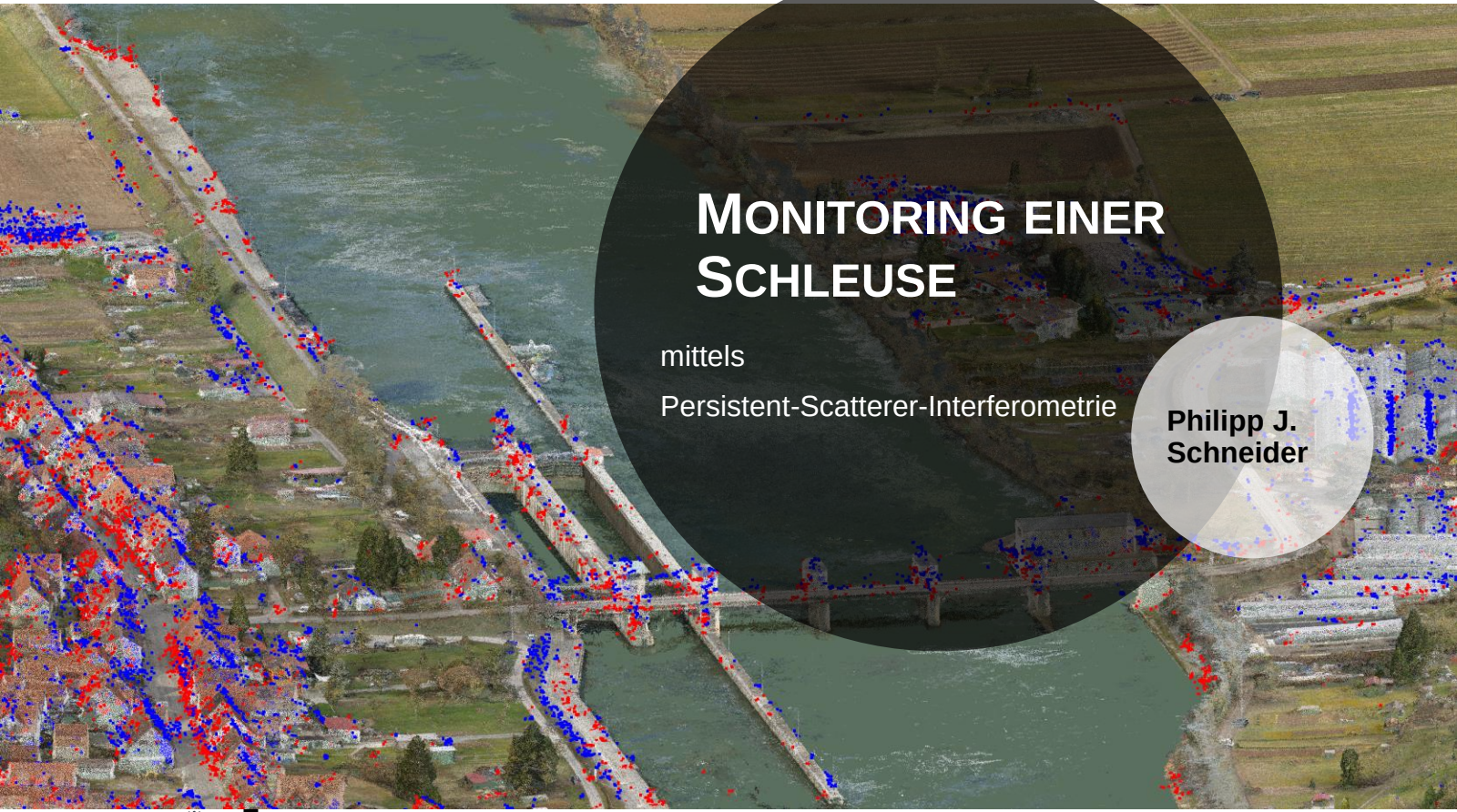
Universität Stuttgart

ifp

bfg Bundesanstalt für Gewässerkunde



Monitoring einer Schleuse

mittels

Persistent-Scatterer-Interferometrie

Philipp J. Schneider

ifp Universität Stuttgart bfg Bundesanstalt für Gewässerkunde

Monitoring of a river lock in *Hessigheim*

outline

- Introduction of the Project
- Persistent Scatterer
- Results
- Decomposition of Two-Orbit Observation
- Some things you need to know before getting into PS-InSAR

Introduction of the project

“Lock Hessigheim”

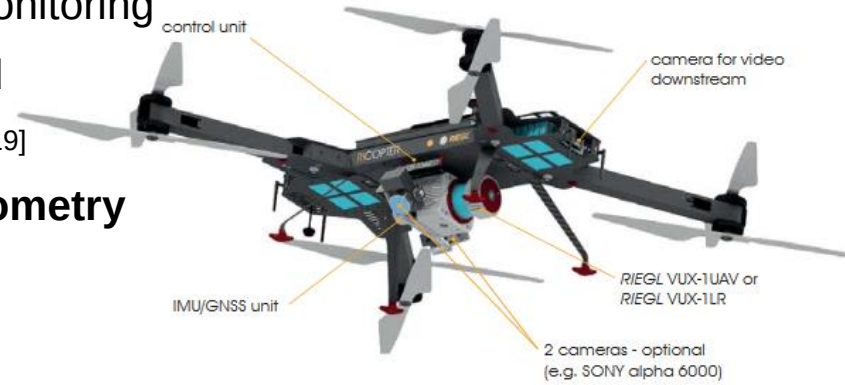
- Expected deformations 1mm/year to 2cm/year

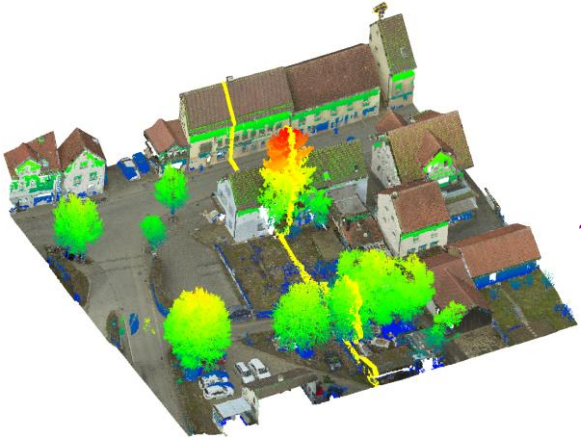
[FRANZIUS, L. 1990],[KAUTHER, R., & SCHULZE, R., 2015], [KAUTHER, R., & WOLF, C., 2018]

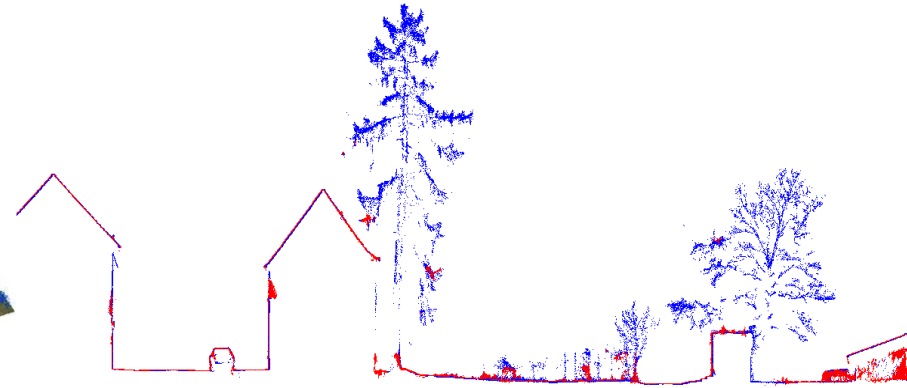
Introduction of the project

Airborne laser scanning, dense image matching and **PSInSAR**

- Exploring **new techniques** in monitoring
  - UAV-based laser scanning and photogrammetry [N. HAALA et al. 2019]
  - **Persistent Scatterer Interferometry**







section cut of LIDAR (blue) and DIM point cloud (red)

Introduction of the project

Persistent Scatterer Interferometry (PSI)

