Ground Deformation from Meteorological, Seismic and Anthropogenic Changes Analysed by Remote Sensing, Geomatic Experiments and Extended Reality (GERMANE)

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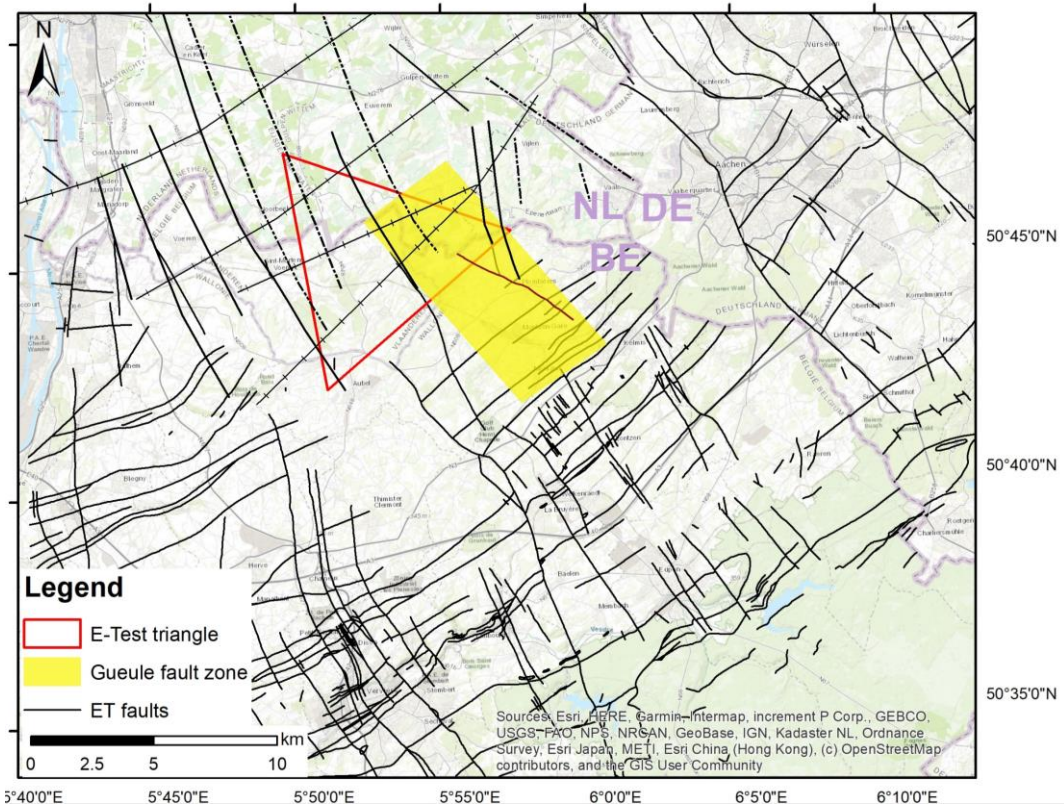
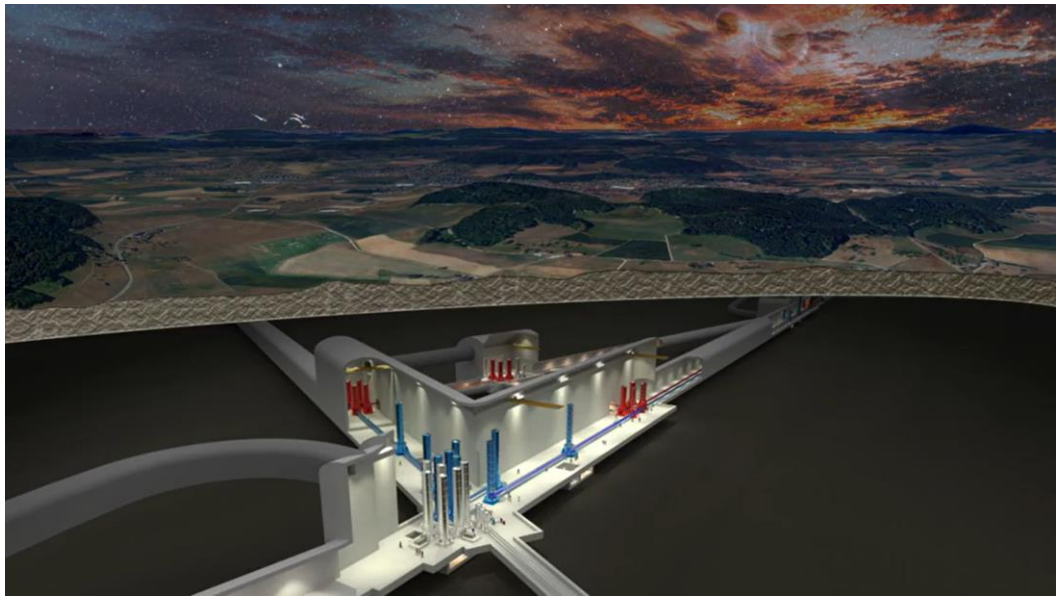
Project achievements for NoR sponsorship, June 2023

The future Einstein telescope

- Studying gravitational waves at 300-m depth requires better understanding of neotectonics, geology and geomorphological processes





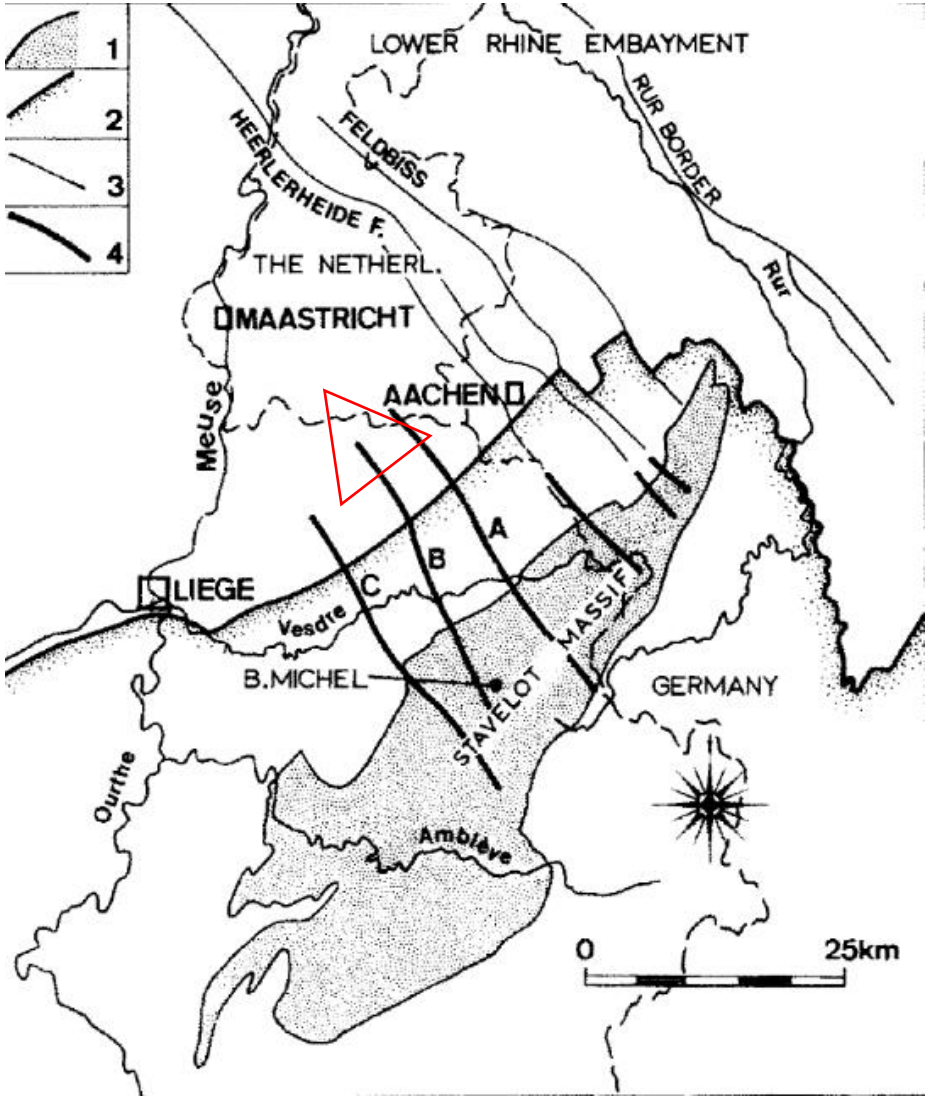
- Possible site: Euregio Meuse-Rhine border region between Belgium, the Netherlands & Germany
- low people/infrastructure density and cutting-edge scientific institutions and companies
- The Interreg project E-TEST (www.etest-emr.eu/) is performing an underground study to map and model the geology of this region while this work focus on Earth surface deformations

