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Hydreco Geomec B.V.
HAL Modelling Monitoring Configuration

Preliminary report

08/11/2019

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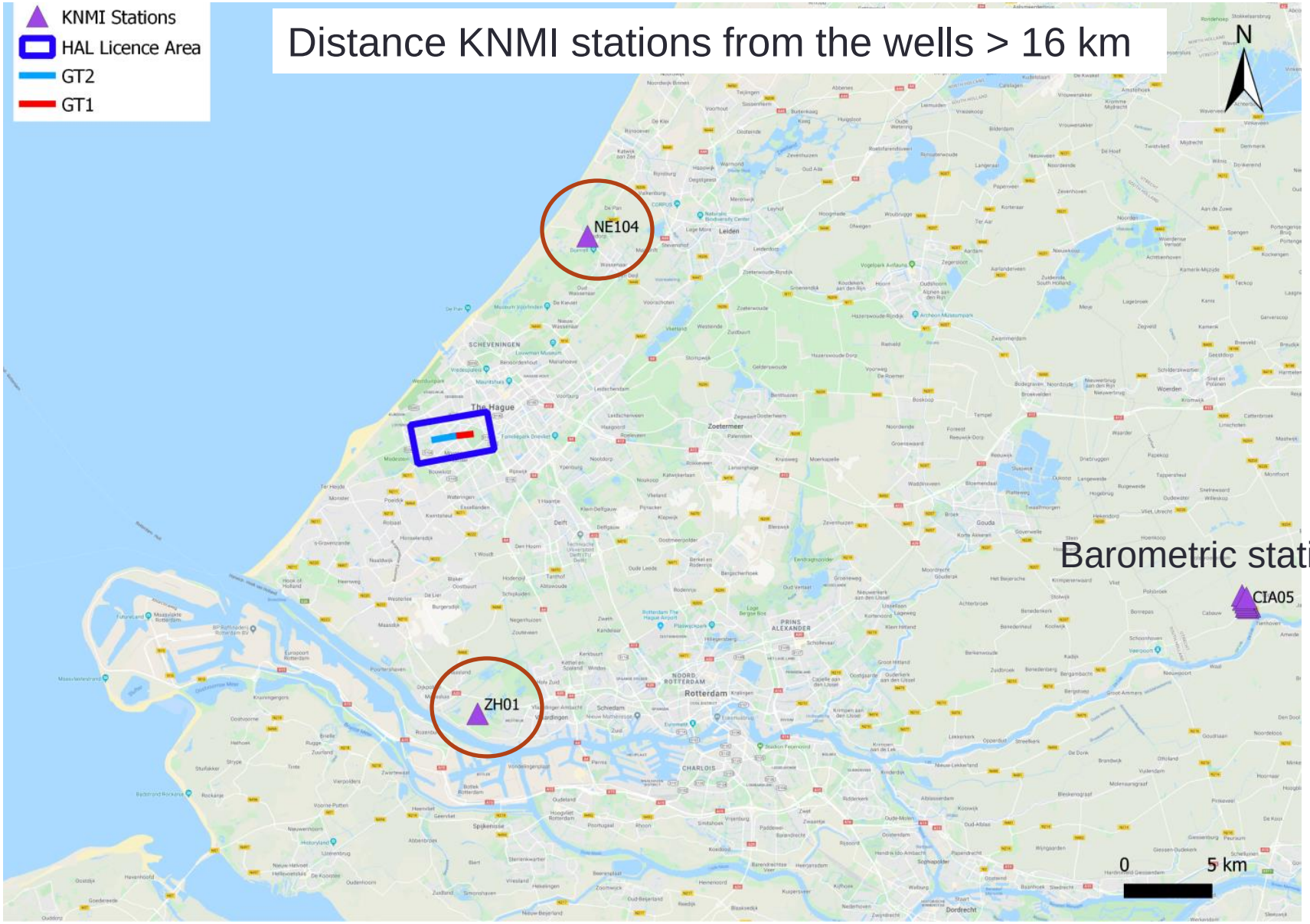
Noise Levels for the Initial Modeling
KNMI Public Stations

- KNMI (Royal Netherlands Meteorological Institute) closest seismic stations with publicly available data were chosen to evaluate input levels of seismic noise for the initial seismic network modeling.
- The closest stations locations are shown in the next slide.
  - NR.NE103: broadband sensor
    - No data since 21/06/2015
  - NR.NE104: broadband sensor
    - No data since 23/11/2015
  - NL.CIA01 to NL.CI10: microbarometers
    - 0 to 1 m-depth
    - Cannot be use
  - NL.ZH010 to NL.ZH014: borehole sensors
    - 1 accelerometer + 4 geophones
    - depths TVD? (not in the metadata) – from 0 to 200 m
- Data and metadata available on http://rdsa.knmi.nl/dataportal/
- Selected 1 week of data (outside school holidays).

Noise Levels for the Initial Modeling
KNMI Public Stations



Noise Levels for the Initial Modeling
KNMI stations – Data quality – PSD calculation

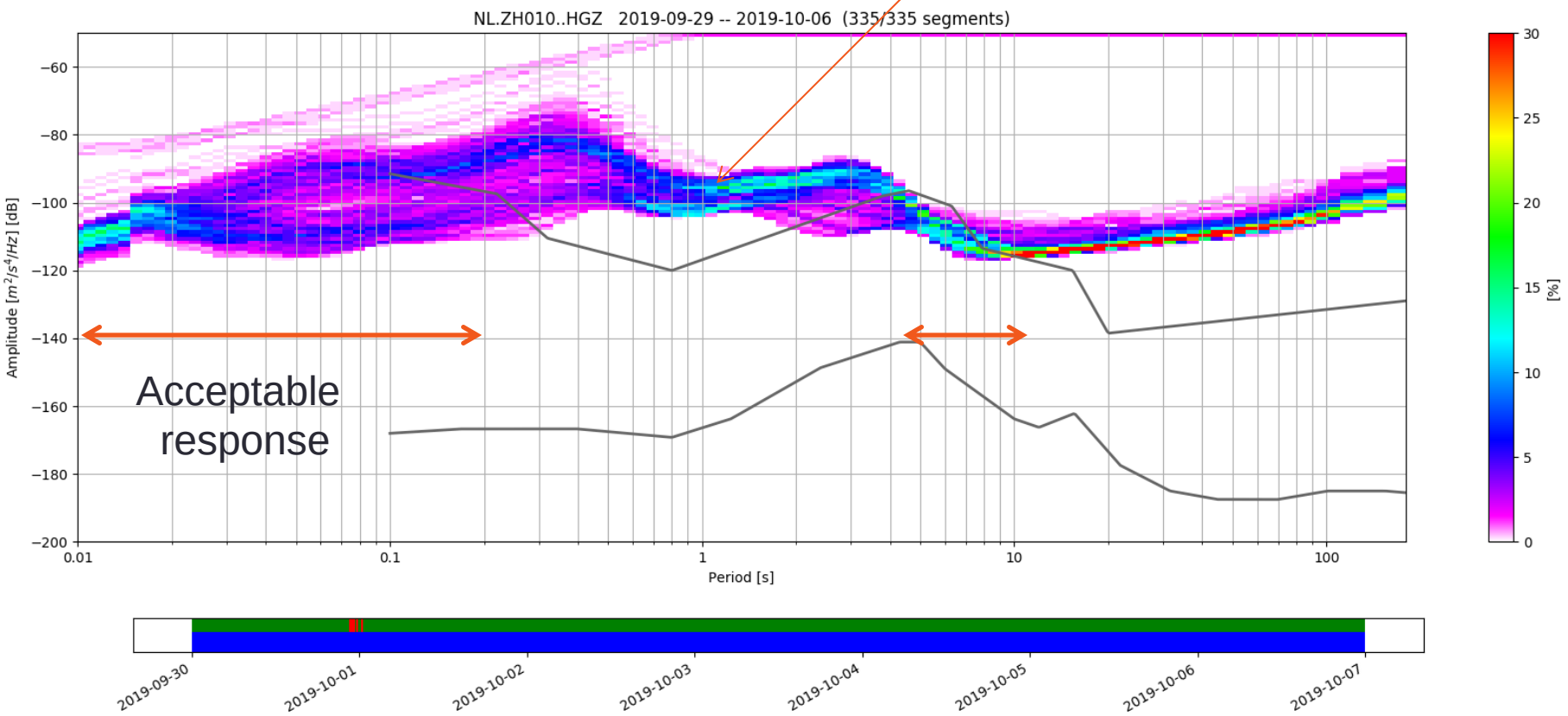
- The quality of available data was verified before the noise level was calculated.

- Power Spectral Density (PSD):
  - Response at all frequencies
  - Reference: Peterson's high and low noise model curves = accepted standard curves for expected limits of seismic noise.
  - Except exceptional noise, response should be between the Peterson's curves. If not, sensitivity of the acquisition has been modified and instrument is probably compromised.

- Calculated for each component of each sensor.

