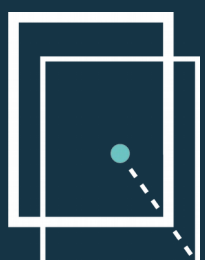


M Ű E G Y E T E M 1 7 8 2

Regional scale monitoring results of surface deformation in the Transcarpathian Region

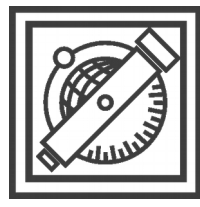
Presenter: Balint Magyar^{[1][2]}

Co-author: Roland Horvath^[2]



**[1] Budapest University of Technology and Economics - Faculty of Civil Engineering -
Department of Geodesy and Surveying
[2] Lechner Nonprofit Ltd. - Satellite Geodetic Observatory**

**In: EGU 2022 Session NH6.5: EGU22-9443
2022.05.26. 09:39 (CEST)
APC, Vienna, Austria**

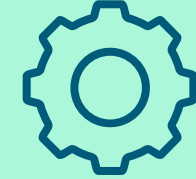


CONTENT



GEOSSES

Project description
Area of Interests



INSAR

Materials
Applied workflow



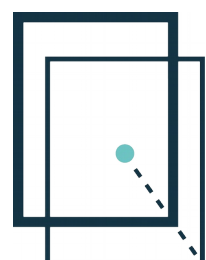
RESULTS

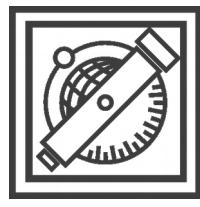
Deformation map
WebViewer



OUTLOOK

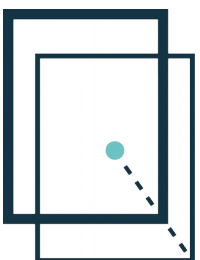
Upgrades
Discussion

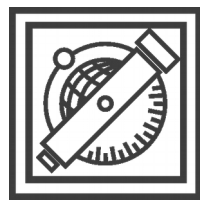




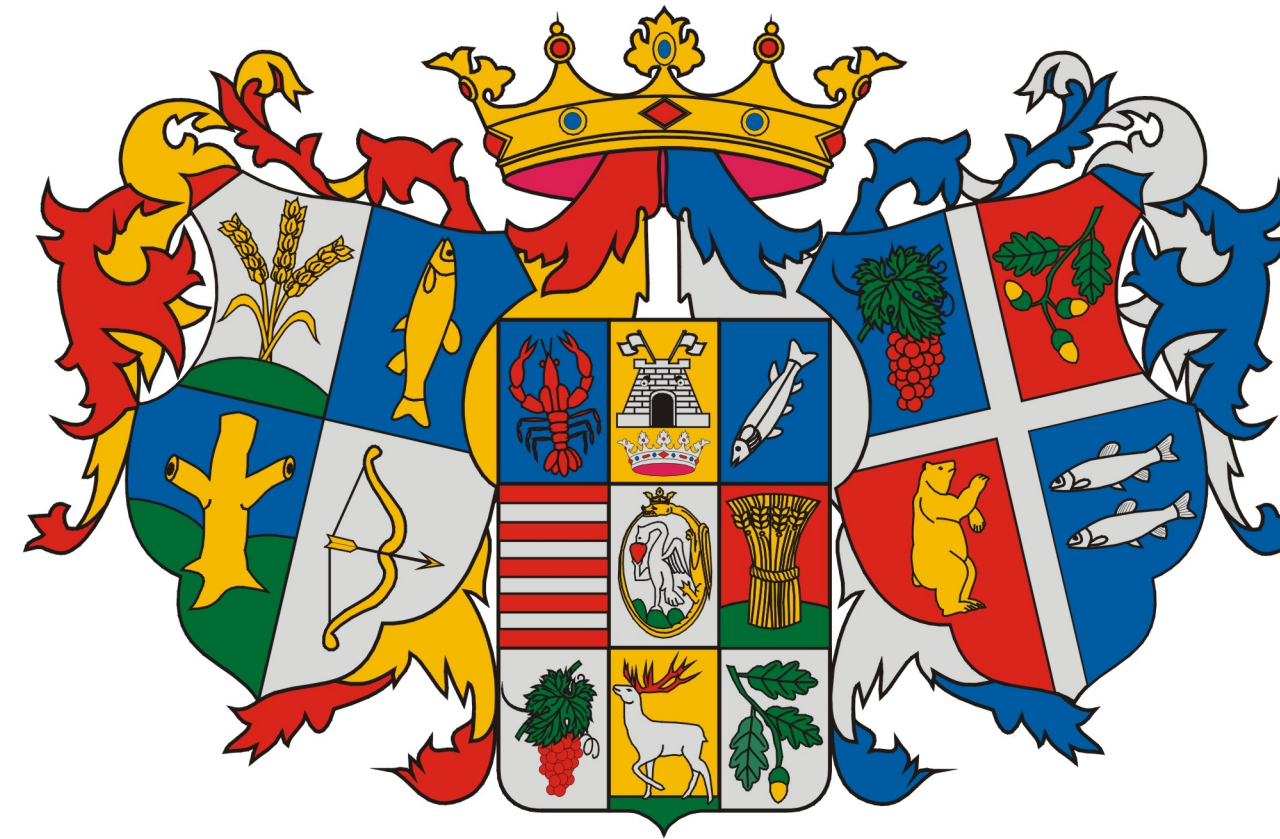
GEOSSES PROJECT

Project description and Area of Interests





GeoSES Partners



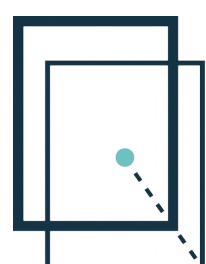
Hungary
Slovakia
Romania
Ukraine

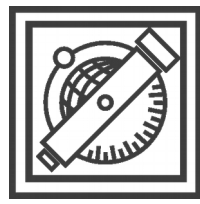


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GeoSES Objectives

Dedication

- ENI Cross-border Cooperation Programme 2014-2021
- Extension of the operational Space Emergency System

Partners

- Hungary: Self Government of SZSZB County / BME (+LTK)
- Slovakia (UPJS), Romania (UTC-N) , Ukraine (UZHNU - lead)

Specified objectives

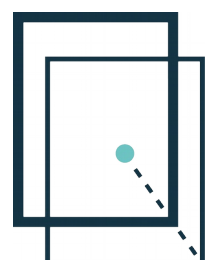
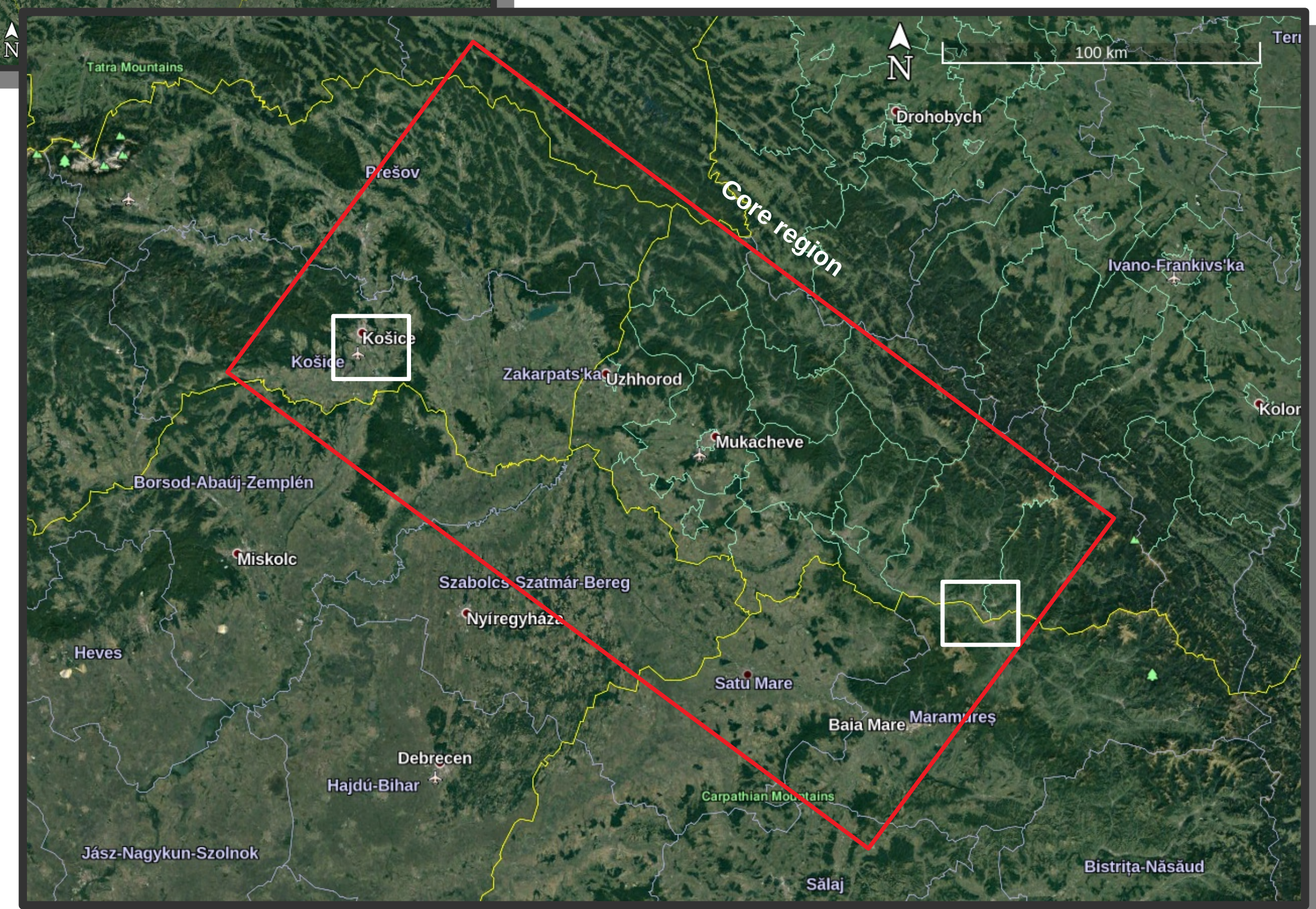
- Monitoring natural and anthropogenic geo-processes
- Integration innovative and advanced techniques, including EO with InSAR

