Update on Seismic Campaigns at the EMR-site

Ambient seismic & magnetic noise measurements at surface, and active source surface seismic

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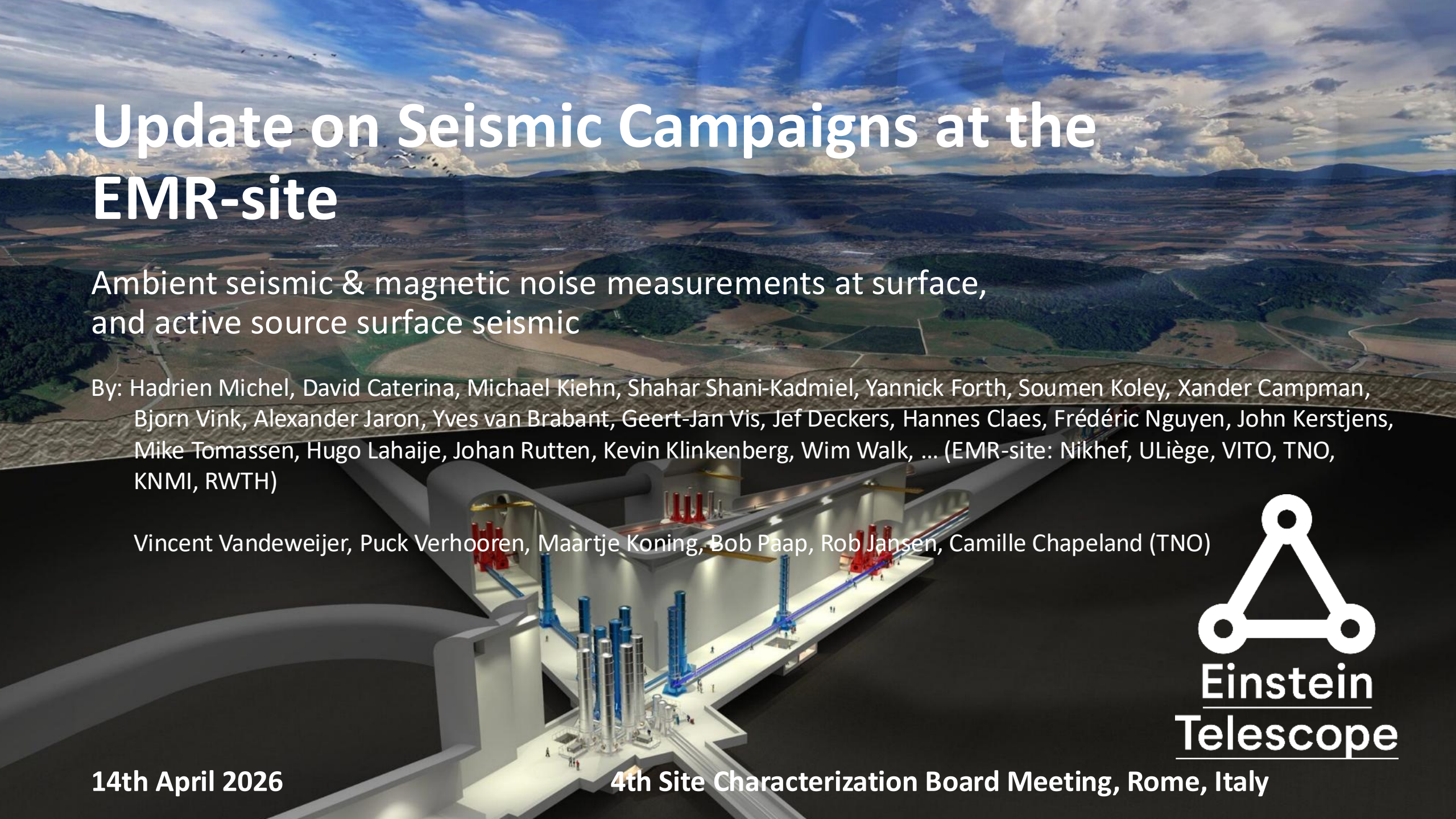
Vincent Vandeweijer, Puck Verhooren, Maartje Koning, Bob Paap, Rob Jansen, Camille Chapeland (TNO)



Einstein Telescope

14th April 2026

4th Site Characterization Board Meeting, Rome, Italy

Outline

Ambient seismic noise measurements

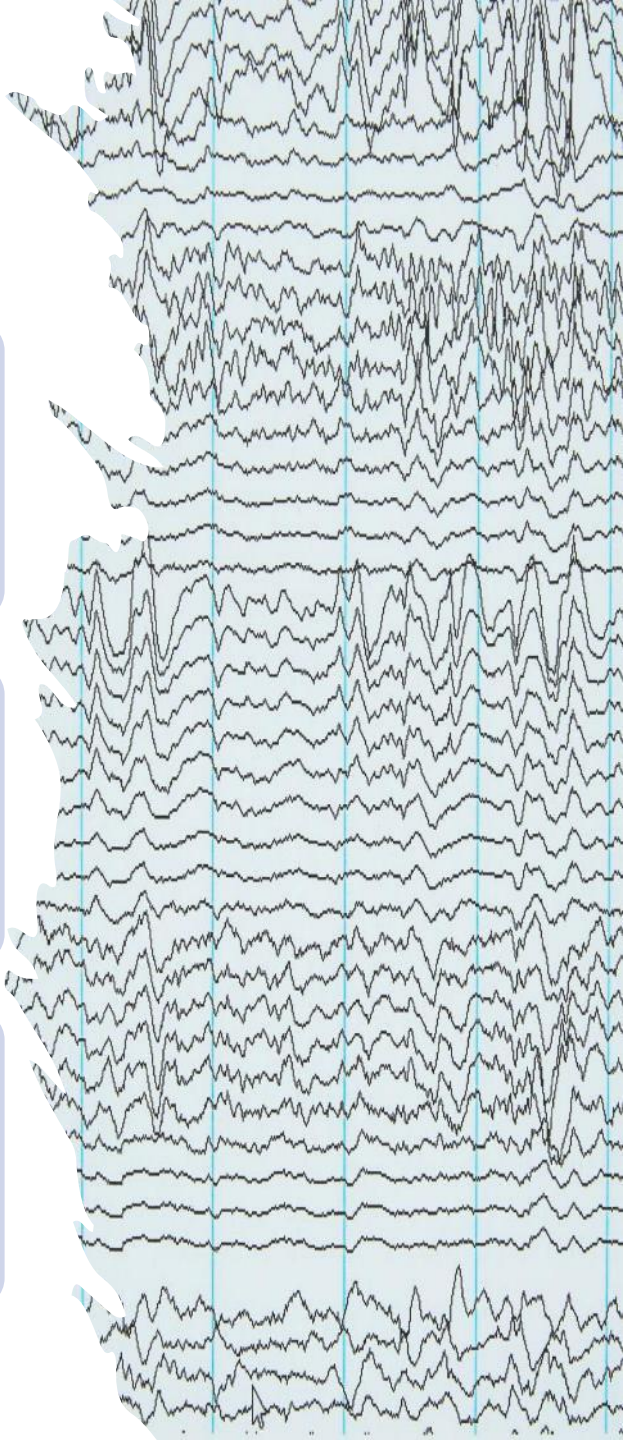
- Summary of the 2024/2025 results around Terziet
- Design of the upcoming “scan-line” campaigns