Geological context

- Tectonic landforms in Belgium -located in the most seismically active region of stable Europe- are generally modest in stable plate interiors

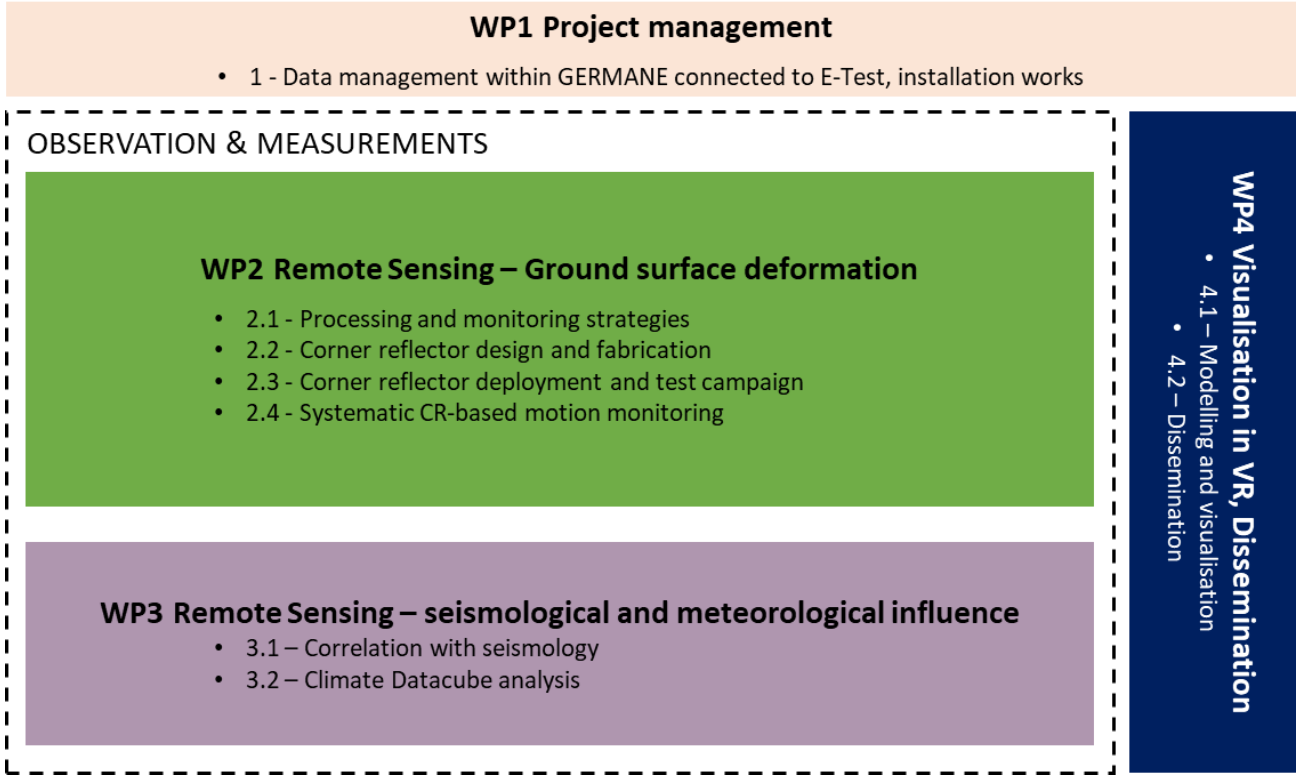
But **major faults** in the western edge of the Ruhr graben, namely the faults of Feldbiss and Heerlerheide

- Three radial-faulting zones are observed in the north of the Pays de Herve (BE):
  - the Eupen faulting zone (A), stretches from the Gueule Valley to Hautes Fagnes crest;
  - the Baelen faulting zone (B), stretching from the Gulp valley in the NW to the Botrange peak of Belgium towards the southeast and;
  - the Hockai faulted zone (C) which forms the western boundary, active in the Neogene and Quaternary, which extends from the Lower Rhine Embayment.



