Cross-checking of the nationwide Ground Motion Service (GMS) of Sweden with the previous InSAR-based results: Case studies of Uppsala and Gävle Cities

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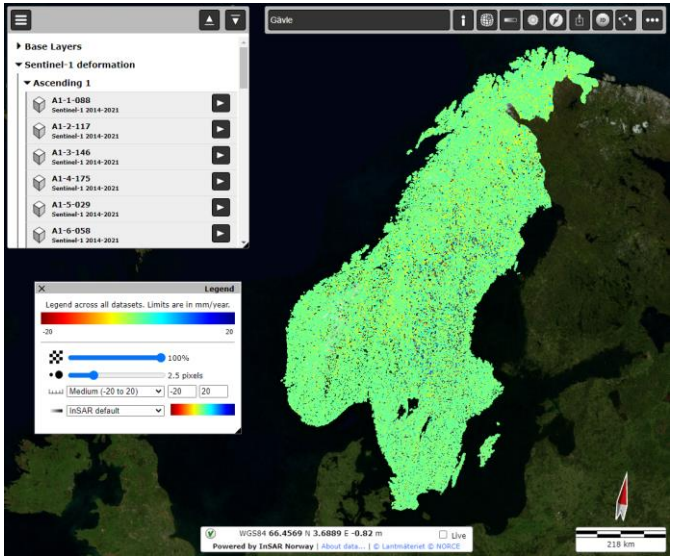
LANTMÄTERIET

InSAR-based National Ground motion service (GMS) of Sweden

- **Started: 2020-10-15, finish: 2022-12-31**
- **GMS of Sweden**, produced by NGU
- Totally two products during the project
- Based on **PSI** technique using both **ascending and descending Sentinel 1** data (**2015-2021**),
- **~1500,000,000 PS** points with their time series (**LOS**)
- **Possible to add user-defined layers (**faults, deposits, SWEPOS stations, …**)**

