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Making ground movement data accessible

Monitoring highways assets with InSAR

Friday, 09 January 2026

Introduction to SatSense

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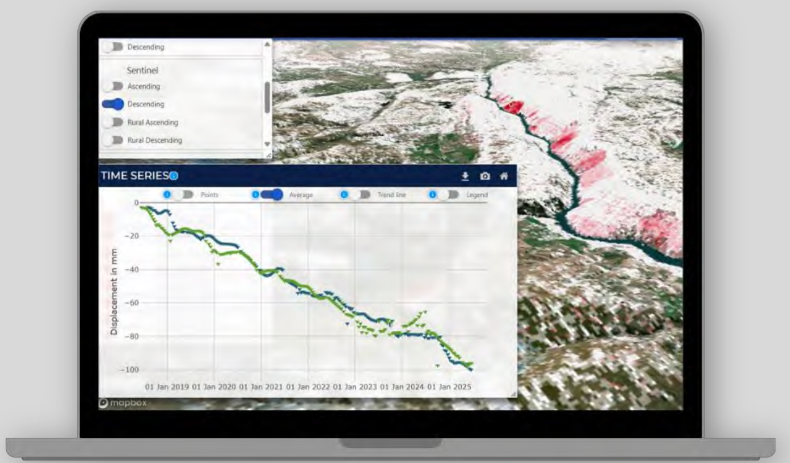
Core sectors:

Rail, Highways, Utilities, Geotechnical, Extractive, Energy, Insurance

Bespoke applications:

Complex structures, Disaster response, Defense analysis



We specialise in:

- Wide-area InSAR processing
- Near real-time with unique IP
- Flood mapping
- Change detection & alerting
- Corner reflector services

Enablers:

- Web Platforms - Marketplace and Analysis
- Data via API, GIS plugins
- Machine Learning
- Volcanoes and earthquakes expertise

Recent transport project highlights

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NetworkRail | ARUP | national highways | Amey | national highways | Die Autobahn

Network-wide API InSAR data stream into in house GIS (20,000 miles of track)

Arup and National Highways InSAR trials (Pritchard et al., BGA Geo-Resilience 2023)

Complex structural investigation of a UK motorway bridge from 1992 to present

Awarded tender for high-resolution X-band monitoring with in-situ validation

2023 — 2024 — 2025

M4 motorway tollbooth roadbed settlement investigation

Over 50 corner reflectors delivered to NR for deployment on earthworks

Vegetation capable commercial L-band monitoring along a military road

Expected availability of NISAR for open-source UK-wide L-band SAR data

wsp | Llywodraeth Cymru Welsh Government

CGL GEOTECHNICAL & GEOENVIRONMENTAL CONSULTANCY A PHENNA GROUP COMPANY

NISAR NASA - ISRO SAR Mission

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What is InSAR?

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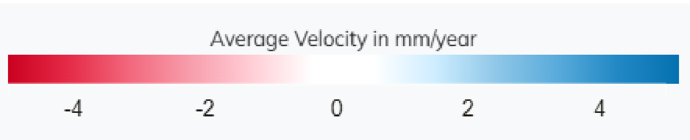
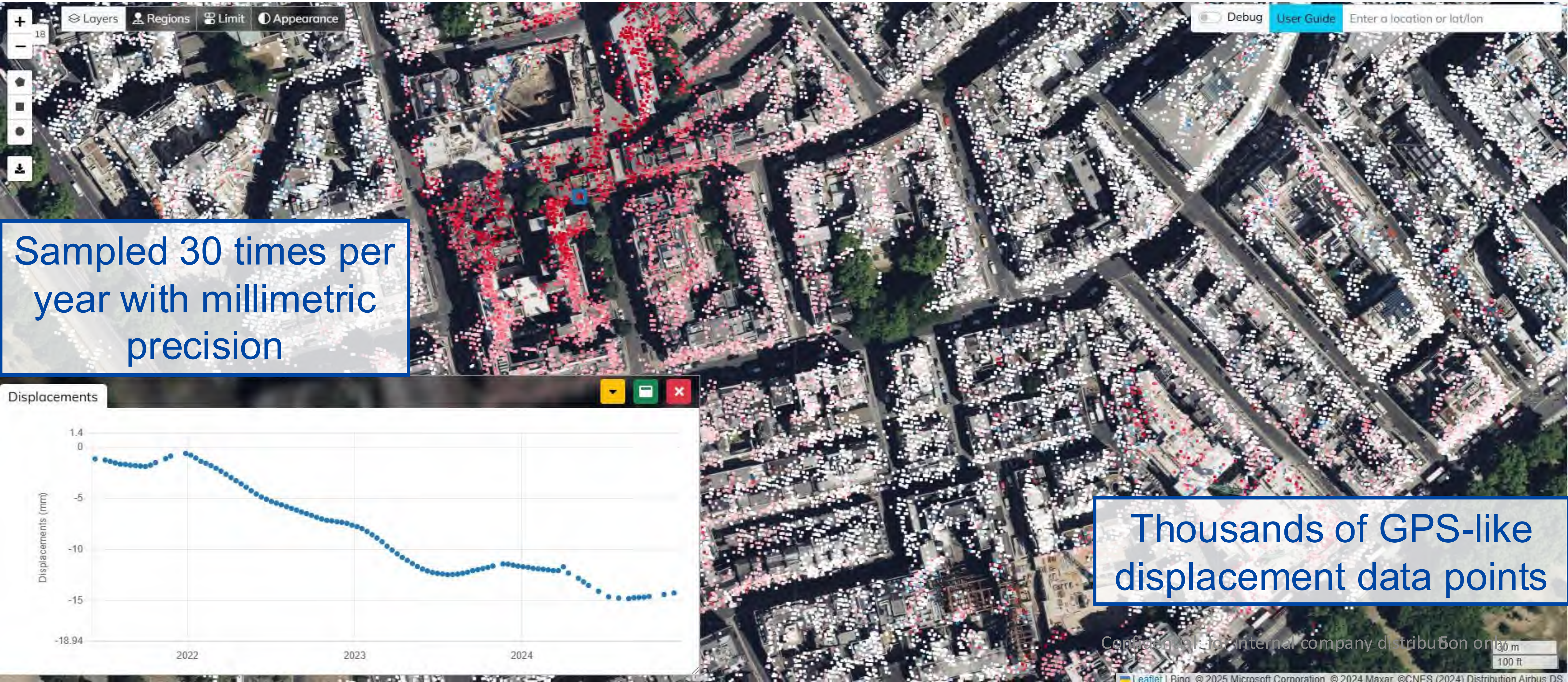
InSAR = Interferometric Synthetic Aperture Radar





Sampled 30 times per year with millimetric precision

Thousands of GPS-like displacement data points

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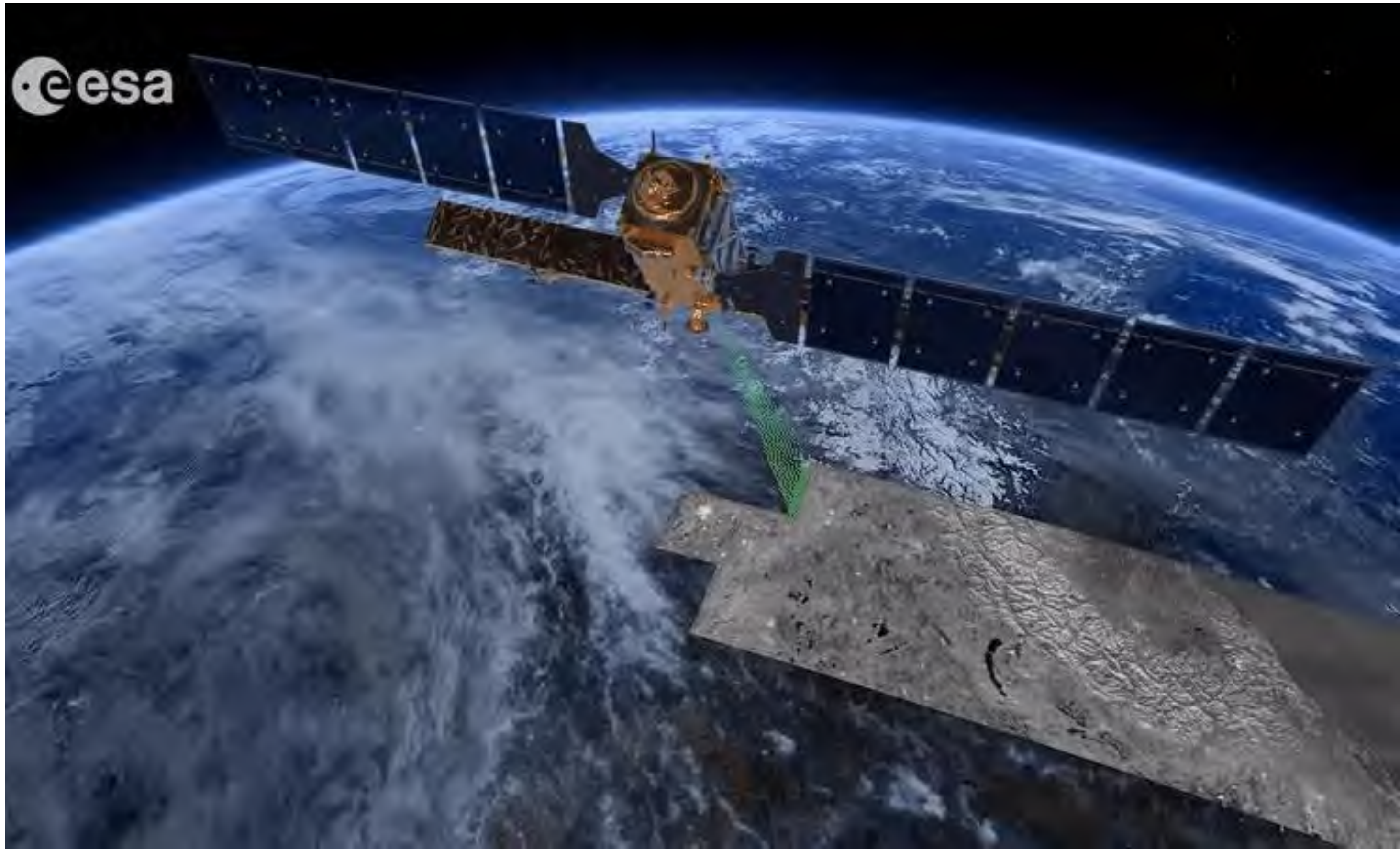
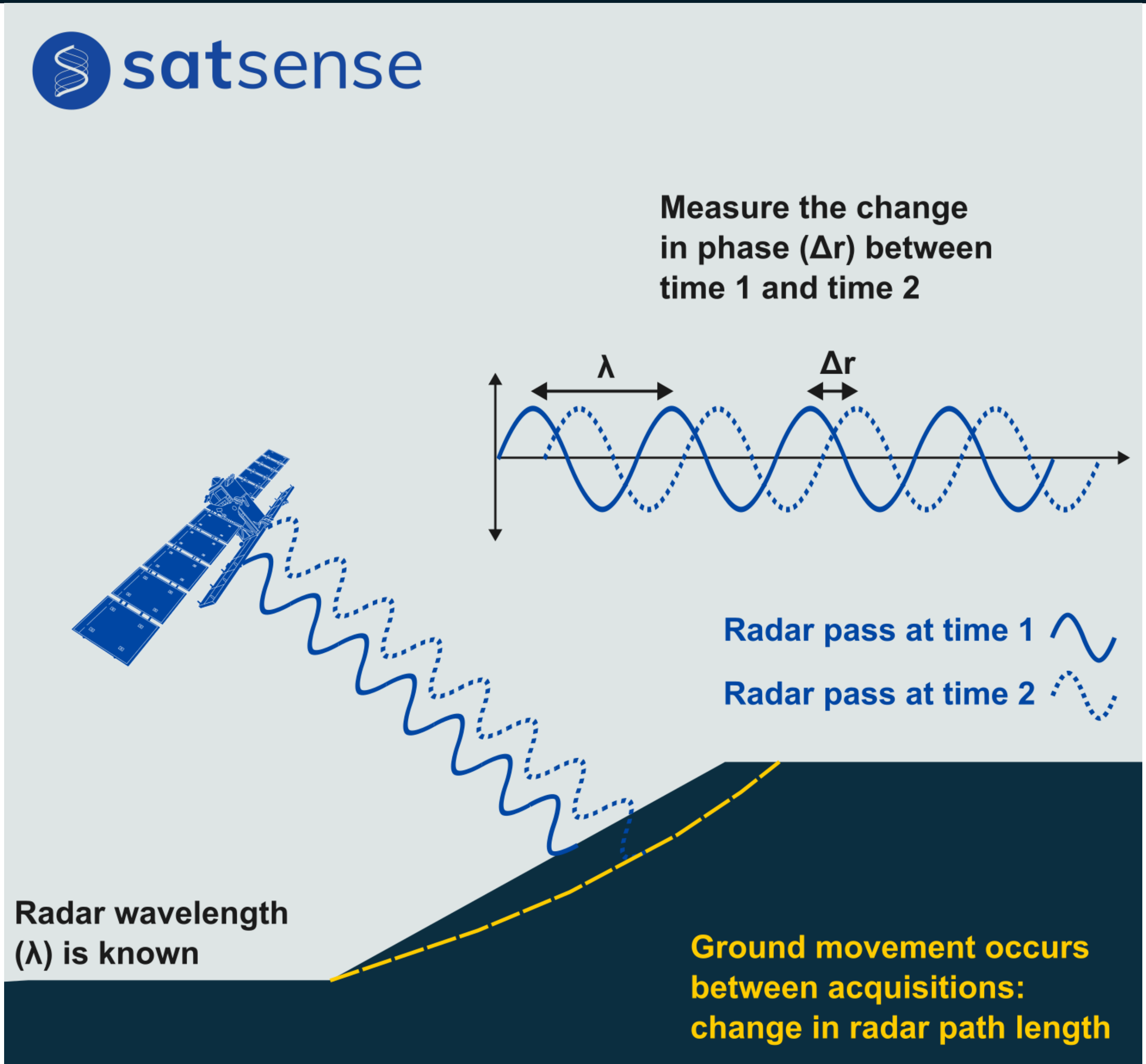
SAR

