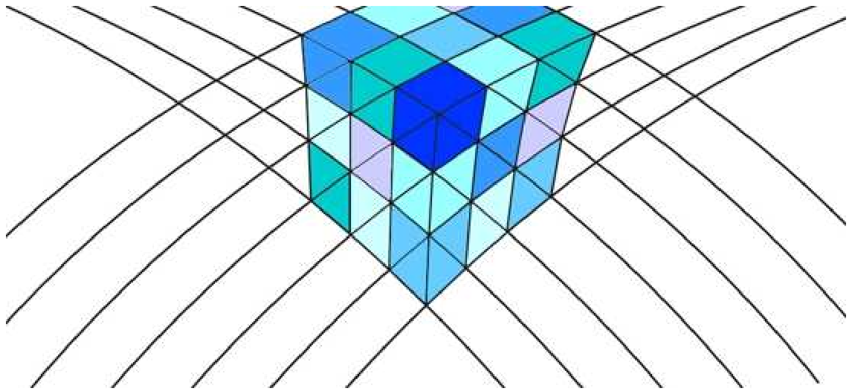
Change Analysis in Structural Laser Scanning Point Clouds:

The Baseline Method

Lindenbergh, Van Goor, Soudarissanane, Shen, Puente, Schippers



NCG Symposium, November 2 2017

Dept. of Geoscience & Remote Sensing

Delft University of Technology

Overview

A. Terrestrial Laser Scanning

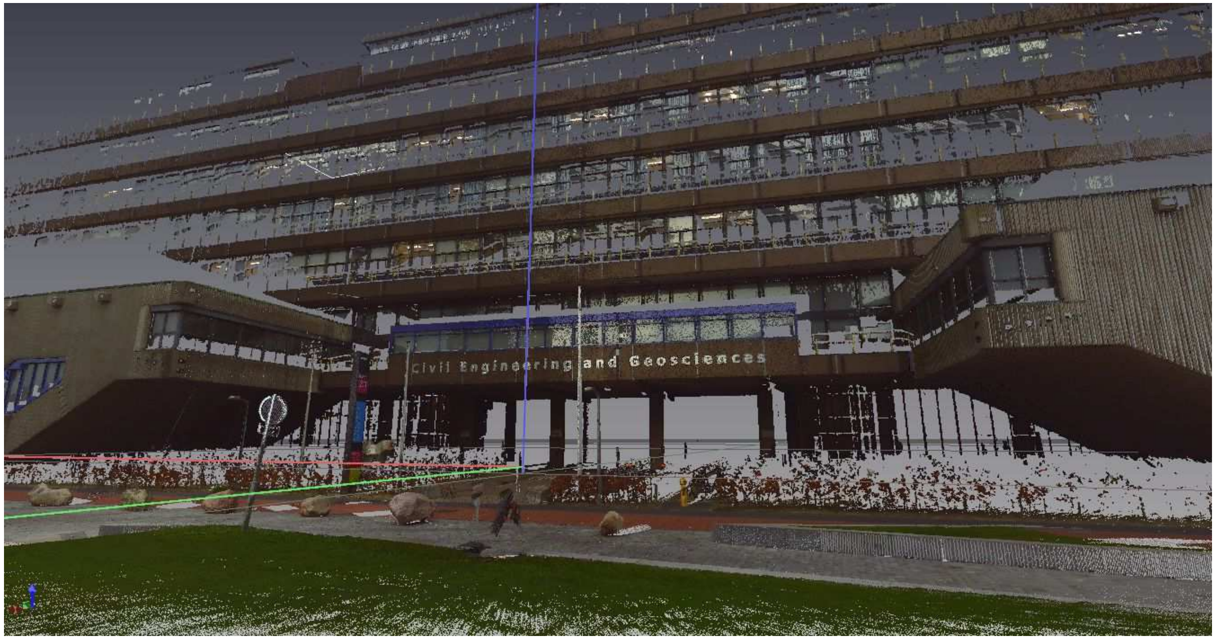
B. Registration

C. Registration free change detection

D. The moving house example

E. Concluding remarks

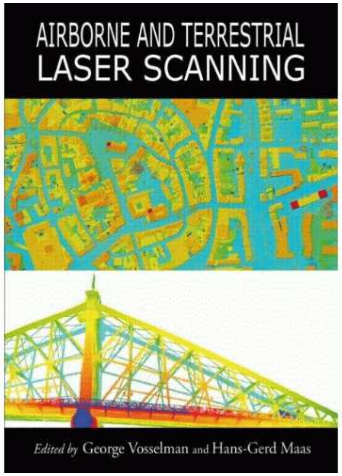
Terrestrial laser scanning



A. Applications of repeated TLS data

- Industrial installation monitoring
- Damage assessment
  (After earthquake/avalanche)
- Road environment management
- Tree and plant movement
- Open pit mining
- Landslide monitoring
- Coastal monitoring
  (Sandy beach, Dunes, Sea cliffs)
- ...

