Reviewer 2 (Dr. Andreas Piter):

Dear Saeid, dear co-authors,

thank you for submitting your interesting work. Ground motion services have received a lot of attention which highlights the importance of its validation which you are carrying out in this paper.

This paper analyses and compares the results from the EGMS with a local processing using SARvey software for the specific case of linear infrastructure monitoring. Several metrics are considered for the comparison and are computed for 5 study areas in Sweden with different characteristics.

I agree with Mahdi's comments stating that the paper focuses much on consistency between the methods while differences are not sufficiently highlighted.

In addition, I have some comments on the methodological part of the paper and hope that my comments help you improve the paper.

Best, Andreas

Authors' Response:

Thank you, Andreas, for your constructive feedback. We agree with your and Mahdi's point that the original manuscript emphasized consistency over differences; we have now addressed this through a new point-level comparison (see also our response to Reviewer 1). We have addressed your remaining suggestions point by point below. Your comments (Reviewer 2 Comments; RC-2) are in orange and our responses in black.

1. **RC-2:**

Processing:

In section 2.5, you state that you are excluding the winter acquisitions from the local processing. Does it mean that you remove the winter images from the SLC stack before starting the processing or do you remove it after SARvey processing from the final displacement time series? Both lead to particular challenges which need to be considered:

If you remove before the processing, this will result in longer temporal baselines of roughly half a year. Do the interferograms maintain coherence during that period? As you are using an SBAS interferogram network, the estimated linear displacement velocities will most likely be underestimated due to the winter gaps.

If you exclude the winter images after the SARvey processing, the results are heavily affected by the low coherent interferograms from winter acquisitions. This would result in less coherent pixels, unwrapping errors and will propagate to the whole displacement time series during

interferogram network inversion. I would highly recommend to avoid this processing strategy. SARvey has not been developed nor been tested for cases with regular data gaps in winter.

Please clarify which of the two approaches you have taken and how you handle these challenges. Please also report how it is dealt with in EGMS.

AC:
Thank you for this comment. We removed winter acquisitions from the SLC stack before processing, and we used a single-reference (star) interferogram network, not a small-baseline network.

EGMS uses the same approach. It removes scenes with persistent snow cover before processing using Copernicus snow cover products, so both datasets share the same acquisition dates (Ferretti, et al., End-to-end implementation and operation of the European Ground Motion Service (EGMS): Algorithm Theoretical Basis Document, 2025).

In a revised version, we have edited Sect. 2.3.3 and Sect. 2.5 to mention the exclusion of winter months and the use of star-network more clearly.

2. **RC-2:**

The number of selected pixels is one of the main features of the comparison. You have chosen to select pixels following the approach of Mirzaee et al. (2023) which selects DS pixels after Phase Linking and PS pixels by combining Top Eigenvalue Percentage (TEP) and Amplitude Dispersion (ADI). Even though the selection of PS pixels using TEP+ADI is possible in SARvey, it is not recommended and will not be supported in a future version of SARvey. As we have demonstrated in our paper (Piter et al., 2024), TEP does not reflect the phase quality of the pixels. Hence, TEP+ADI yields an unreliable selection of pixels which has an immediate impact on your comparison with EGMS. Please reprocess without these pixels and instead rely on the Temporal Phase Coherence (TPC) approach implemented in SARvey for selecting PS pixels. From my experience, pixels below a TPC of 0.7 are more likely to be unreliable.

AC:

Thank you for pointing this out. We agree that TEP+ADI may not be a good criterion for PS selection and you are right that the MiaplPy PS mask (TEP+ADI) was enabled in our SARvey configuration. We have now quantified the effect of these PS pixels and edited the text and reported the values in the revised manuscript (Sect 2.3.2 and 2.3.3). The results show that PS mask did not alter the first-order network, since all first-order points satisfy the TPC threshold on their own (0.9). Among second-order points, those entering the solution only through the TEP+ADI criterion (inside the PS mask with TPC < 0.7) make up between 0% and 4.9% of all points per corridor (Stockholm 0%, Gothenburg 0.05%, Lilla Edet and Lödöse 3%, Kiruna 4.9%). Therefore, excluding them does not change the corridor-level offset, so our conclusions are unaffected.

3. **RC-2**

Overall goal of the paper:

As far as I understand, your goal is to validate the quality of the EGMS. For the comparison, you have chosen to process the same areas yourself (local processing). Which of the two methods do you consider to be more accurate and more precise - and how would you actually know? As long as there is no independent reference data (e.g. leveling, GNSS), your analysis will be a relative comparison. This is a common issue in the validation of InSAR methodology. Nevertheless, the overall goal of the paper could be one of the following:

- The local processing offers many advantages which arise from the user's flexibility during the processing. So, how far do I get with the out-of-the-shelf EGMS products which do not require any processing by the user? And what additional information do I achieve when adding a local processing?

