

An aerial Synthetic Aperture Radar (SAR) image of a mining site in the Saar Mining District, Germany. The image shows a large, dark, irregularly shaped area, likely a mine or processing plant, surrounded by green vegetation. Numerous colored dots (yellow, orange, red, green) are overlaid on the image, indicating specific locations or data points. The dots are most densely clustered in the lower-left and central areas of the mine site.

## Characteristics of L- and C- Band A-DInSAR datasets in the Saar Mining District, Germany

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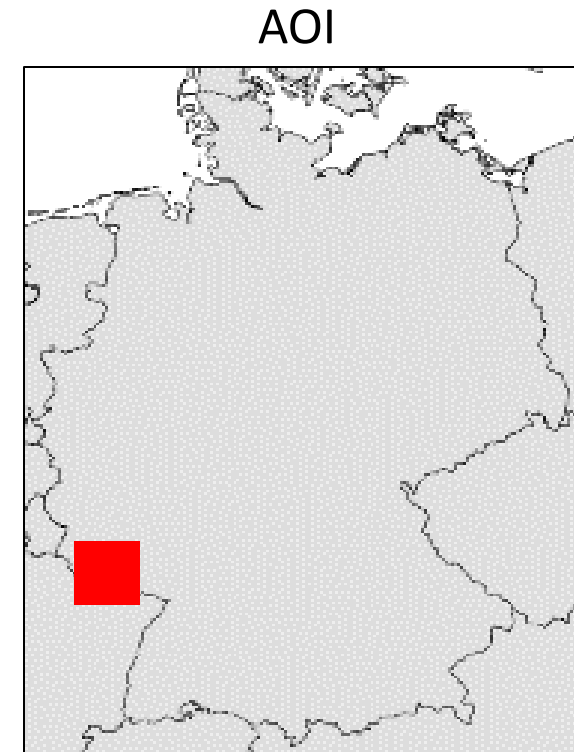
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<sup>2</sup>RAG K-SG -Post Mining -Geodata -Remote Sensing, RAG Aktiengesellschaft, Essen, Germany

# Motivation: Copernicus ROSE-L Pre-Launch: Geo-Hazard pilot site exploring synergies of C- and L-Band

## Saar Mining district:

- Abandoned Mining site in higher latitudes
- Urban subsidence and uplift
- Cross border phenomena Germany/France
- Patches of forested area, farmland, pastures, urban area
- Opencast mines, tailing piles
- Several subsiding and uplifting areas
- Extensive data of subsurface geology and mining activity
- Existing C-Band Ground-Motion-Services
- Extensive terrestrial monitoring incl. levelling
- Multisensor stations (MSST) combining GNSS, levelling and corner reflectors (CR)






# Saar Mining district: subsidence and uplift



Activity	Location	Time	Deformation
Active minning	French/German border	Until 2005	Subsidence
Flooding of abandoned mine sites	French/German border	After 2005	Uplift
Active mining	Germany	Until 2012	Subsidence
Flooding of abandoned mine sites – 1 <sup>st</sup> Phase	Germany	After 2012	Small uplift/stable
Flooding of abandoned mine sites – 2 <sup>nd</sup> Phase	Germany	Start foreseen ~2025	Uplift (~20cm expected)

# Motivation: Ground Motion Monitoring of Uplifts whilst the controlled flooding of abandoned mine workings

-  Saarland border
-  Boundary of minewater handling areas
-  Plumb Shafts

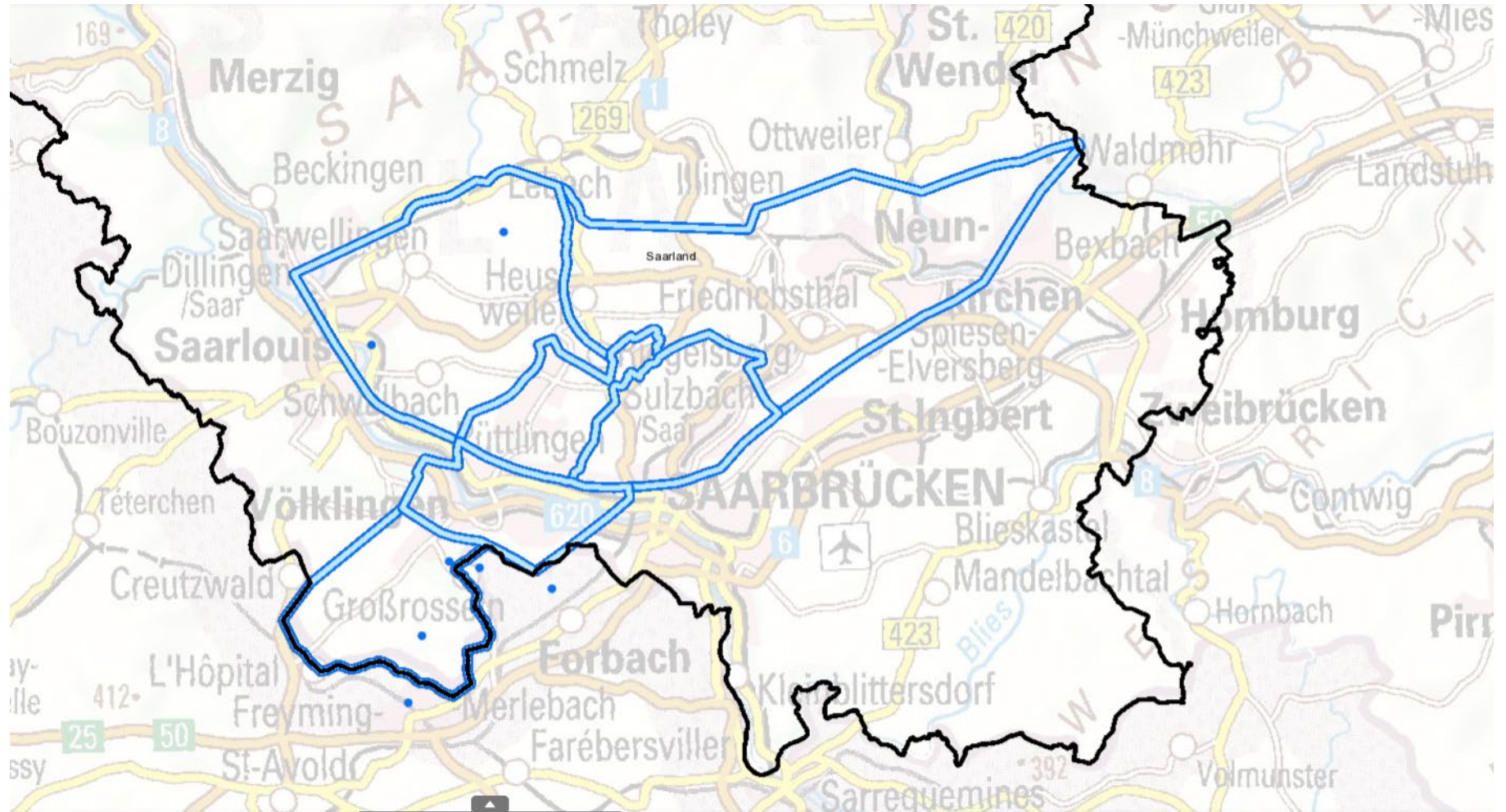






Image Area: 45 km x 82 km

# Motivation: Ground Motion Monitoring of Uplifts whilst the controlled flooding of abandoned mine workings

-  Saarland border
-  Boundary of minewater handling areas
-  Plumb Shafts
-  Mining before 1969