Literature



Chapter. 7.2: Structural monitoring and change detection

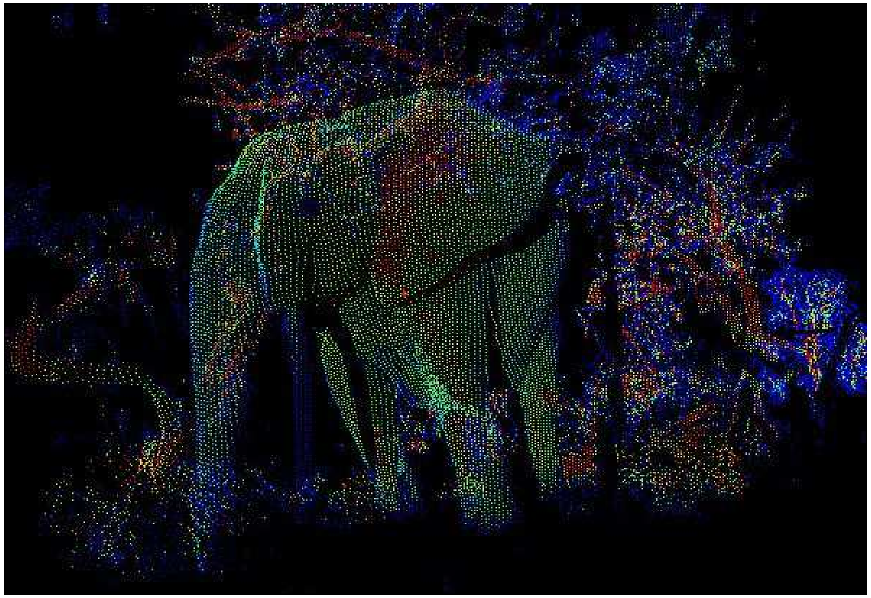
Change detection and deformation analysis using static and mobile laser scanning,
R. Lindenbergh and P. Pietrzyk,
Applied Geomatics, 7(2), pp 65-74, 2015

Change Analysis in Laser Scanning Point Clouds: The Baseline Method
Y. Shen, R. Lindenbergh, J. Wang
Sensors, 17(1), 26, 2017;

Dealing with spatial and temporal scales

Easy: often standard software is powerful enough

- High Signal/Noise level
- Many redundant measurements and simple objects
- Known processes
- Small number of epochs
- Small scenes



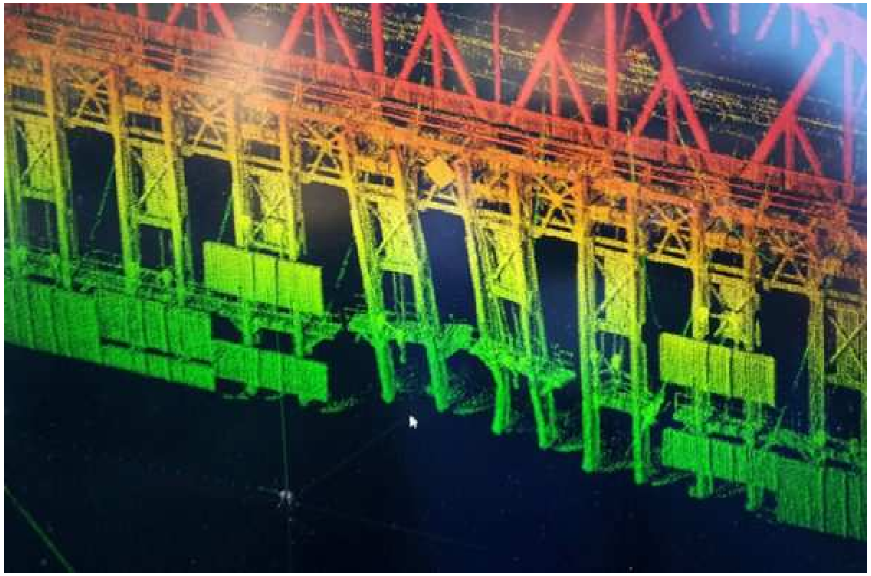
Example question: did the elephant enter the scene?

Dealing with spatial and temporal scales

Difficult: we need to work hard!

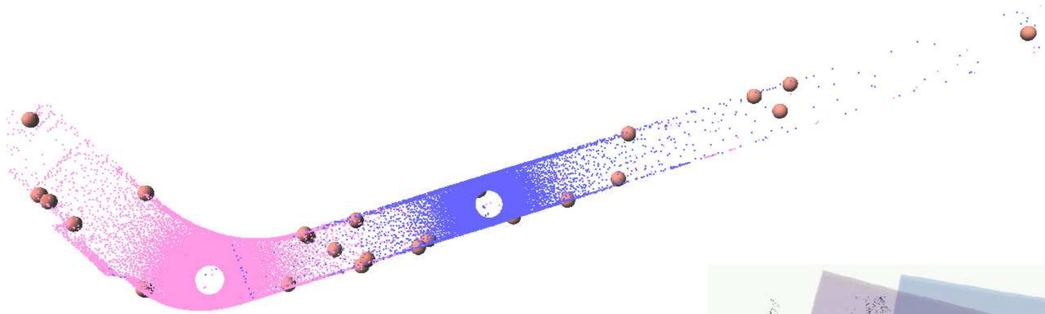
- Signal change at the [mm] level
- Objects difficult to recognize, also for human operator
- Irregular objects (trees or boulders): geometric primitives less useful.
- Serious temporal dimension (many epochs)
- Large and detailed scenes: 'all Yangtze River bridges at 0.01 m voxels'