- Does the one-(is-supposed-to)-fit-all methodology used in EGMS provide reasonable displacement results? Can it be reproduced using a different methodology? To which degree do they differ and what could be the reason?

AC:

Thank you for this helpful comment. Our objective corresponds primarily to your first option: to assess how far infrastructure operators can rely on ready-to-use EGMS products and what additional information local processing can provide.

We agree that, without independent reference measurements at the locations being assessed, our analysis constitutes a relative comparison rather than an independent validation. Therefore, we do not claim that either solution is more accurate. The reported RMSE values should not be interpreted as measures of accuracy against independent ground truth, but as a measure of the "precision" of each time series. We have revised the Discussion to clarify this aspect. Nevertheless, the comparison remains useful for identifying similarities and differences in the displacement patterns and time series obtained from the two approaches, and for assessing the complementary information provided by local processing.

4. **RC-2**

Methodological differences EGMS vs. SARvey:

You are stating that the methods are different and cannot be compared to each other. While this is true, please provide the reader with the main concept of each method and discuss the main methodological differences. This would help the reader to understand the differences in the results and sets the experiments into context.

AC:

Thank you. To make the main methodological differences easier to compare, we have now added a compact table (below) summarizing them side by side (placed in the Supplement given the journal's page limit), and we refer to it where these differences are used to explain the results. However, the main concept of each method is described in Sect. 2.2 (EGMS/PSI) and Sect. 2.3 (phase linking and SARvey), and for the full descriptions, the readers are referred to the EGMS algorithm and user documentation (Costantini et al., 2021; Kotzerke et al., 2022; Ferretti et al., 2025) and in Piter et al. (2024 & 2026) for SARvey.

Table S1. Main methodological differences between EGMS Calibrated and the locally processed PS+DS workflow

	EGMS Calibrated (Sweden)	**Locally processed**
Scatterers	PS only	PS+DS (locally processed)
Phase estimation	PSI on full-resolution pixels	Phase linking of DS (EMI/EVD), then single-reference (star) network
Pixel selection	Amplitude stability and model-based temporal coherence	Temporal phase coherence (TPC); DS from phase-linking fit
Temporal model	Parametric (polynomial and seasonal terms)	None imposed; linear and non-linear motion retained
Atmosphere	Data-driven filtering	Estimated from first-order points, Kriging interpolation
Unwrapping	Model-based, on the PS network	Temporal (arcs) and spatial (PUMA)
Reference	GNSS-calibrated, continent-wide (absolute)	Arbitrary scene reference (relative)
Winter scenes	Snow-covered scenes removed	Snow-covered scenes removed
Processing	Fixed, continental	User-configurable per site

5. RC-2

Displacement time series:

In your comparison, you mainly address the mean velocities. Please also provide a comparison based on the displacement time series and show a few representative time series from both EGMS and SARvey.

AC:

Thank you for this suggestion. We have now made a comparison of the displacement time series and added this to the revised manuscript. The RMSE reported elsewhere in the manuscript describes the noise of each series on its own; the new analysis tests whether the two solutions record the same displacement history at the same place.

Pairing: Each corridor was divided into non-overlapping 30 m × 30 m cells. For each cell we formed one EGMS series and one PS+DS series, each as the per-date median of the points in that cell. Both series were set to zero at the first common date.

Datum: Please refer to our answer to comment 1 of the first reviewer.

Agreement measures: RMS difference: the root mean square of the remaining difference between the two time series in each cell, after the datum correction and after removing its mean.

Local correlation: The Pearson correlation between the two series after removing the scene-wide median EGMS motion from both. At locally stable cells the two series differ only by independent noise, so their correlation is close to zero. Therefore, we report it only for cells with a local EGMS velocity of at least 2 mm/yr, and separately for at least 5 mm/yr, the level below which Li et al. (2026) recommend treating InSAR velocities with caution.

Results: The median RMS difference between the two time series is 2.4–3.3 mm across the five corridors (95th percentile 4.4–4.9 mm; 8.6 mm in Kiruna), comparable to the noise of the individual series. In the two corridors with substantial local land motion, Lilla Edet and Lödöse, the local correlation is 0.87 and 0.81 for cells above 2 mm/yr, and rises to 0.95 and 0.93 for cells above 5 mm/yr, respectively. In Gothenburg, Stockholm and Kiruna it is lower at the 2 mm/yr threshold (0.26–0.48). Only 5–12% of cells there exceed 2 mm/yr, and only 1–3 cells per corridor exceed 5 mm/yr, so their local signal is mostly close to the noise level. Where those corridors do move strongly, the series agree closely: the three Gothenburg cells above 5 mm/yr have a median correlation of 0.99. Stockholm (2 cells) and Kiruna (1 cell) have too few such cells for a meaningful value. Therefore, agreement increases with the strength of the local signal.

