Effective PolInSAR Coherence Optimization for Deformation Monitoring using Compact Polarimetry

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Overview

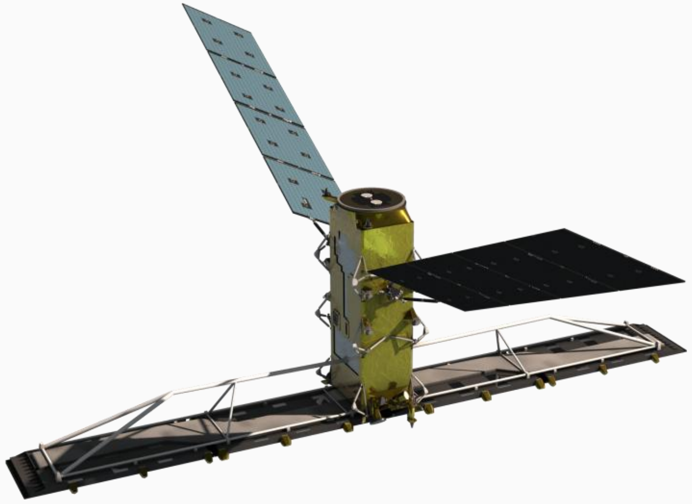
- **MDA CHORUS™** (Q4 2026) offers unique capabilities for advanced maritime and land analytics.
- CHORUS-C will provide the first operational repeat-pass InSAR using commercial compact polarimetry data.
- Using RADARSAT Constellation Mission (RCM) compact-pol data, we are developing fast algorithms to leverage the enhanced polarimetric content in compact-pol for higher-density point coverage in deformation maps.
- This application illustrates just one of the many transformative applications CHORUS will enable.

MDA CHORUS™ Mission Overview

Building on the substantial heritage of the RADARSAT program, MDA Space is developing the CHORUS mission, a next generation commercial dual-frequency (C+X band) SAR constellation

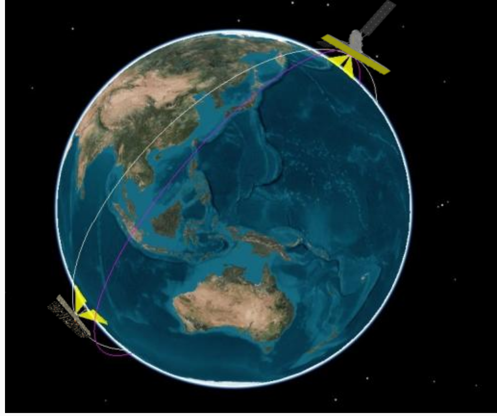
CHORUS-C
- C-band SAR, MDA Space 4th generation
- Designed, built, owned & operated by MDA Space
- Broad area coverage
- Right- and left-looking
- Fast tasking (1 hour) and NRT delivery (30 min)
- Imaging 20 minutes per orbit

CHORUS-X
- X-band SAR, supplied by leading commercial provider
- Sub-metre resolution
- Right- and left-looking
- Tip and cue from CHORUS-C
- Very fast tasking (<< 1 hour) & NRT delivery (30 min)
- Imaging 3 minutes per orbit



Parameter	CHORUS-C	CHORUS-X
Spacecraft Mass	2500 kg	115 kg
Mission Life	15 years	3-5 years + replenishment
SAR Aperture (elev x azim)	1.37 x 13.5 m	0.4 x 3.3 m
Peak Tx Power	3840 W	3200 W
Centre Frequency	5.405 GHz	9.6 GHz
Pulse Bandwidth (Max)	100 MHz	600 MHz
Look Direction	Right & Left	Right & Left
Receive Apertures	Dual azimuth	Single
Downlink	2x300 Mbps	500 Mbps
Imaging capacity/orbit	20 mins	3 mins

CHORUS Enabled InSAR: Pol-InSAR and 3D-InSAR



- Medium inclined non-sun-synchronous orbit
  - ***Increased angular diversity***
- Reliable repeat coverage
  - ***Tight orbital control***
- Short repeat cycle (9.85 days)
  - ***Improved coherence***
- Wide area monitoring
  - ***Multiple beam modes at different resolutions***

CHORUS-C will offer the first opportunity for operational repeat-pass InSAR using commercially available, fine resolution, compact polarimetry data

CHORUS-X will separately support repeat-pass InSAR at VV polarization

Launch scheduled for Q4 2026!

CHORUS-C InSAR Supported Modes

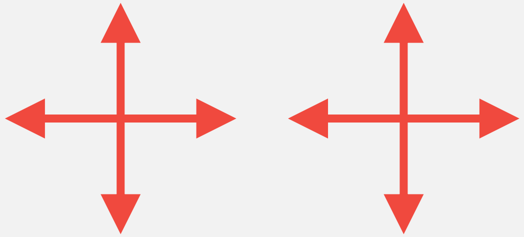
Beam Mode		Swath width	Swath positions	Resolution	Sensitivity (max NESZ)
Spotlight		10 km x 7 km	128	3 m x 1 m	-17.5 dB
Stripmap	**3 m**	50 km	26	3 m	-20 dB
	5 m	100 km – 180 km	20	5 m	-21 dB
	8 m	120 km – 180 km	6	8 m	-23 dB

- Polarizations: SP – Single Pol, DP - Dual Pol, CP - Compact Pol
- Looks (Rg x Az): 1x1
- Incidence Angle Range: 24.5 to 63.9 degrees

CHORUS performance numbers are preliminary and subject to change

What Advantages Does Compact-Pol Have?

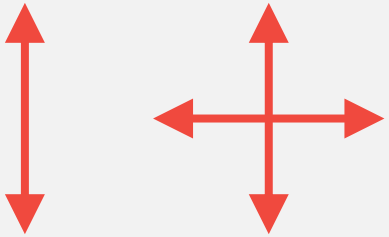
Quad-pol (QP)



Tx Rx

- Full 2x2 scattering matrix
- Reduced swath width
- Reduced resolution
- **High quality but limited applications**

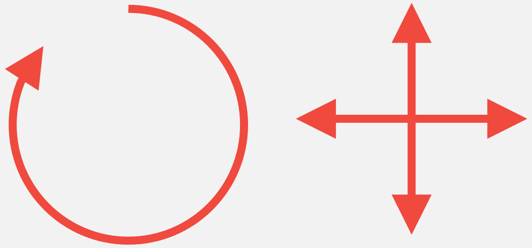
Dual-pol (DP)



Tx Rx

- Full characterization of Rx
- Large swath/high resolution
- **Strong bias** in target response
- **Poor characterization of different scatterers**

Compact-pol (CP)



Tx Rx

- Full characterization of Rx
- Large swath/high resolution
- **Weak bias** in target response
- **Information Content Approaches QP**

Summary

Motivation and Goal

Motivation

- PS InSAR campaigns require high-density point coverage and high precision for deformation monitoring.
- Fast processing and rapid turnaround are critical for operational use.
- Lowering quality thresholds (e.g., temporal coherence) increases coverage but compromises precision.
- Studies show leveraging polarimetric content in dual- and quad-pol improves point density without lowering thresholds.
- This work investigates the use of compact-polarimetry to enhance point density in PS deformation time series.
- Develop a computationally scalable approach suitable for commercial use at MDA Space.