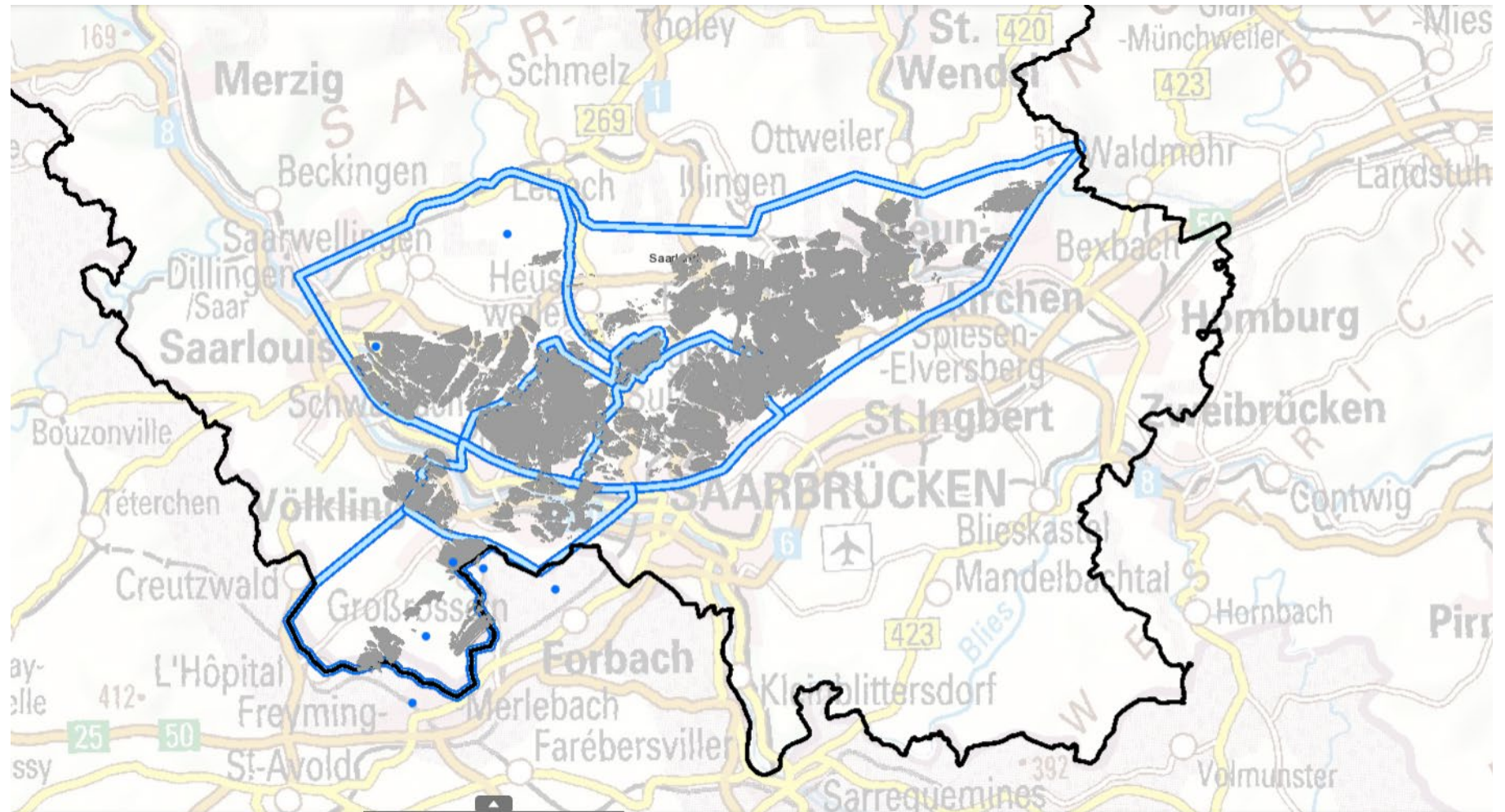







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-  Saarland border
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-  Mining before 1969
-  Mining 1969 – 2012

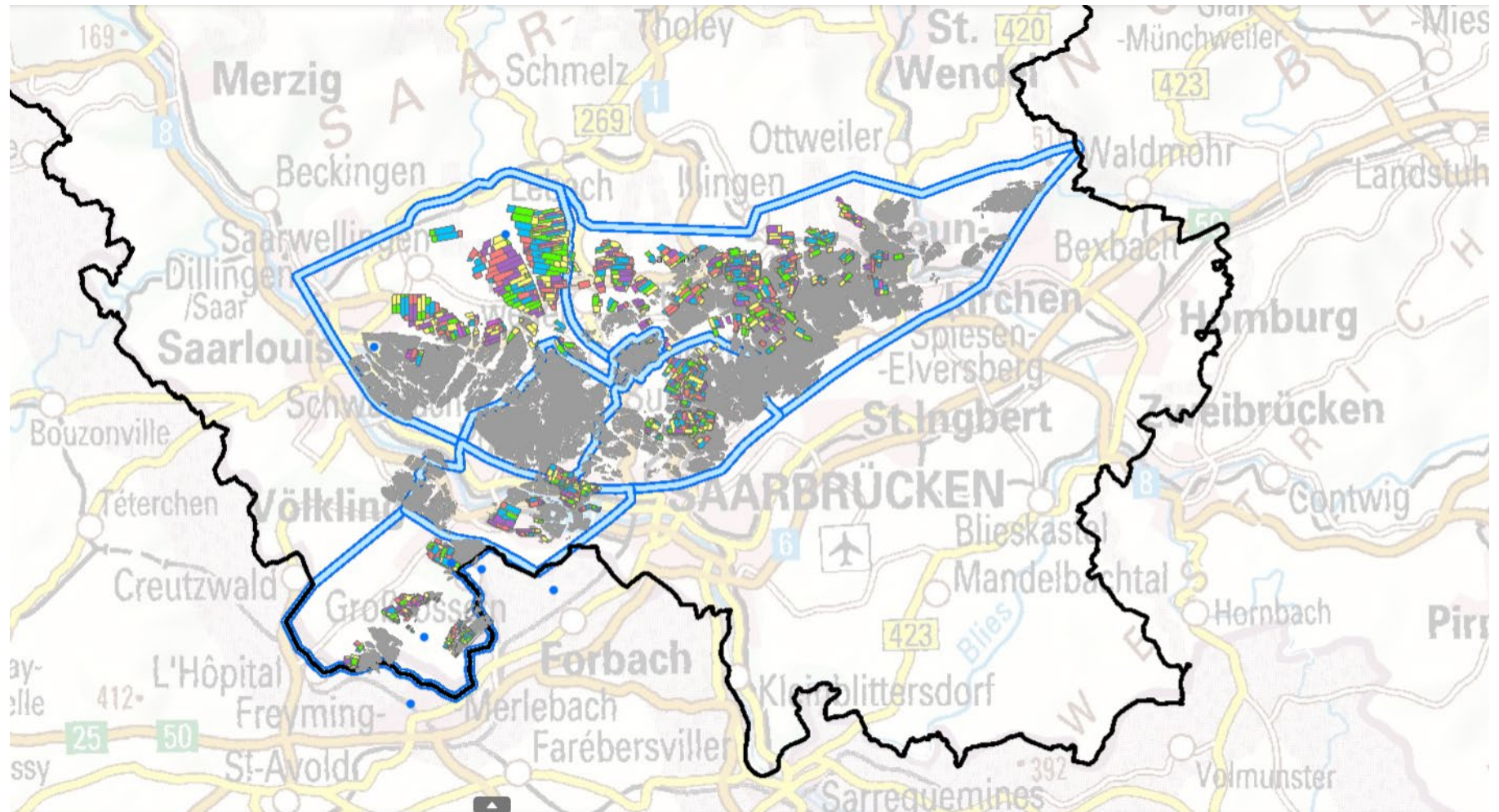


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-  Saarland border
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-  Mining before 1969
-  Mining 1969 – 2012
-  MSST (CR + GNSS etc.)

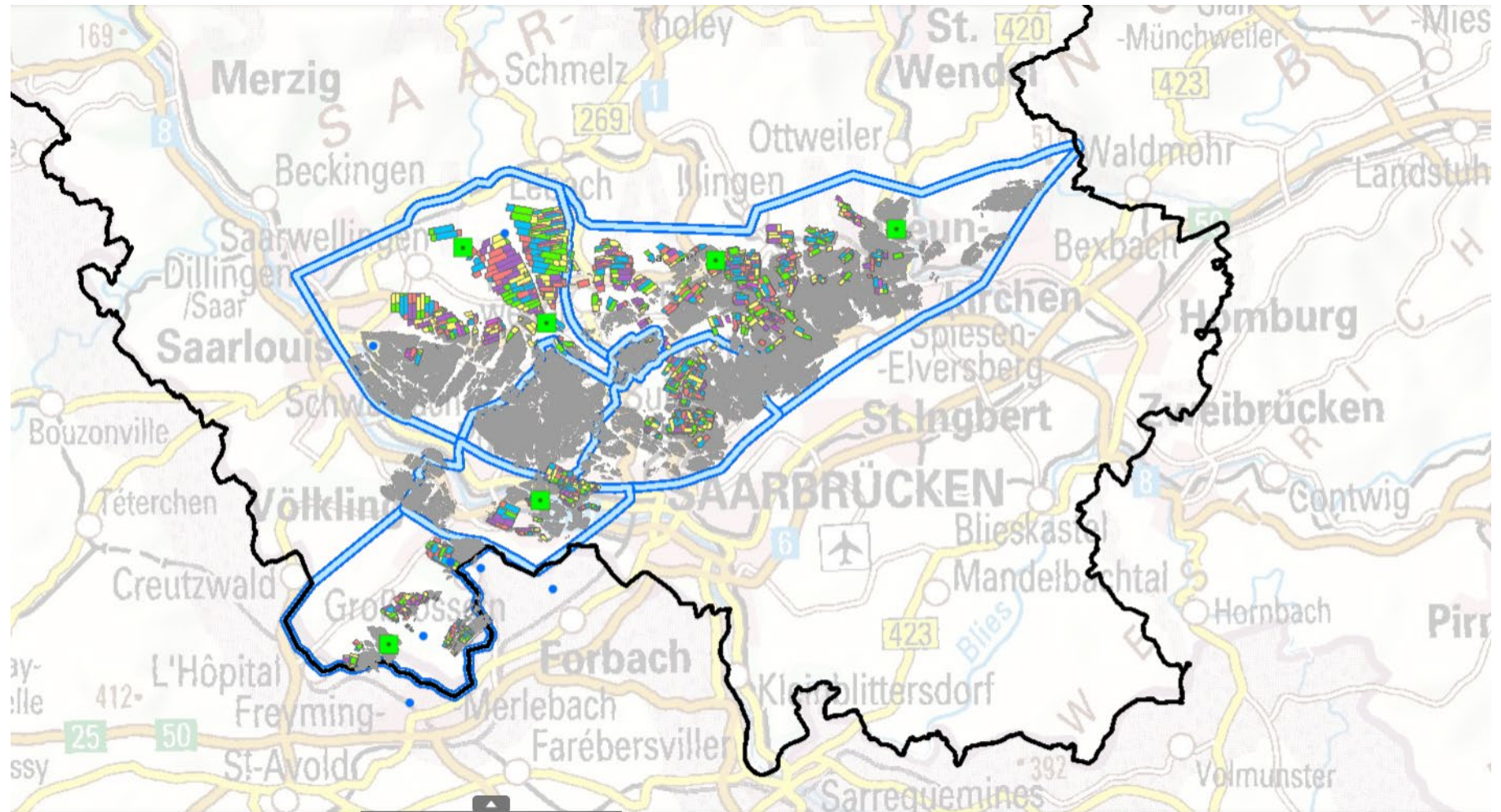









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-  Saarland border
-  Boundary of minewater handling areas
-  Plumb Shafts
-  Mining before 1969
-  Mining 1969 – 2012
-  MSST (CR + GNSS etc.)
-  Shafts & Openings