Representative time series: To avoid choosing examples by eye, we selected three cells per corridor by fixed rules: the cell with the median RMS difference (**typical agreement**), the cell with the largest local velocity among cells with an RMS difference below the 75th percentile (**local land motion**), and the cell at the 95th percentile of the RMS difference (**disagreement**). They are shown below (and in the Supp).

Table 3. Time-series agreement between EGMS-PS and PS+DS in 30 m cells. r_loc is the median local correlation for cells whose local EGMS velocity is at least 2 or 5 mm/yr (number of cells in parentheses); "–" means fewer than 3 cells. The trend of the common-mode datum series is given for comparison with the velocity offsets in our answer to comment 1 of the first reviewer.

Corridor	Median RMS (mm)	P95 RMS (mm)	r_loc for velocity ≥ 2 mm/yr	r_loc for velocity ≥ 5 mm/yr	Datum trend (mm/yr)
Kiruna	3.33	8.59	0.26 (9)	– (1)	−5.59
Lilla Edet	2.77	4.75	0.87 (93)	0.95 (33)	−2.99
Lödöse	2.91	4.89	0.81 (84)	0.93 (19)	−2.70
Gothenburg	2.39	4.47	0.48 (25)	0.99 (3)	−1.34
Stockholm	2.38	4.38	0.42 (26)	– (2)	−3.84