Goal

- Determine a fast coherence optimization technique for persistent scatterers (PS), effectively using the polarimetric information content in compact-pol.

Summary

Method and Findings

Method

- Use polarimetric information in compact-polarimetry to identify the dominant, most temporally stable polarization component to increase high-quality PS coverage.
- Determine this component on a pixel-by-pixel basis, ensuring the projection basis for each pixel across the stack is equivalent (i.e., an equal scattering mechanism – ESM).
  - The ESM is necessary to produce a consistent time series of phases related to deformation.

Findings

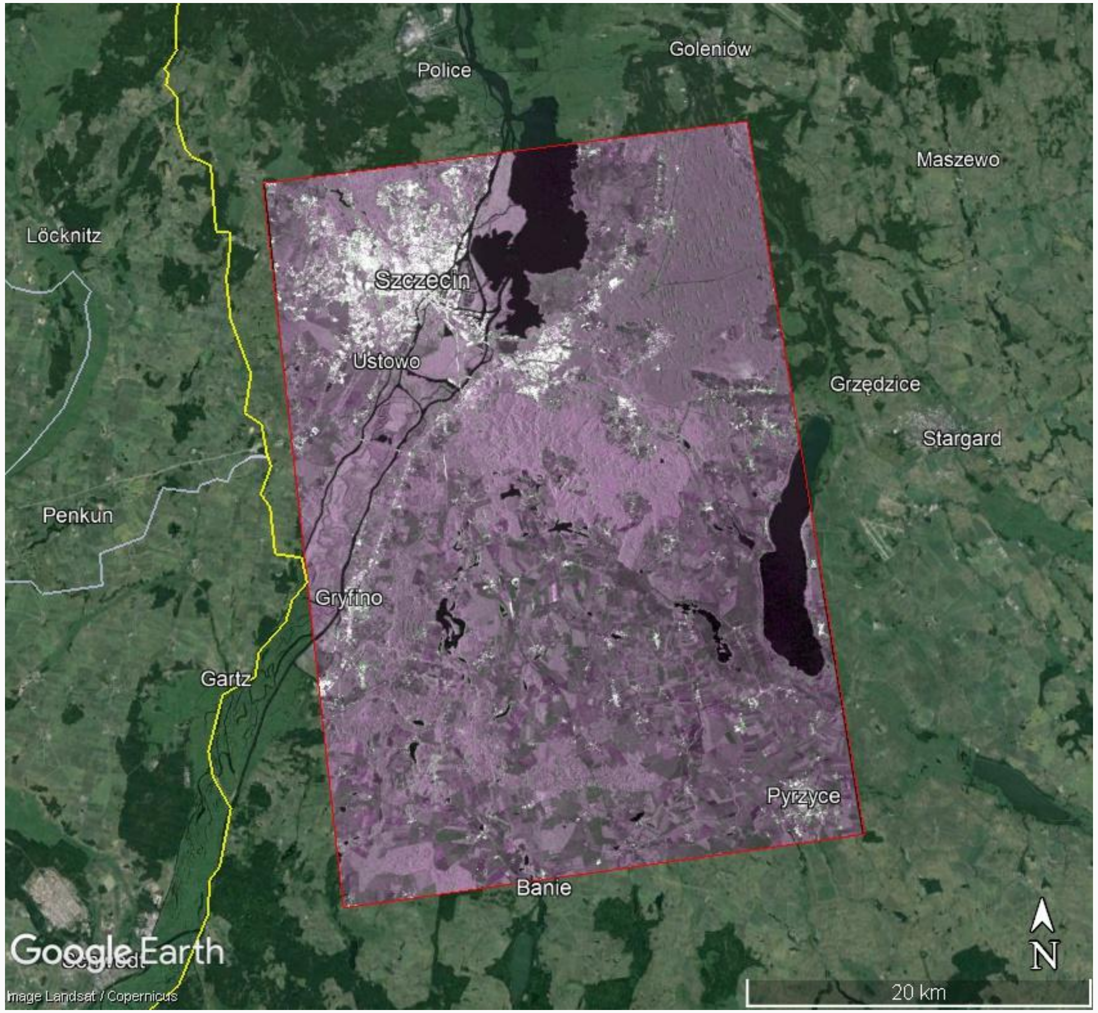
- Our solution increases high-quality PS points compared to single-channel interferograms (e.g., RH).
- By directly identifying the dominant and temporally stable polarization component, our method avoids computing all possible combinations (or a subset of these combinations), making it an order of magnitude faster than exhaustive Pol-InSAR coherence optimization techniques.
- Interferograms are projected directly based on the determined basis; no optimization required!

Case study: Szczecin, Poland

- A stack of 29 images of 5MCP22 beam mode (ascending/right looking) RADARSAT Constellation Mission (RCM) from April 2023 to April 2024 was selected for its 12-day repeat cycle and 5 m resolution, ensuring suitable data density and detail.

- The AOI encompasses a mix of urban, forested, clear-cut, and agricultural land types, with European Ground Motion Service (EGMS) data showing clear subsidence in Szczecin for comparison.

- Compact-pol beam mode was used, assuming the transmitted wave is perfectly circular, despite potential elliptical distortions at the high 52º incidence angle.