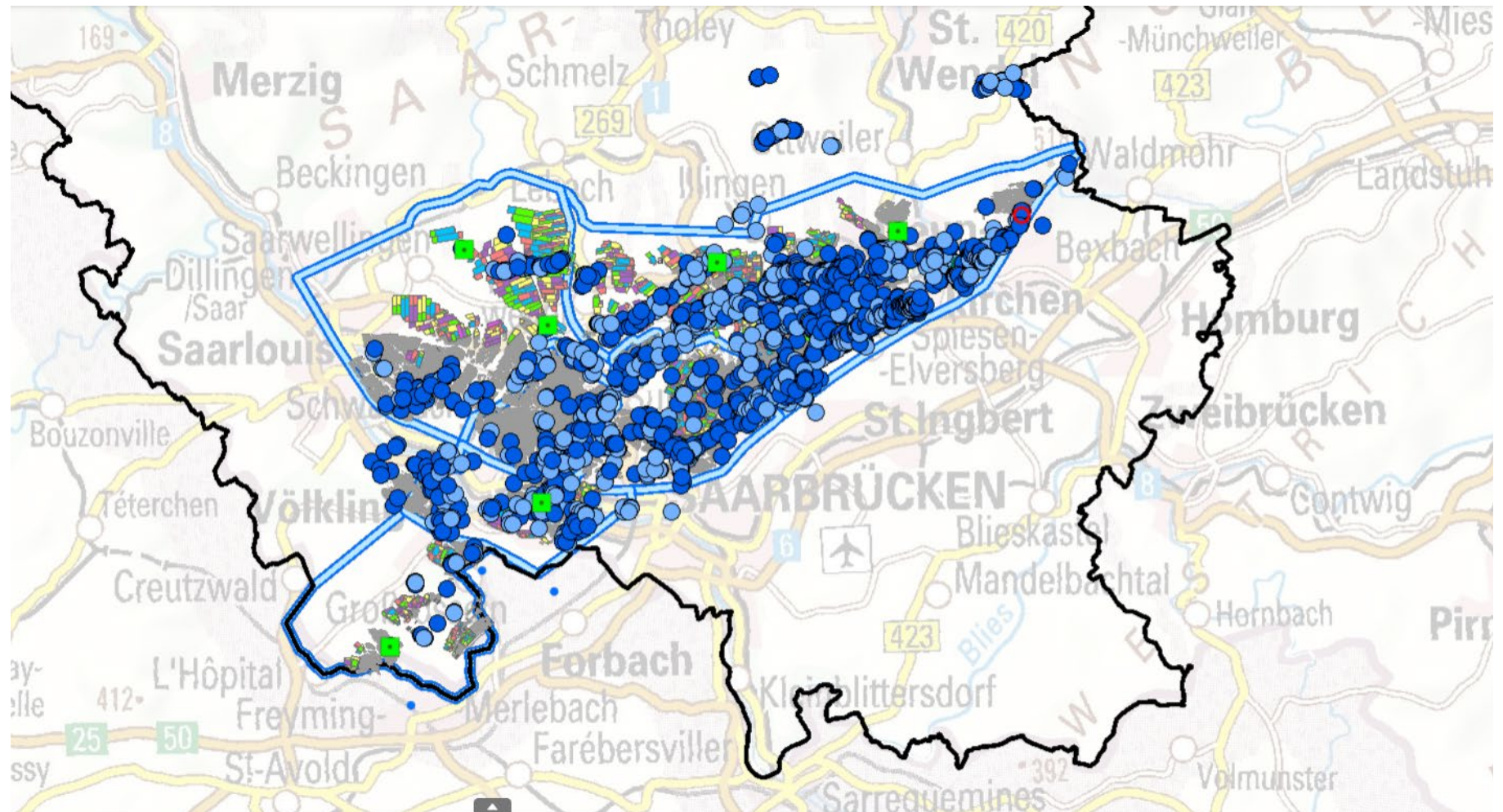


Image Area: 45 km x 82 km



Station SUES



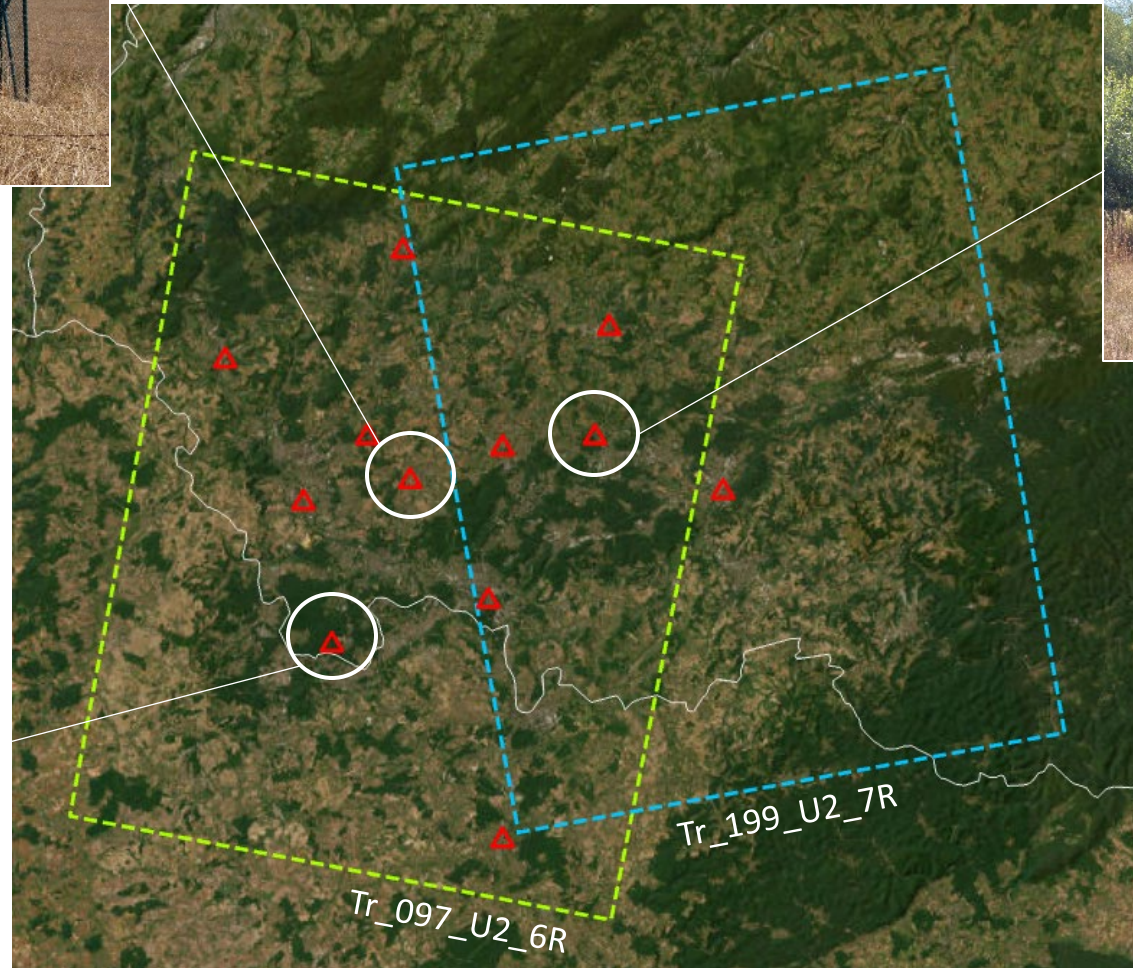
# Area of Interest and datasets



Station ANNA



GNSS Stations operating since 2021



Station LAUT



 ALOS-2 Descending Track 097

 ALOS-2 Ascending Track 199

 MSST

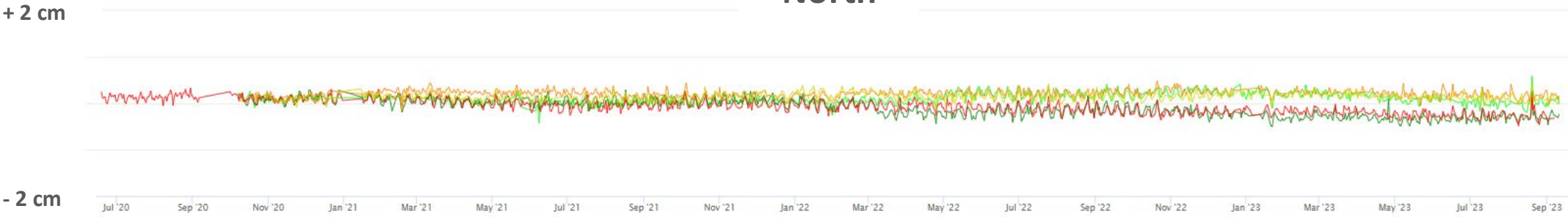
# Permanent GNSS measurements on MSST: daily mean; July 2020 – September 2023