Ambient magnetic noise measurements

- First measurements of background field
- Plans for in-well measurement

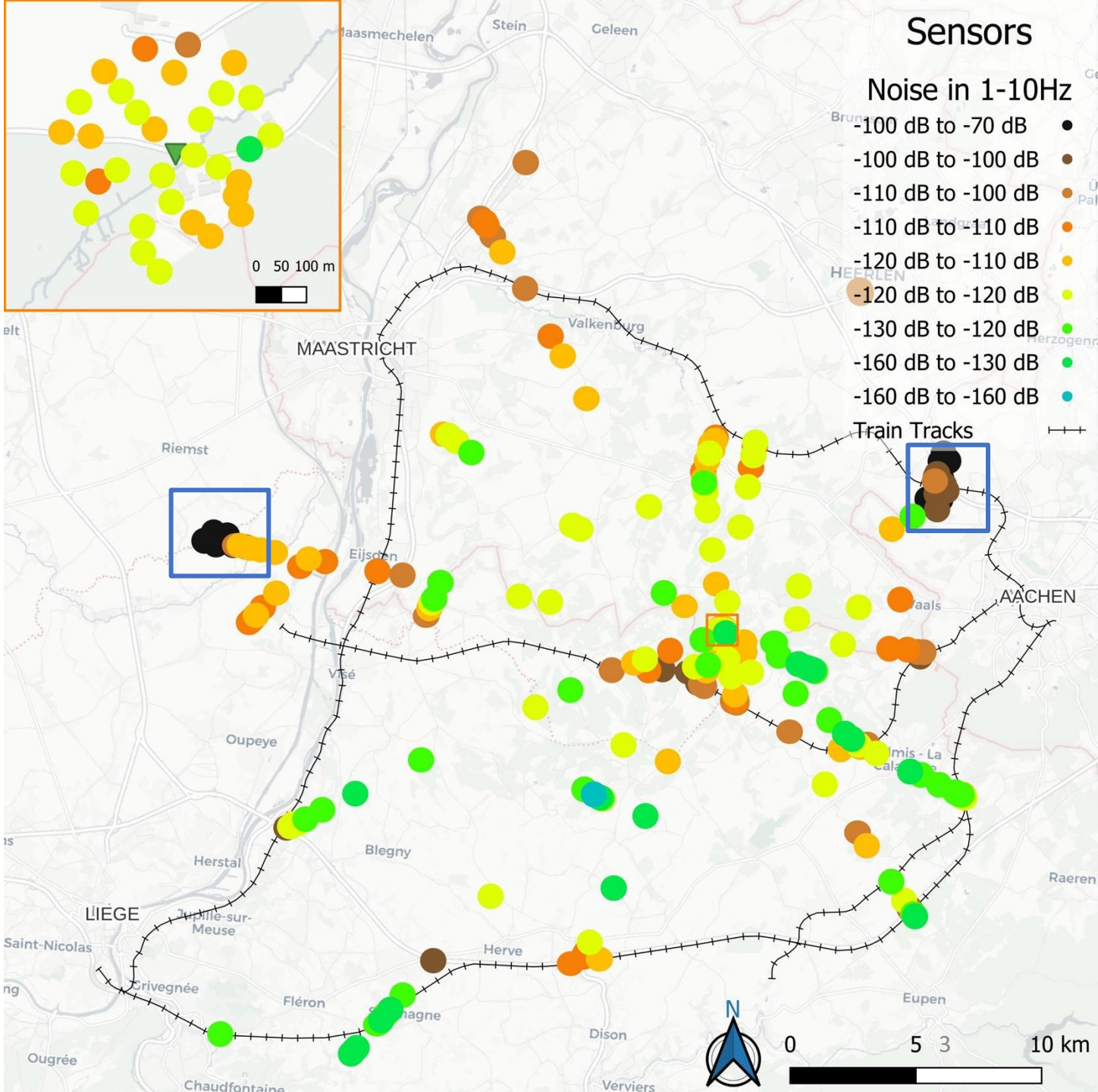
2D surface seismic and DAS-VSP’s

- DAS-VSP and check-shot results
- Results of 2D surface seismic
- Plans for 2026



Seismic noise levels at surface obtained from “scan-lines”

- Array centered around Terziet (NL.TERZ)
- Scan-lines towards identified potential noise sources
  - Wind-turbines
  - Bridges/Tunnels
  - Railways
  - Airport
  - Industrial pumps
  - Etc.
- Pilot sensors: sensors positioned as close a possible from source
- Wind turbines are the main noise source in the area
- Train tracks (bridges/tunnels) are also significant