Noise Levels for the Initial Modeling KNMI stations – Example of PSD

- NL.ZH010.HGZ (accelerometer)

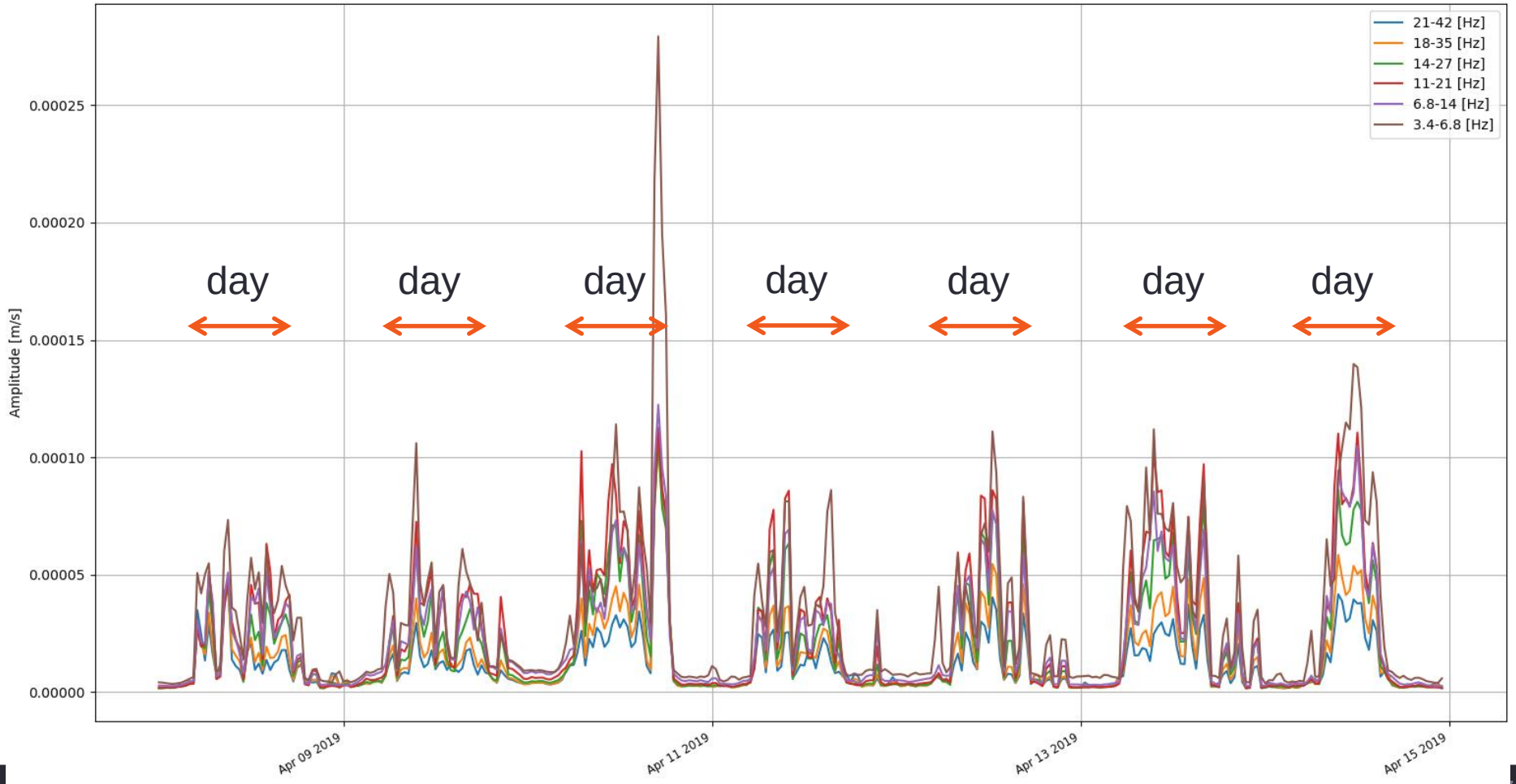


According to the sensor specification: response should be good from 1-2 Hz, which is not the case here. The acquisition has probably derived (which is frequent for long term installations)

Acceptable response for frequencies > 5 Hz

Noise Levels for the Initial Modeling
KNMI stations – Example of variation of noise level / Hz

- NL.ZH010.HGZ (accelerometer → integrated absolute signal)
  - Disregarding frequencies > 50 Hz (which will be filtered, as higher than the expected events frequencies at the level of the station)
  - Main variations between night and days



Noise Levels for the Initial Modeling
KNMI stations – Average Noise level

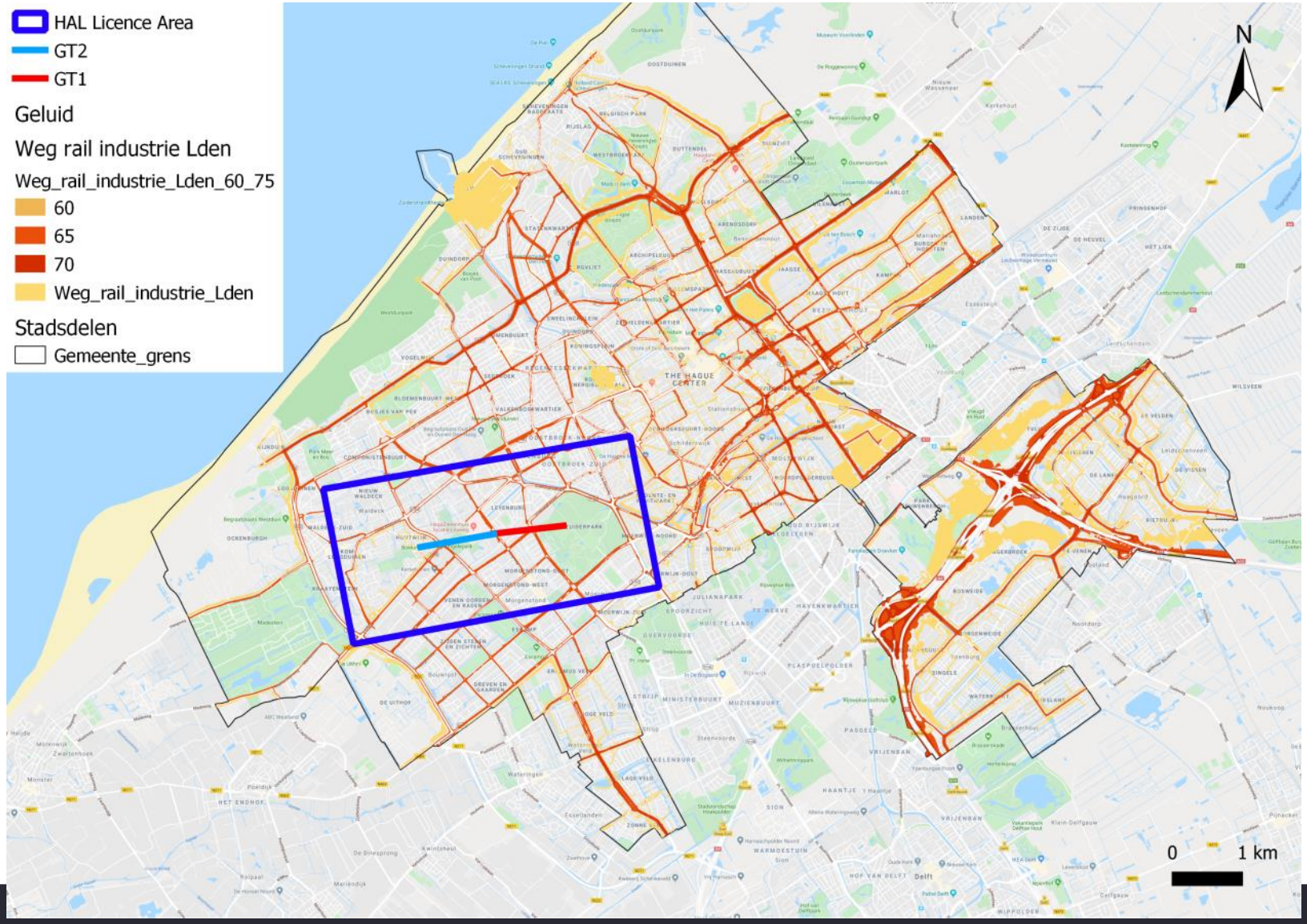
- Main differences are between night and day
- The average noise, for each sensors, has been calculated from the values of the 90-th percentile of the noise, between 6 and 31 Hz:

Stations	90th percentile Noise (m/s)
NR.NE103	5E-06
NR.NE104	1.4E-05
NL.ZH010	4E-05 (night ~1-05)
NL.ZH011 (50 m-depth)	4E-06
NL.ZH012 (100 m-depth)	2.5E-06
NL.ZH013 (150 m-depth)	1E-06
NL.ZH014 (200 m-depth)	1E-06

⇒ High noise in the area
⇒ Burrying the sensors at 50 m-depth could help to reduce the noise by 10