Source https://www.shoremonitoring.nl/



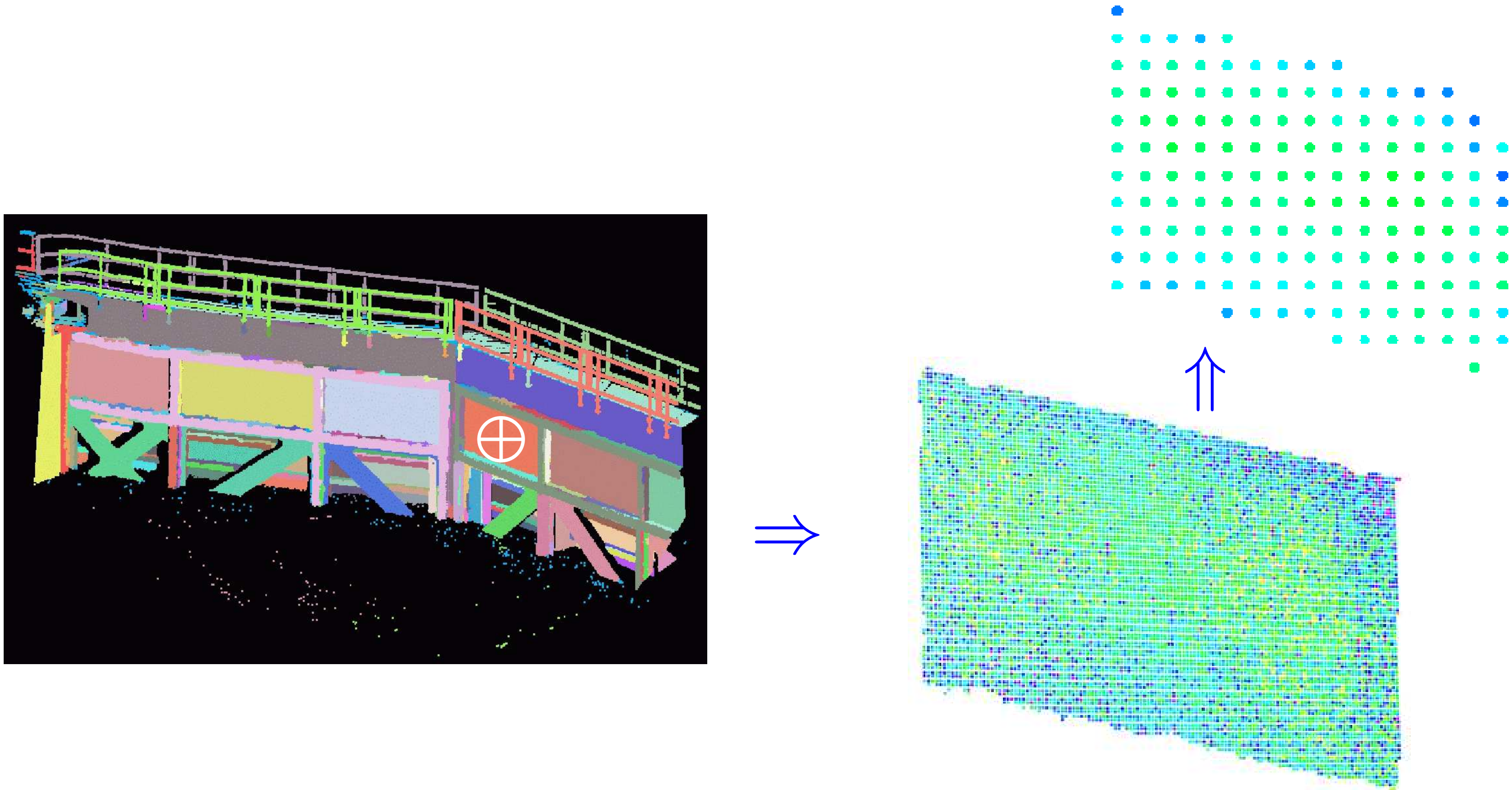
Registration

Aligning static scans in a common coordinate system.



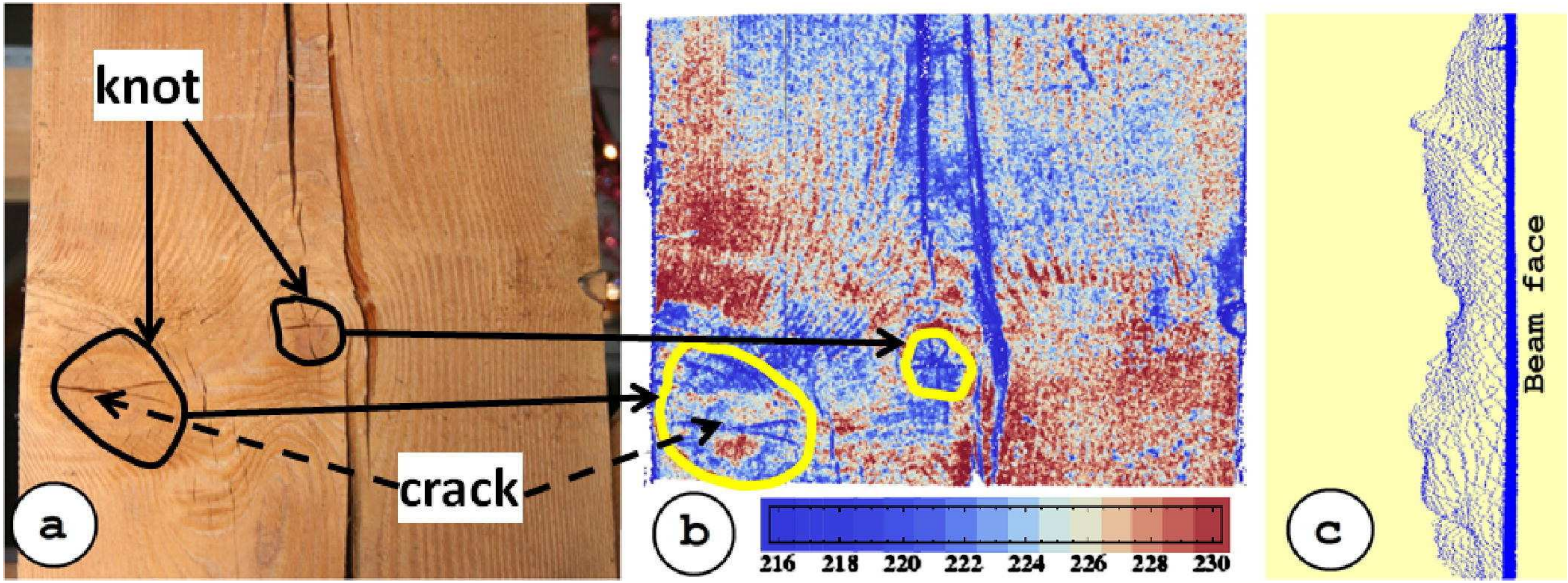
Error budget: mm to cm level.