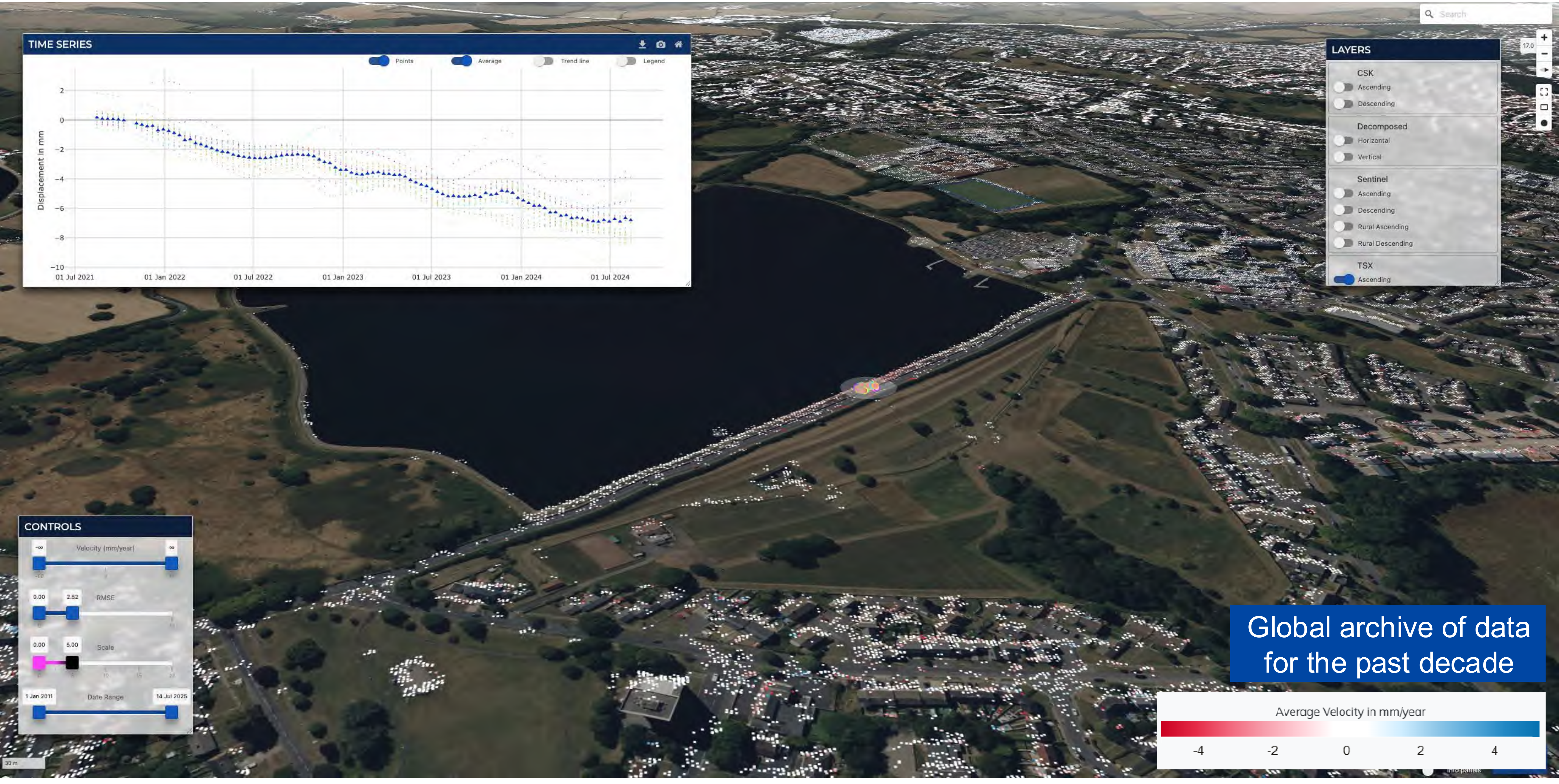
- Synthetic Aperture Radar
- Active remote sensing technique
- Penetrates cloud/smoke, works day or night
- Captures both amplitude and phase



How does InSAR work?

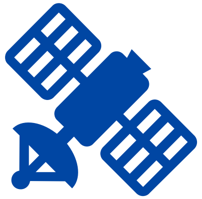


Opportunistic data with retrospective archive



Bridges

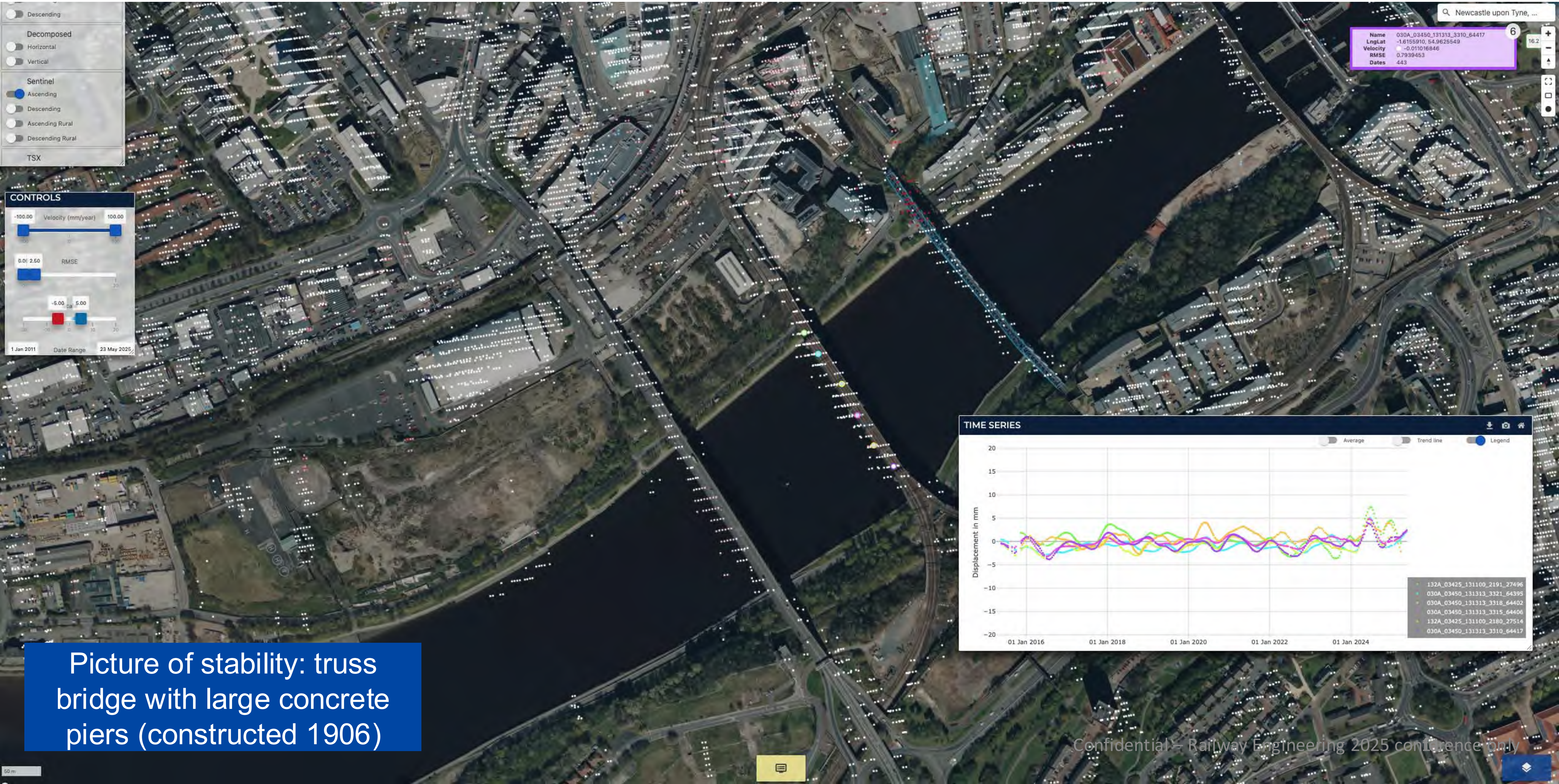
- Many bridges around the UK (and world) are nearing the end of their design life.
- Ever increasing operational loads.
- 86 structures currently in use by National Highways are past modern design life standards of 120 years.
- National Highways – inspections typically every 2 years with more detailed inspections every 6 years (cost and labour intensive).
- Structural health monitoring is becoming more common – extensive deployment of I&M solutions.