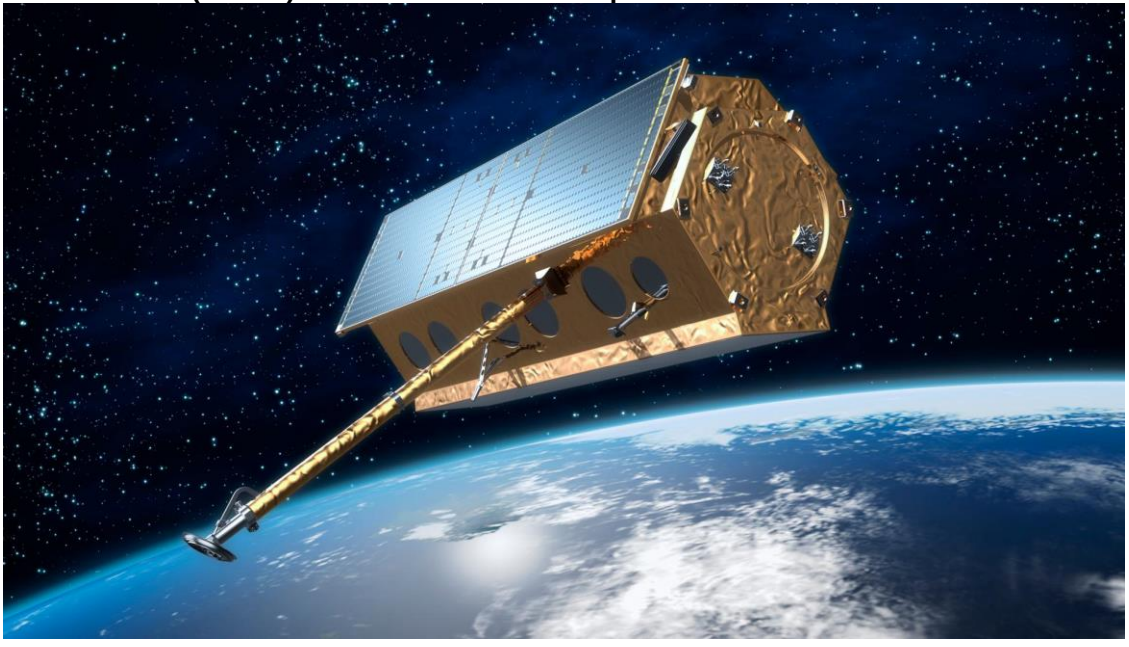
Requirements:

- Sub-centimeter accuracy ✓
- Capable of building sharp monitoring ✓
- Scalable technique to potentially monitor all locks in Germany [✓]

Persistent Scatterer

TerraSAR-X

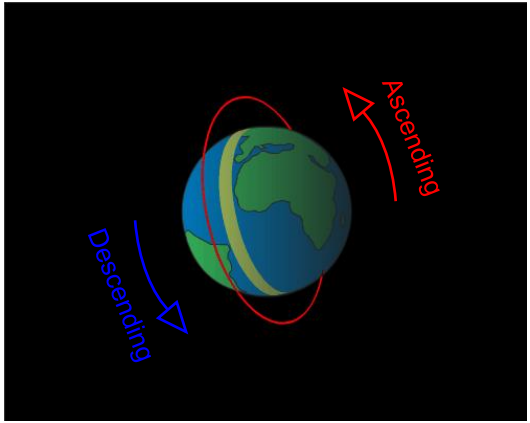
- A German Synthetic Aperture Radar (SAR) Satellite (2007-???)
- DLR and AIRBUS in Public-Privat-Partnership
- X-Band (3cm) with a GSD of up to ~1m x 1m



Persistent Scatterer

Data set

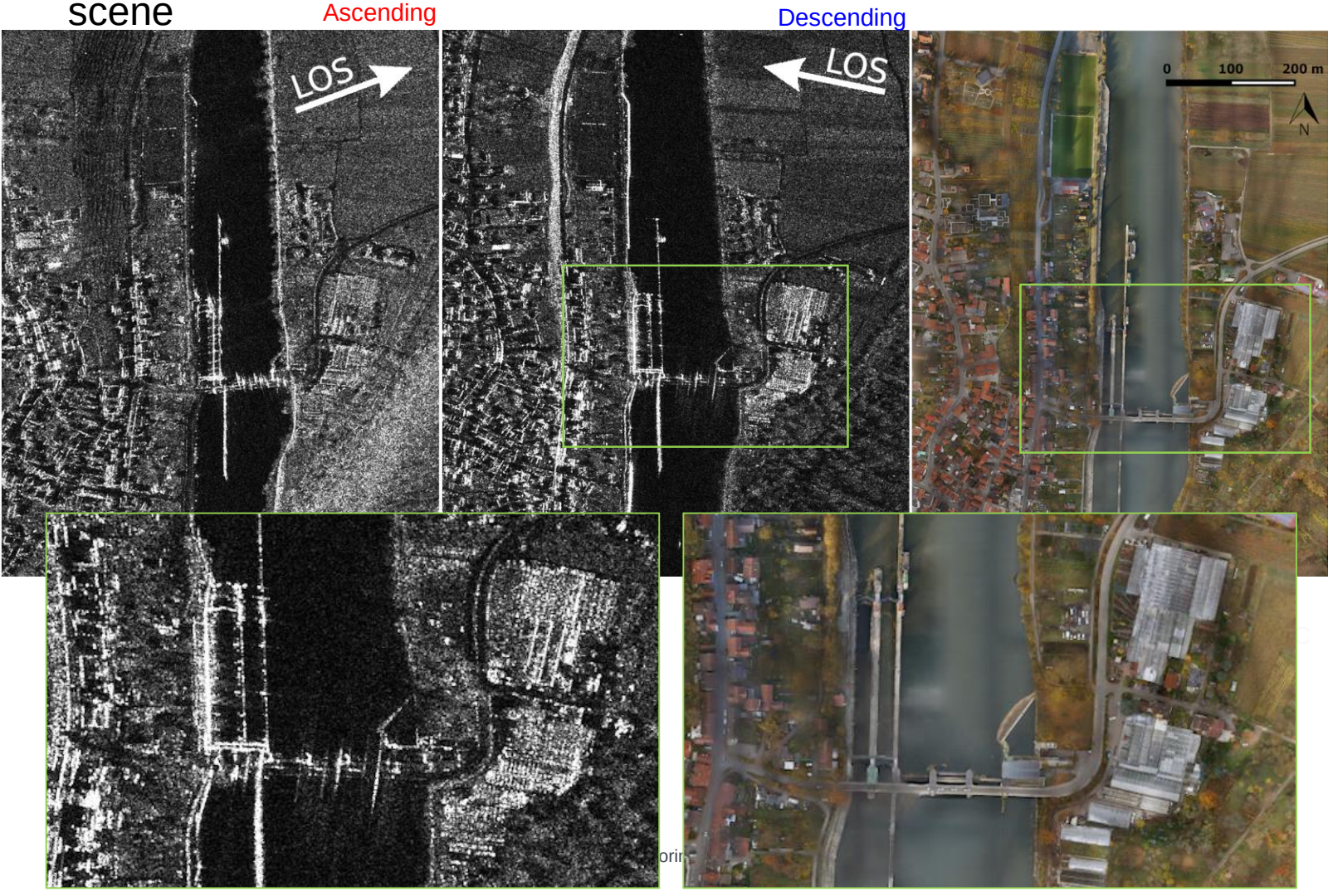
- Terra SAR-X *High Resolution SpotLight mode 5km x 8km*



- Two stacks Images:
  - Ascending and descending orbit
  - Repeat Orbit: 11 Days
  - Long (interrupted) time series for 5.5 Years