RADARSAT Constellation Mission Imagery © Government of Canada (2023, 2024)

PS InSAR Deformation Case Study

Case study: Szczecin, Poland

Processing

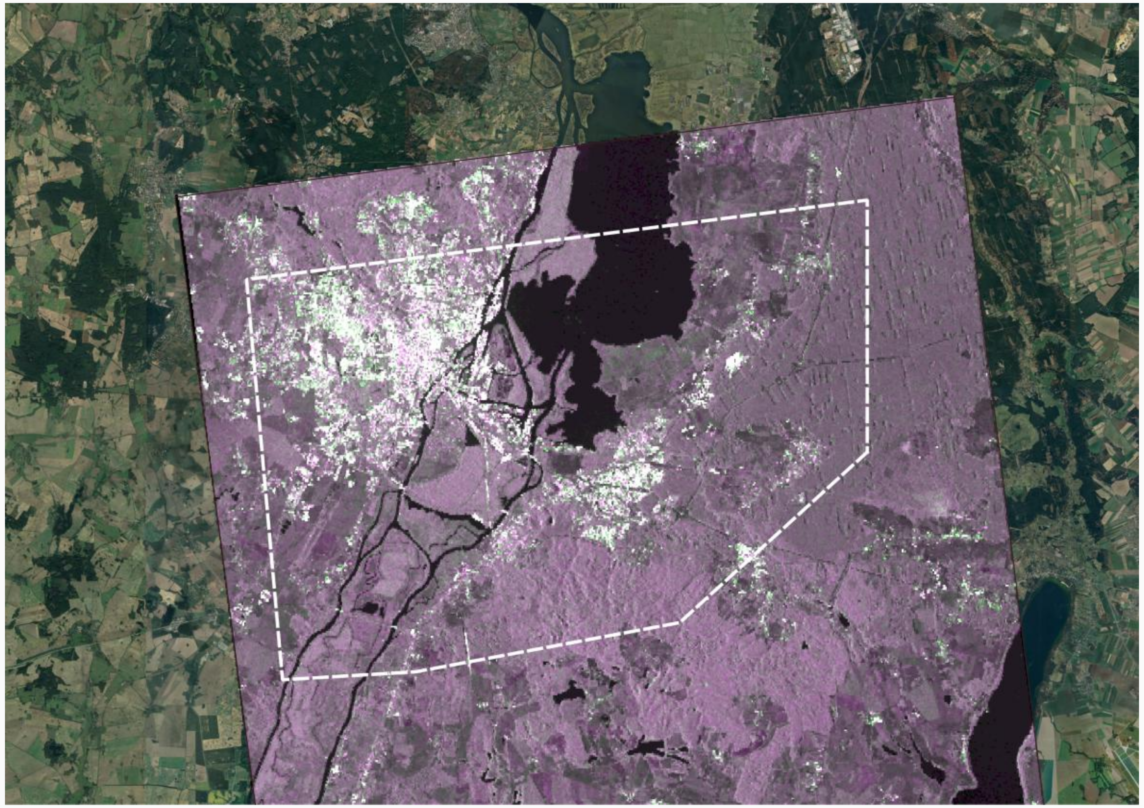
- Performed identical PS processing on two sets of interferograms for comparison:
  - RH channel
  - OPT interferograms

Metrics

- Temporal coherence
- Number of PS targets above common threshold
- Agreement in final deformation result

AOI

- Chose a subset of scene to highlight deformation present in EGMS

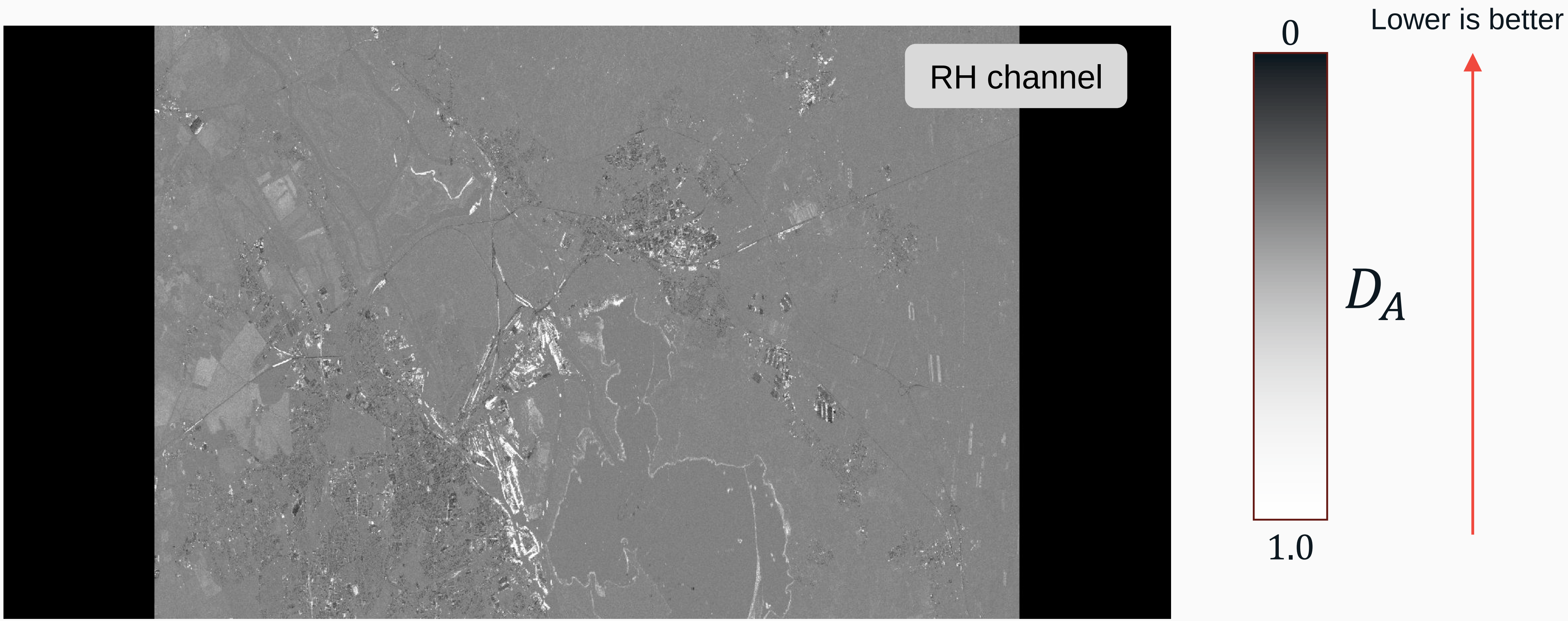


RADARSAT Constellation Mission Imagery © Government of Canada (2023, 2024)

Amplitude Dispersion

Case study: Szczecin, Poland

- Candidate PS targets selected based on amplitude dispersion metric (< 0.4)
- OPT: interferograms projected based on most dominant and temporally stable polarization state