Can remote InSAR monitoring help?

Newcastle – comparison of three bridges

Thermal response - seasonality



Picture of stability: truss bridge with large concrete piers (constructed 1906)

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Thermal response - seasonality

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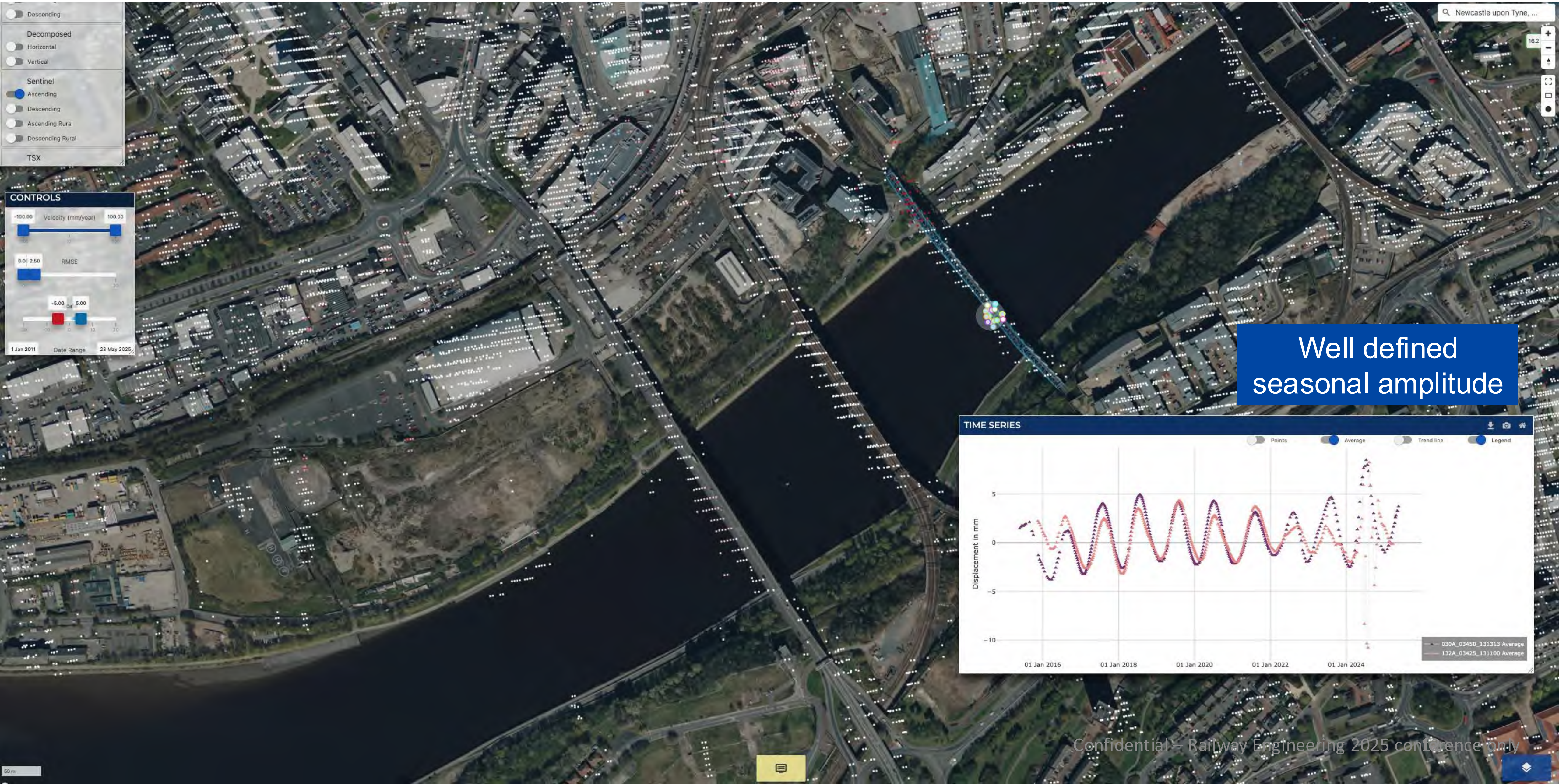

Well defined seasonal amplitude

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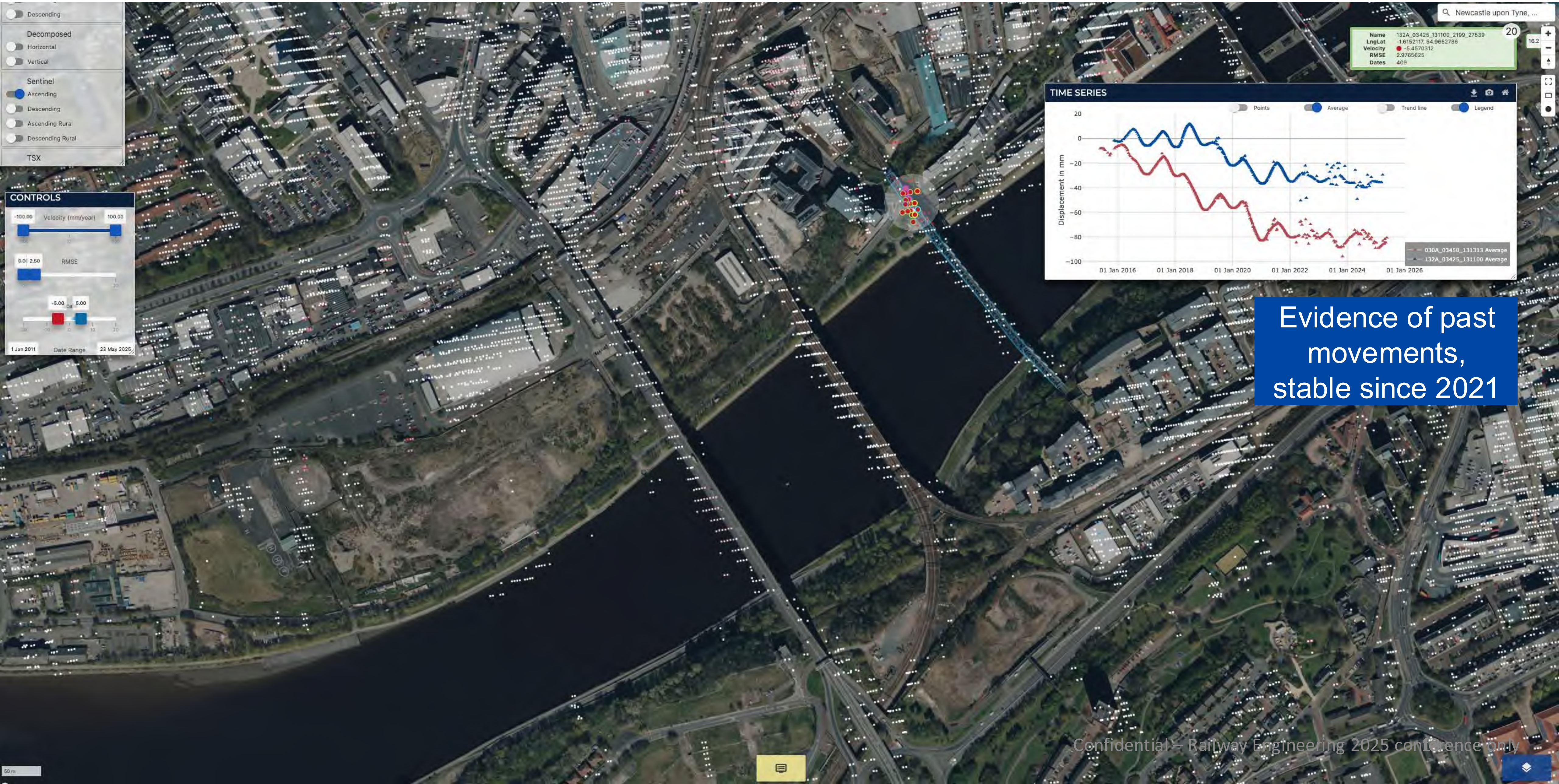
Obvious movement signals