Deformations relative to an object

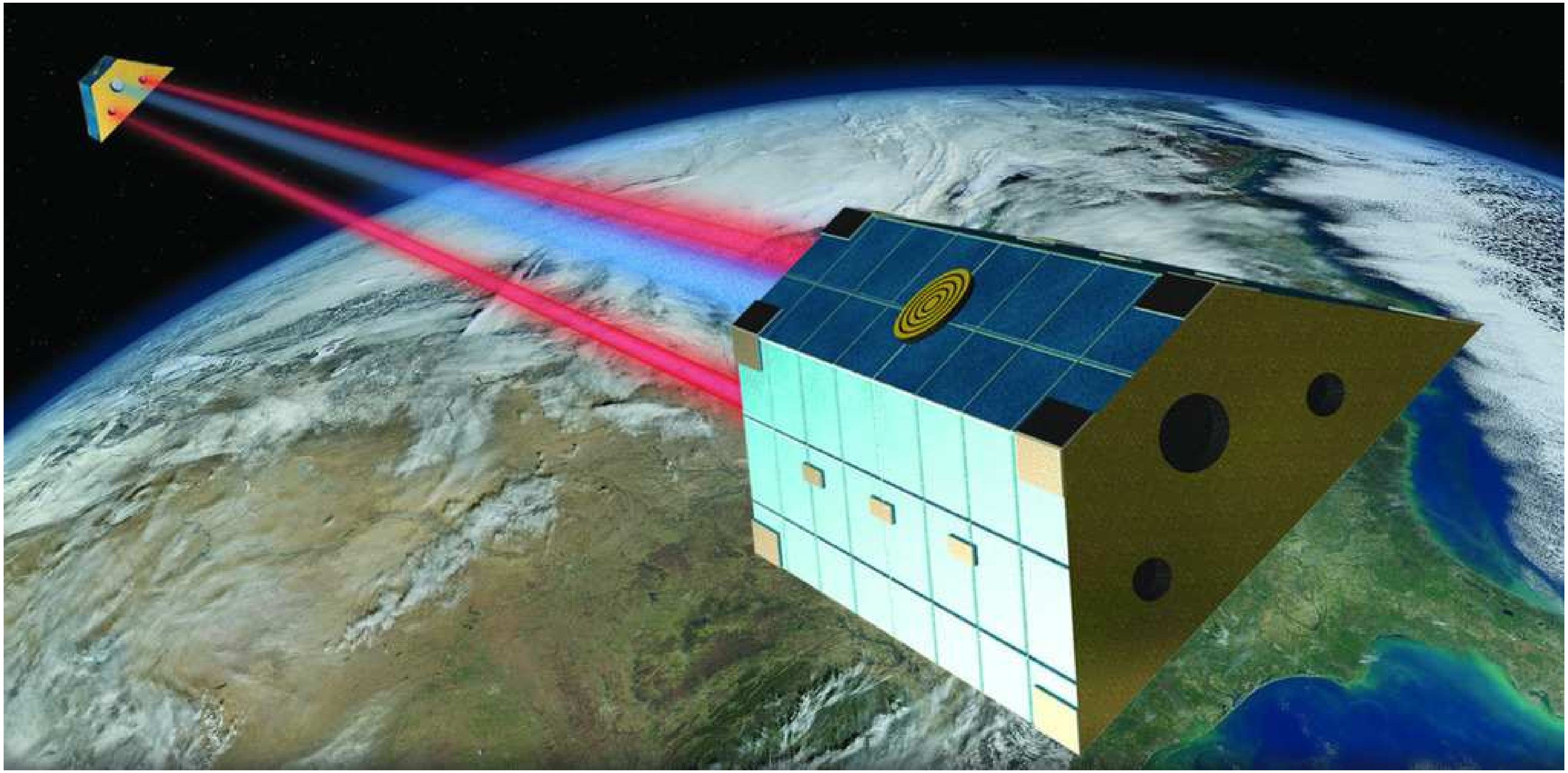


1. Collect points that sample the same object
2. Use these points to estimate idealized object shape (like: plane/cylinder)
3. Evaluate individual distances from points to idealized shape