Acoustic Noise map

- "Geluidsbelasting in Den Haag 2016" : indicator of anthropic activity



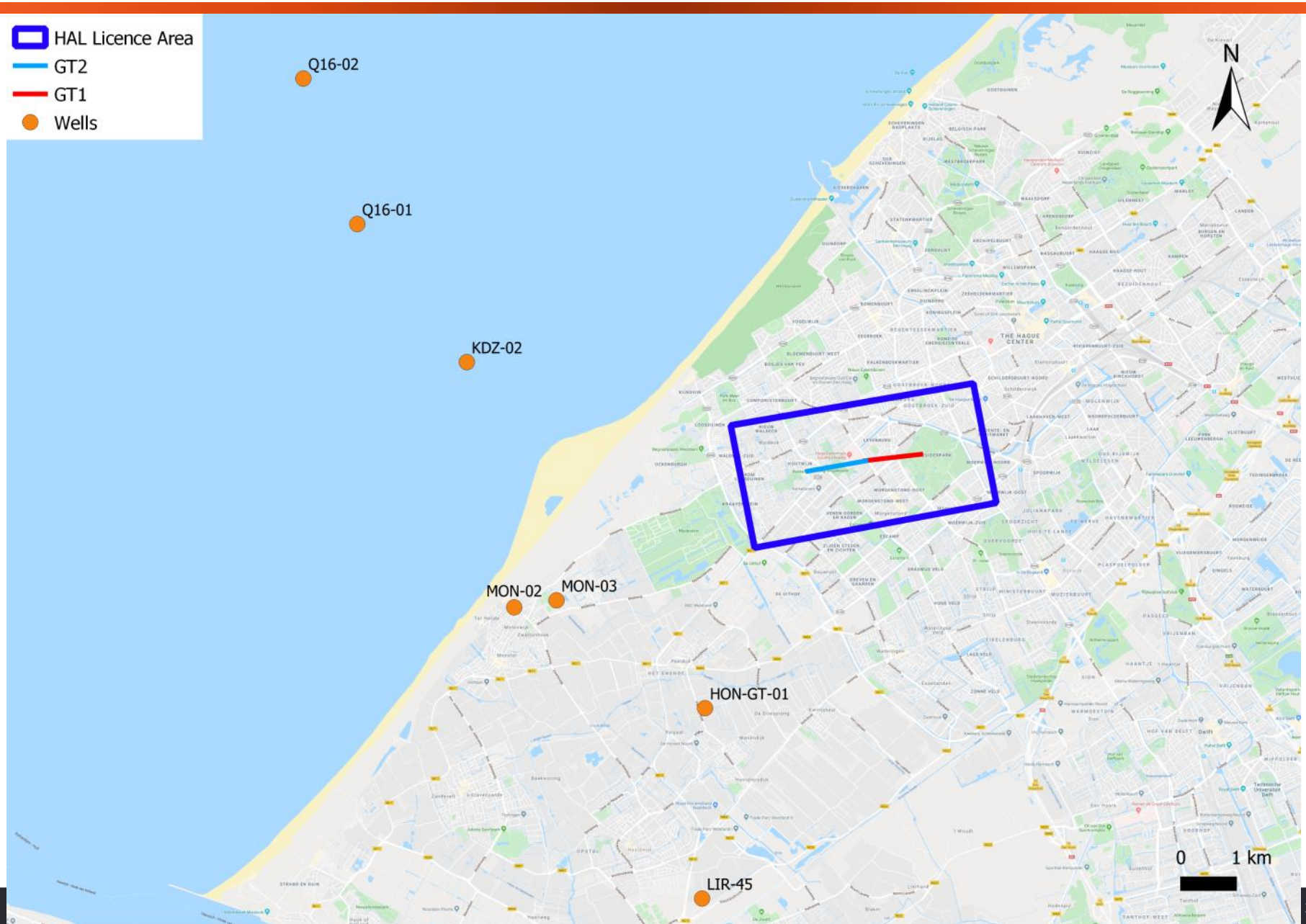
Velocity Model for the Initial Network Modeling Sonic Logs

- **Available Sonic Logs:**

Wells	Latitude	Longitude	Top (m)	Bottom (m)
LIR-45	51.98447	4.22456	749	3909
HON-GT-01	52.01535	4.22535	2136	3146
KDZ-02	52.07143	4.16263		
MON-02	52.03169	4.17511	550	2639
MON-03	52.03283	4.18625	6888	10418
Q16-01	52.09379	4.13380	91	2623
Q16-02	52.11734	4.11960		
PNA-13	Not found			

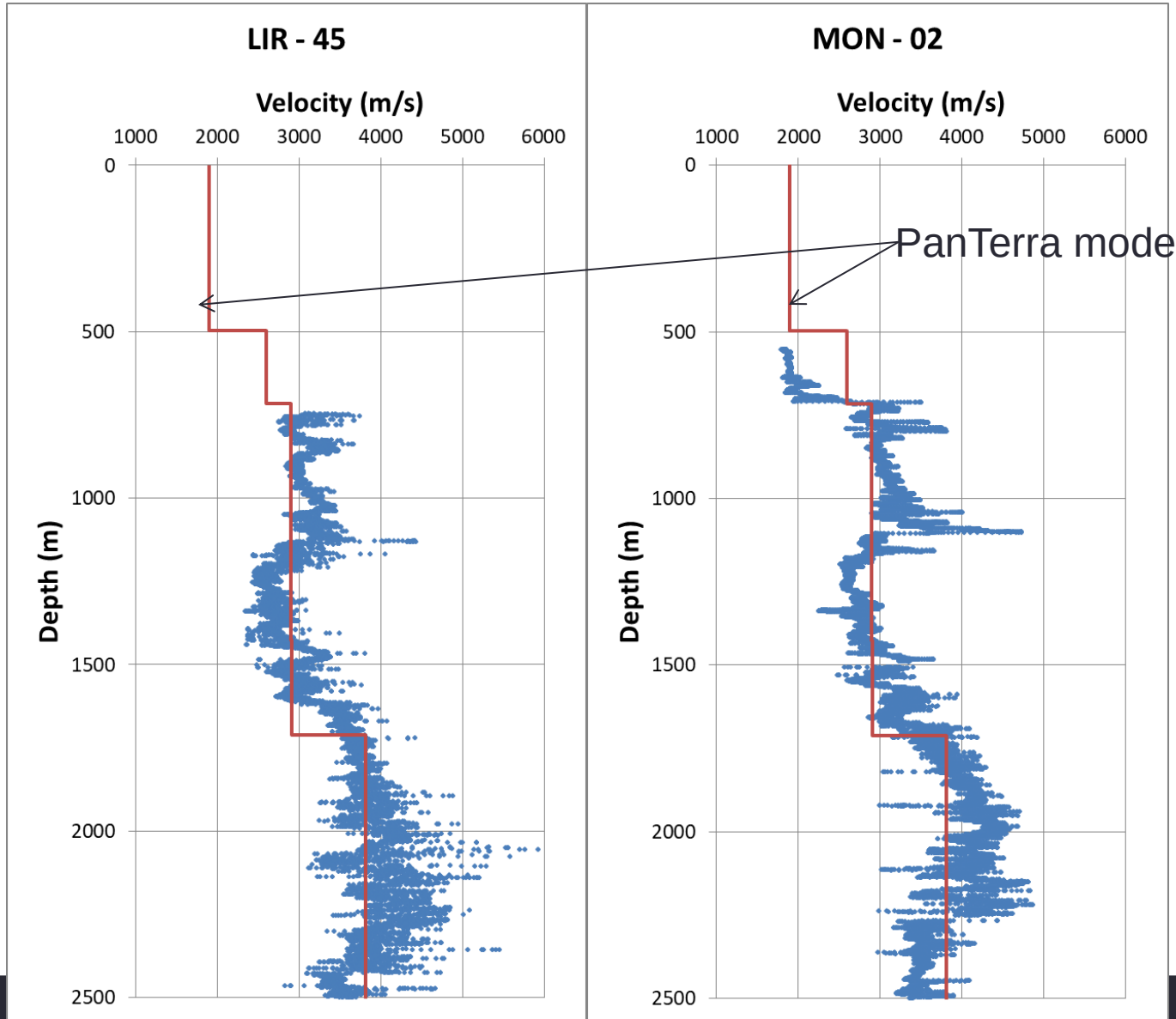
- **No dipole sonic found → V_P/V_S taken from the article:** An integrated shear-wave velocity model for the Groningen gas field, The Netherlands, Bulletin of Earthquake Engineering, September 2017, Volume 15, Issue 9, pp 3555–3580, Pauline P. Kruiver et al., https://link.springer.com/article/10.1007/s10518-017-0105-y
  - ▶ See next slides for details