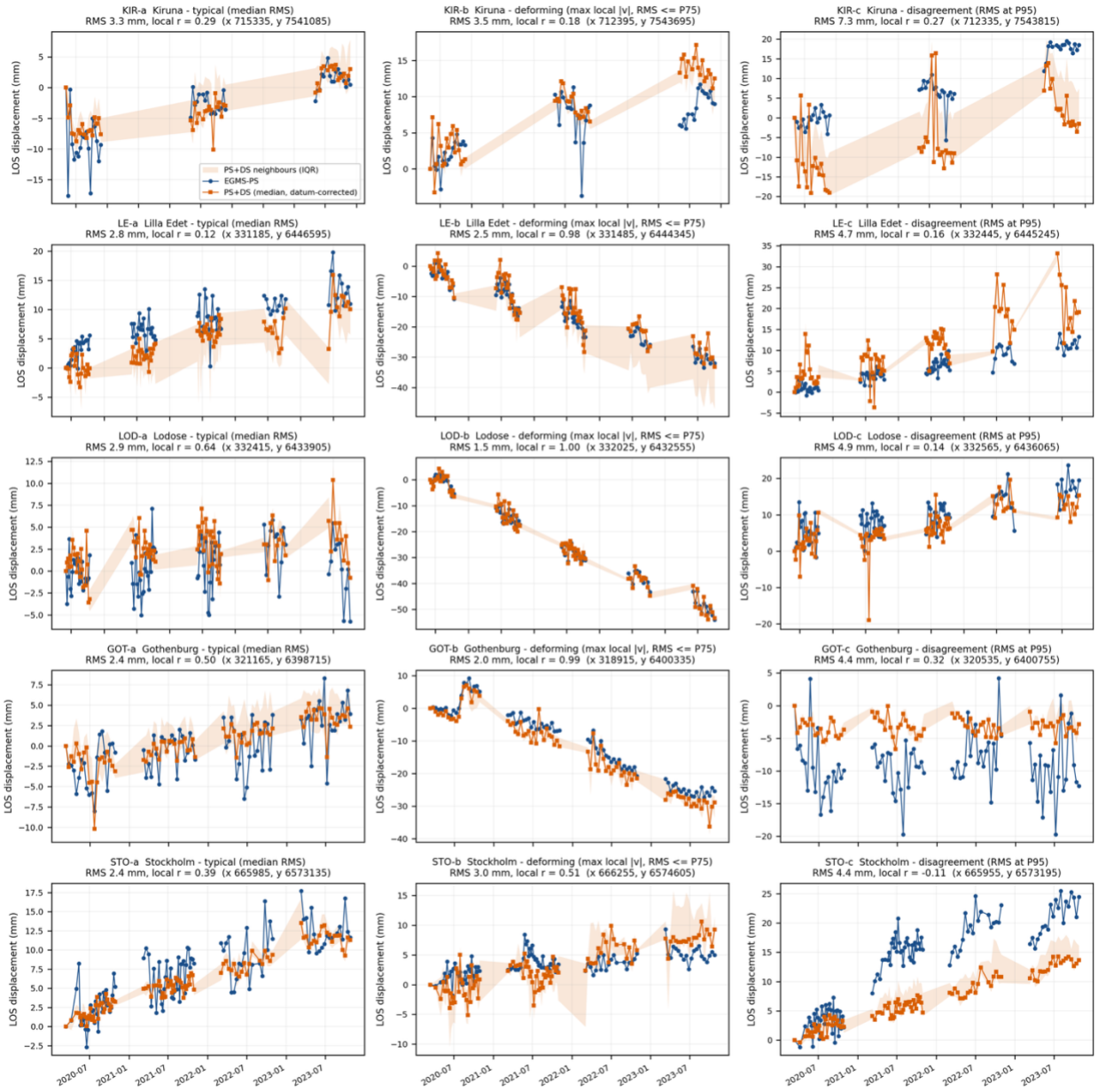


Figure S1. *Comparison of the time series between EGMS-PSand PS+DS for three examples of a typical cell, a fast moving cell and a cell at the 95th percentile of the RMS time series difference for each corridor.*

6. RC-2

Metrics:

From my point of view, the selection of quality metrics could be discussed in more detail. Why did you choose the given metrics? What do they tell and, importantly, what are their limitations?

AC:

Thank you. We have expanded Sect. 2.4 and added a supplement table (see below) to describe for each metric why it was chosen, what it indicates and what its limitations are. The main limitation applies to all of them: without independent ground truth, they measure agreement and internal consistency, not accuracy.

Table S3. Evaluation metrics, what they indicate and their limitations.

Metric	What it indicates	Limitations
Point count (per 100 m segment and per land-cover class)	Spatial coverage of the infrastructure and its surroundings	Says nothing about quality. Depends on selection thresholds, which are not equivalent across chains (Sect. 3.6). Neighbouring DS points share pixels through phase linking and are not fully independent.
RMSE of the displacement time series (Kotzerke et al., 2022)	Precision (noise level) of each point	Measured relative to a fitted temporal model: real non-linear motion raises it, and temporal smoothing lowers it. Insensitive to errors shared by neighbouring points (residual atmosphere, reference point). Precision, not accuracy.
Median velocity along the chainage (100 m segments)	Whether both products show the same deformation pattern at the scale relevant for maintenance	The median hides variability within a segment. Referenced to the first segment. Less robust where segments contain few points.
Distance to centreline	How closely points sample the road or railway	Not a measure of geolocation accuracy. Affected by geocoding error, the accuracy of the mapped centreline, and nearby objects inside the 20 m buffer. Additionally, resolution cell size and height error, comparable to the distance bins; does not indicate quality.
RMSE and elevation versus distance	Whether points near the centreline belong to the structure	Informative only where the structure differs in height from its surroundings. Limited by DEM resolution.
Metrics per land-cover class	Whether performance depends on surface type	Classes come from a 10 m map, so points on mixed or boundary pixels may be assigned to the wrong class.
Velocity offset and regression	Agreement of velocities at co-located points	Includes the datum difference between products.
Time-series RMS difference and local correlation	Whether both products record the same displacement history at the same place	Correlation is meaningful only where the local signal clearly exceeds the noise. Results depend on cell size and on the dates common to both products.

7. RC-2

I would argue, that the distance of the points to the centreline of the infrastructure does not tell anything about the quality of the results. It is affected by the low geolocation accuracy of the pixels in Sentinel-1 images and the selection of pixels. The respective results (Fig. 6) do not show any significant difference between the datasets. I would recommend to remove this section from the analysis.

AC:

Thank you for this suggestion. We have moved the figure to the supplement and reduced Sect. 3.5 to a short paragraph in the revised manuscript.

8. **RC-2**

The comparison between the EGMS and SARvey based on the RMSE of the displacement time series is not yet fair. As far as I know, the pixels in the EGMS are selected if their RMSE is below 4mm (see also Fig. 4). Please consider applying the same selection approach for the pixels from SARvey to make the results comparable. Moreover, please check whether EGMS applies any temporal smoothing of the displacement time series. If so, please also filter the time series retrieved with SARvey to make it comparable. No temporal filtering is applied in SARvey which would lead to higher RMSE values compared to the (probably filtered) EGMS results.

AC:

Thank you for this important comment that has made our results more interesting. The EGMS Product defines RMSE as the residual about a third-order polynomial plus a seasonal model. We have now recomputed the RMSE of both datasets from the displacement time series using the EGMS model. Applied to EGMS, this reproduces the official values (median difference −0.01 mm).

As the reviewer noted, EGMS-PS RMSE values do not exceed about 5 mm, consistent with a selection on RMSE. Intentionally, we did not apply this threshold to PS+DS, so that the full range of the denser dataset is shown. We have now shown the 4 mm distinction and ratios in the figures (see below) and they are in the revised text. With the same definition, 86–91 % of PS+DS points already have an RMSE ≤ 4 mm, and the median PS+DS RMSE (1.8–2.6 mm) is equal to or lower than that of EGMS-PS (2.6–3.5 mm). We have updated RMSE Figures 3, 4, and 5 and Sects. 2.4 and 3.3 accordingly.