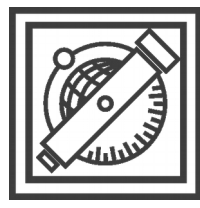
InSAR specific roles AG 1.

- Processing chain development and PSI analysis (AOIs – Requests of Partners', preliminary, core region)
- Deformation map and database

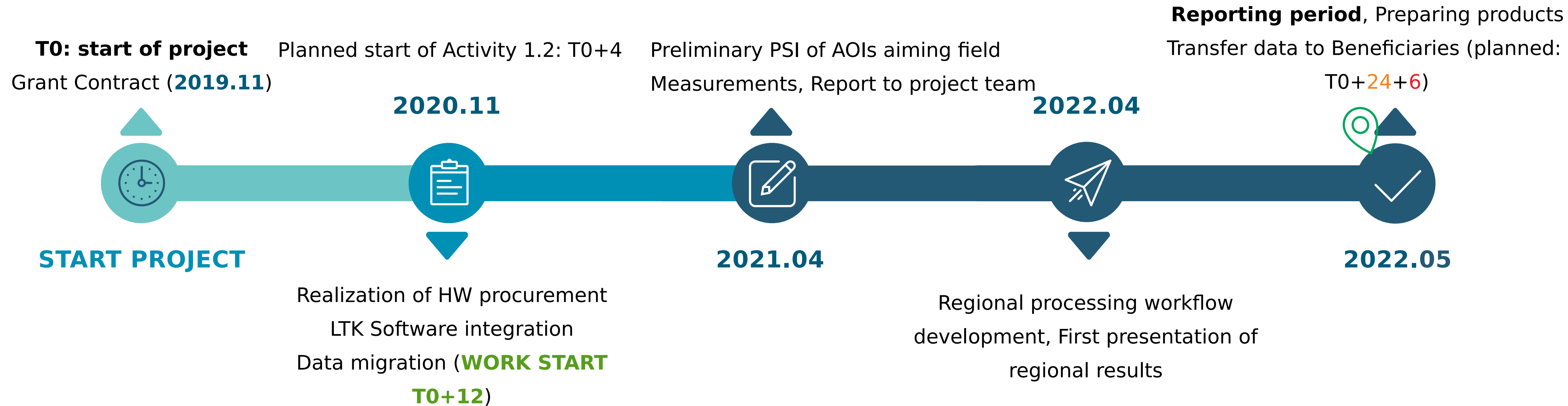


**GeoSES -
HUSKROUA/1702/8.1/0065**

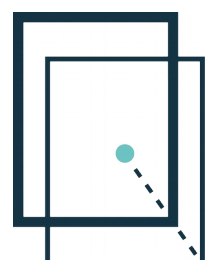


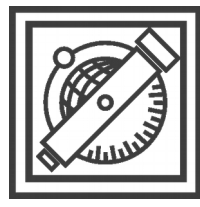


GeoSES Project: InSAR Timeline



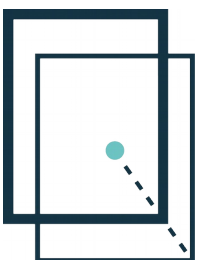
NOTE: HW procurement delays and Covid19 situation results to project extension (~6 months), some delay due to technical (HW+SW+WF) problems

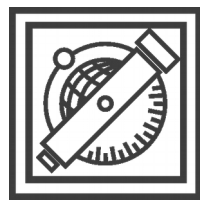




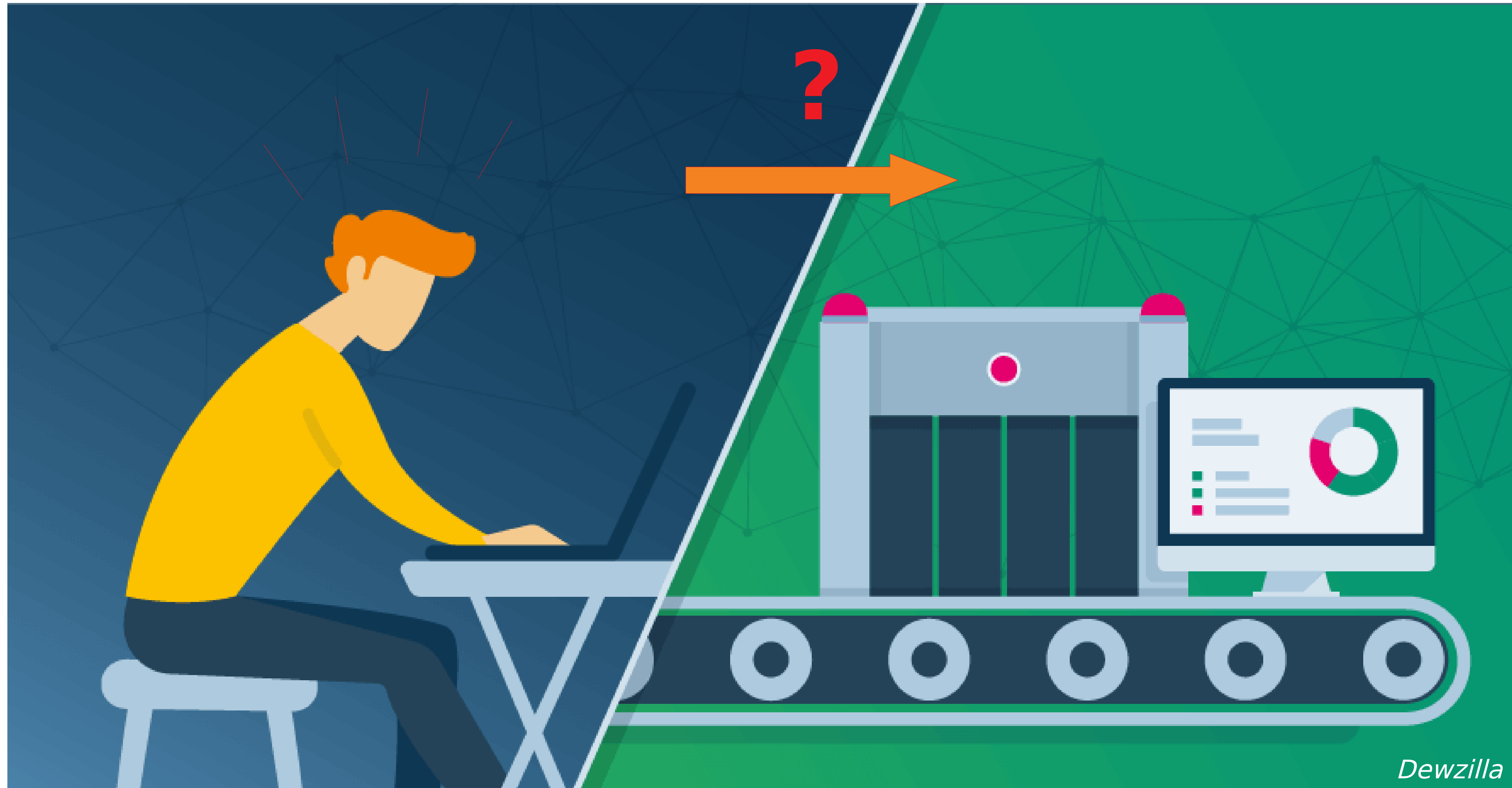
INSAR WORKFLOW

Materials and Applied Workflow

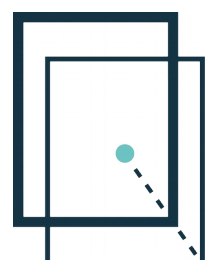


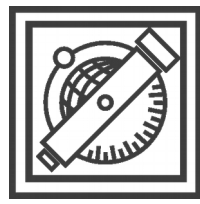


From manual to automated:

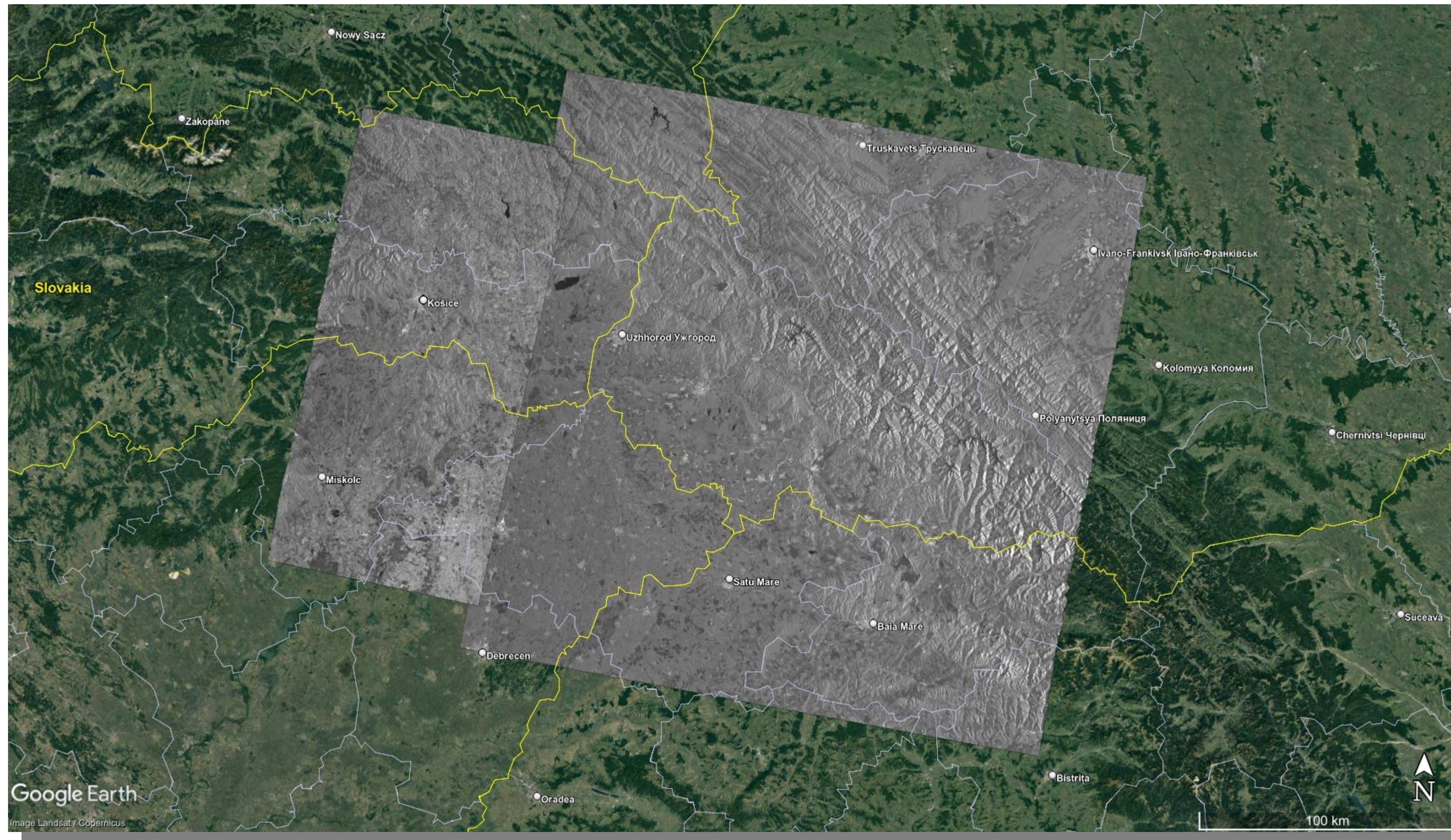


Dewzilla





Area of Interest - SAR RMLI



Core Area

- Transcarpathia (UKR)
- E-Slovakia (SLO)
- NW-Romania (ROM)
- NE-Hungary (HUN)

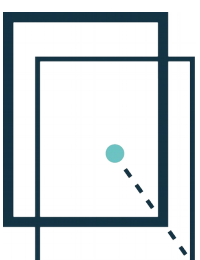
Characteristics

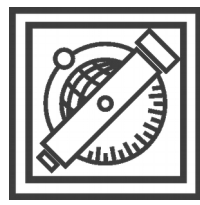
- Area: $\sim 60\,000\text{ km}^2$
- Timespan: 2014-2021
- **>460 diff int / ROI**
- Single-look phases

RONs

- DESC 153
- DESC 080

GOAL:
Obtain LOS & U-D
components





Input data and management

SAR Level-1 SLC products

- Interferometric researches requires SLC products
- Copernicus SchiHub (archive data on request)
- Alaska Satellite Facility (ASF) – **quick access**



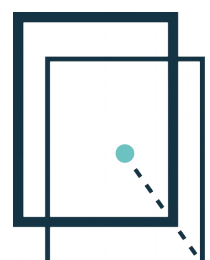
Auxiliary data

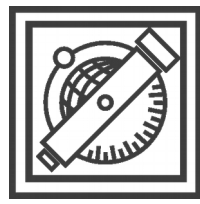
- Digital Elevation Model (DEM) 1 arcsec
- Precise orbit data
- Ground Control Points, AOI metadata