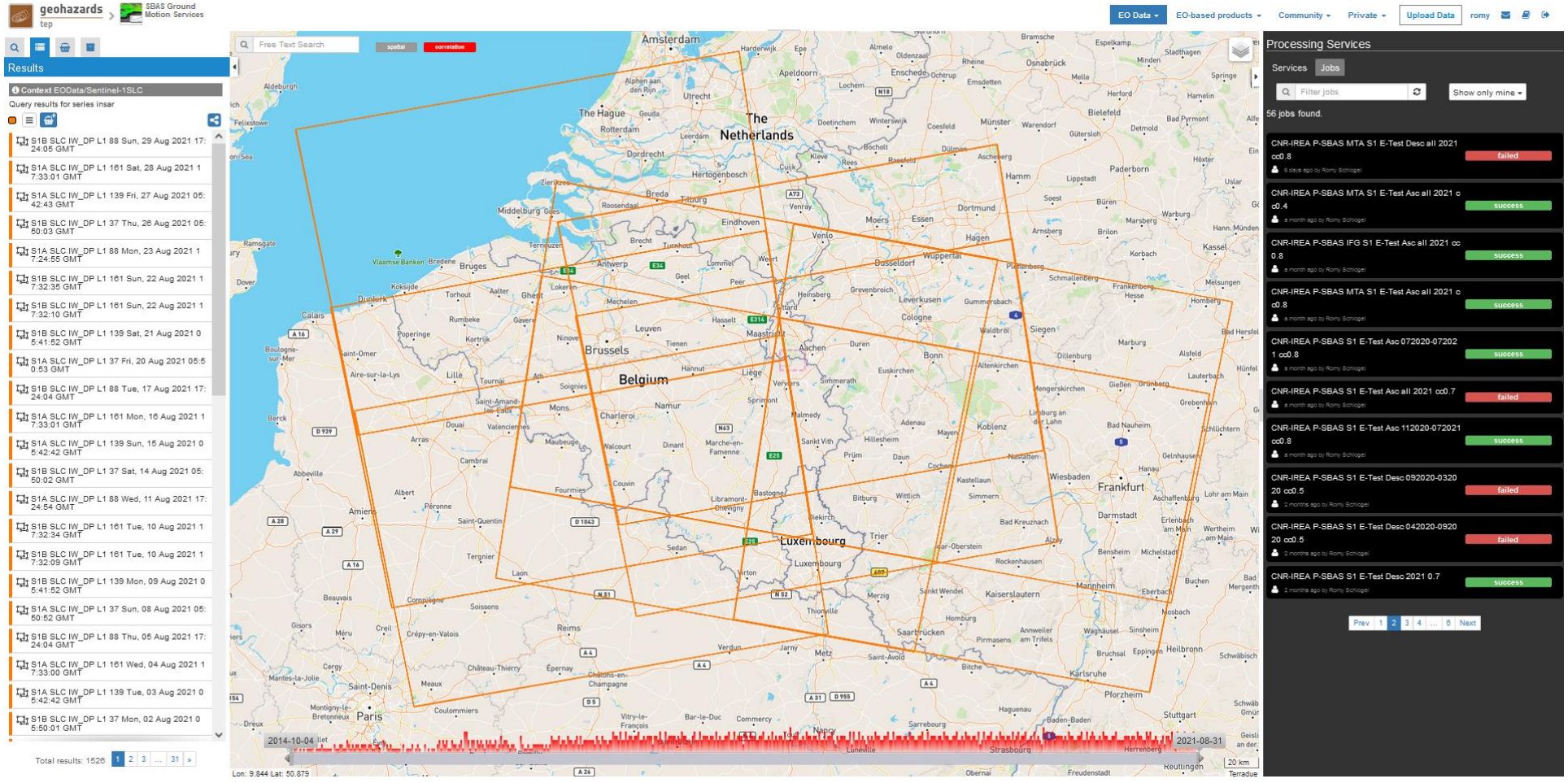
Goal and objectives

- Detect neotectonic and anthropogenic ground displacements using **InSAR** technology in the **BE-NL-DE** transborder area
- Differentiate between **local, regional** ground uplift and **sub-regional** subsidence
- Identify and characterize climatically influenced **faults** and **ground deformation** hazards, using combined geodesy, drone and satellite remote sensing –as well as seismological techniques-
- Integrate into a single model visualized in Extended Reality **(XR)** to understand field deformation according to the geological context



InSAR Methods

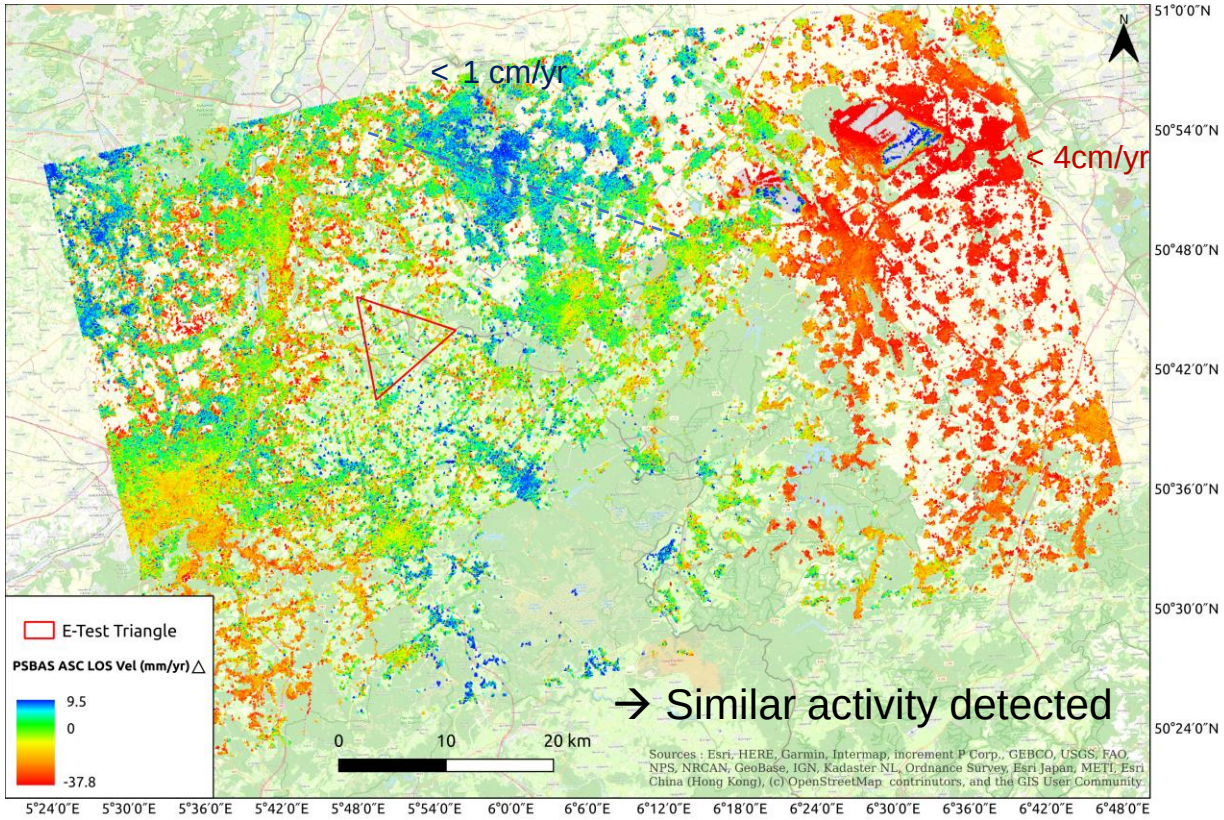
- **Geohazards platform** (GEP): **P-SBAS** (Parallel Small BAseline Subset) developed by CNR-Irea (Cigna et al. 2021); SNAPPING (Surface motioN mAPPING) based on SNAP V6 and StaMPS v4.1b **PSI** (Permanent Scatter Interferometry) by AUTh, MJaen & Terradue