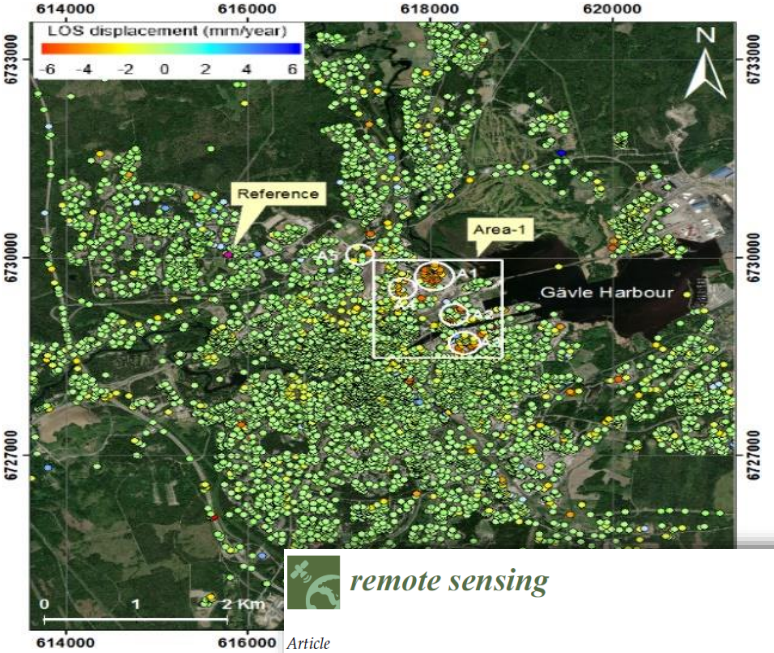


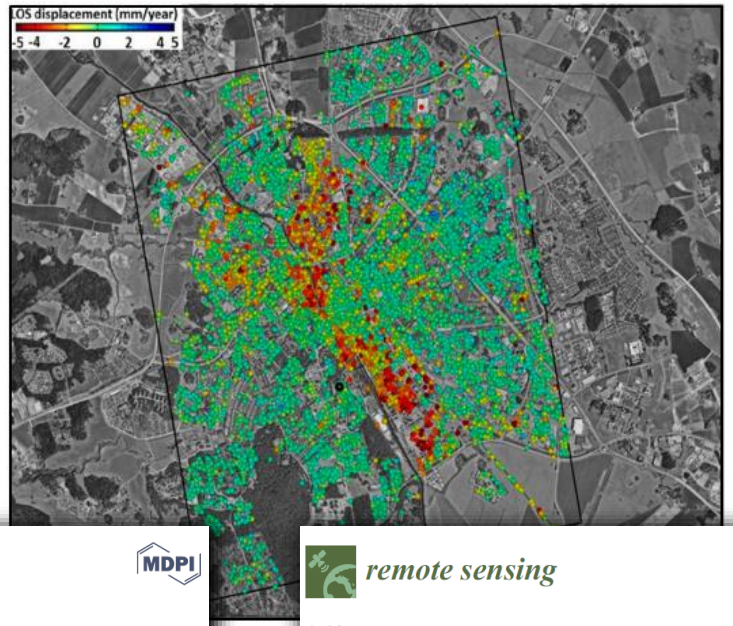
https://insar.rymdstyrelsen.se

FOI SGU Geological Survey of Sweden GEOLOGICAL SURVEY OF NORWAY - NGU -

Rymdstyrelsen Swedish National Space Agency LANTMÄTERIET CHALMERS UNIVERSITY OF TECHNOLOGY TRAFIKVERKET SWEDISH GEOTECHNICAL INSTITUTE

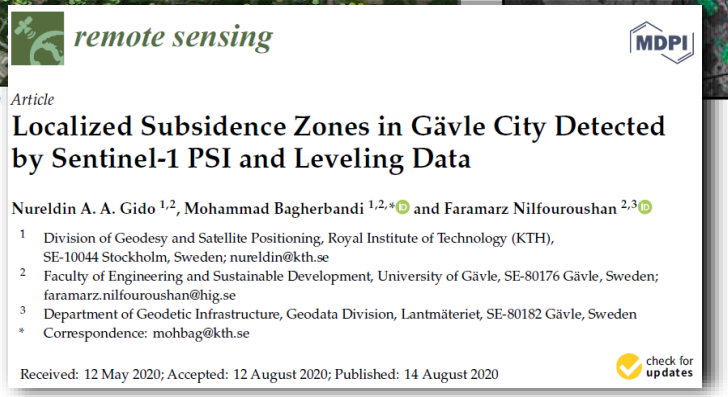
Land subsidence in Gävle and Uppsala cities





- **Uppsala** subsidence map using PSI
- **42 Asc_44 Dsc,** S1
- **20150305-20190413**
- Leveling data
- Subsiding mostly due to Postglacial clay

- **Gävle** subsidence zones using PSI
- **41 Asc.** & **50 Dsc.**, S1
- **20150116 – 20200519**
- **45** years leveling data
- Due to artificial fill



remote sensing

MDPI

Article

Localized Subsidence Zones in Gävle City Detected by Sentinel-1 PSI and Leveling Data

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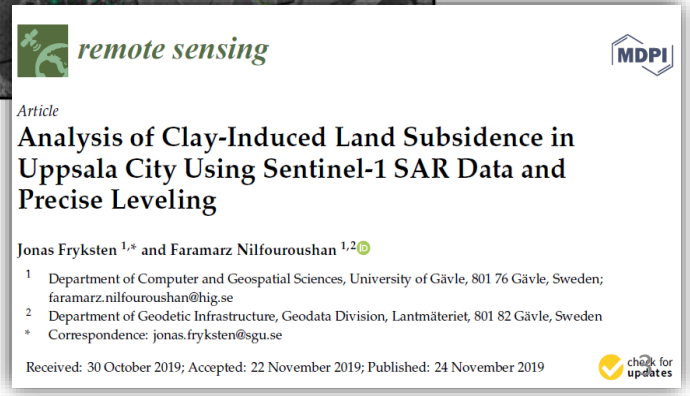
check for updates



remote sensing

MDPI

Article

Analysis of Clay-Induced Land Subsidence in Uppsala City Using Sentinel-1 SAR Data and Precise Leveling