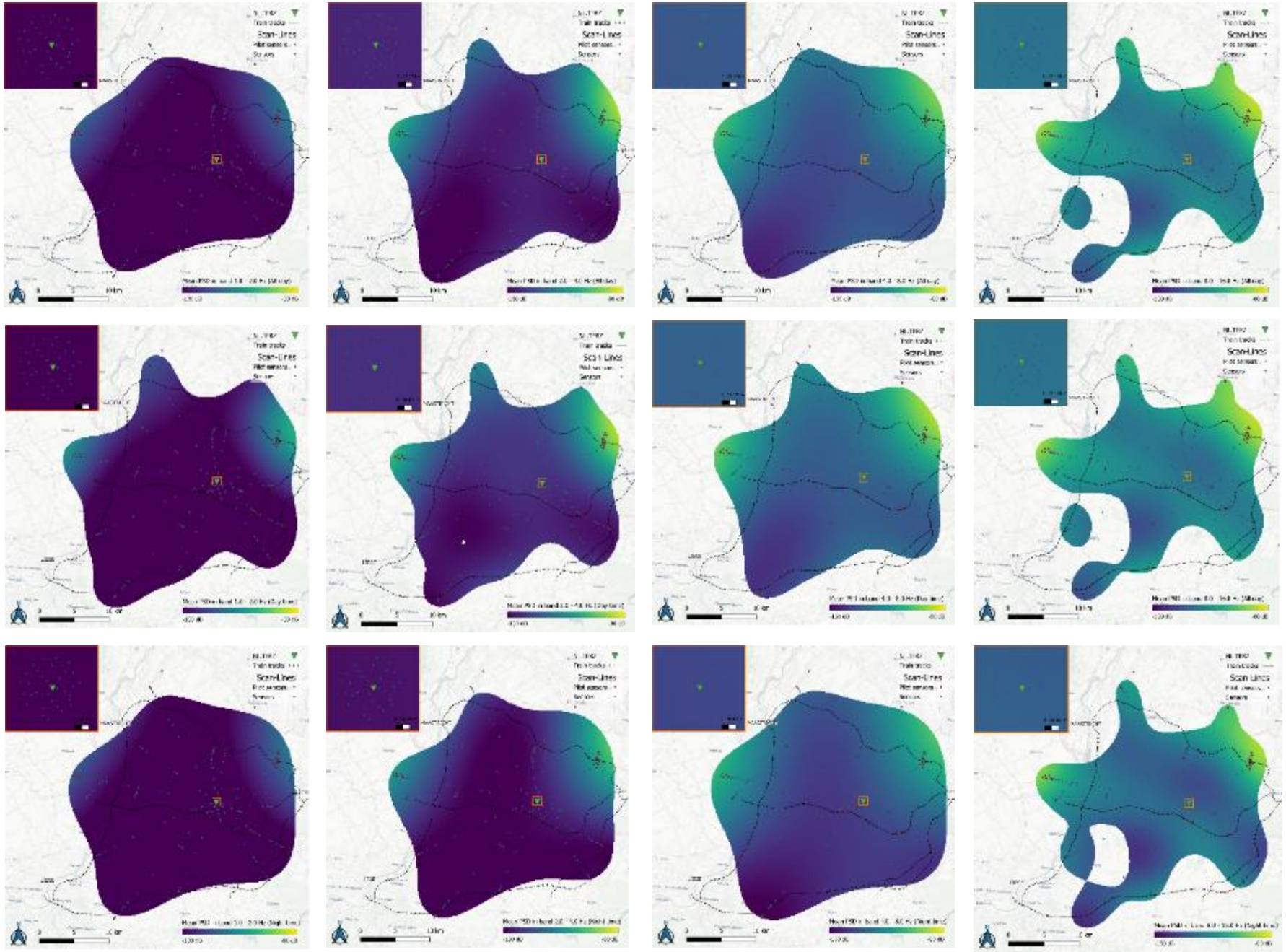


Band 1.0 – 2.0 Hz | Band 2.0 – 4.0 Hz | Band 4.0 – 8.0 Hz | Band 8.0 – 16.0 Hz

All Day

Day time

Night time



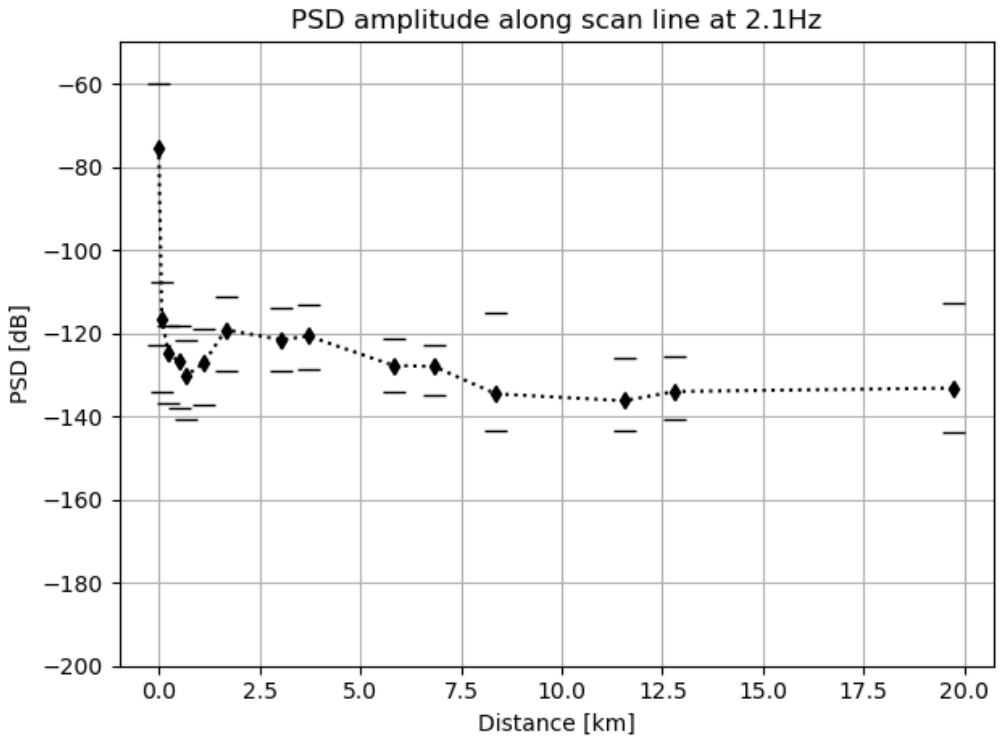
-80 dB

-130 dB

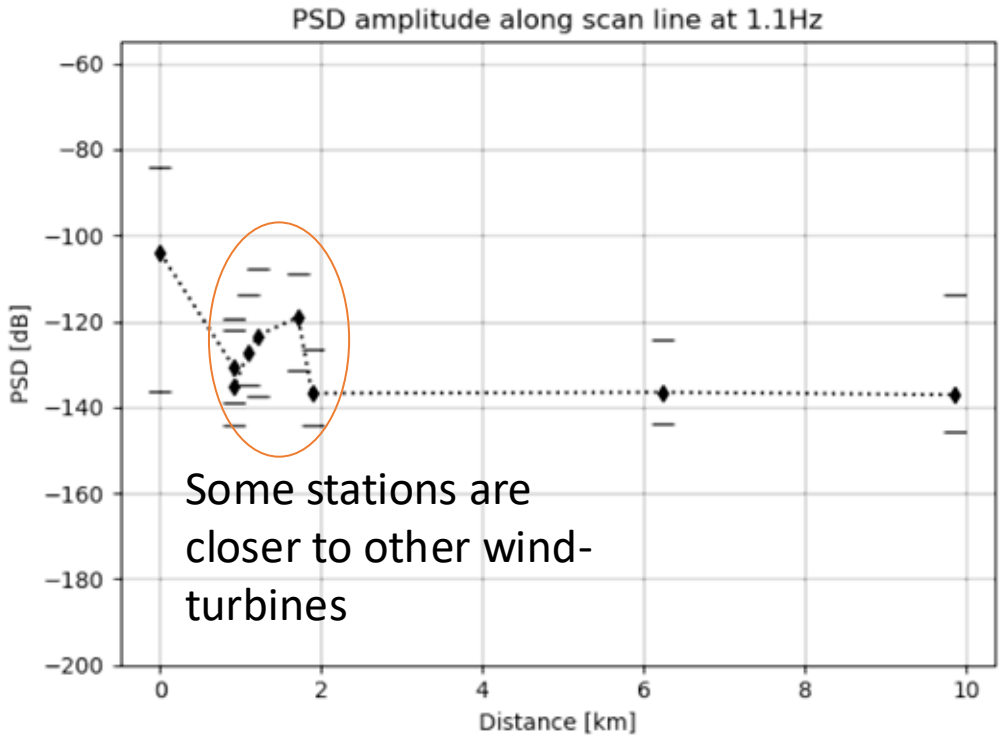
PSD maps obtained from the 2024 Scan-line campaign around Terziet.
Different frequency ranges displayed.