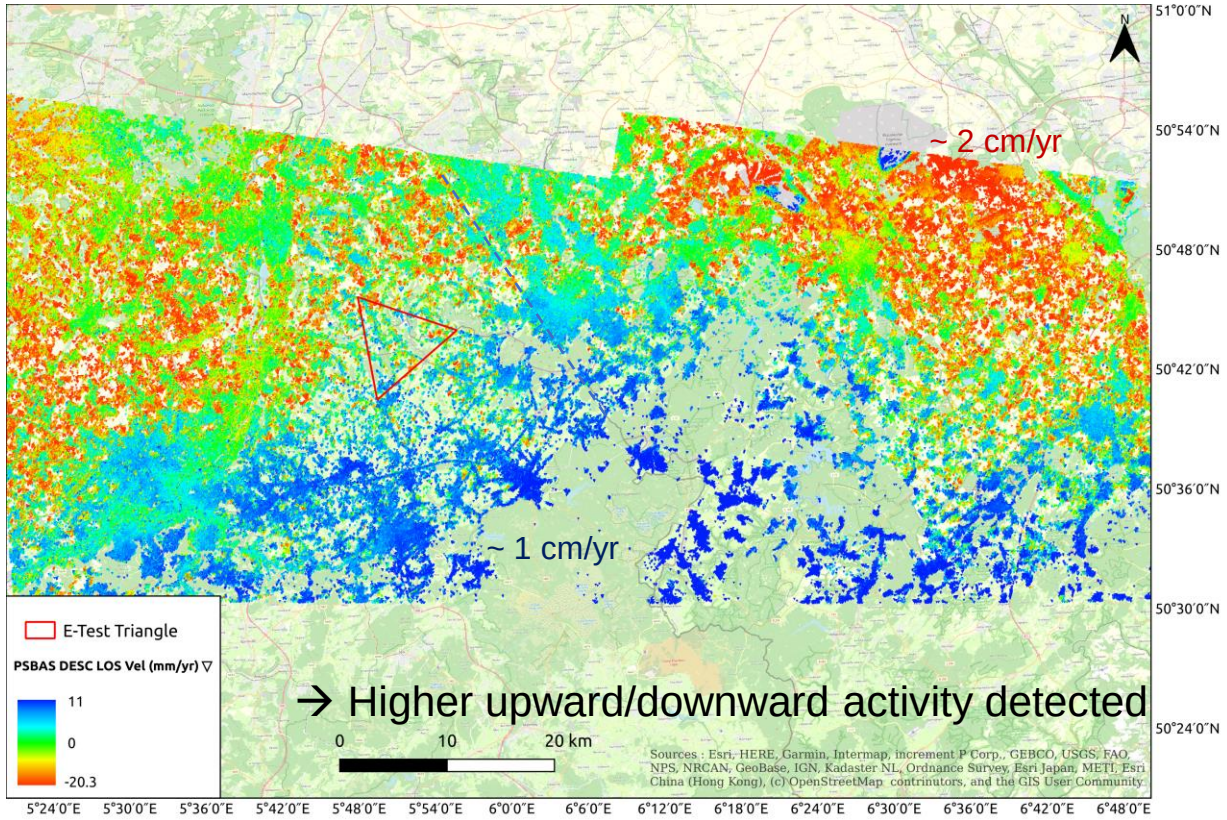
Regional P-SBAS analysis

Average LoS velocities with similar velocity ranges in:

- Ascending track #88 btw **2020**/12/26 & **2021**/07/24 (35 img; cc= 0.4)

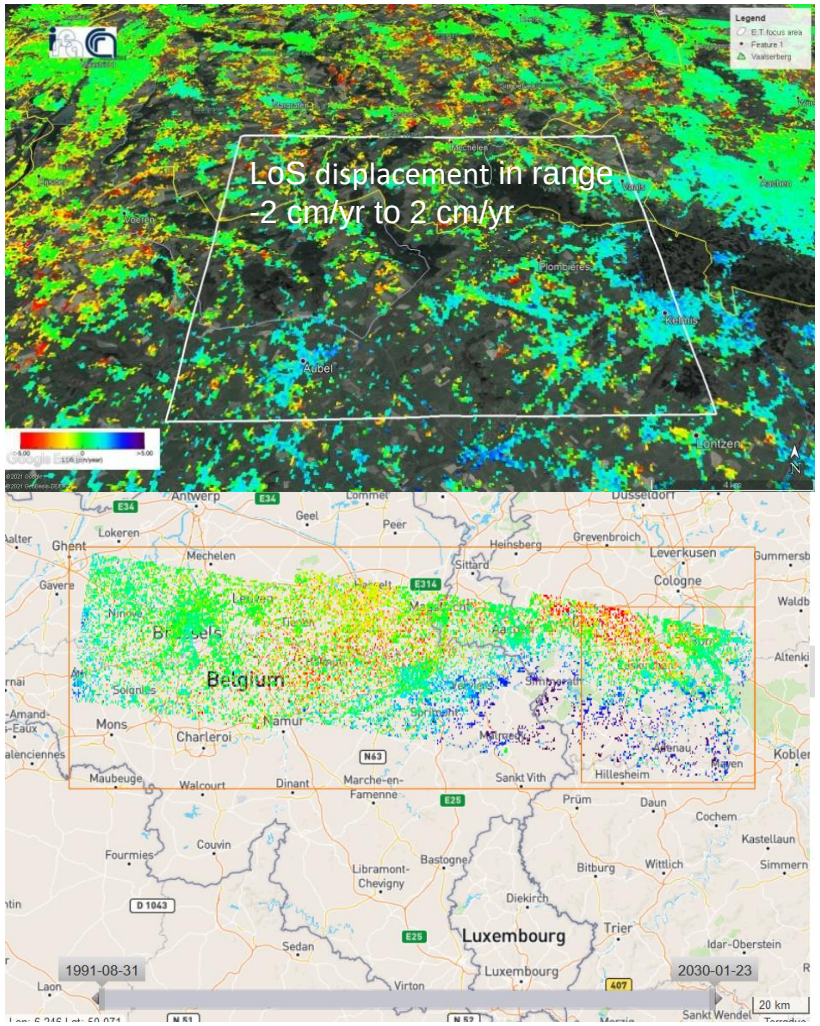


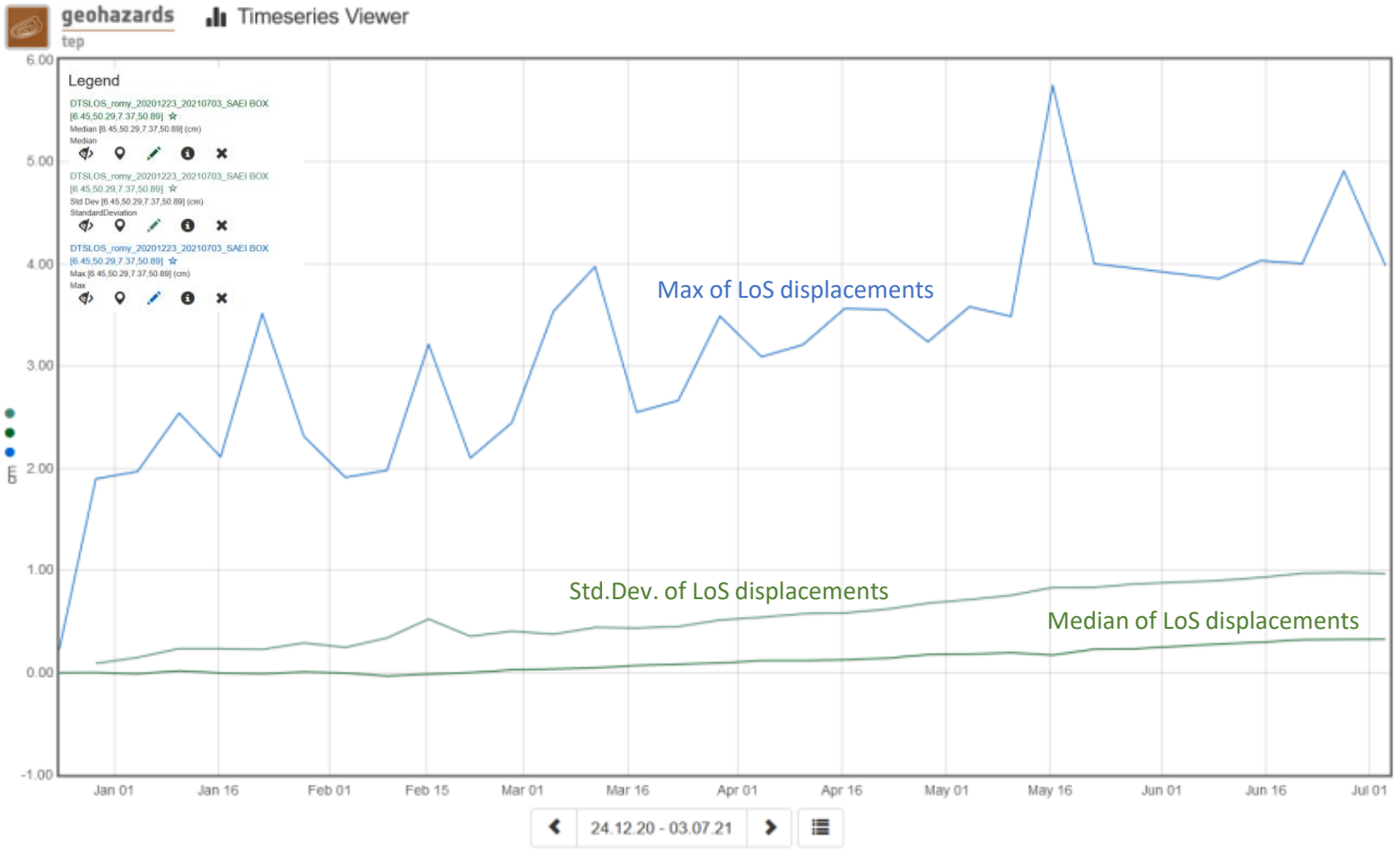
- Descending track #37 btw **2020**/12/23 & **2021**/07/03 (32 img; cc= 0.4)