Crack detection in wooden beams

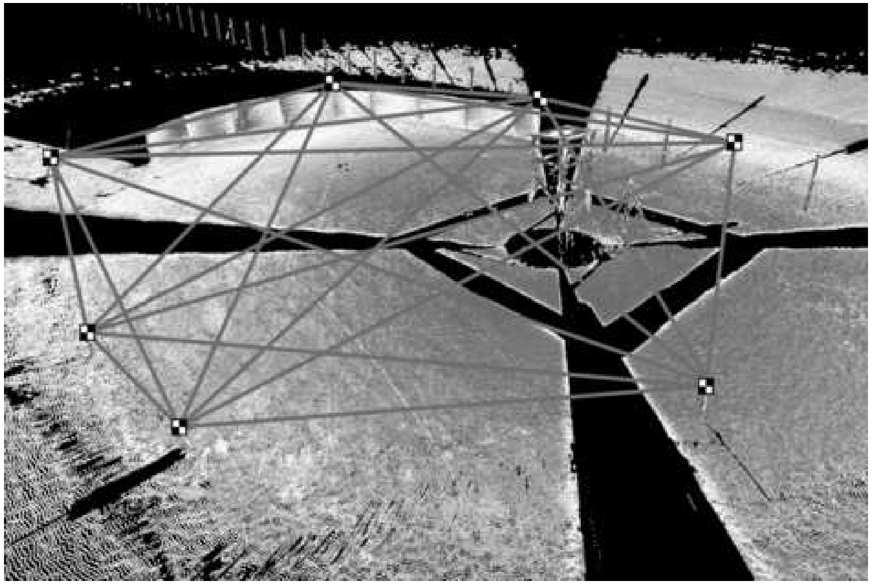


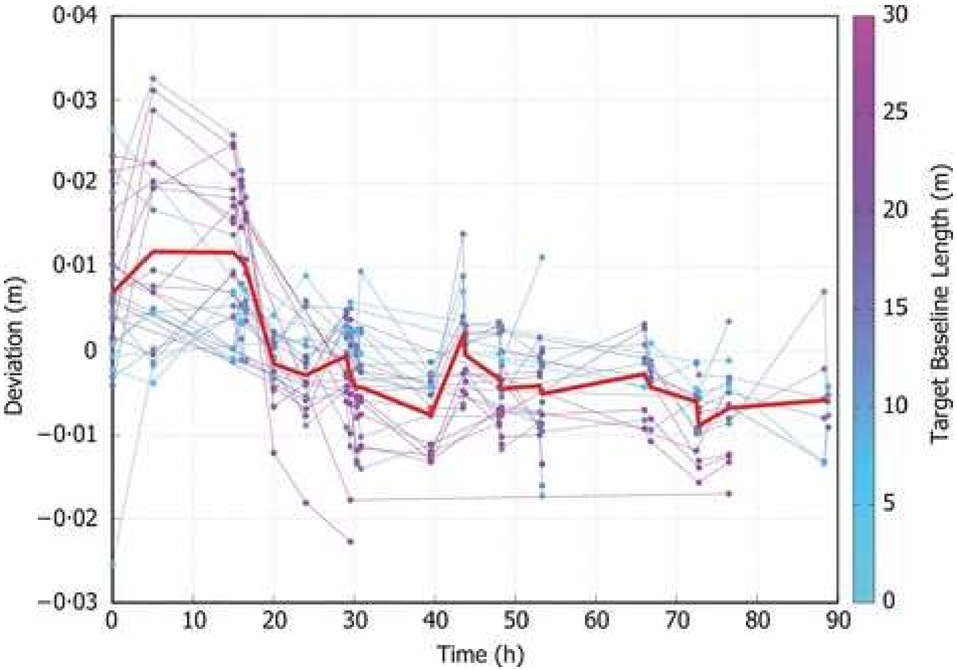
Monitor distance between known objects



Principle: used in Grace gravimetry mission

Check distances between targets



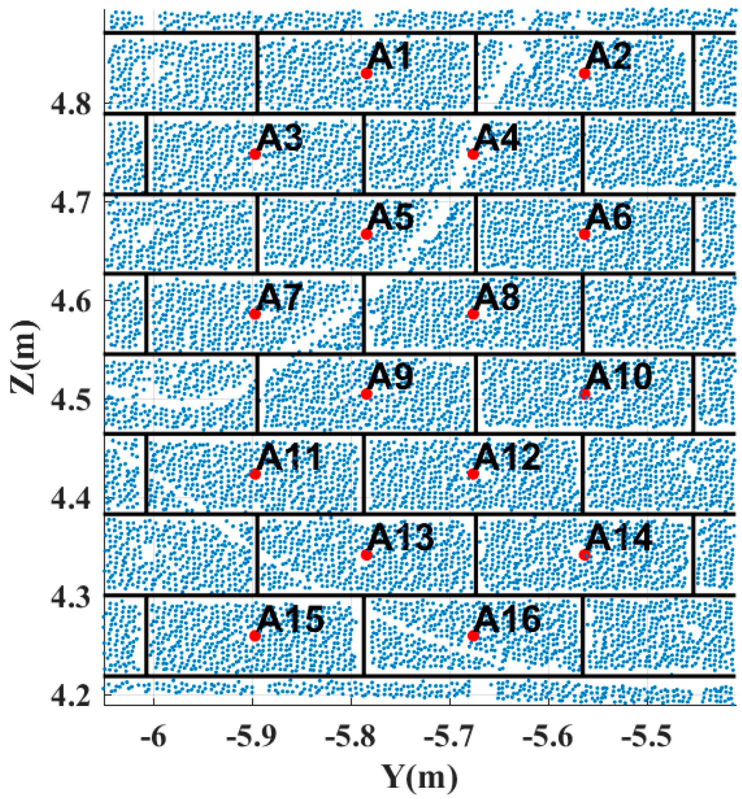


Deviations of the mean target baseline length, per epoch. Each deviation is coloured according to the corresponding baseline length.

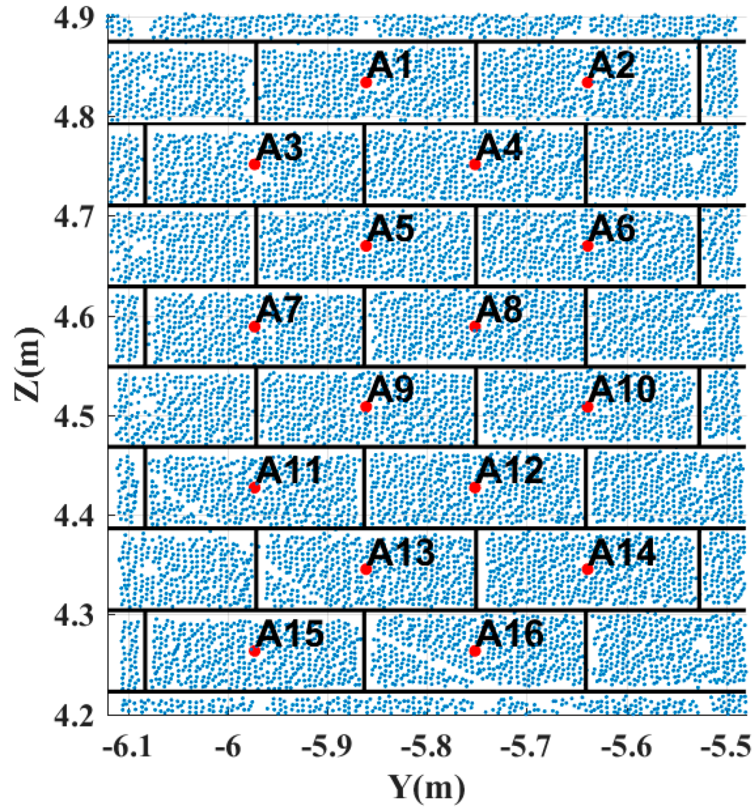
Deviations from the same baseline in different epochs are connected through time. The red line represents the mean deviation per epoch.