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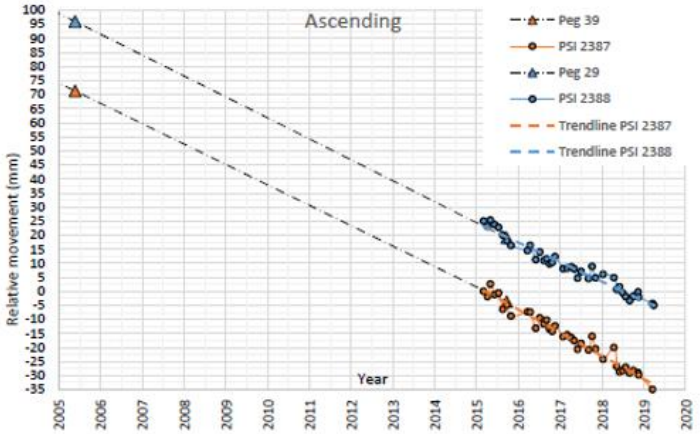
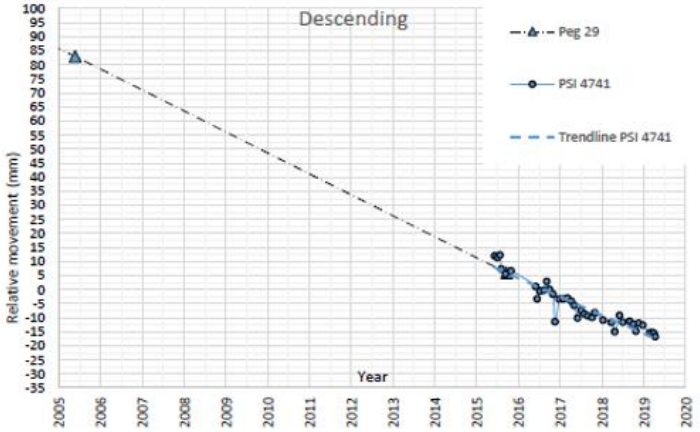
Validation of PSI results using leveling data of Uppsala City

- Long record of leveling data

Technique	Track	Point	Time series σ (mm)	Movement (mm/year)
PSI	Ascending	2387	1.6	-8.2
Prec. lev.		Peg 39		-7.3
PSI	Ascending	2388	1.8	-6.9
Prec. lev.		Peg 29		-7.5
PSI	Descending	4741	2.8	-6.6
Prec. lev.		Peg 29		-7.5