Evidence of past movements, stable since 2021

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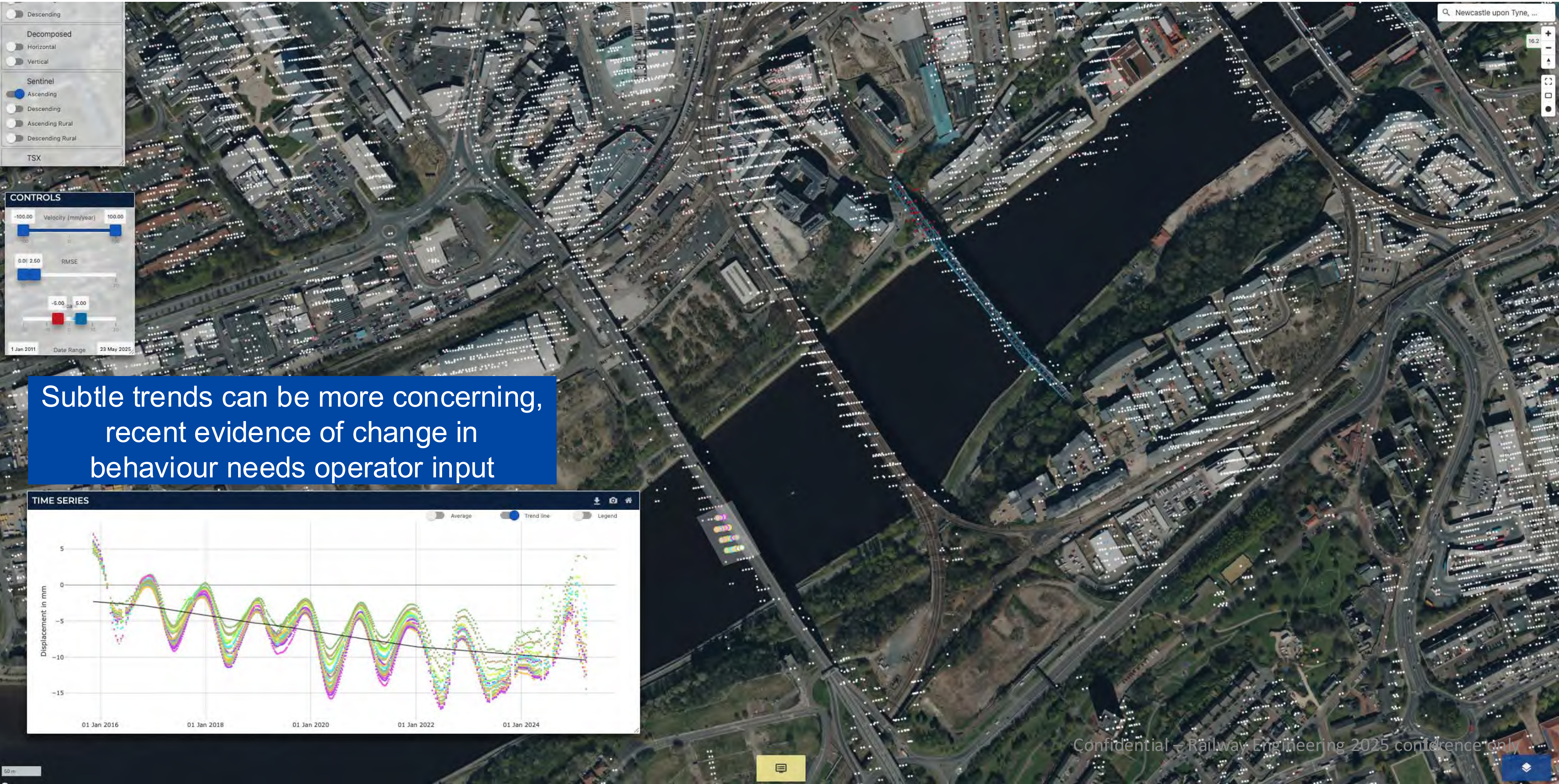
Subtle movement signals



Subtle trends can be more concerning, recent evidence of change in behaviour needs operator input

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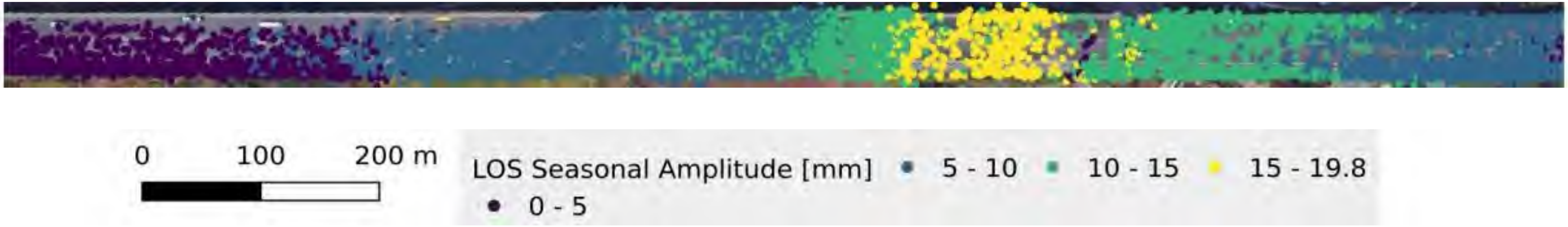
Challenges for InSAR on bridges

Bridges have many movement signals:

- Thermal expansion/contraction (seasonal)
- Traffic loading response (random at time sampling)
- Structural degradation (important)
- Others (e.g. wind; random)

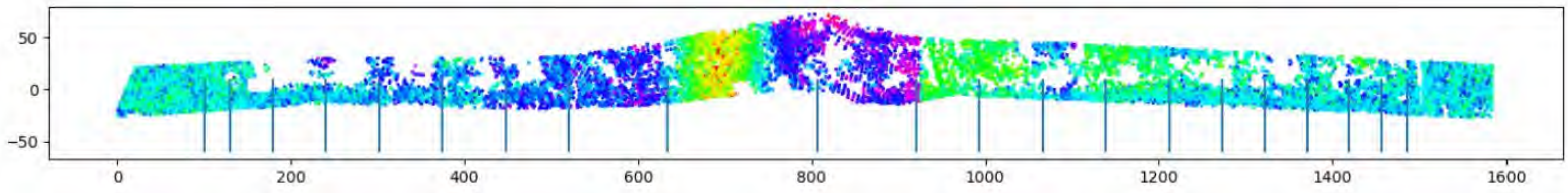
Seasonality on a steel girder bridge



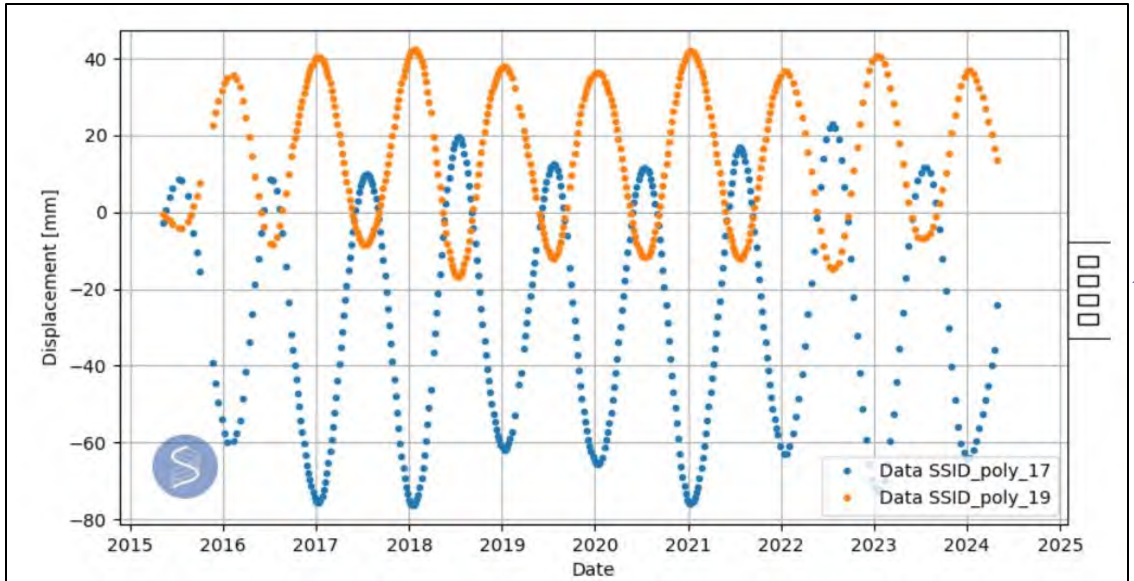
InSAR challenges for bridges

Interferogram (displacement between two dates)

Central span moving in a different direction to neighbouring anchor spans



Expansion joint



Movement on either side of the expansion joint (each side moving in opposite directions)

Signal separation

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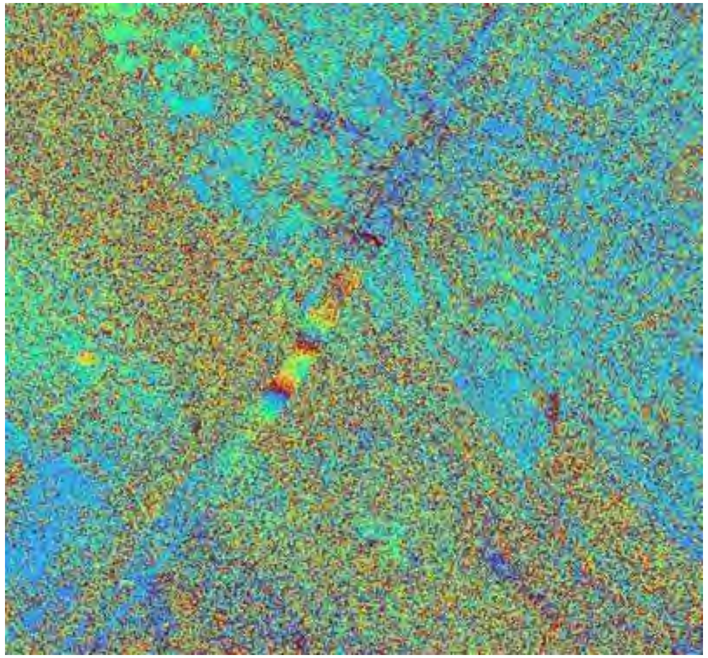
To identify signals related to degradation or other instabilities, techniques must be applied to deduce the relevant signals from "noise”.