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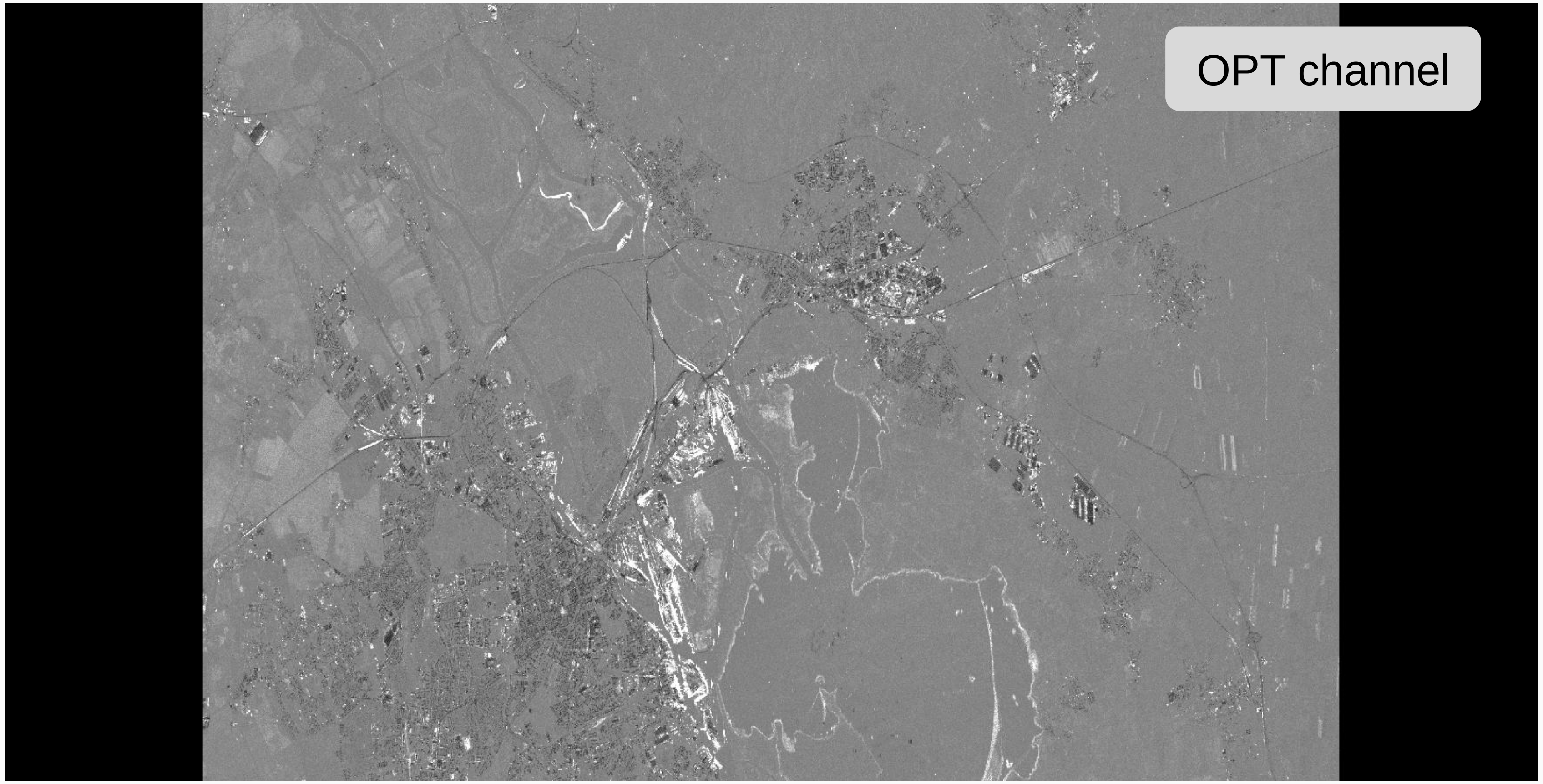
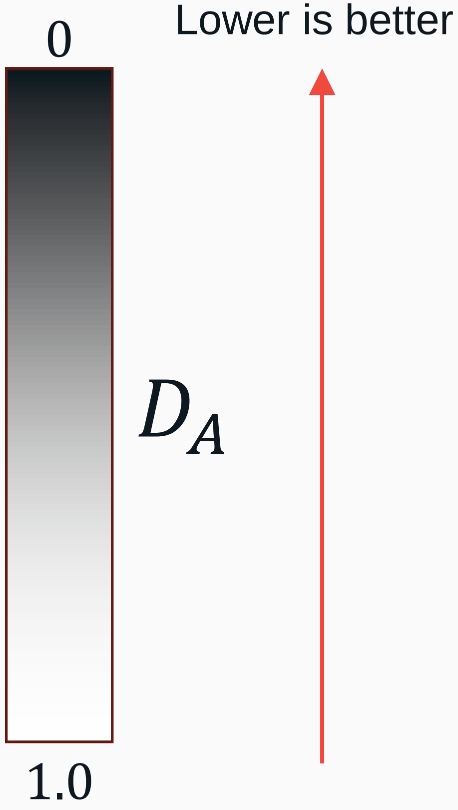
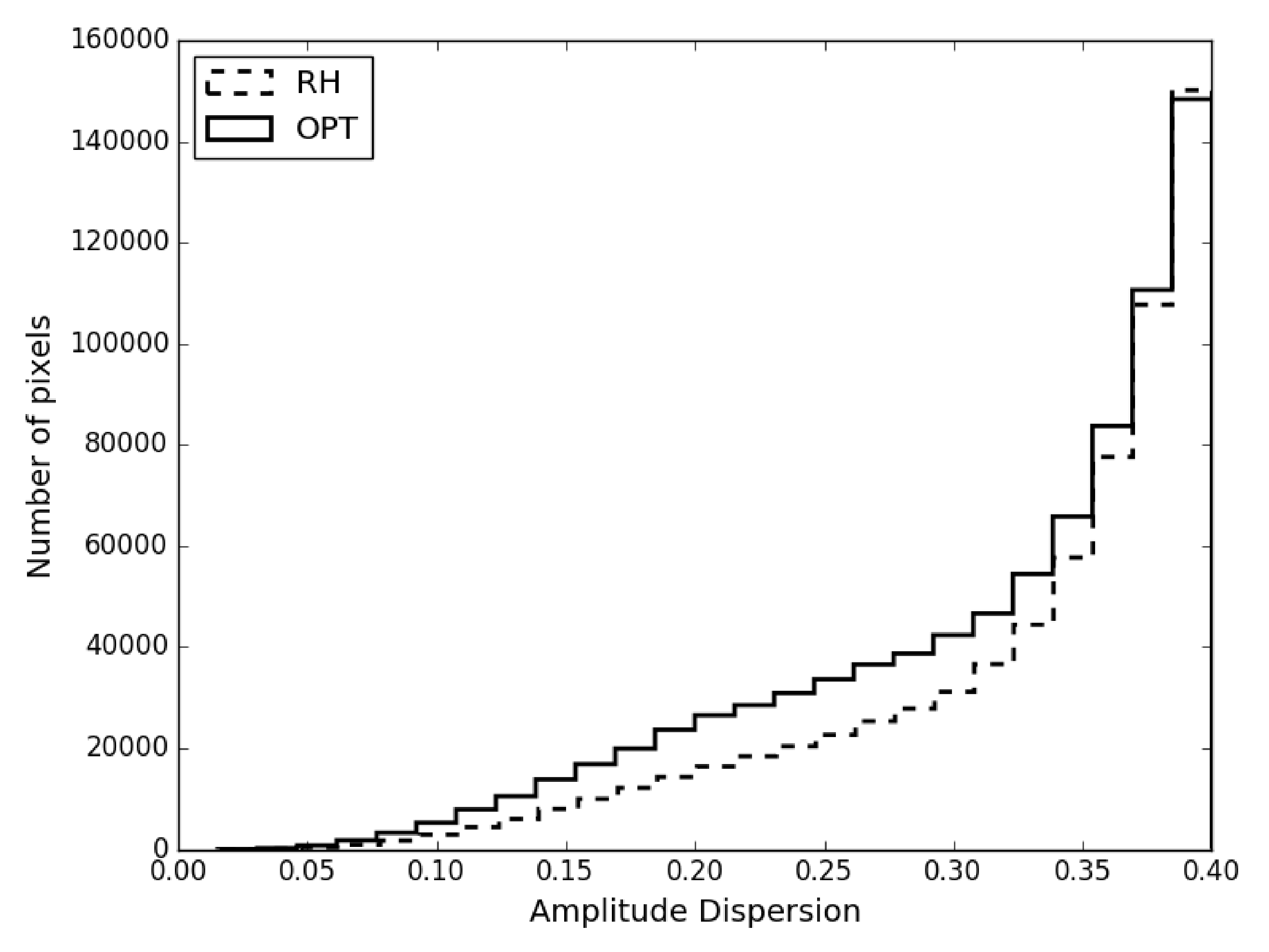