Local P-SBAS analysis

- Descending track #37 btw **2020**/12/23-**2021**/07/03 (32 img; cc= 0.8 & 0.4)

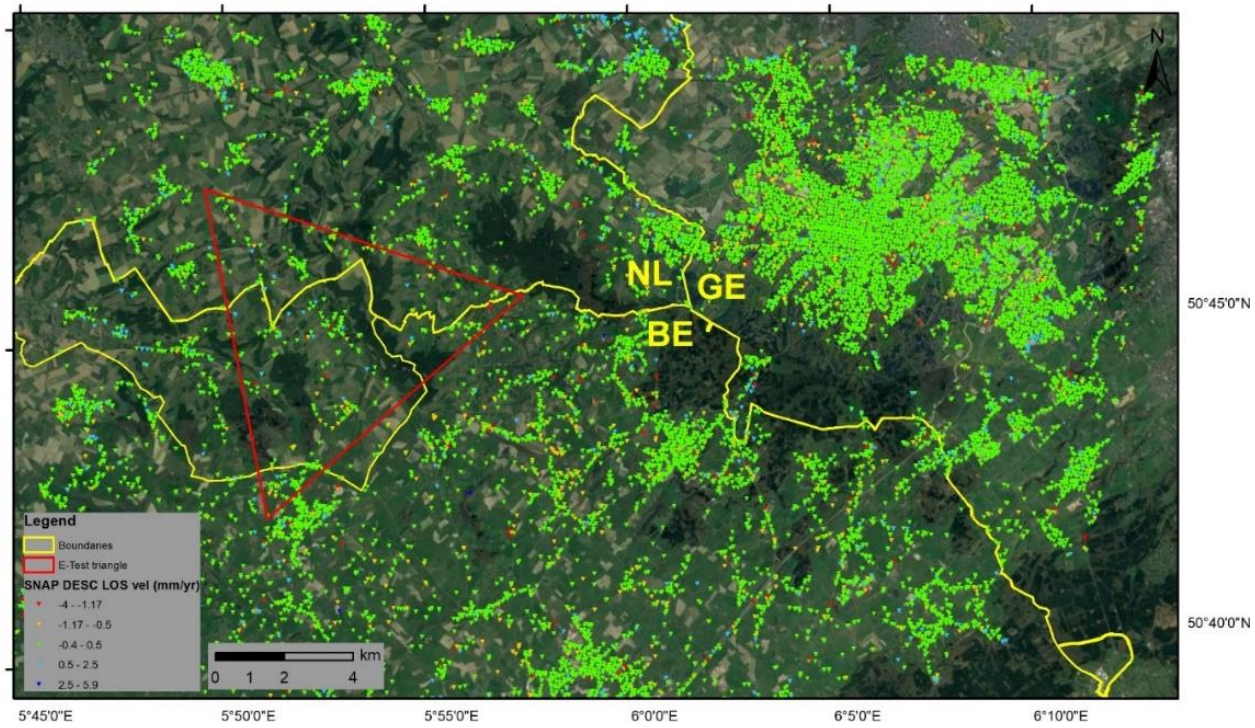


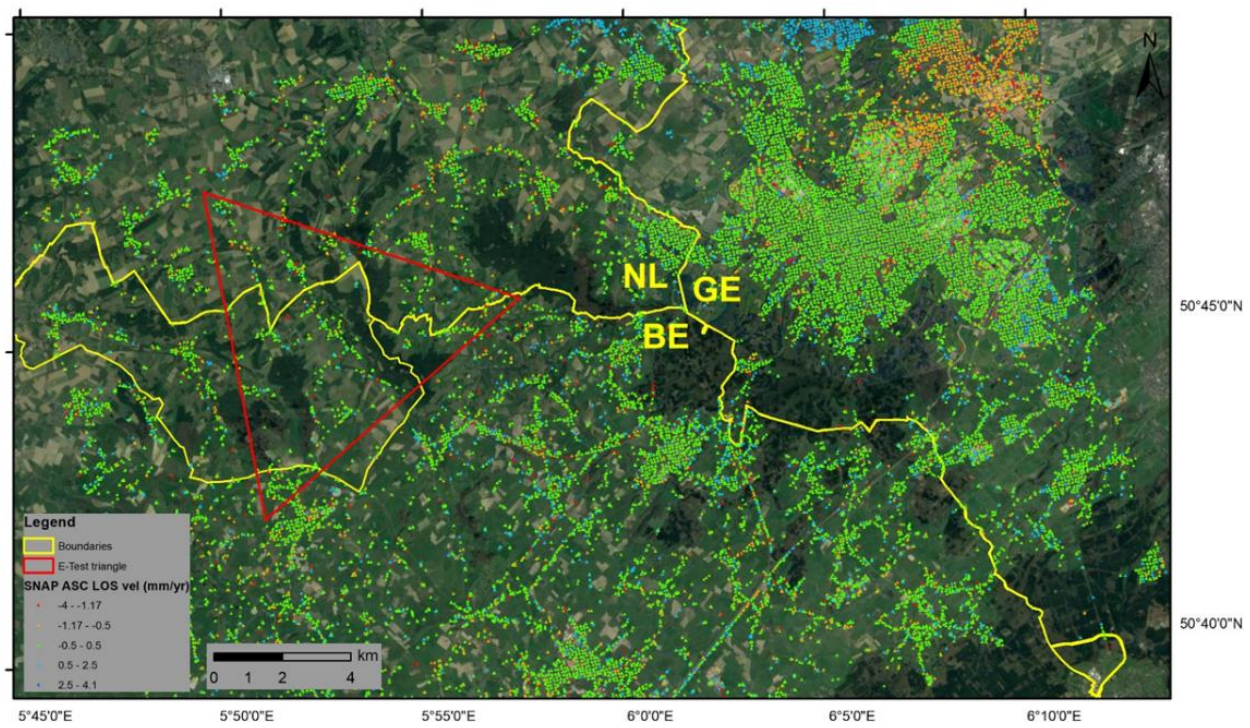


Regional SNAPPING PSI analysis

Average LoS velocities at medium resolution between

- **2018**/06 and **2021**/10/22 (i.e. 200 images in the Ascending track #88; up)
- **2018**/05/22 and **2020**/04/30 (Descending track #37; down)