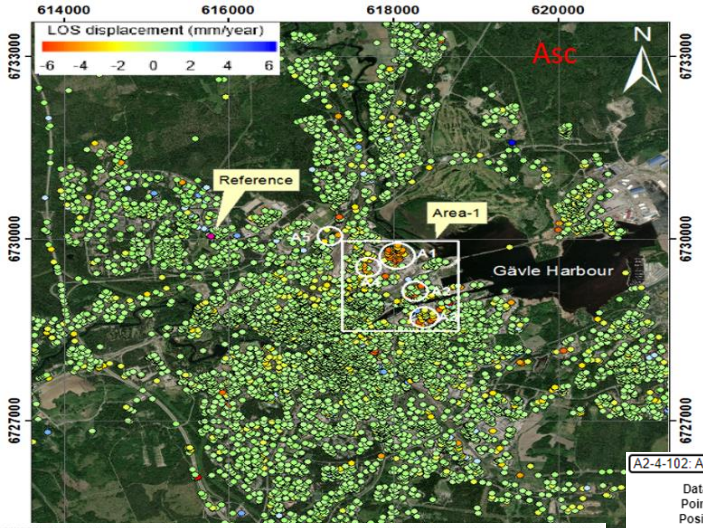


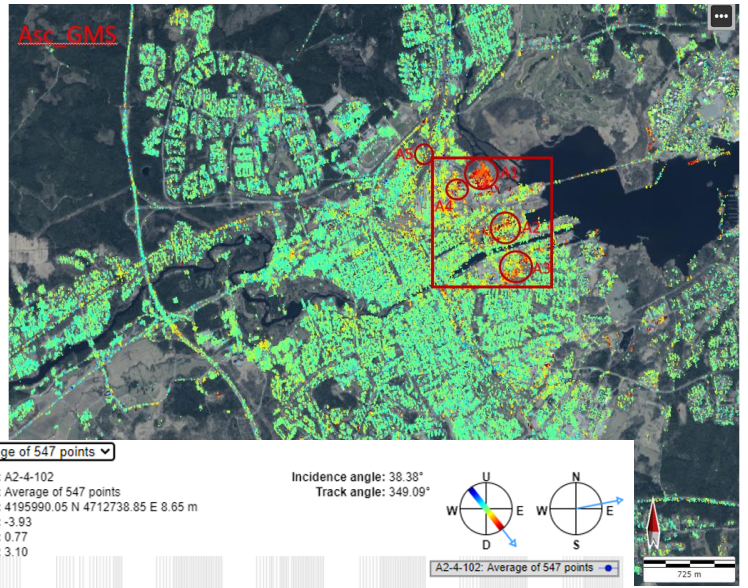


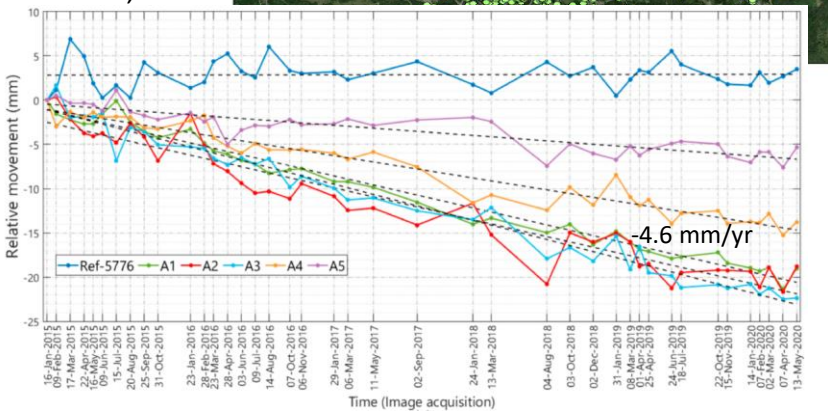
Fryksten and Nilfouroushan (2019)

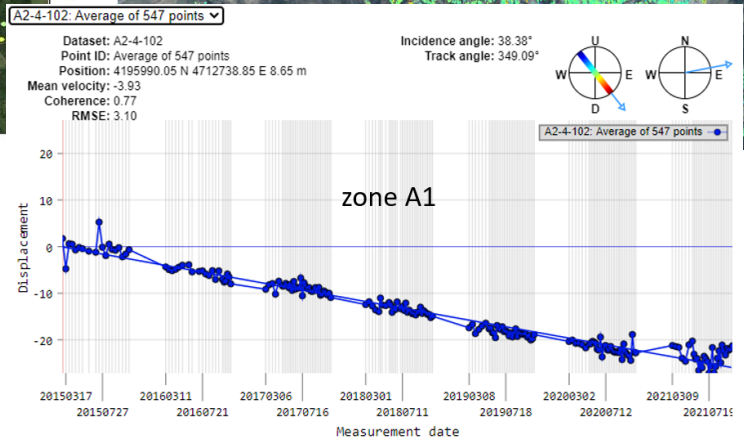
Gävle ground motion (Gido et al. 2020) vs National GMS

- **Similar localization** of deformation in both studies
- **Points** and **areas** comparisons for Asc. & Dsc. Geometry
- Using same tracks (**Asc_102**, **Dsc_95**)
- Time series analysis
- Differences in time span (4 years, 6 years)
- Number of images(41, 209)
- Reference selection, ..