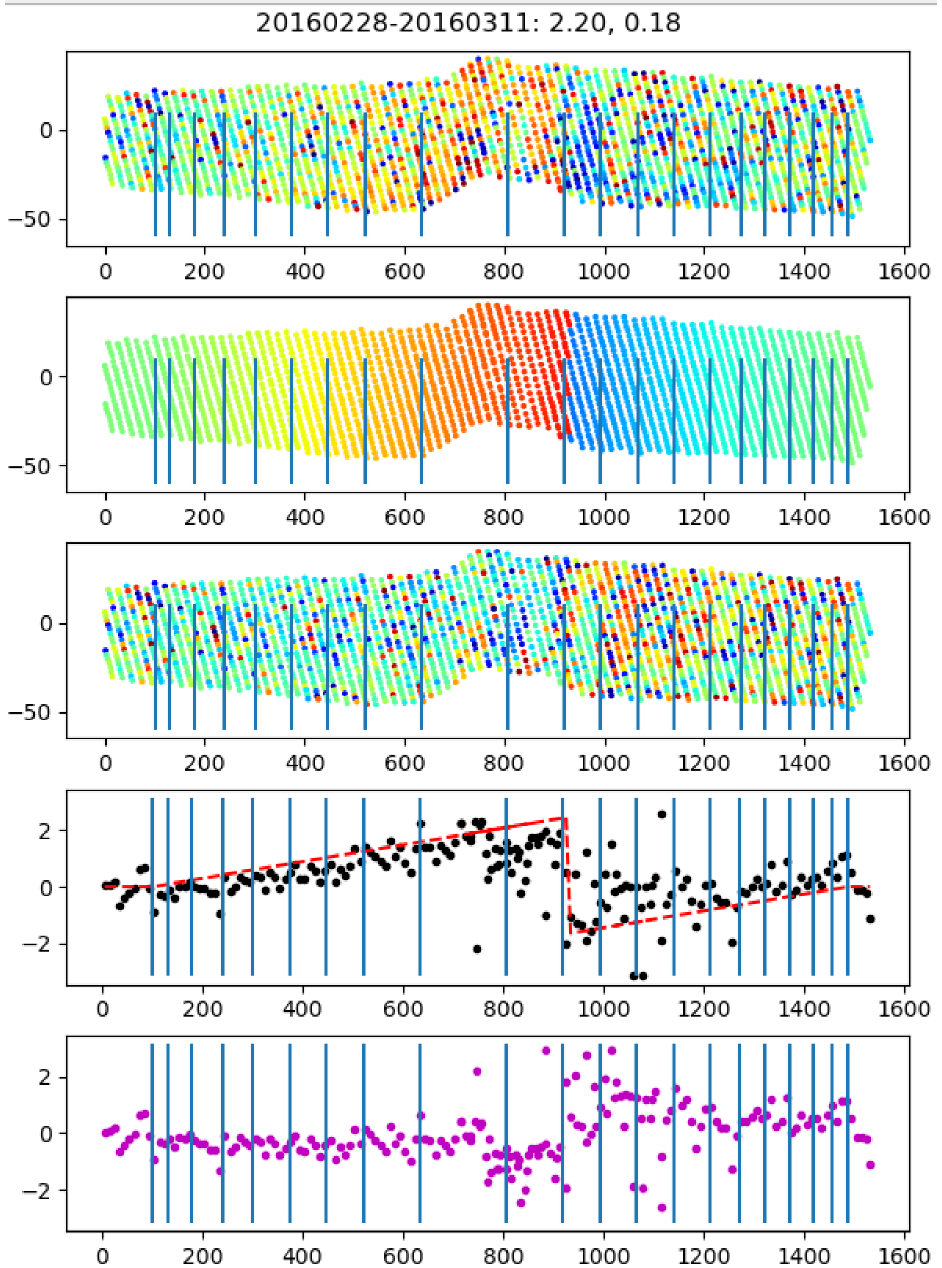
Interferogram

Thermal model prediction

Residual

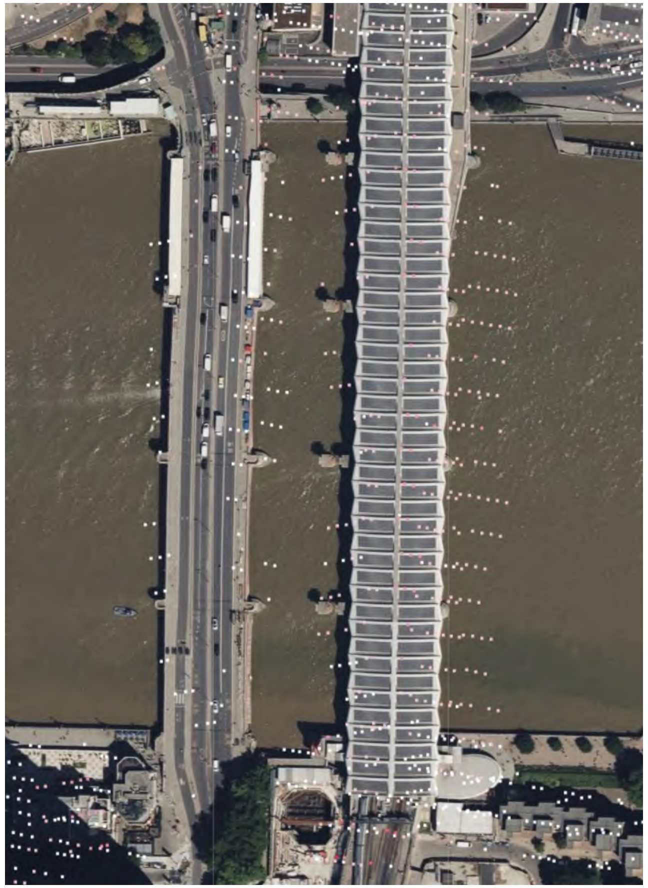
Interferogram average across bridge deck and model