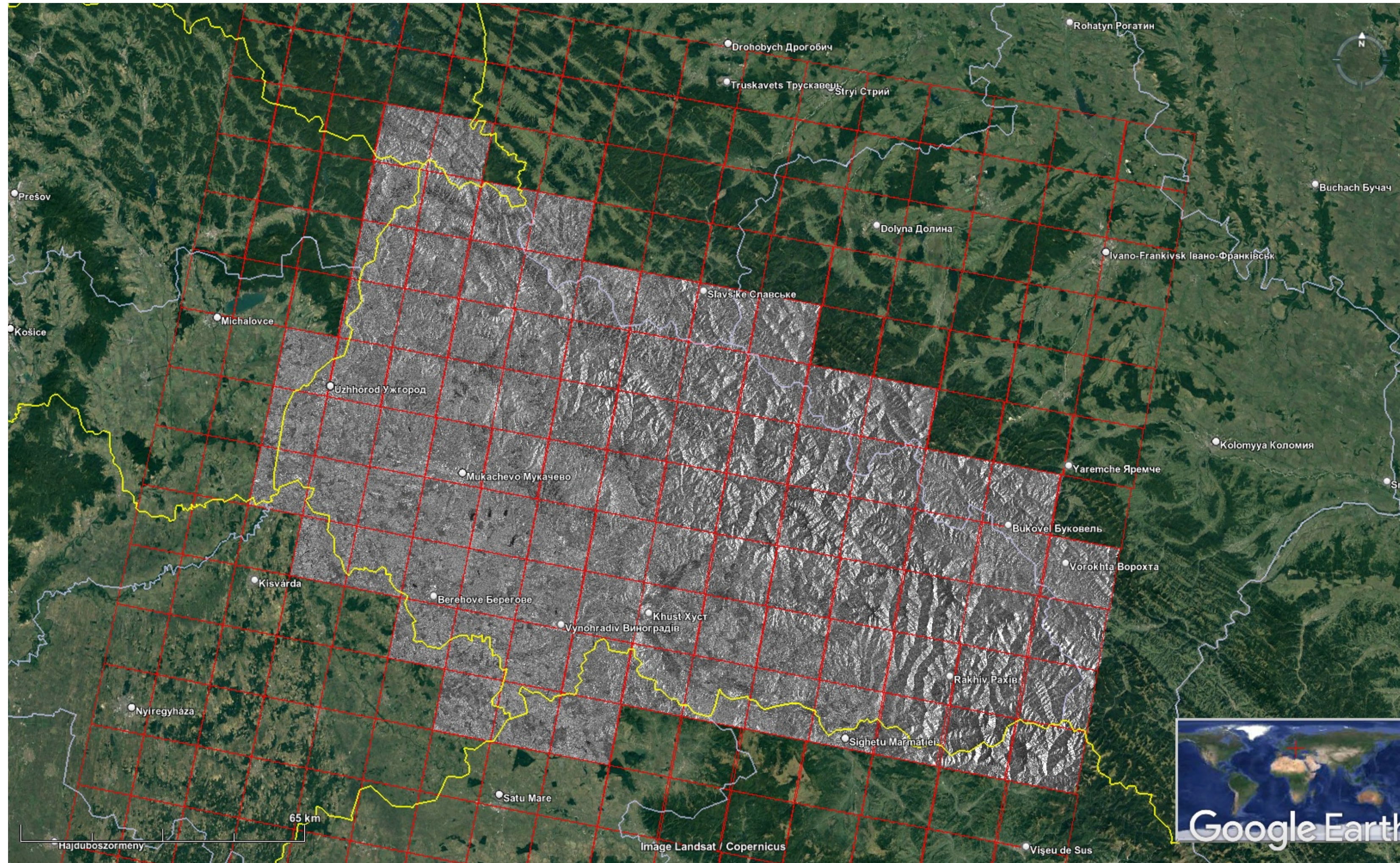
Softwares

- GAMMA Remote Sensing (all modules)
- ANACONDA + required packages
- PC: Ubuntu 18.04, SERVER: DEBIAN 10





Tiling of AOs



Tile Characteristics

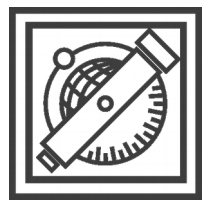
- D080 Stack is tiled to 256 imgs
- D153 Stack is tiled to 78 imgs
- approx 160km² tiles

Full Frame Operations

- Preprocessing steps: noise Filtering, precise orbit addition
- initial geocoding