Amplitude Dispersion

Case study: Szczecin, Poland

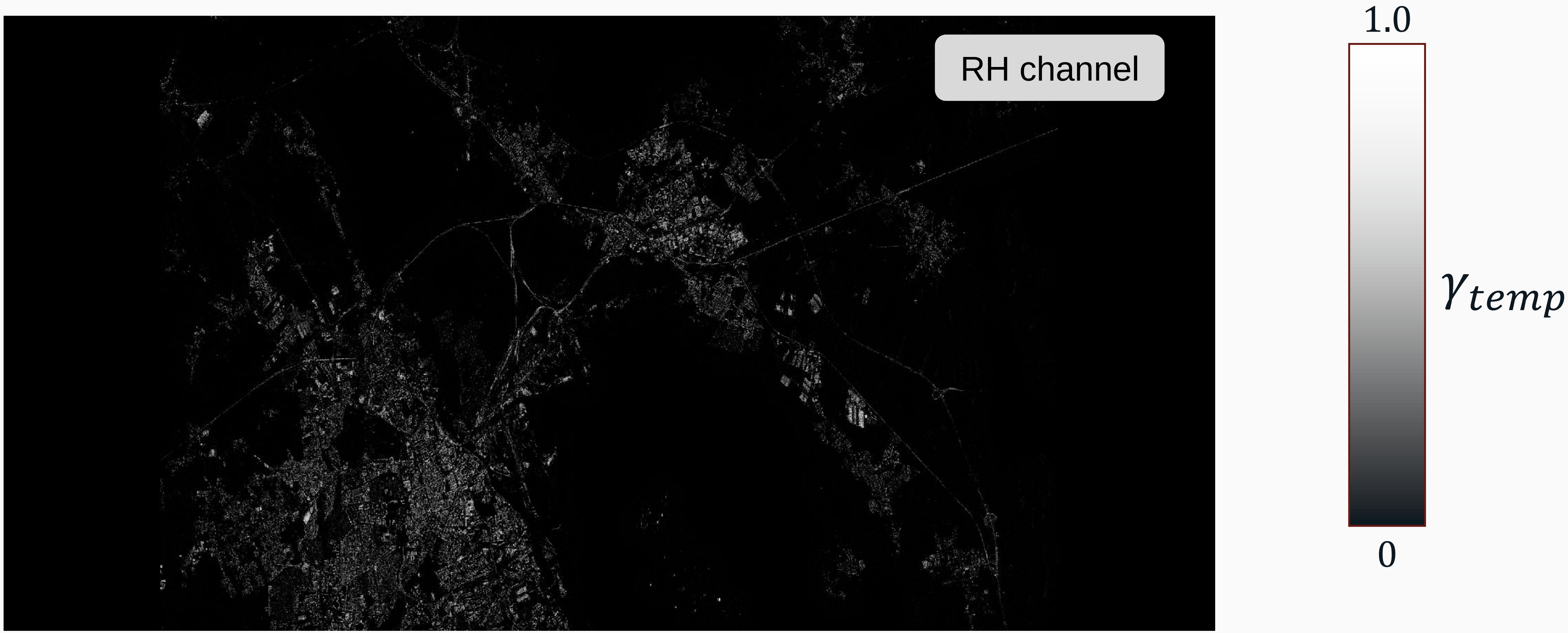
- Significant improvement in preliminary target selection through amplitude dispersion index, D_A
  - +55% increase for $D_A < 0.3$
  - +22% increase for $D_A < 0.4$
- Projection of interferograms to dominant polarization state results in more amplitude stability through time
- As this only a proxy for phase stability, additional insight can be gained from examining the temporal coherence of selected PS targets



Temporal Coherence

Case study: Szczecin, Poland

- Temporal coherence computed based on candidate targets from amplitude dispersion (< 0.4)