Velocity Model for the Initial Network Modeling Sonic Logs



Velocity Model for the Initial Network Modeling Sonic Logs

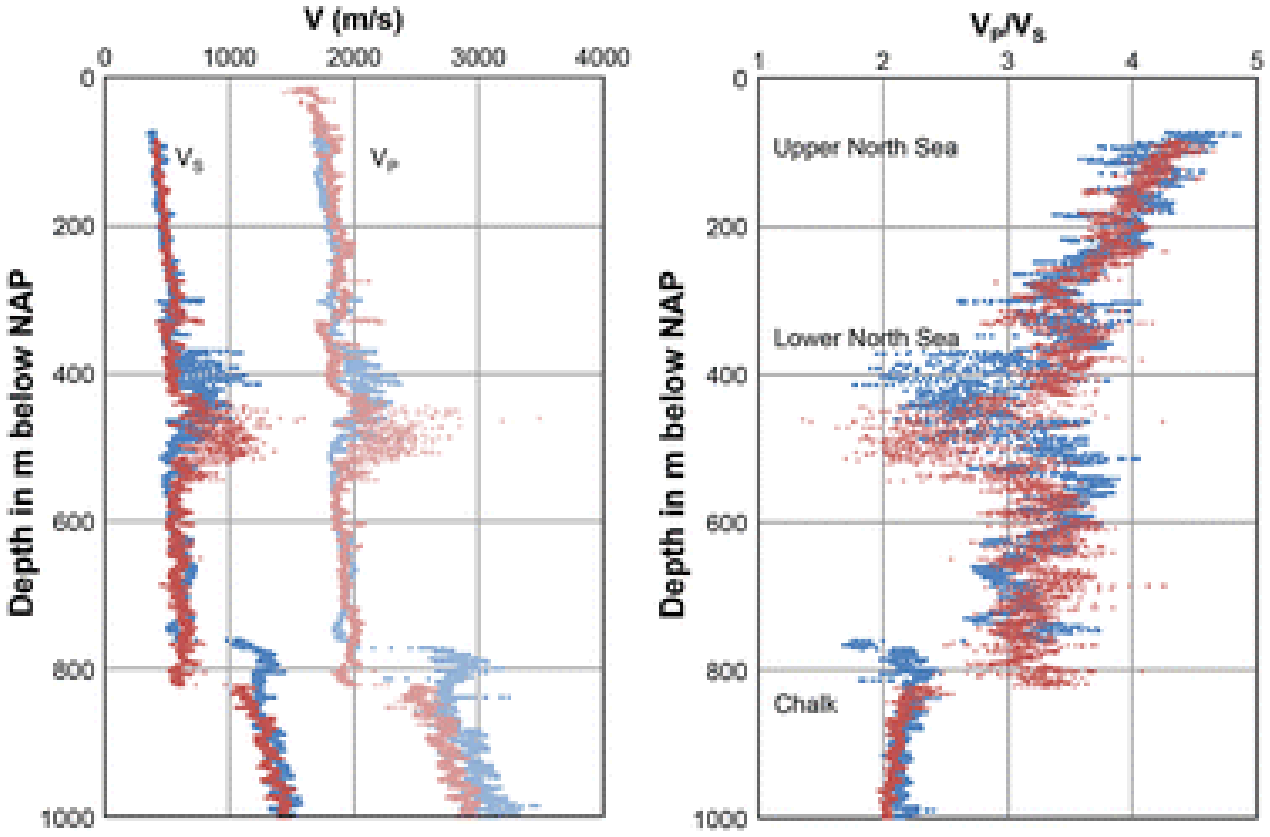
- Comparison with PanTerra 1D-model for P-waves



Velocity Model for the Initial Network Modeling Vp/Vs

- Groningen gas field data were used
- Vp/Vs = 3.2 above 800 m
- Vp/Vs = 2.0 bellow 800 m

Similar P-waves as in PanTerra model



Other Inputs for the Initial Modeling

Seismik

Results of the initial network modeling are presented on the following pages.
Three input levels of noise were used.
A four stations monitoring array was used for the modeling, in addition a five stations monitoring array is modeled for one noise level.
Two sets of output are presented – minimum detectable magnitude and location accuracy in horizontal and vertical direction.

- **Noise Level (three levels of noise were evaluated):**
  - Best case scenario noise level: 5E-06 m/s
  - Average case scenario noise level: 1E-05 m/s
  - Worst case scenario noise level: 5E-05 m/s
- **Velocity model:**
  - PanTerra 1D-model for P-waves
  - Vp/Vs from published data for Groningen field. Uncertainty.
  - P- and S-wave Q-factor: 70 – uncertainty, probably not constant
- **Minimum number of station to detect an event:** 3 (usual, needed to locate)
- **Minimum SNR:** 2 (usual)
- **Target depth:** 2 km (usual)