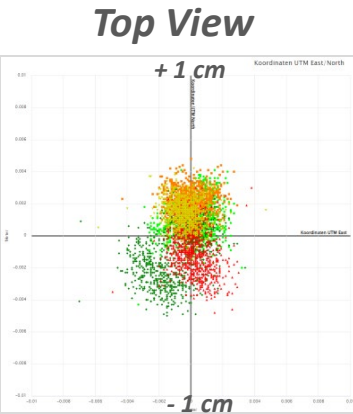
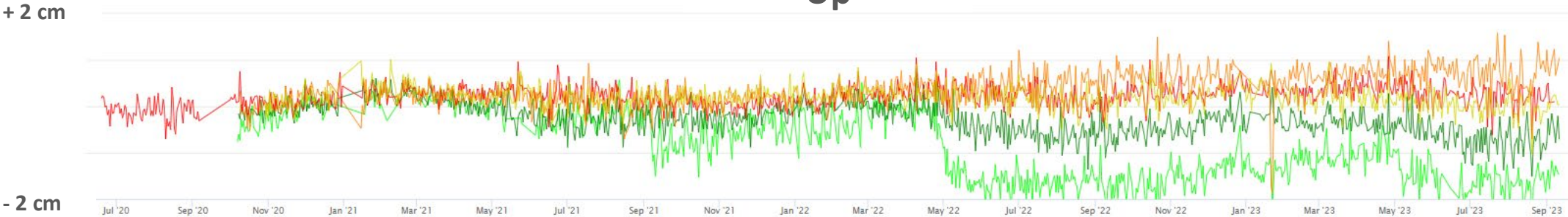
East



North

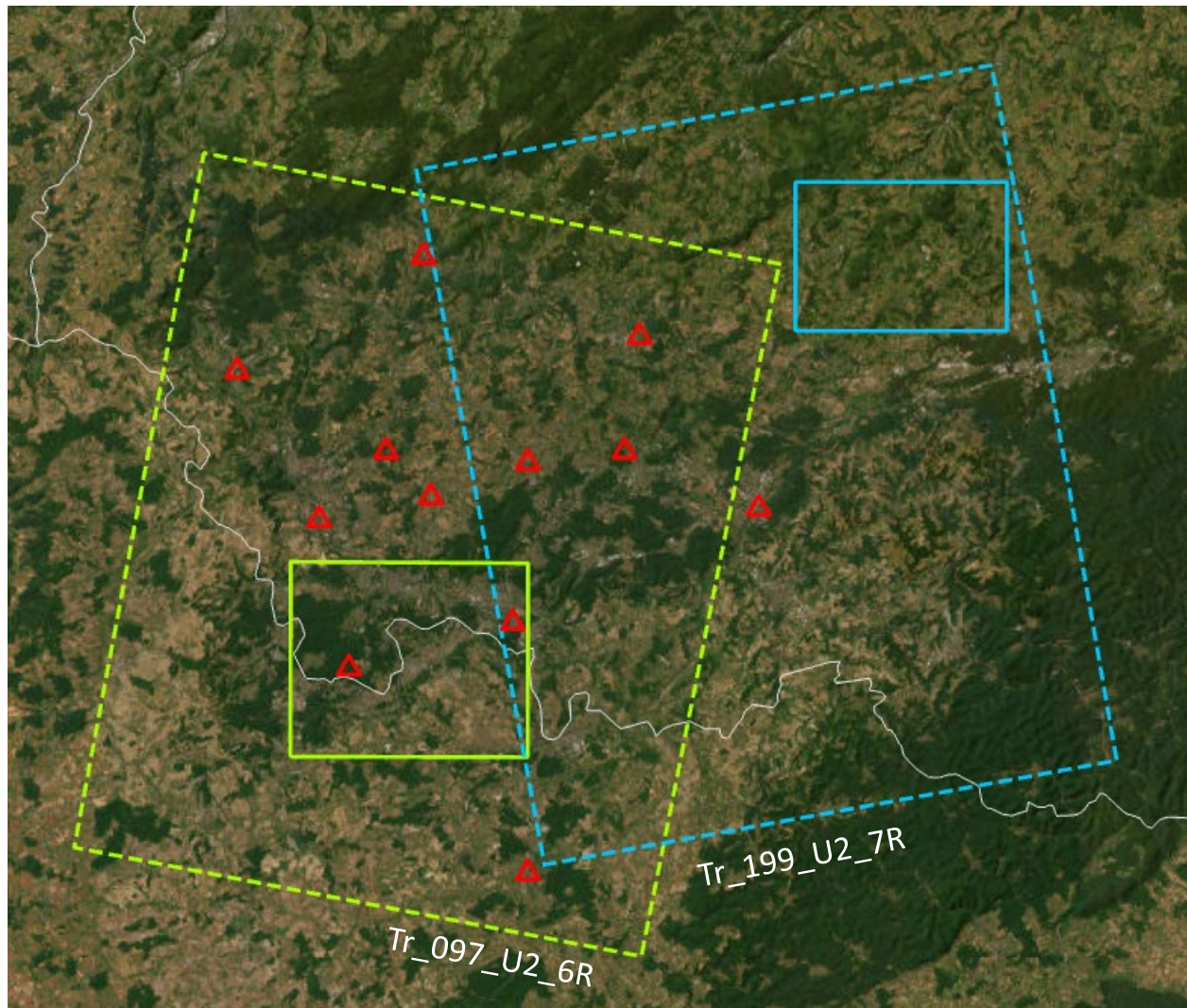





Up

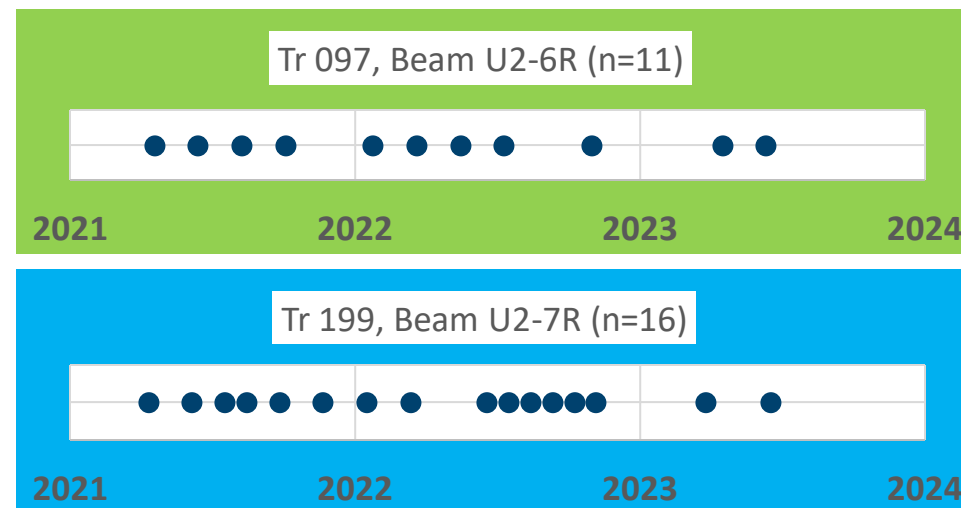


- ANNA
- HAHN
- LAUT
- PRIM
- SUES

# Area of Interest and ALOS-2 datasets



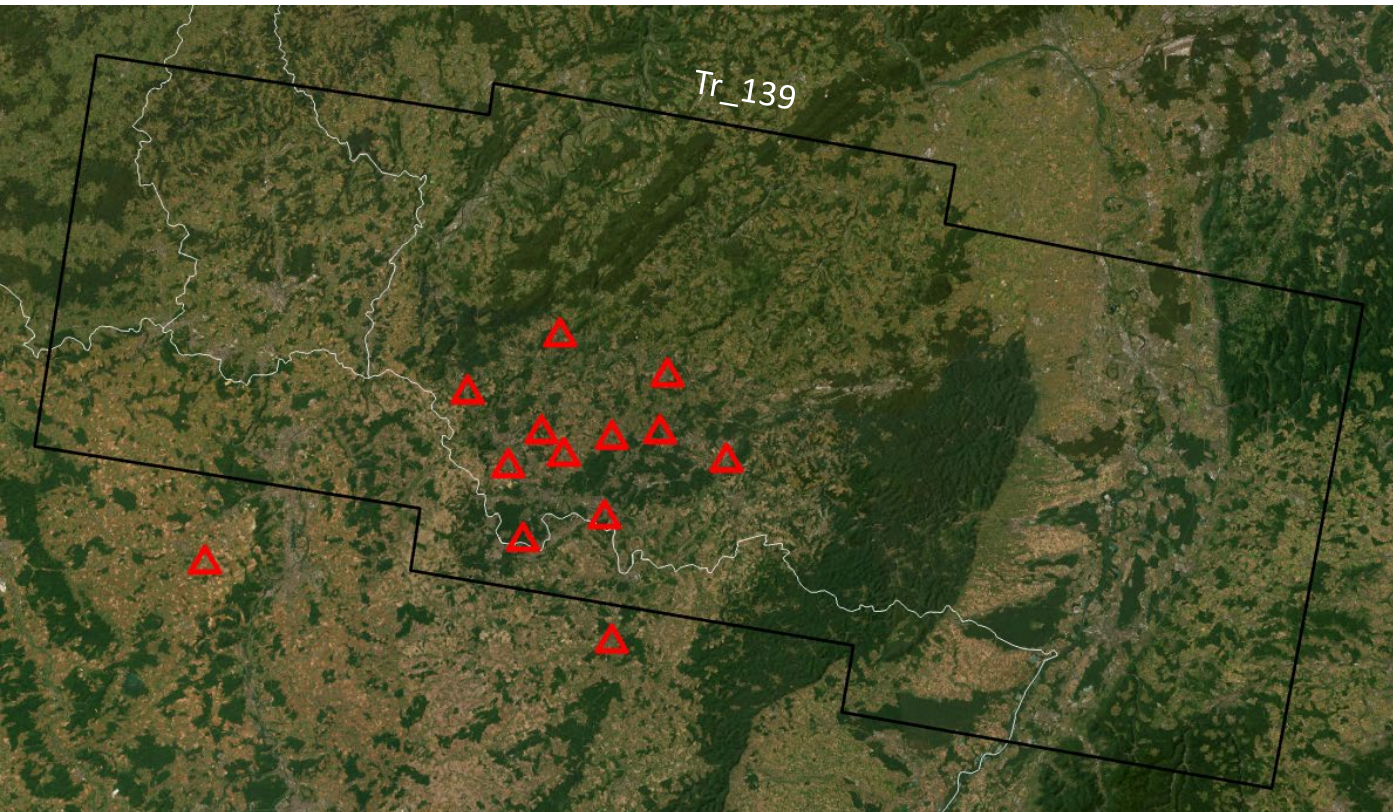
-  MSST
-  ALOS-2 Descending Track 097
-  ALOS-2 Ascending Track 199





