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TAKING THE PULSE OF OUR PLANET FROM SPACE

SUMO4Rail - Subsidence Monitoring for Railway Tracks:

PS InSAR data integration for Infrastructure Planning, Maintenance & Operation

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GAF AG
an e-GEOS (ASI / Telespazio) Company

Eisenbahn-Bundesamt

ISL

Room: Addis Abeba
Session: D1.02.1 Satellite EO for Monitoring Infrastructures

27.05.2022

Company Overview GAF AG

More than 35 Years Geotechnology Solutions

▷ 230 Employees (Multidisciplinary Scientists – Agriculture, Forestry, Environment, Geology..)

▷ Munich (Headquarter) & Neustrelitz (MV)

<u>Geoinformation: Solutions from Single Source</u>

▷ **Geodata:**

Reception – Distribution - Processing

▷ **Services & Products :**

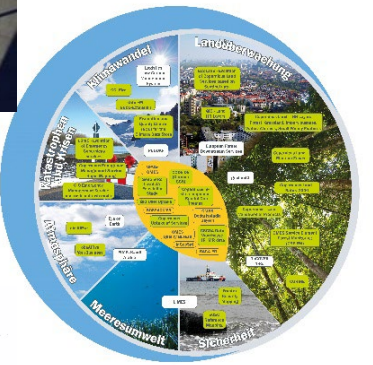
Geoinformation Products, Systems, Software & Integrated Satellite Services

▷ **Consulting Services in > 100 Countries**

Professional & Institutional Consulting, Project Management

GAFAG

an e-GEOS (ASI / Telespazio) Company



Objectives & Project Structure

SUMO4Rail aims at

- enhanced monitoring of railway infrastructure to **detect damages at an early stage** to enable effective countermeasures
- **innovating** the inspection process of railway infrastructure
- **predictive detection** of deformation risks or subsidence damages at or in the vicinity of rail tracks
- **avoid or limit** effects of failure

Project partners

Collaborators

BGR

DLR Deutsches Zentrum für Luft- und Raumfahrt

duisport

User Requirement Specification → Technical Specification → Test Case → Assessment of Results → Outreach and Dissemination

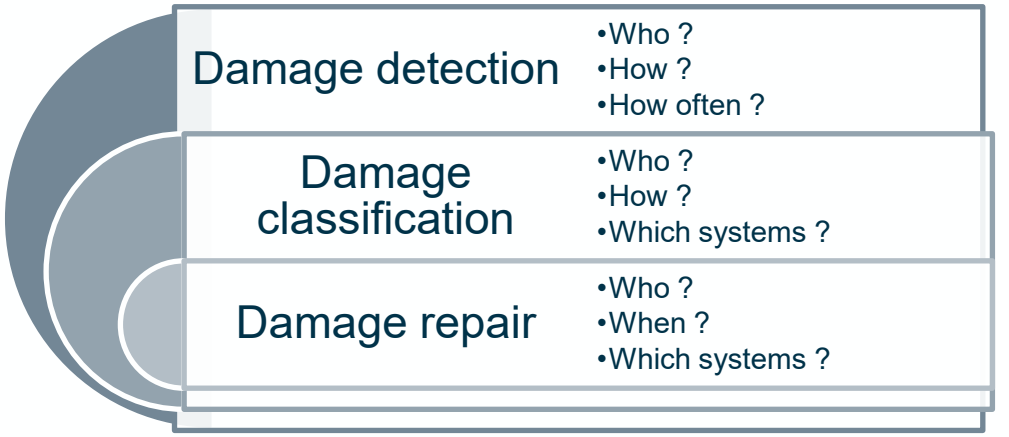
User Requirements

Workshop at EBA

- Professionals from different sectors of EBA, ISL, Deutsche Bahn (DB), Duisport and Geological Survey of Northrhine-Westfalia (NRW)

Discussions

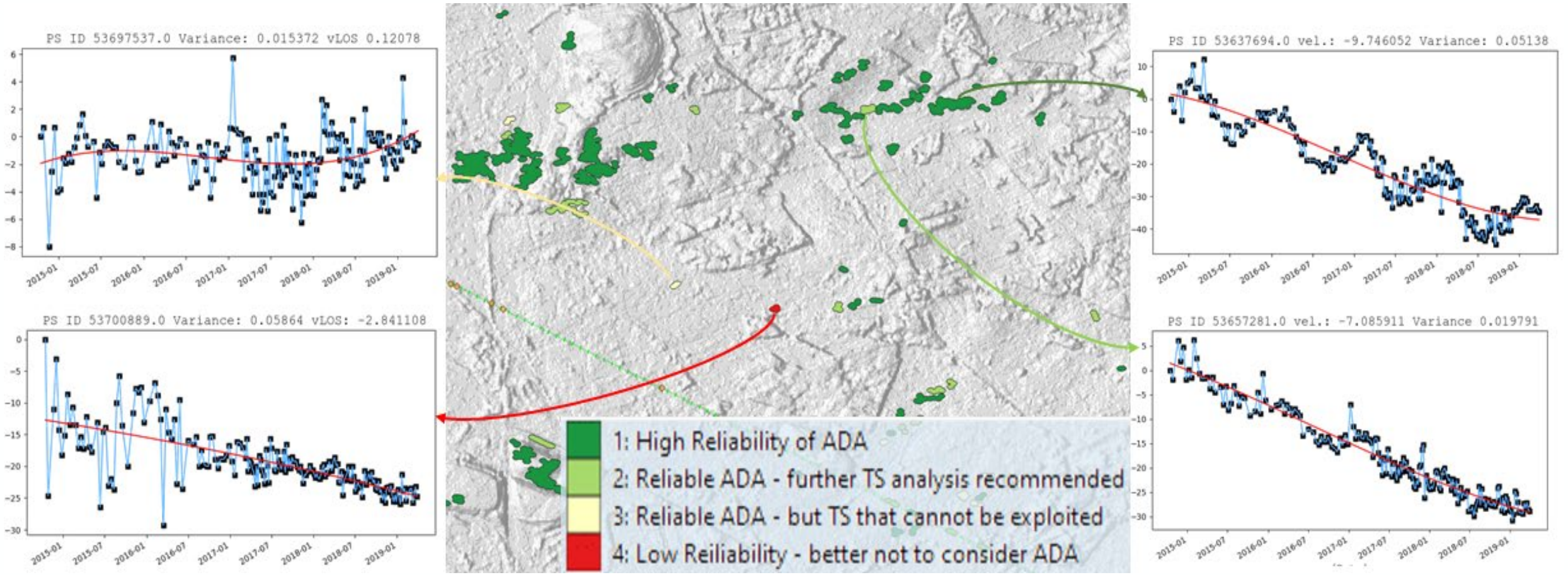
- Is there experience with vertical and / or horizontal displacement of the tracks?
- How are field inspections and maintenance tasks performed?
- Damage recording by track marshals/traction vehicle drivers?
- How are changes documented?
- Availability of high precision sensors mounted on trains (such as GBR, high precision GPS, laser ...)?
- Responsibilities for planning and execution of these tasks?
- How would a system have to look in order to generate value in operational use?



User Need

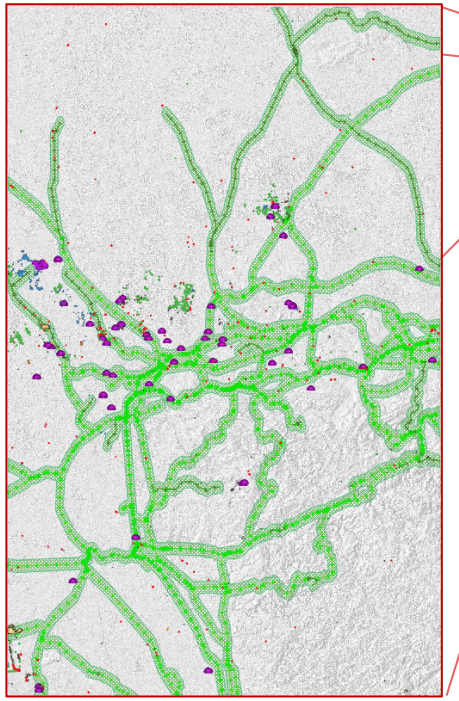
- Planing Assistant
- Maintenance Assistant
- Early Warning Assistant