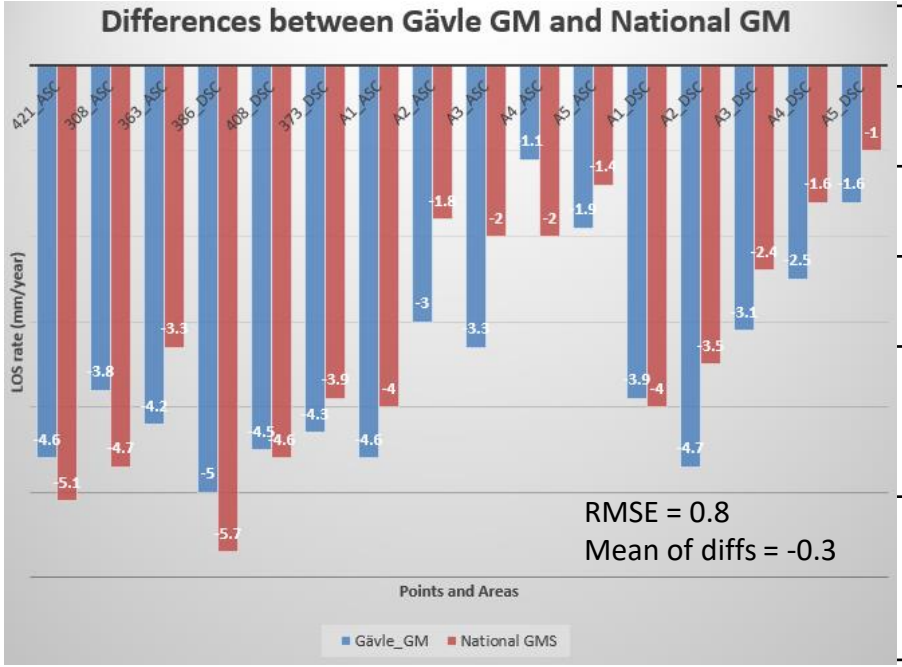






Gävle ground motion (Gido et al. 2020) vs National GMS

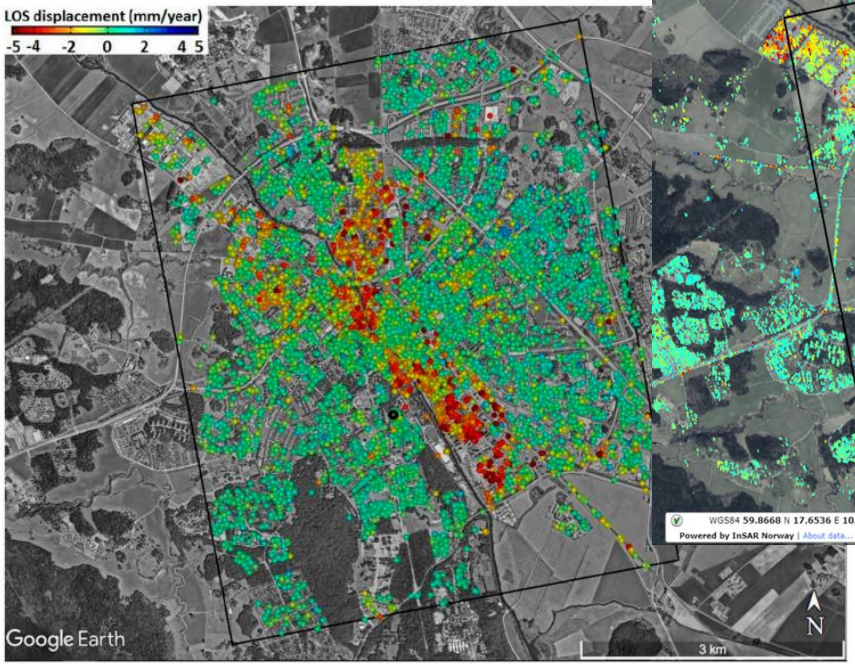
- **PS Points** and **Areas** comparison
- Compare similar tracks Asc_102 & Dsc_95