‘Earthquake‘ damage

No fixed points are measured



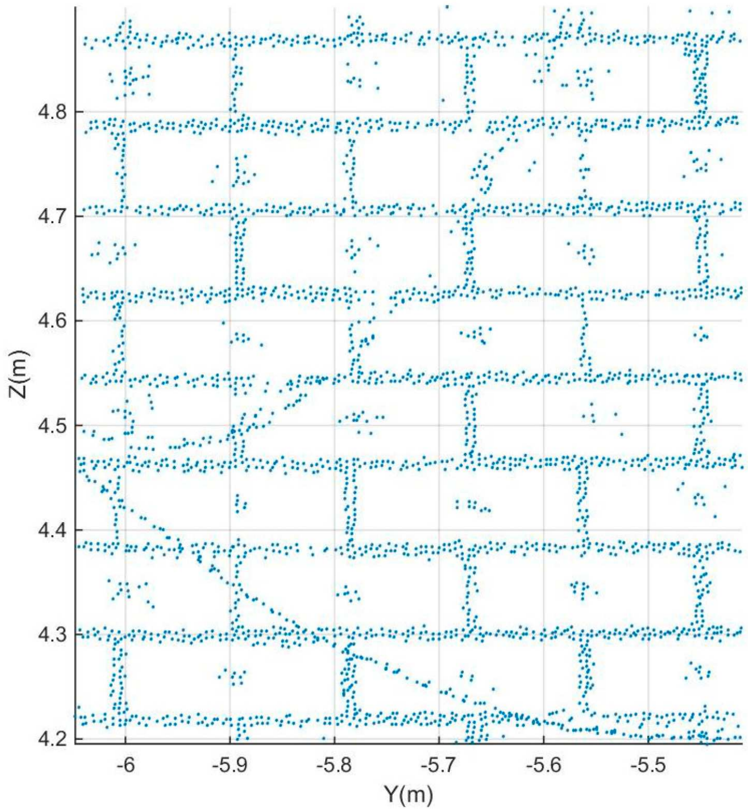
(a) Epoch I



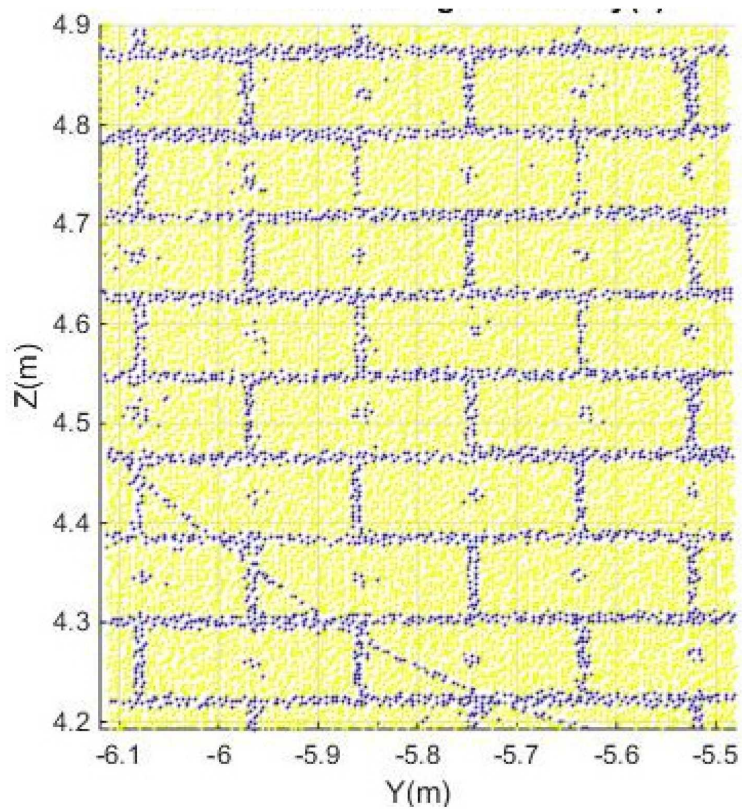
(b) Epoch II

(Re) construct feature points from the data

Estimate brick centres



(**a**) Epoch I



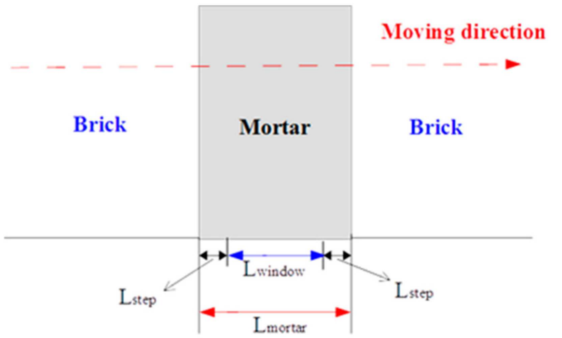
(**b**) Epoch II

Separate brick points from notably mortar points using (k=2)-means clustering.

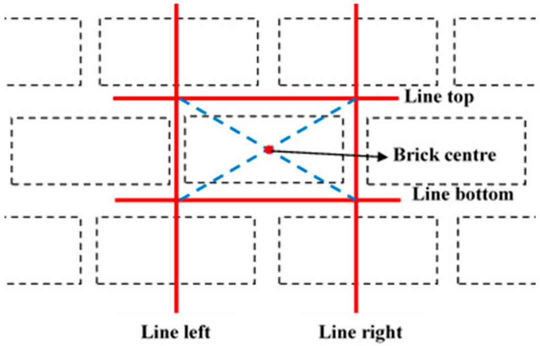
Blue points: mortar points, points reflecting from small targets or wires

yellow points: in general sample the brick surfaces.