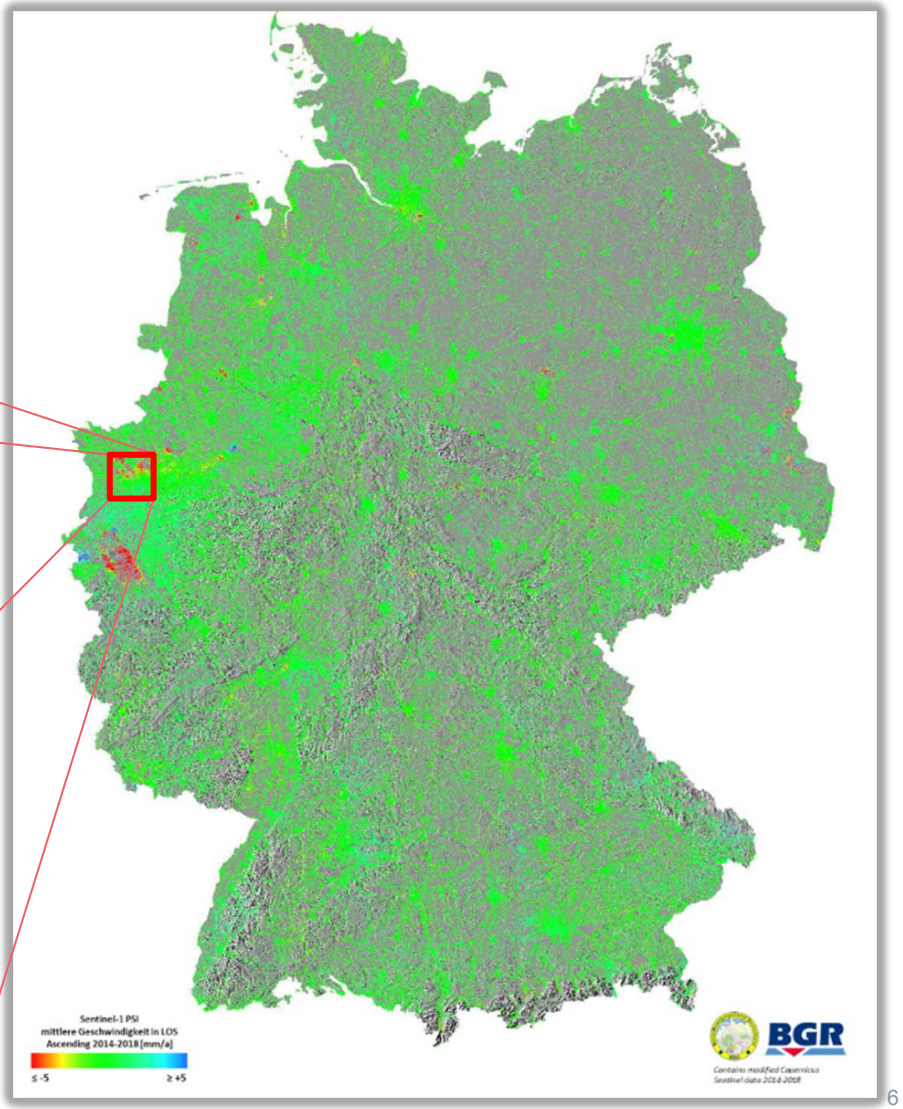
Quality index classes resultant from temporal noise index and spatial noise



Use Case ‘Duisburg Hinterlands‘

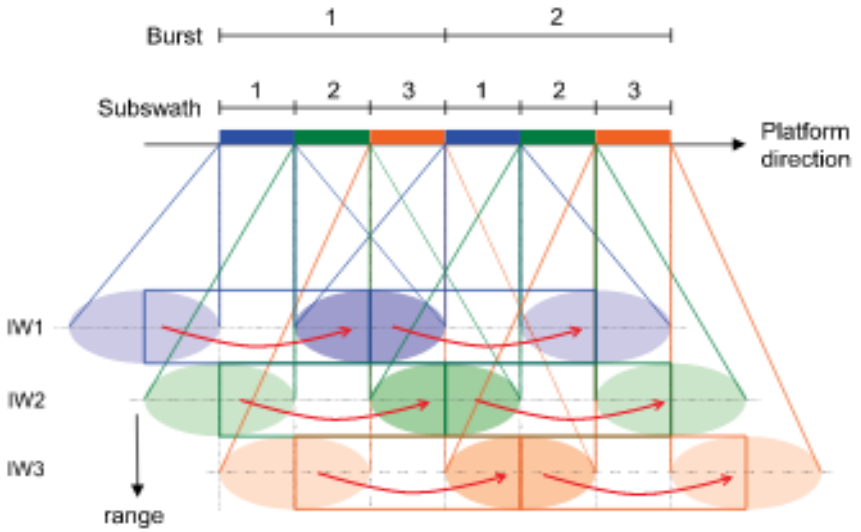
- Important Rail transport routes to the south and east, which cross the traditional mining areas, are subject to tectonic, seismic and anthropogenic influences.
- Port of Duisburg as terminal of the New Silk Road
- Assessing risks along rail tracks affecting the logistics chain
- Long-term monitoring of geological, climatological and hydrological induced deformations for route planning and life-cycle management
- Rail tracks and highways cross mining territory of the Ruhr Basin