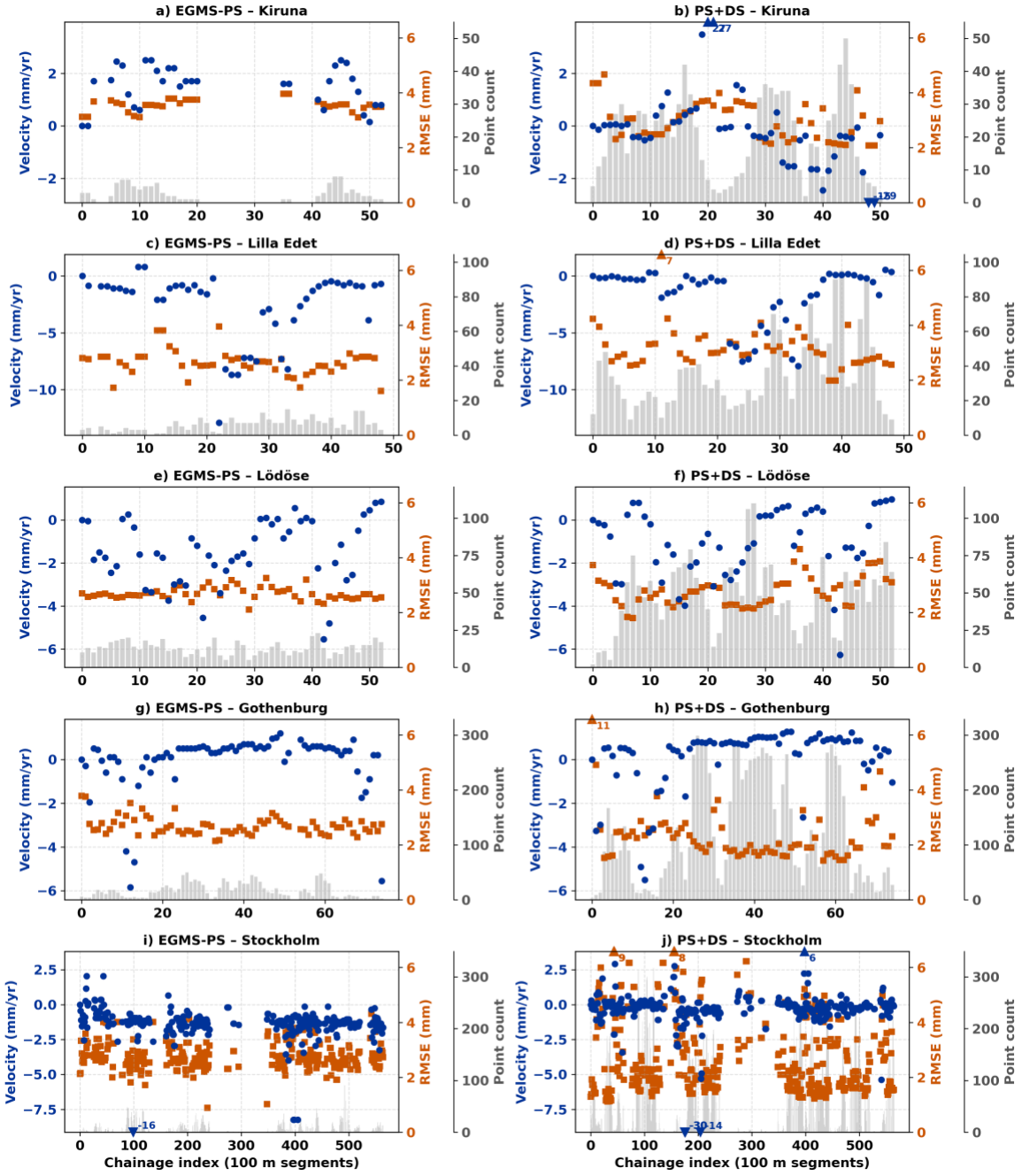


Figure 3. Summary statistics (median) of velocity and displacement RMSE every 100 m chainage along the corridors, with EGMS-PS (left panels) and PS+DS (right panels). Left axes show LOS velocity referenced to the first chainage; right axes show RMSE (mm), with grey bars indicating point counts. RMSE follows the EGMS definition for both datasets. Triangles mark isolated segments outside the axis range, labelled with their value.

