Terrestrial radar and laser scanning for deformation monitoring: first steps towards assisted radar scanning

Daniel Wujanz [1], Frank Neitzel [1], H.P. Hebel [2], J. Linke [2], W. Busch [2]

[1] Chair of Geodesy and Adjustment Theory, Technische Universität Berlin, Germany

[2] Chair of Mine Surveying and Geoinformation, Technische Universität Clausthal

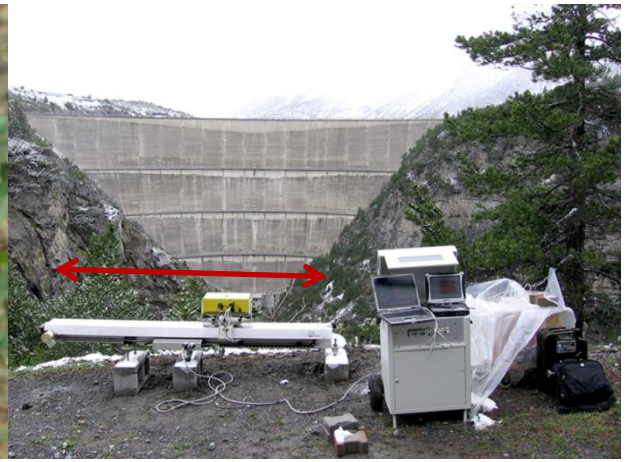
Vertical Geology Conference 2014 | Université de Lausanne | 07.02.2014

Sensor fusion for laminar deformation monitoring

3D-Acquisition of an area of interest at spatial and temporal continuity

Aim of the „Engineering Geodesy“ section (German Geodetic Commission -DGK)

- Terrestrial Laser Scanning (TLS)
- Terrestrial or ground based RADAR systems (GB-RADAR)



TLS vs. GB-RADAR

	Advantage	Problems
TLS	• Absolute approach • Spatially laminar quasi-continuity • High range	• Sequential data acquisition • Poor / unknown stochastic models • Too simplified post processing software
GB-RADAR	• Simultaneous and high frequent data acquisition • High range and precision for geometrical changes (depth) • Laminar continuity	• Ambiguous for larger deformations • Complex post processing • Linked to one standpoint • Low spatial resolution

Aim of this investigation

Laminar monitoring

Terrestrial Laser scanning

GB-RADAR

Complete picture of an areal: Spatial and temporal continuity

In this talk

Comparative investigations

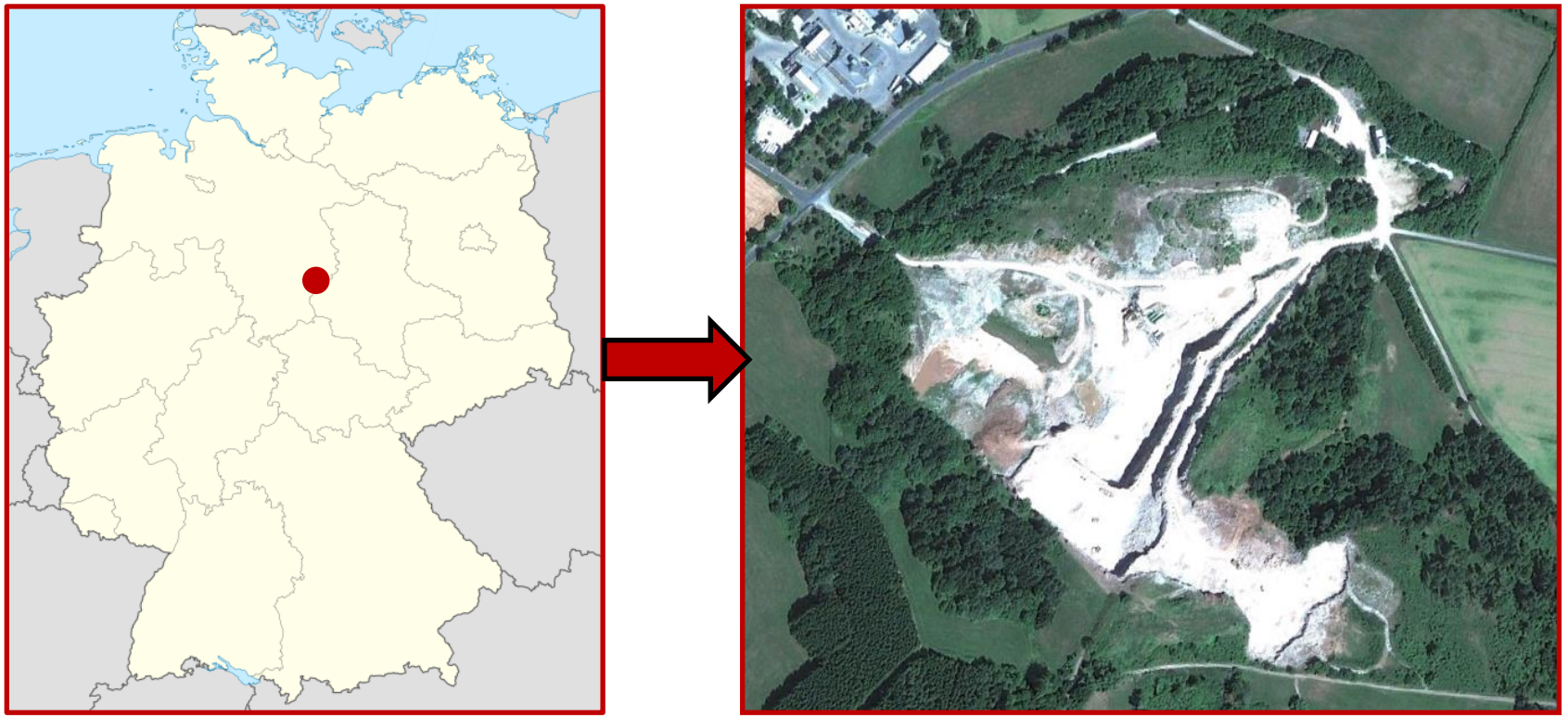
- Introduction of the test case
- Introduction of the applied instrumentation
- Transformation into a common coordinate system of results for comparative reasons