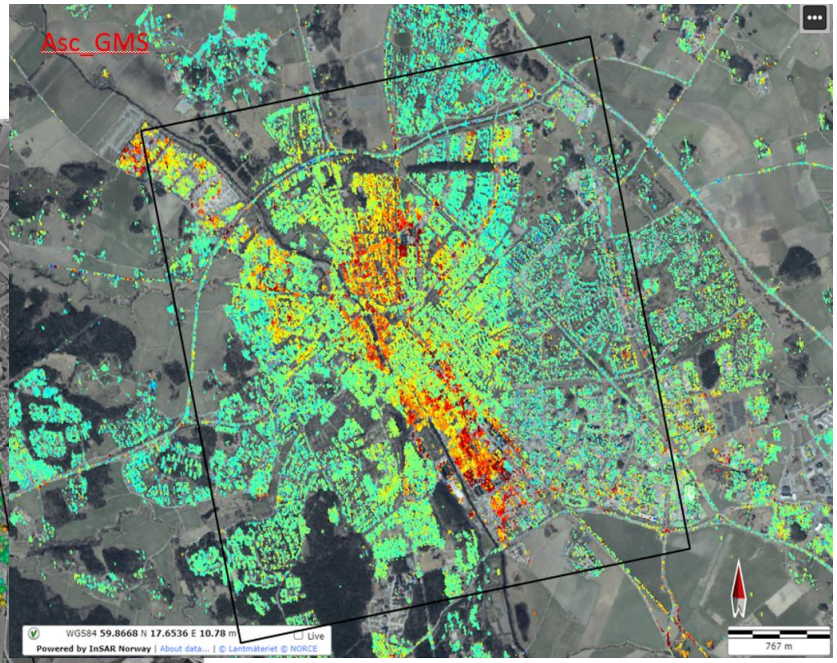
Gävle ground motion (20150116- 20200519)					GMS (20150305- 20211011)		
Zone/ID	Track	LOS rate(mm/yr)	Coherence	St. Dev. (mm)	LOS rate (mm/yr)	Coherence	RMSE
421	Asc_102	-4.6	0.91	2.1	-5.1	0.82	2.2
308	Asc_102	-3.8	0.83	2.8	-4.7	0.82	2.3
363	Asc_102	-4.2	0.92	1.8	-3.3	0.93	1.6
386	Dsc_95	-5.0	0.71	4.0	-5.7	0.59	4.9
408	Dsc_95	-4.5	0.89	2.3	-4.6	0.85	2.5
373	Dsc_95	-4.3	0.82	3.2	-3.9	0.89	3.2
A1	Asc_102	- 4.6	0.89	5.6	-4.0	0.76	3.1
A2	Asc_102	- 3.0	0.90	3.6	-1.8	0.71	3.6
A3	Asc_102	- 3.3	0.90	4.0	-2.0	0.71	3.6
A4	Asc_102	-1.1	0.94	1.5	-2.0	0.70	3.7
A5	Asc_102	-1.9	0.83	2.4	-1.4	0.64	4.2
A1	Dsc_95	-3.9	0.86	4.1	-4.0	0.69	3.8
A2	Dsc_95	-4.7	0.86	5.1	-3.5	0.73	3.4
A3	Dsc_95	-3.1	0.90	3.3	-2.4	0.74	3.3
A4	Dsc_95	-2.5	0.78	3.2	-1.6	0.69	3.9
A5	Dsc_95	-1.6	0.82	2.0	-1.0	0.67	3.9

Uppsala ground motion (Fryksten and Nilfouroushan, 2019) **vs national GMS**

- **Similar localization** of deformation in both studies
- **Points** comparisons for Asc. & Dsc. Geometry
- Similar tracks (**Asc_102**, **Dsc_95**)
- Differences in time span (**4 years**, **6 years**)
- Number of images (**42** & **209** images)
- Reference selection ..