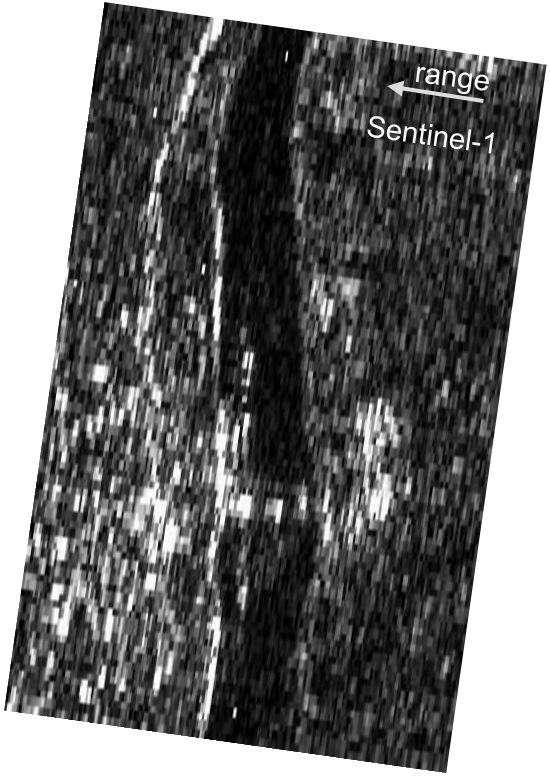
Persistent Scatterer

scene

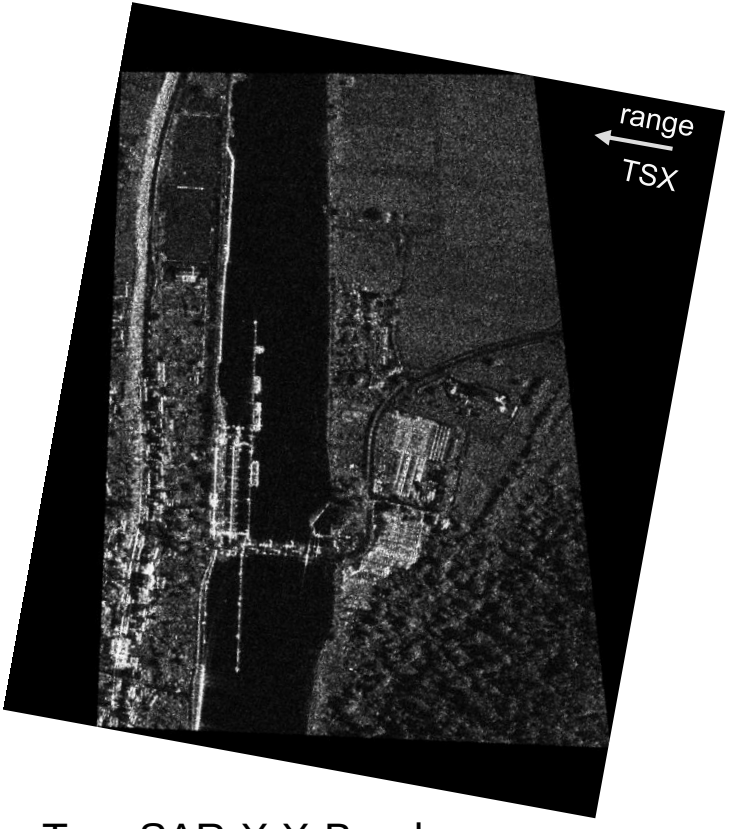


Persistent Scatterer

Other Sources

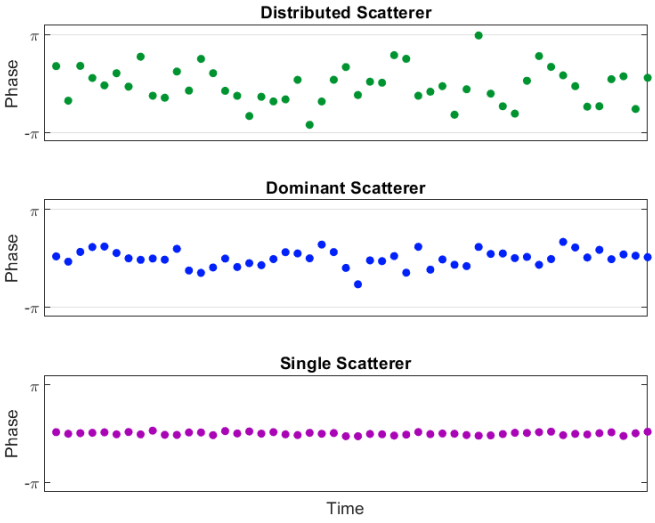


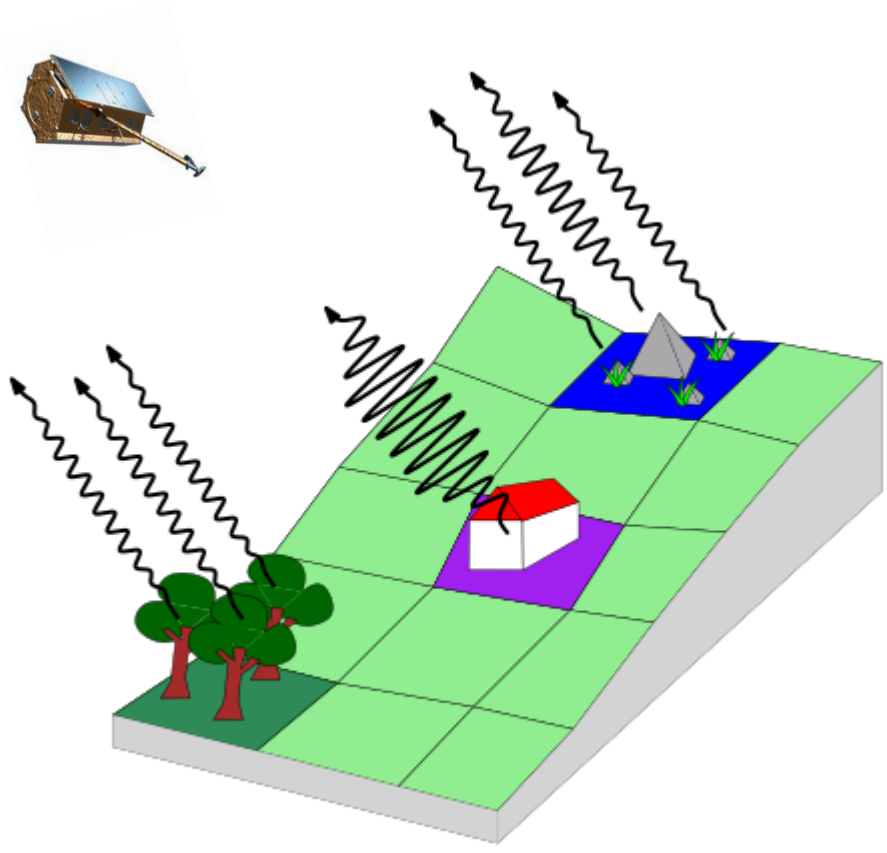
Sentinel-1 C-Band
@ 20mx5m GSD



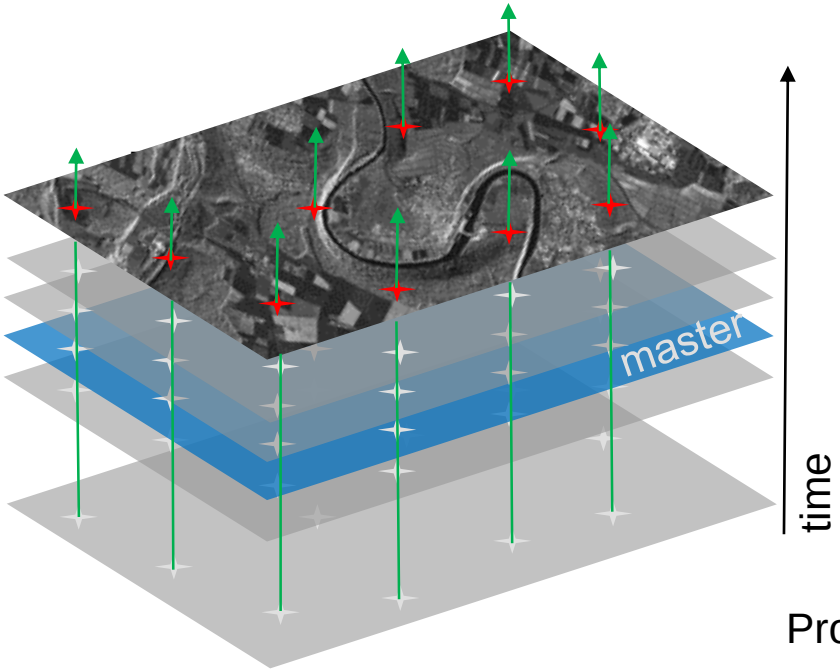
TerraSAR-X X-Band
@ 1mx1m GSD

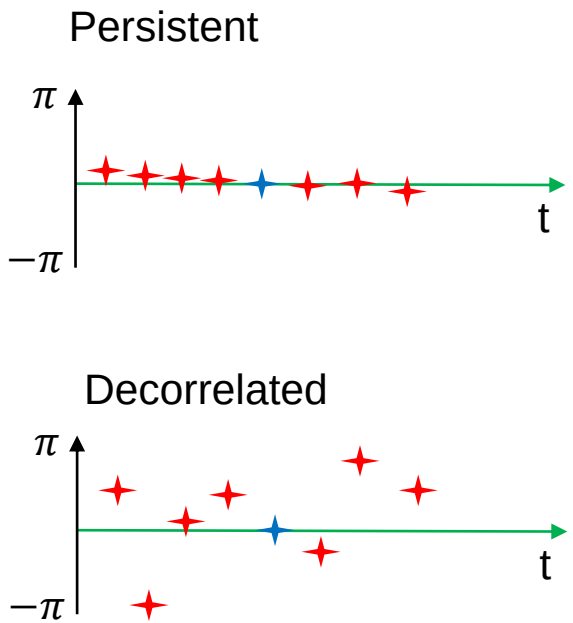
Persistent Scatterer





Persistent Scatterer





Product:

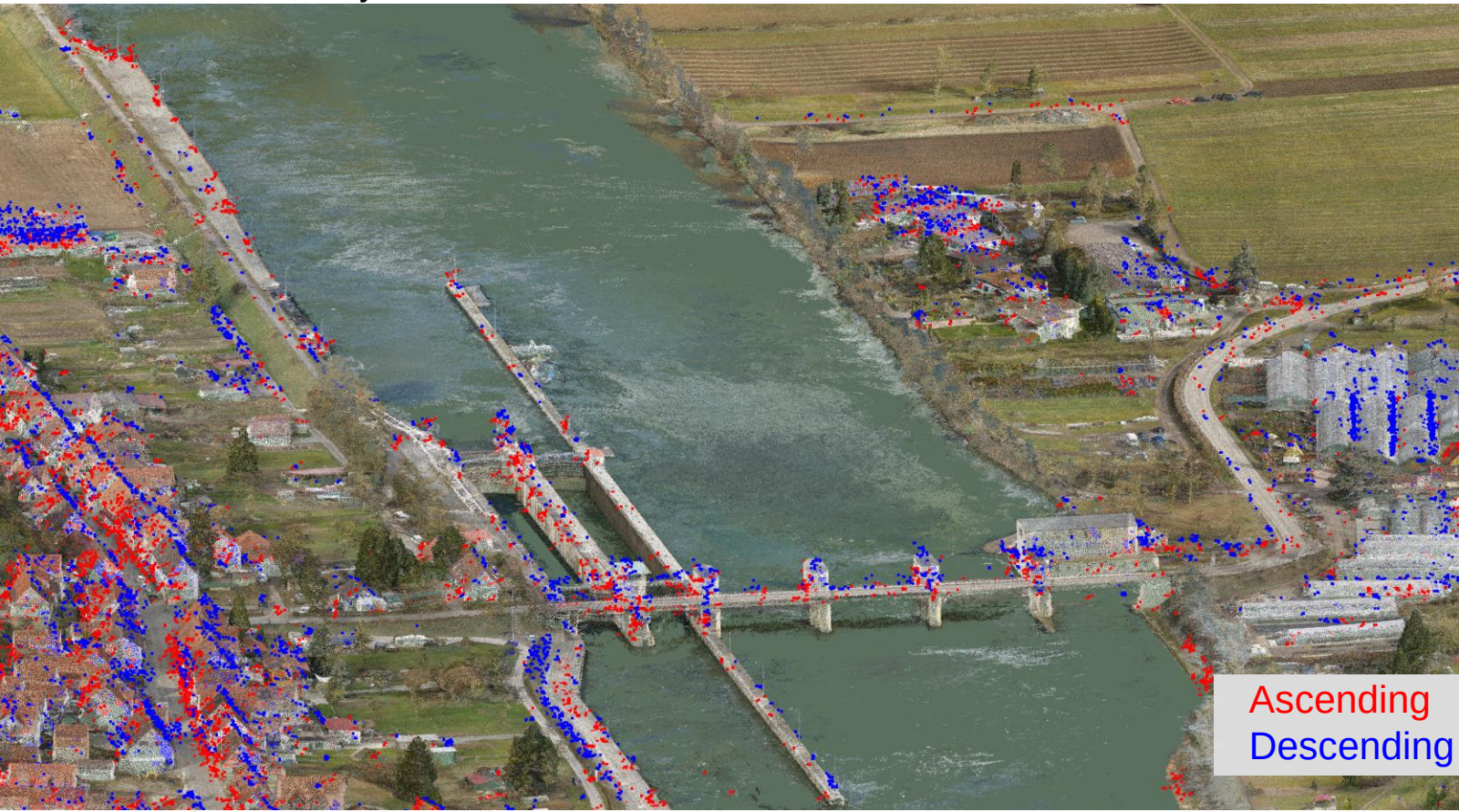
- 3D PSI Point cloud.
- Deformation history for each point.

(FERRETTI, A., PRATI, C. and ROCCA, F., 2000, 2001)