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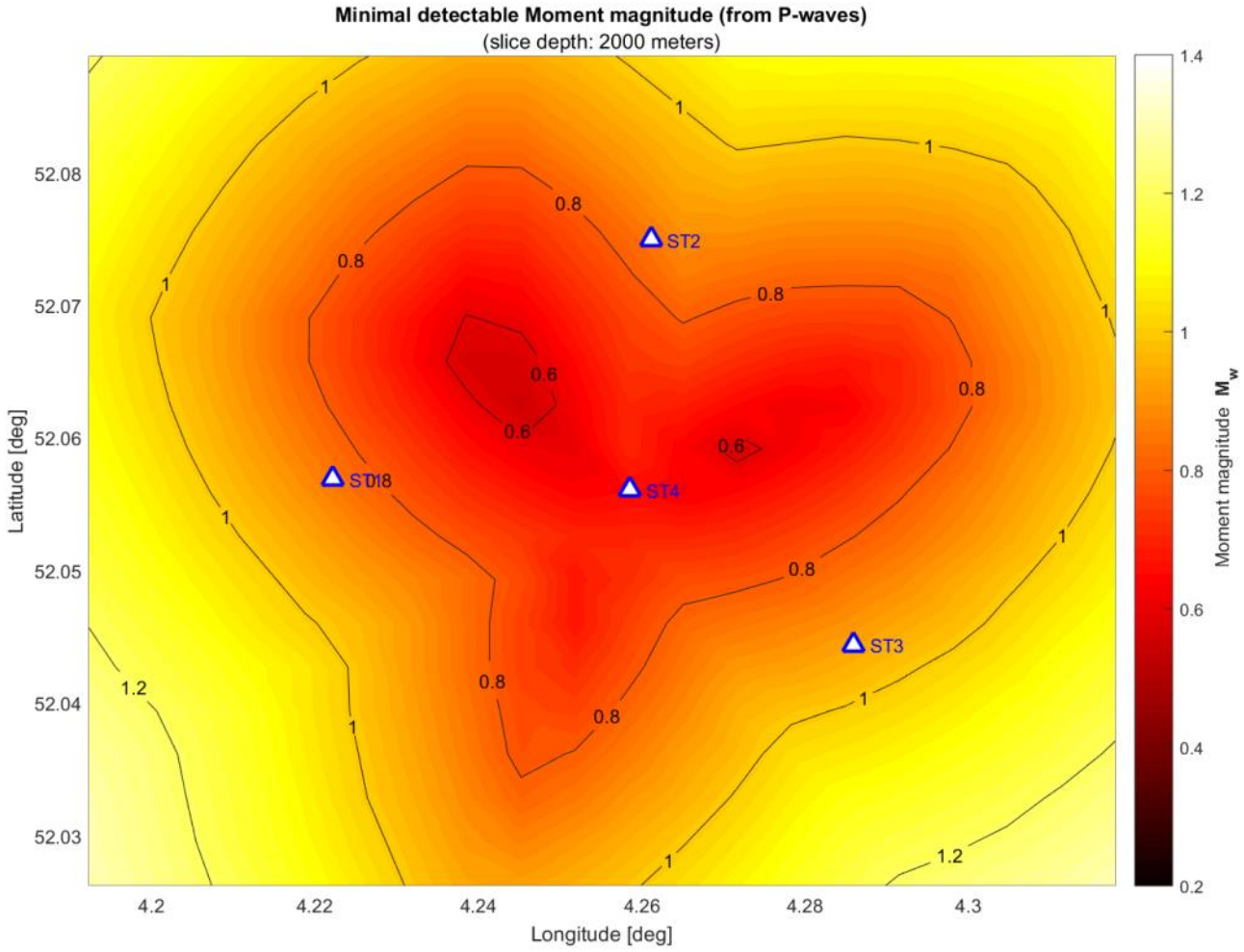
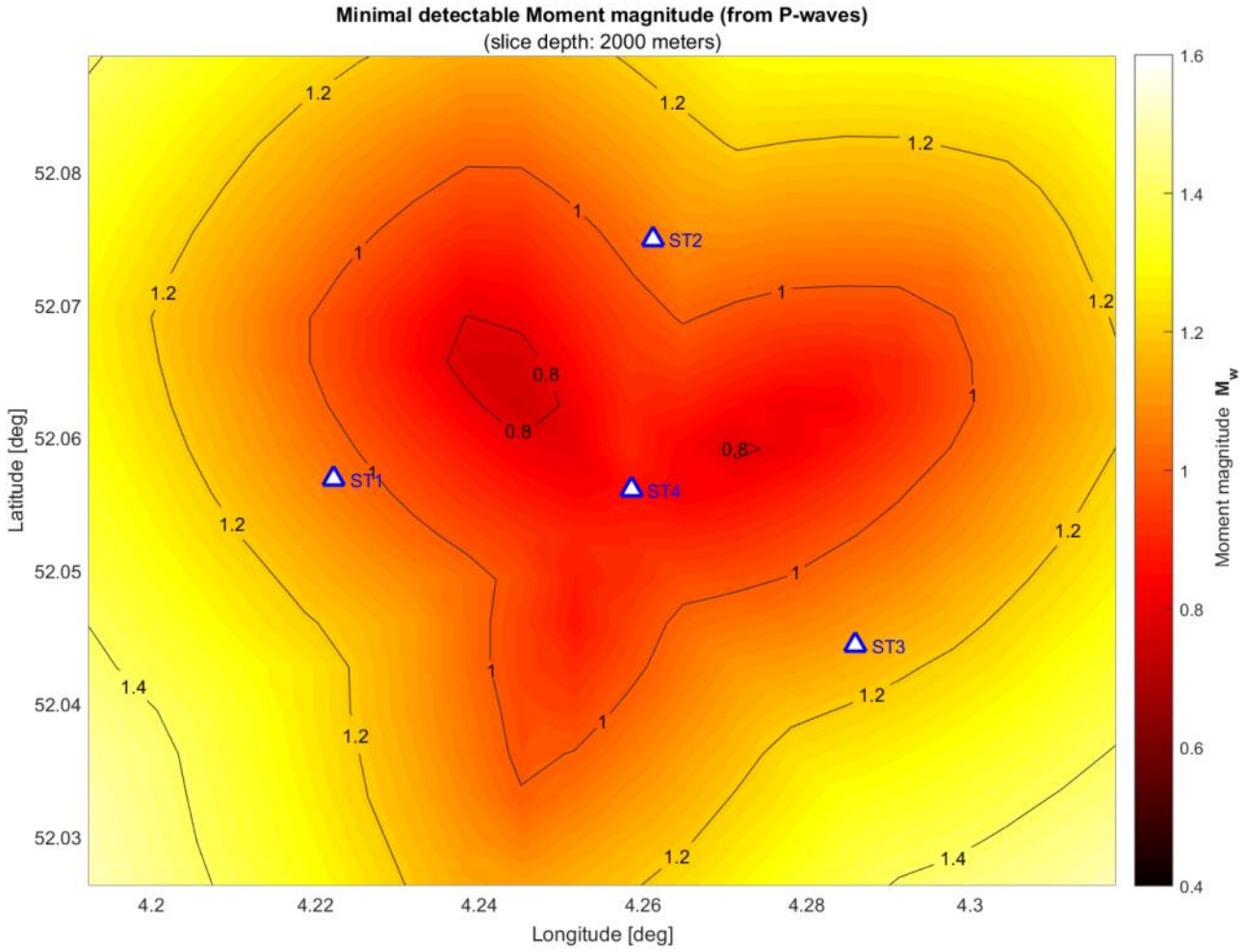
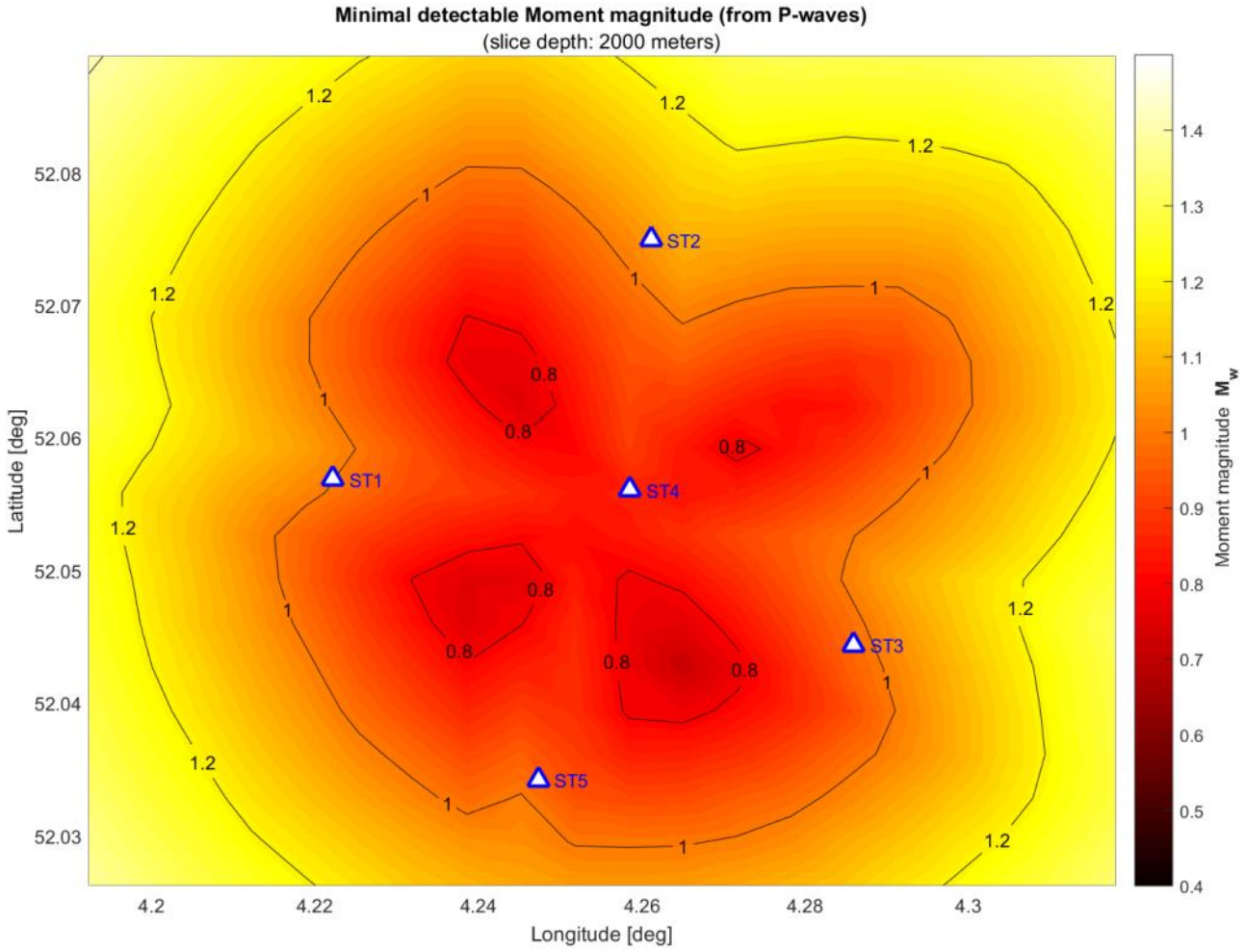
Network Modeling
Best case scenario – Minimum detectable magnitude



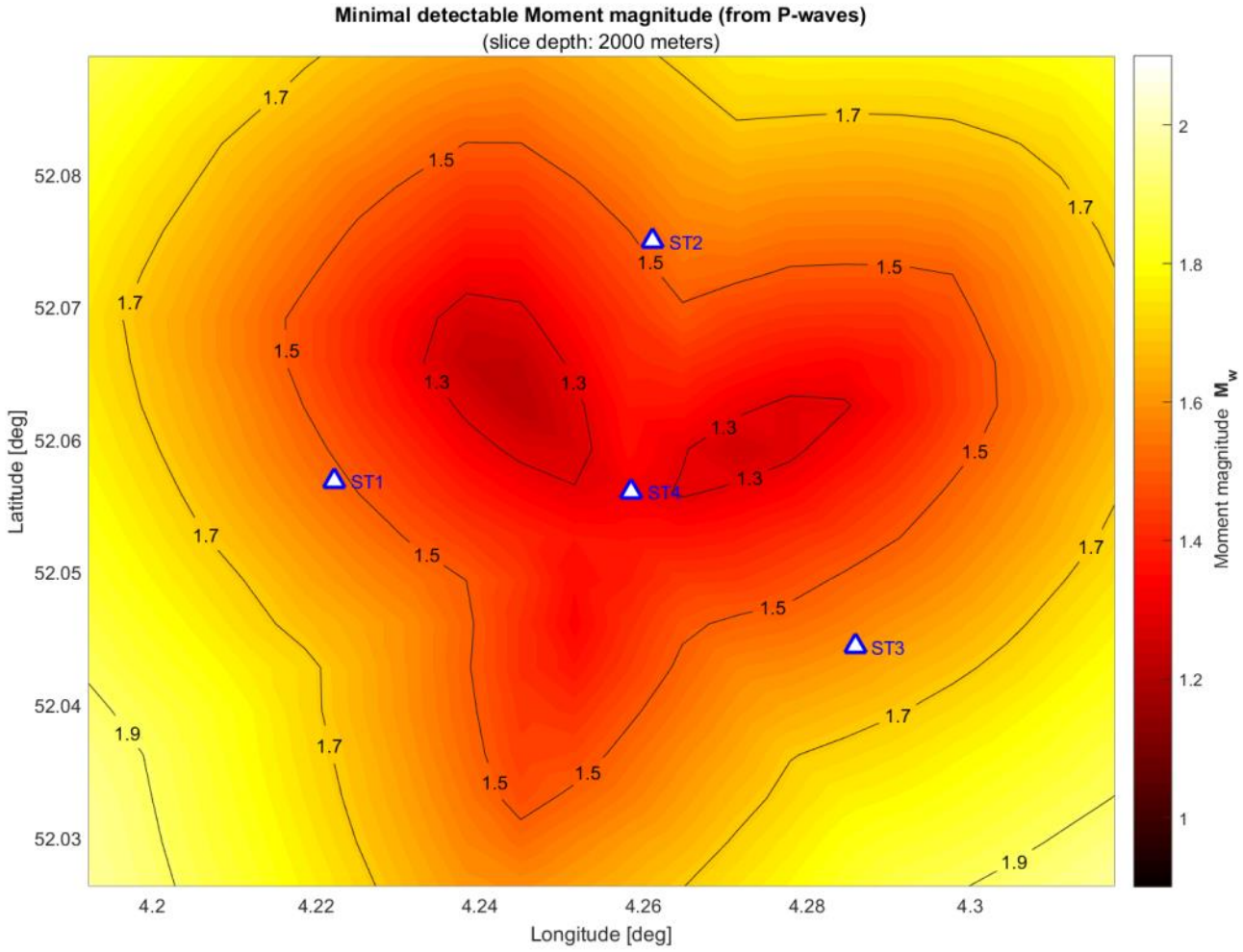
Network Modeling
Average case scenario – Minimum detectable magnitude