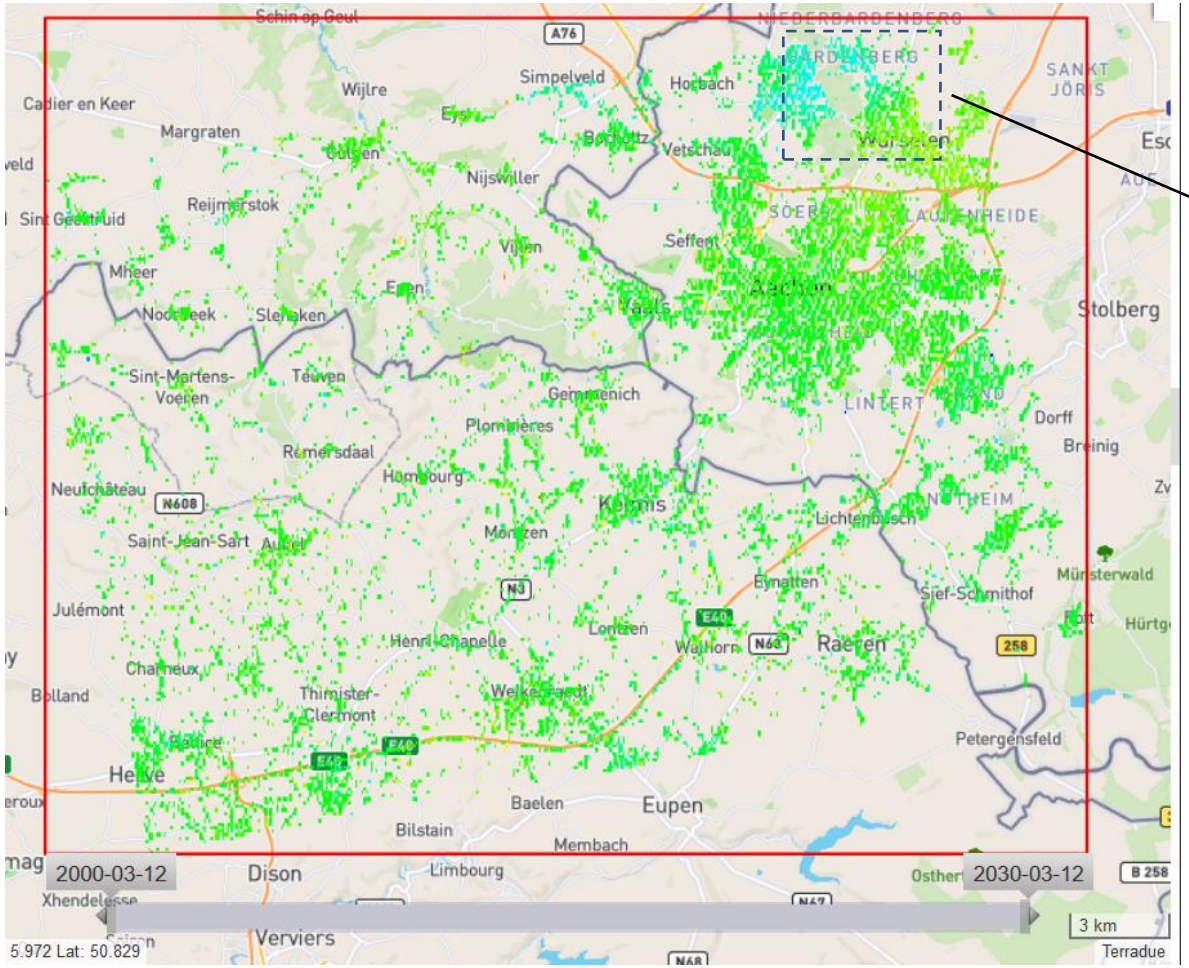


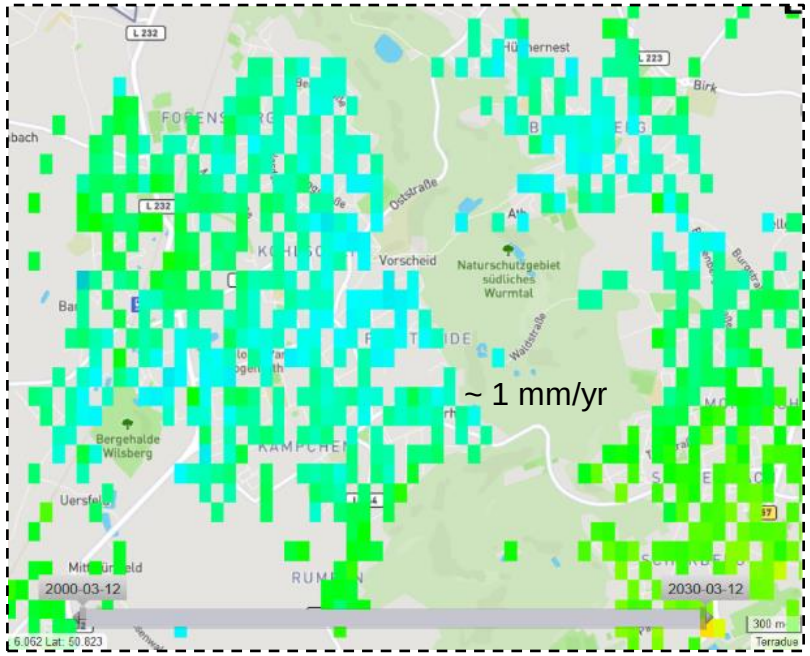


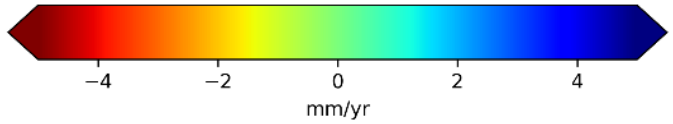
→ Similar LoS displacement in both tracks, dominant values in range -0.5 mm/yr to 0.5 mm/yr

Local SNAPPING PSI analysis

- Ascending track #88 between **2018**/06 and **2021**/10/22 (i.e. 200 images)