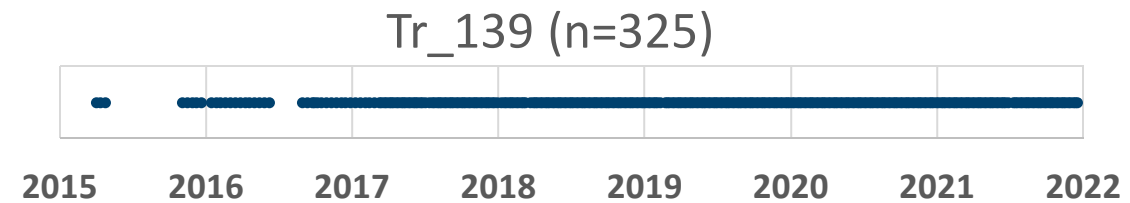
Observation time span: > 2 years

Observation mode: Stripmap  
Spatial resolution: 3 x 3m

# Sentinel-1 dataset



-  Corner Reflector
-  Sentinel-1 Descending Track 139

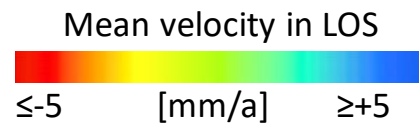
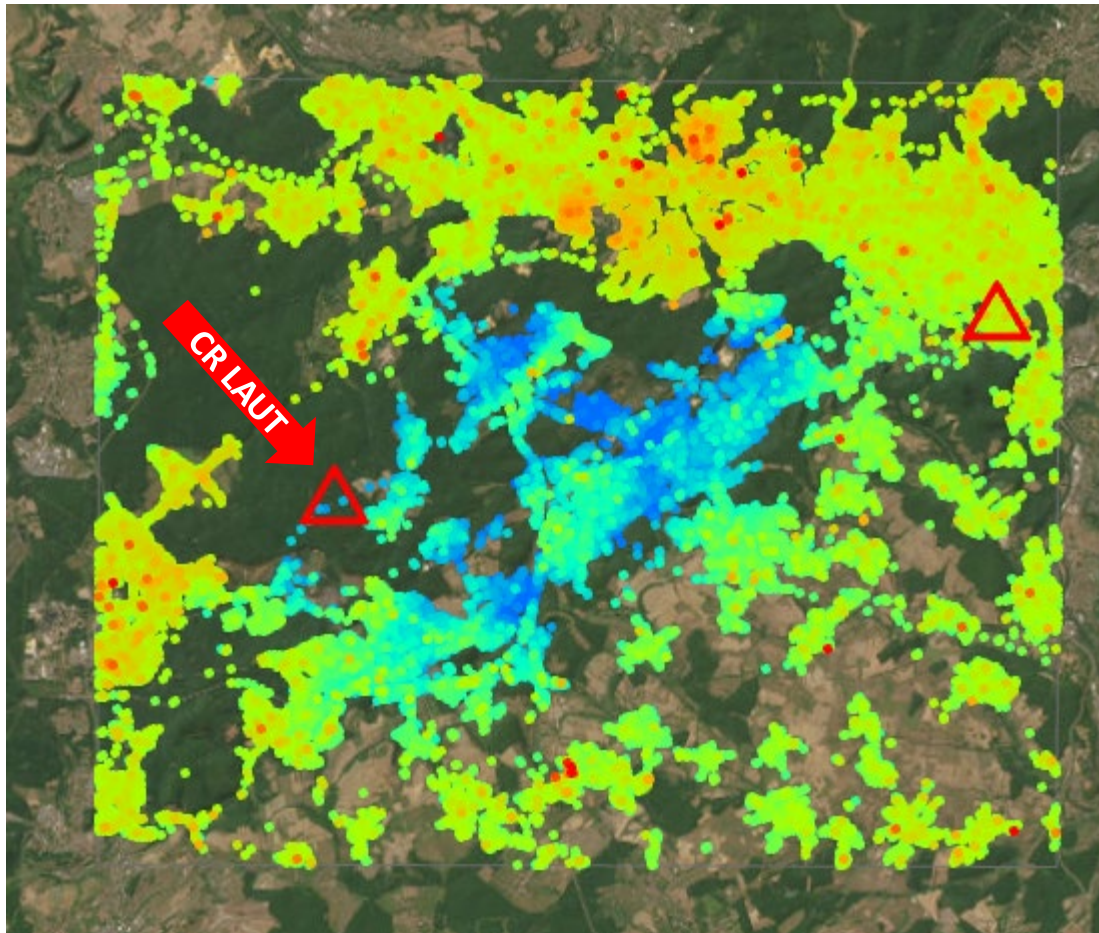


Observation time span: > 6 years

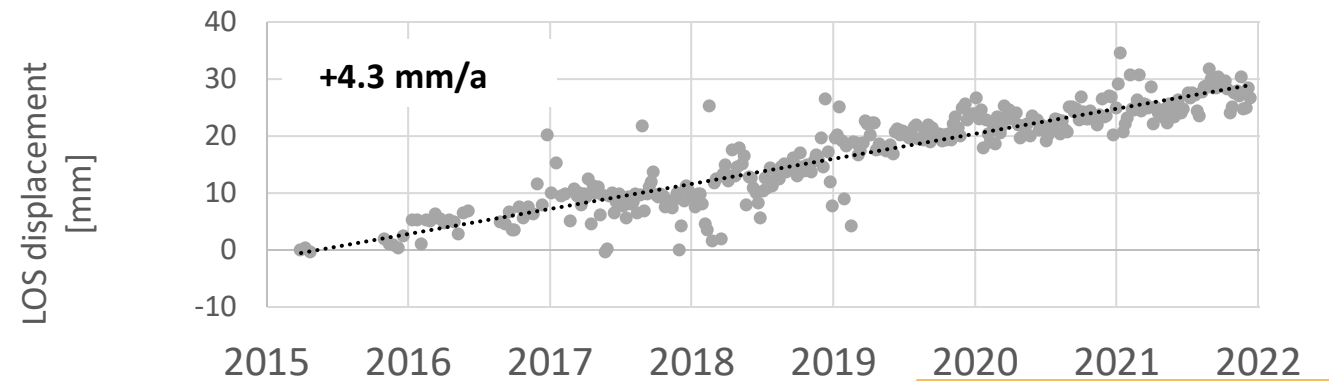
Observation mode: Interferometric wide swath  
Spatial resolution: 20 x 5m (Az x Rg)