- iterative coregistration
- deramping and oversampling (~1 week, 32 CPU, 64 GB RAM)

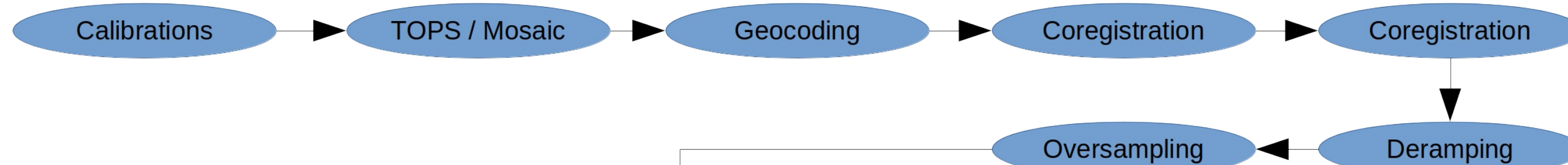
Tile Operations

- PSC eval, IPTA, multi/single-ref
- deriving LOS and UP (~2 days, 32 CPU, 64 GB RAM)

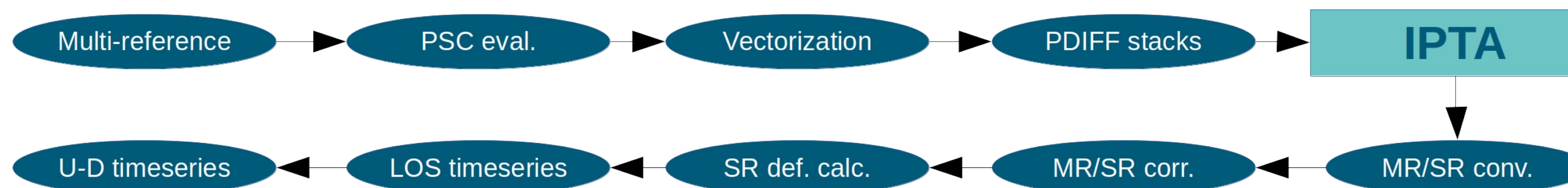


Automated workflow (MultiRef)

Preprocessing



IPTA processing

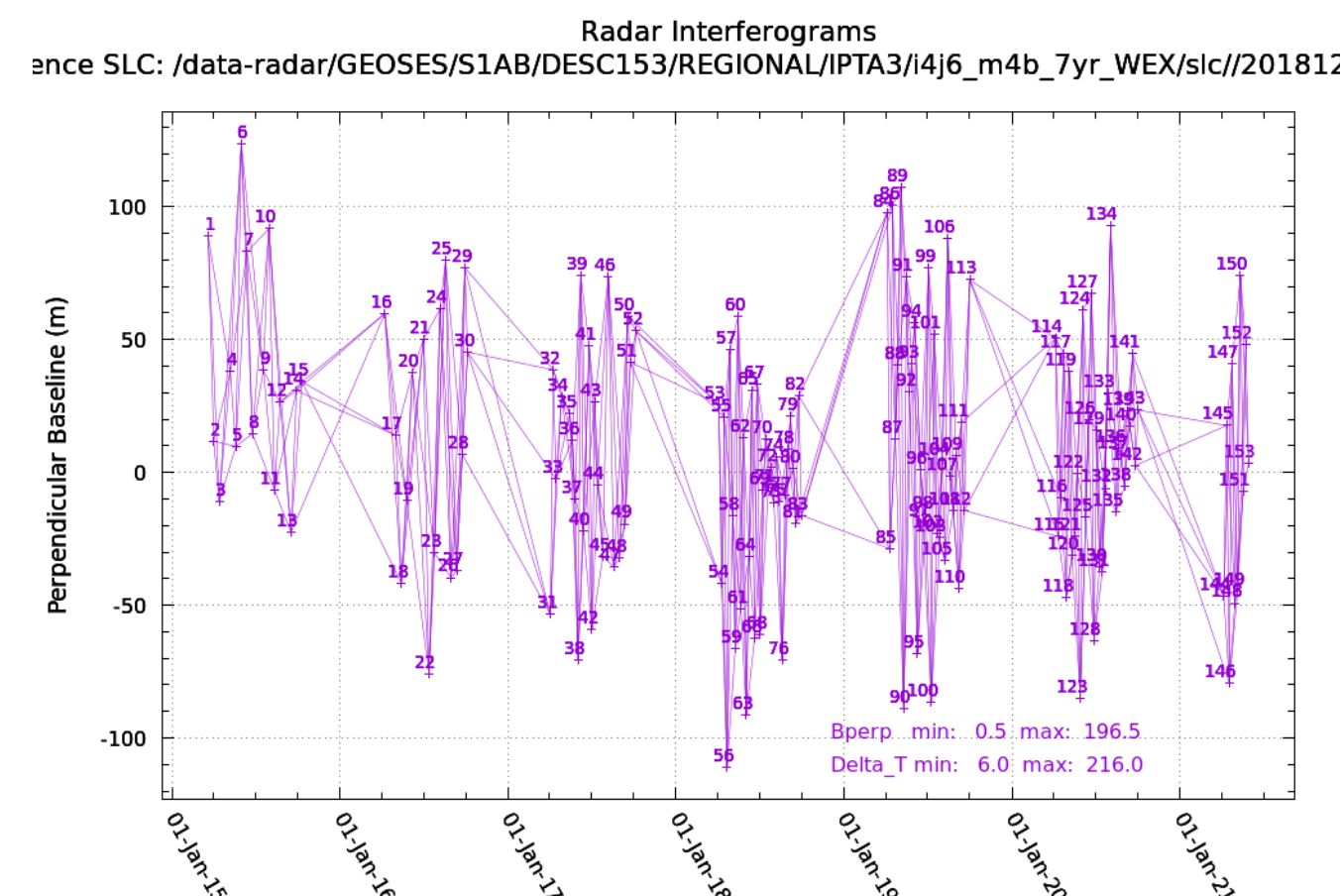
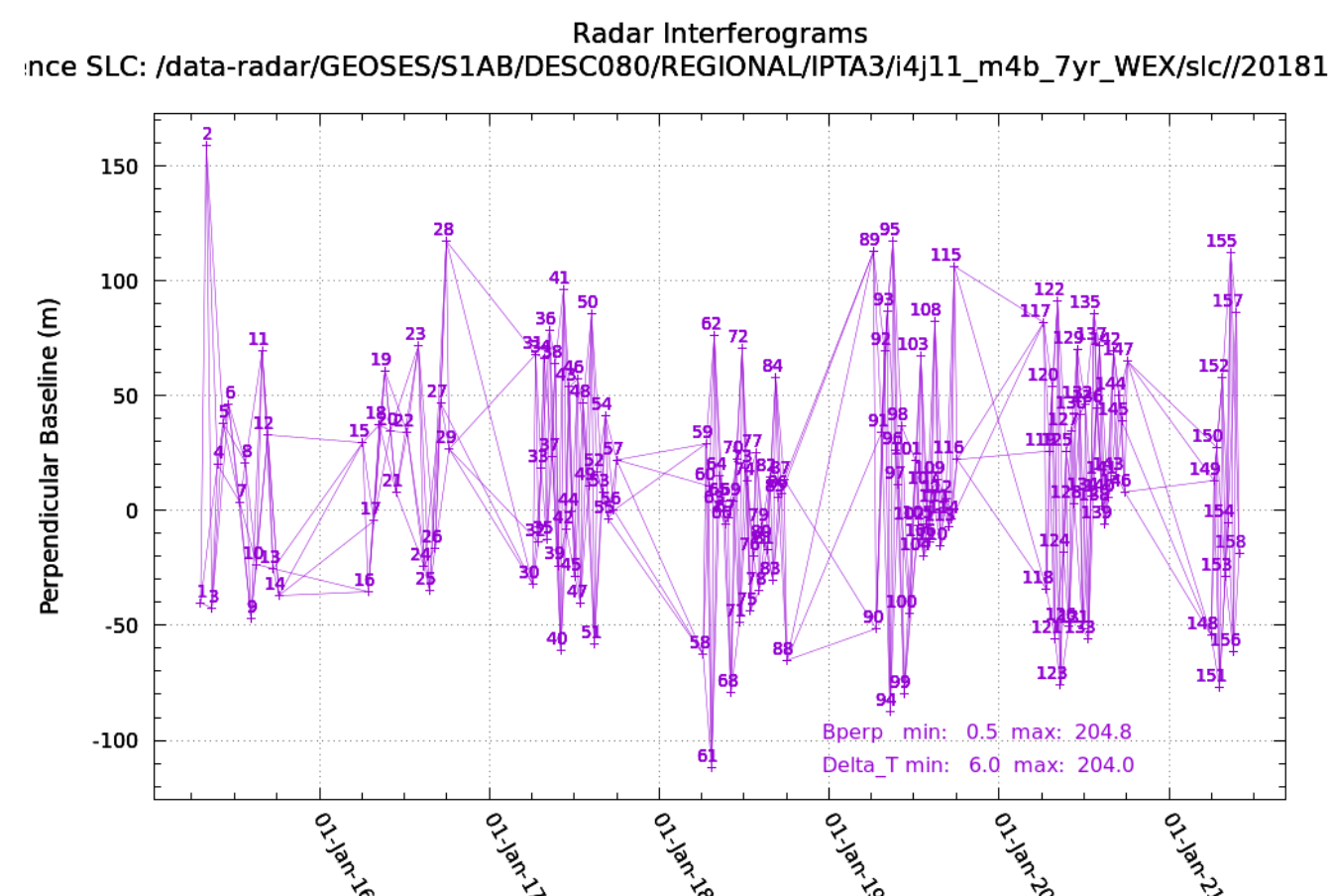