Residuals of running average



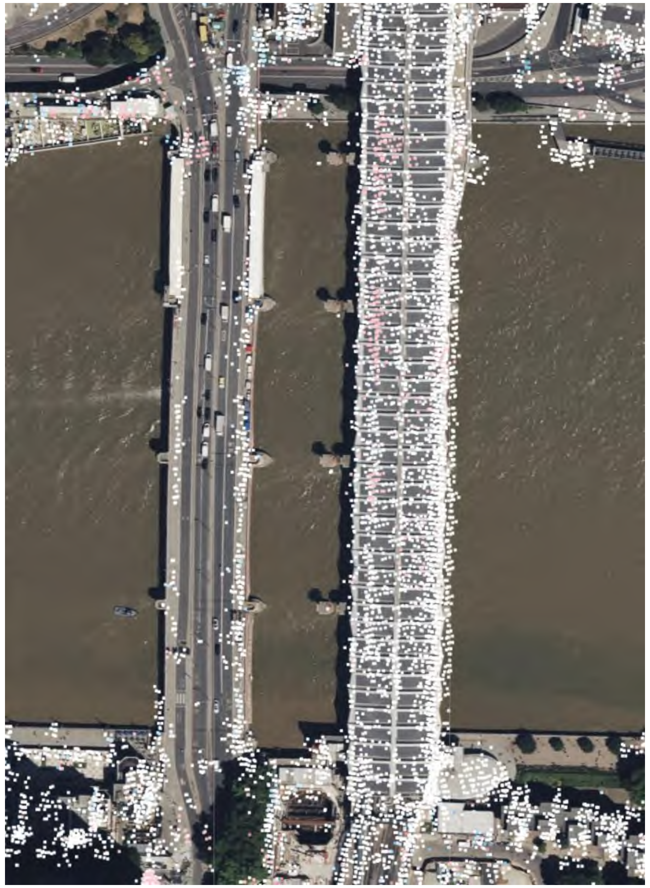
Spatial resolution

Sentinel-1 C-band
4 x 14 m resolution



Open-source input data
Global decade archive

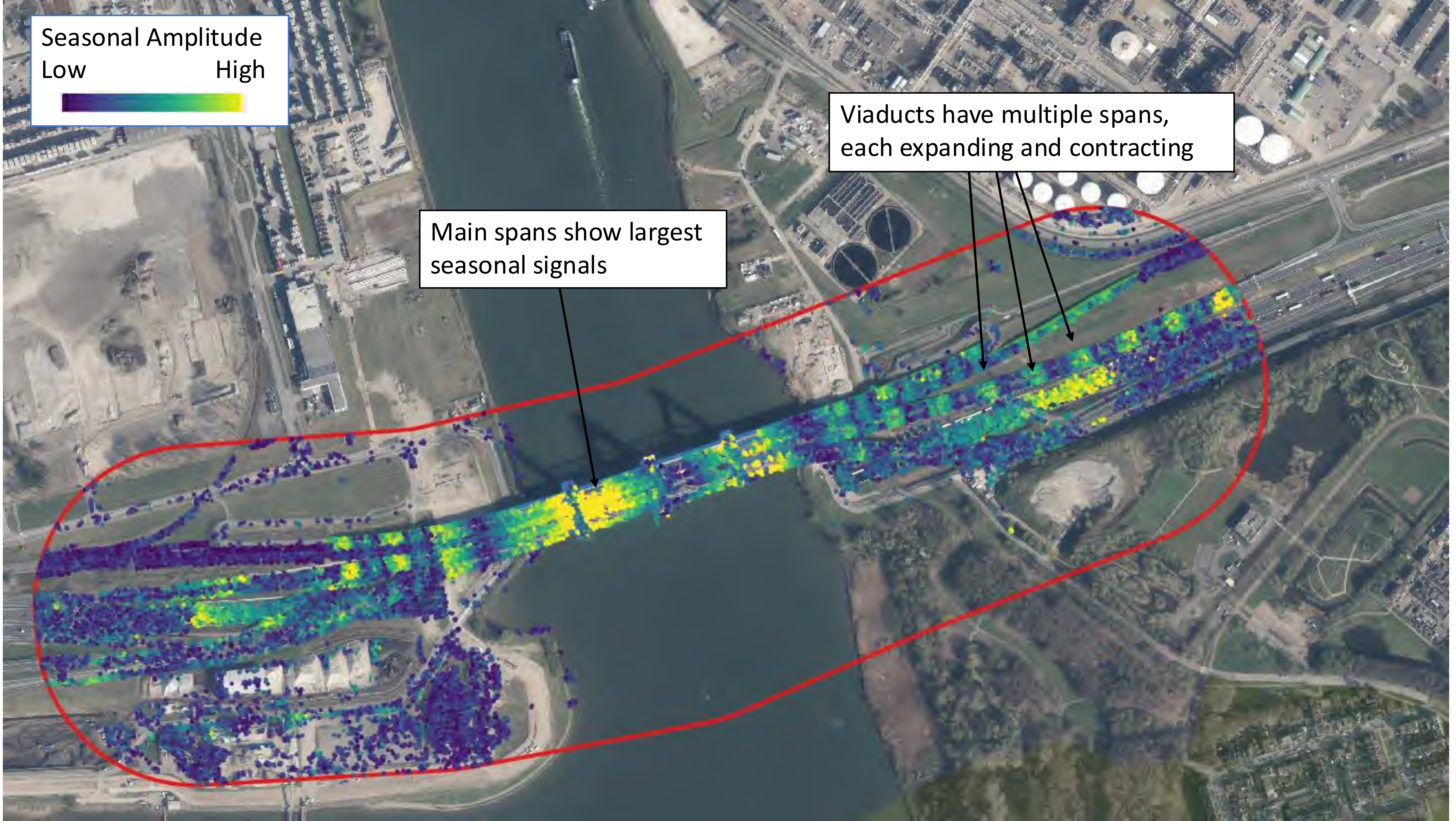
CSK and TSX X-band
3 x 3 m resolution

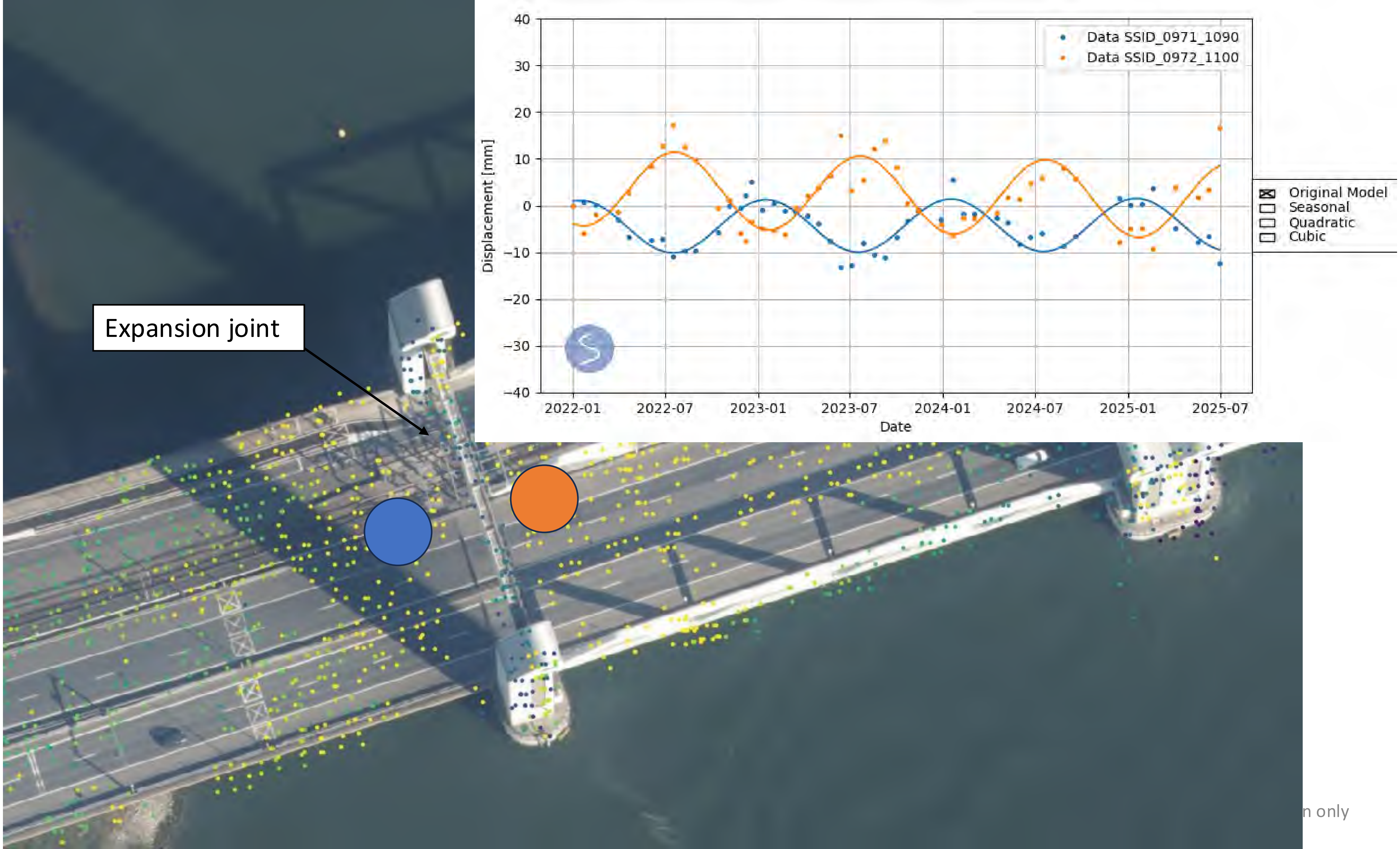


Higher point density
Improved geo-positioning

Trial using InSAR data for Rijkswaterstaat (RWS)

- High resolution X-band data
- Hundreds/thousands of measurements on the bridge and viaducts
- 3D point positions – separate deck from pillars
- Measure long term and seasonal movements


Seasonal Amplitude
Low
High
Viaducts have multiple spans, each expanding and contracting
Main spans show largest seasonal signals


Expansion joint
Data SSID_0971_1090
Data SSID_0972_1100
Original Model
Seasonal
Quadratic
Cubic
Displacement [mm]
Date
40
30
20
10
0
−10
−20
−30
−40
2022-01
2022-07
2023-01
2023-07
2024-01
2024-07
2025-01
2025-07

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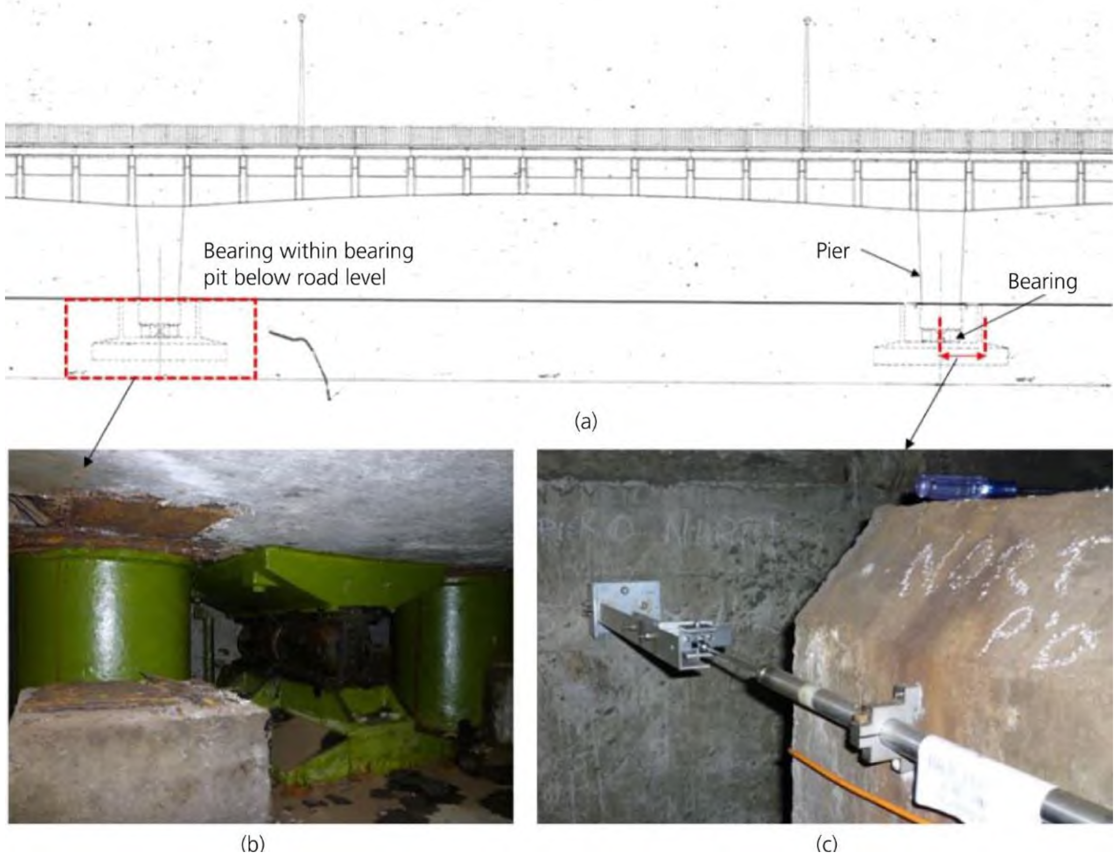
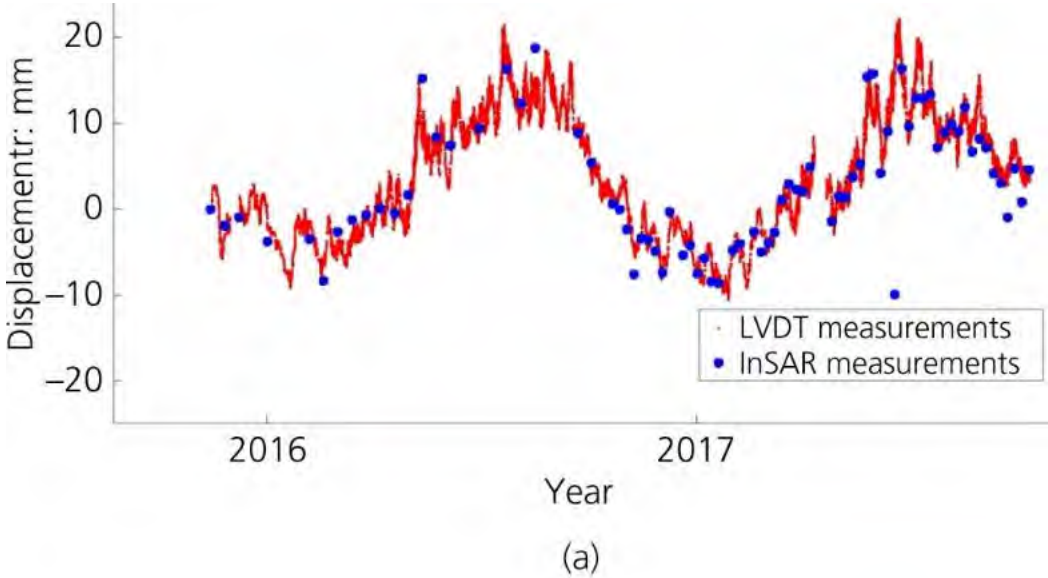
Comparison with in-situ monitoring