# Sentinel-1 PSI based on data from GMS Germany

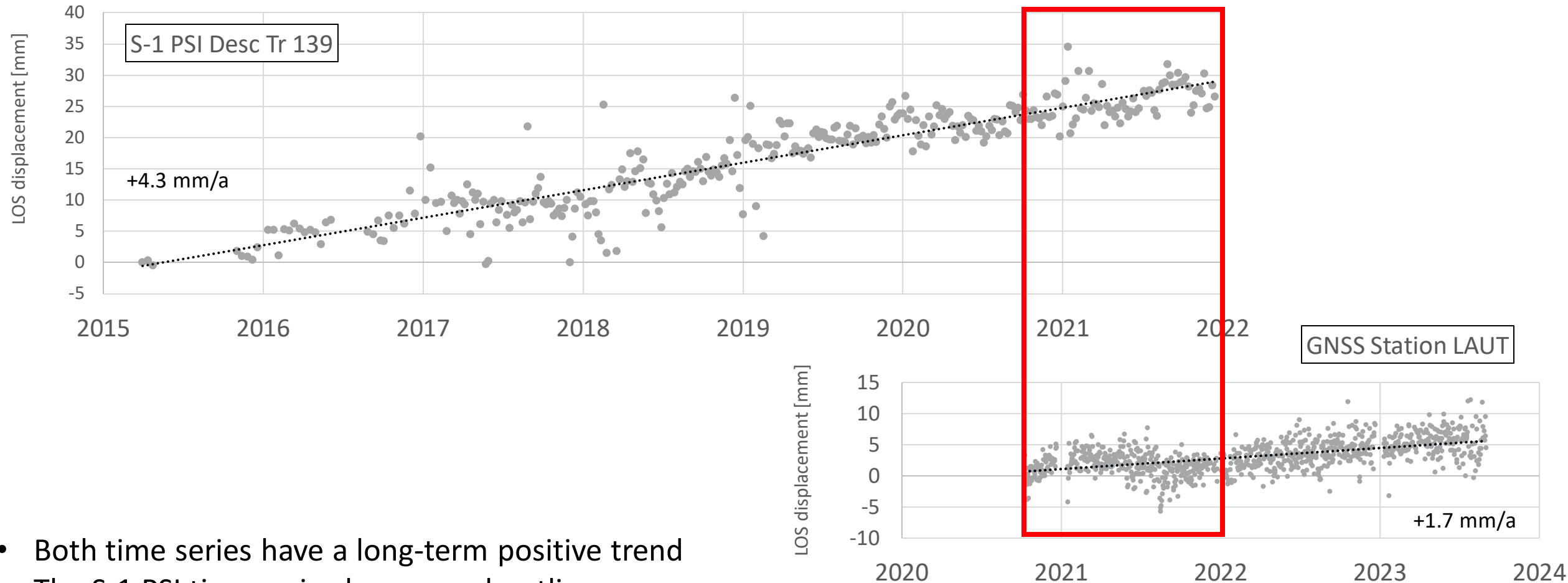
S-1 Persistent Scatterer 2015-2021



S-1 Persistent Scatterer 2015-2021



# Sentinel-1 PSI vs. GNSS displacement time series



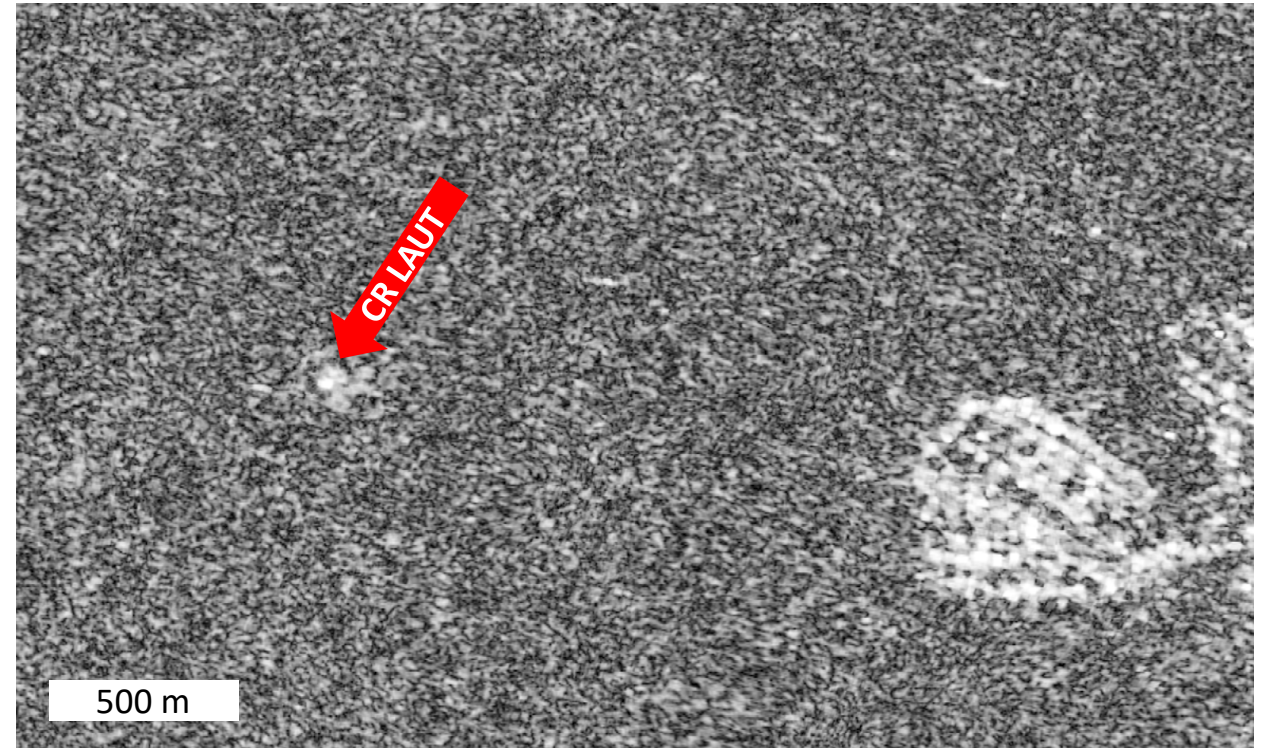
- Both time series have a long-term positive trend
- The S-1 PSI time series has several outliers
- The GNSS time series shows a small negative trend in 2021