Wind turbines
Decrease of the amplitude with distance

Bassenge – Resonance at 2.1 Hz

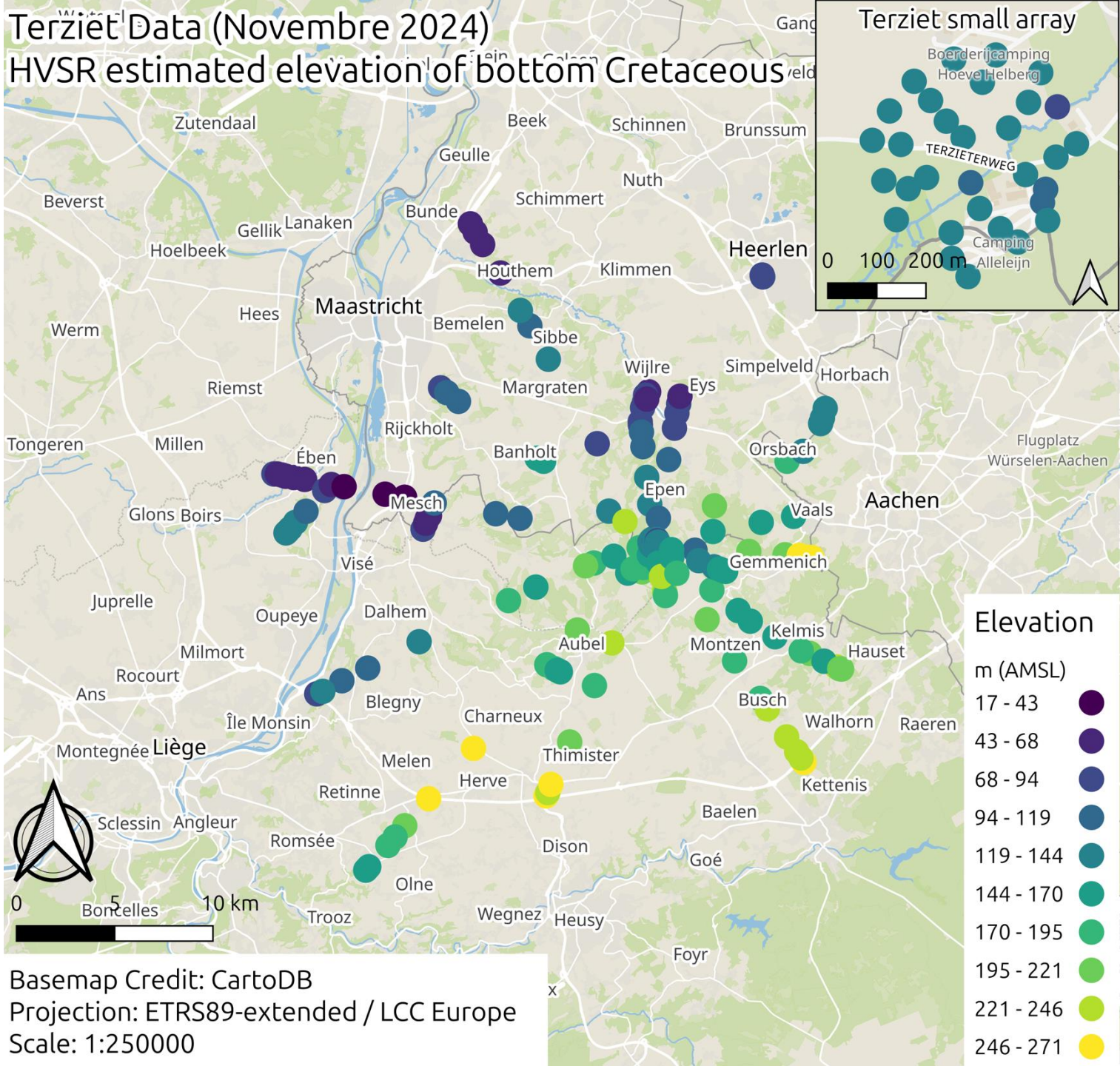


Aachen – Resonance at 1.1 Hz



Near-surface layer from HVSR

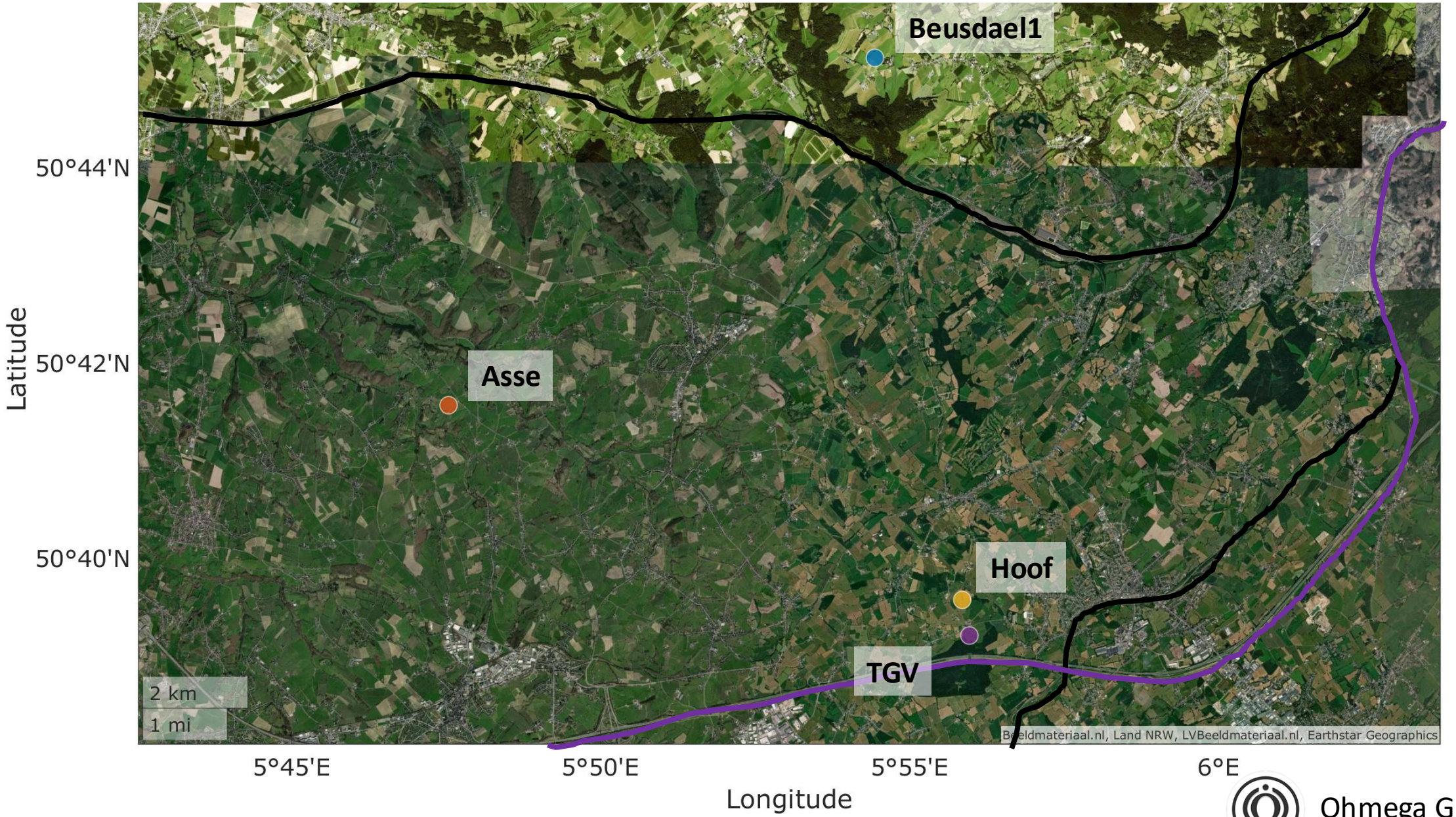
- HVSR processed for all stations (using Geopsy)
- V_s = 250 m/s
- Good fit with the observation in Terziet
- Overall: plane dipping towards the north-west