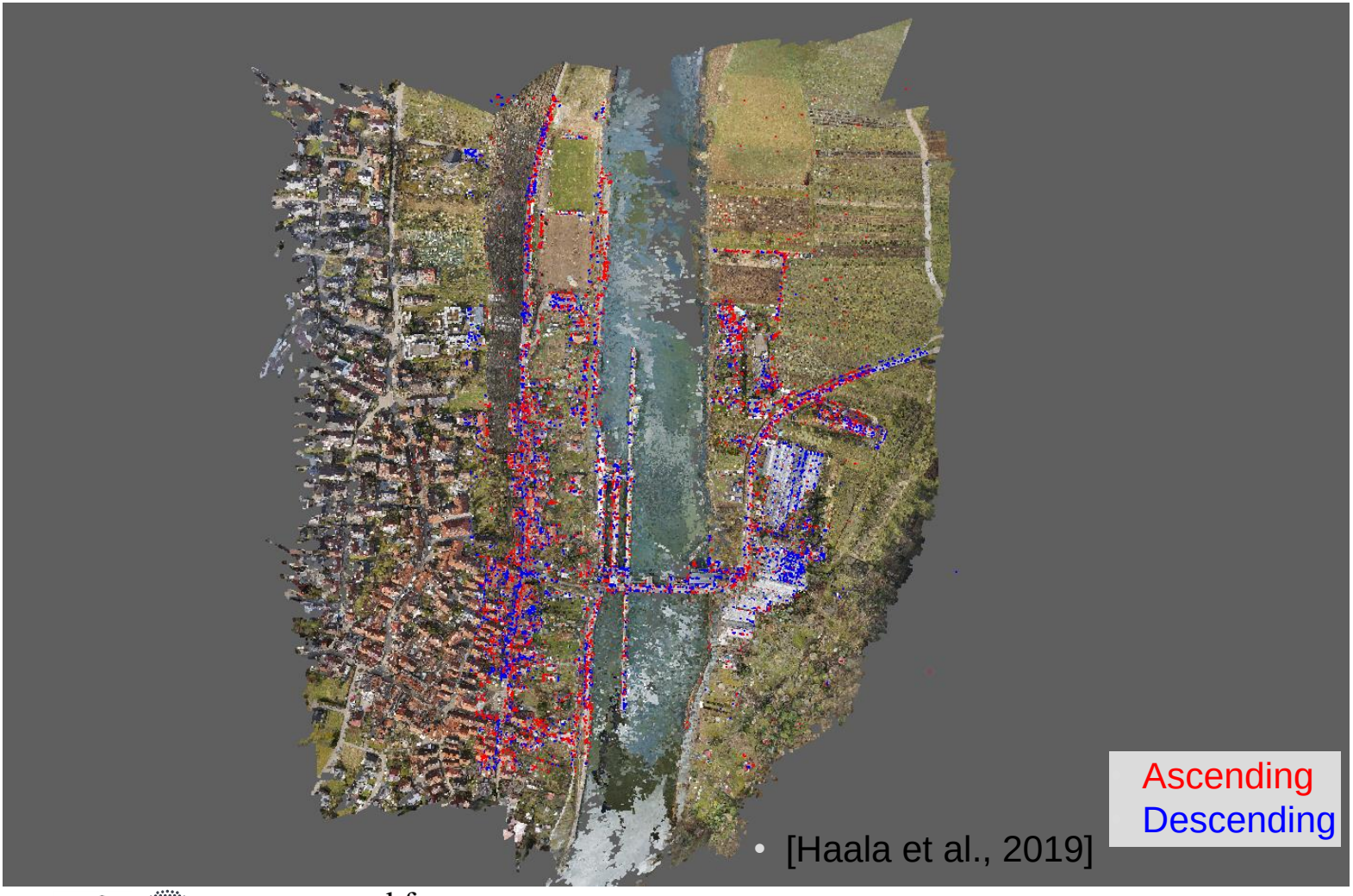
Persistent Scatterers

Results

Distribution on Objects

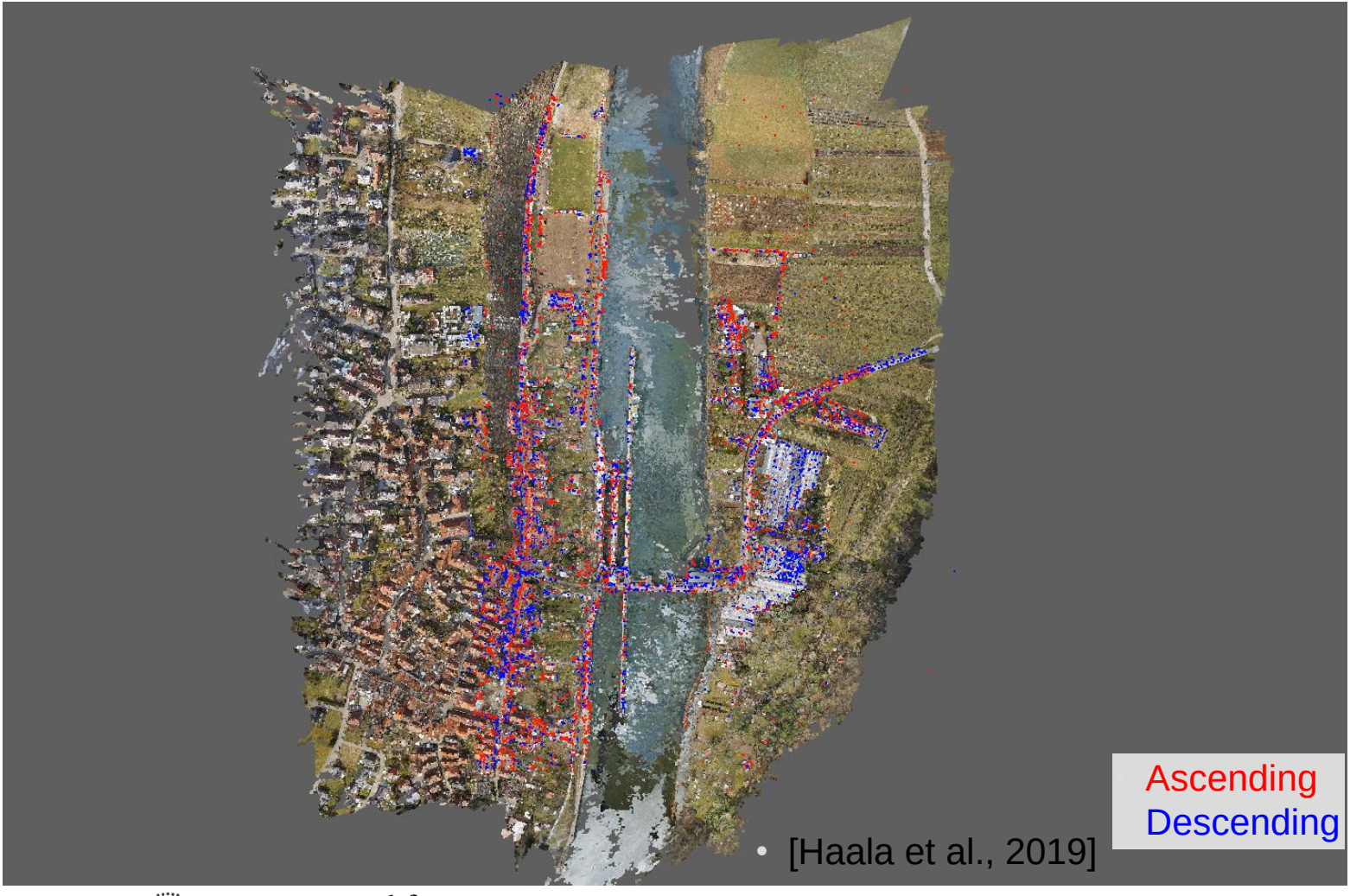


Persistent Scatterers



- [Haala et al., 2019]

Persistent Scatterers



- [Haala et al., 2019]

Decomposition of two-orbit observation

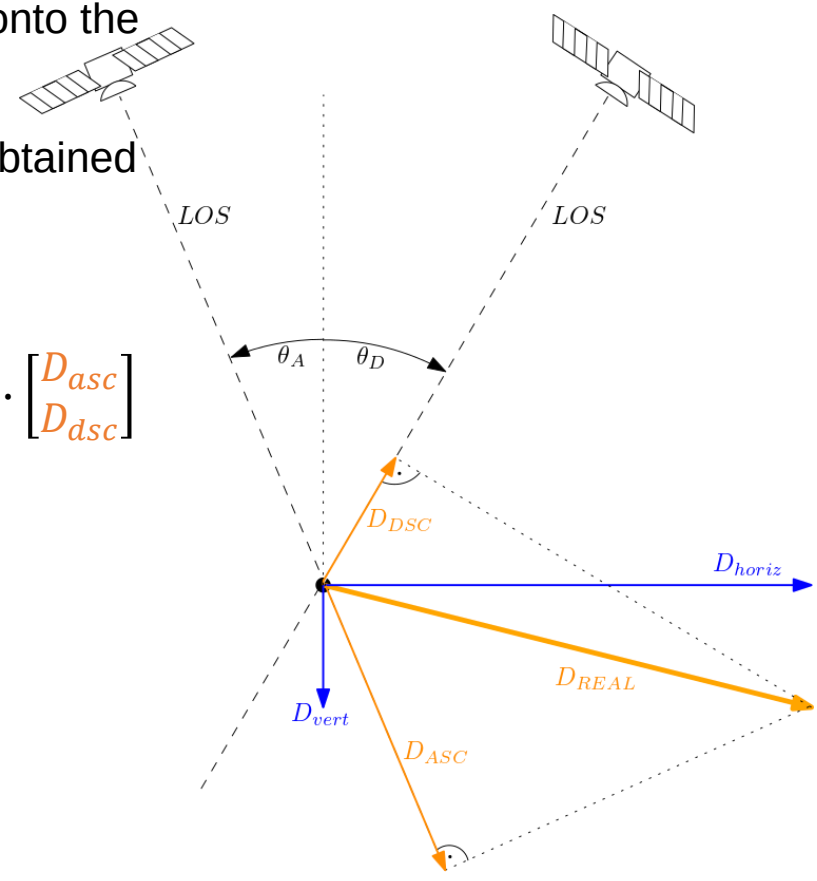
Line-of-Sight (LOS) geometry

The deformation D_{real} get projected onto the line-of-sight direction: D_{asc}, D_{dsc}.

The D_h and D_v components can be obtained by solving:

$$\begin{bmatrix} D_v \\ D_h \end{bmatrix} = \begin{bmatrix} -\cos\theta_A & -\sin\theta_A \cdot \cos\alpha_A \\ -\cos\theta_D & -\sin\theta_D \cdot \cos\alpha_D \end{bmatrix} \cdot \begin{bmatrix} D_{asc} \\ D_{dsc} \end{bmatrix}$$