# ALOS-2 interferometric coherence at MSST

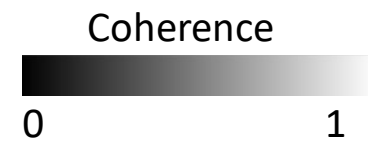
Station LAUT



ALOS-2 interferometric coherence 18.4.2021-11.6.2023



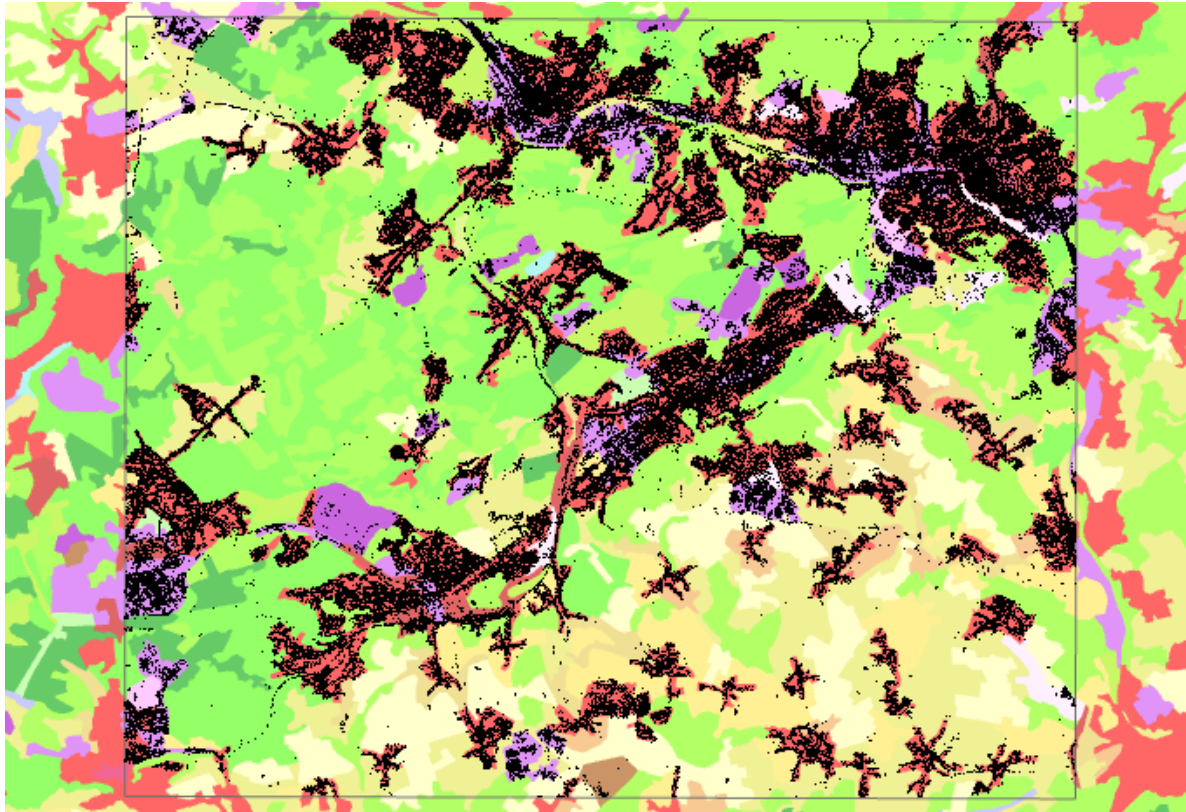
$$\gamma_{CR\_LAUT} = 0.97$$



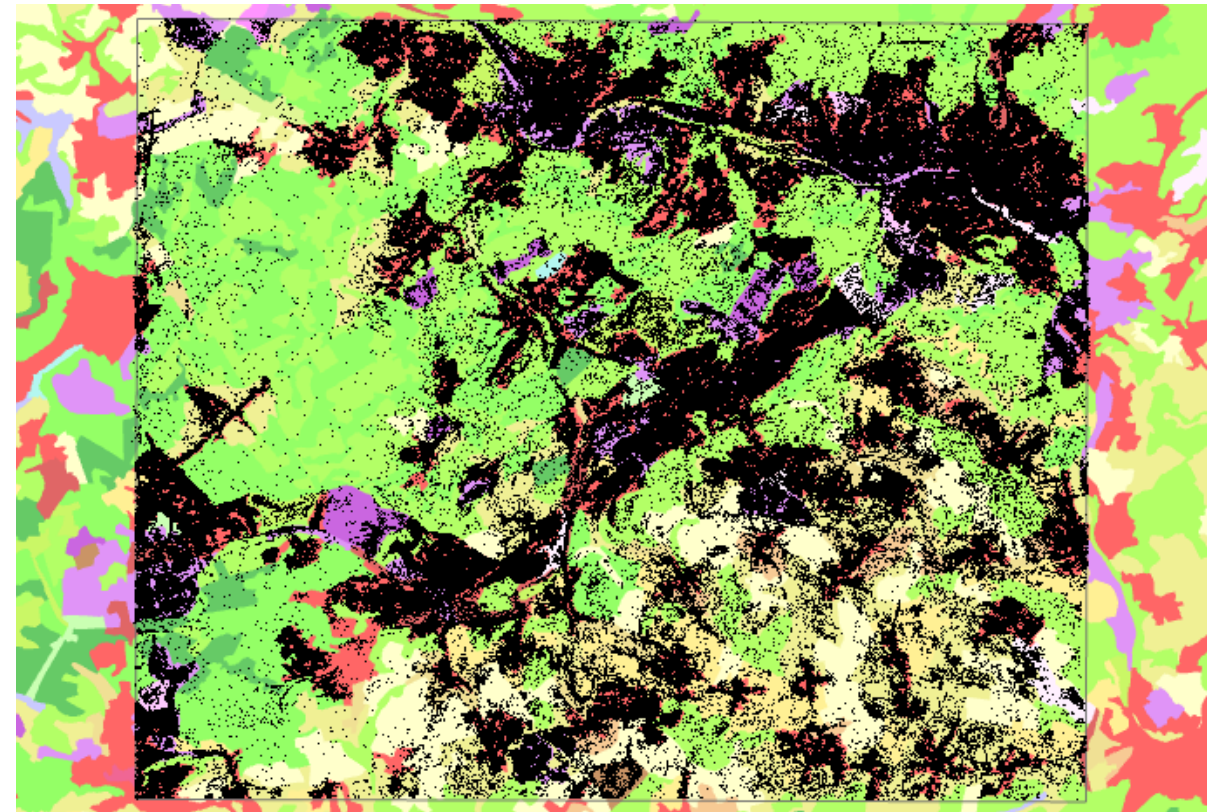
# Sentinel-1 vs. ALOS-2 PS density - preliminary



S-1 Persistent Scatterer (200 PS/km<sup>2</sup>)



ALOS Persistent Scatterer (2251 PS/km<sup>2</sup>)