Assess magnetic noise levels in the EMR-region

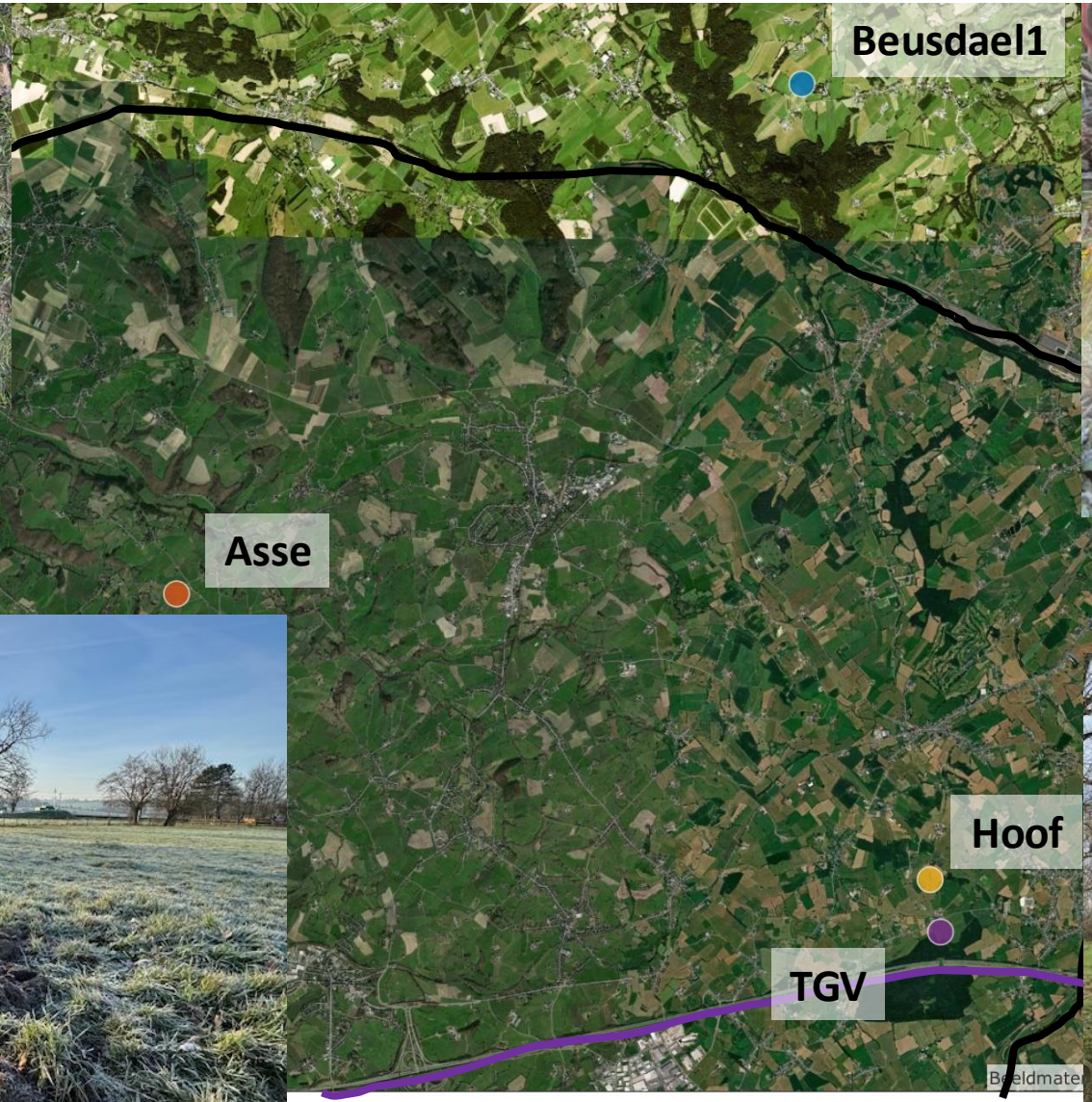
- **Data Collection & Spectral Analysis:**
  Measure electric and magnetic fields (surface and depth) over 2–3 weeks to estimate time- and frequency-dependent spectral energy.
- **Noise Characterization:**
  Quantify noise levels and variability using Spectral Density Matrices (SDMs) to distinguish between site-specific (incoherent) and shared (coherent) noise.
- **Source Identification:**
  Use eigenvalue decomposition and transfer functions to determine the number of independent noise sources and their spatial-temporal behavior.
- **Predictive Modeling:**
  Develop a statistical model to forecast surface-noise variations within the EMR region.

Locations of magnetic noise measurements at surface



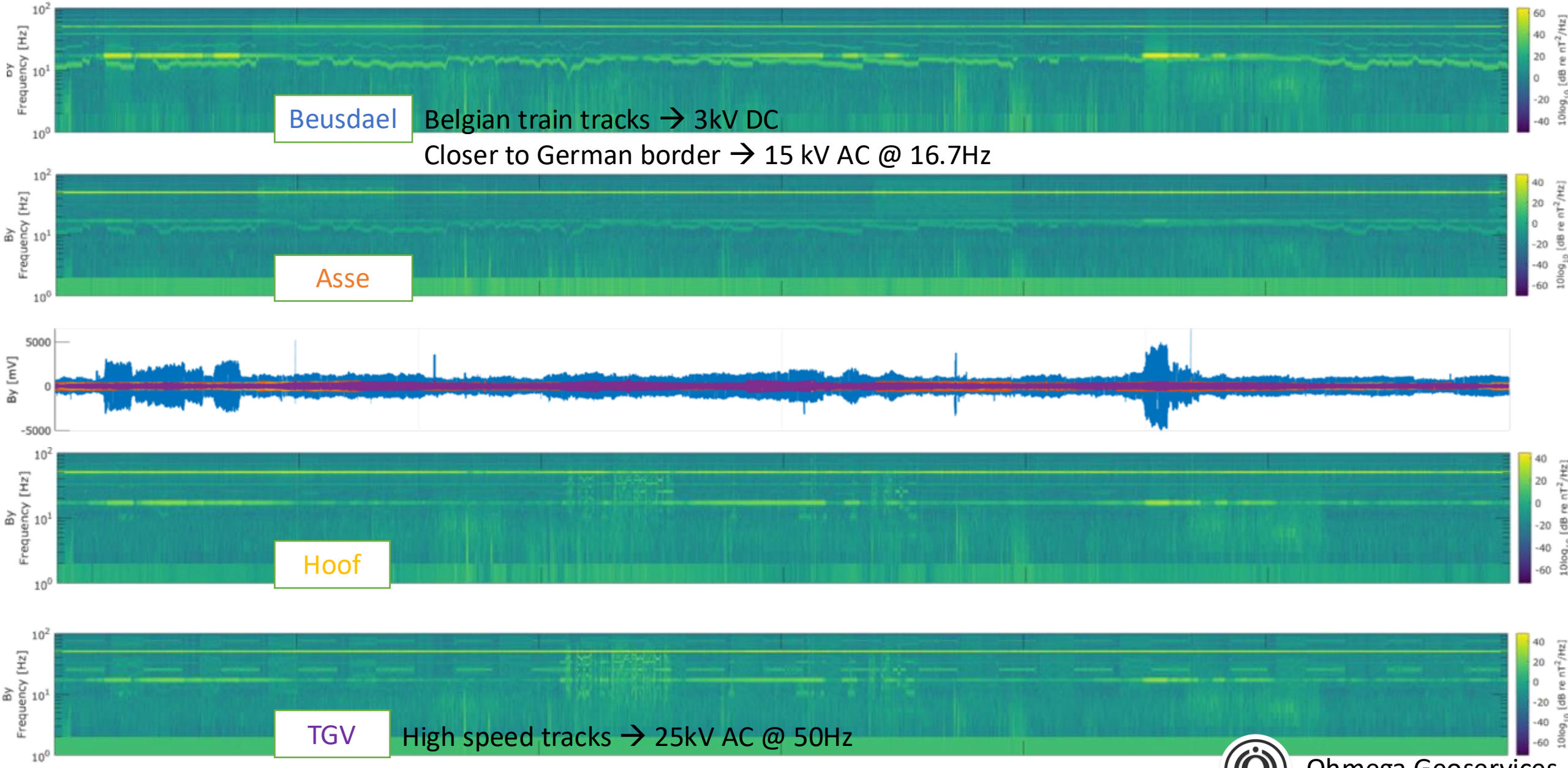
Ohmega Geoservices

Locations of magnetic noise measurements at surface



Ohmega Geoservices

Dynamic Spectra of a 1h time series (19-20h, @29.01.2026)