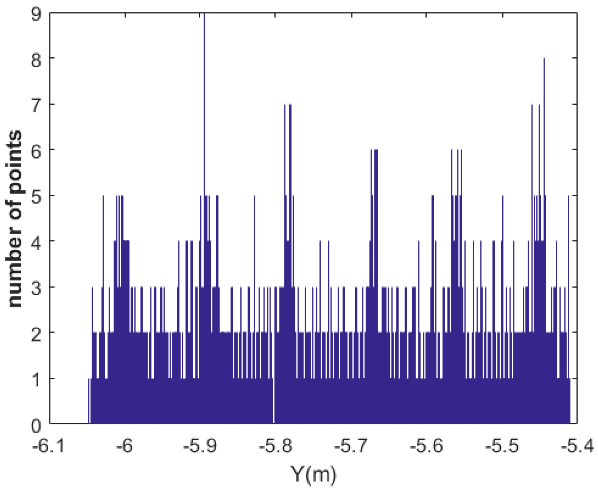
Estimate brick centres, II



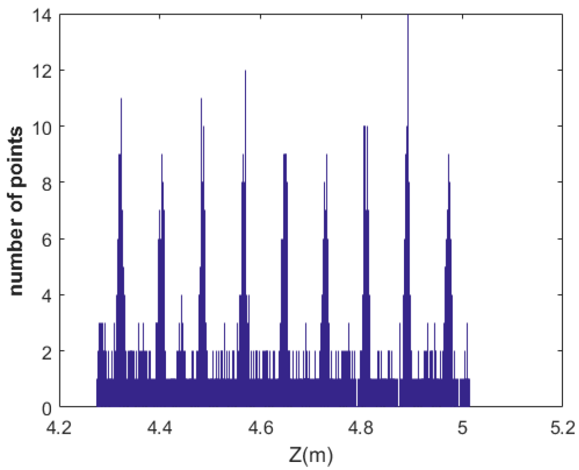
(**a**) A sketch illustrating the parameters used in the extraction of the mortar lines



(**b**) Extracting brick centres from mortar lines



(**a**) Epoch I Y axis



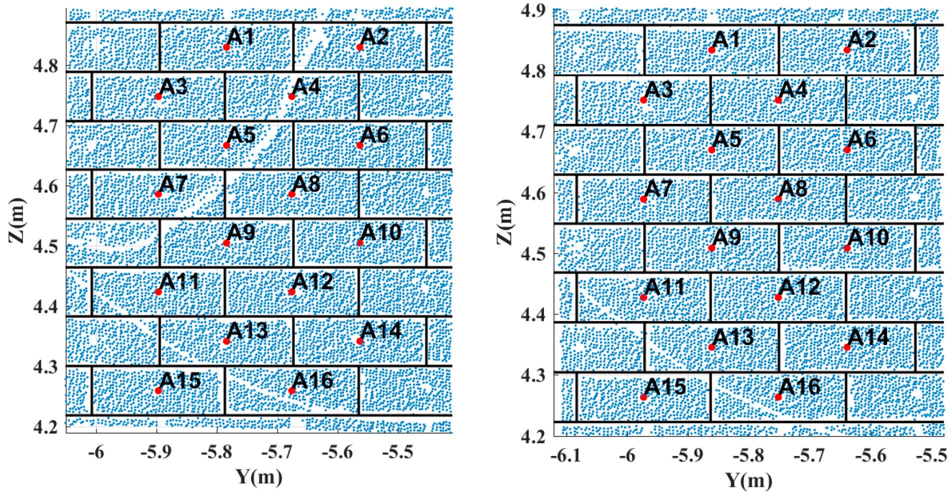
(**b**) Epoch II Z axis

Monitor baselines between feature points

Issue: registration is an extra processing step: $\Rightarrow$ Introduces additional errors

Solution: Monitor distances (baselines) between corresponding feature points

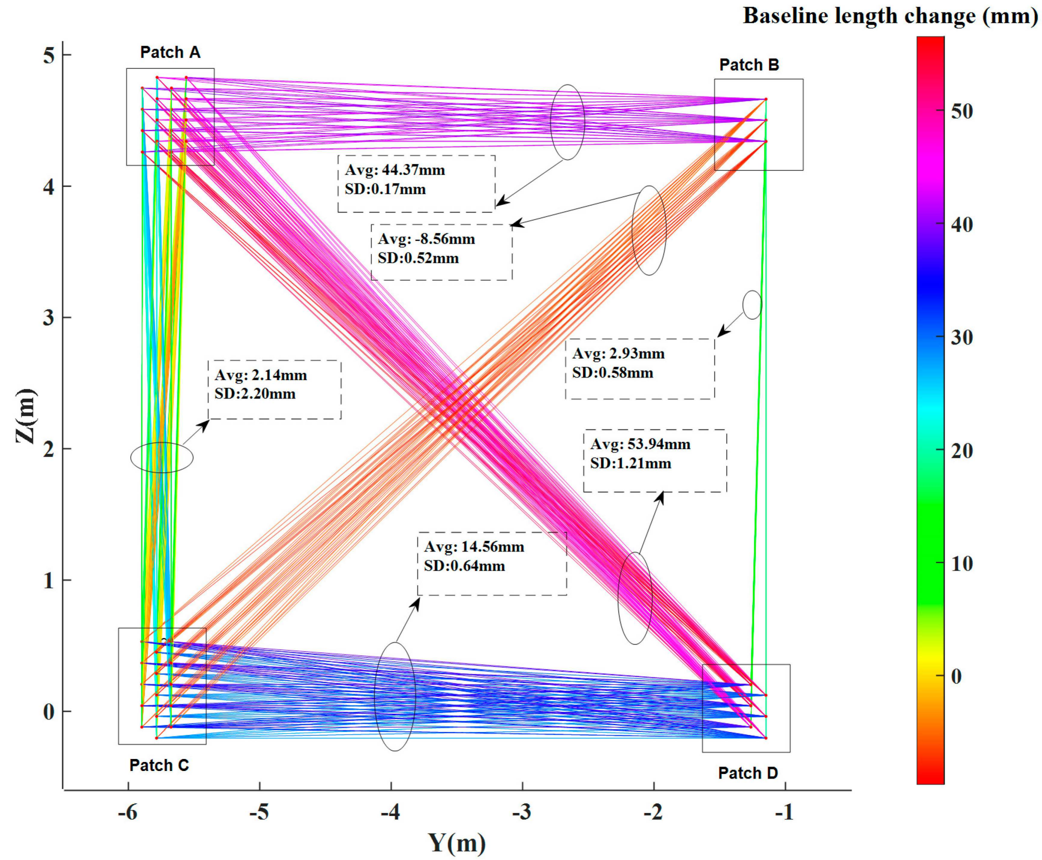
Example. Below: monitor distance between **A1** and **A16** through time.