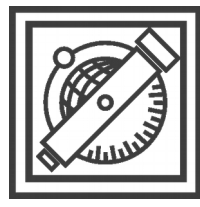
IPTA data and processing characteristics

- Regional scale processing of HUSKROUA
- Sentinel 1A and Sentinel 1B
- 158 acquisitions / RON
- Bperp < 250m, 6 days interval,
- Single look phases (SL) and Vector format
- Multi-reference stack (>460 diff intf.)
- No reduced point list application
- Automatically selected SRP
- Unwrapping strategy (1D + 2D correction)
- Unwrapping error mitigation: rewrap/filt/MCF
- Applied high-level strategy:

1. Height correction based on multi-ref
2. APS (1.8 km) estimation based on mr
3. Conversion of multi-ref to single-ref
4. Derive LOS and UP deformation

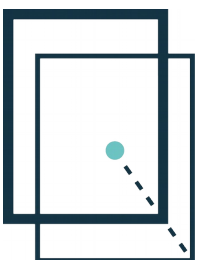
- Adequate for uniform and non-uniform defs.
- Temporally smooth deformation assumed
- Snow strategy: exclude October-April data
- No temperature dependent phase correction
- No temporary and redundant point strategy

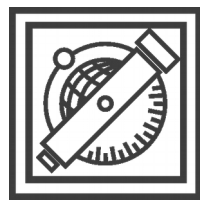




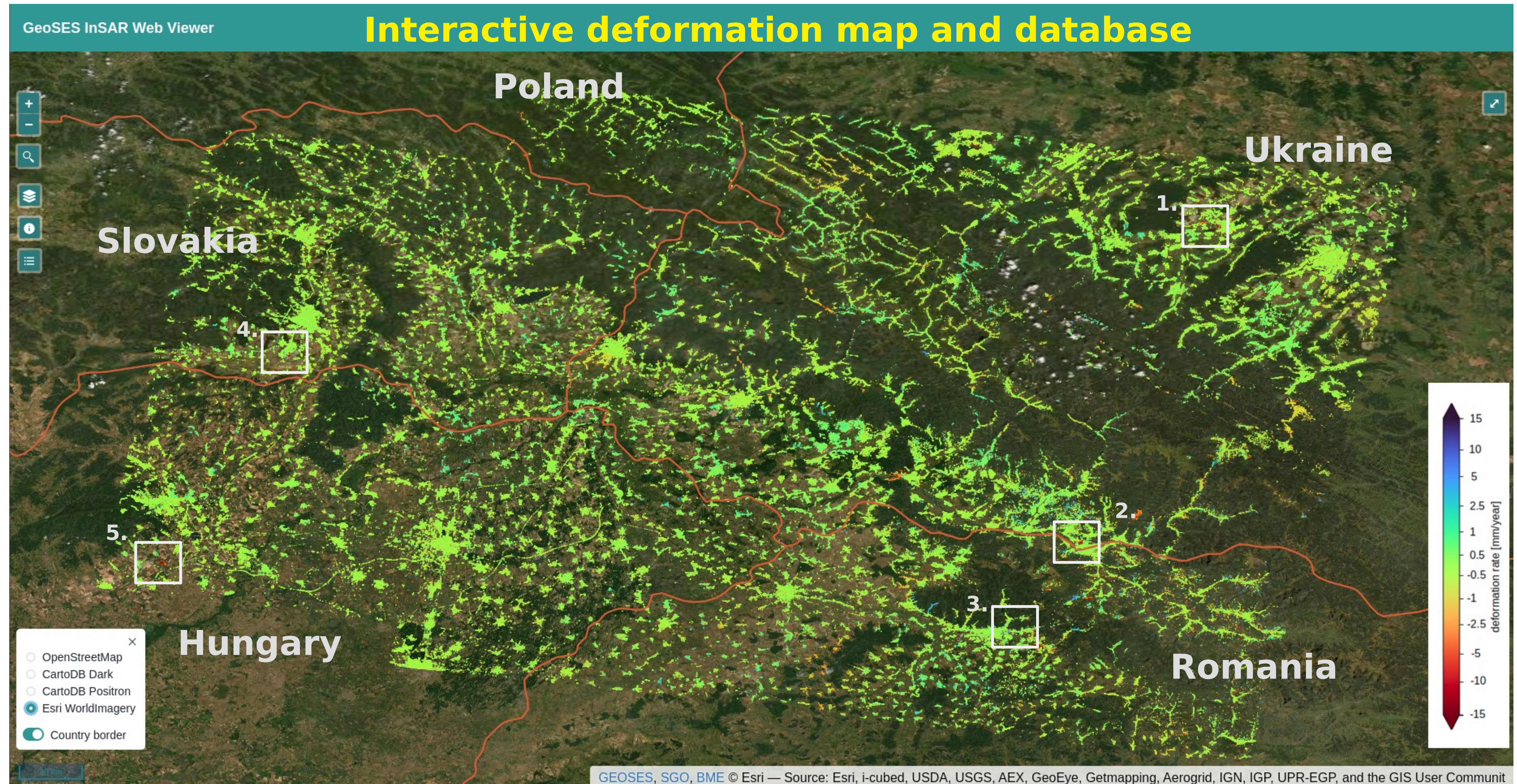
Results

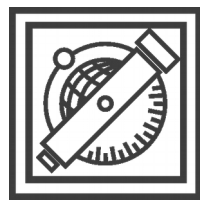
Deformation map and WebViewer



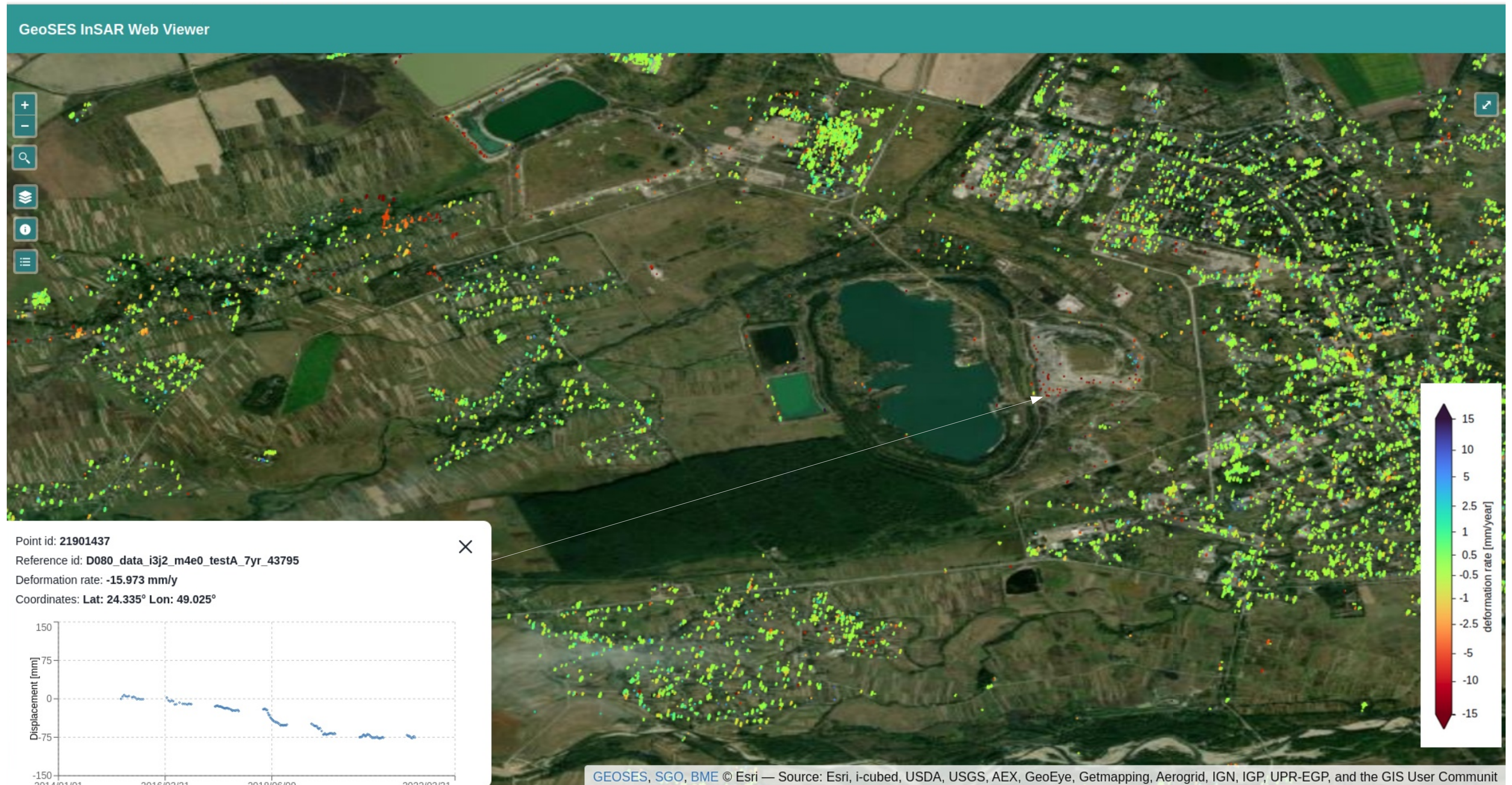


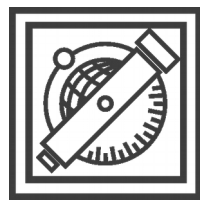
GeoSES Interactive InSAR WebViewer



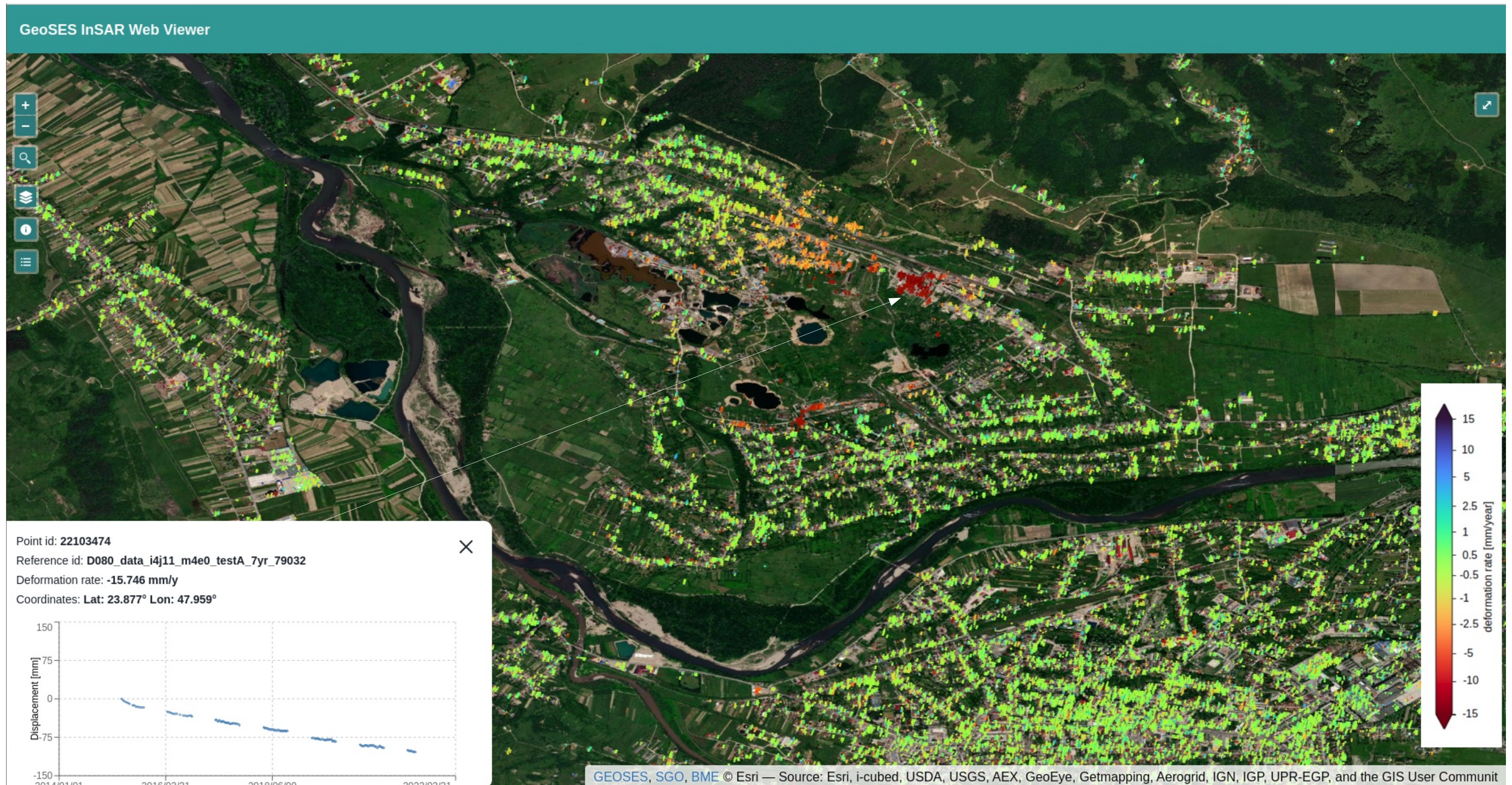


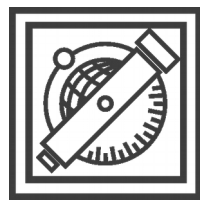
Highlighted Results 1. - Kalush (UKR)