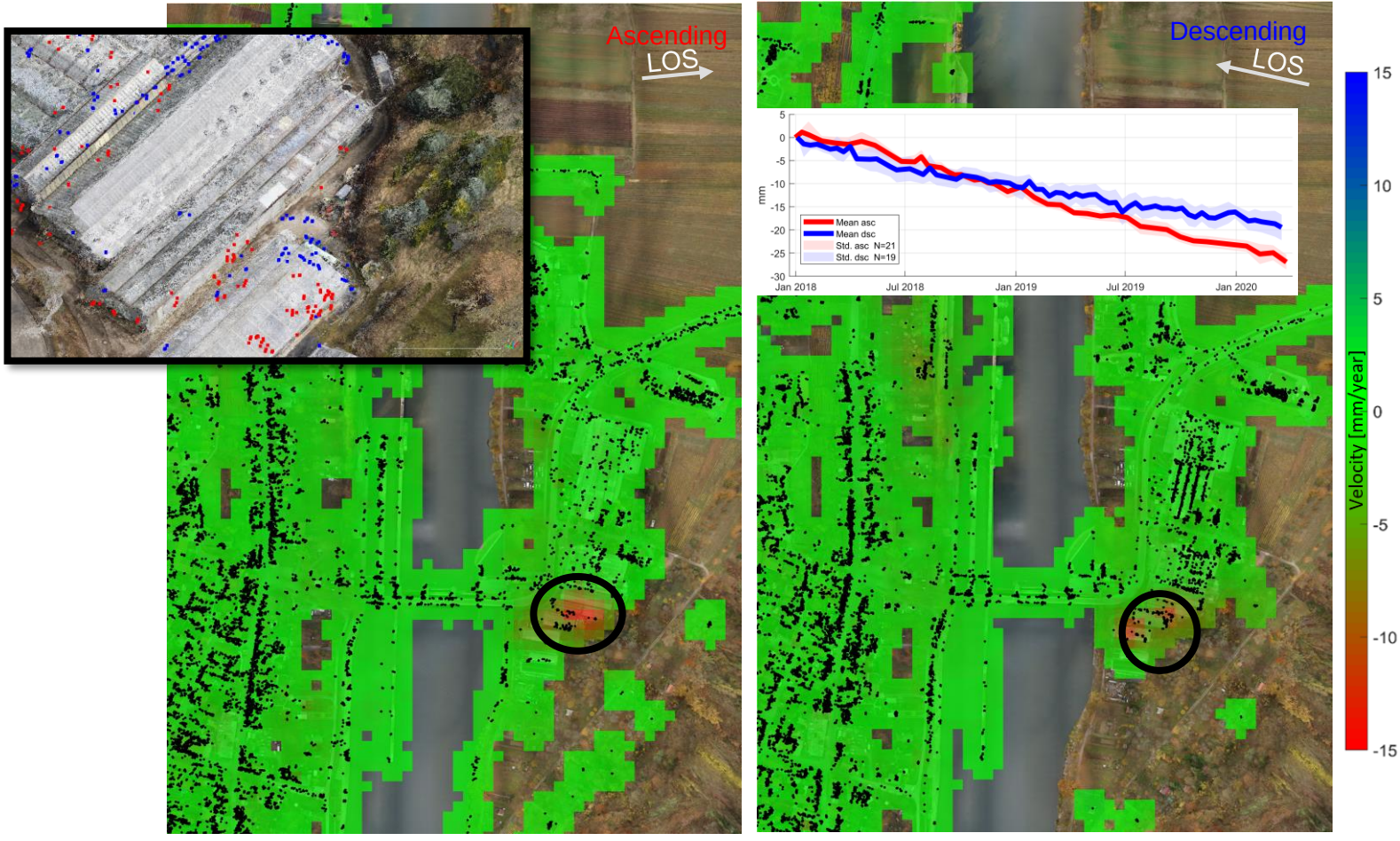
- α : Azimuth (north heading)



[O. Mora et al. 2016]