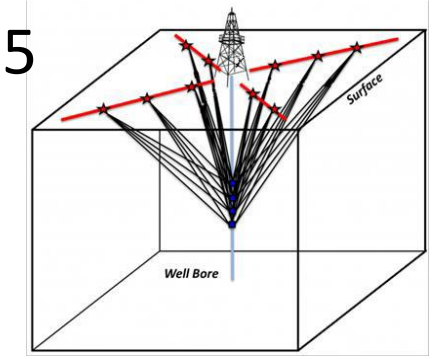


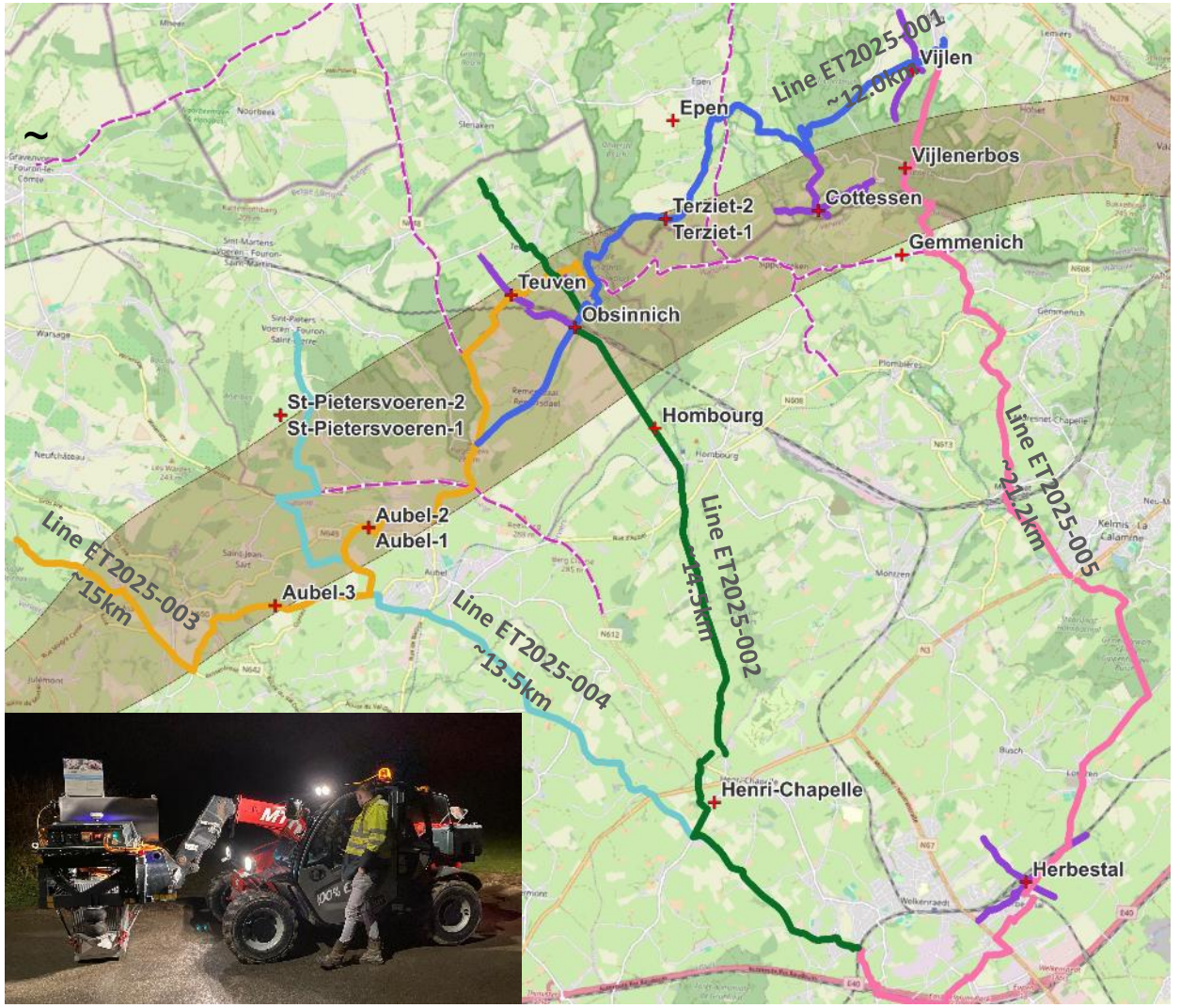
Correlation to e.g. the TGV schedule outstanding

Ohmega Geoservices

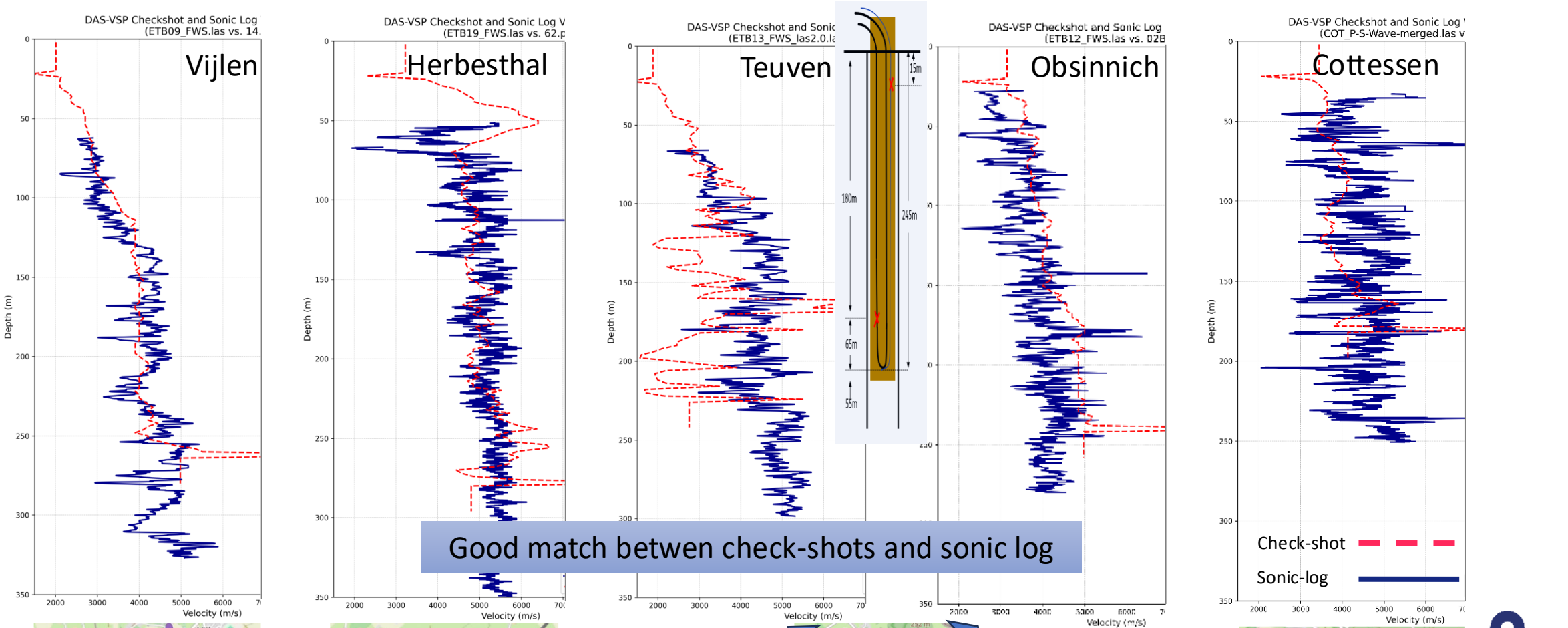
2025 active seismic program

- About 90 km of 2D seismic lines along potential ET corridor legs
  - Vibroseis source, 4m spacing, 2–120 Hz, 1200m max offset
- 5 DAS-VSP surveys (Cottessen, Vijlen, Teuven, Obsinnich, Herbesthal)
  - VSPs enable near-wellbore imaging, check-shots & absorption measurement (1–15 Hz)
  - Consistent parameters across borehole logging & VSP acquisition
- Finished 11.04.2025





