

Reviewer 1 (Prof. Mahdi Motagh):

This is a very important and timely study evaluating the usability of publicly available EGMS data versus more advanced and adapted InSAR processing approaches for linear infrastructure monitoring. The authors have selected five case studies in Sweden and investigate how differences in the assumptions and processing strategies adopted by different InSAR approaches affect the resulting deformation estimates and their suitability for an operational railway-monitoring application.

I consider this to be a valuable and critical assessment that deserves publication. In my view, however, the manuscript still needs a revision as it does not fully communicate the importance and richness of the results the authors have obtained.

Authors' Response:

Thank you, Prof. Motagh, for your time and great feedback, and that you find our manuscript valuable. We have now addressed all your comments point-by-point below. Your comments are in dark orange (RC), and our comments in black (AC).

1. RC-1:

My main concern is that, in its current form, the authors somewhat underrepresent the valuable results of their analysis. Reading the manuscript, one gets the impression that the main emphasis is on the general consistency between the different results and on the fact that the PS+DS approach provides a denser set of observations. While the latter is already relatively well established, the detailed results presented in the manuscript indicate that there are also important and potentially consequential differences between the products.

For example, in Fig. 2c, uplift/stability appears to be detected at the northern end of the railway, whereas the PS+DS results in Fig. 2d indicate subsidence at approximately the same location. A similar inconsistency appears in the southern part of the study area. This raises an important question: which of these deformation estimates is more reliable, and what is the possible reason for the discrepancy?

When examining the results presented in the Supplementary Material, I find several other locations where similarly interesting discrepancies occur. Since one of the main objectives of the study is to objectively assess and compare the different processing approaches, I strongly recommend that the authors make better use of these differences. Rather than focusing primarily on the consistency of the results, the manuscript would be considerably more valuable if it explicitly highlighted where the approaches disagree, investigated the possible causes of these discrepancies, and discussed their implications for operational infrastructure monitoring.

AC:

Thank you for this comment which made us investigate the discrepancies between the two solutions quantitatively rather than describing them qualitatively. You correctly observed that at several locations, including the northern and southern ends of the West Link in Gothenburg in

Fig. 2c–d, the EGMS-PS map indicates stability or uplift while the PS+DS map indicates subsidence at approximately the same place. Before showing our analysis, we should clarify how the two products were referenced for plotting, as this turns out to be important to the apparent disagreement. The two datasets are in different reference frames: the EGMS Calibrated product is tied to GNSS and reports motion in an absolute, continent-wide harmonised datum, whereas our locally processed PS+DS velocities are relative to an arbitrary reference point within each scene. To display them on a common scale in Fig. 2, we used the QGIS plugin InSAR Explorer v2.10 (<https://insar-explorer.eodeck.com/>) and selected a small common area in each corridor and referenced both datasets to it. This anchoring relies on a limited number of measurement points within that small area, and individual scatterers, even neighbouring ones, can differ in velocity. A small error in the anchor value is then applied uniformly to every point in the scene. Given that the colour scale in Fig. 2 spans only ± 5 mm/yr, a residual anchoring difference of 1–2 mm/yr is enough to shift points lying near zero from the cyan (uplift) part of the scale into the yellow-to-red (subsidence) part, without any change in the underlying measurement. So, the visual impression of disagreement at a given location can be misleading, particularly in corridors such as Gothenburg where most of the signal is small and clustered around zero.

To determine whether the differences reflect genuinely different deformation estimates rather than this referencing effect, we did a point-level comparison in all five corridors. For every EGMS-PS measurement point we identified all PS+DS points within a fixed search radius (5m, 10m, 15m, and 50 m were tested), took the median velocity of those neighbours where at least three were available, and differenced it against the co-located EGMS-PS velocity. We restricted the comparison to co-located pairs to make sure any difference found cannot be attributed simply to the two solutions sampling different places. Then, we examined four properties of these paired differences, each diagnostic of a different possible cause: **1)** their median, which isolates a constant offset between the products; **2)** their median absolute deviation, which measures the scatter about that offset and is insensitive to outliers; **3)** their correlation with easting and northing, which would reveal an uncorrected ramp or large-scale atmospheric residual; **4)** and their variation across land-cover classes sampled from the Swedish National Land Cover Database, which would reveal the two solutions measuring physically different surfaces, for example persistent scatterers on piled building foundations versus distributed scatterers on the surrounding ground.

