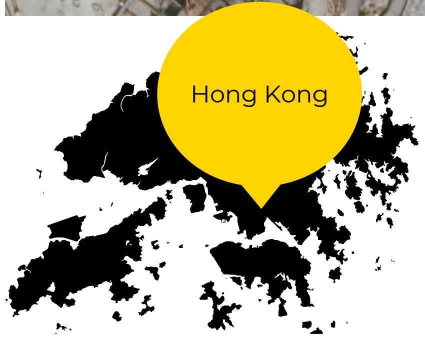
# Trunk road monitoring in Hong Kong




**Hong Kong:** Measure the impact of the bridge during maintenance work (12 sensors provide +/-1mm data 24 hours a day)

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# Trunk road monitoring in Hong Kong


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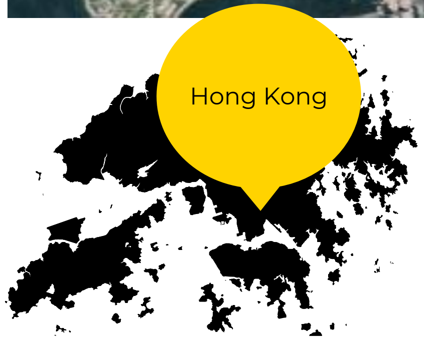
# Breakwater monitoring in Hong Kong




**Hong Kong:** Measure the impact of the seawall during tunnel construction in the underground with millimeter accuracy (5 sensors provide +/-1mm data 24 hours a day)

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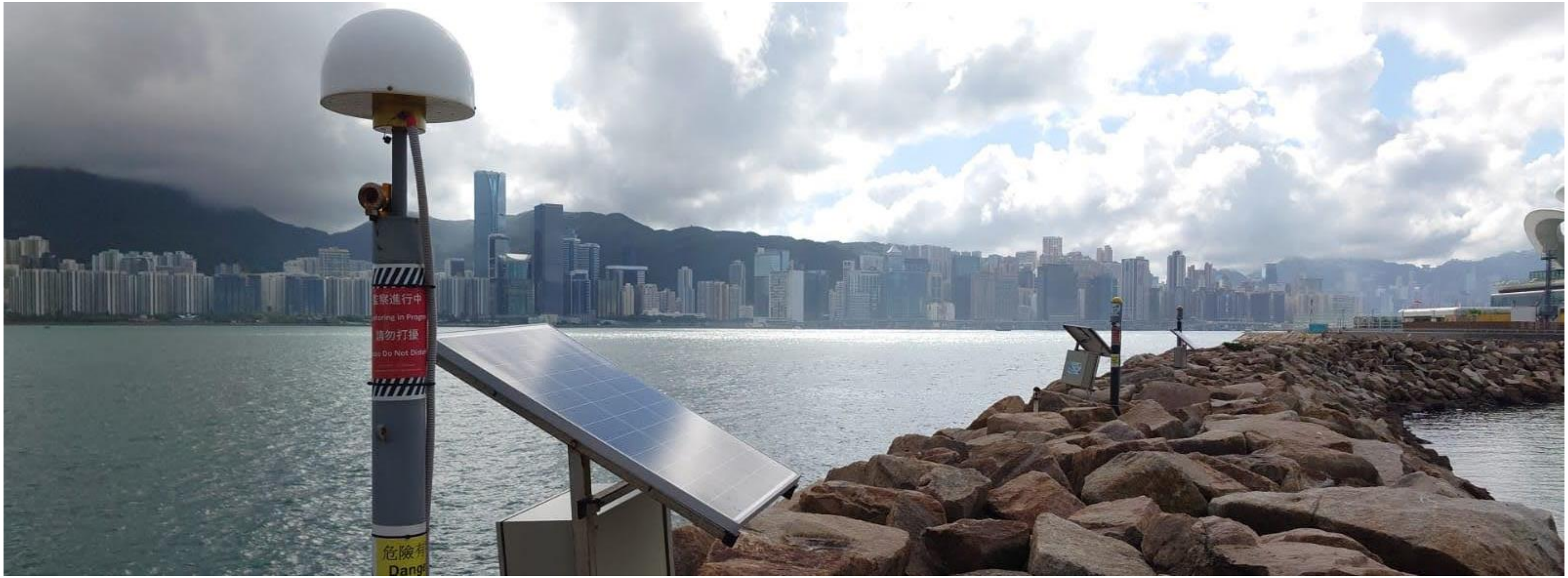
# Breakwater monitoring in Hong Kong

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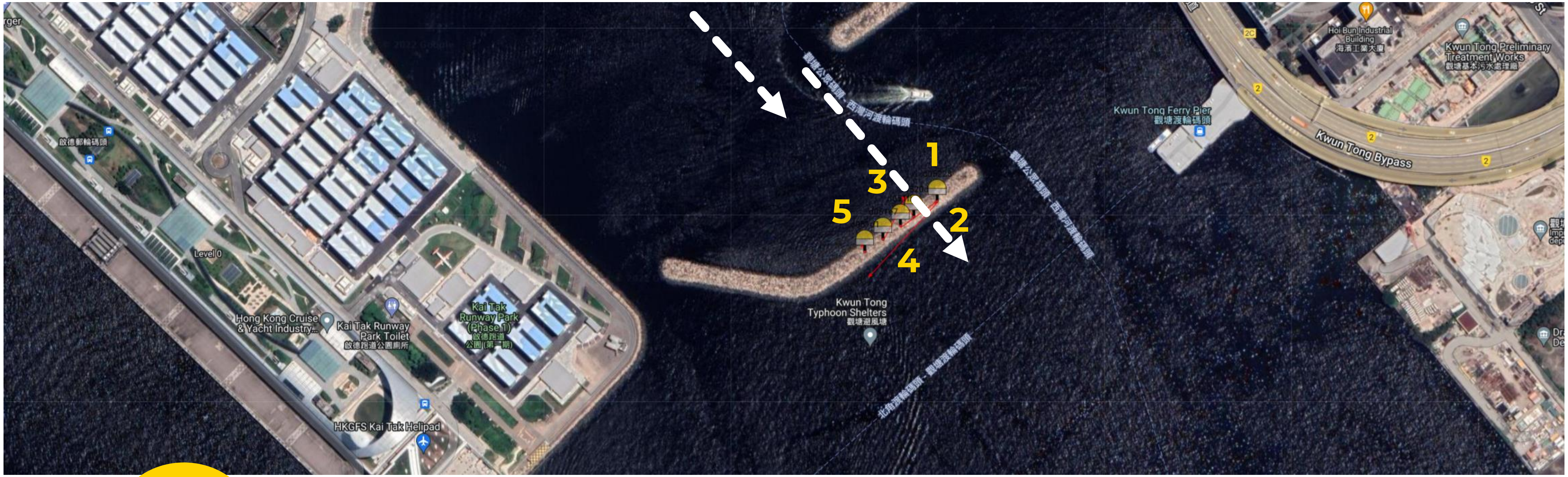
# Breakwater monitoring in Hong Kong





**Hong Kong:** Seewall

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# Contact

**René Schnider** – rene.schnider@happymonitoring.com

**www.happymonitoring.com**

**www.happysurvey.ch**

# Thank you!

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