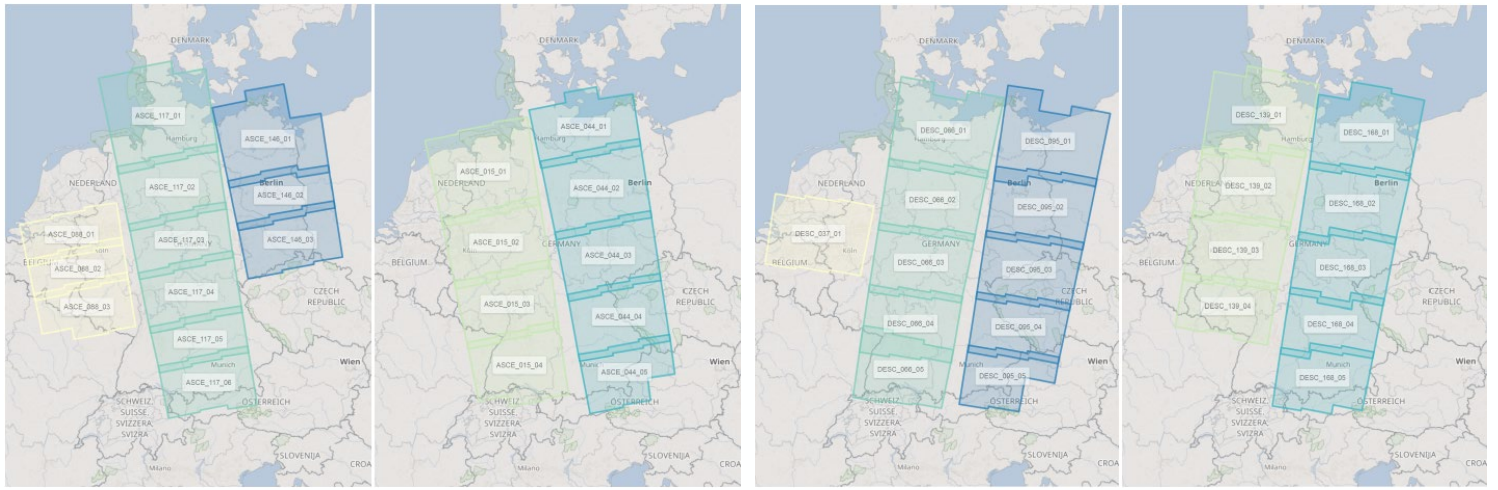


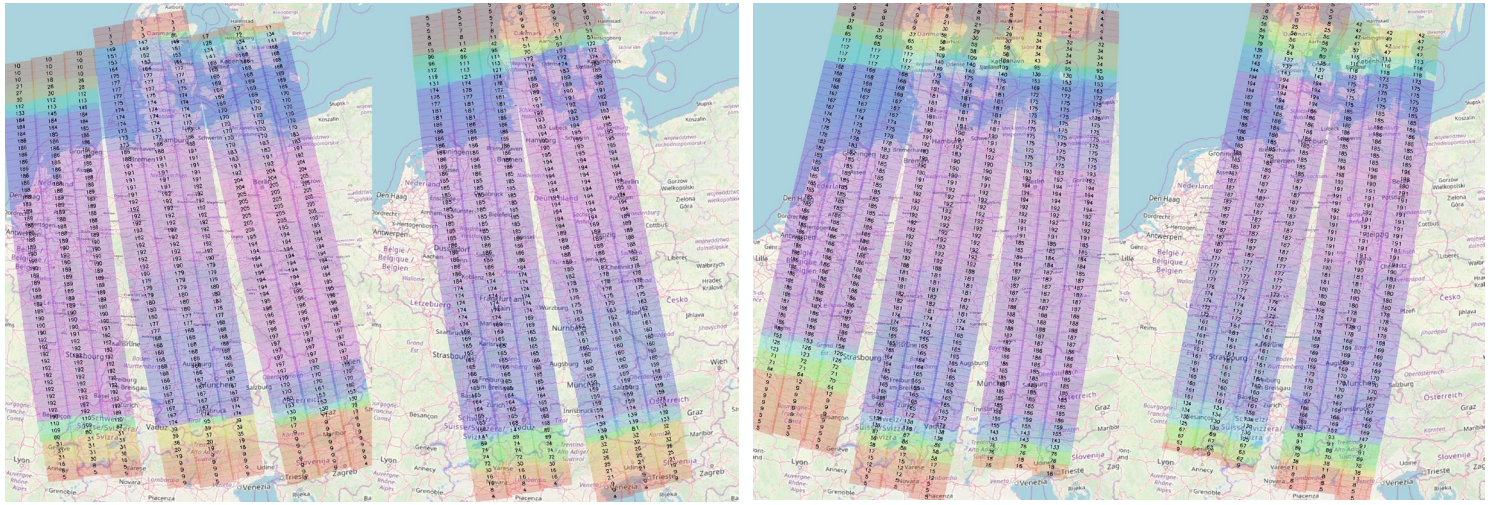


Sentinel 1 Aquisition

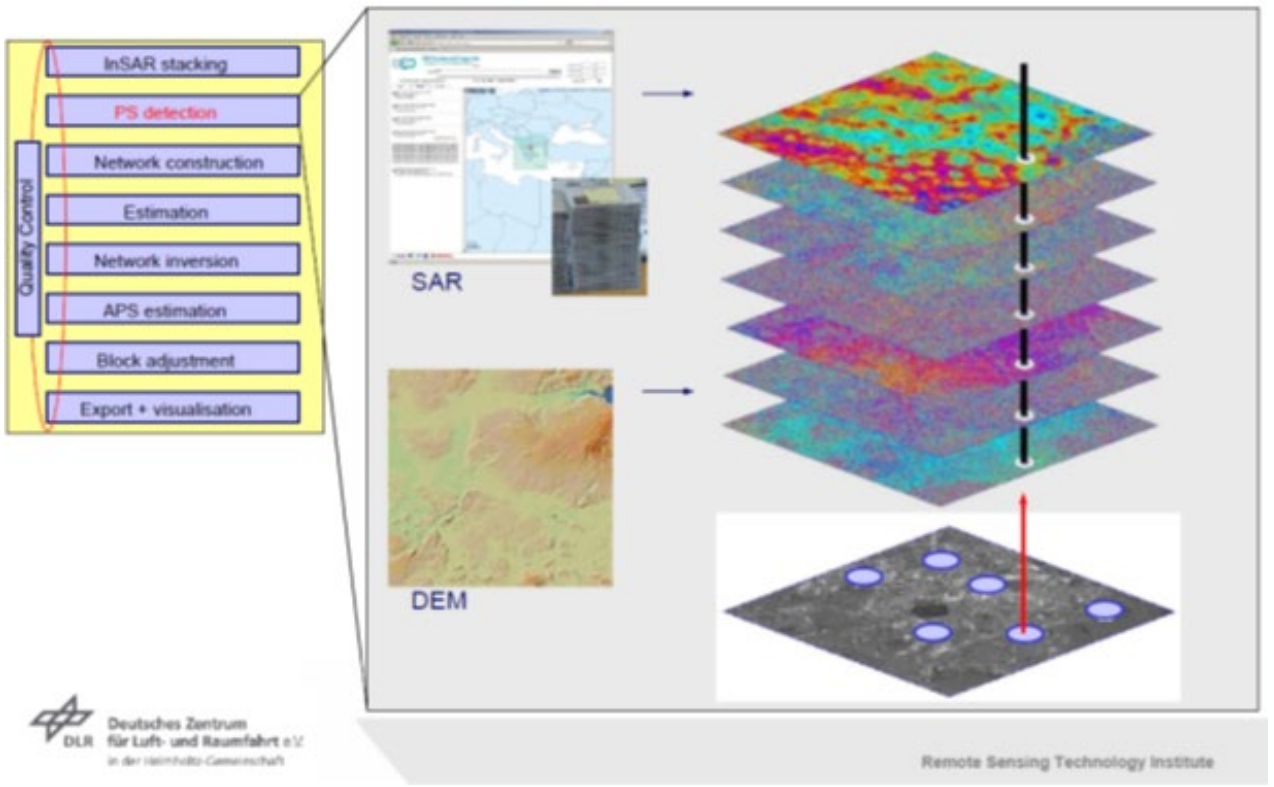
Interferometric Wide Swath (IW) are achieved with a new acquisition mode, the Terrain Observation by Progressive Scans (TOPS) resulting in 3 subswath with ground resolution of 5m x 20 m and 250 km swath width at the IW mode.