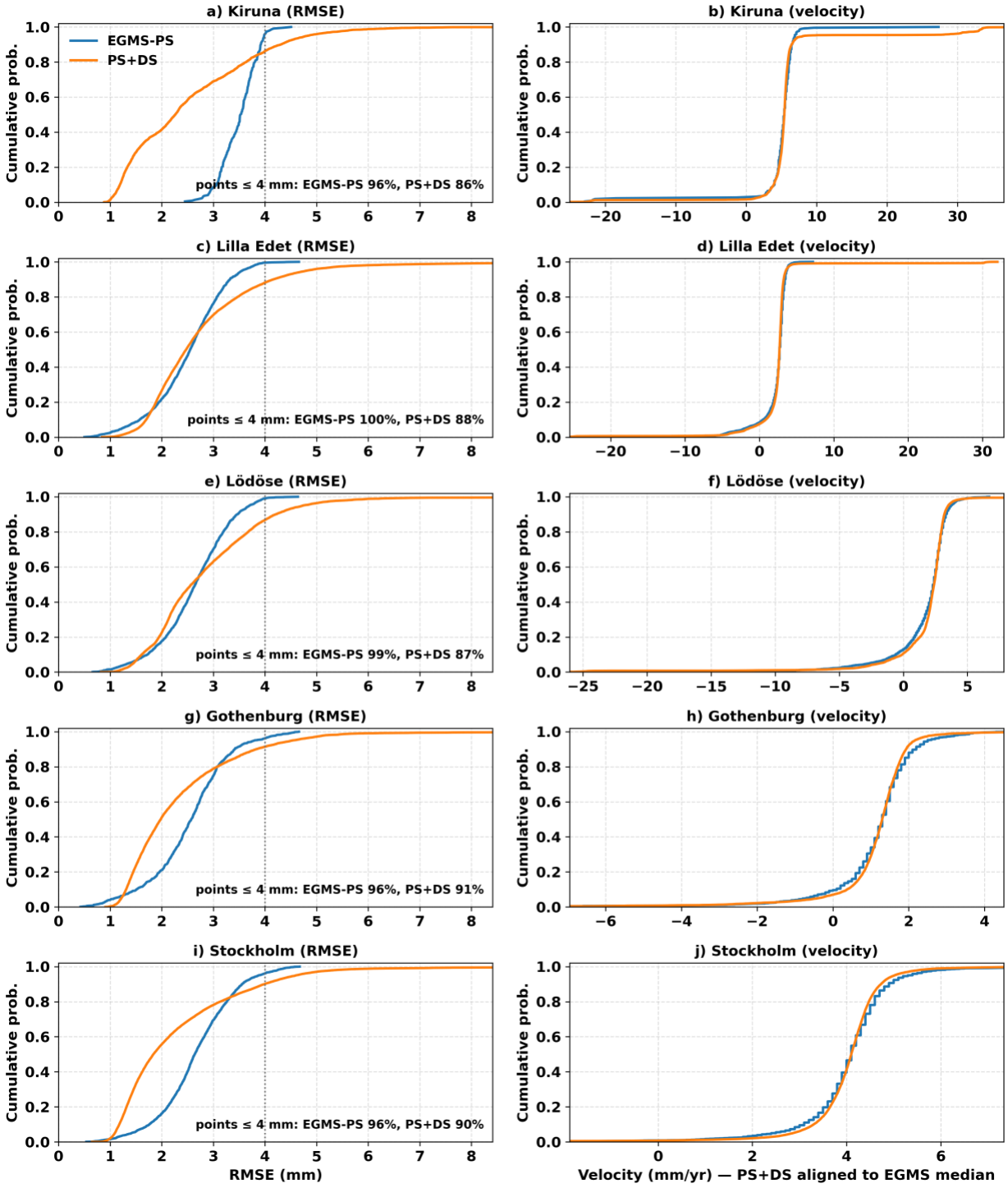


Figure 4. Cumulative distributions of RMSE (left) and LOS velocity (right) of EGMS-PS and PS+DS measurement points. RMSE follows the EGMS definition for both datasets; the dotted line marks 4 mm. PS+DS velocities are shifted by the difference of the two medians to remove the datum offset (Sect. 3.1).