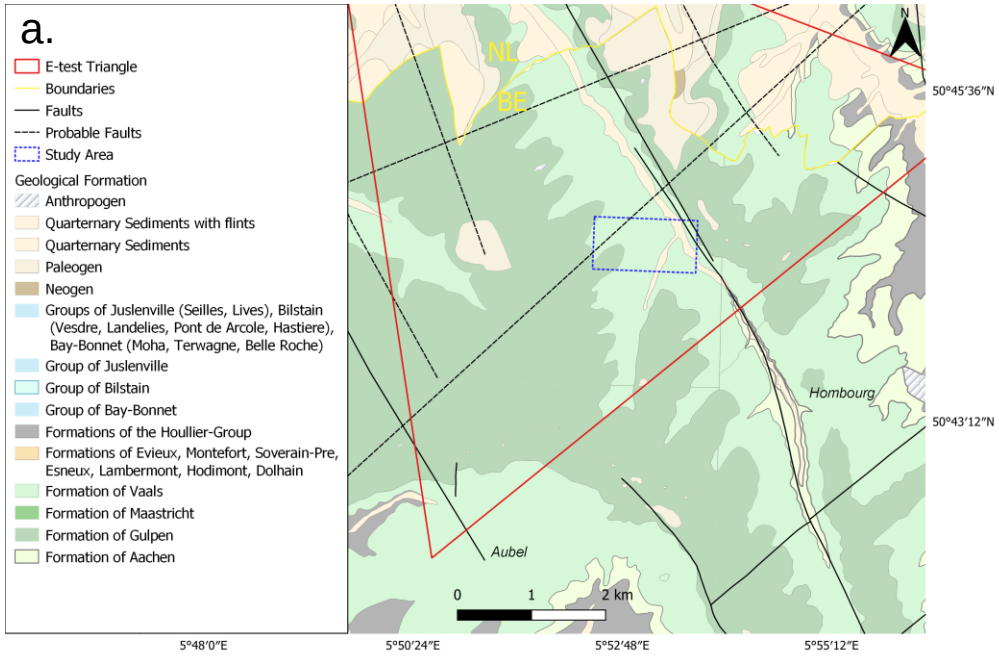




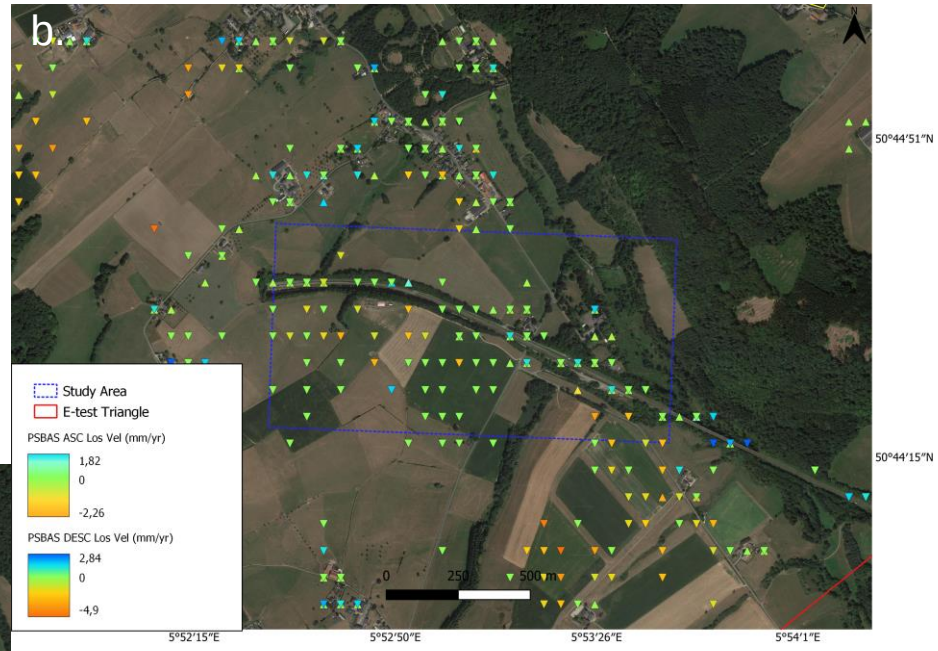


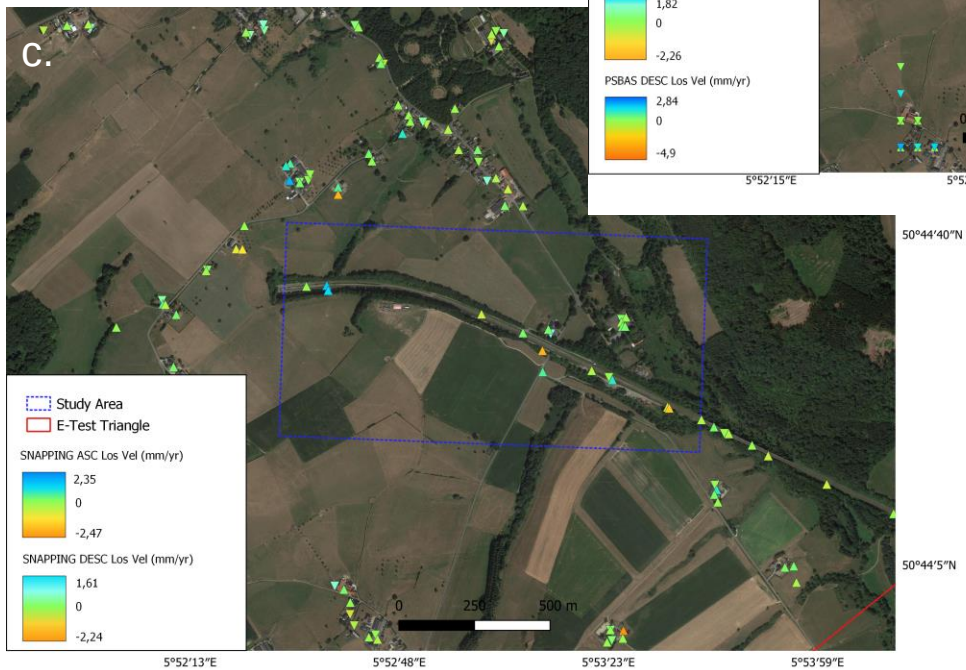
Local InSAR analysis: railway

- Mean LoS velocities along railway in the AOI



→ Negative LoS displacement to max value – 5 mm/yr



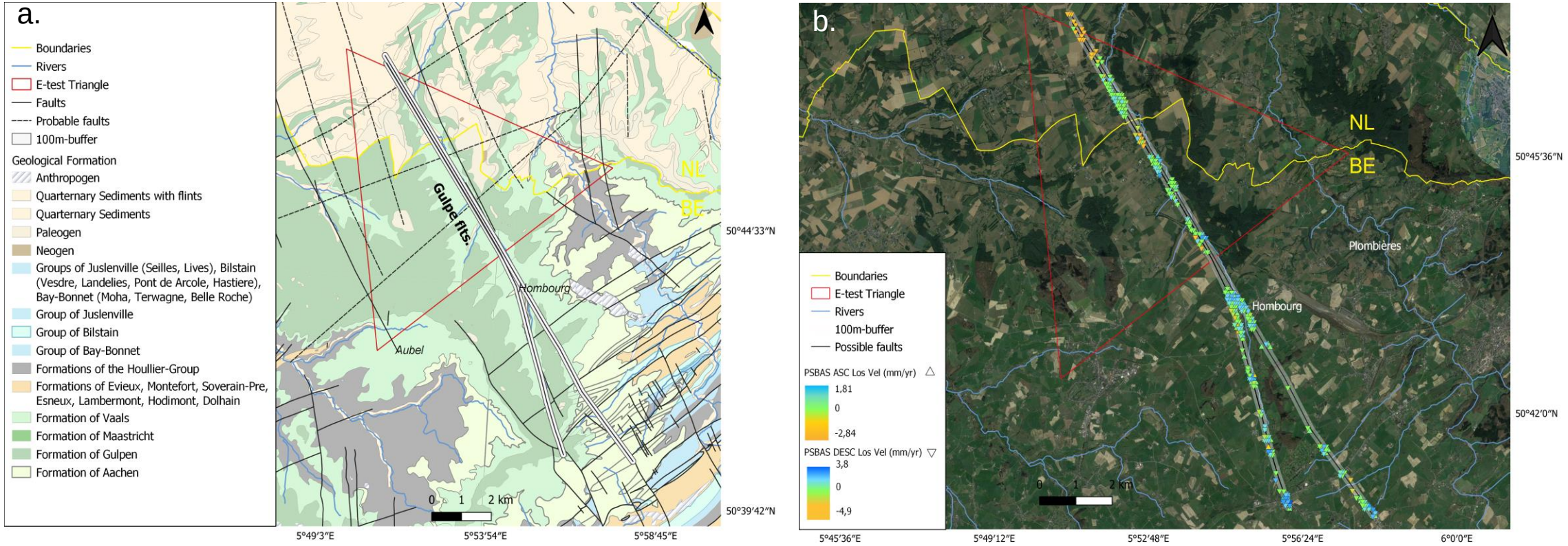


S1 images processed with in ascending track between 2020/12/26 and 2021/07/24 and descending between 2020/12/23 and 2021/07/03 using PSBBAS (b); S1 processed with SNAPPING between 2018/05/22 and 2020/04/30 (c)

→ Limited recorded points, mean LoS velocities around < 2 mm/yr

Local InSAR analysis: Gulp fault

- Mean LoS velocities in the Baelen faulting zone (100-m buffer area along the possible Gulp fault)