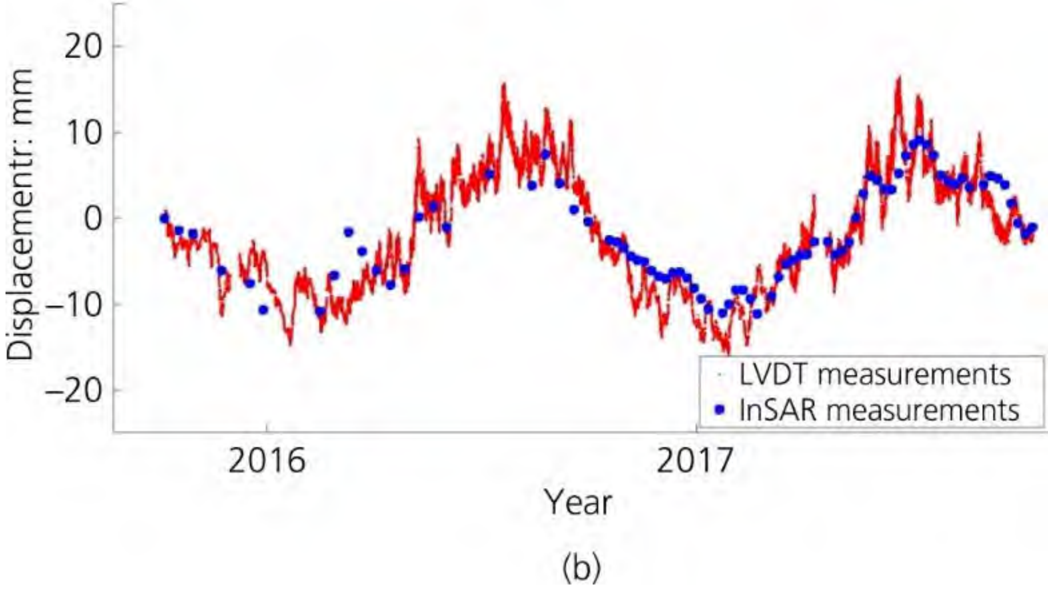
Hammersmith Flyover

Example from published literature with SatSense Professors as co-authors

Selvakumaran et al. (2022; Smart Infrastructure and Construction); Comparison of in situ and interferometric synthetic aperture radar monitoring to assess bridge thermal expansion.



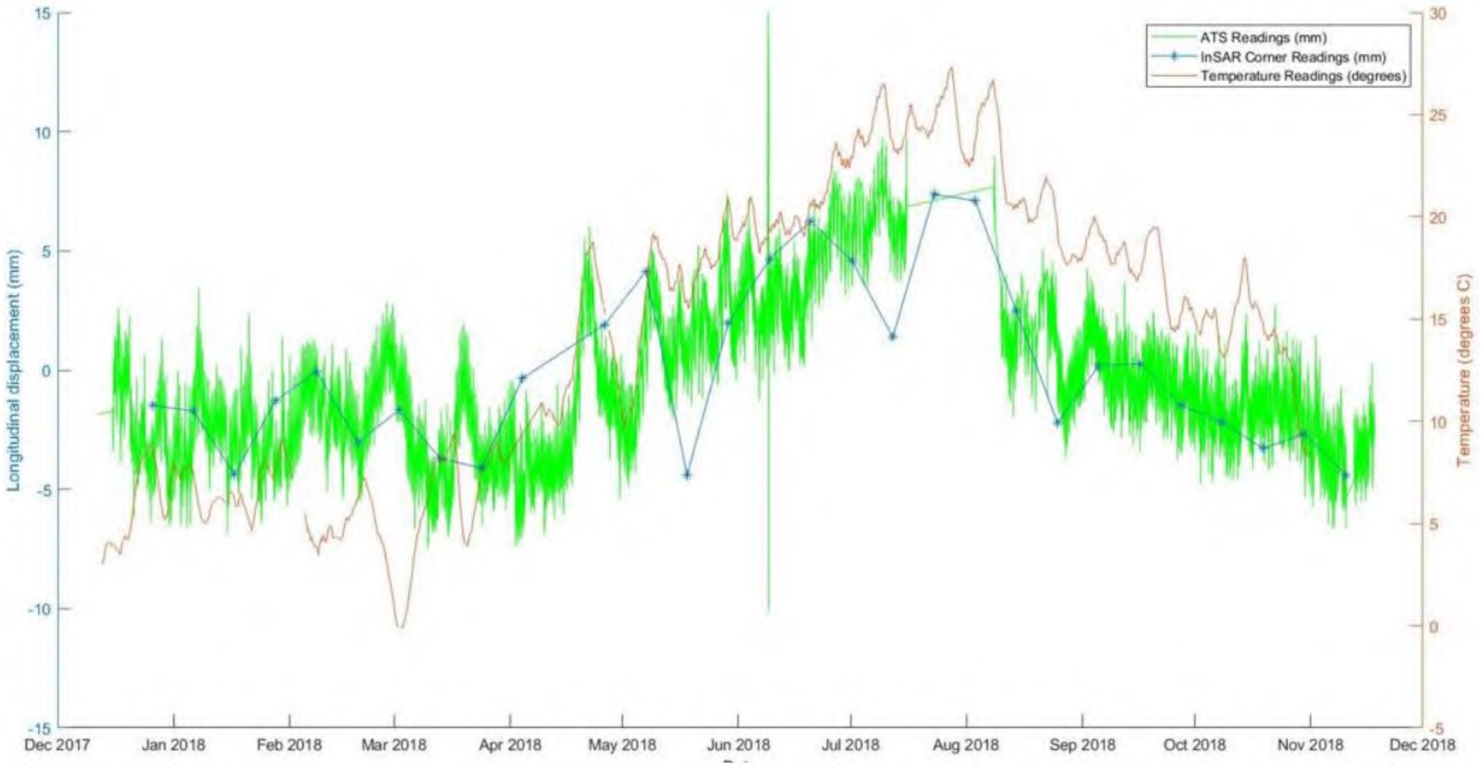




Comparison with in-situ monitoring

Waterloo Bridge

Example from published literature with SatSense co-authors
Selvakumaran et al. (2020; IEEE Transactions on Geoscience and Remote Sensing);
Combined InSAR and Terrestrial Structural Monitoring of Bridges.



Additional geospatial expertise

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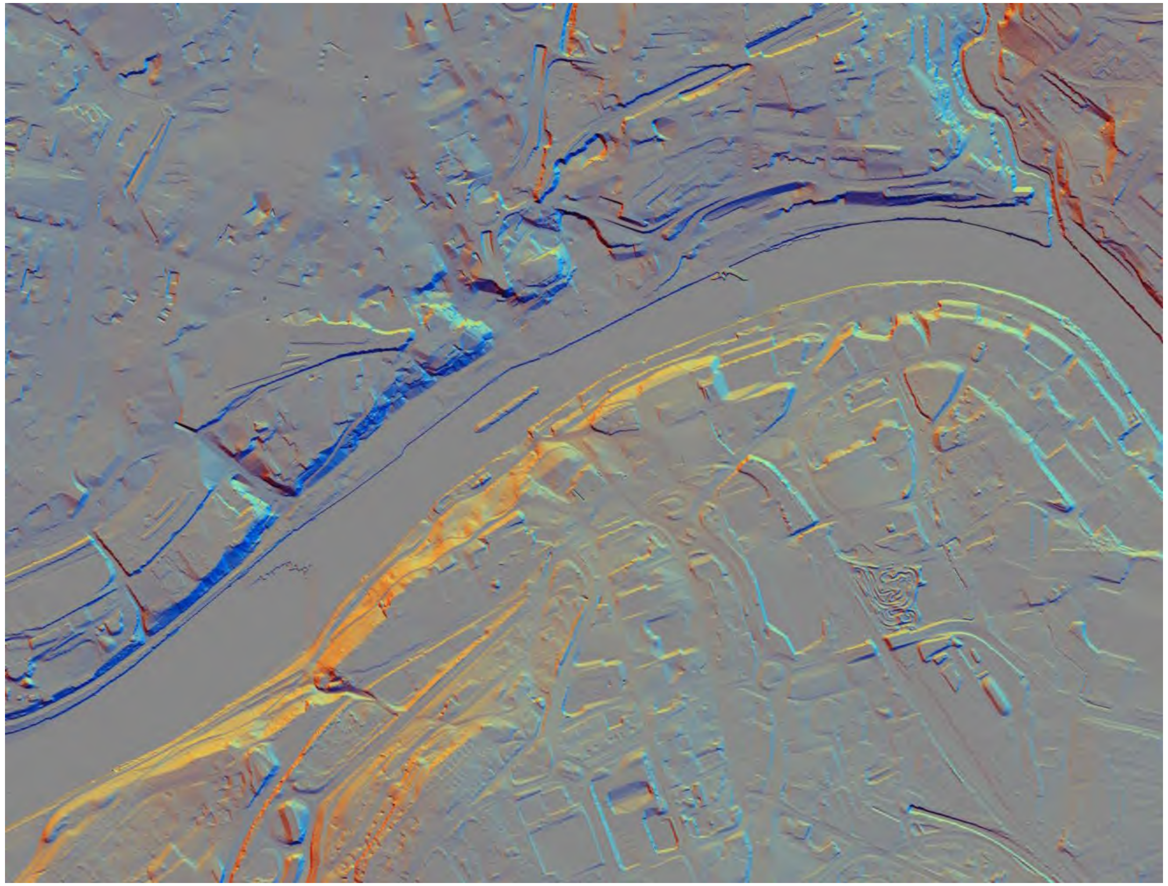