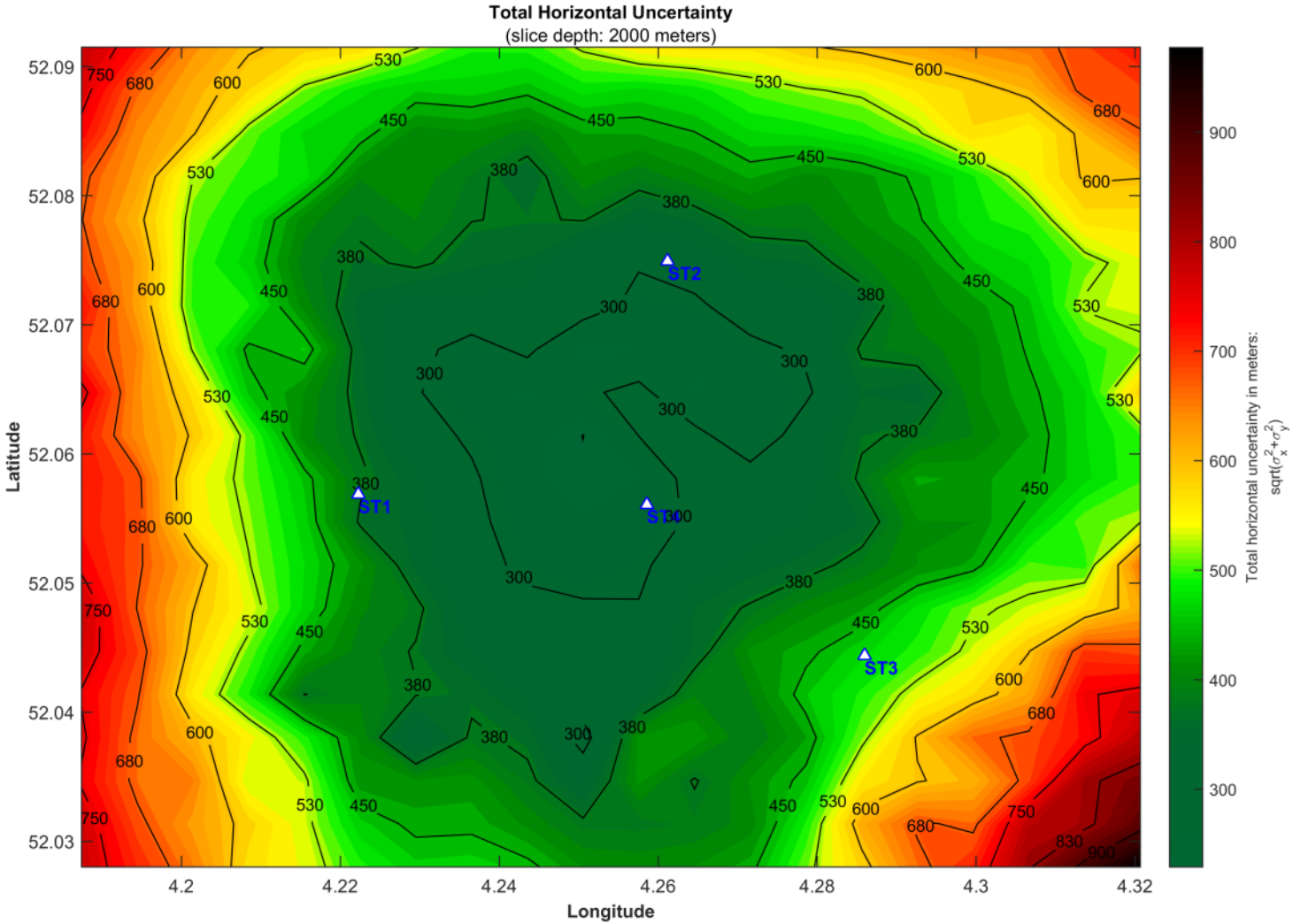
Network Modeling (Five stations)
Average case scenario – Minimum detectable magnitude



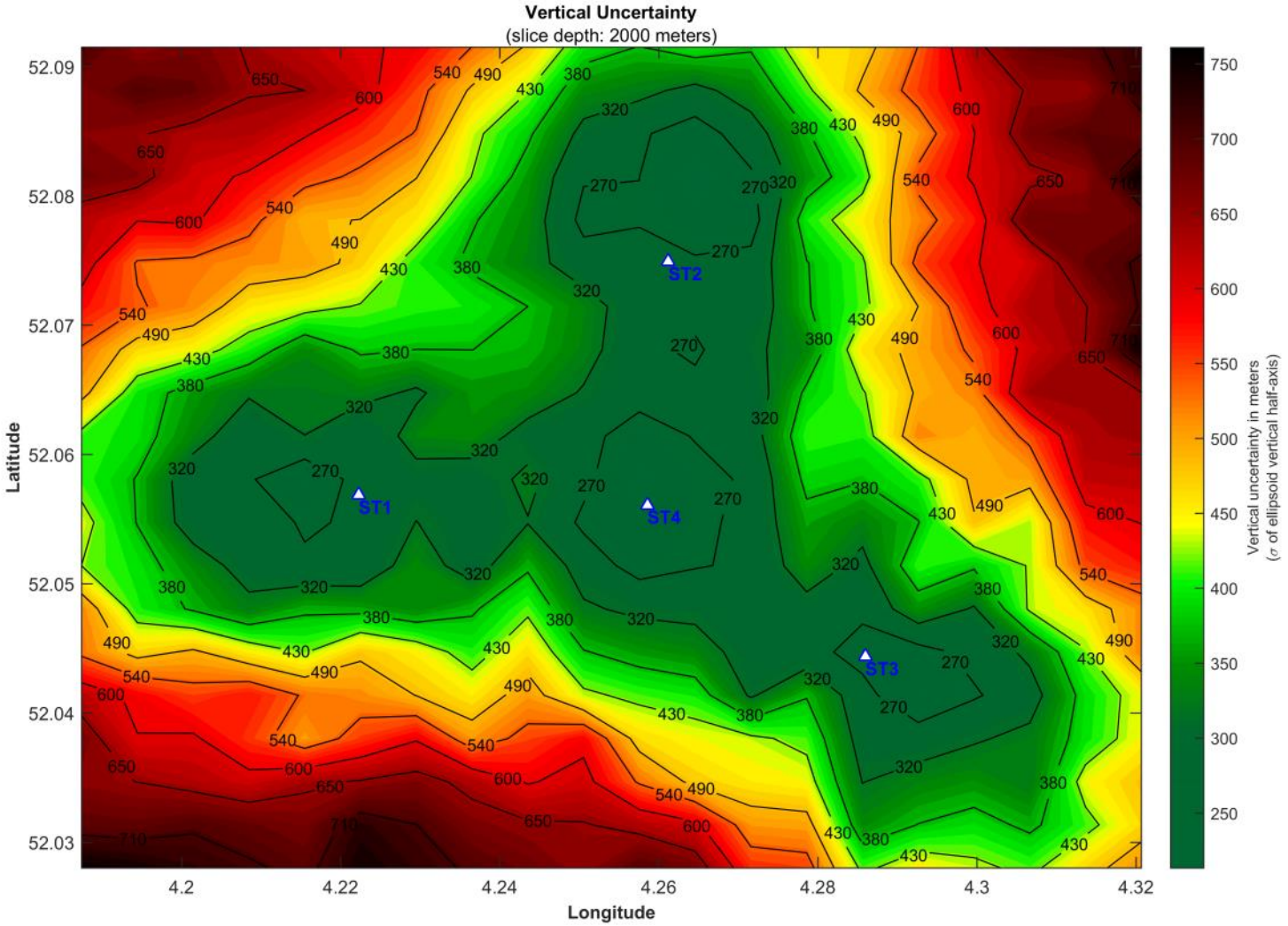
Network Modeling
Worst case scenario – Minimum detectable magnitude