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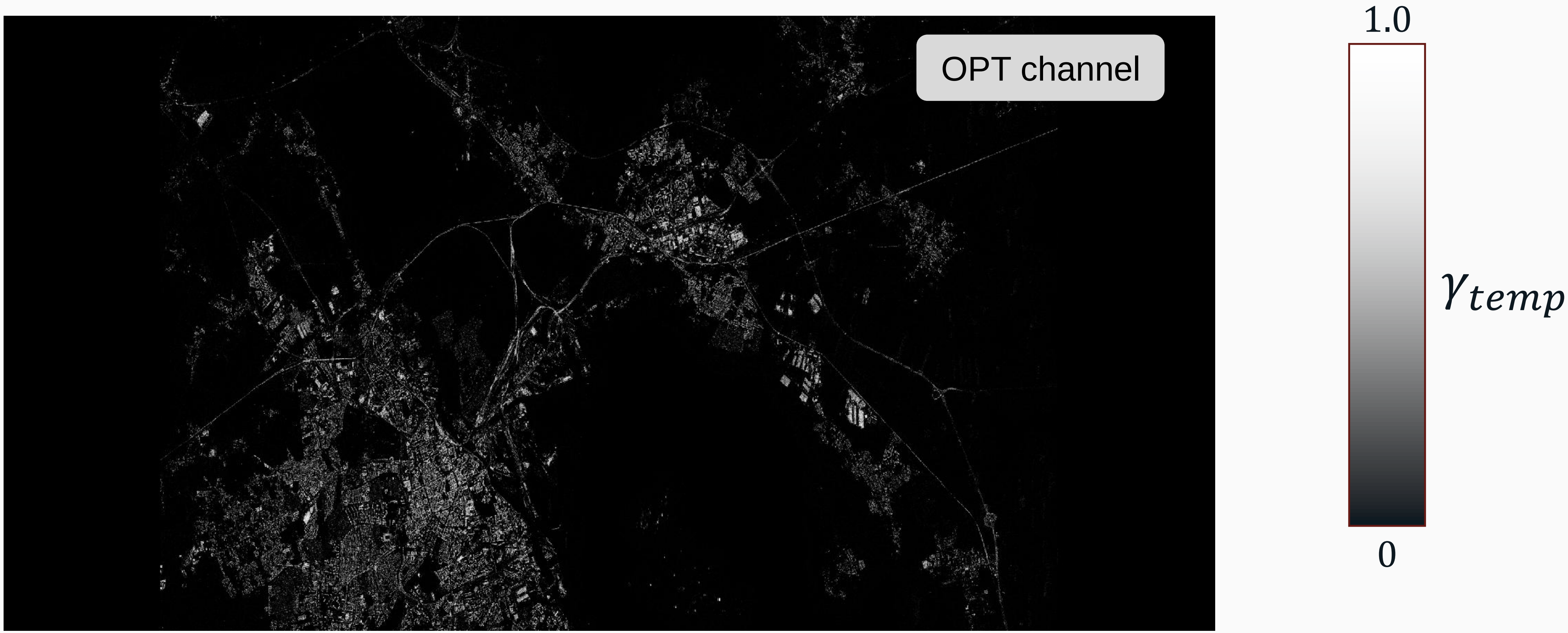
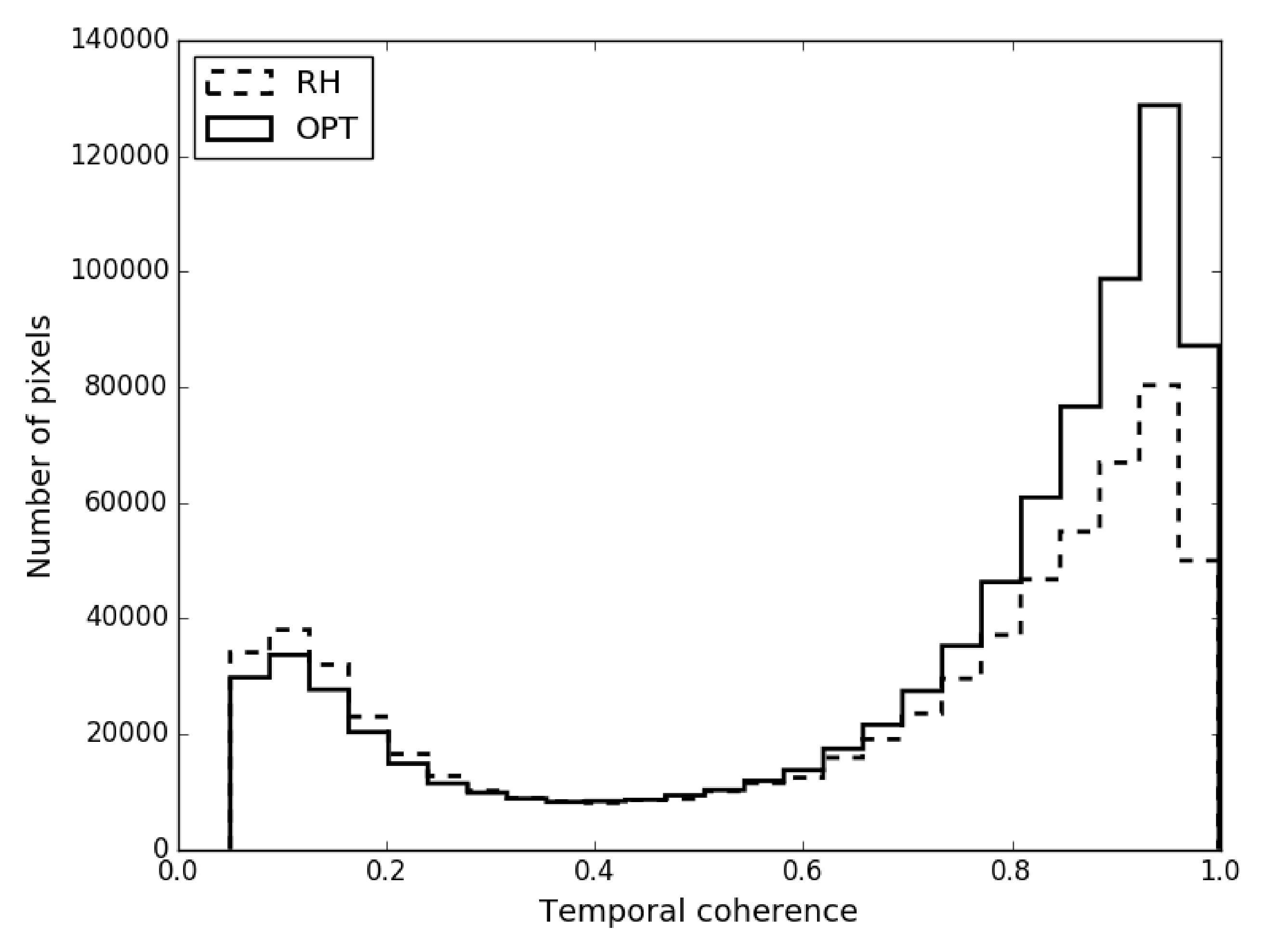