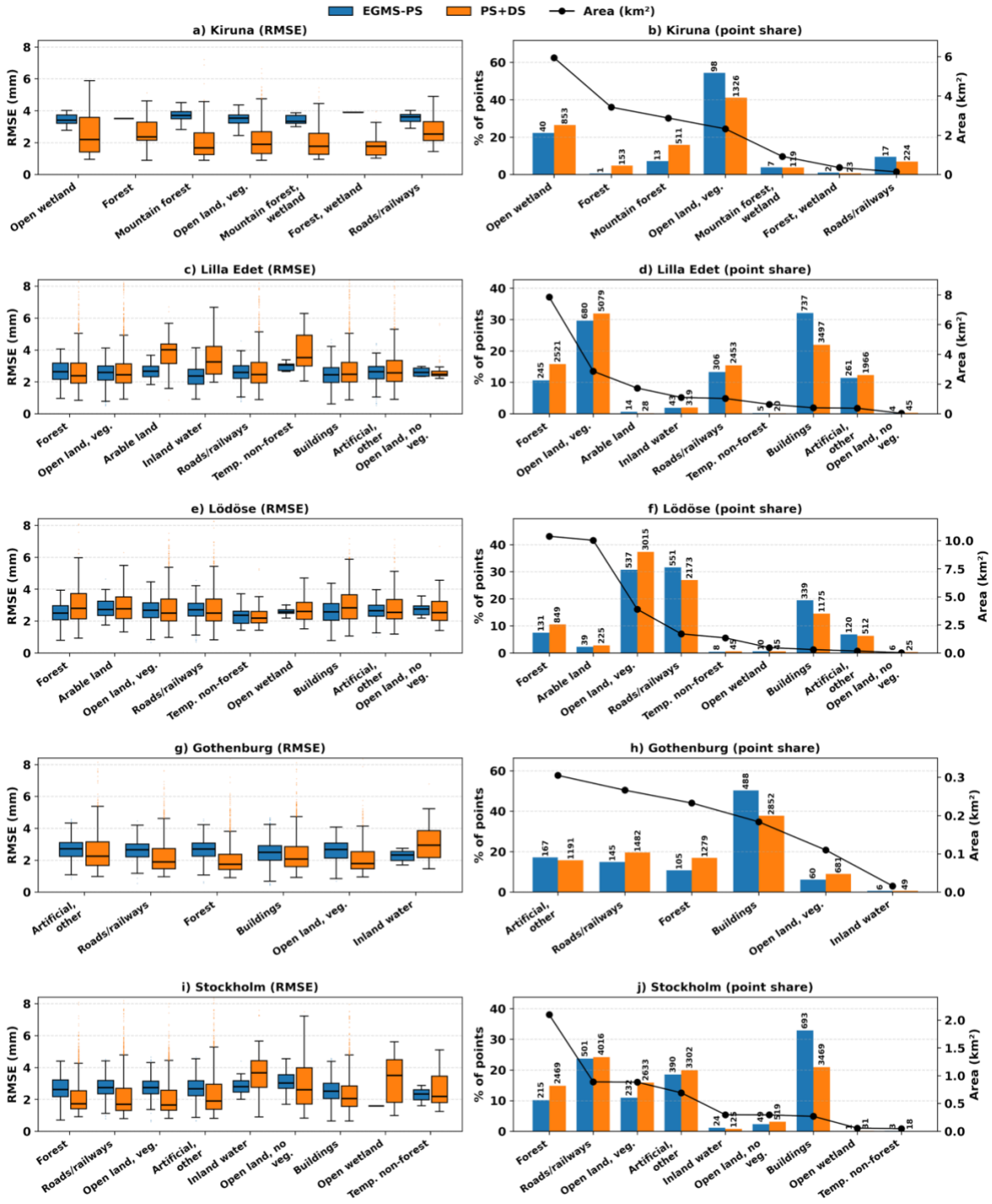


Figure 5. Left panels: RMSE of EGMS-PS and PS+DS measurement points per land-cover class (RMSE following the EGMS definition for both datasets). Right panels: share of measurement points per class (bars, left axis; numbers give the point count) and class area within the corridor (line, right axis). Land cover from the 10 m Swedish National Land Cover Database (NMD 2023). Classes are sorted by area, and classes with fewer than 10 points in both datasets are omitted. Points over water bodies originate from bridges, near-shore pixels or sidelobes of onshore scatterers.

9. RC-2

It is important for the comparison to bring the displacement results to the same local reference point. It is visible in Fig. 4b and d that they do not have the same reference point.

AC:

Thank you. Both datasets are now brought to a common reference throughout. In Fig. 3 (please see above), velocities of both products are referenced to the first chainage segment. In Fig. 4 (please see above), PS+DS velocities are shifted by the difference of the two medians. In the time-series comparison, the reference-point motion is removed at each date. Instead of a single reference point, we use a reference formed from all points, so that the noise of one point is not passed on to the whole dataset.

10. RC-2

In my opinion, the selected study areas are relatively small. Particularly in the urban area you are subsetting the points to small corridors which makes it hard to interpret the displacement signal. Is the displacement really related to the excavation? Or is it part of a larger displacement phenomenon? I have looked into the EGMS and there are several displacement signals present in Gothenburg. Please show your displacement results in the context of its neighbourhood.

AC:

Thank you. For Kiruna, Lilla Edet and Lödöse, the analysis covers the full processed area. For Gothenburg and Stockholm, it is restricted to a 100 m-wide corridor centered on the underground alignment. This choice follows the aim of the study, which is to compare the two InSAR products where infrastructure owners need the information: on and immediately around the corridor. Mapping regional displacement patterns, and attributing signals to excavation, is beyond our scope, and we do not interpret the detected signals as construction induced. We have not made sure to clarify this in the revised manuscript and in the description of the Gothenburg results. We agree that several displacement signals in Gothenburg extend beyond the corridor, consistent with the widespread settlement of the city's soft clay deposits.