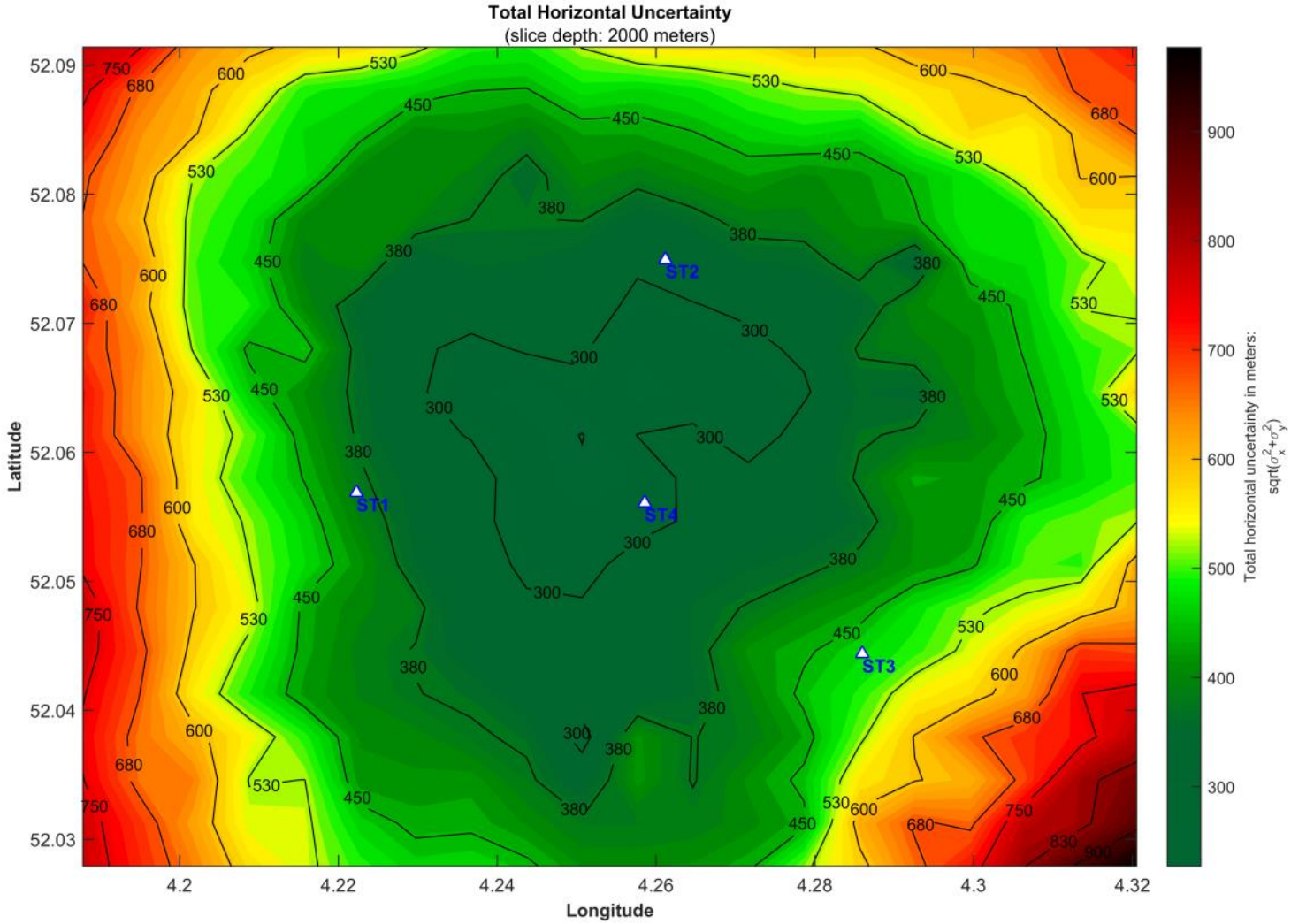
Network Modeling
Best case scenario – Horizontal location accuracy



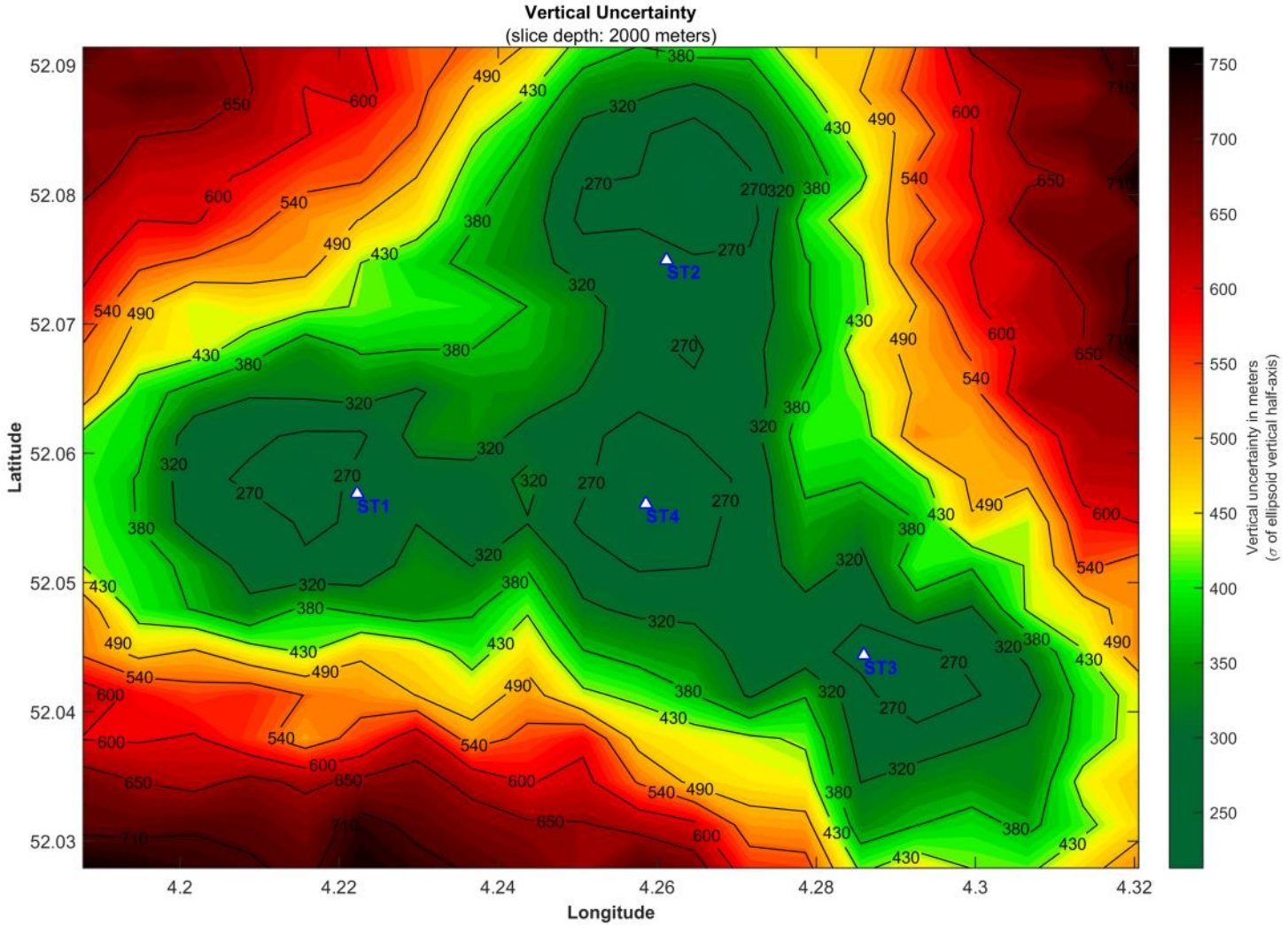
Network Modeling
Best case scenario – Vertical location accuracy



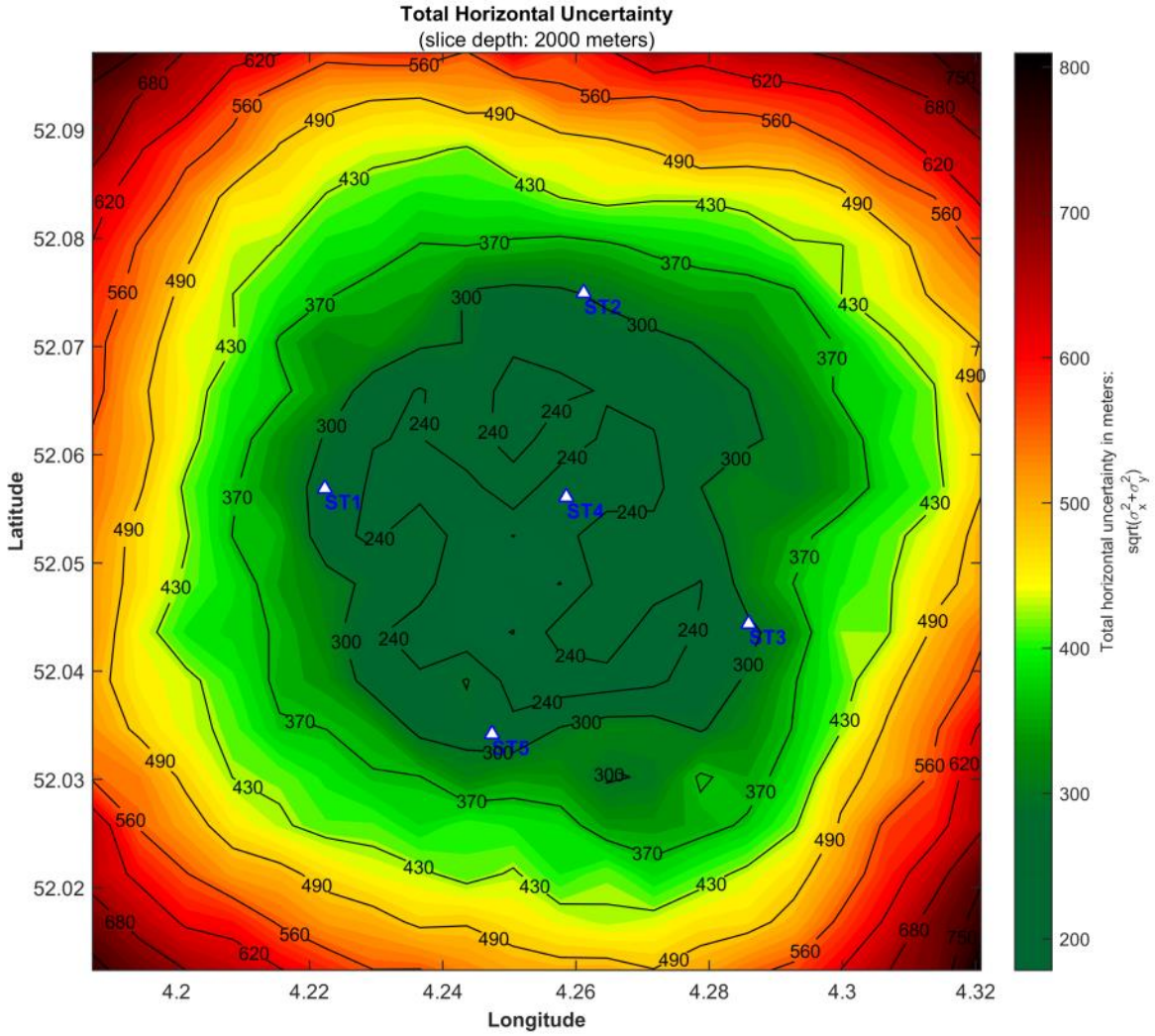
Network Modeling
Average case scenario – Horizontal location accuracy