Data fusion

- Presentation of aGB-RADAR
  → Combined usage of TLS and GB-RADAR data

Description of the test case

Quarry in secondary mountains „Harz“

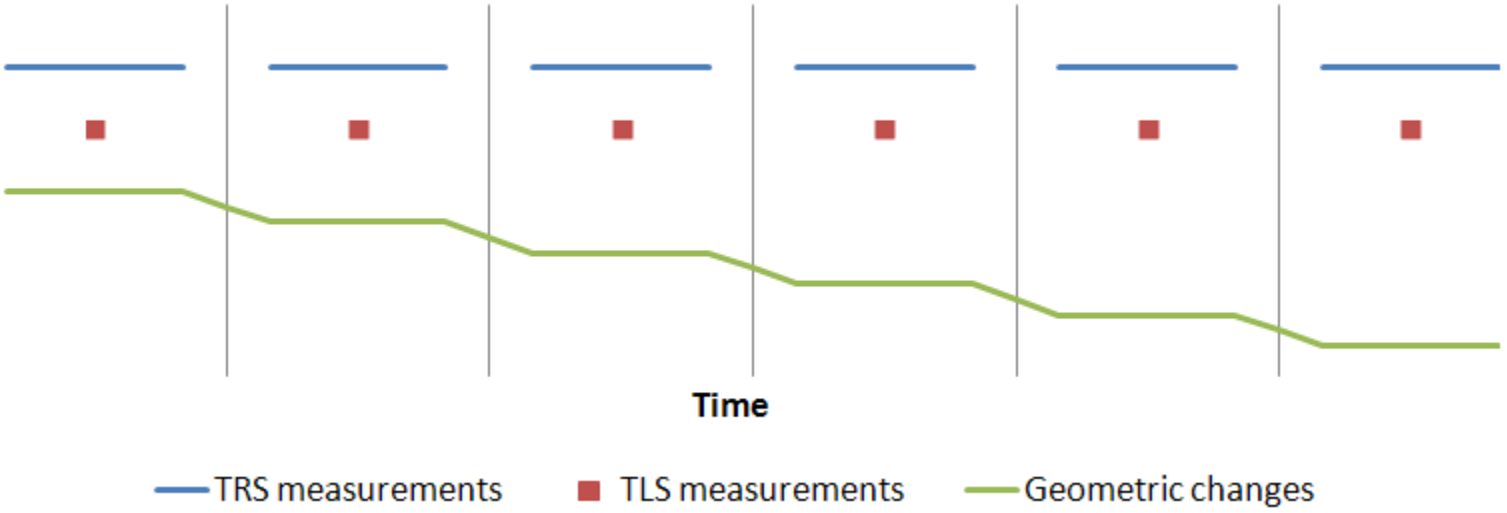


Description of the test case

Quarry in secondary mountains „Harz“

- Acquisition of a reference epoch
- Five successive epochs including „controlled changes“
- Deformation monitoring with TLS and GB-RADAR

Is the GB-RADAR system capable to identify the occuring deformations?