11. RC-2

You are highlighting that "the underlying quality metrics are not identical across processing chain" in Section 2.4. Nevertheless, you apply the same coherence thresholds to both methods even though they correspond to totally different characteristics of the data. I would recommend to avoid using the "same" thresholds and instead use only the RMSE w.r.t. a displacement model for selecting the pixels at the end.

AC:

Thank you. We will remove the statement that the same thresholds were applied to both datasets. Each dataset is now described with the native quality filter of its processing chain, and the

RMSE about a common displacement model (the EGMS definition) is used as the comparable quality measure for both.

12. RC-2

Vegetation:

You are discussing vegetated areas in multiple locations in the paper (e.g. "Moreover, Li et al. (2026) recommend treating InSAR velocities below 5 mm yr^{-1} with particular care given InSAR's difficulties in vegetated terrain"). In my eyes, this discussion seems to be inappropriate as you are not dealing with vegetation. InSAR should not be used over vegetated areas due to decorrelation - that is clear. However, you are here working with infrastructures (railway, highway, buildings). Please remove the discussion related to vegetation.

AC:

Thank you. We have removed it in the revised version.

13. RC-2

Citation:

I find the citation of the paper Aziz Zanjani (2024) misleading in two sentences:

- "These localized tunnel-corridor signals resemble construction-related subsidence patterns reported, by Aziz Zanjani et al. (2024), which showed that InSAR can capture localized settlement from large-scale construction when combined with contextual information such as construction timelines and geotechnical data."

However, the paper was not about tunnel-corridor signals.

- "Consistently, Aziz Zanjani et al. (2024) report that at national and local scales PS+DS yields significantly higher point counts along man-made infrastructure, while PSI provides a sparser but more conservative displacement field."

Please consider that the paper does not discuss any national scale processing.

Please adjust the sentences accordingly.

AC:

Thank you for pointing this out. We have rephrased the first sentence to refer to construction-induced building settlement and to the contextual information needed for attribution. We have also removed the national scale from the second sentence.

14. RC-2

Reproducibility:

Please provide more details on the data and processing to make it reproducible. Which EGMS version/update/time span has been used? What is specific to the EGMS methodology that is used for Sweden? Please also highlight that your findings are not generalizable to the rest of Europe due to different processing strategies used for different areas in the EGMS.

AC:

Thank you. We used the EGMS Calibrated (Level 2b) product, release 2019–2023 (version 1, VV polarisation), from Sentinel-1 tracks 58 (Kiruna) 095 (Stockholm), 146 (Lilla Edet, Lödöse) and 066 (Gothenburg). We have added this info to the revised manuscript and stated in the Conclusions that our findings refer to the EGMS product over Sweden and cannot be generalized to the rest of Europe.

15. RC-2

Reproducibility:

Please provide details on the processing parameters used for SARvey (e.g. look into our paper about SARvey: Piter et al., 2026).

AC:

Thank you. We have added the main processing parameters of MiaplPy and SARvey, taken from the configuration files, as Table S2. Because of the journal's page limit (12 pages), we summarise the processing in Sect. 2.3 and refer to Piter et al. (2026) for a detailed description of the SARvey processing steps.

Table S2. Main MiaPlPy and SARvey processing parameters.

Step	Parameter	Value	Meaning
Input	Phase-linking results / PS mask	MiaplPy, TEP + ADI mask (maskPS.h5)	Phase-linked DS and PS candidates used as input
Preparation	Interferogram network	Star	Single-reference network
	Filter window size	9	Window for the temporal phase coherence estimate
First-order points	Temporal coherence coherence_p1	0.9	Selection of first-order points
	Grid size	100 m	Grid for spatially uniform selection
	Neighbours / min. arcs	30 / 3	Network construction
	Velocity / DEM-error bounds	0.1 m/yr / 100 m	Search space for arc parameters
	Arc unwrapping coherence	0.6	Arcs below this are removed
Unwrapping	Temporal + spatial	Temporal unwrapping, PUMA	Unwrapping of the first-order network
Atmosphere	APS filtering	Kriging, 1000 m grid	Spatially correlated phase removed

Step	Parameter	Value	Meaning
	Max. temporal autocorrelation	0.3	Excludes moving points from APS estimation
Second-order points	Temporal coherence coherence_p2	0.7	Selection of densification points
	Connections / max. distance to p1	5 / 2000 m	Densification network
	Velocity / DEM-error bounds	0.15 m/yr / 100 m	Search space for densification
	Arc unwrapping coherence	0.5	Minimum arc quality in densification
Phase linking (MiaplPy)	Estimator / SHP test	[EMI / KS]	Fill in from your MiaplPy config