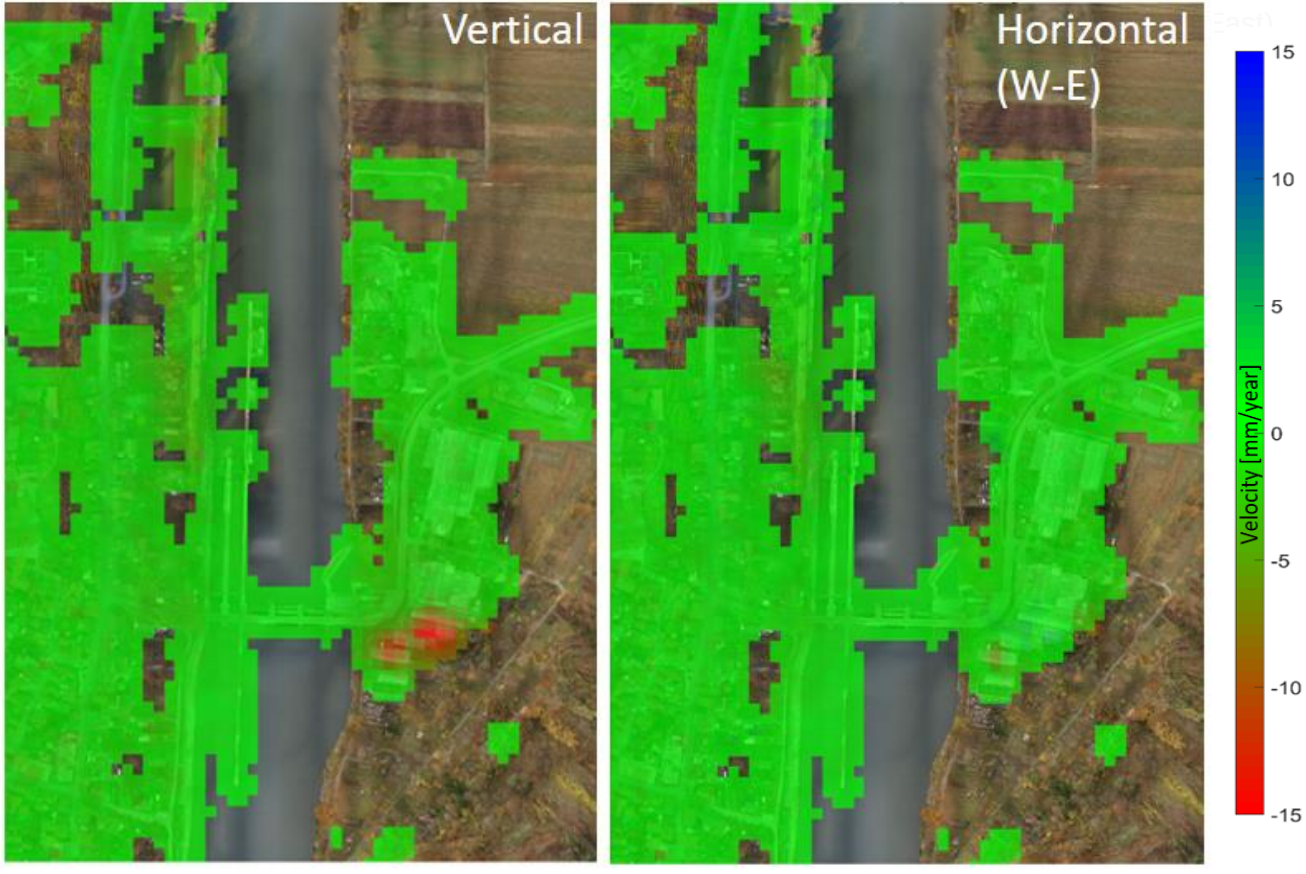
Persistent Scatterers

Results



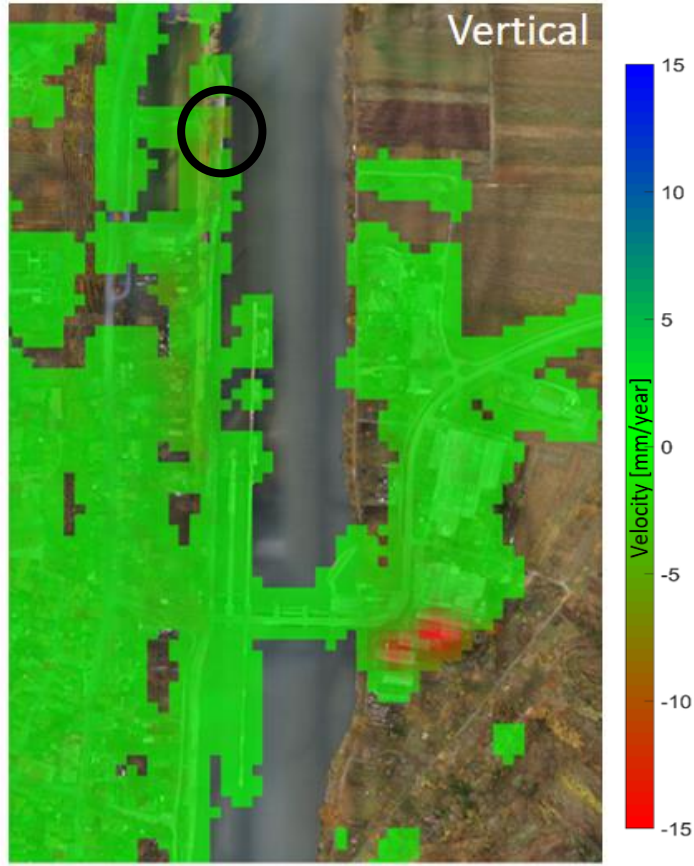
Decomposition of two-orbit observation

Results



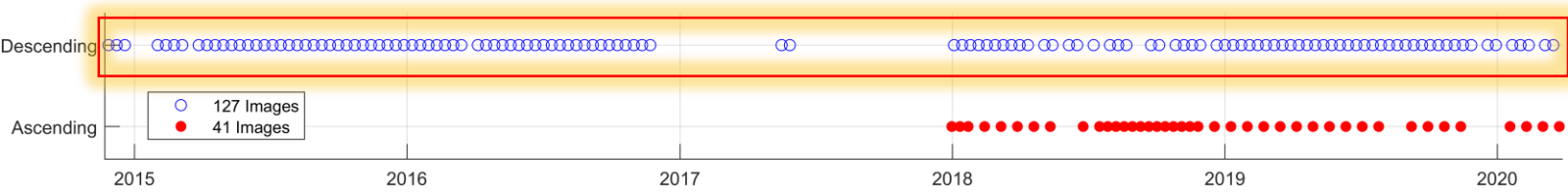
Decomposition of two-orbit observation

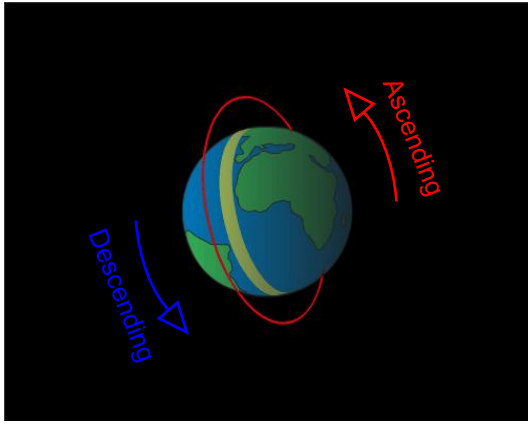
Results



Multiannual time-series

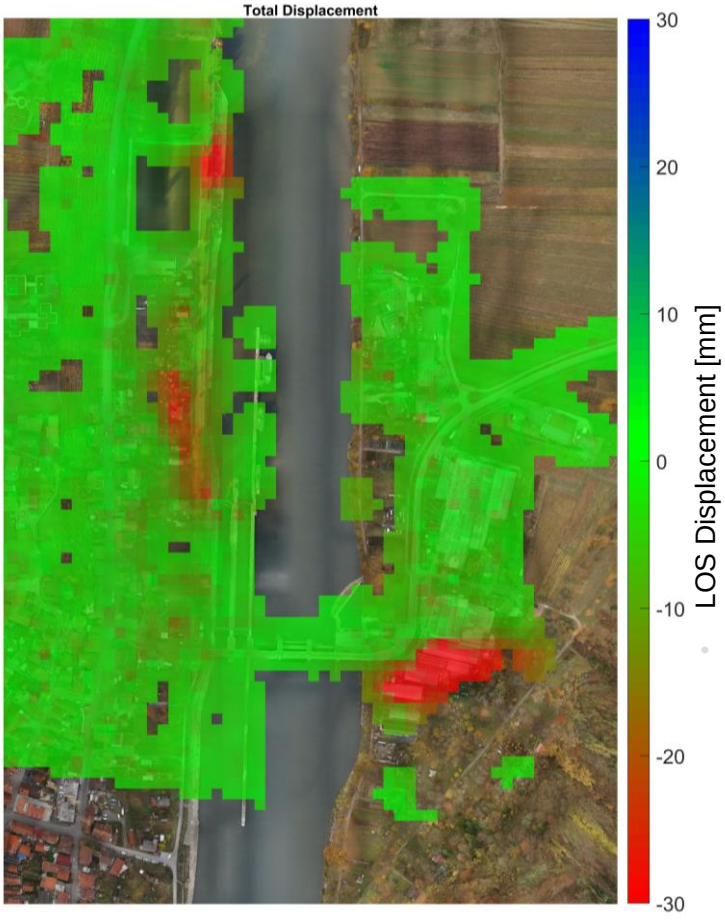
Previous data





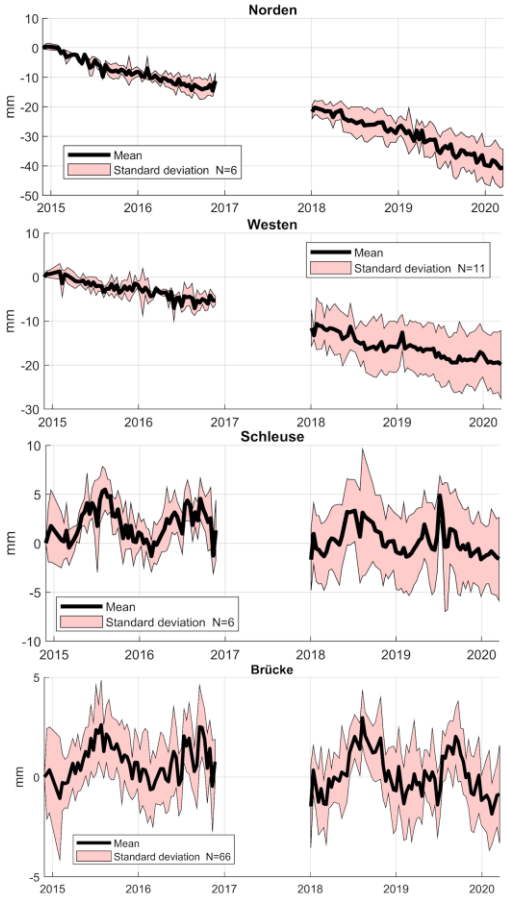
Multiannual time-series

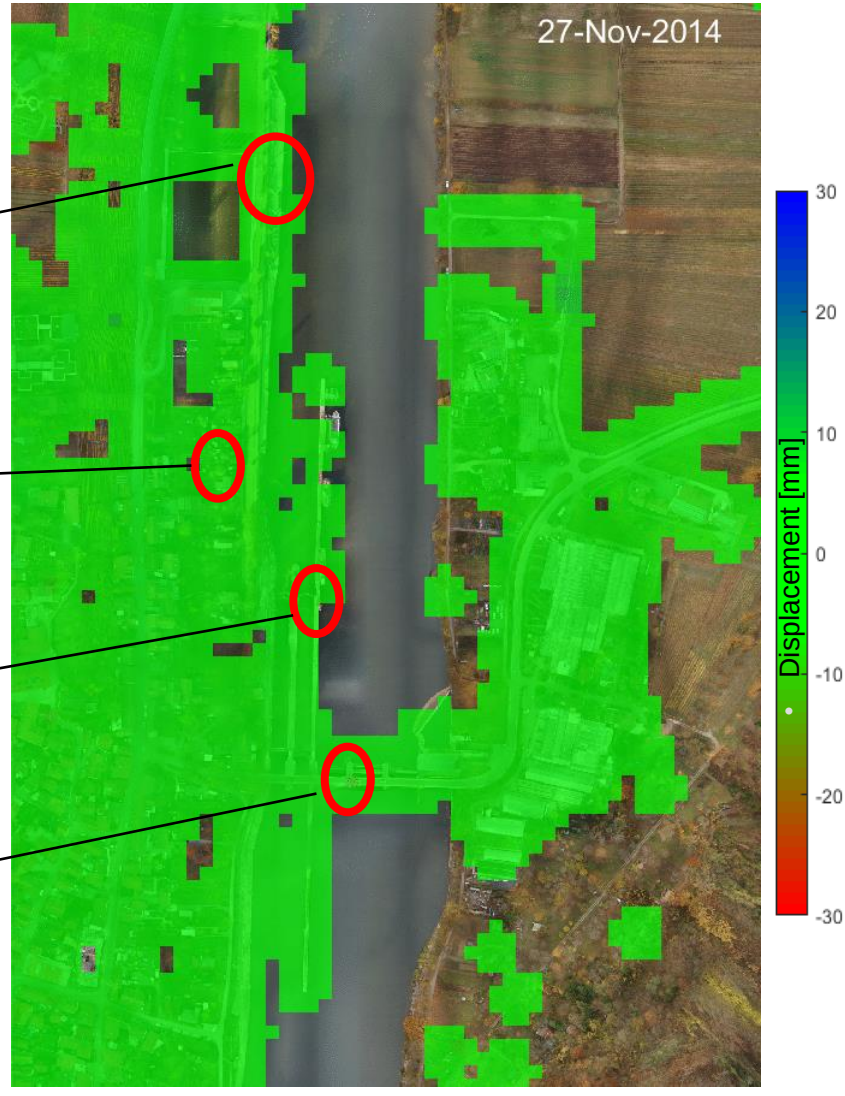
Results



Multiannual time-series

Results





[Schneider & Soergel, 2020]