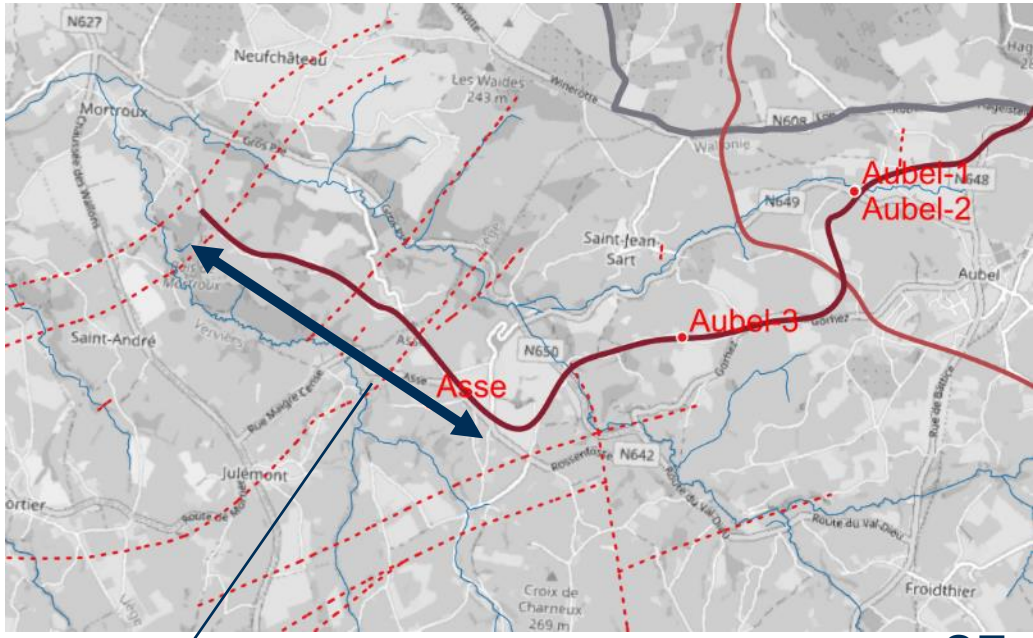
DAS-VSP check-shots



Good match betwen check-shots and sonic log

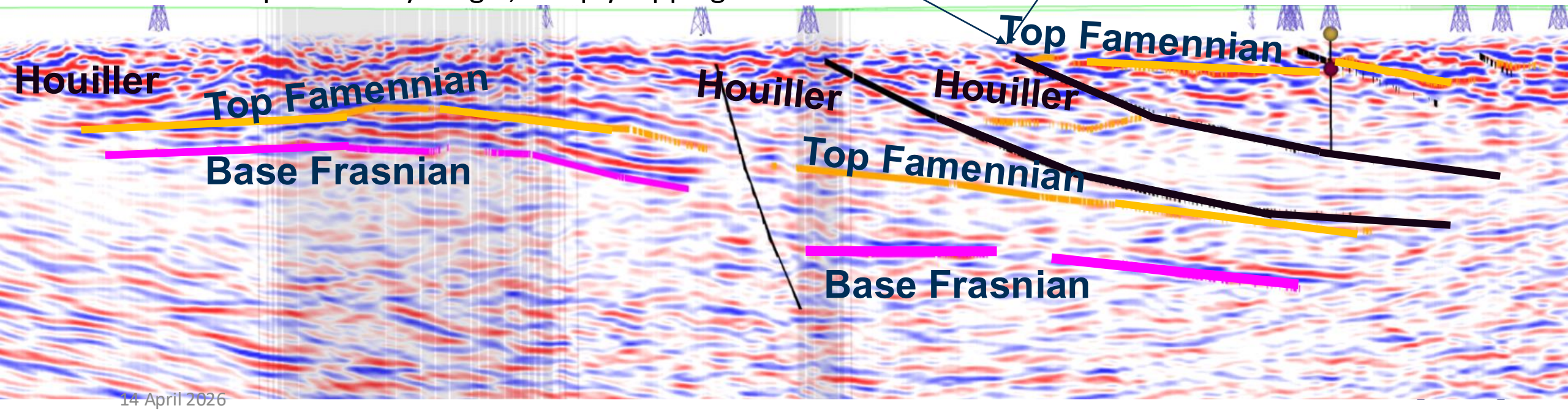
Seismic Interpretation Example of Asse

- Booze – Le Val-Dieu structure
- Interpretation based on nearby outcrop data + seismic facies
- Nearby observation of Asse thrust fault, with Famennian outcrop south of younger, steeply dipping Namurian