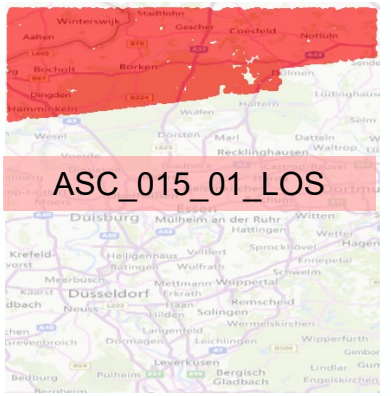


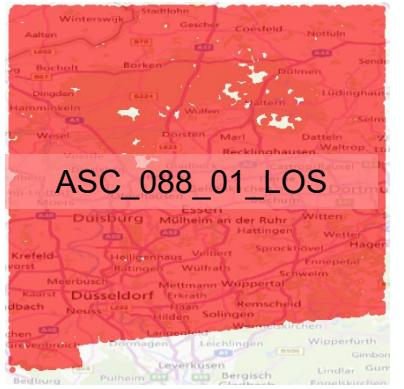


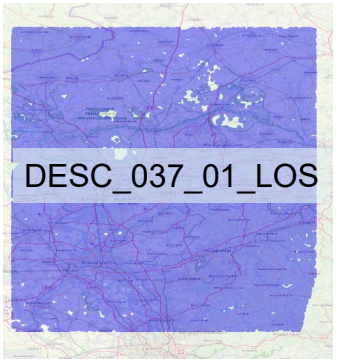
PSI Processing

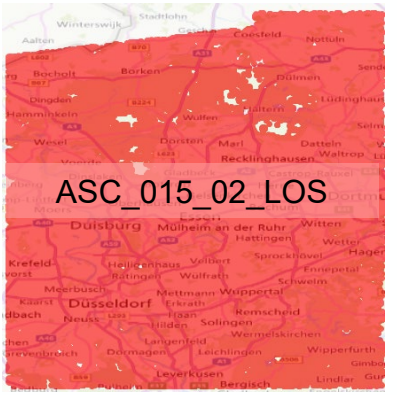


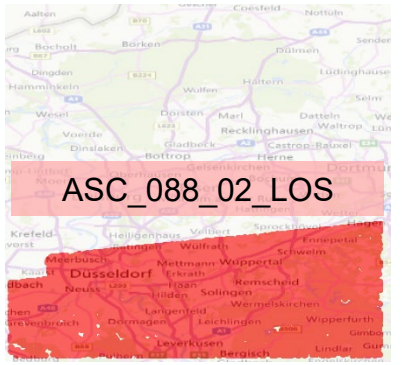
PSI-WAP PROCESSOR

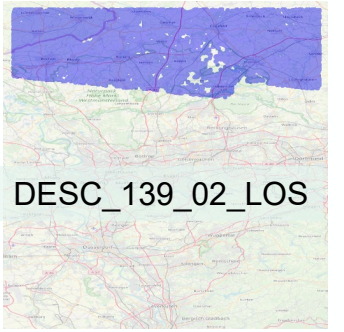


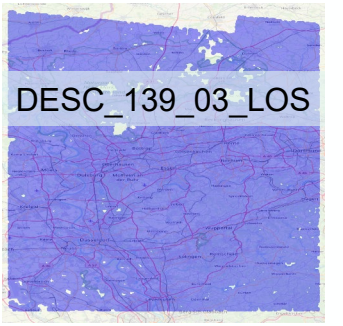






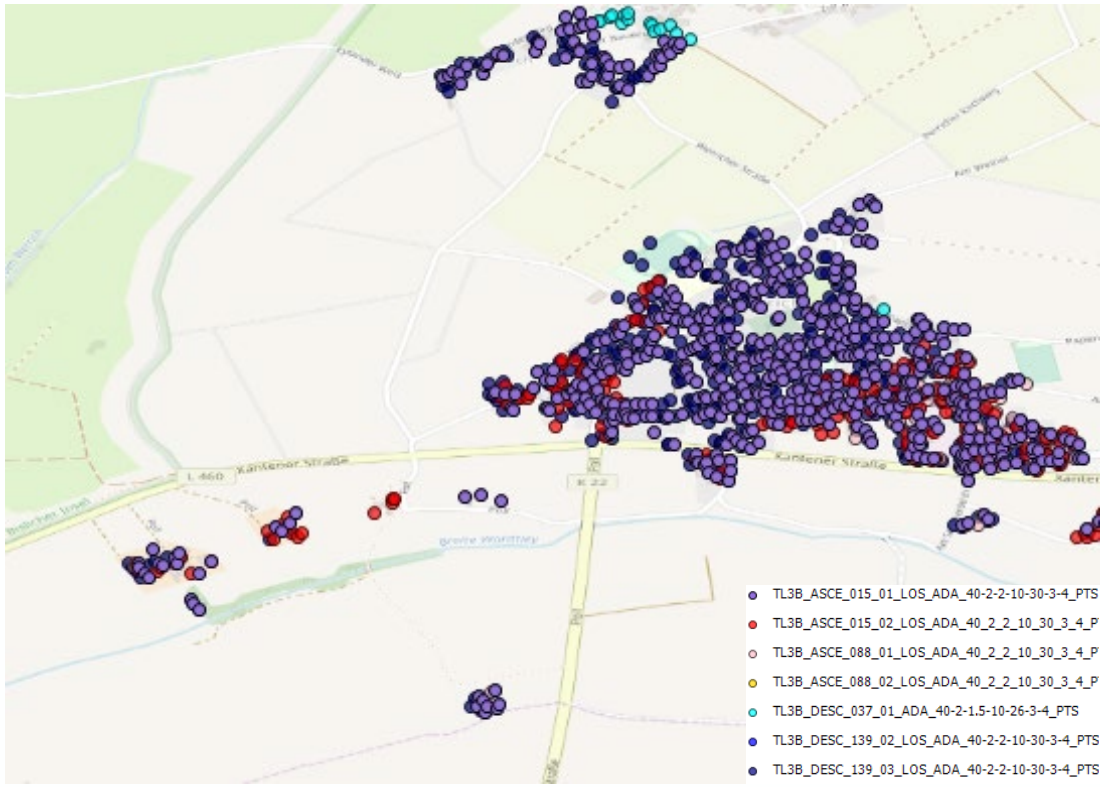




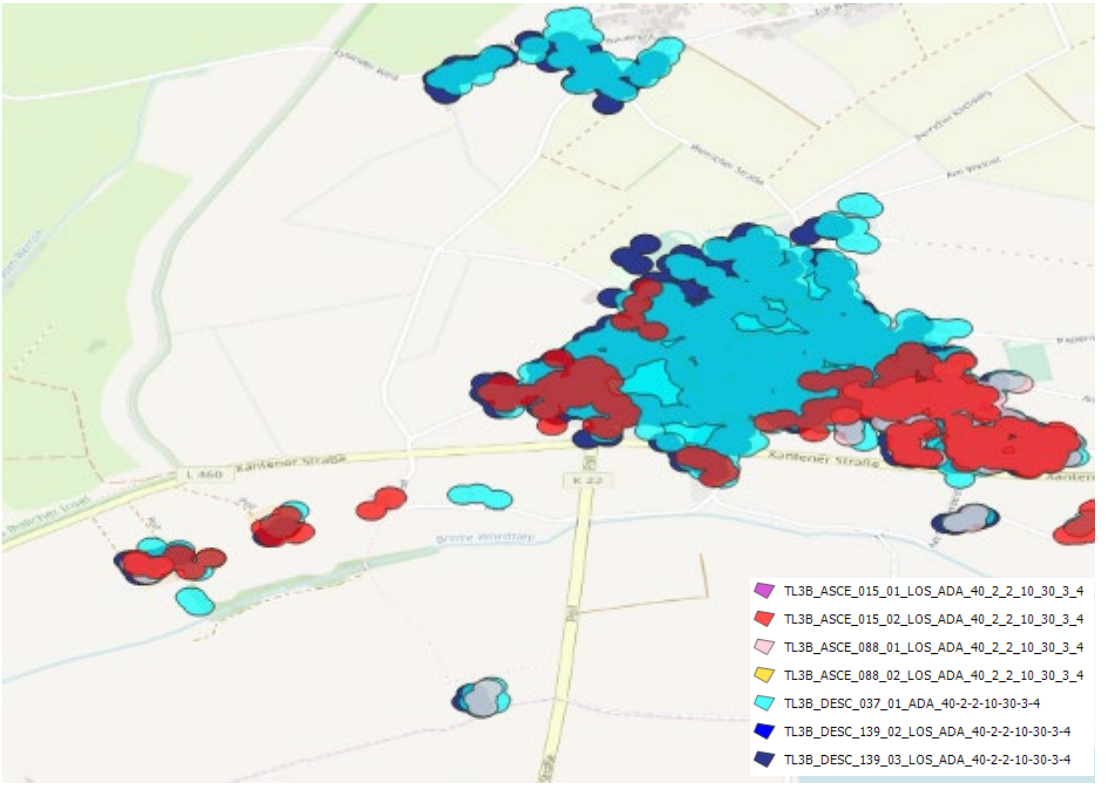


Detection of Active Deformation Areas (ADA)

ADA Toolbox from Centro Tecnológico de Cataluña was used for the project.

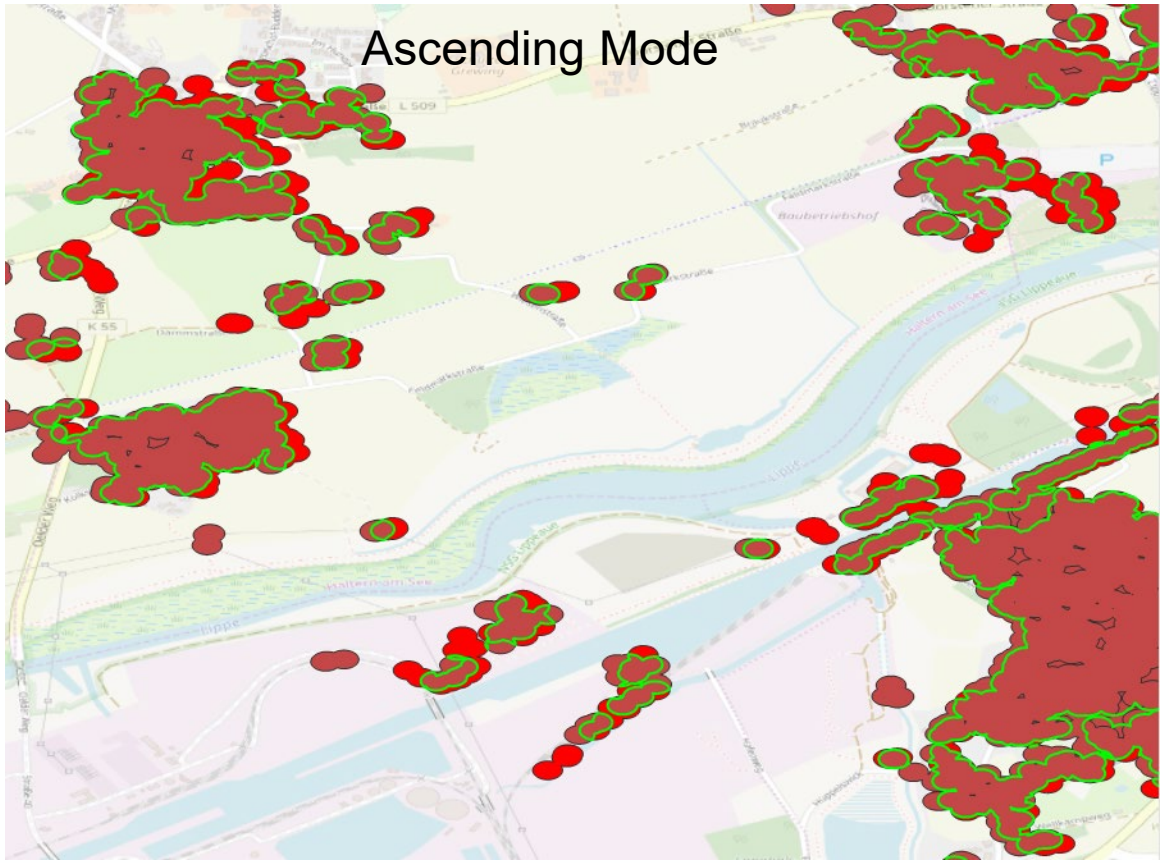


Selection of relevant PS points with predefined thresholds of mean deformation velocity, acceleration, temporal coherence, vicinity, among others, for each one of the input PSI datasets.

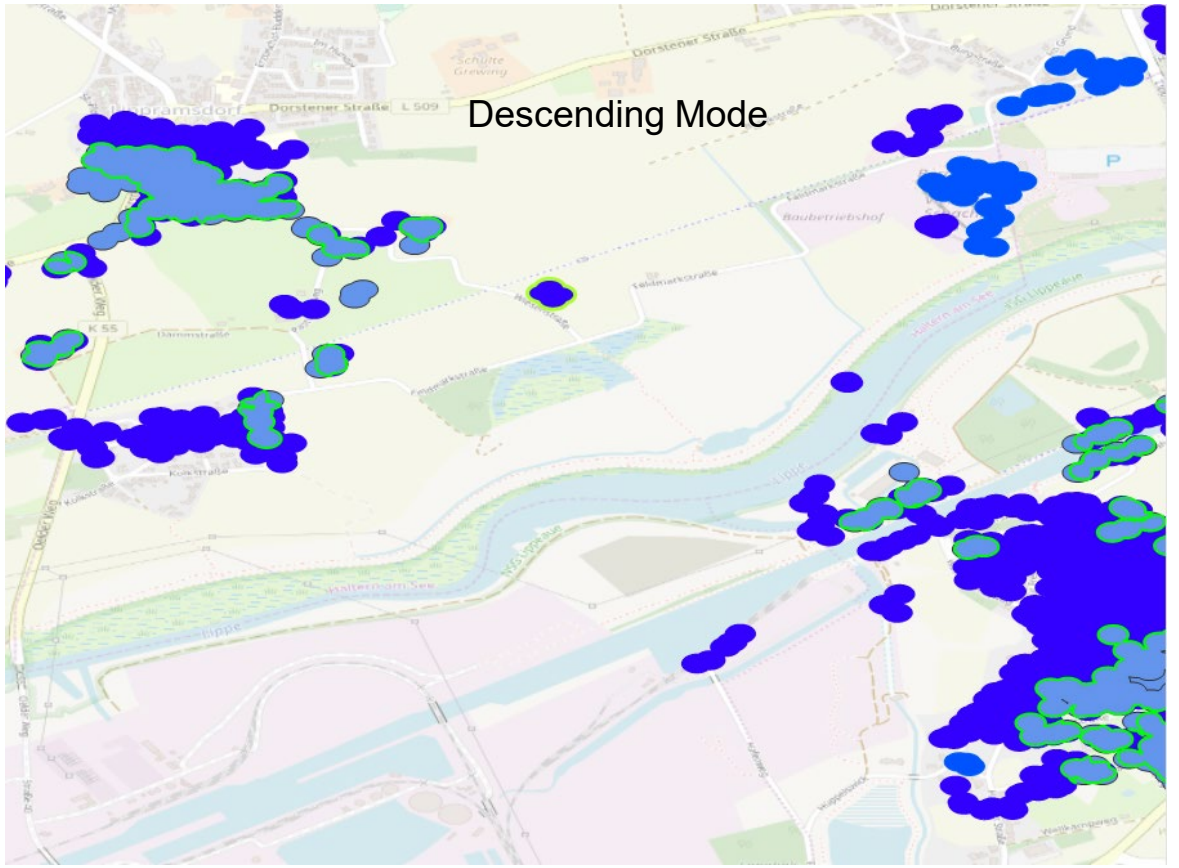


Calculation of ADA polygons based on the remaining PS points applying enhanced buffer analysis.