- Persistent Scatterer

Background: CORINE Landcover 2018

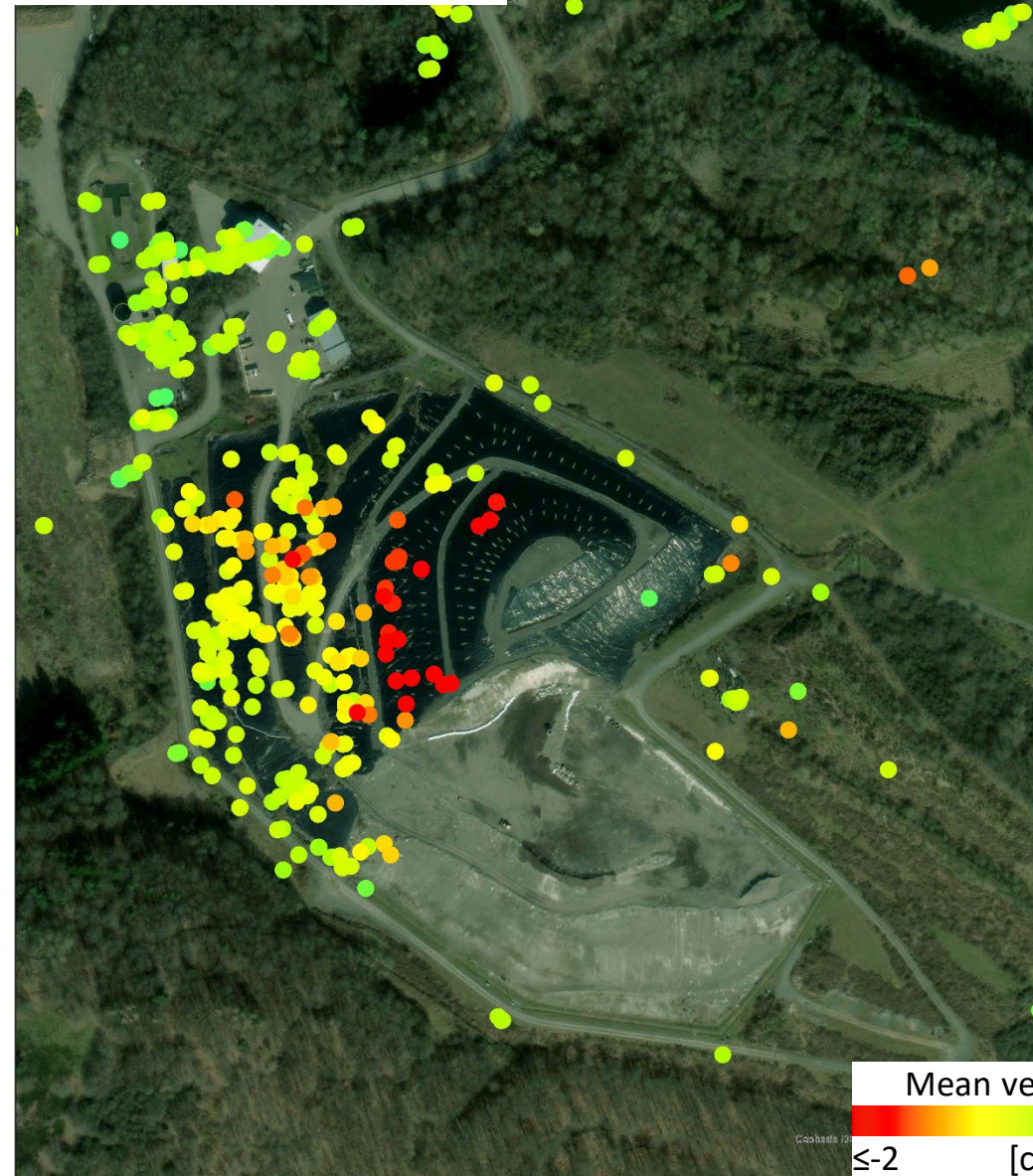


# Sentinel-1 vs. ALOS-2 PSI: Schneeweiderhof, Landfill

Sentinel-1 PSI 2015-2021



ALOS-2 PSI 2021-2023

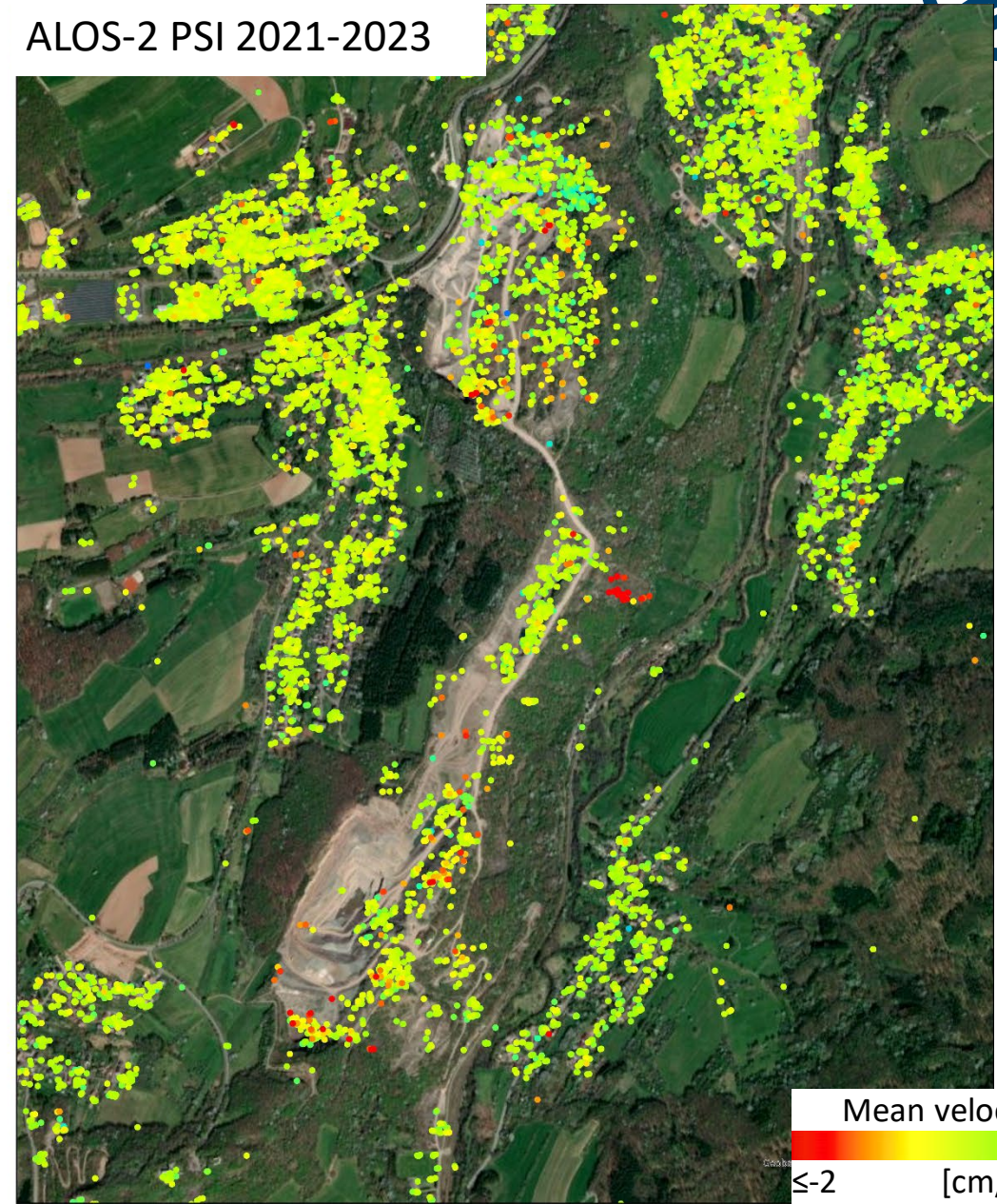


# Sentinel-1 vs. ALOS-2 PSI: Rammelsbach, Basalt mining

Sentinel-1 PSI 2015-2021



ALOS-2 PSI 2021-2023



Mean velocity in LOS

≤-2 [cm/a] ≥+2

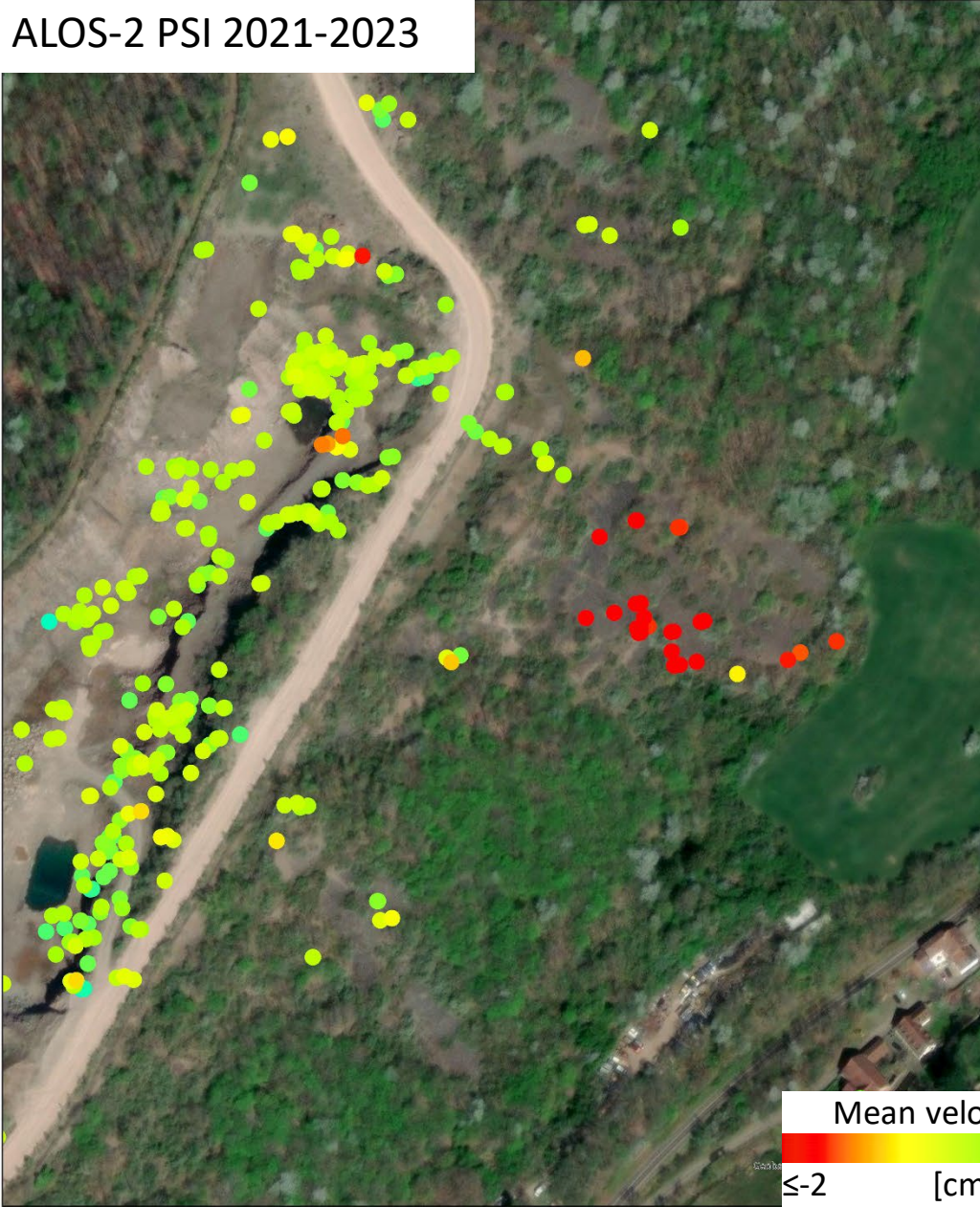
# Sentinel-1 vs. ALOS-2 PSI: Rammelsbach, Basalt mining



Sentinel-1 PSI 2015-2021



ALOS-2 PSI 2021-2023



100 m

Mean velocity in LOS

$\leq -2$  [cm/a]  $\geq +2$

# Conclusion

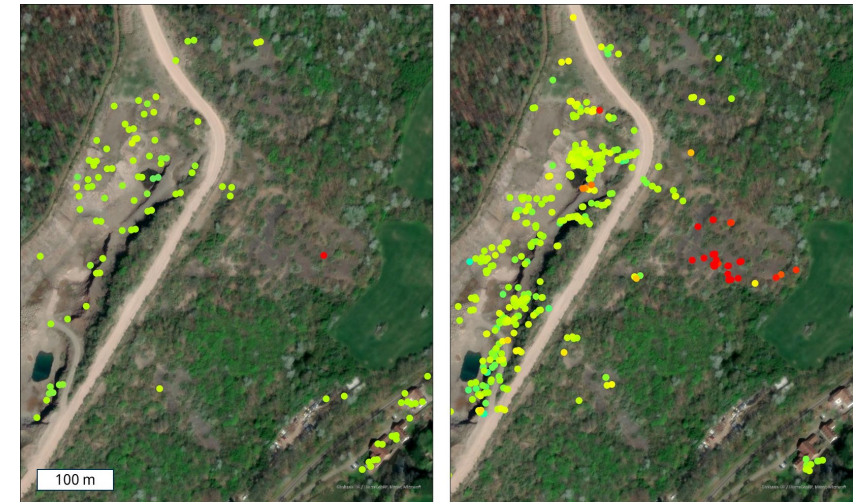


MSST Station LAUT is highly coherent in the 2 year ALOS-2 interferogram

Comparison of S-1 PSI displacement time series vs. GNSS at MSST shows similar long-term positive trend

Observations w.r.t. to the complementary characteristics of C- and L- band PSI:

- higher spatial resolution of ALOS-2 L-band data
- higher spatial PS density of ALOS-2 L-band data
- Higher temporal resolution of Sentinel-1 C-band data

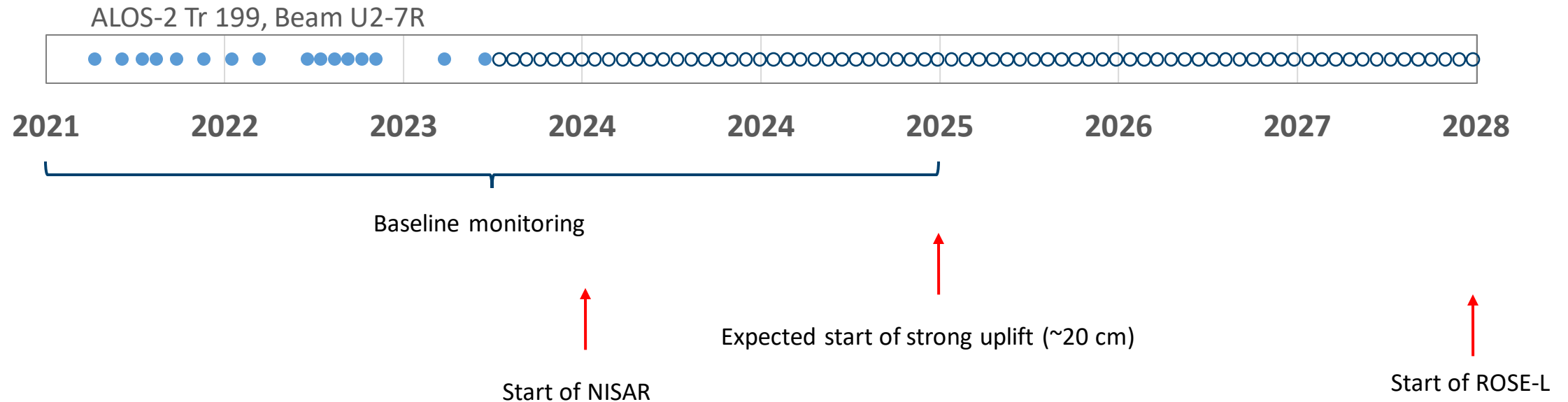


# Conclusion



First tests regarding the characteristics of L-band and C-band PSI in the AOI

- Dense and long L-band time series are required
  - to perform baseline monitoring of small displacements until 2025
  - to monitor expected strong uplift: start 2025



**Thank you for your attention!**