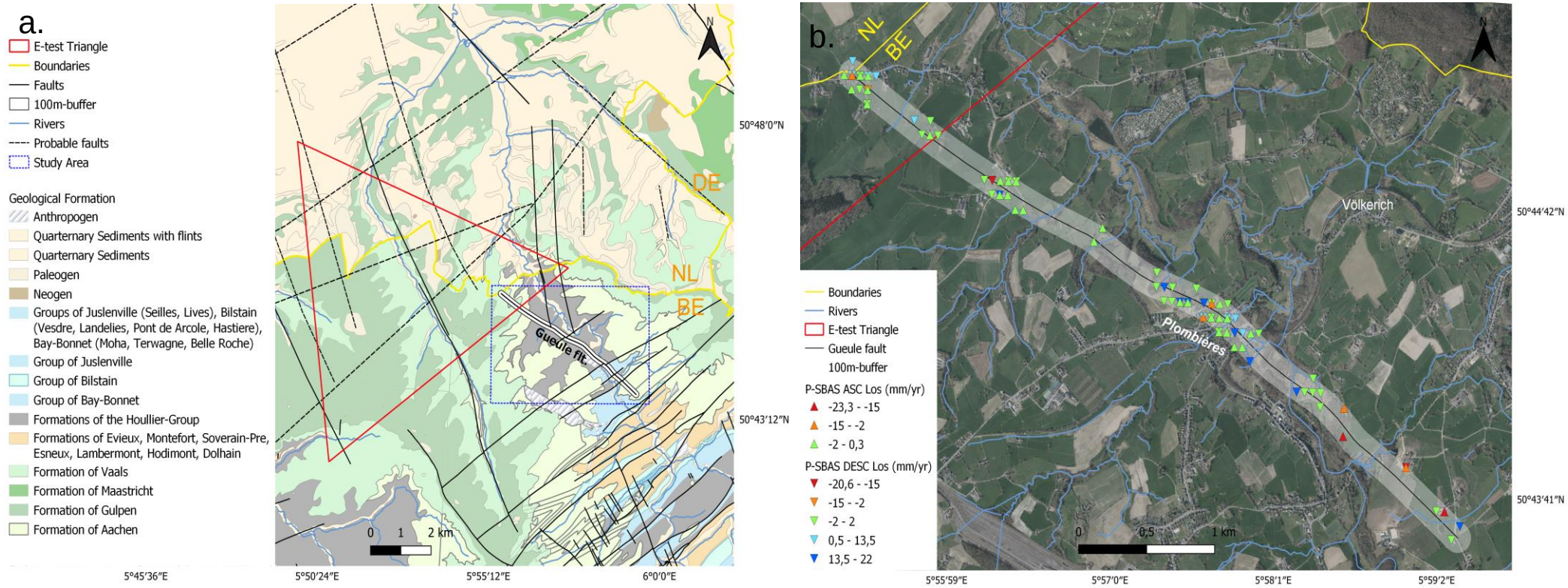


S1 images processed with in ascending track between 2020/12/26 and 2021/07/24 and descending between 2020/12/23 and 2021/07/03 using PSBAS (b)

→ Positive LoS displacement – max value around 4 mm/yr

Local InSAR analysis: Gueule fault

- Mean LoS velocities in the Eupen faulting zone (100-m buffer area along the Gueule fault)



S1 images processed with in ascending track between 2020/12/26 and 2021/07/24 and descending between 2020/12/23 and 2021/07/03 using PSBAS (b)

→ Mean LoS velocities around < 2 mm/yr

Conclusion

- The use of the GEP platform as part of NoR sponsorship made it possible to complete task 2.1 (Processing and monitoring strategies) in WP2,
- Based on the results: PSBAS and SNNAPING detected neotectonic and anthropogenic ground displacements in the **BE-NL-DE** transborder area,
- InSAR analyzes were regional and local scope, respectively outside and inside possible location of the Einstein Telescope (E-Test; red triangle),
- Regional analysis of AOI shows relative stability (mean values: < 2 mm/yr),
- Local analysis along faults reveals interesting observations but maybe also linked to anthropogenic activities: difficult to reject the hypothesis that the faults are both aseismic.

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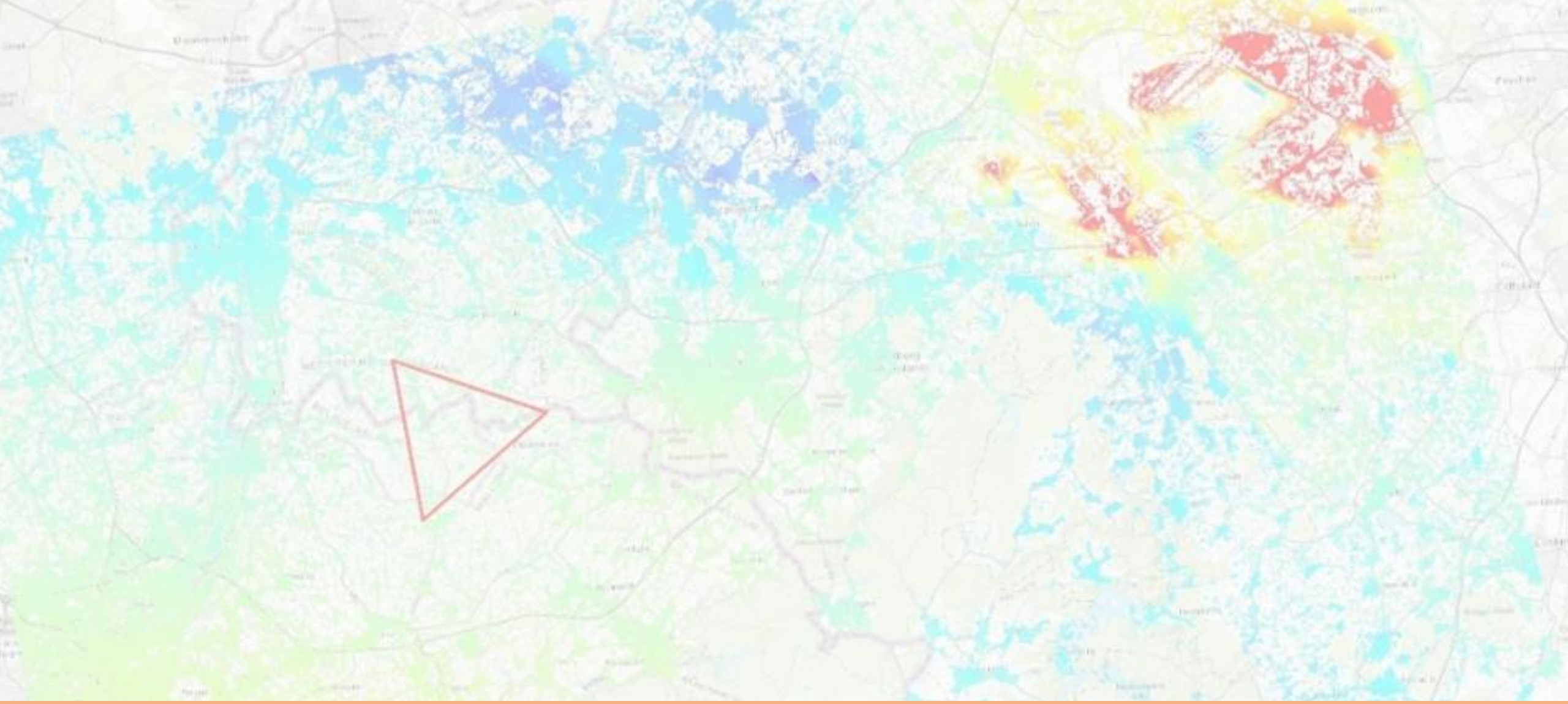

Thanks for your attention.

Any questions?

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