Merge of Active Deformation Areas

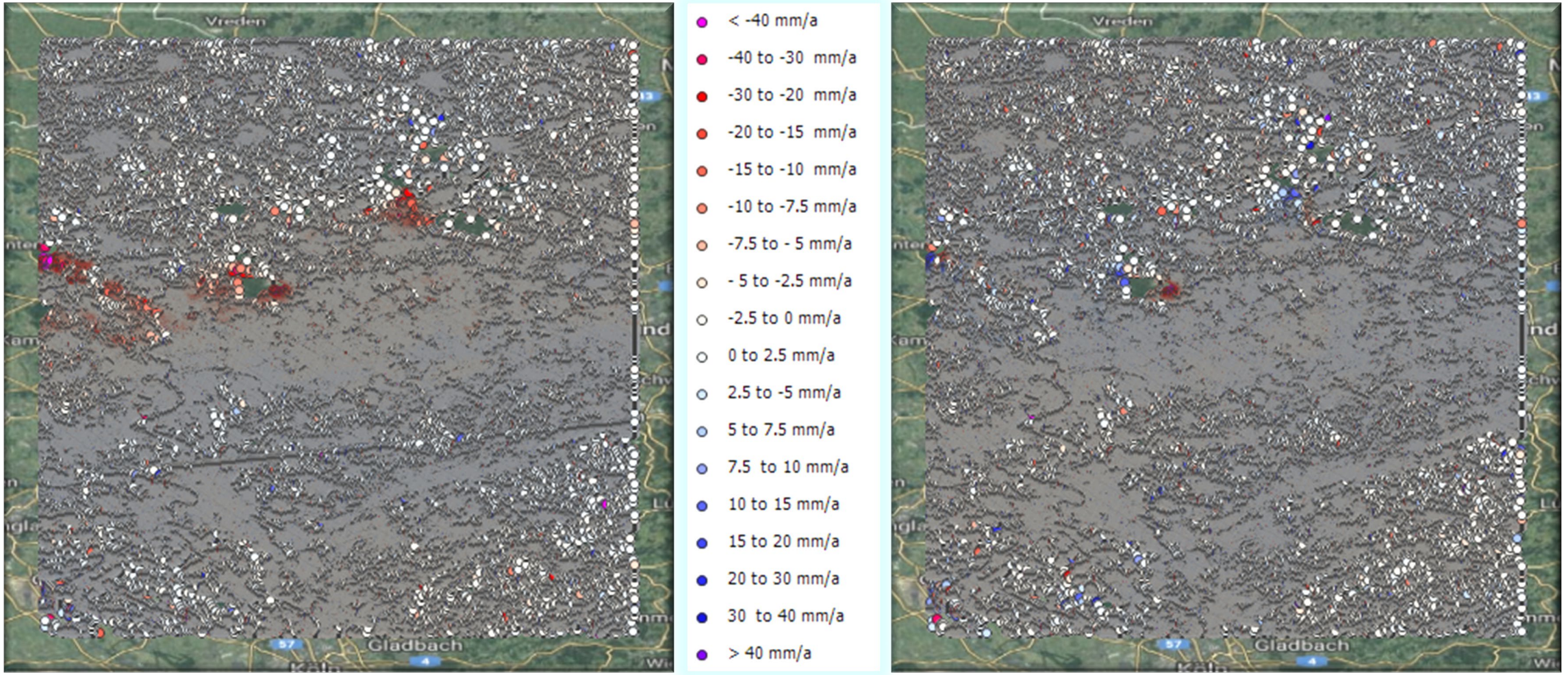


Merge of ADA from ASCE_015_01 and ASCE_015_02 (red)
Merge of ADA from ASCE_088_01 and ASCE_088_02 (dark red)
Common ADA of both ascending orbits (green line)



Desc 037_01
Merge of ADA from DESC_139_02 and ASCE_139_03 (Light blue)
Common ADA of both ascending orbits (green line)

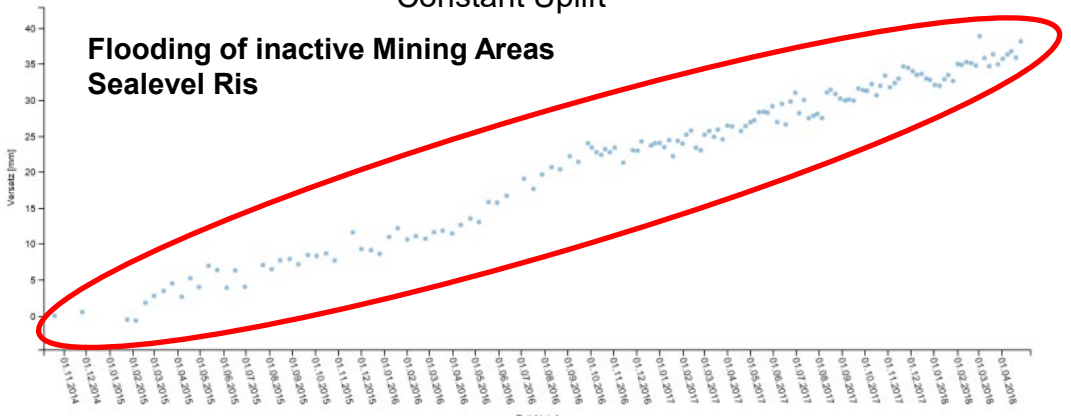
Vertical & Horizontal (E-W) Displacement Maps