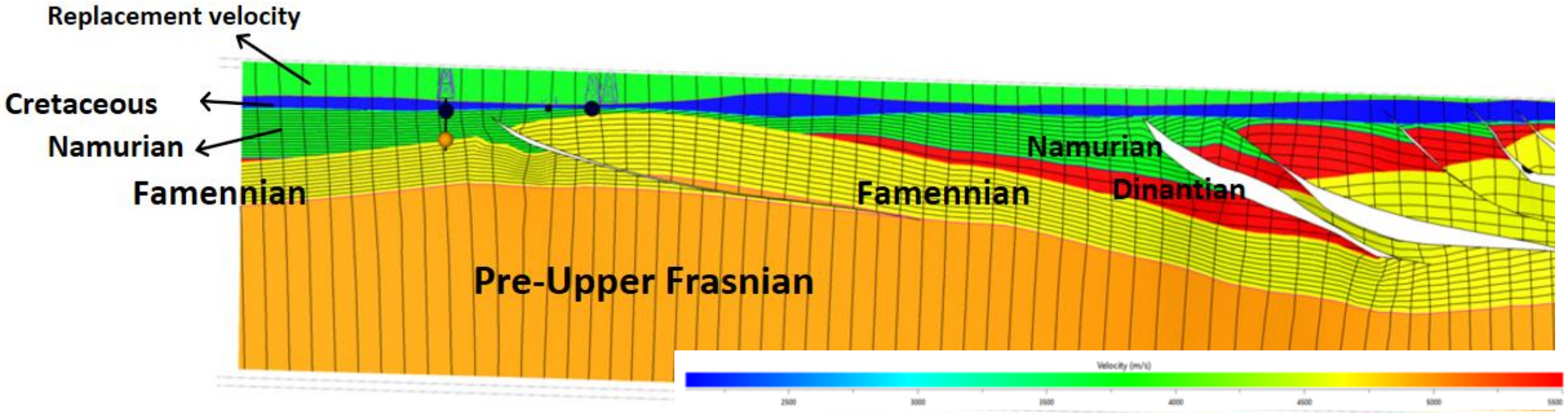


NW

SE



Construction of a 3D subsurface model ongoing

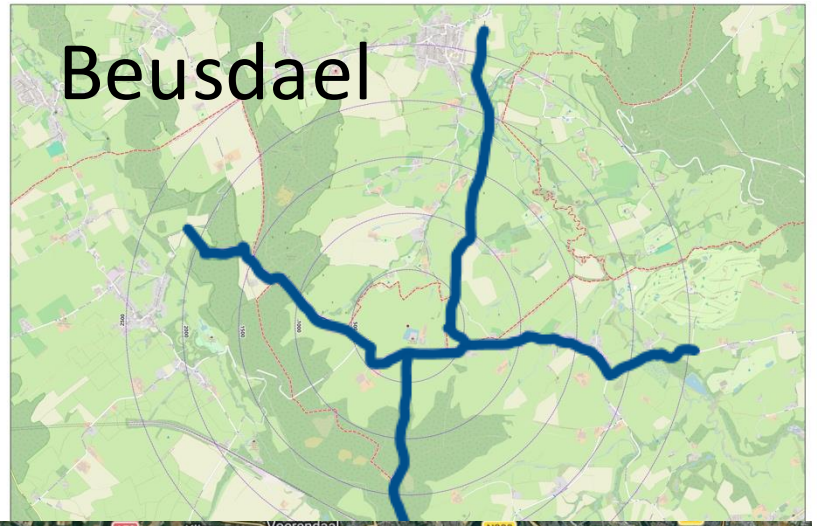


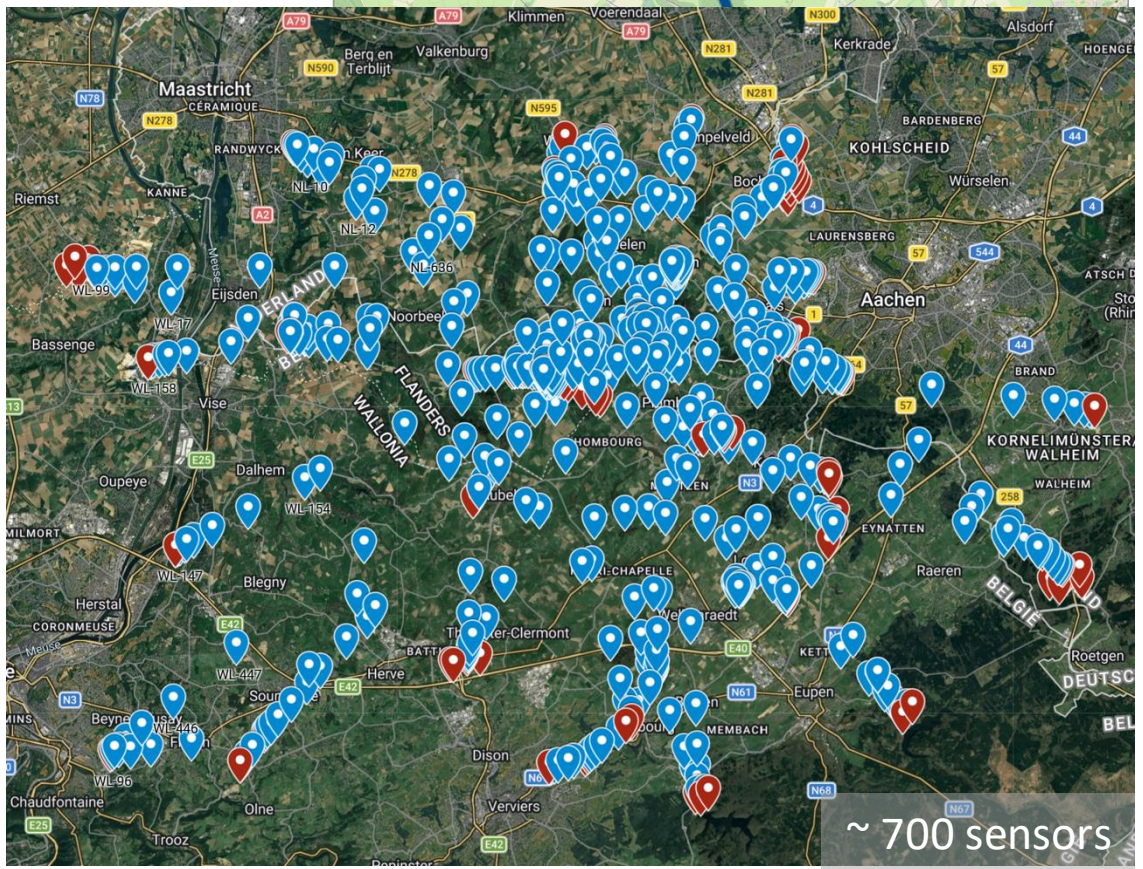
- Structural framework based on:
  - Outcrop
  - Seismic
  - Borehole data
  - Gravity data

- Volume properties derived from:
  - (geophysical) logs
  - Seismic
  - DAS-VSP
  - Empirical relationships

Upcoming measurements

- Ambiant seismic noise
  - 2 campaigns centered around all available boreholes (~700 sensors each)
  - Spring and summer 2026
- Magnetic measurements in boreholes
  - Pilot test at available borehole (Obsinnich?)
  - Measurements in boreholes at Hoof, Asse, Beusdael after seismic data acquisition
- Active seismic at Beusdael, Asse and Hoof
  - Cross-spread and DAS-VSP

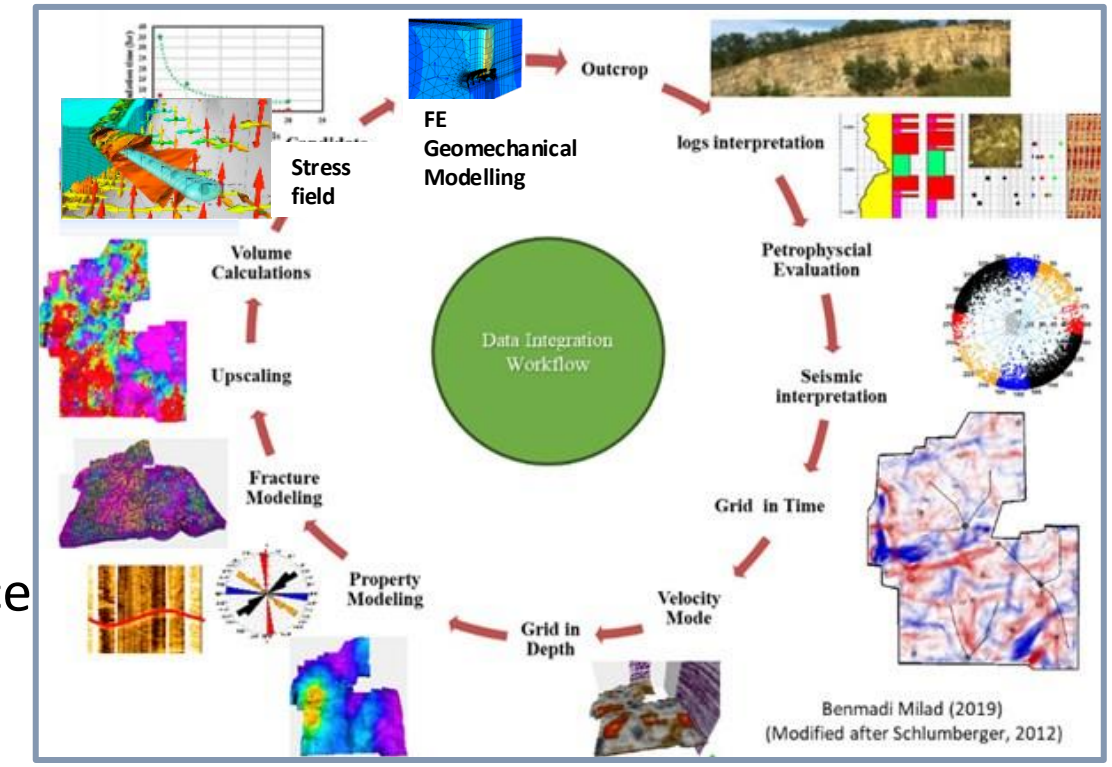




Summary

- Ambient seismic noise measurements along scan-lines
  - Identify near-surface layer and noise sources
- Magnetic noise measurements at surface
- Successful seismic acquisition campaign Check-shots agree overall with sonic logs
  - Reasonable seismic to well-ties
  - DAS-VSP's planned at potential corner-points
- Supports creation of an integrated 3D subsurface model for:
  - Geotechnical and civil engineering
  - Hydrological modelling
  - Geophysical modelling

    ➔ Input to Newtonian noise modelling



To be continued…

Question?

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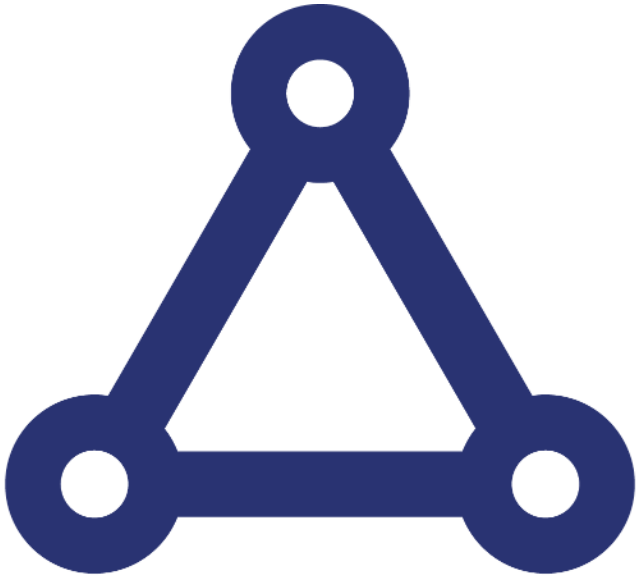

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