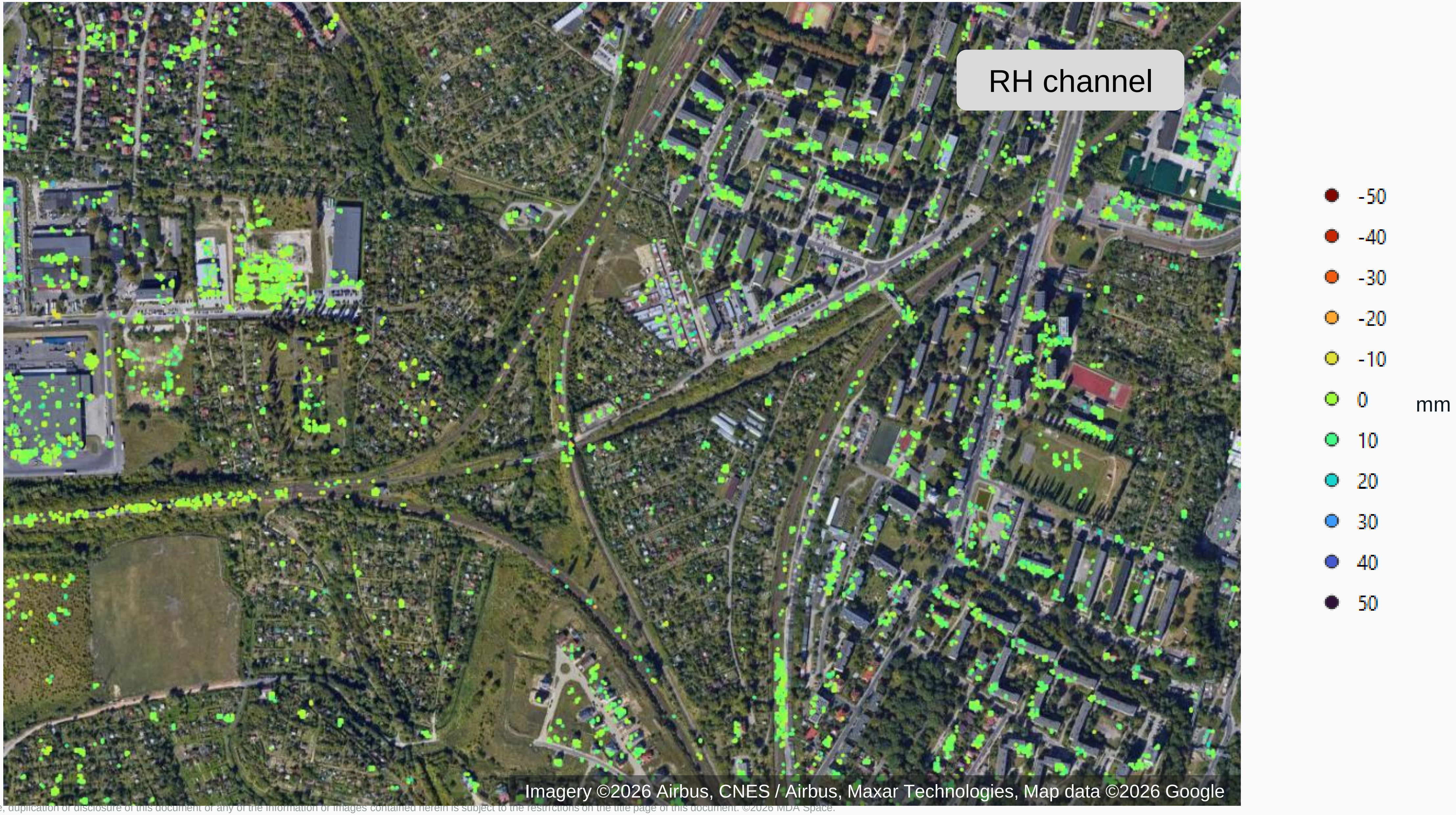
Temporal Coherence

Case study: Szczecin, Poland

- Significant improvement in number of high temporal coherence targets
  - +63% increase for $\gamma_{temp} > 0.9$
  - +51% increase for $\gamma_{temp} > 0.8$
- Coherence optimization increases PS target density while retaining high temporal coherence threshold
- Critical for monitoring infrastructure and targeted assets