Types of Ground deformation

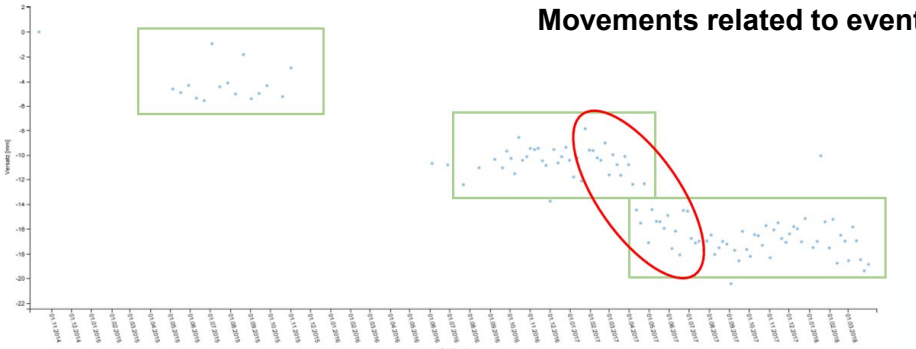
Constant Uplift

Flooding of inactive Mining Areas
Sealevel Ris



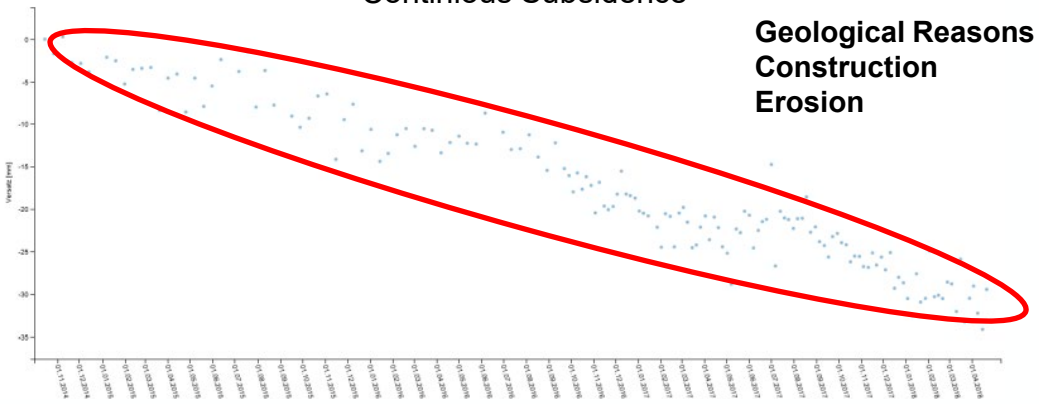
Discontinous Movements

Movements related to events



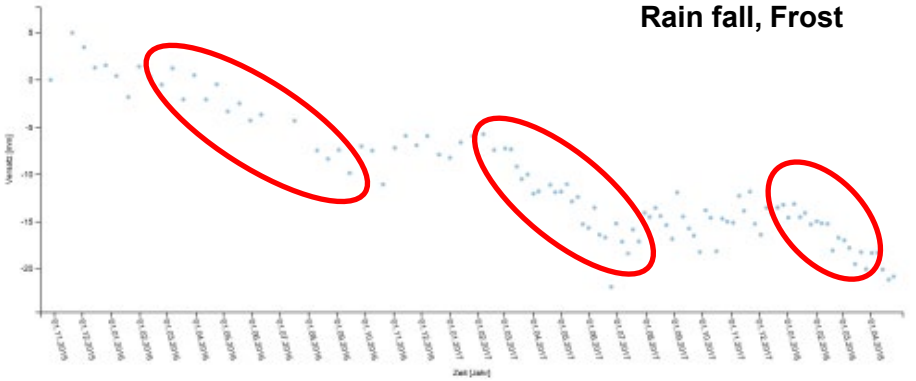
Continious Subsidence

Geological Reasons
Construction
Erosion

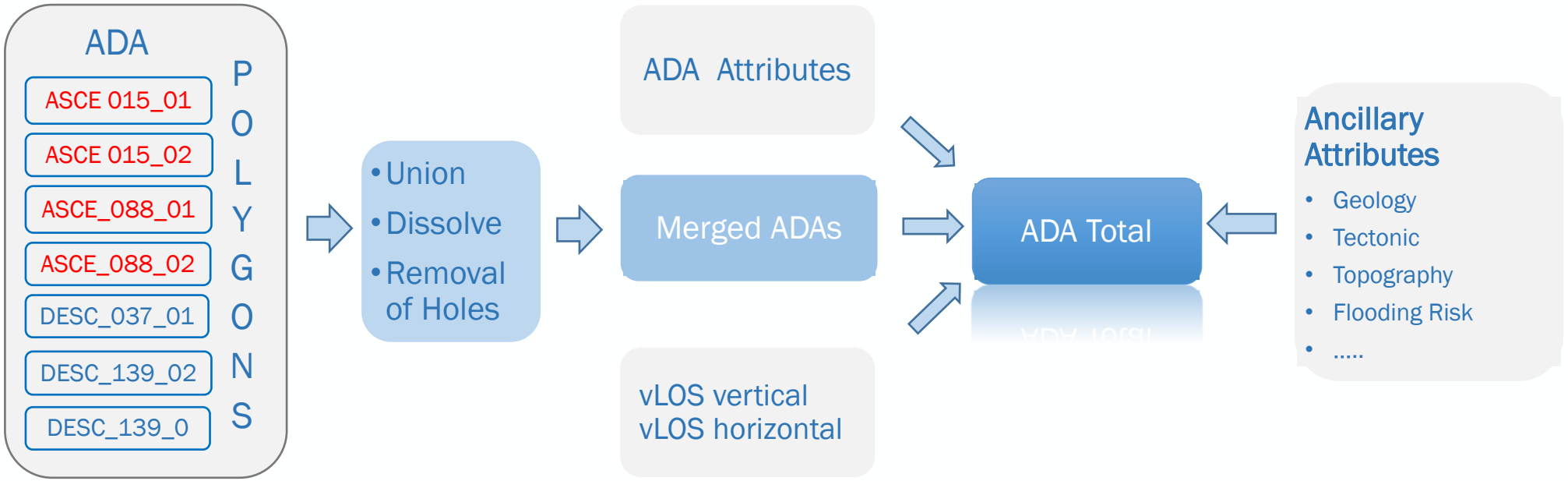


Seasonal Movements

Rain fall, Frost

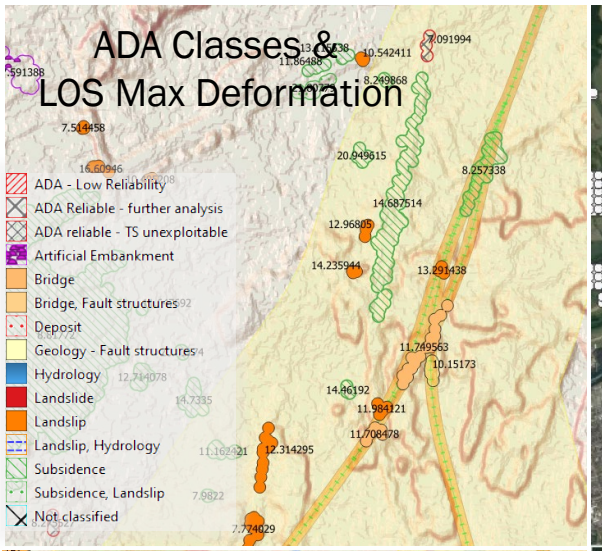


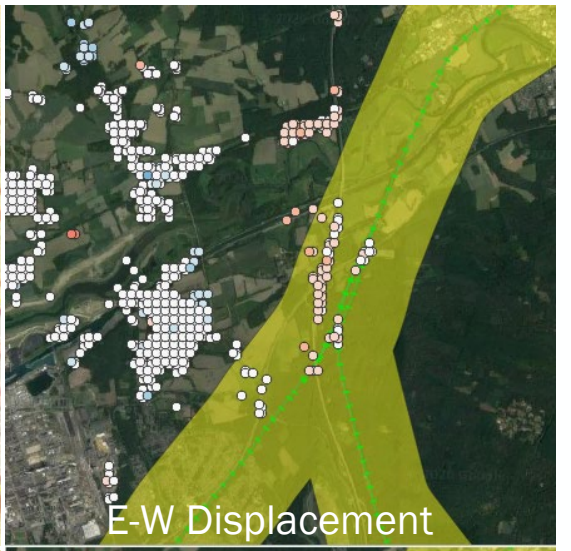
Concept of ADA Union and attribute transfer

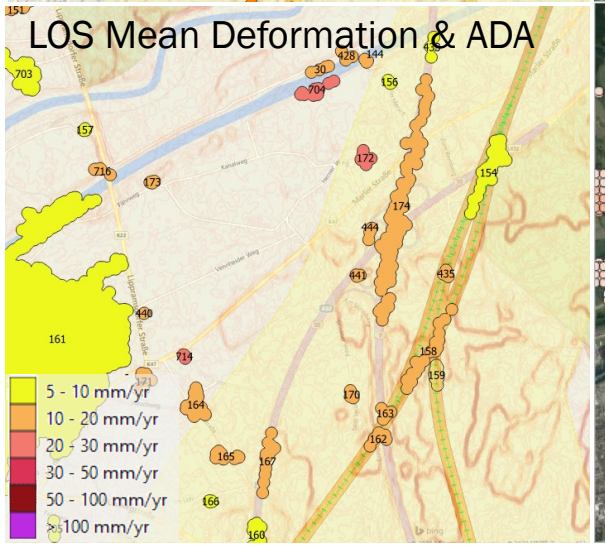


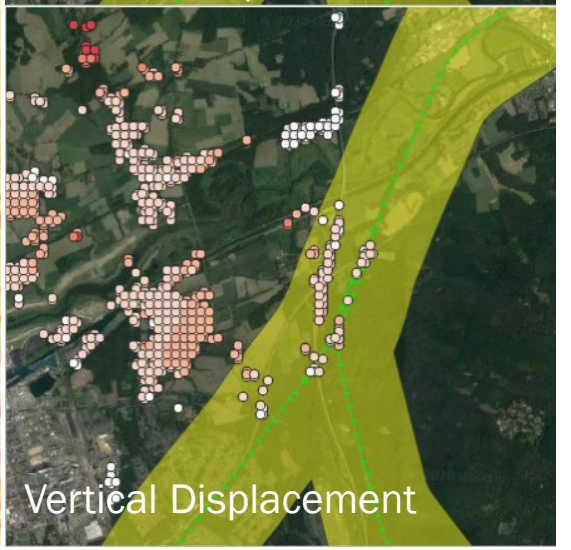
Hamm - Infrastructures

Location Name	Hamm – Haltern am See SW	ADA ID	158
Coordinates UTM	795936.599E,6745957.053 N	Coordinates Lon/Lat	7.15002 E,51.69941N
ADA Class	Bridge	ADA Quality Index	1
Corridors	60 m	Temporal Noise Index	1
LOS velocity	-10 mm/yr	Mean Deformation	-37 mm
Vertical Velocity	-9.8 mm/yr	Horizontal Velocity	-2.1 mm/yr
Slope mean	13.8°	Slope max	40.5°
Mining area	yes	Fault	no
Users	Infrastructure Experts Operation Managers Life Cycle Management	Use Case	1
Lithology	Marl: sandy, partly glauconitic, gray-green, and sand marl stone, gray, subordinate to sand-lime stone, gray, partly Fine sand, silty, calcareous.		
ADA Description	Bridge - Ground Motion 5-10 mm in inactive mining areas, vertical and horizontal displacement on rail track, highways and bridges nearby inactive mining areas		