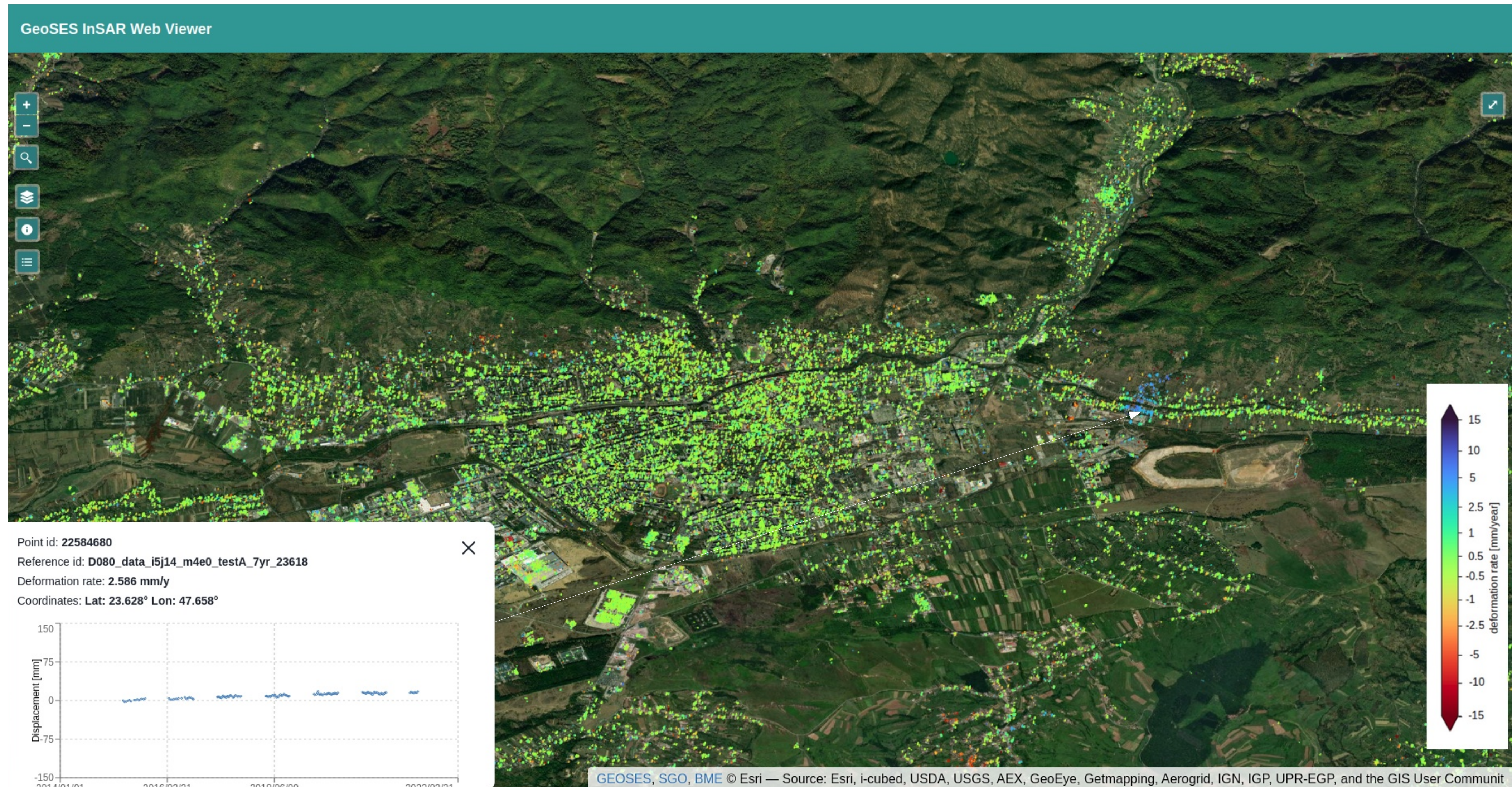


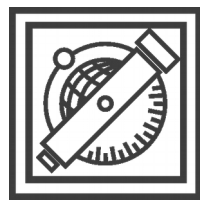
Highlighted Results 2. - Solotvyno (UKR)





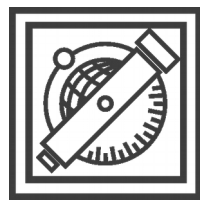
Highlighted Results 3. - Baia Mare (ROM)



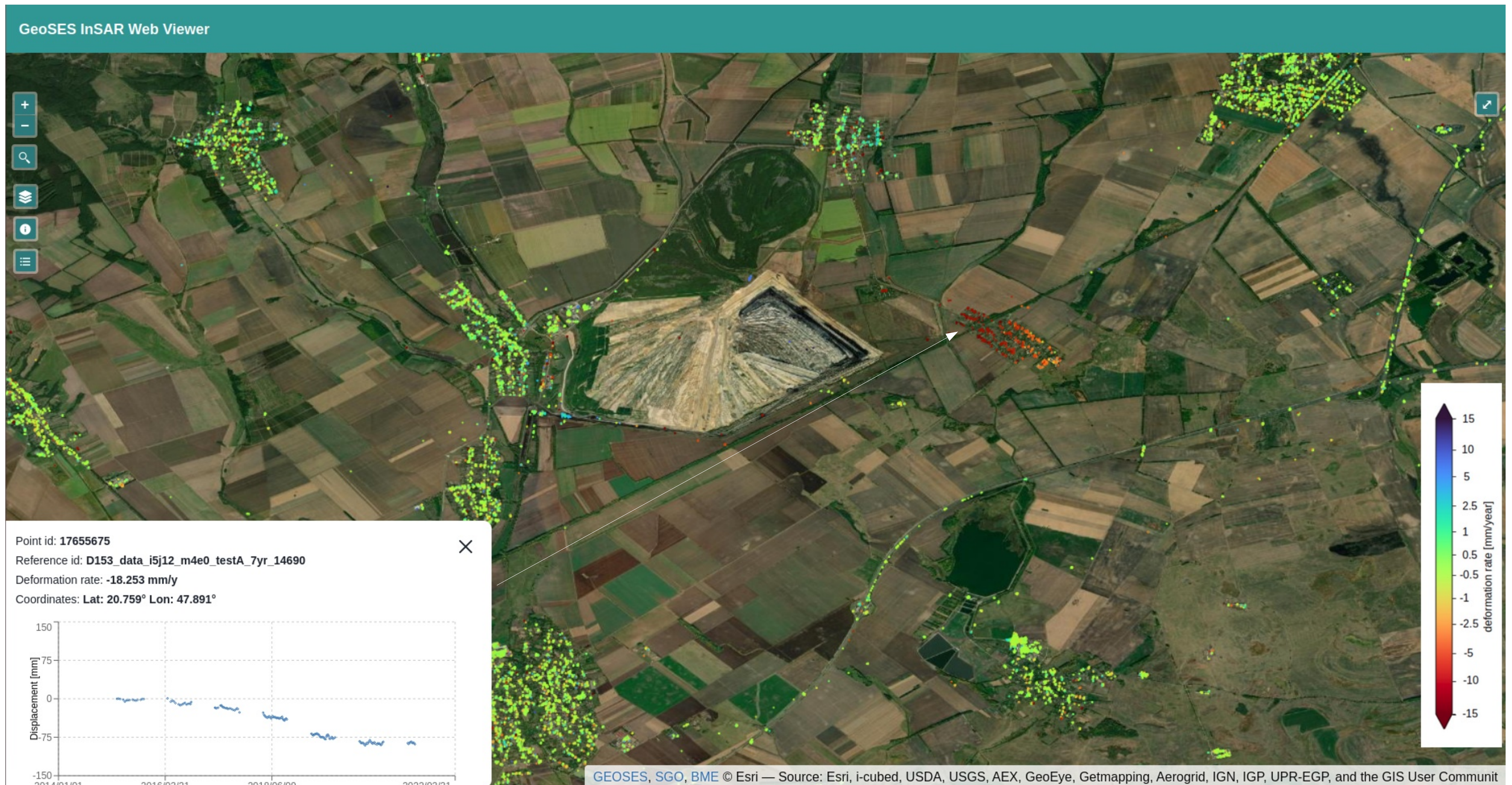


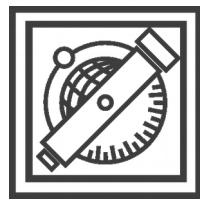
Highlighted Results 4. - Velka Ida (SLO)





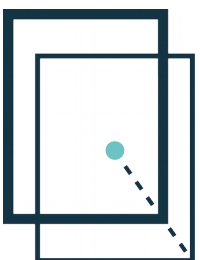
Highlighted Results 5. - Csincse (HUN)

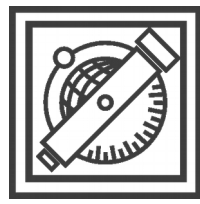




Outlook

Upgrades and discusssion





Discussion

Single-phase and multi-reference regional PSI analysis were performed in the HUSKROUA Region
Related automated processing workflows have been presented

Output products: descending LOS deformation and converted vertical displacement time series

InSAR related Activity Group outputs and result are finalized. All products and documentation will be reported until **end of May of 2022**

WebViewer serves as **Deformation Map and Database** to disseminate (public) and distribute results within and out of the GeoSES project.