Description of the instruments

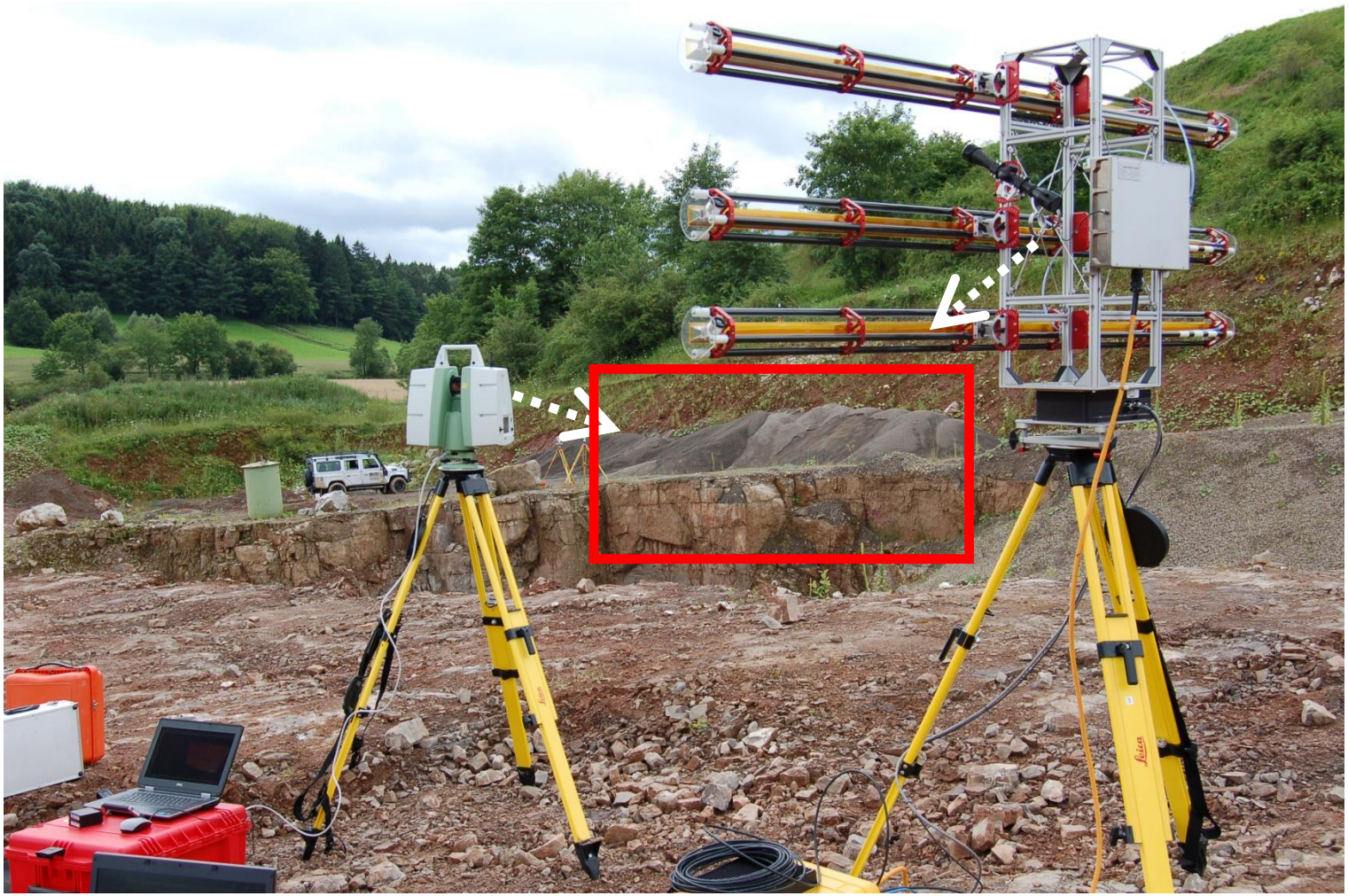
Radar scanner GPRI-2 (TU Clausthal)

- Reach up to 6 km
- Scan rate: 10° / s
- Field of view: 360° horizontal
  60° vertical
- Resolution: 0.75 m in line of sight
  8 mrad in rotational direction
- Accuracy: under 1 mm

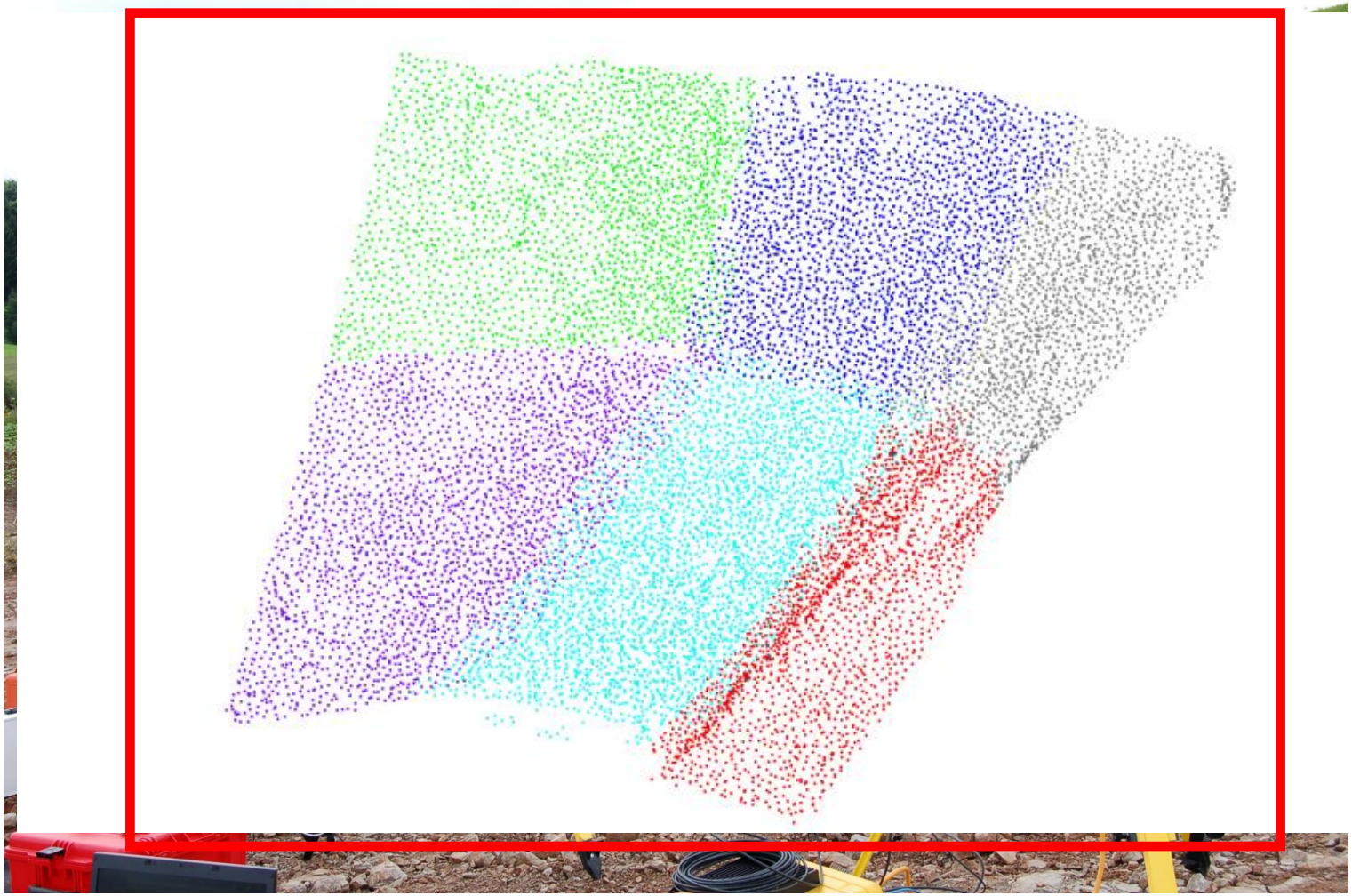
Leica Scanstation C10 (TU Berlin)

- Reach up to 300 m
- Scan rate: up to 50.000 pts / s
- Field of view: 360° horizontal
  270° vertical
- Accuracy: 6 mm (within 50 m)

Data acquisition



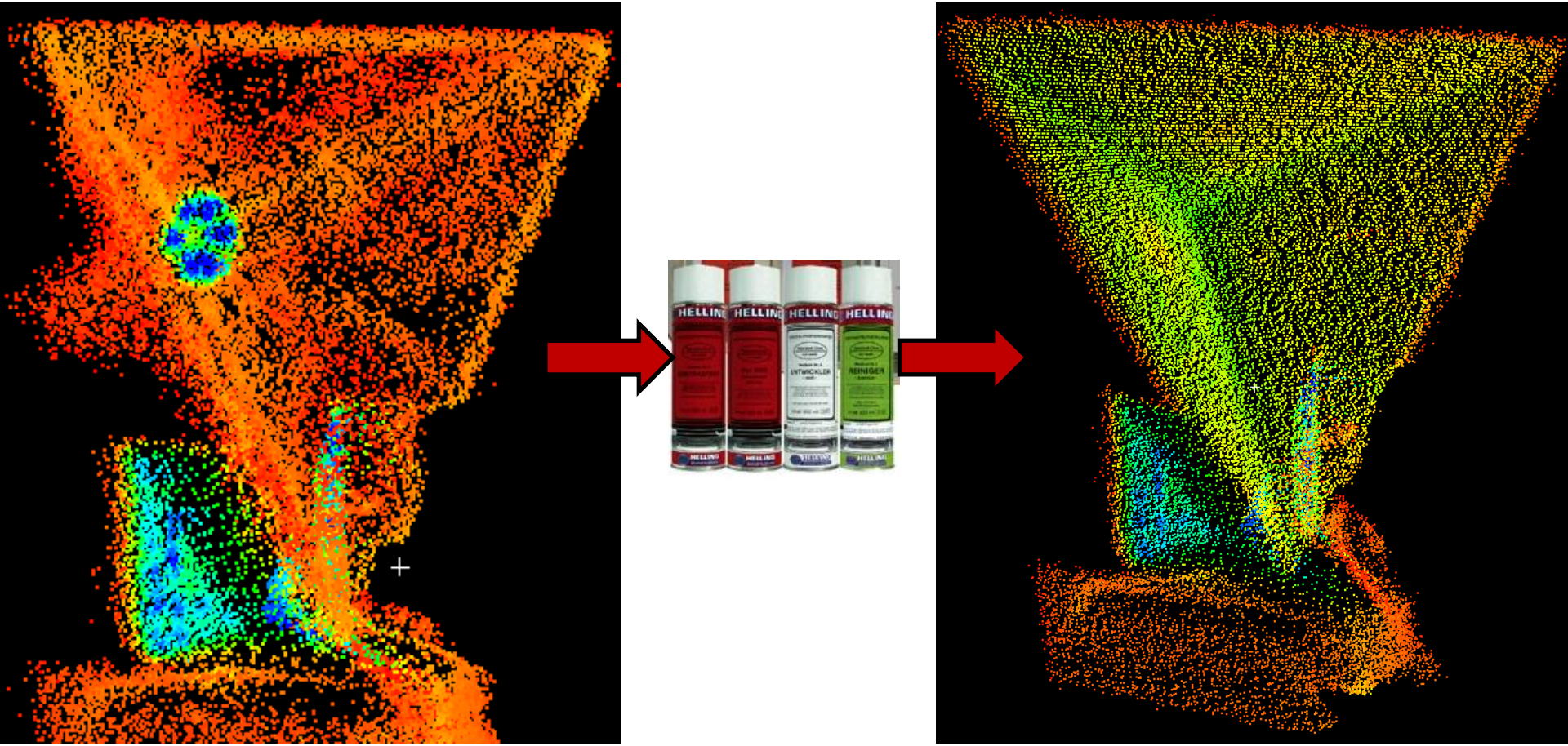
Data acquisition



Data fusion

Data fusion

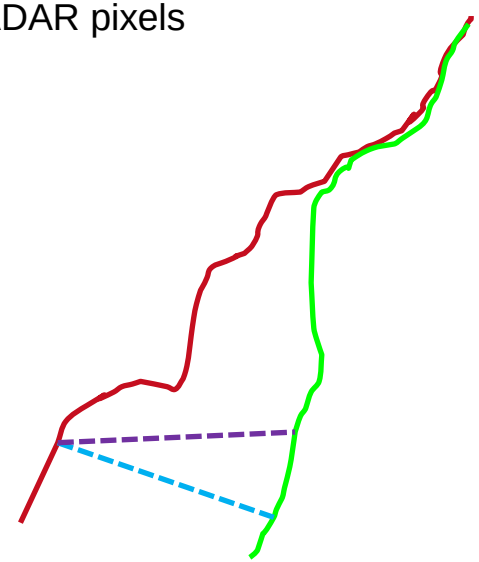
Data fusion

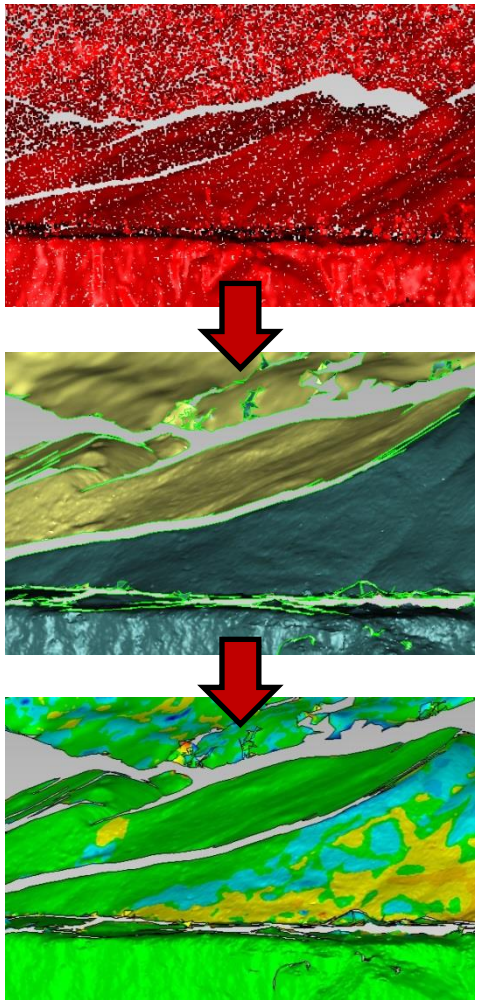


Data fusion

Conversion of TLS point cloud

- Triangulation of reference epoch
  → Triangular mesh
- TLS-based deformation monitoring
  → Monitoring in LOS
- Assignment of TLS points to RADAR pixels

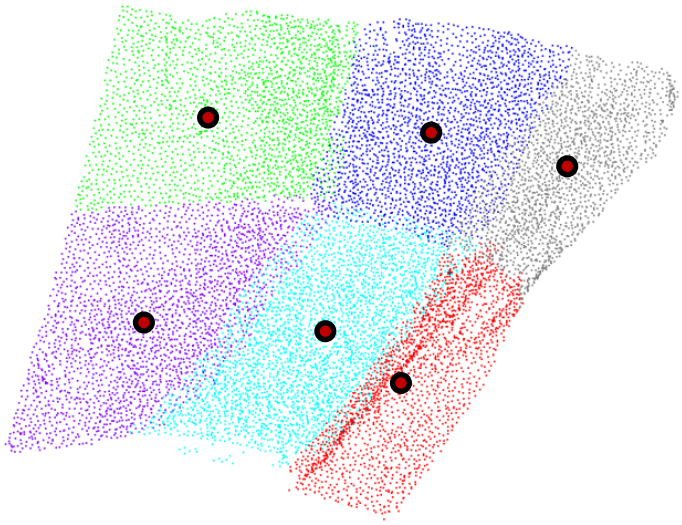




Data fusion

Conversion of TLS point cloud

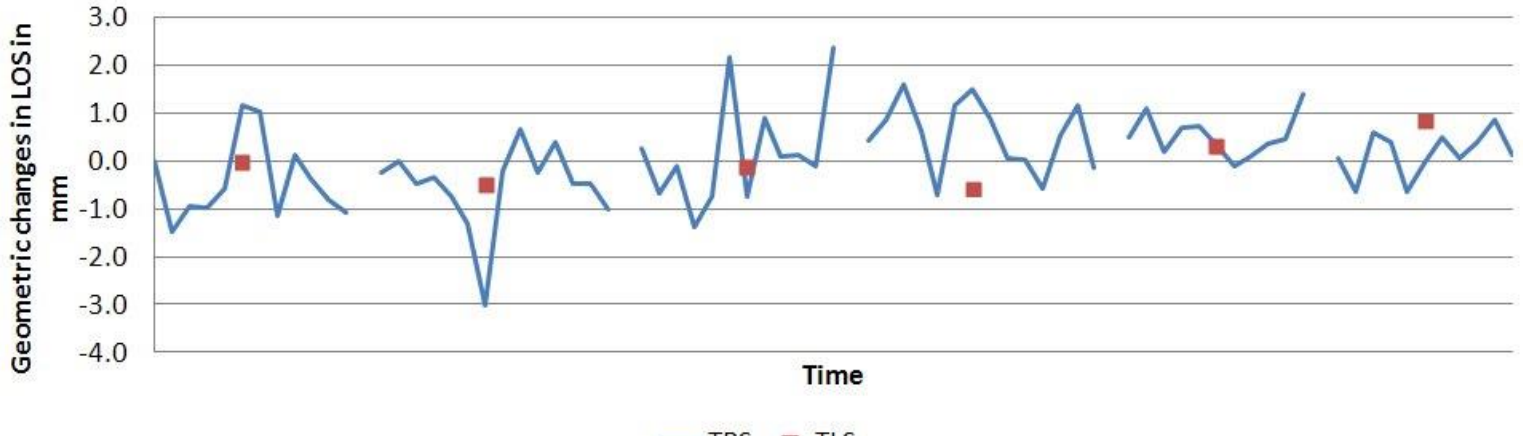
- Triangulation of reference epoch
  → Triangular mesh
- TLS-based deformation monitoring
  → Monitoring in LOS
- Assignment of TLS points to RADAR pixels
- Averaging of all TLS deformation vectors „within“ a RADAR pixel



Comparison between TRS and TLS is realisable

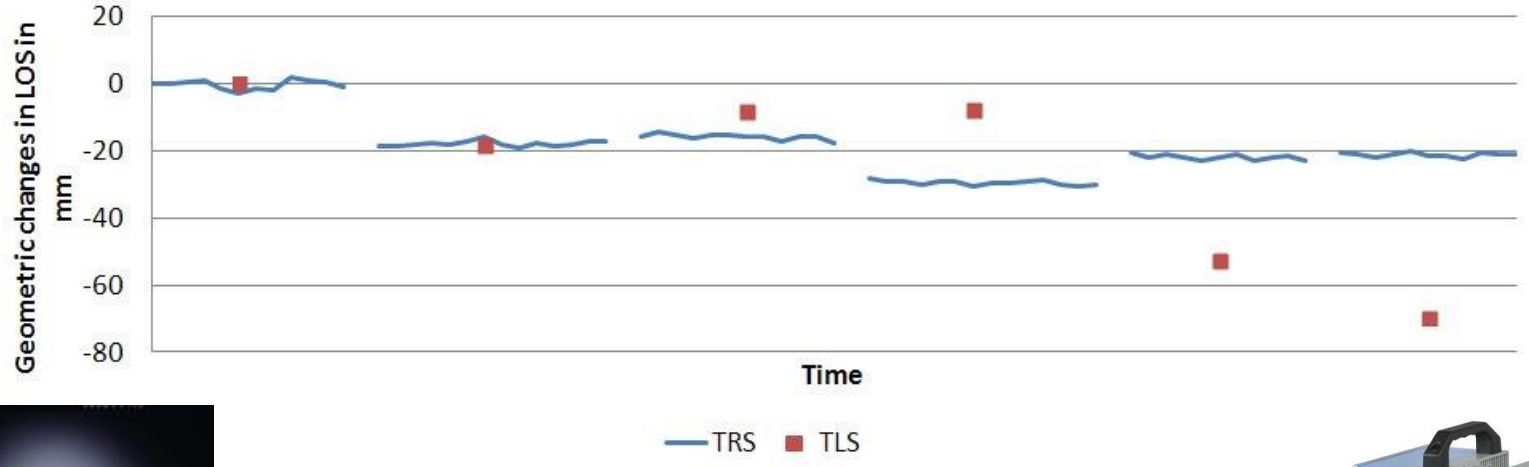
Comparison between TLS and TRS

Area of interest <u>without</u> artificial geometric changes



Comparison between TLS and TRS

Area of interest <u>with</u> artificial geometric changes



Occurance of phase unwrapping
(amiguity effects)

Fusion of TLS and TRS

Assisted RADAR – aGB-RADAR

- Conversion of geometric changes based on TLS into phases:

$$\phi_{\mathrm{L}} = 2 \cdot \frac{2\pi}{\lambda} \cdot \Delta r$$

- Computation of $\Delta\phi_{\mathrm{L}}$ that lies between +π and – π:

$$\Delta\phi_{\mathrm{L}} = \phi_{\mathrm{L}} \bmod \pi$$

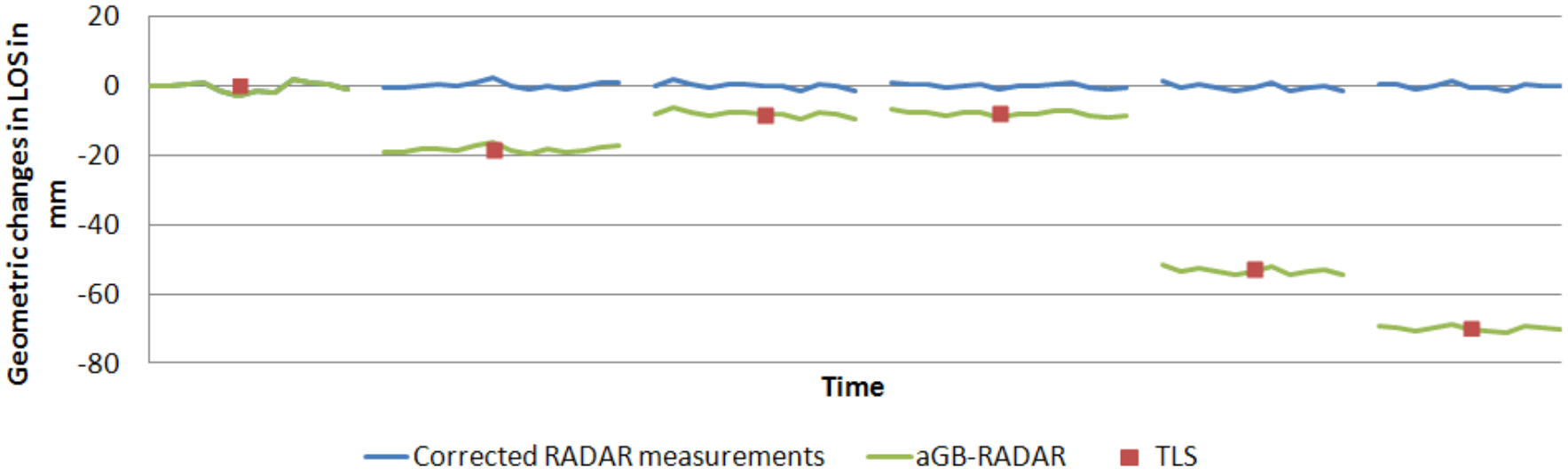
- Correction of measured phase values of the TRS:

$$\Delta\phi_{\mathrm{new}} = \Delta\phi_{\mathrm{R}} - \Delta\phi_{\mathrm{L}}$$

Solution of ambiguities by usage of TLS data

Results aGB-RADAR

Area of interest <u>with</u> artificial geometric changes



Conclusion: aGB-RADAR

- Geometric changes within area of interest caused phase-unwrapping
  → ambiguities
- TLS data has been successfully used to solve these ambiguities
  → assisted GB-RADAR (aGB-RADAR)
- Update of RADAR-pixels ONLY in case of significant TLS-deformation (local update of DEM)
  → High frequency of RADAR-scanning
- aGB-RADAR allows to interrupt RADAR campaigns in permanent monitoring processes

Terrestrial radar and laser scanning for deformation monitoring: first steps towards assisted radar scanning

Daniel Wujanz [1], Frank Neitzel [1], H.P. Hebel [2], J. Linke [2], W. Busch [2]

[1] Chair of Geodesy and Adjustment Theory, Technische Universität Berlin, Germany

[2] Chair of Mine Surveying and Geoinformation, Technische Universität Clausthal

Vertical Geology Conference 2014 | Université de Lausanne | 07.02.2014