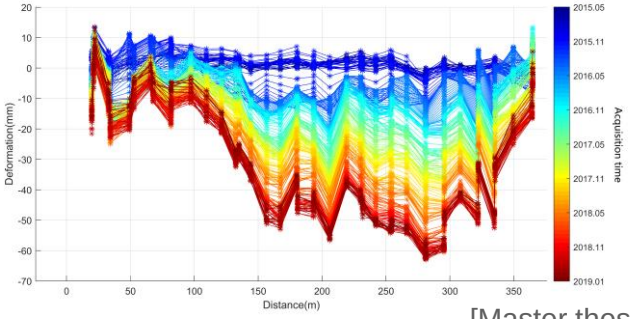
Recap

- DInSAR is a valuable technique for geodetic building monitoring
- It can not replace traditional methods (leveling etc.), but can help **to plan and evaluate** such methods.
- Its high frequent sampling allows deformation type analysis and can help to track and prove single change events

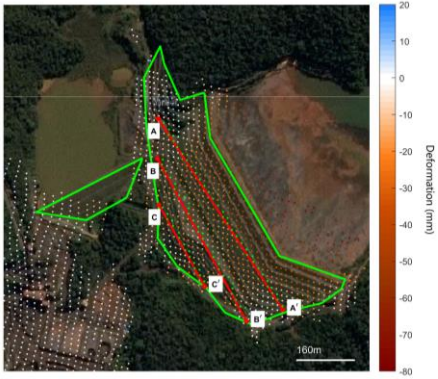
Some things you need to know before getting into PS-InSAR

Data Sources

- High Resolution SAR images are captured on demand.
  - First results will take a year.
  - You might have to pay significantly for this.
  - New private constellations could disrupt this in the future.
- Sentinel-1data is publicly available for free online within 24 hours of observation.
  - First results will take a week.
  - You can „look into the past“ until 2015. Worldwide.
  - Allows you to observe earthquakes, volcano activity and landslides.



[Master thesis @ifp]



Some things you need to know before getting into PS-InSAR

Choose your Software:

- ENVI SARscape (Commercial)
  - All in one
  - Pricy and partly black box
- StaMPS/MIT (free under MIT License)
  - Requires several preprocessing steps.
- GAMMA (Commercial)
- InSAR as a service
  - Several companies provide complete analysis pipeline.

Some things you need to know before getting into PS-InSAR

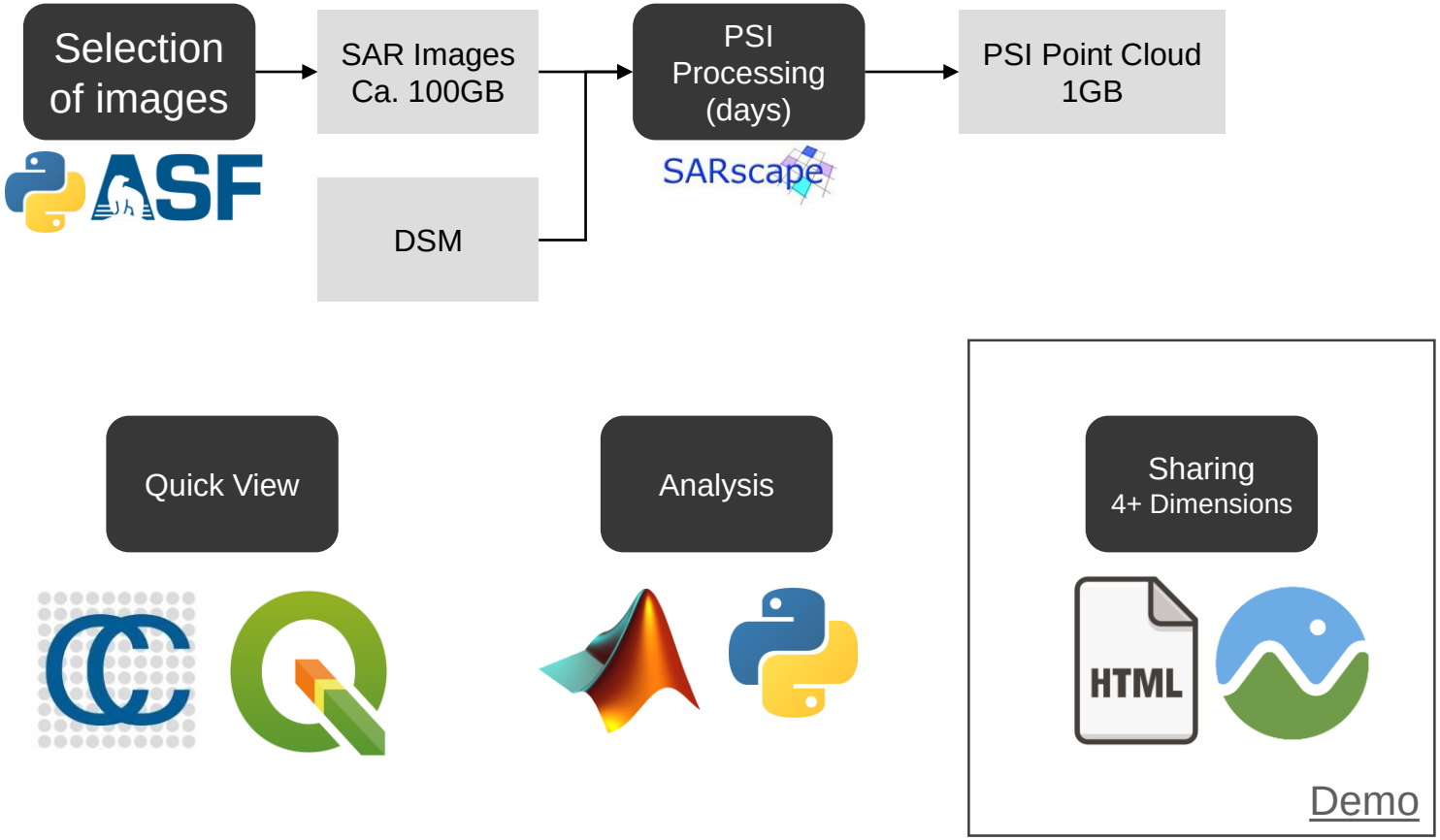
- Nationwide PSI analysis exists.
  - BodenBewegungsDienst Deutschland
  - Also Italy, Netherlands, UK

Nutzung von PSI-Daten zur Erfassung von Bodenbewegungen in Niedersachsen

Vanessa Koppmann, *LGLN*
Marco Brockmeyer, *LGLN*
Christian Schnack, *LGLN*
Cord-Hinrich Jahn, Dr.-Ing., *LGLN*
Hamza Alkhatib, Dr.-Ing. habil., *Leibniz Universität Hannover*
Ingo Neumann, Prof. Dr., *Leibniz Universität Hannover*
05. März 2021 | 13:15 Uhr

Some things you need to know before getting into PS-InSAR

An exemplary pipeline



Vielen Dank!

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References

KAUTHER, R., & WOLF, C. : Detection of Cavities in Karst Subsoil Affecting Civil Engineering. IFMGM (2018), 89-93

KAUTHER, R., & SCHULZE, R. Detection of subsidence affecting civil engineering structures by using satellite InSAR. Proceedings of the Ninth Symposium on Field Measurements in Geomechanics, Australian Centre for Geomechanics (2015), 207-218.

FERRETTI, A., PRATI, C., and ROCCA, F. Permanent scatterers in SAR interferometry. IEEE Transactions on Geoscience and Remote Sensing 39, 1 (2001), 8–20.

MORA, O., ORDOQUI, P., IGLESIAS, R., BLANCO, P., 2016. Earthquake rapid mapping using ascending and descending Sentinel-1 TOPSAR interferograms. Conference on ENTERprise Information Systems 2016.

SCHNEIDER,P., SOERGEL U., 2020. Monitoring einer Schleuse mittels Persistent-Scatterer-Interferometrie. Allgemeine Vermessungsnachrichten avn Ausgabe 03/2020.

FRANZIUS, L., 1990. Verpressungen durch Gipsauslagerungen bedingter Hohlräume im Untergrund der Staustufe Hessigheim/Neckar.

HAALA, N., MANDLBURGER, G., CRAMER, M., LAUPHEIMER, D., KÖLLE, M., 2019. Kombinierte Analyse hochpräziser Punktwolken aus UAV-Photogrammetrie und -Laserscanning im Hinblick auf Setzungsmessungen. 20. Internationale Geodätische Woche Obergurgl 2019