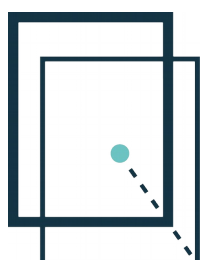
All data/database are located in BME-AFGT GeoSES Server (physically located in SGO). All processed data/database are available on request.

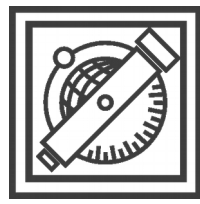
Planned and scheduled updates in the next 2 years.

Further development directions

Increase spatial density of PS points, involve SBAS points, test statistical homogeneity based approaches, integrate ZTD data etc.

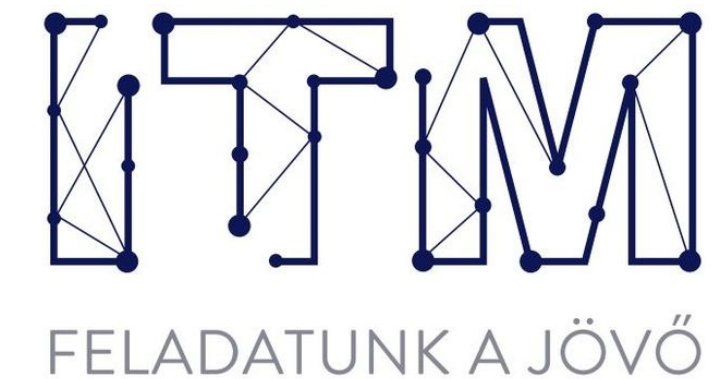
Further expansion of features and user privileges of the introduced WebViewer





Acknowledgment

Prepared with the professional support of the Doctoral Student Scholarship Program of the Co-operative Doctoral Program of the Ministry for Innovation and Technology from the source of the National Research, Development and Innovation Fund.



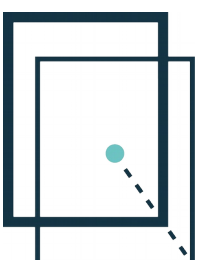
This research was co-financed by the HUSKROUA ENI CBC 2014-2020 Programme and it directly linked to the HUSKROUA/1702/8.1/0065 GeoSES project.

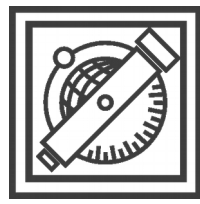


Thank you for the technology and software related consultancies and insights for Urs Wegmüller

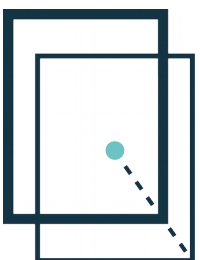


Thank you for the research related consultancies for Lajos Völgyesi^[2], Szabolcs Rózsa^[2], Béla Paláncz^[2] and Ambrus Kenyeres^[1]





Discussion: Q&A





Thank you for your attention!

Contacts



Balint Magyar



00 36 27 200 802

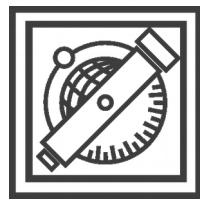


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www.sgo-penc.hu





References

- [1] Alaska Satellite Facility DAAC: <https://asf.alaska.edu/data-sets/sar-data-sets/sentinel-1/>
- [2] Boncori, M. J. P. "Measuring Coseismic Deformation With Spaceborne Synthetic Aperture Radar: A Review." *Frontiers in Earth Science*, Volume 7:16, 2019, doi: 10.3389/feart.2019.00016
- [3] Costantini, M. (1998) A novel phase unwrapping method based on network programming, *IEEE Transactions on Geoscience and Remote Sensing*, 36(3), pp. 813-821, May 1998, doi: 10.1109/36.673674
- [4] Ferretti, A., Prati, C. and Rocca, F. (2001) "Permanent scatterers in SAR interferometry," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 39, no. 1, pp. 8-20, Jan. 2001
- [5] Frey, O., Santoro, M., Werner, C.L., Wegmüller, U. "DEM-based SAR pixel-area estimation for enhanced geocoding refinement and radiometric normalization", *IEEE Geoscience and Remote Sensing Letters*, Volume 10, pp:48-52, 2012, doi: 10.1109/LGRS.2012.2192093
- [6] Goldstein, R.M., Zebker, H.A., Werner, C.L. "Satellite radar interferometry: two-dimensional phase unwrapping." *Radio Science*, Vol. 23, pp. 713-720. 1988
- [7] Goldstein, R.M., Werner, C.L. "Radar interferogram filtering for geophysical applications", *Geophysical Research Letters*, Vol. 25, No. 21, Pages 4035-4038., 1998
- [8] Hanssen, R., Teunissen, P., Joosten, P. "Phase Ambiguity Resolution For Stacked Radar Interferometric Data." *Mathematical Geodesy and Positioning*, Delft University of Technology, 2001
- [9] Magnard, C. & Wegmüller, U., Werner, C. (2021). Persistent Scatterer Interferometry in mountainous areas: advantages of working in map geometry. *Procedia Computer Science*. 181. 10.1016/j.procs.2021.01.123.
- [10] Magyar, B., Horváth, R., Völgyesi, L. (2021). Regional scale monitoring of surface deformation in Transcarpathia using InSAR technology. *Scientific Bulletin Series D : Mining, Mineral Processing, Non-Ferrous Metallurgy, Geology and Environmental Engineering*, 35(2), 59-67.
- [11] Pepe, A., Caló, F. "A Review of Interferometric Synthetic Aperture RADAR (InSAR) Multi-Track Approaches for the Retrieval of Earth's Surface Displacements.", *Applied Sciences*, Volume 7, pp: 1264; 2017, doi:10.3390/app7121264
- [12] Sentinel-1 Product Specification [S1PRD] ESA, available at: <https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-1-sar/products-algorithms>
- [13] Sentinels POD Product Handbook [S1POD] (2020) ESA, available at <https://sentinel.esa.int/documents/247904/3372484/Sentinels-POD-Product-Handbook.pdf>
- [14] Scheiber, R., Moreira, A. "Coregistration of Interferometric SAR Images Using Spectral Diversity." *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 38, No. 5, pp: 2179-2191, 2000
- [15] Shuttle Radar Topography Mission 1 Arc-Second Global (SRTM) DOI: number: /10.5066/F7PR7TFT
- [16] Werner C, Wegmüller U, Strozzi T and Wiesmann A (2003). "Interferometric point target analysis for deformation mapping". *Proceedings of IGARSS 2003*, 4362-4364.
- [17] Wegmüller U et al (2016) Sentinel-1 Support in the GAMMA Software, *Procedia Computer Science*. 100, pp. 1305-1312. doi: 10.1016/j.procs.2016.09.246
- [18] Werner, C., Wegmüller, U., Strozzi, T. "Processing strategies for phase unwrapping for INSAR applications", *Proceedings, EUSAR Conference*, Cologne, Germany, June, 2002
- [19] Xu B et al (2020) Kinematic Coregistration of Sentinel-1 TOPSAR Images Based on Sequential Least Squares Adjustment. In *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 13, pp. 3083-3093, 2020, doi: 10.1109/JSTARS.2020.3000043.
- [20] Yague-Martinez, N., Prats-Iraola, R., Gonzalez, F.R., Brcic, R., Shau, R., Geudtner, D., Eineder, M., Bamler, R. "Interferometric Processing of Sentinel-1 TOPS Data." *IEEE Transactions on Geoscience and Remote Sensing*, 54 (4):2220-2234, 2016, doi: 10.1109/TGRS.2015.2497902