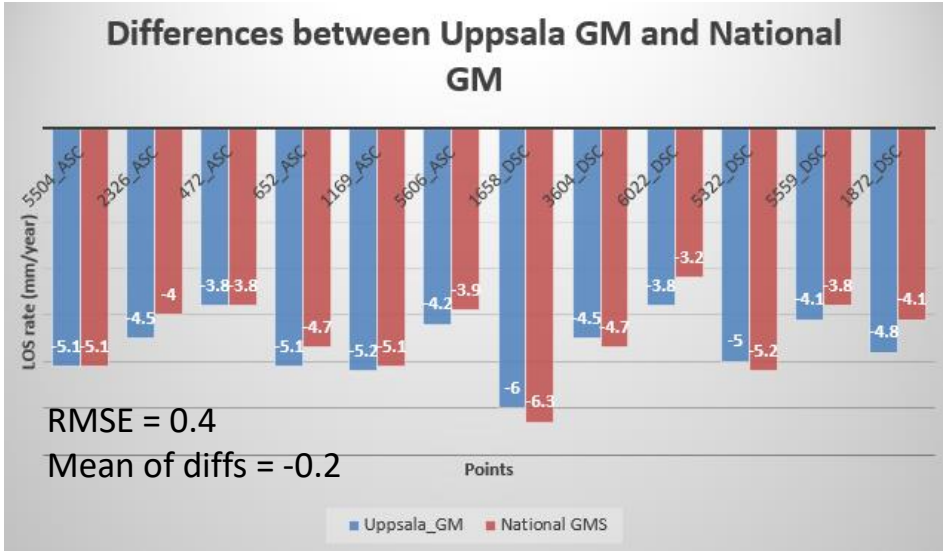
Uppsala ground motion, Ascending



National GMS, Uppsala city

Uppsala ground motion vs national GMS

- **PS Points** comparison
- Compare similar tracks Asc_102 & Dsc_95



Uppsala ground motion (20150305-20190413)					National GMS (20150305-20211011)		
Zone/ID	Track	LOS rate (mm/yr)	Coherence	St. Dev. (mm)	LOS rate (mm/yr)	Coherence	RMSE
5504_Asc	102	-5.1	0.94	1.5	-5.1	0.92	1.8
2326_Asc	102	-4.5	0.94	1.6	-4.0	0.85	2.5
472_Asc	102	-3.8	0.85	2.9	-3.8	0.87	2.1
652_Asc	102	-5.1	0.86	2.5	-4.7	0.81	2.7
1169_Asc	102	-5.2	0.89	2.2	-5.1	0.85	1.9
5606_Asc	102	-4.2	0.96	1.3	-3.9	0.93	1.8
1658_Dsc	95	-6.0	0.80	3.0	-6.3	0.88	2.3
3604_Dsc	95	-4.5	0.81	3.3	-4.7	0.70	3.7
6022_Dsc	95	-3.8	0.92	2.1	-3.2	0.94	1.7
5322_Dsc	95	-5.0	0.94	1.6	-5.2	0.91	1.5
5559_Dsc	95	-4.1	0.90	2.2	-3.8	0.95	1.4
1872_Dsc	95	-4.8	0.83	2.8	-4.1	0.96	1.3

Conclusions:

- Firstly, the two InSAR-based studies (Uppsala and Gävle) were validated with available **long record of levelling data**
- Generally, the two published studies agreed with the national GMS, with minor differences due to:
  - Differences in time spans
  - Number of used Images
  - Processing technique and factors (e.g., coherence, masks, etc)
  - Density of the PS points
  - Accuracy of georeferencing of the PS points (for comparison of the same points from different solutions/studies, **corner reflectors** are useful, already installed 9 in Sweden)

Thank you for your attention!

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InSAR corner reflectors and GNSS stations, Visby, Sweden