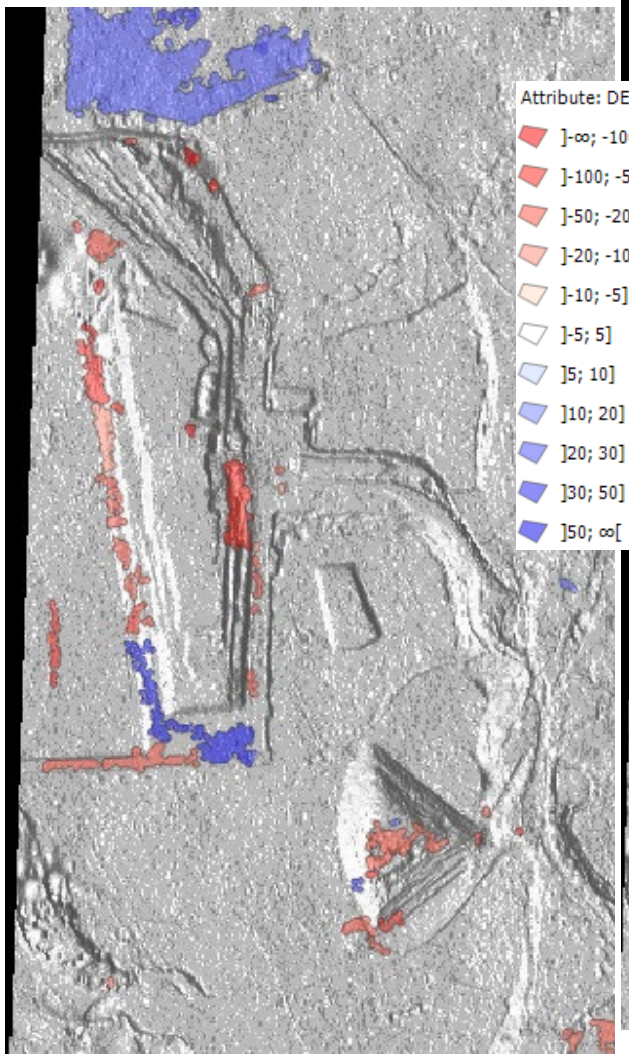




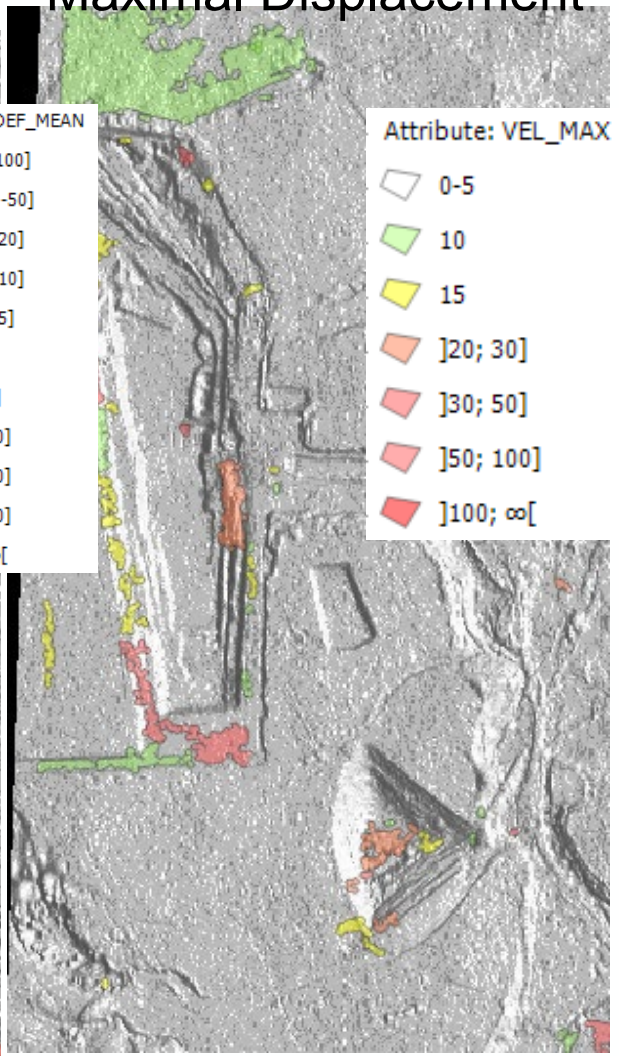


Garzweiler – Mining Activities

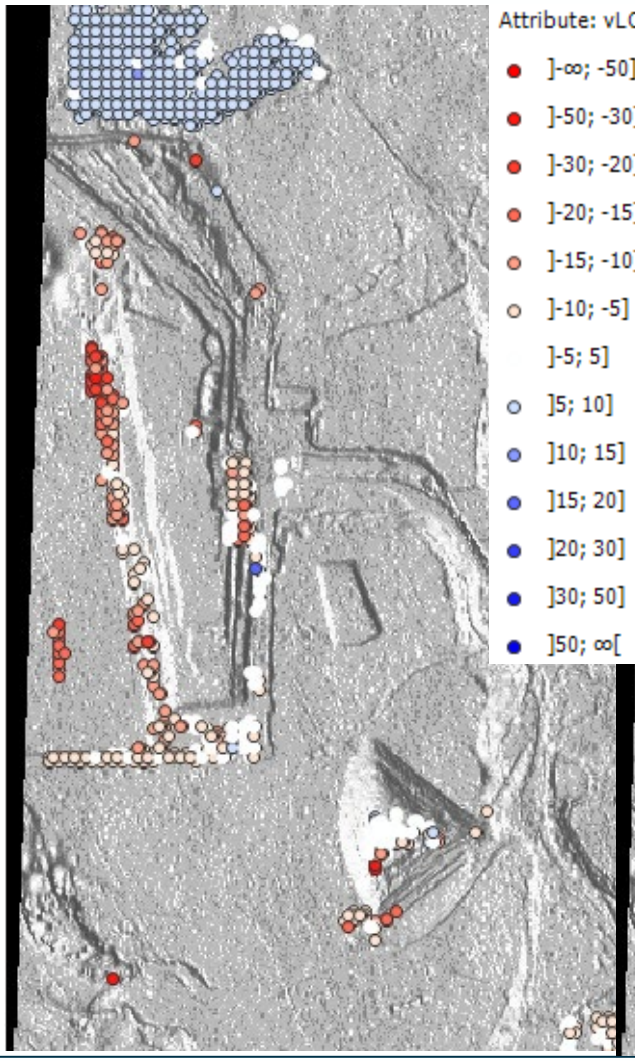
Mean Velocity



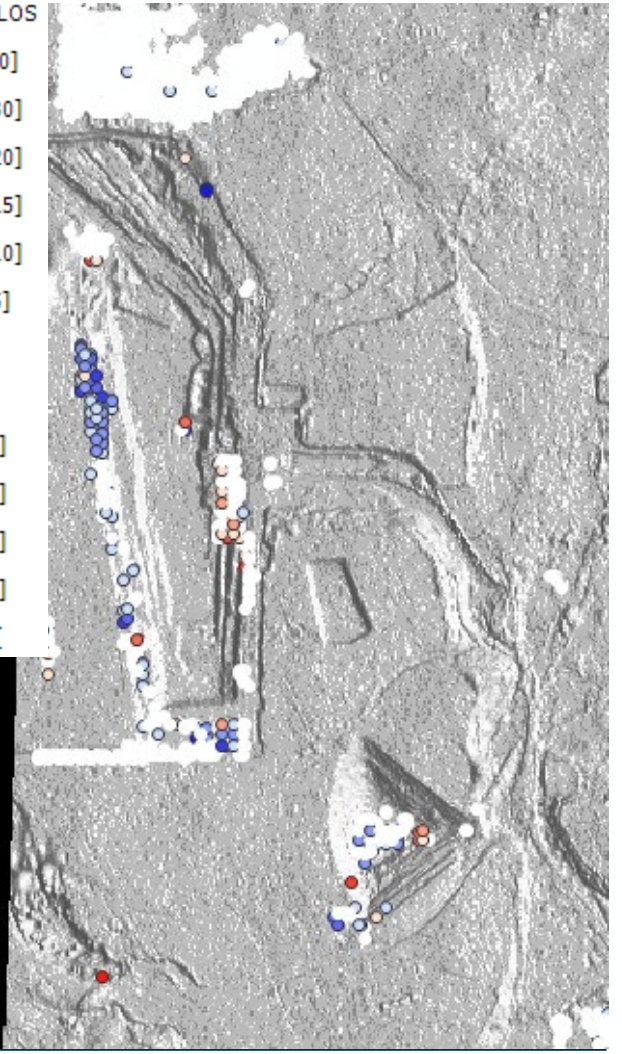
Maximal Displacement



Vertical Displacement

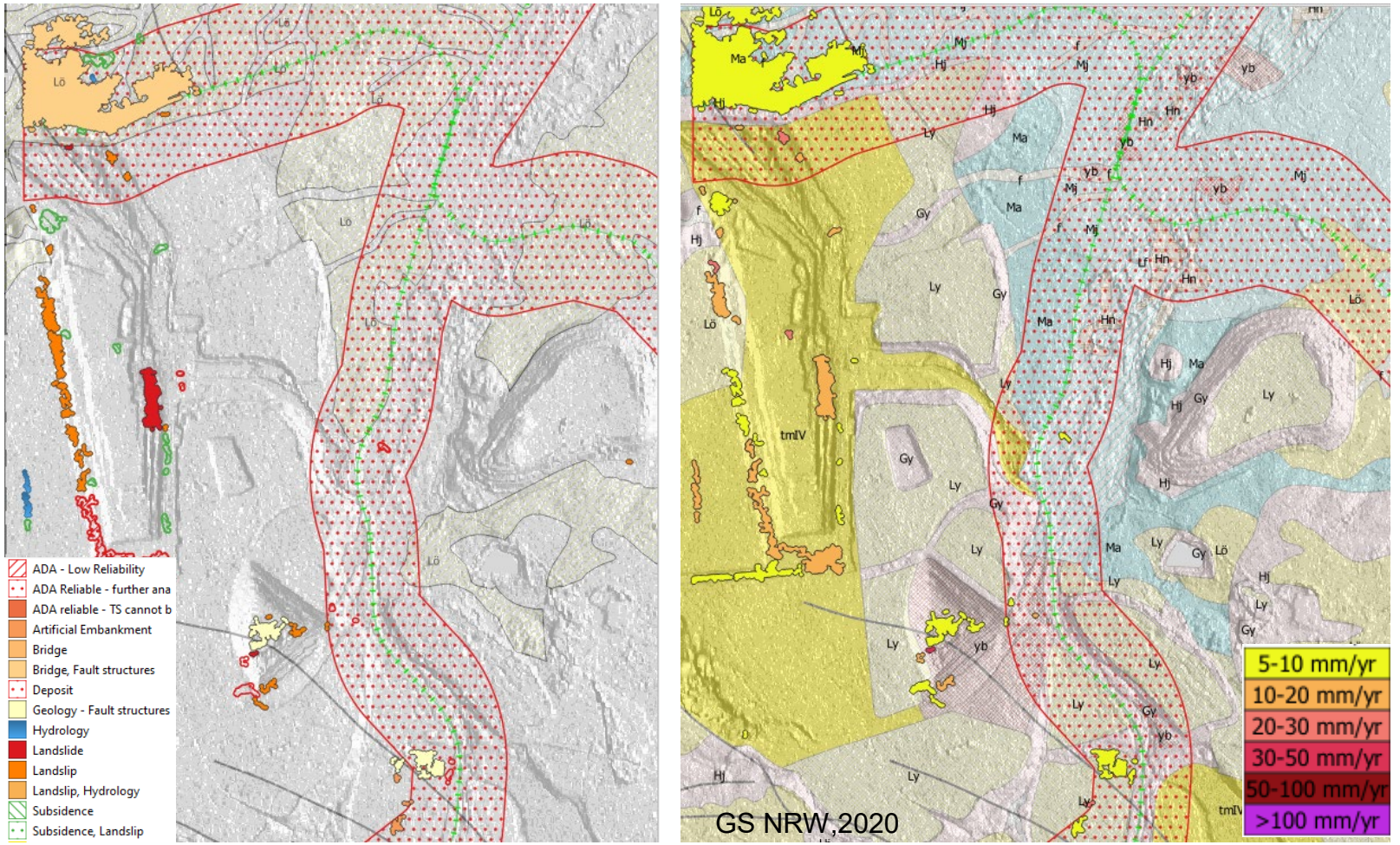


E-W Displacement



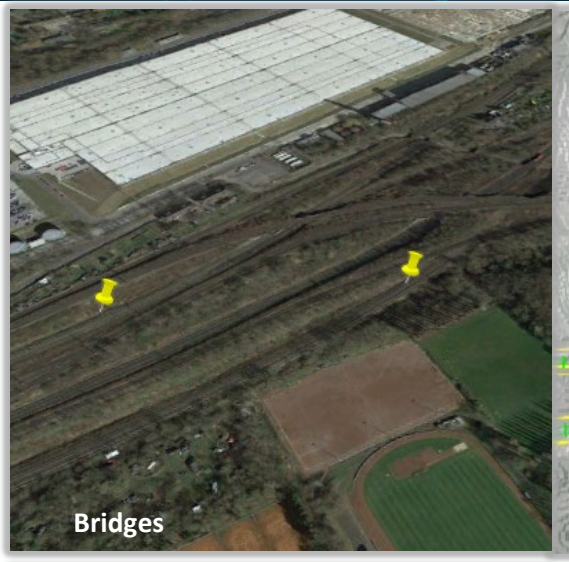
Garzweiler – coal mine

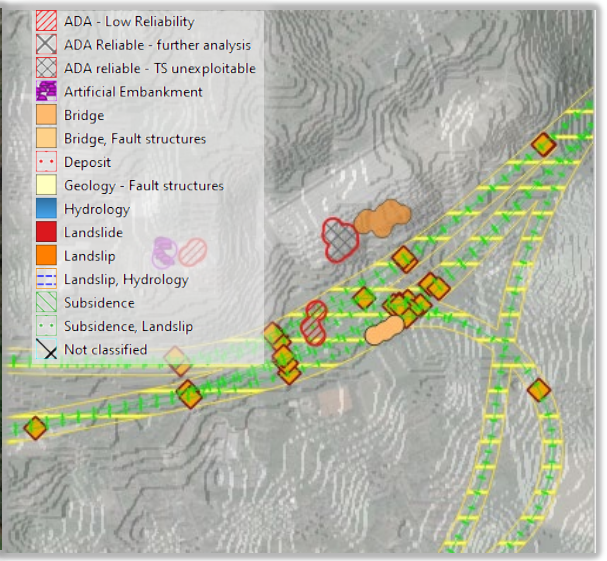
- Class: Landslide, Geology-Fault structures *Subsidence, Hydrology, Artificial Embankment, Bridge*
- Corridor: all
- Small to medium uplifts N of the coal mine and subsidence on several points along rail track E of the mine.
- Several maijor faults crossing the track.
- Subsidences up to - 50mm/yr
- Slope: 10° (mean), 38° (max)
- Lithology: Löss
- User:
  - Bridge Monitoring Experts
  - Infrastrucure Managers
  - Route Planning Experts

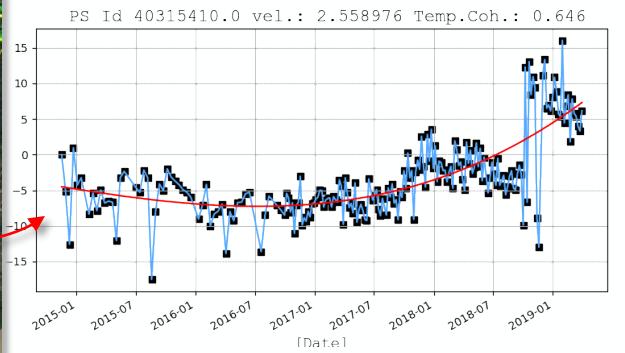


Bochum - Langendreer

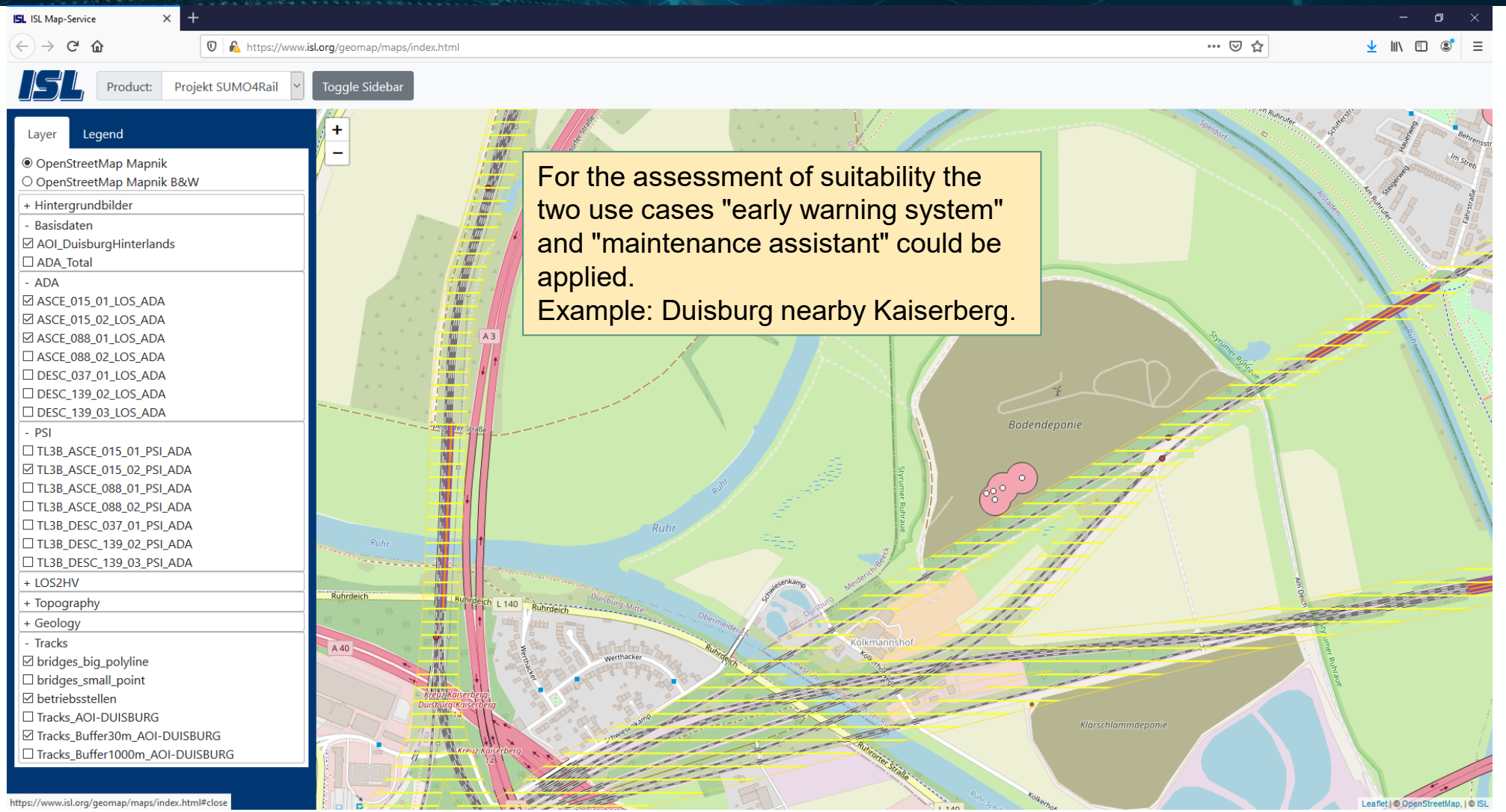
Location NamUTM e	Bochum-Langendreer Bridges	ADA ID	**396**
Coordinates	7.33227 E,51.47985 N	Coordinates Lon/Lat	7.33227E,51.47985N
ADA Class	Bridge ADA not reliable	ADA Quality Index	4 (bad)
Corridors	60 m	Temporal Noise Index	3 (poor)
LOS velocity	-3.5 mm/yr	Mean Deformation	-13 mm
Vertical Velocity	-1.16 mm/yr	Horizontal Velocity	-3.1
Slope mean	1.3°	Slope max	8°
Mining area	yes	Fault	no
Users	Bridge Monitoring Experts Infrastructure Managers Route Planning Experts	Use Case	1
Lithology	Deposits in stream and river valleys: Silt, clayey, sandy, and sand, silty, gravelly, gray to gray-brown, subordinate gravel, sandy, stones, local peat		
ADA Description	Signal not Reliable, but ground displacements in buildings nearby track.		







Validation Platform



Results

- Enhanced monitoring of railway infrastructure to detect damages at an early stage
- Predictive detection of deformation risks or subsidence damages at or in the vicinity of rail tracks
- Innovation potential mainly in infrastructure planning and identification of potential subsidence risks
- Suitable to avoid or limit effects of failure in case of identification of potential subsidence risks
- Practical application as a decision making support system for enhancement of infrastructure planning as well as the identification of potential subsidence risks feasible

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