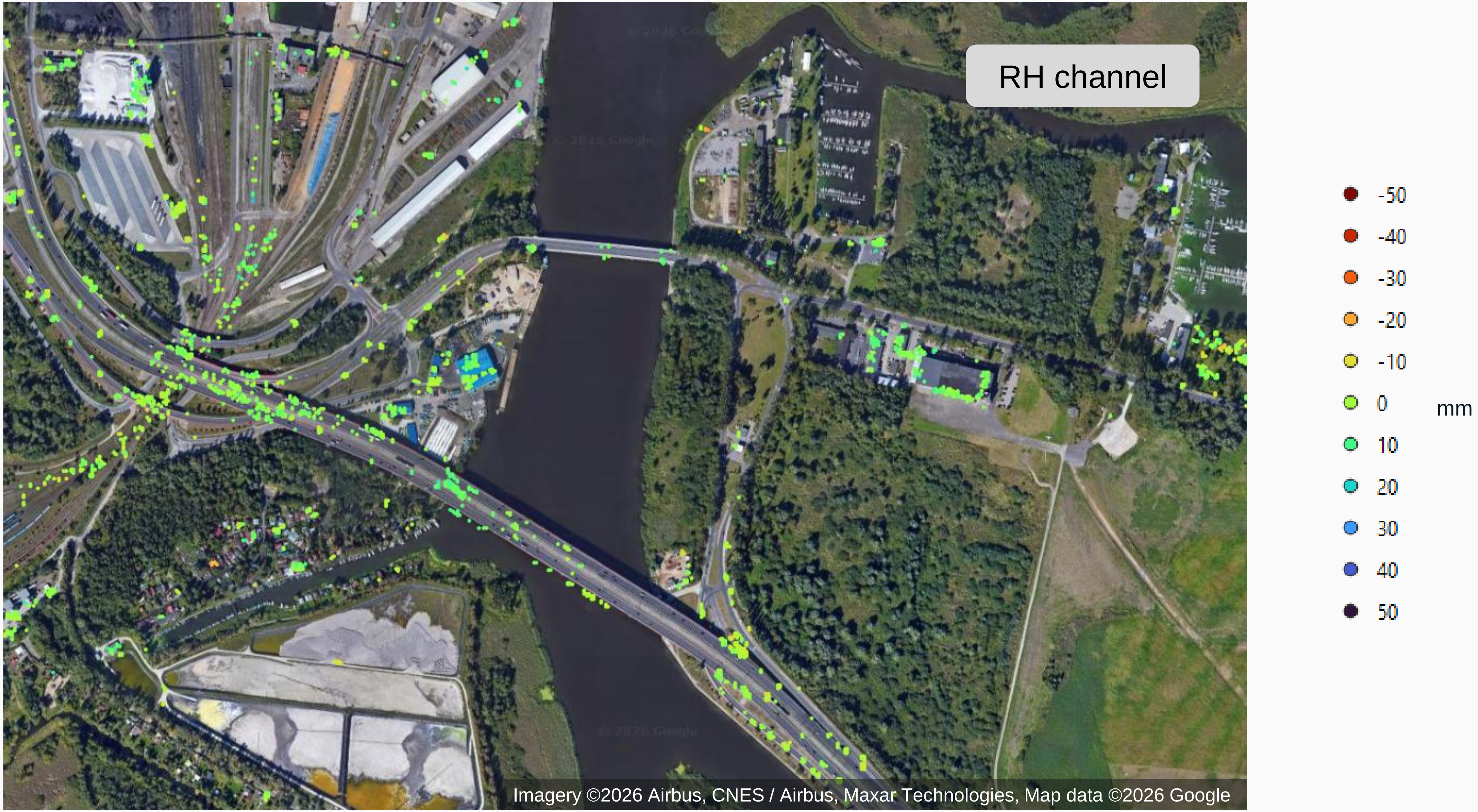


PS InSAR Target Coverage Over Rail Lines

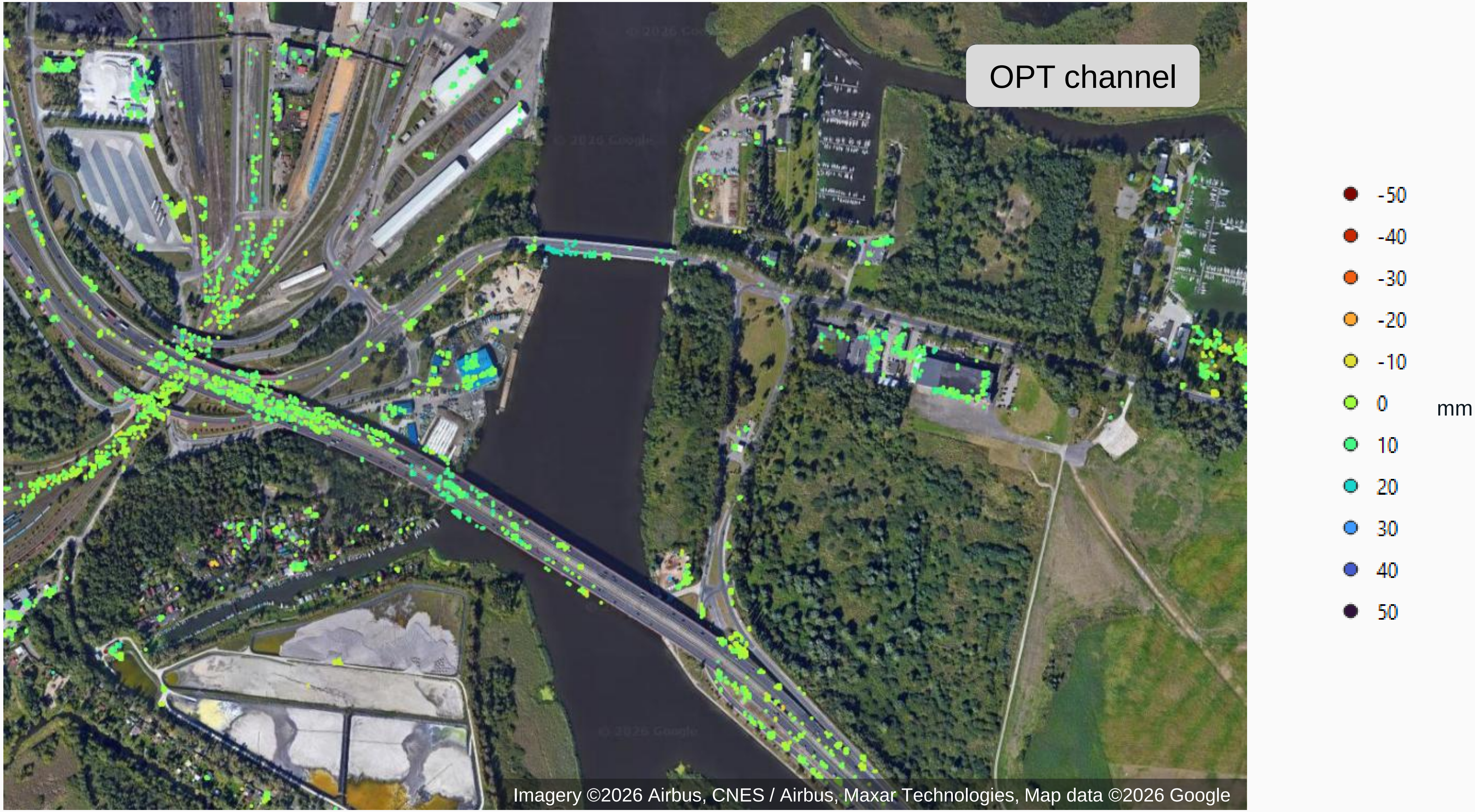


PS InSAR Target Coverage Over Rail Lines

PS InSAR Target Coverage Over Bridges



PS InSAR Target Coverage Over Bridges



PS InSAR Measurements in Deforming Region

PS InSAR Measurements in Deforming Region

PS InSAR Measurements in Deforming Region

“EGMS_L2b_146_0315_IW3_VV_2020_2024_1. European Union's Copernicus Land Monitoring Service information, **https://egms.land.copernicus.eu/insar-api/archive/download/EGMS_L2b_146_0315_IW3_VV_2020_2024_1.zip?id=16a2952ea47b4dfa909725f6b518f296 (Accessed on 11.06.2026). <DOI:** 10.2909/e2dd658f-8835-4b17-bcd5-eeb921a79a6>"

Conclusion

Summary

- **MDA CHORUS™** (Q4 2026) Compact-Pol InSAR has the potential to significantly improve deformation monitoring with only a minor increase in processing.
- A new algorithm has been developed to increase high-quality point density coverage in the deformation monitoring solution.
- Applications focus on PS Pol-InSAR for urban areas and infrastructure monitoring.
- Highlights the advantage of unique CHORUS-C compact polarimetry beam modes for InSAR deformation monitoring campaigns.

Future Work

- Significant potential for further development and improvements, particularly for joint PS and DS processing.
- Perform assessments comparing with the proposed method using dual- and compact-pol.
- Demonstration using CHOURS-C compact-pol data once available.

Thank You

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