The results (Table 1. below): in every corridor the difference between the two solutions is dominated by a single constant offset, with no residual structure. The offset ranges from -1.25 mm/yr in Gothenburg (south-west Sweden) to -5.5 mm/yr in Kiruna (Northern Sweden) and is essentially identical whether computed from all points or from co-located pairs only, confirming a genuine systematic shift rather than a sampling artefact. After removing it, the residual scatter between the two solutions is 0.44 – 0.85 mm/yr, comparable to the intrinsic precision of the two products; no corridor shows any spatial correlation; and the residuals are independent of land cover. In Lilla Edet, for instance, the median residual between the two solutions is $+0.00$ mm/yr

on buildings, -0.01 mm/yr on roads and railways, $+0.02$ mm/yr in forest, and $+0.03$ mm/yr on open vegetated ground. Persistent scatterers on built structures and distributed scatterers on surrounding vegetated ground yield the same velocity to well within measurement precision.

Table 1. Point-level comparison at 15 m co-location radius. Offset is the median paired difference (PS+DS minus EGMS-PS); MAD is the median absolute deviation of the differences; spatial correlation is the larger of $|r|$ against easting and northing; land-cover spread is the range of median of differences across classes with ≥ 8 points, excluding inland water and unclassified pixels. The land uplift rate is derived from the NKG model (Häkli et al., 2023).

Corridor	Pairs (n)	Offset (mm/year)	MAD (mm/year)	Max spatial correlation	Land-cover spread (mm/year)	Land uplift rate LOS (mm/year)	EGMS-PS LOS (mm/year)
Kiruna	129	-5.50	0.85	0.11	0.19	5.23	5.40
Lilla Edet	1800	-2.93	0.44	0.03	0.08	3.48	2.70
Lödöse	1179	-2.69	0.55	0.03	0.50	3.38	2.40
Gothenburg	959	-1.25	0.61	0.09	0.27	2.26	1.30
Stockholm	1962	-3.93	0.57	0.08	0.14	4.86	4.10

The magnitude of the offset between the two solutions is itself informative. It increases from the south to the north across our five corridors. This is the Fennoscandian postglacial rebound signal: Sweden is still rising isostatically following deglaciation, at rates that peak near the Gulf of Bothnia and decrease toward the southwest coast, as described by the Nordic Commission of Geodesy land uplift (Vestøl et al., 2019, <https://doi.org/10.1007/s00190-019-01280-8>). To test this interpretation quantitatively, we sampled the three-component land uplift velocity model from the Nordic Geodetic Commission (Häkli et al., 2023) at every EGMS-PS point and projected it into the line of sight using each point's own incidence and heading angles (Table 1, the last two columns). Across the four southern corridors the median of the predicted line-of-sight velocities (from the NKG model) and the median of the observed line-of-sight velocities (from the EGMS-PS) differ by a nearly constant -0.86 mm/year (range -0.74 to -0.99 mm/yr), despite substantial differences in geology, orbit direction and viewing geometry between sites. The Kiruna corridor, which has by far the fewest measurement points, differs by $+0.16$ mm/year. The consistency of this residual indicates a systematic difference between the reference realisations of the two InSAR solutions rather than local deformation and confirms that the offset between EGMS-PS and PS+DS corresponds to the regional land uplift retained by the GNSS-referenced product. Thus, the offset is the expected consequence of one product reporting absolute and the other relative motion.

We have added this analysis to the manuscript, together with a table summarizing the offset, residual scatter, spatial correlation, and land-cover dependence for all five corridors (Lines 202-239). We have also revised the abstract and conclusions accordingly. We have additionally stated explicitly the limitation that this comparison covers only locations observed by both solutions

and therefore does not validate the additional PS+DS points in areas where EGMS-PS has no measurements.

2. RC-1:

I am not in favor of presenting the results of Cases 3–5 primarily in the Supplementary Material. The conclusions drawn from Cases 1–2 are not necessarily generalizable to the other study areas, particularly given the differences that may exist in land cover, deformation characteristics, measurement density, and processing performance.

Since the paper aims to evaluate the applicability of the different InSAR products for operational railway monitoring, the results from all five cases are important for demonstrating the robustness and generality of the conclusions. I therefore recommend moving at least the key results from Cases 3–5 into the main text, while retaining additional details in the Supplementary Material if necessary.

AC:

We agree and have moved the results of all five cases into the main text, so that all five corridors are presented together and the generality of the conclusions can be judged directly. The Supplementary Material now has only supporting detail. We hope the editor will accept the resulting increase in length, given the journal's guideline of approximately 12–13 journal pages.

3. RC-1

If possible, I recommend providing a statistical assessment of the relationship between the different InSAR products, for example for the results shown in Fig. 2. A straightforward approach would be to perform a linear regression, with the deformation estimates from EGMS on one axis and those from the PS+DS processing on the other. And reporting about statistical correlation.

AC:

Thank you for this suggestion. We have now done the recommended regression analysis, and it was very useful (Lines 240-266).