(**a**) Epoch I (**b**) Epoch II

Challenge: how to identify feature points in point clouds?

Network comparison



Colors highlight changes in lengths of baselines connecting points in areas A, B, C and D.

Bonus: Permanent Laser Scanning

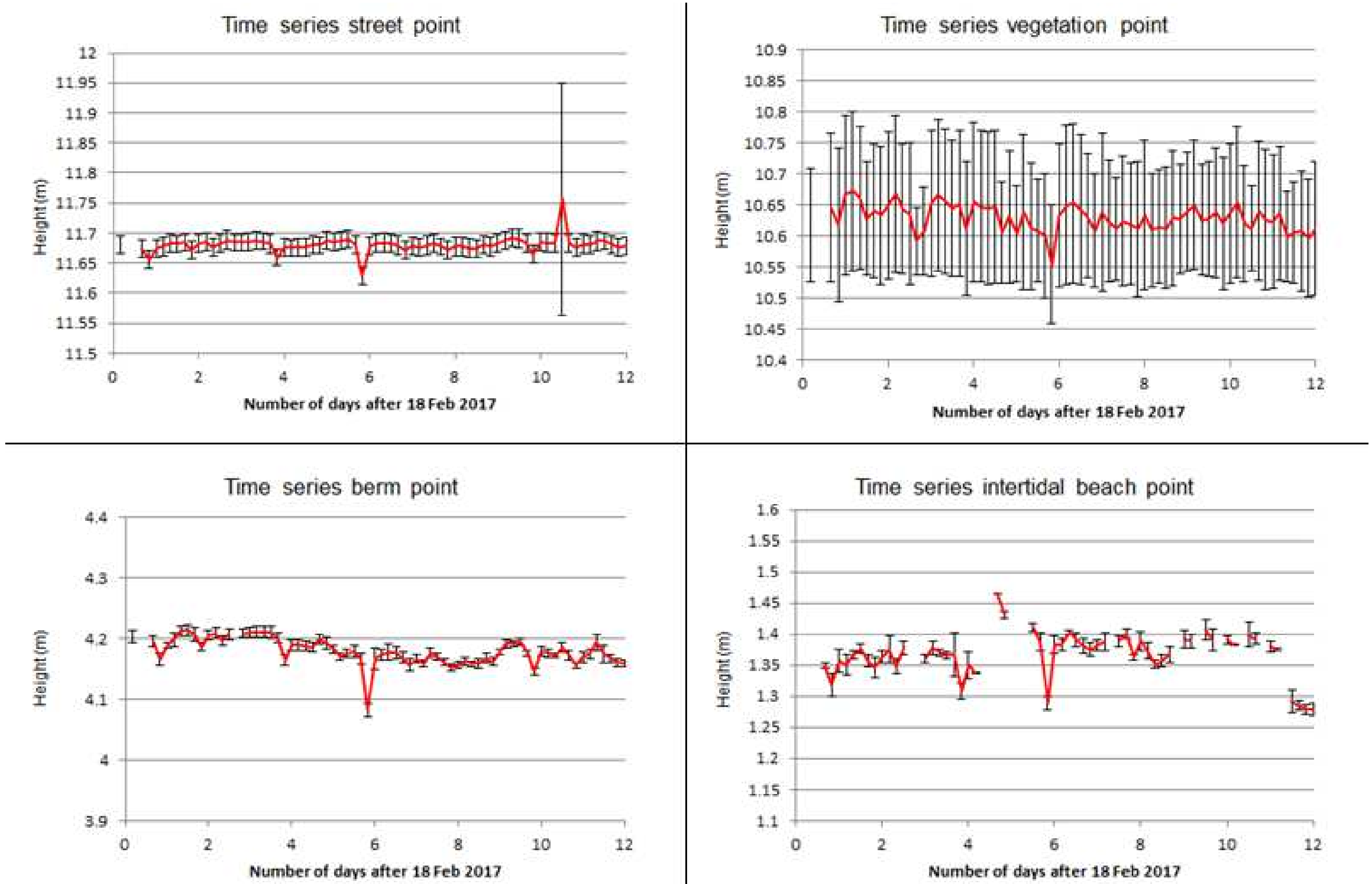
Riegl VZ2000 ‘permanently‘ installed on the roof of a beach hotel in The Hague - The Netherlands by Sander Vos

Bonus: Permanent Laser Scanning

Every hour a new scan:
Now: $\approx$ four months = 3000 epochs of hourly data!

Methodology: designed but not implemented

Bonus: Permanent Laser Scanning



Laser scan time series for different locations

Conclusions

Using baselines you may avoid registration

Issues:

- Extracting feature points strongly depends on scenario
- But could be done using 2D and 3D feature descriptors
- Cracks not yet automatically detected or delineated
- Matching corresponding features

Questions?

After the succes of Moving House I, stay tuned for the sequel: