



# Digitaler Zwilling: Fusion von BIM und SAR (BIMSAR) für zukünftiges Gebäudemonitoring



Technische  
Hochschule  
Georg Agricola



VIVAWEST

Gefördert durch:



aufgrund eines Beschlusses  
des Deutschen Bundestages



## BIMSAR 1 (2021 – 2022)

## BIMSAR 2 (2024 – 2025)

Gefördert durch:



aufgrund eines Beschlusses  
des Deutschen Bundestages

- KI, Machine Learning
- SAR, InSAR, PSI. etc.
- Fusion
- Pattern Recognition
- GIS Platform

**F&E**

- Gebäudemonitoring
- Autobahnmonitoring
- Brückenmonitoring
- Stadtgebietsmonitoring
- Bergbaugebietmonitoring

**Marketing**



# BIMSAR 1



Technische  
Hochschule  
Georg Agricola



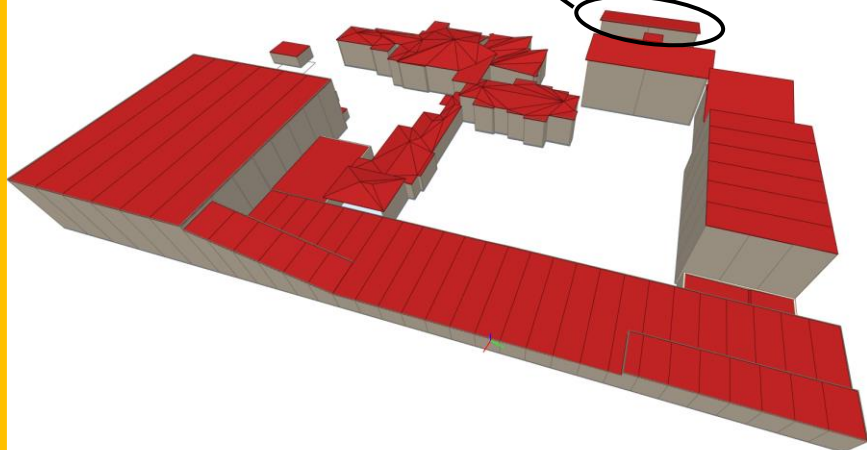
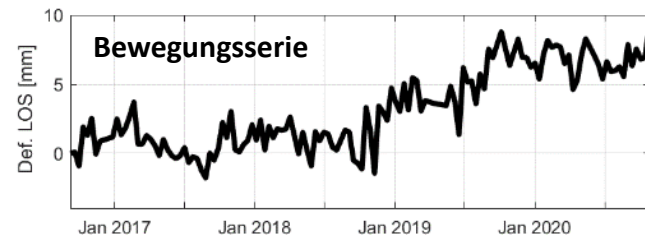
Gefördert durch:



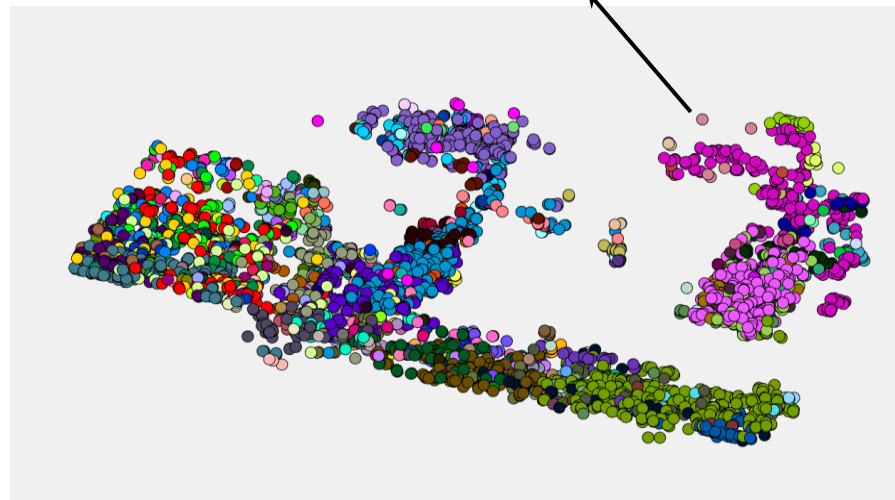
aufgrund eines Beschlusses  
des Deutschen Bundestages

# Ziel: BIM + SAR für interaktives und intuitives Gebäude-Monitoring

Pset_insar	
AquisitionMode	Stripmap
d2021-01-16	0
d2021-01-27	2,1
d2021-02-07	3,9
d2021-02-18	3,3
d2021-03-01	4,02
d2021-03-12	5,03
d2021-03-23	4,7
d2021-04-02	3,6
d2021-04-13	2,3
d2021-04-24	1,2
EndDate	2021-01-16T21:45:15
MeasuresExist	Ja
Number of Measures	42
Satellite	TerraSAR-X
Velocity	9,12



## BIM-Modell



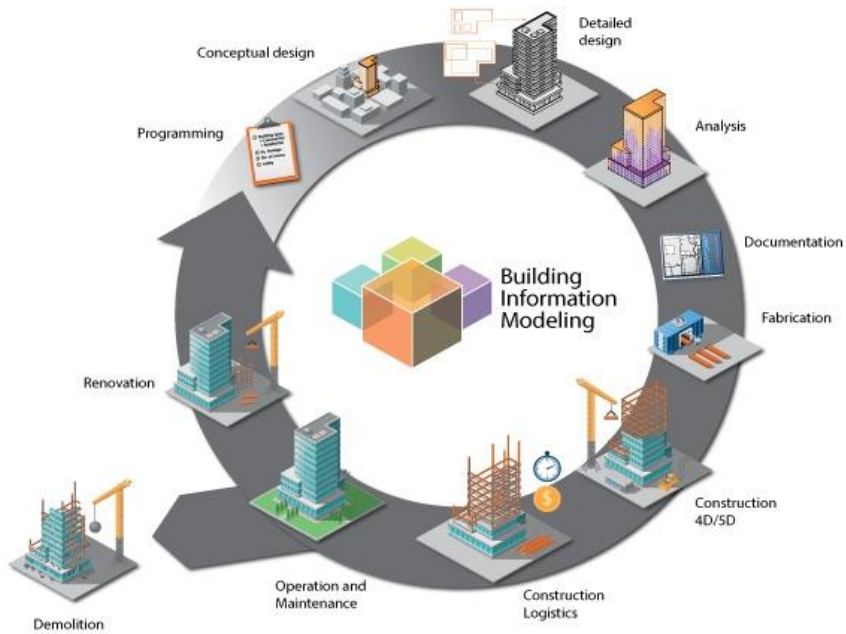
## SAR-abgeleitete PS-Punkte



# Inhalt

- **BIM-Modell**
- **SAR-Produkt**
- **Fusion: BIM + SAR**
- **Demo-Plattform**

# BIM : Building Information Modeling



<https://bimmda.com/en/what-is-bim>

## 2D data exchange



## BIM interoperability

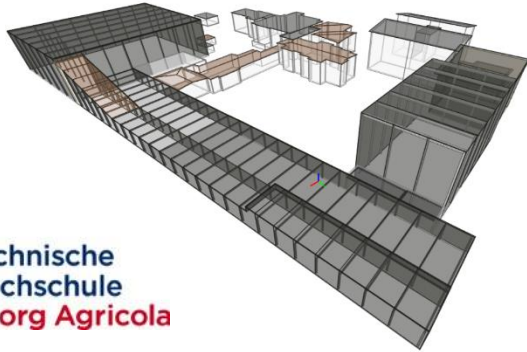


<https://bloggershrutidoshi.wordpress.com/2020/06/10/building-information-modeling-in-construction-industry/>

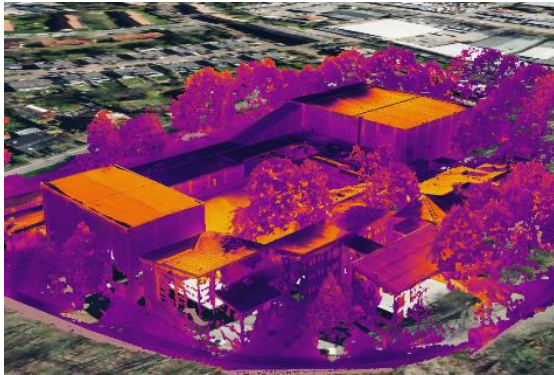
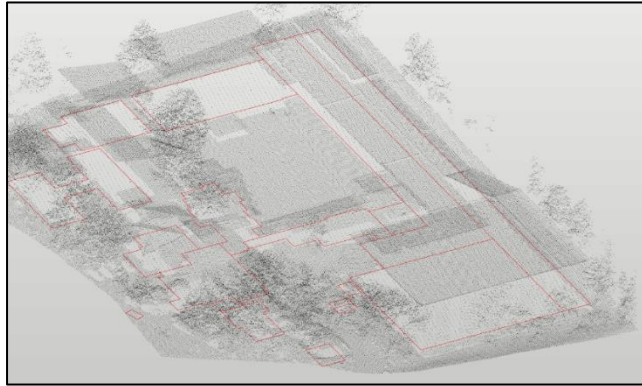




# Ein BIM von Grund auf neu erstellen - Olympiastützpunkt Westfalen/Bochum

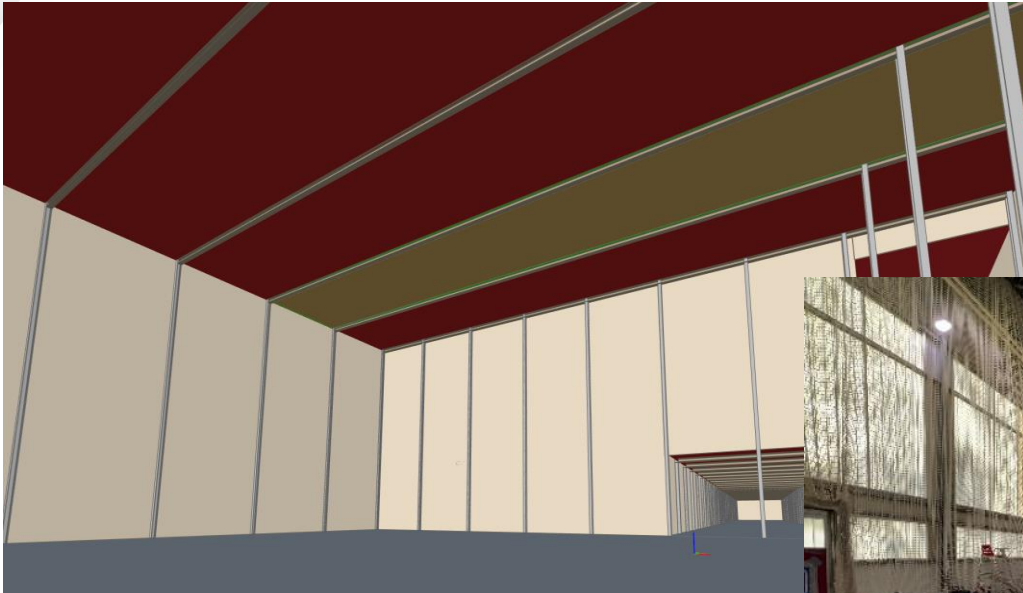


Technische  
Hochschule  
Georg Agricola





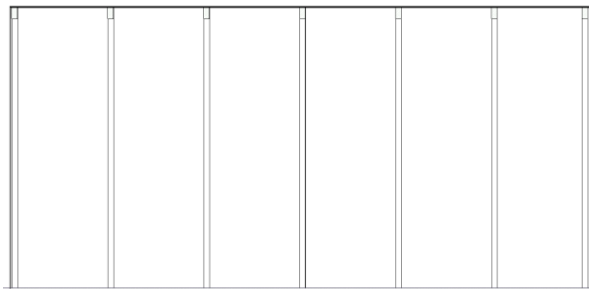
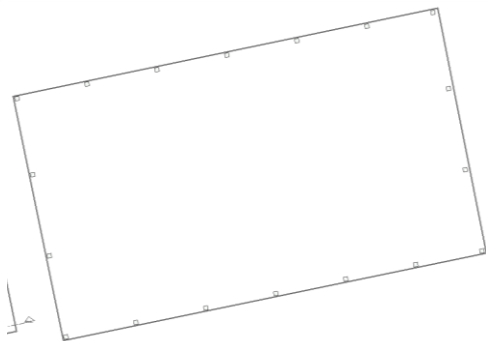
# Inspektion und Untersuchung vor Ort







# Konstruktion mit Autodesk Revit und City2BIM



Georeferencing

Postal Address

Address lines:

Postal Code:  Town:

Region:  Country:

Geographic site coordinates

Latitude [°]:   Deg  DMS

Longitude [°]:  True North [°]:

Projected coordinates

Eastings [m]:  Northings [m]:

Scale:  Grid North [°]:

EPSG-Code (CRS):

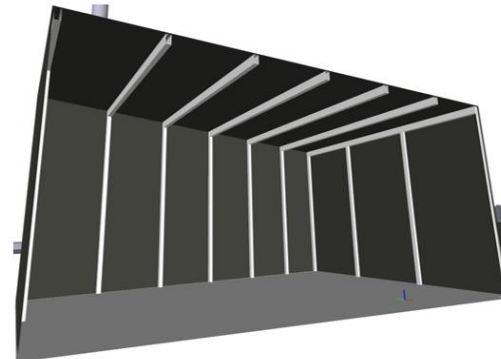
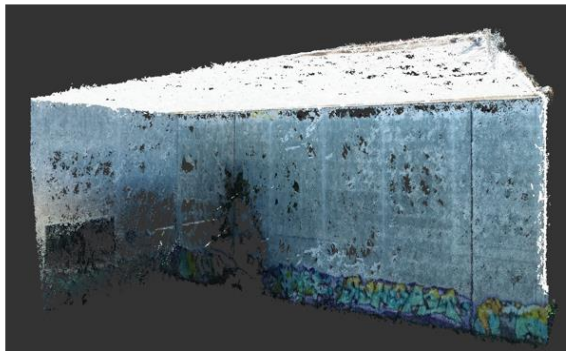
Elevation

Orthometric Height [m]:  Vertical Datum:

UTM transformation

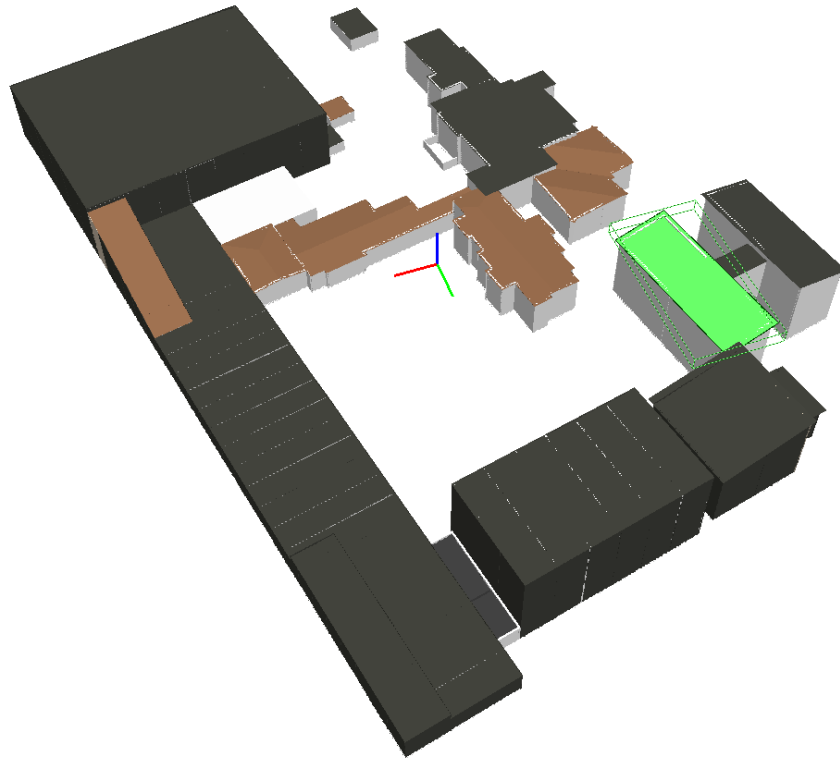
Site (LatLon) to Projection (UTM)

Projection (UTM) to Site (LatLon)





# BIM Olympiastützpunkt Ruhr-Ost



Industry Foundation Classes (IFC) Format  
International Standard ISO 16739-1:2018

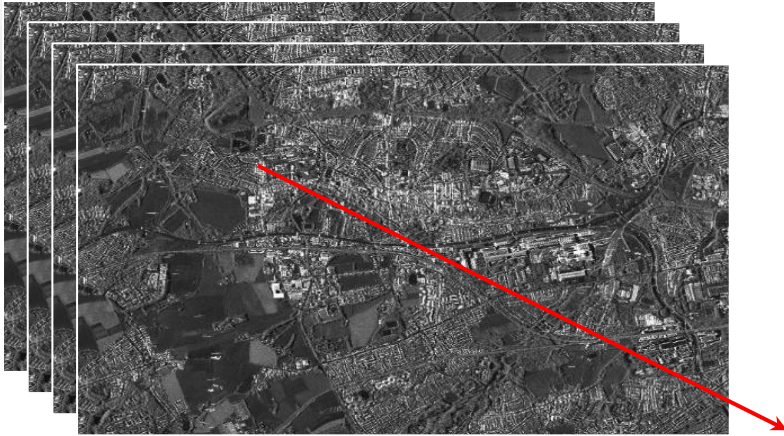


# Inhalt

- BIM-Modell
- **SAR-Produkt**
- Fusion: BIM + SAR
- Demo-Plattform



# TerraSAR-X-Bilder

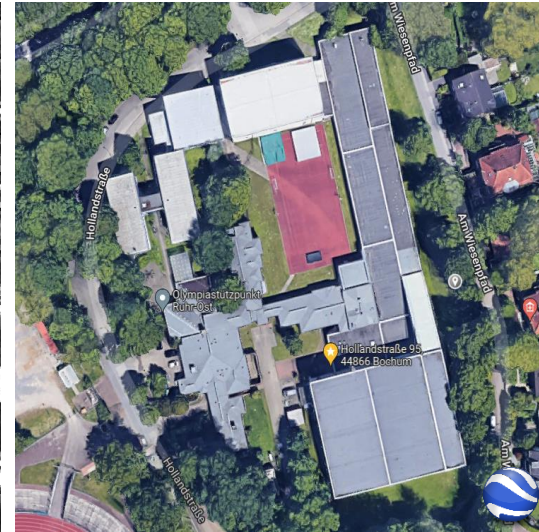
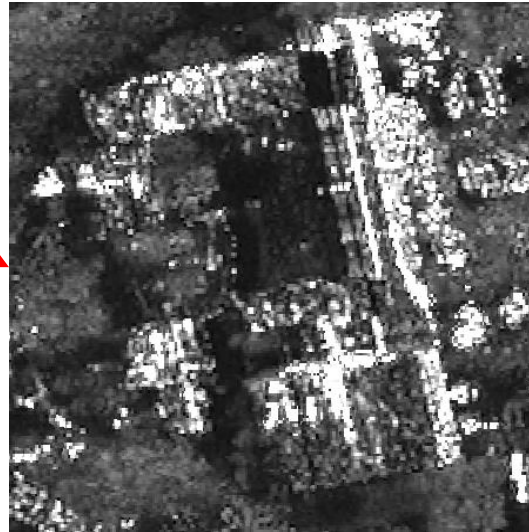


28 Bilder

Zeitraum: Januar 2018 – Oktober 2019

HR SpotLight 300 MHz

HH-Polarization

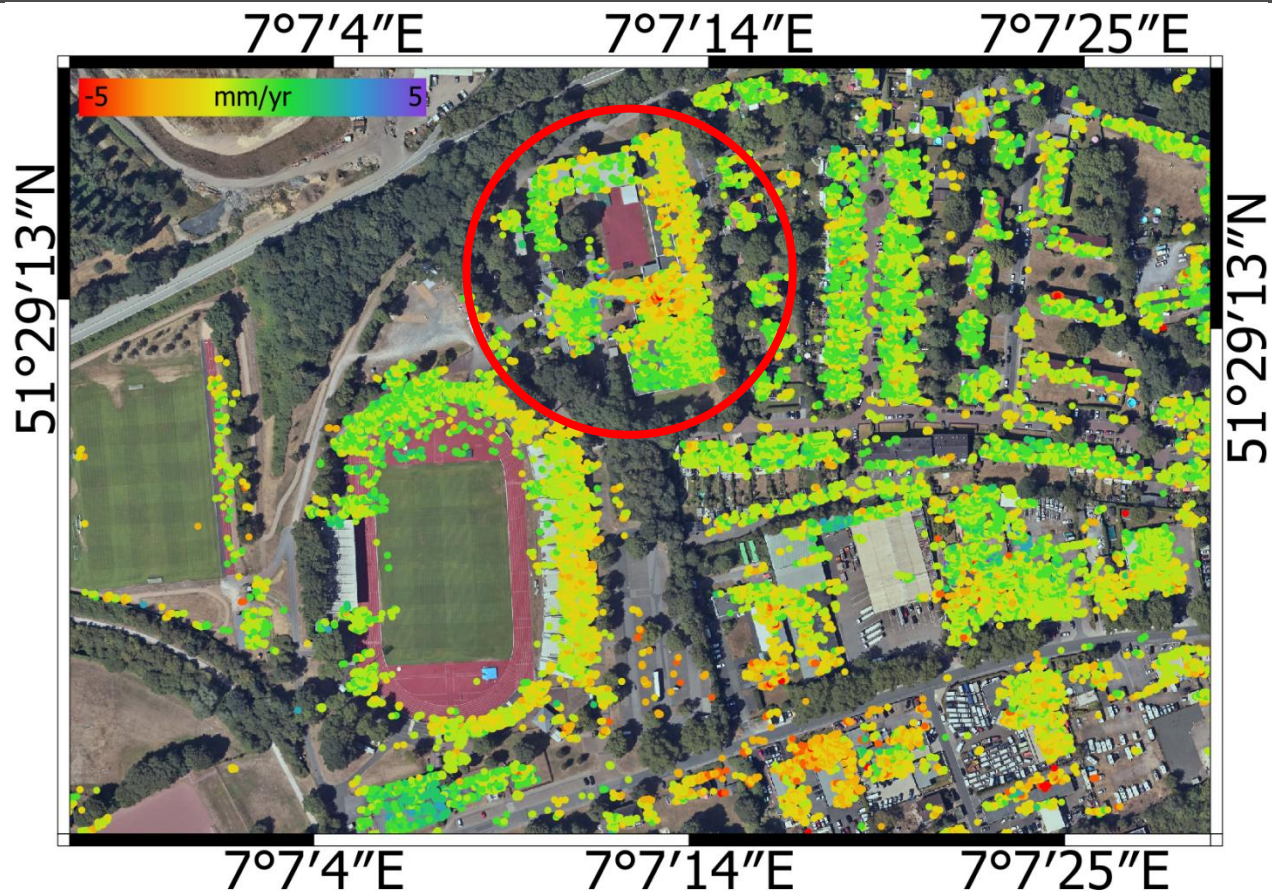


(DLR-Project MTH3793)





## PSI-Karte





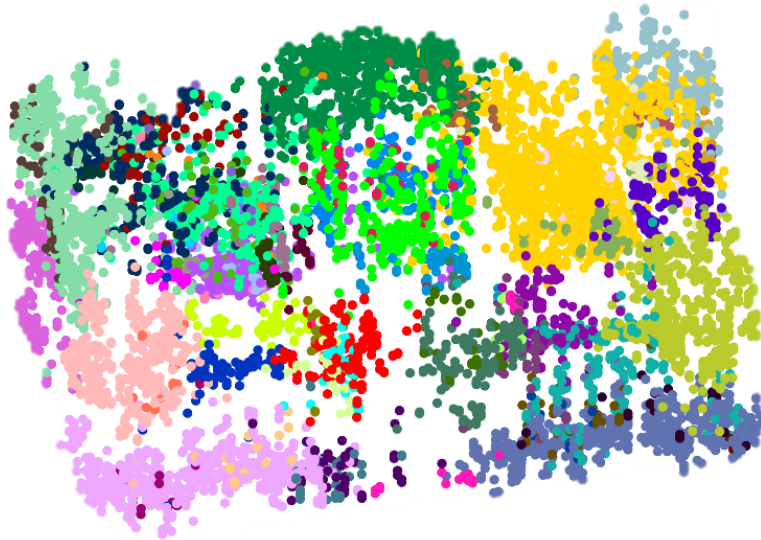


# Inhalt

- BIM-Modell
- SAR-Produkt
- **Fusion: BIM + SAR**
- Demo-Plattform



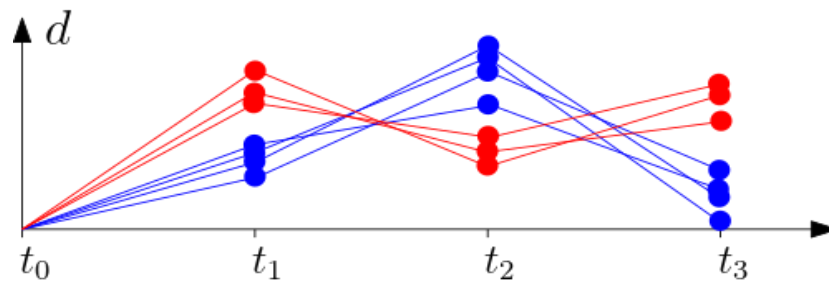
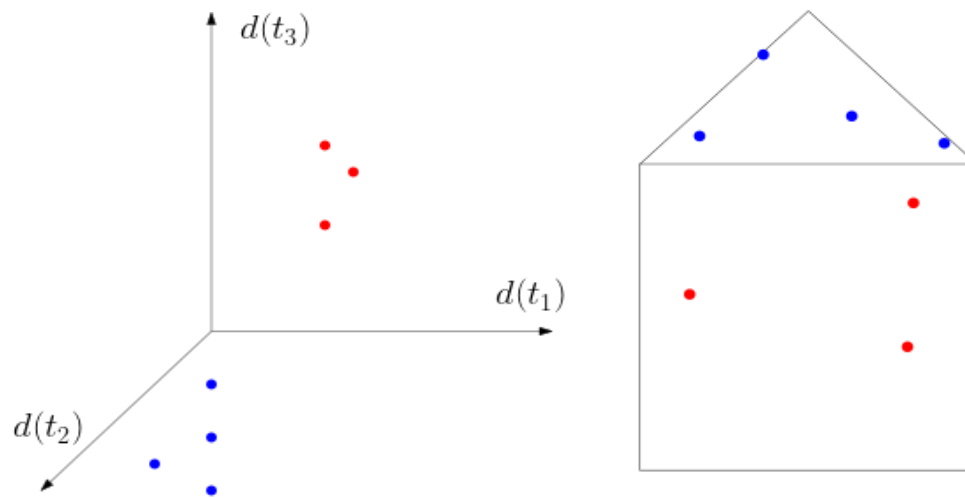
# Zuordnung von PS-Punkten zu Teilstrukturen



Schneider, P. J. & Soergel, U. [2021] Clustering Persistent Scatterer Points Based on a Hybrid Distance Metric. In: Pattern Recognition. DAGM GCPR 2021. Lecture Notes in Computer Science, vol 13024. Springer.

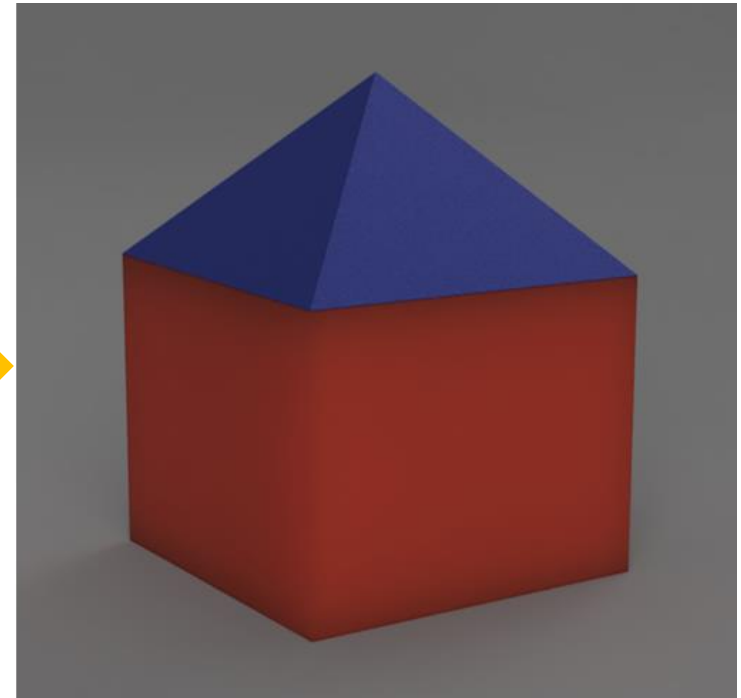
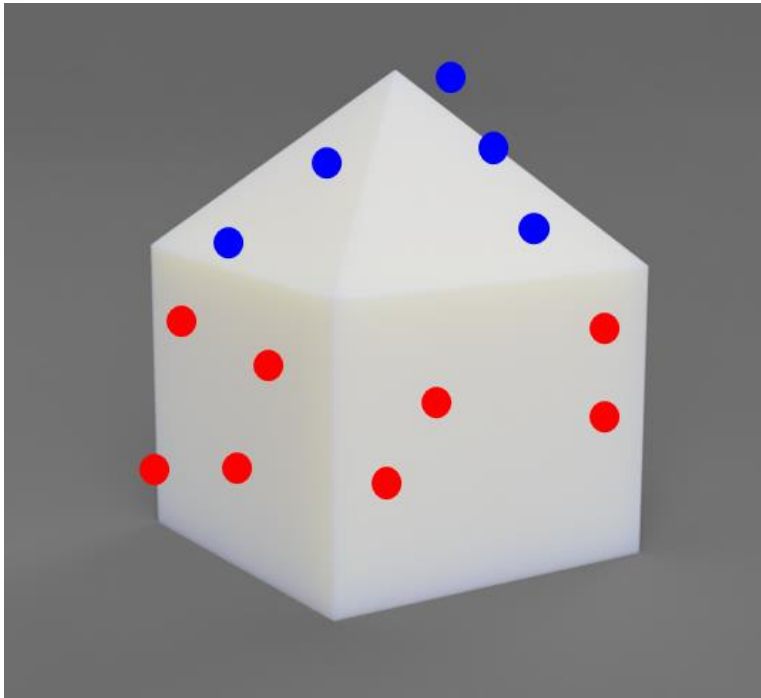


## Clustering von PS-Punkten



Schneider, P. J. & Soergel, U. [2021] Clustering Persistent Scatterer Points Based on a Hybrid Distance Metric. In: Pattern Recognition. DAGM GCPR 2021. Lecture Notes in Computer Science, vol 13024. Springer.

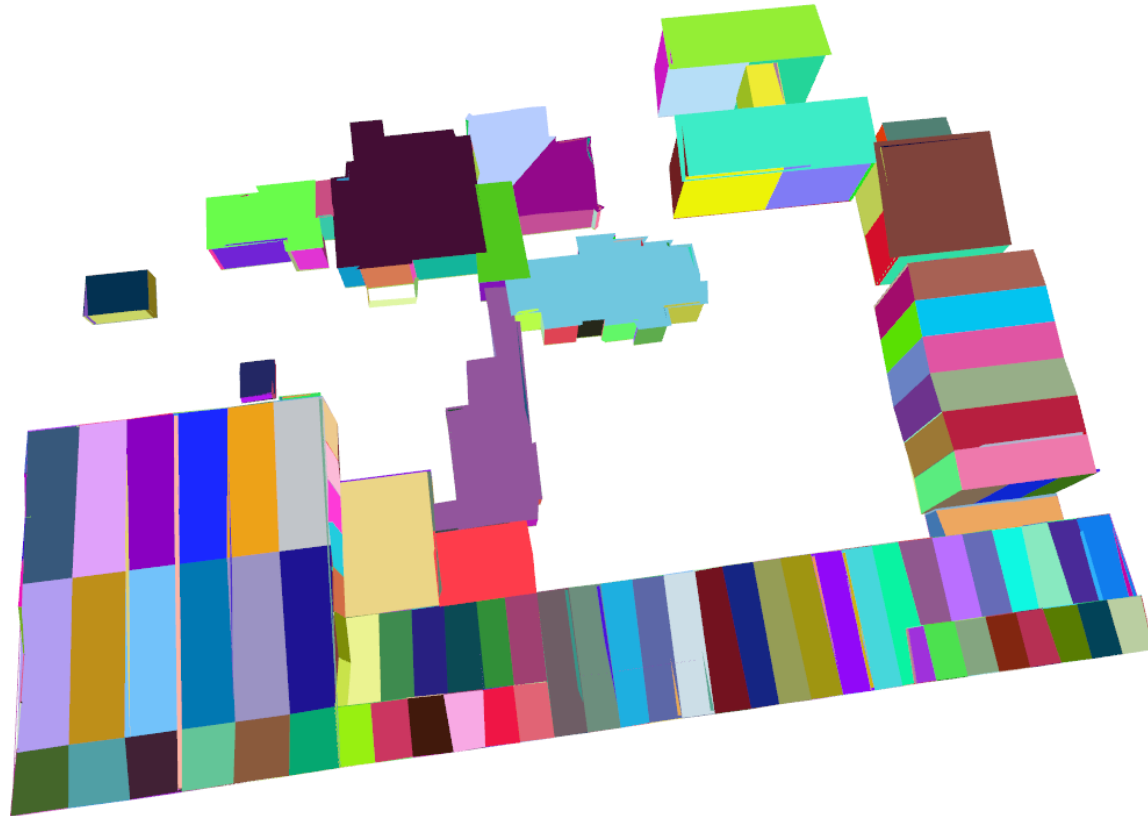
# Fusion von PS-Gruppen und BIM-Modell



Schneider, P. J. & Soergel, U. [2021] Clustering Persistent Scatterer Points Based on a Hybrid Distance Metric. In: Pattern Recognition. DAGM GCPR 2021. Lecture Notes in Computer Science, vol 13024. Springer.



# Fusioniertes BIM-Modell







# Inhalt

- BIM-Modell
- SAR-Produkt
- Fusion: BIM + SAR
- **Demo-Plattform**

# GeForce Experience



- Select All
- WALLS
  - SLABS
  - ROOFS
  - BEAM
  - COLUMN

**Screenshot**  
Alt+F1

**Photo mode**  
Alt+F2

**Game filter**  
Alt+F3

**Instant Replay**

Off

**Record**

Recording

**Broadcast LIVE**

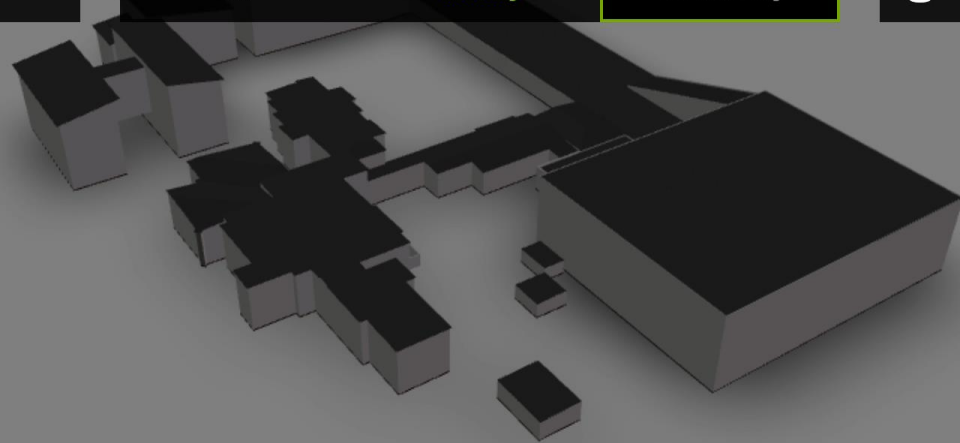
Not broadcasting

**Performance**

**Gallery**

Microphone icon, Video camera icon, Gear icon

Recording has started





# BIMSAR 2



Technische  
Hochschule  
Georg Agricola

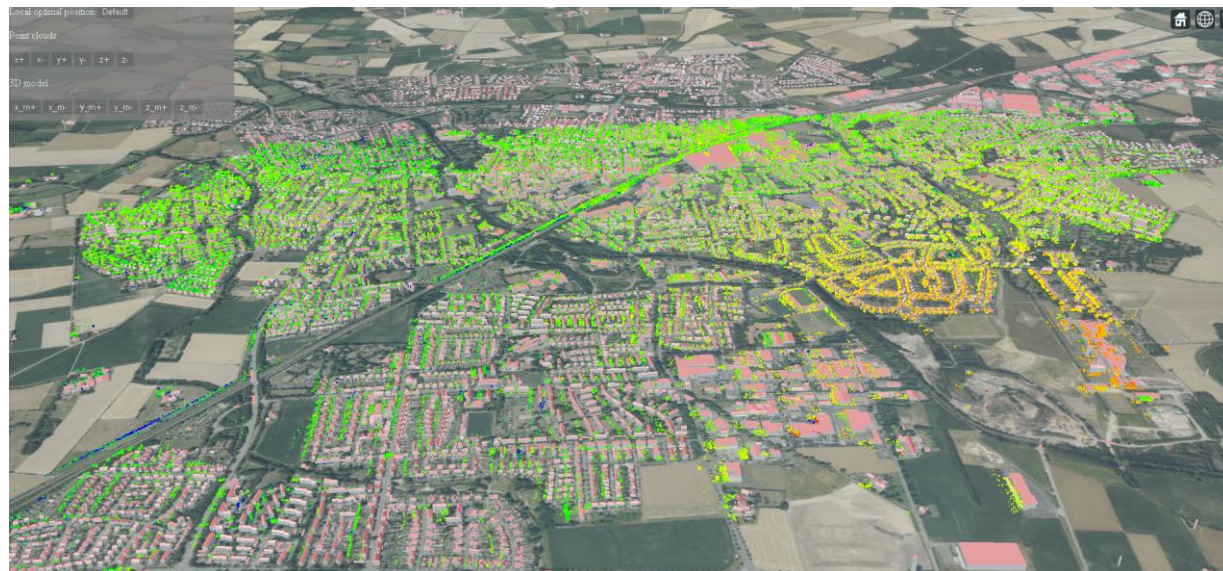
Gefördert durch:



aufgrund eines Beschlusses  
des Deutschen Bundestages



# Ziel

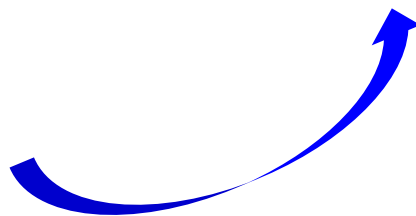
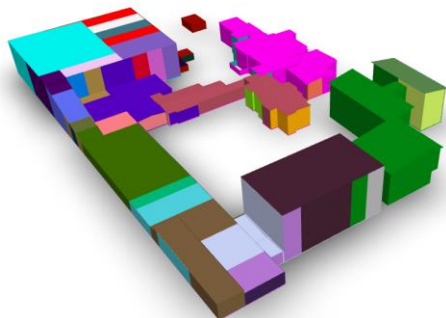


Ahlen

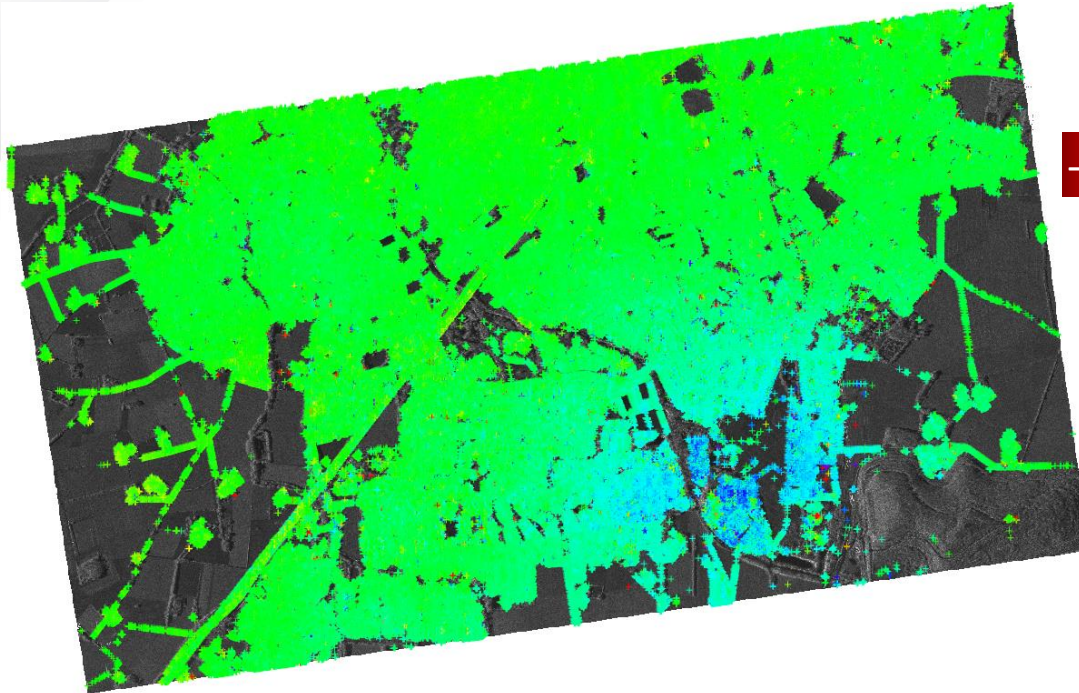


Select All

- ClusterID0
- ClusterID1
- ClusterID3
- ClusterID5
- ClusterID6
- ClusterID7
- ClusterID8
- ClusterID9
- ClusterID10
- ClusterID17
- ClusterID25
- ClusterID29
- ClusterID31
- ClusterID32
- ClusterID34
- ClusterID36
- ClusterID38
- ClusterID39



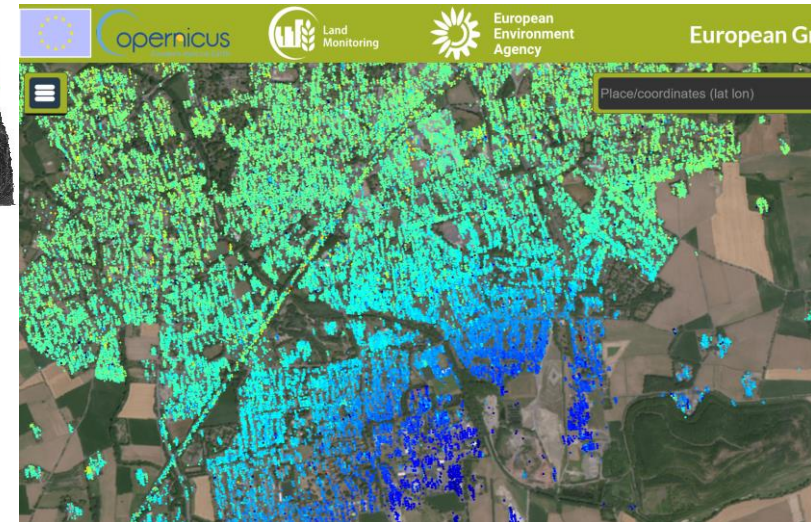
# Bewegungsanalyse durch E-MTInSAR



Sliding Spotlight TSX, PS- + DS-Punkte



## Sentinel-1, PS-Punkte







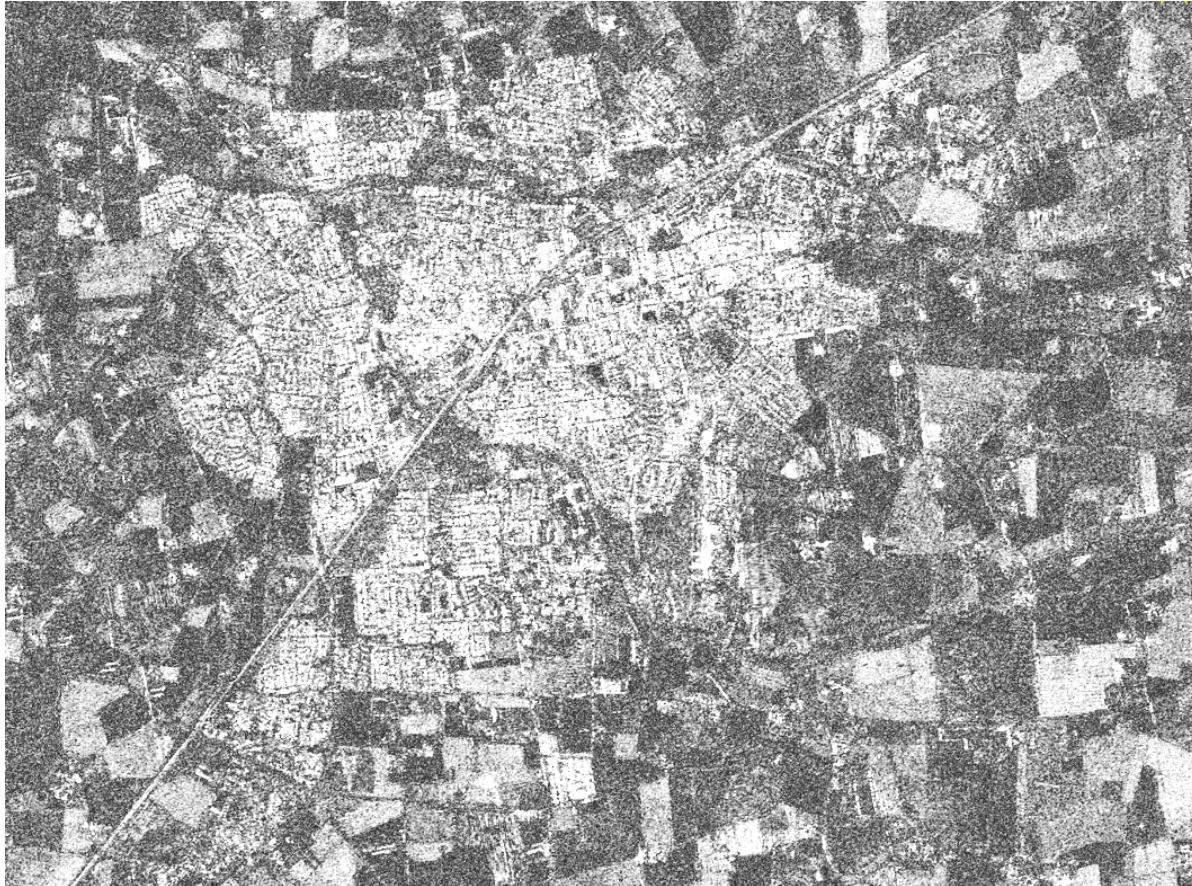
# Verwendung von PALSAR2-Daten (L-Band) in E-MTInSAR

## ALOS2 PALSAR-2 Observation Request Sheet

No.	Obs. Mode	Polarization	Obs. Direction	Fly Direction	Beam No.	Off Nadir Angle	Altitude[m]	Obs. Start Time (UTC)	Obs. Start PATH Number	Obs. End Time (UTC)	Obs. End PATH Number	Obs. Area
1	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/5/27 23:10:03	198	2024/5/27 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
2	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/6/10 23:10:03	198	2024/6/10 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
3	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/6/24 23:10:03	198	2024/6/24 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
4	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/7/8 23:10:03	198	2024/7/8 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
5	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/7/22 23:10:03	198	2024/7/22 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
6	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/8/5 23:10:03	198	2024/8/5 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
7	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/8/19 23:10:03	198	2024/8/19 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
8	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/9/2 23:10:03	198	2024/9/2 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
9	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/9/16 23:10:03	198	2024/9/16 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
10	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/9/30 23:10:03	198	2024/9/30 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
11	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/10/14 23:10:03	198	2024/10/14 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
12	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/10/28 23:10:03	198	2024/10/28 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
13	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/11/11 23:10:03	198	2024/11/11 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
14	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/11/25 23:10:03	198	2024/11/25 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
15	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/12/9 23:10:03	198	2024/12/9 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
16	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2024/12/23 23:10:03	198	2024/12/23 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
17	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2025/1/6 23:10:03	198	2025/1/6 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
18	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2025/1/20 23:10:03	198	2025/1/20 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml
19	Ultra-Fine	HH	Right Direction	Ascending	U2-6			2025/2/3 23:10:03	198	2025/2/3 23:10:11	198	PALSAR2 Aufnahme Ahlen.kml



# Coherence, 27.05.2024 vs 08.07.2024





- **Sammeln aus heterogenen Quellen**
  - Bürgerinformationsdienst der RAG
  - Geobasis NRW
  - Open Street Map
  - LANUV
  - Geologischer Dienst
  - ...

## • Evaluierung der Daten

- Allgemeine Informationen (Provider, Referenz, Bereitstellung)
- Qualitätsmerkmale (Positionsgenauigkeit, zeitliche Genauigkeit, Attribuierung, Auflösung)
- Zweck, erste Visualisierungsidee, Verknüpfung zu anderen Daten
- ISO 19157 - Geographic information — Data quality

→ 20 Datensätze mit ihren dazugehörigen

general information							quality information					
provider	topic	name / layer	source	format	service	public / privat	spatial resolution	spatial accuracy	time span	temporal accuracy		
RAG	mining	mining activities	<a href="https://geodaten.rag.de/mapapps/resources/apps/bid/index.html?lang=de">https://geodaten.rag.de/mapapps/resources/apps/bid/index.html?lang=de</a>	json	<a href="https://geodaten.rag.de/wss/service/ags-relay/AGS_DMZ/guest/arcgis/rest/services/BID">https://geodaten.rag.de/wss/service/ags-relay/AGS_DMZ/guest/arcgis/rest/services/BID</a>	private / (public)						
							analysis					
							Shape	attributes	purpose	visualization	direct connected to...	similar to...
							polygon	Herkunft Bergwerk Eaufeld Bauhöhe Abbau_von Abbau_bis Abbaufahr Floez Müll_h Müll_m Shape_Length Shape_Area Floez NN_höhe Mächt	impact to the surface	3D, raster, polygon		<a href="https://www.arcgis.com/home/webcontent/viewer.html?webcene=6d596f0f91a848459284ff40c218f870">https://www.arcgis.com/home/webcontent/viewer.html?webcene=6d596f0f91a848459284ff40c218f870</a>

# Bewegungsklassifizierung auf Stadtebene

## PS/DS-InSAR Daten

Vorab-Zuordnung zu Objekten (z.B. Gebäude)

## Dimensionsreduktion

UMAP - Uniform Manifold Approx. and Projection

## Clustering

HDBSCAN - Hierarchical Density-Based Spatial Clustering

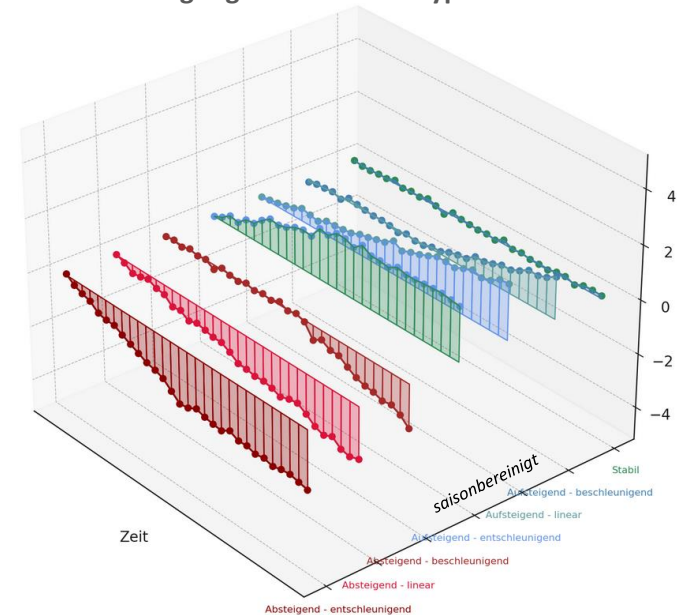
## Zuordnung Objekte (BIM-Elemente)

"Hungarian" Algorithmus (Kuhn)

## Risikoabschätzung

Potenzielle Scherbeanspruchung durch ungleichförmige Bewegung

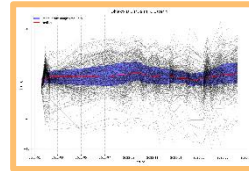
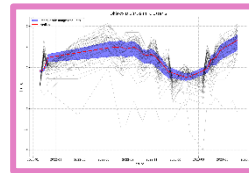
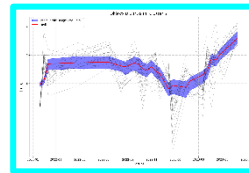
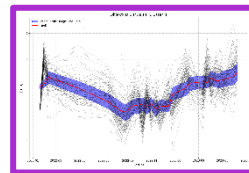
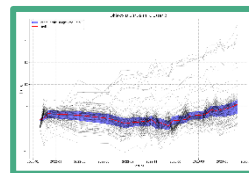
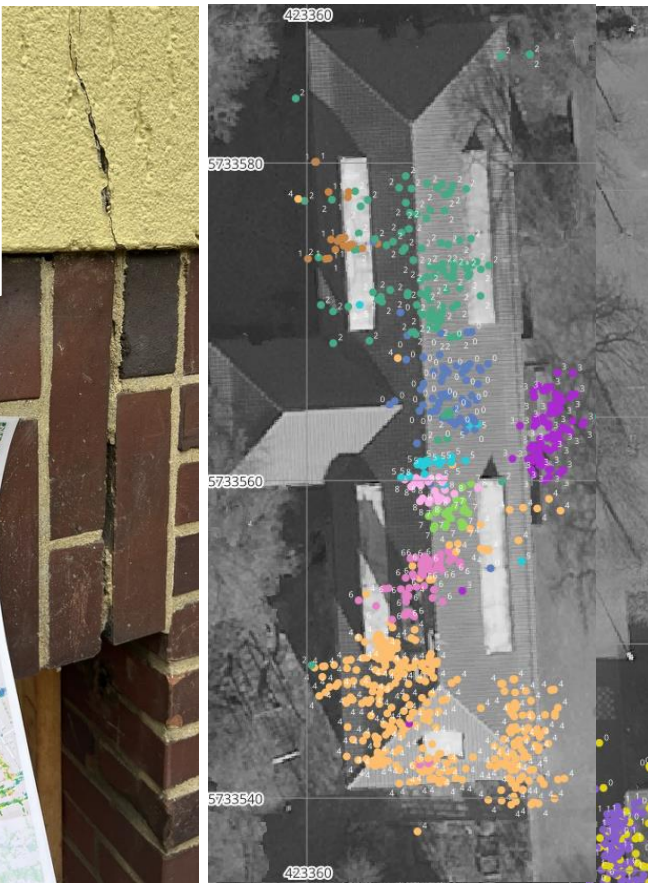
## Bewegungsmuster - Idealtypen



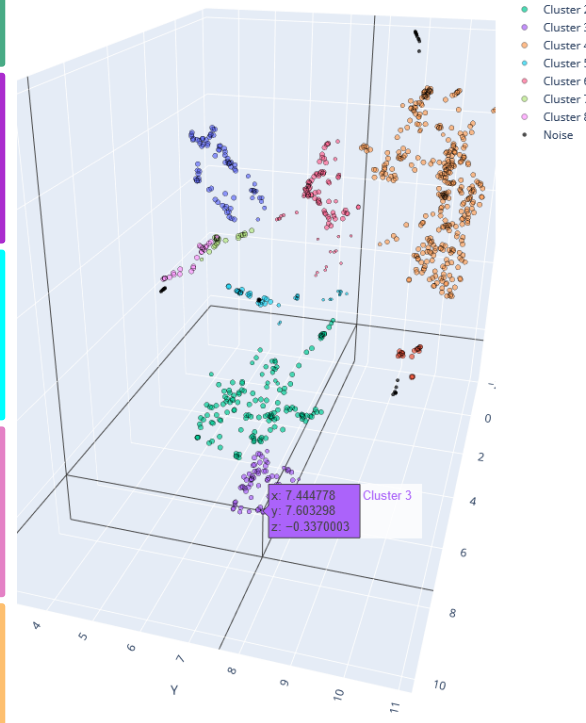




# Auswertung Objektebene – Beispiel Standort “Mammutschule”



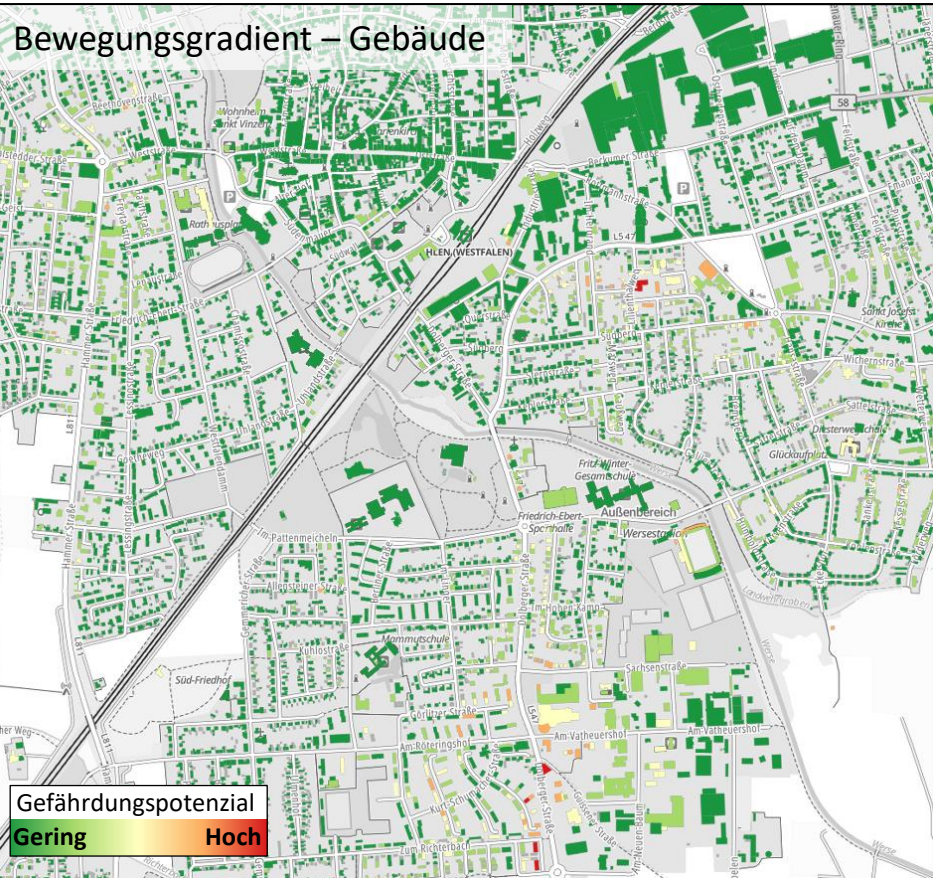
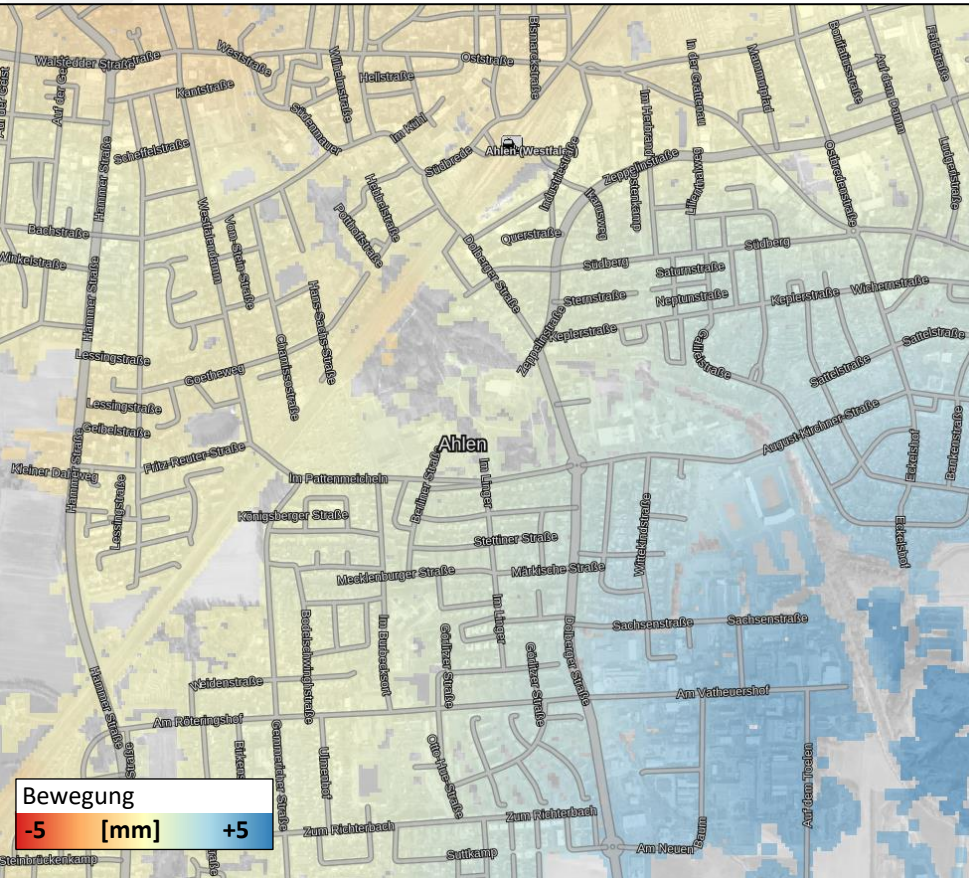
Estimated number of clusters: 9







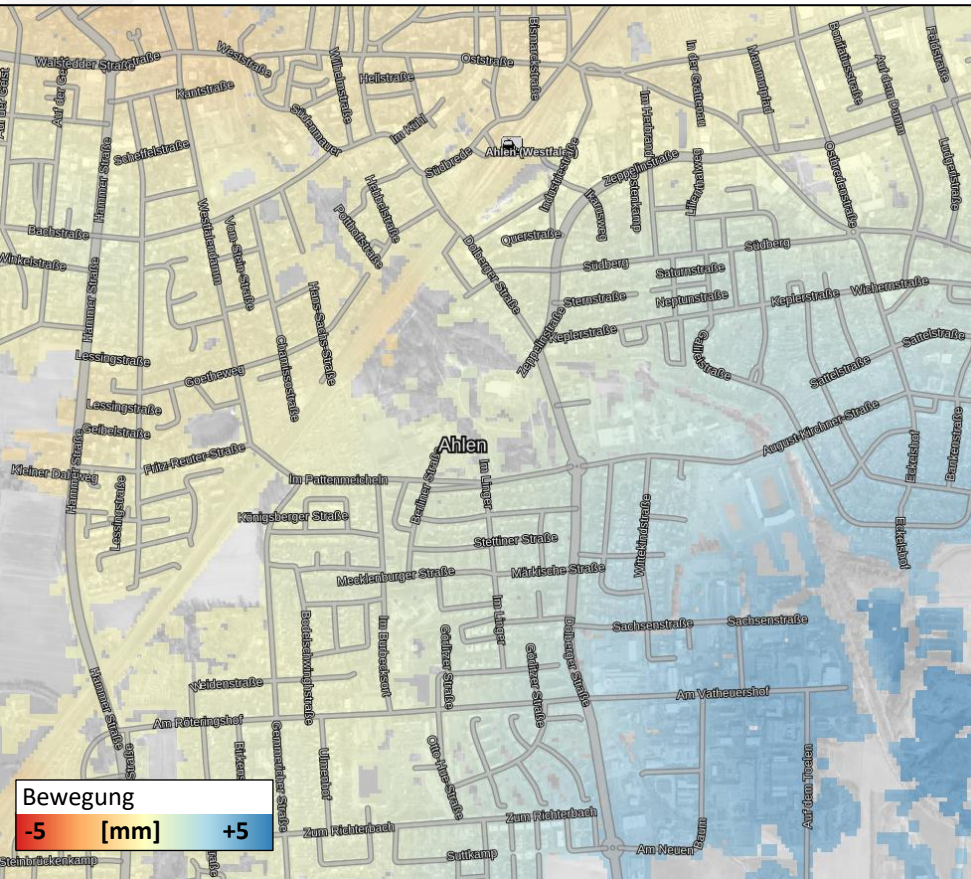
# Bewegungsgradienten



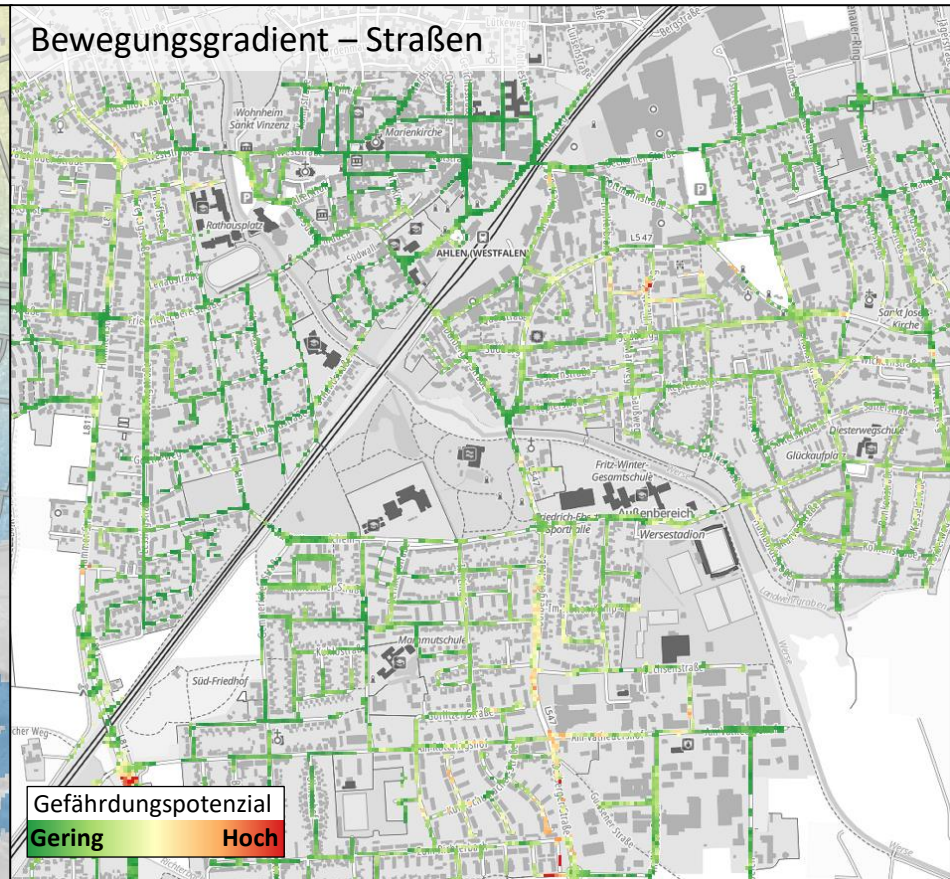




# Bewegungsgradienten



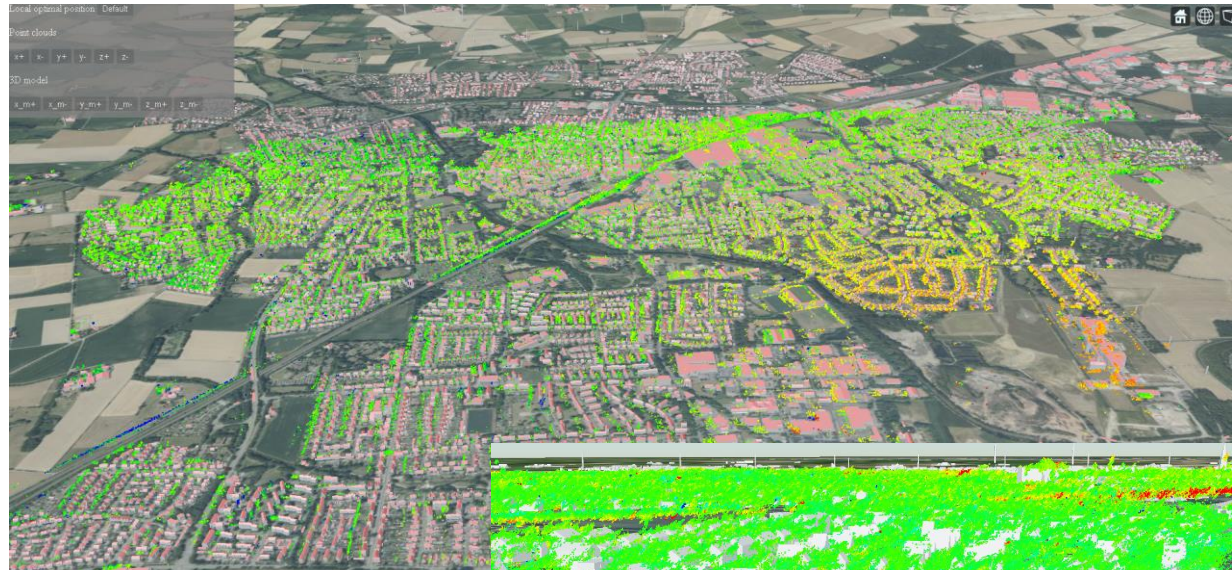
## Bewegungsgradient – Straßen





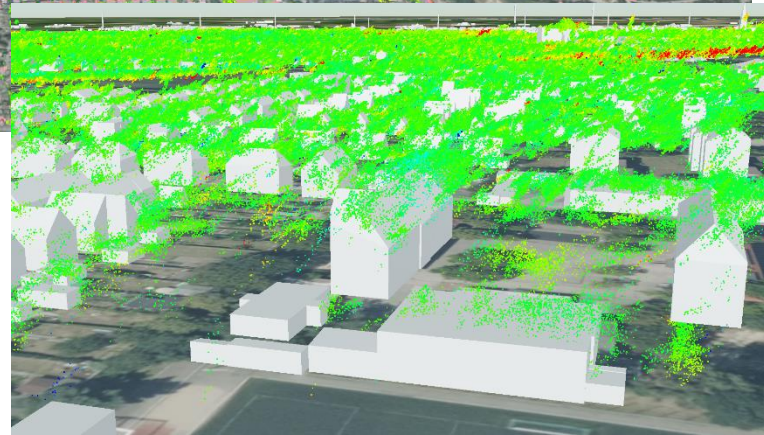
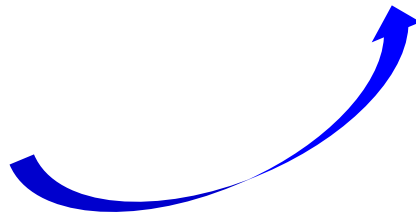
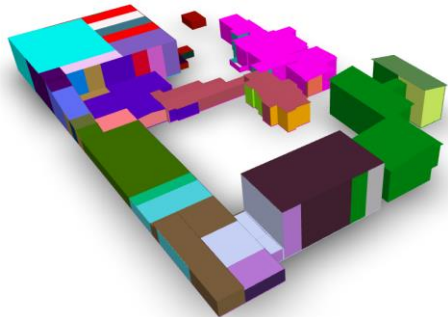


# Online-Plattform zur Bewegungsüberwachung auf Stadtebene



Select All

- ClusterID0
- ClusterID1
- ClusterID3
- ClusterID5
- ClusterID6
- ClusterID7
- ClusterID8
- ClusterID9
- ClusterID10
- ClusterID17
- ClusterID25
- ClusterID29
- ClusterID31
- ClusterID32
- ClusterID34
- ClusterID36
- ClusterID38
- ClusterID39



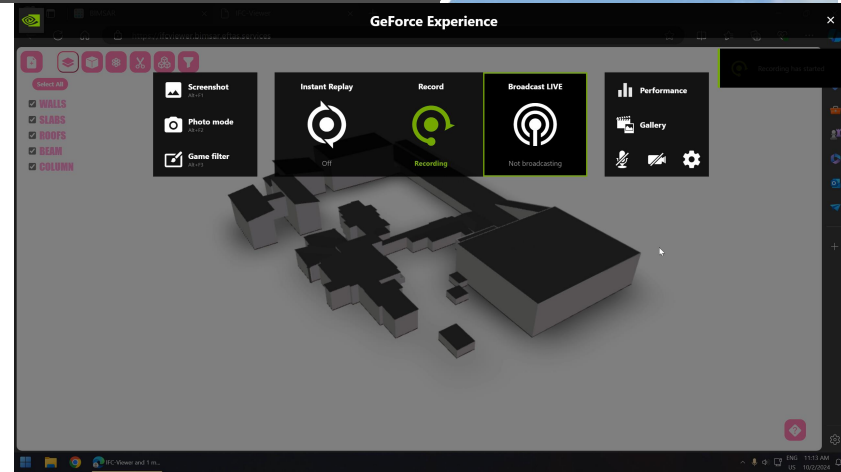


**EFTAS.GeoIT**  
PRECISELY FOR YOUR WORLD

BIMSAR:

<https://bimsar.eftas.services/>

Dr. Chia-Hsiang Yang  
chia-hsiang.yang@eftas.com  
+49 (0)251 133 07-0

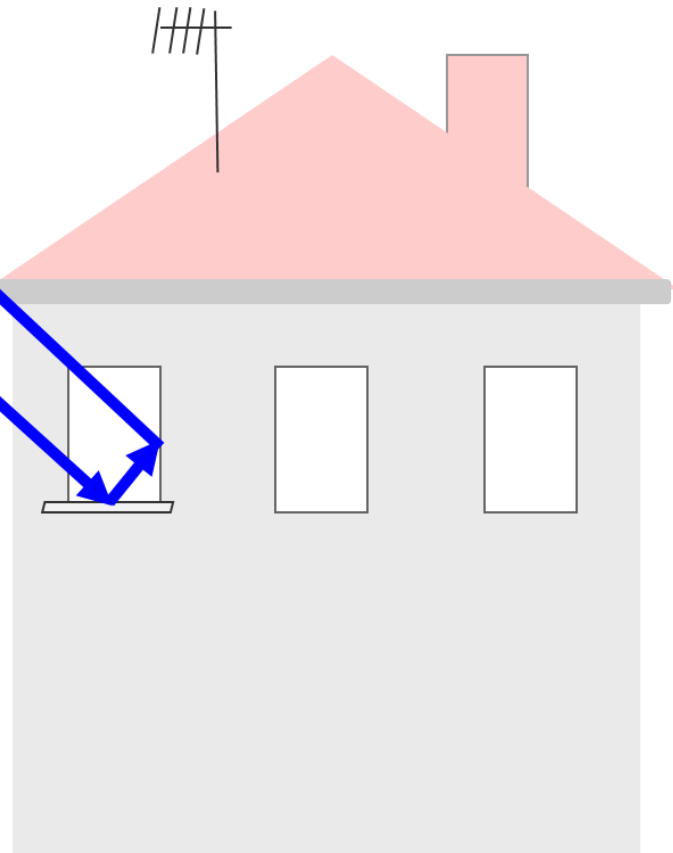
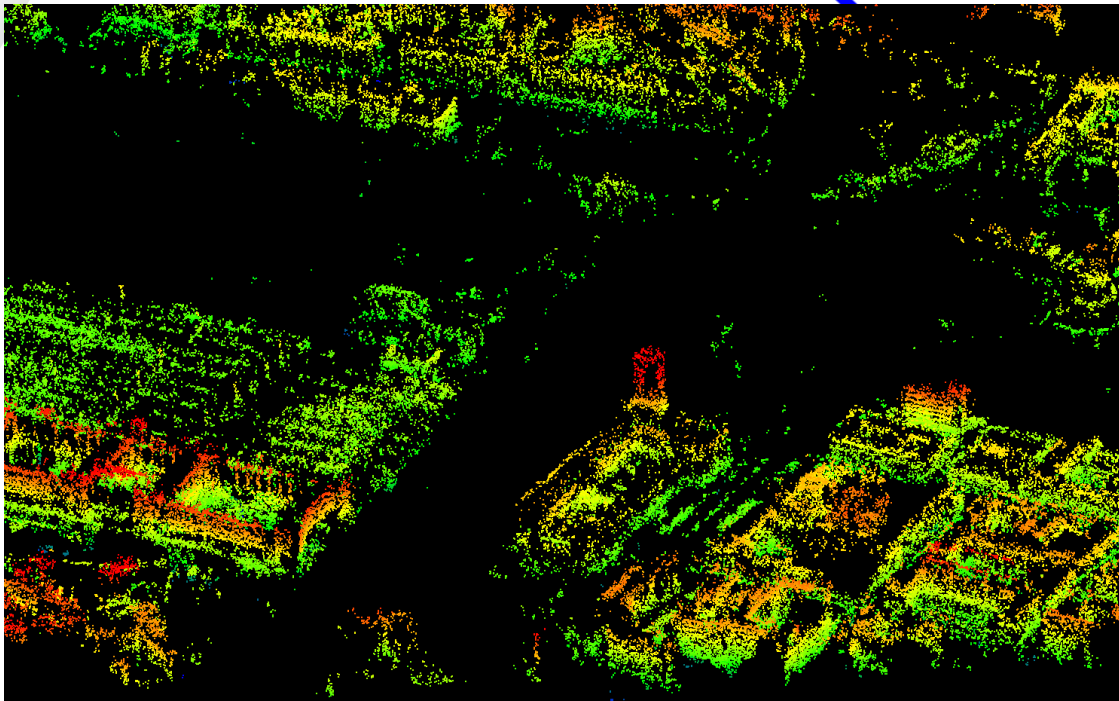


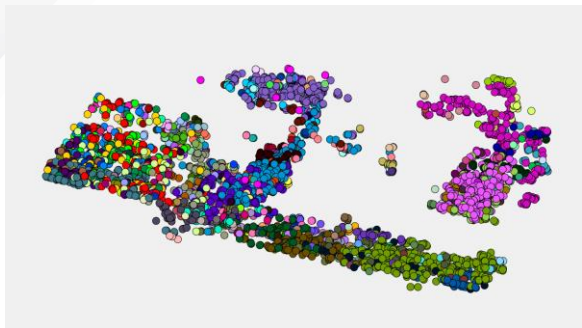




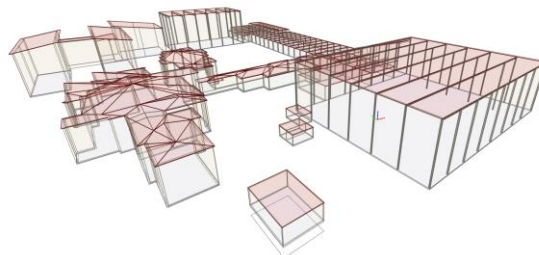


# PS-Punkte am Gebäude





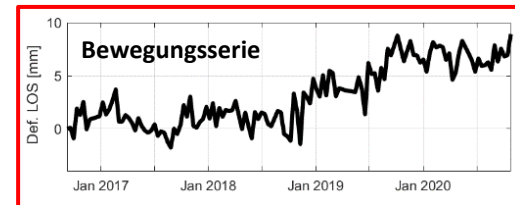
PS-Punkte



BIM-Modell

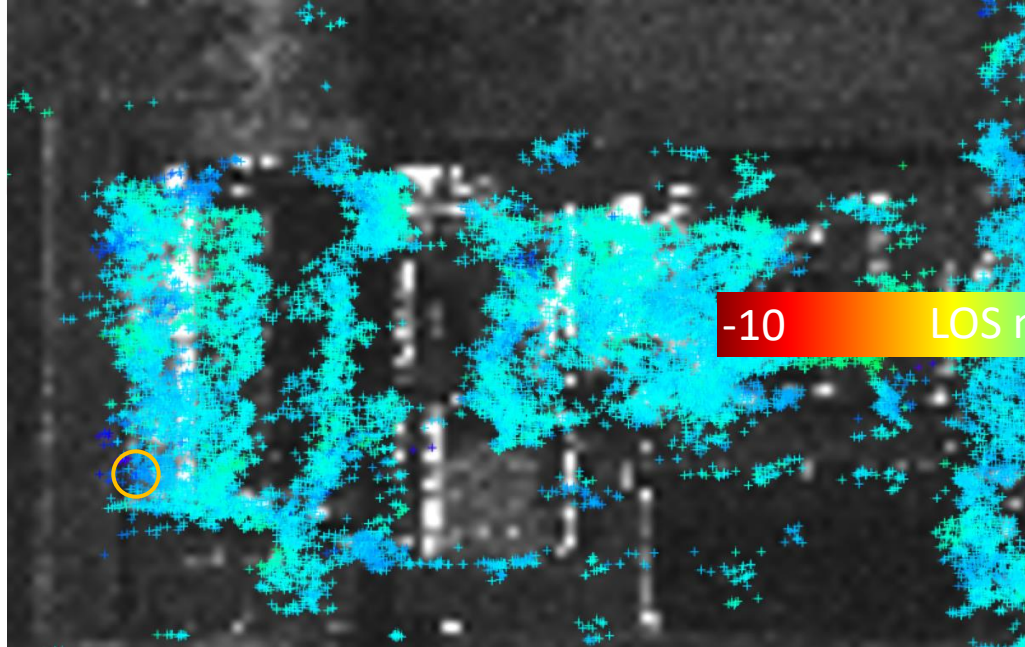


Verschmolzenes BIM-Modell



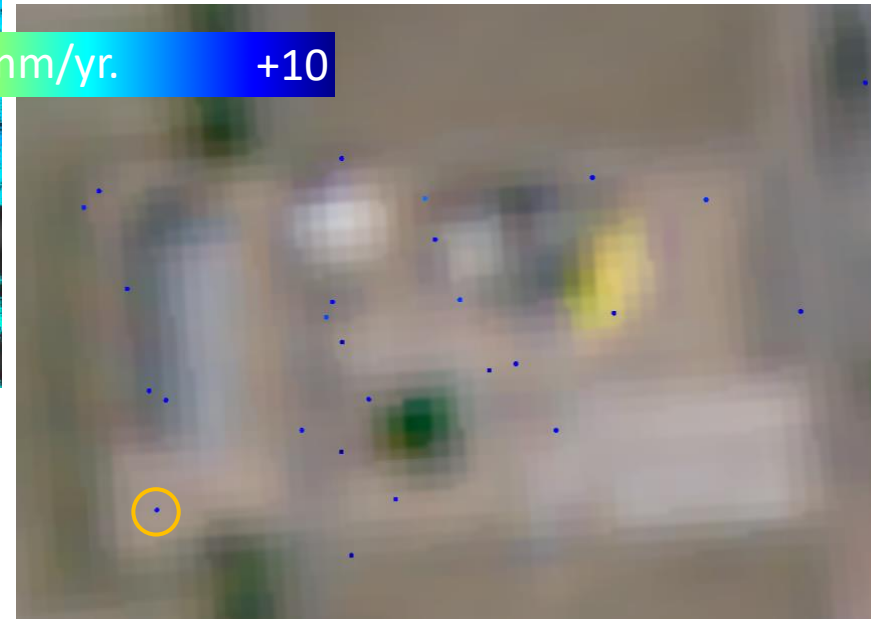
Pset_inсар	
AquisitionMode	Stripmap
d2021-01-16	0
d2021-01-27	2,1
d2021-02-07	3,9
d2021-02-18	3,3
d2021-03-01	4,02
d2021-03-12	5,03
d2021-03-23	4,7
d2021-04-02	3,6
d2021-04-13	2,3
d2021-04-24	1,2
EndDate	2021-01-16T21:45:15
MeasuresExist	Ja
Number of Measures	42
Satellite	TerraSAR-X
StartDate	2021-01-16T21:45:15
Velocity	9,12

# Bewegungsanalyse durch E-MTInSAR



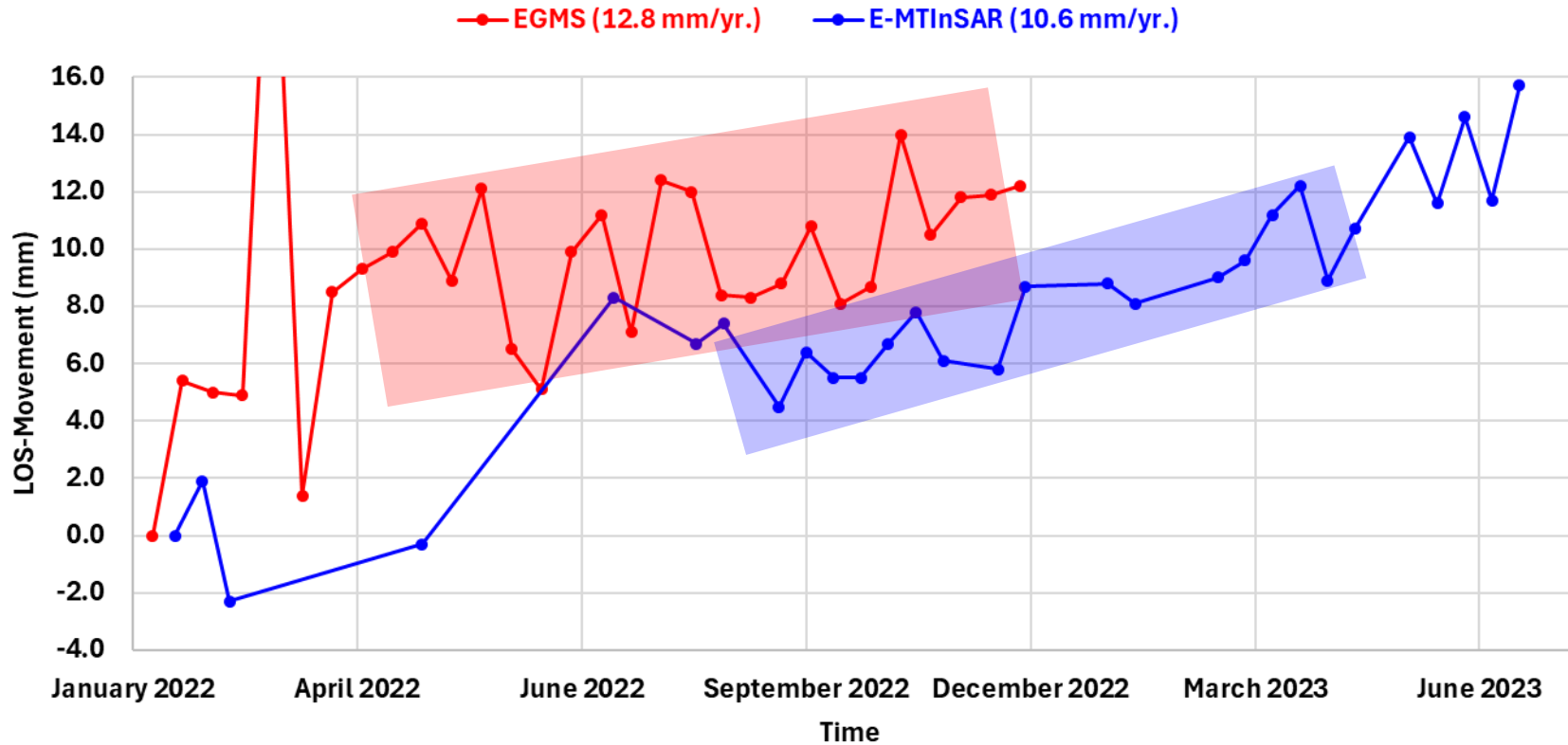
TSX, Asc, HH, Jan 2022 – Juli 2023

Sen1, Asc, VV, Jan 2018 – Dez 2022





# Bewegungsanalyse durch E-MTInSAR





## Ziele

- **Bewegungsanalyse durch E-MTInSAR (ähnlich wie SqueeSAR, PS + DS)**
- **Verwendung von PALSAR2-Daten (L-Band) in E-MTInSAR**
- **Bewegungsklassifizierung mittels KI-Ansatz**
- **Bewegungsanalyse mit Hilfe von Geodaten**
- **Online-Plattform zur Bewegungsüberwachung auf Stadtebene**