Using the co-located point pairs described in our response to Comment 1, we regressed the PS+DS velocities against the EGMS-PS velocities for each corridor. In this framing the slope tests whether the two products report the same land motion magnitude (a slope of 1 indicates agreement; a slope below 1 would mean PS+DS underestimates the amplitude), while the intercept should independently reproduce the datum offset obtained from the median of the paired differences in answer to comment 1.

We report orthogonal regression which accounts for error in both axes. The distributions of paired differences are strongly heavy-tailed: between 3% and 8% of pairs deviate from the median by more than three median absolute deviations. We computed the regression after

trimming pairs beyond three MAD and cross-checked with the outlier-resistant Theil-Sen estimator.

With these precautions, four of the five corridors show slopes between 0.81 and 0.94 with Pearson correlations of 0.78–0.95 (new Table 2). Importantly, the fitted intercepts reproduce the datum offsets determined independently from the median differences: accounting for the sub-unity slope via $\text{intercept} = \text{offset} + (1 - \text{slope}) \times \text{mean (EGMS)}$, predicted and observed intercepts agree to within 0.03 mm/yr in every case.

Table 2. Orthogonal regression of PS+DS on EGMS-PS velocities at 15 m, after trimming pairs beyond three MAD. Predicted intercept is $\text{offset} + (1 - \text{slope}) \times \text{median EGMS velocity}$.

Corridor	Slope	Pearson corr	Intercept	Predicted intercept	Outliers trimmed
Kiruna	0.216	0.364	-1.22	-1.27	3.9 %
Lilla Edet	0.938	0.953	-2.79	-2.76	7.1%
Lödöse	0.925	0.937	-2.52	-2.51	8.1%
Gothenburg	0.918	0.777	-1.14	-1.14	6.7%
Stockholm	0.812	0.783	-3.19	-3.16	5.6%

Kiruna does not support a regression. With only 220 EGMS-PS points in the corridor, 129 co-located pairs, and a land motion range comparable to the measurement noise, the fit is unconstrained. We report this as a null result rather than a disagreement and note that it illustrates a practical limitation of the operational product in sparsely scattering subarctic terrain which is itself relevant to the paper's central question.

We also examined the sensitivity of the regression to the co-location radius (table below). Slopes are stable between 10 and 20 m, Lilla Edet varies by 0.001, but decline systematically at 50 m, reaching 0.231 in Stockholm. The reason is that taking the median of PS+DS points over a larger neighborhood spatially smooths the PS+DS field and clips ground motion peaks, while the EGMS values remain unsmoothed, attenuating the slope. At 5 m the samples become too small (64–144 pairs) for stable estimation, and Kiruna yields only six pairs. We adopted 15 m for the main analysis, corresponding approximately to one Sentinel-1 ground resolution cell, and report the full series as a sensitivity test. That an apparent amplitude difference between two InSAR products can be produced by the co-location radius alone seems a useful caution for other point-level comparisons, and we now state it explicitly.

Sensitivity of the trimmed orthogonal slope to co-location radius (number of pairs in parentheses).

Corridor	5m	10m	15m	50m
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Kiruna	— (6)	0.146 (89)	0.216 (129)	0.466 (183)
Lilla Edet	0.899 (132)	0.939 (1173)	0.938 (1800)	0.897 (2143)
Lödöse	0.786 (64)	0.932 (704)	0.925 (1179)	0.909 (1525)
Göteborg	1.112 (106)	0.891 (850)	0.918 (959)	0.796 (992)
Stockholm	0.478 (144)	0.932 (1620)	0.812 (1962)	0.231 (2127)

Finally, we note that the correlation coefficient must be read together with the ground motion range in each corridor. Corridors with a subsidence signal of several mm/yr (Lilla Edet, Lödöse) yield correlations above 0.93, whereas corridors that are close to stable offer little variance for a correlation to resolve, however well the products agree.

4. RC-1

-Line 100: The authors state:

“The interferometric phase also contains contributions from topography, atmospheric delays, and noise, which different InSAR methods model and separate to isolate the ground-motion signal.”

Given that InSAR is a mature technique with a history of approximately three decades, I suggest citing some of the foundational/original publications on interferometric SAR at this point, rather than relying primarily on recent literature in 2024.

AC:

Thank you, we addressed this comment by citing two foundational publications on two different InSAR methods (Line 106): Berardino et al., 2002; Ferretti et al., 2001

5. RC-1

Line 138:

For the SARvey package, please kindly cite the recent publication explaining the details of the software

Piter, A., et al. (2026). SARvey-survey with SAR: A new Open-Source InSAR Research Software. *Environmental Modelling & Software*, 107004, <https://doi.org/10.1016/j.envsoft.2026.107004>

AC:

Thank you, we have now cited the recent SARvey package paper (Line 136).