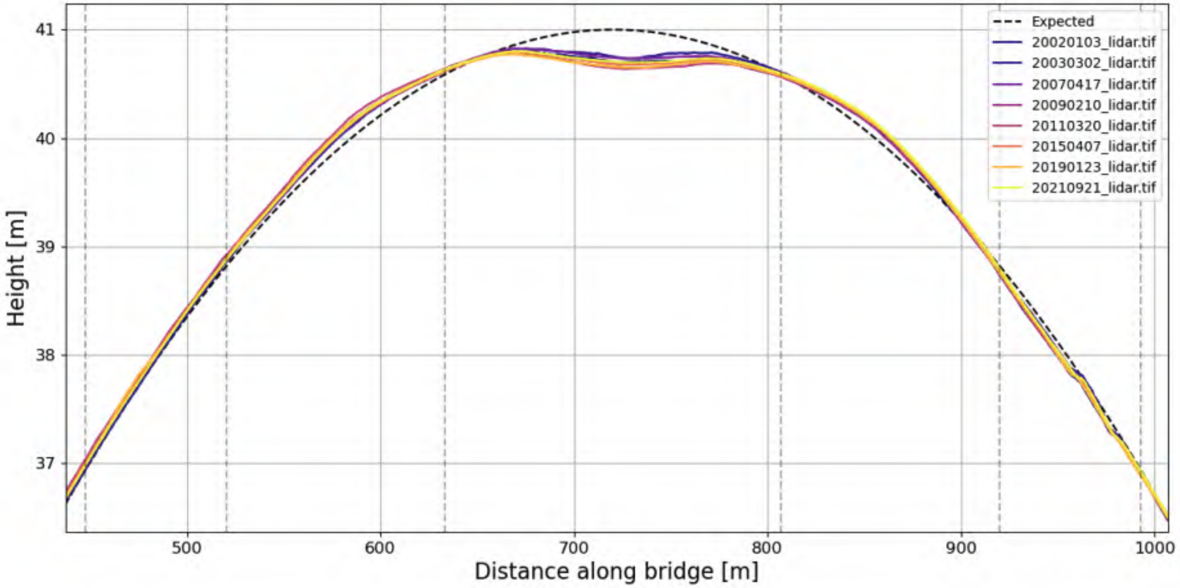

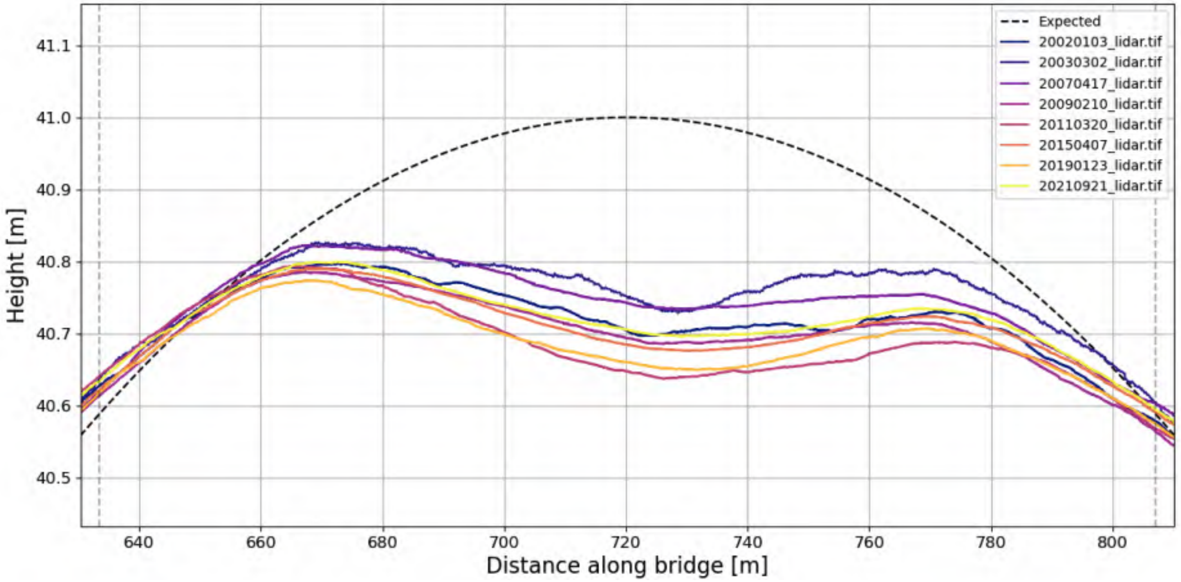

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High-resolution monitoring – M3, UK

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Flood mapping with SAR

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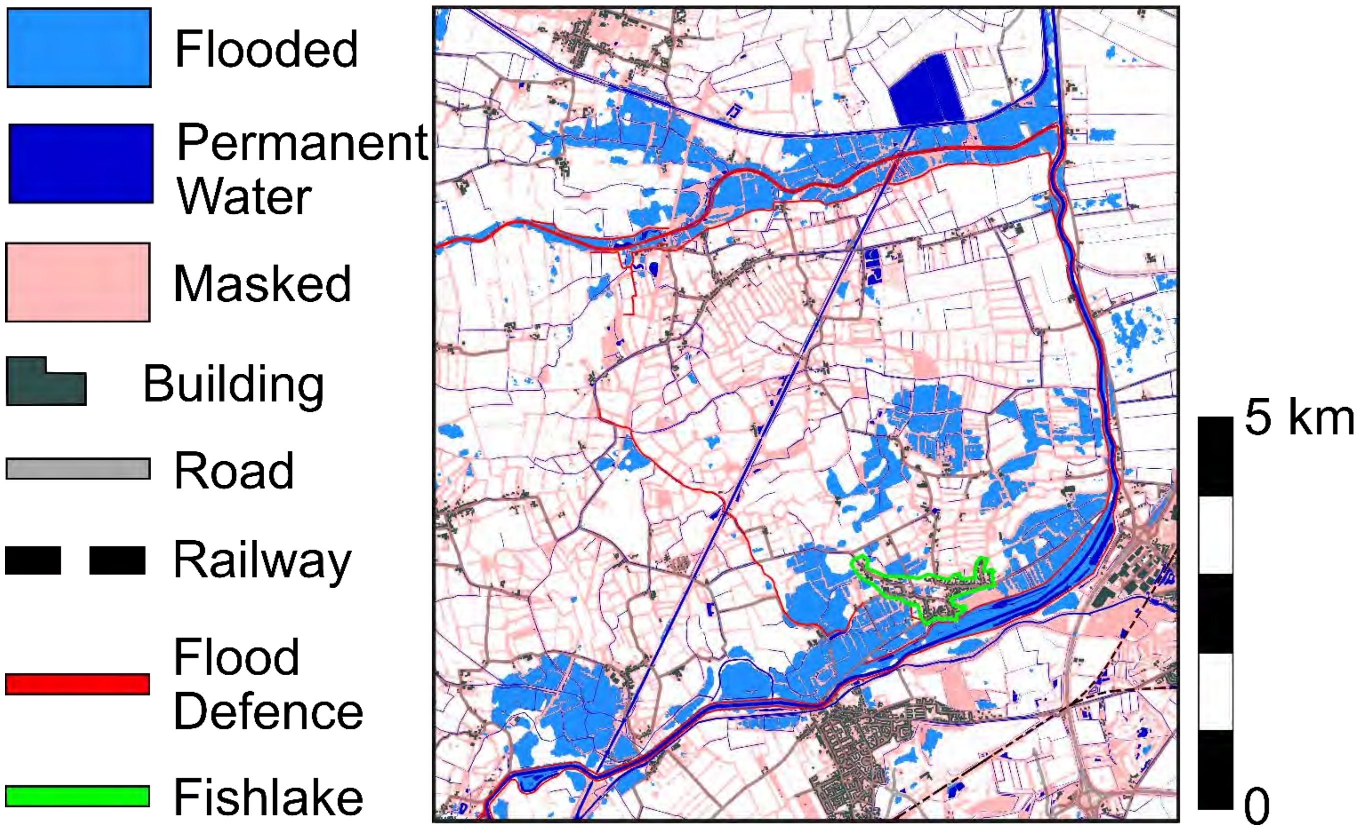

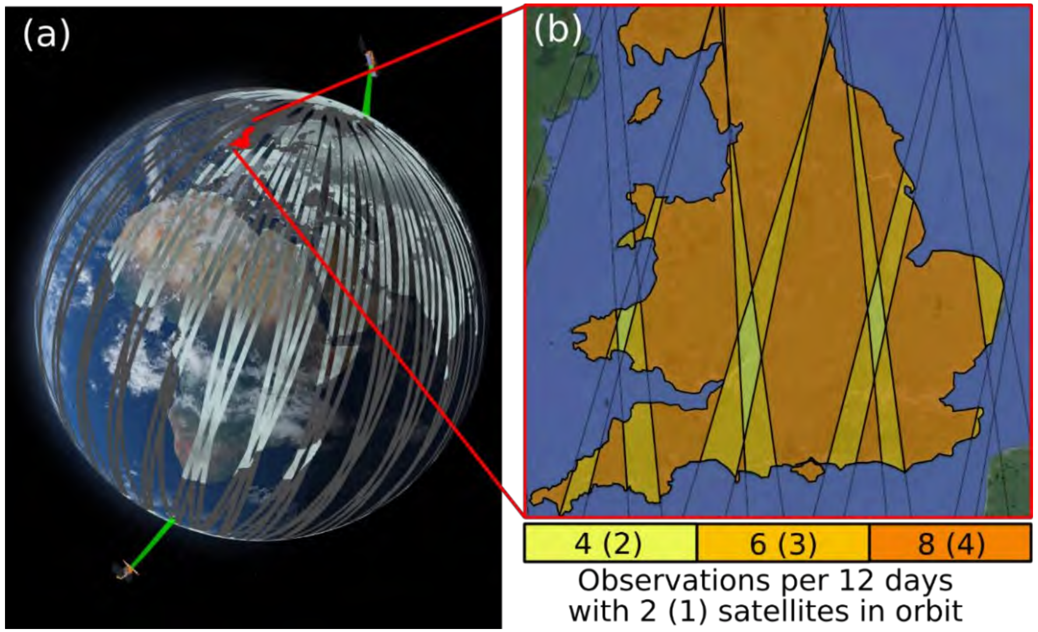

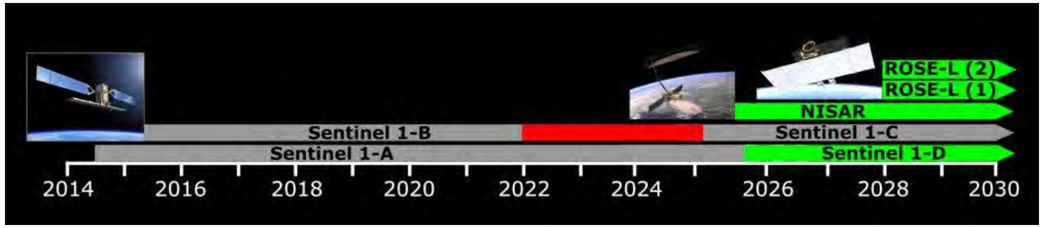

Near daily ongoing and historical assessment of flood extents

SAR flood assessment

Project deliverables

SatSense Analysis platform (or via API)

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Discover
deformation of earthworks and structures across the entire network.

Assess
past and ongoing movement trends on individual assets.

Validate
in situ measurements and supplement ground observations.

Summary – bridge monitoring with InSAR

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- High precision remote monitoring.
- Supports long term assessments.
- Requires expert analysis with contextual information.
- Separate signals associated with degradation from "noise”.
- Interpretation requires engineer input.

Complementary to existing methods:

- Retrospective analysis is possible.
- Spatially rich dataset vs in situ point measurements.
- No access required for set-up or maintenance.
- Reliable back-up if in situ systems go down.

M25 Heathrow Junction Flyover

Why use InSAR

- Detect at risk-areas or structures before they become a problem
- Assess historical movement trends with archive data
- Monitor ongoing ground and structural movements / stability
- Reduce boots on the ground and closures using remote sensing
- Inform proactive maintenance strategy and network resilience