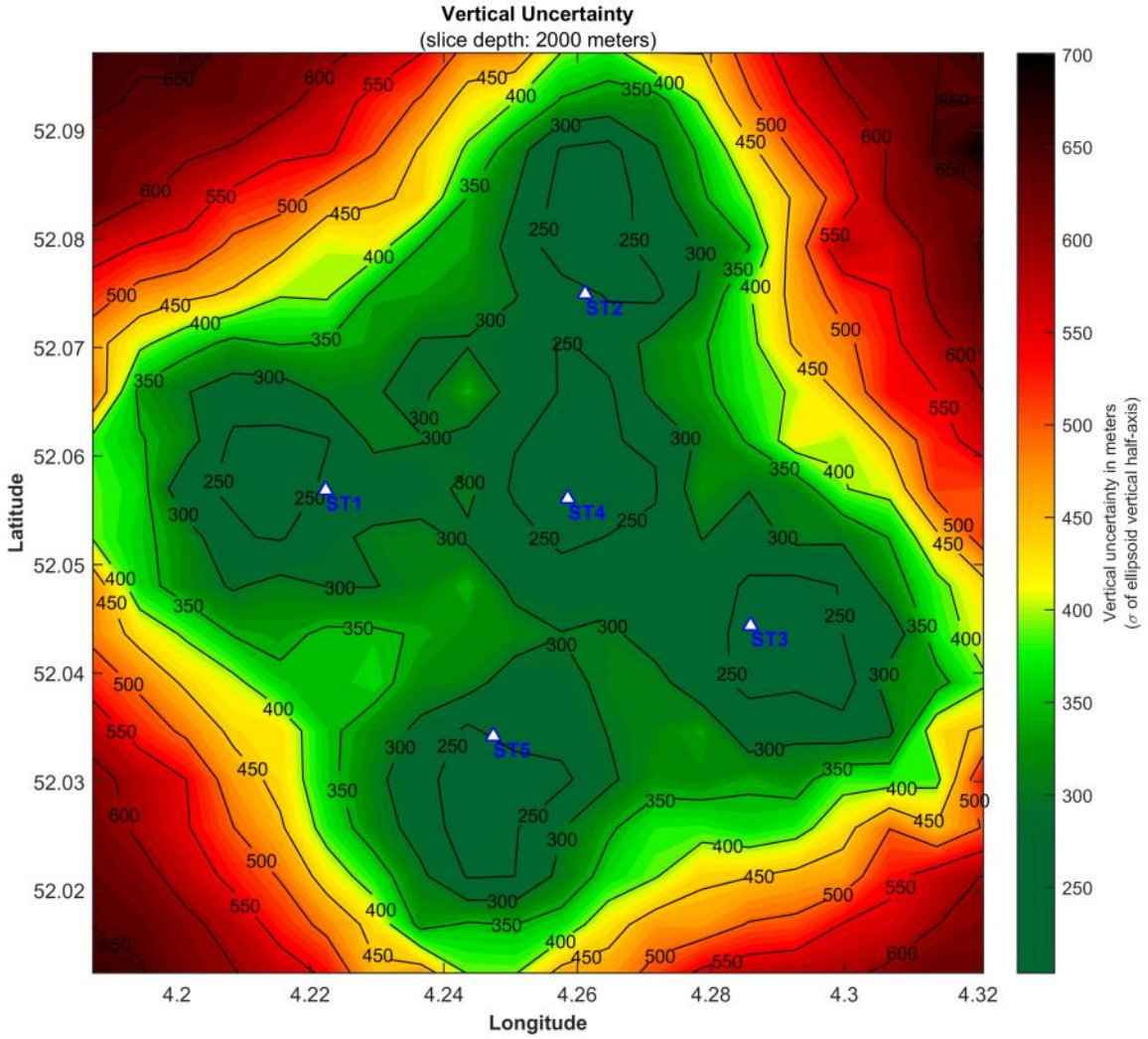
Network Modeling
Average case scenario – Vertical location accuracy



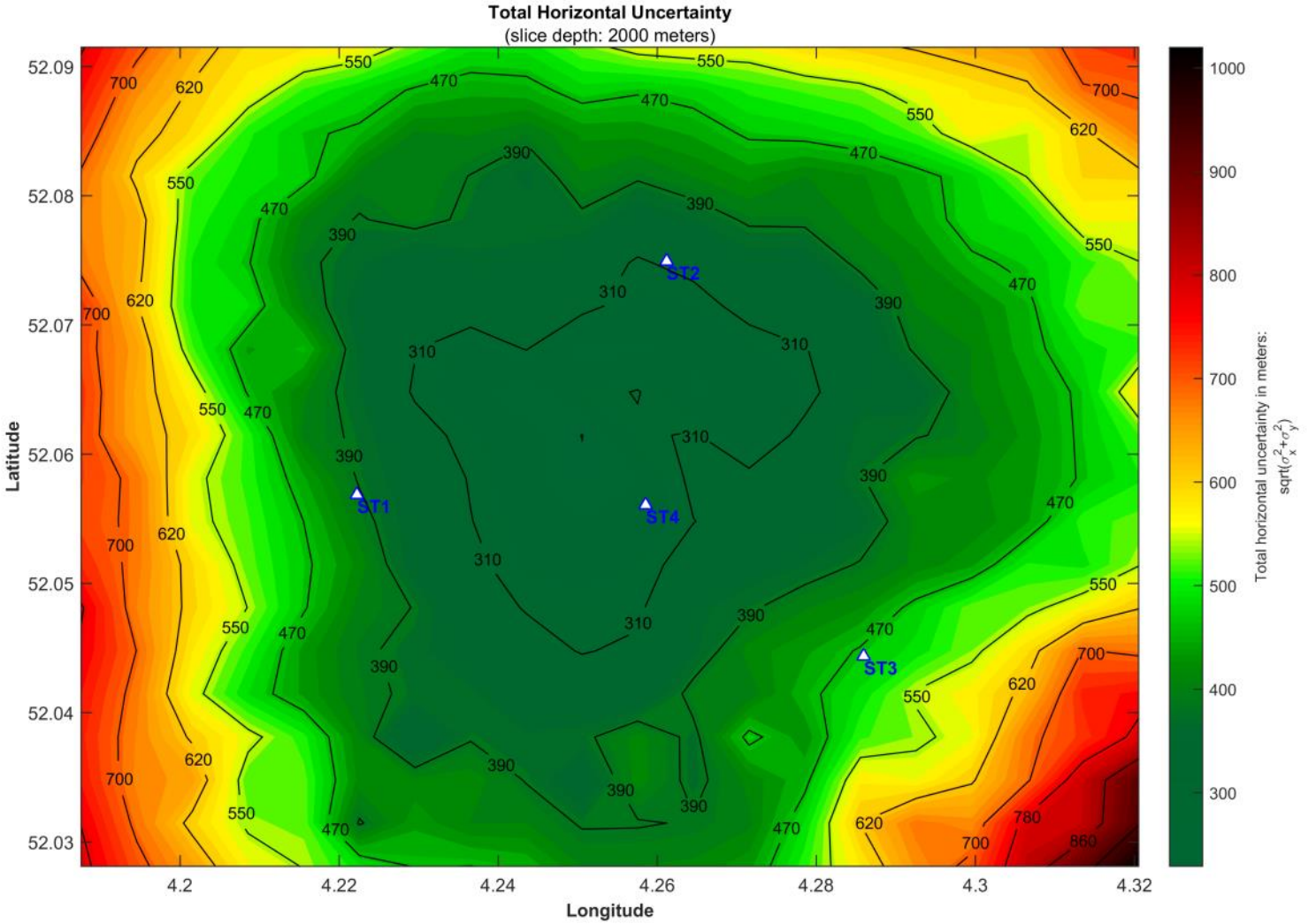
Network Modeling (Five stations)
Average case scenario – Horizontal location accuracy



Network Modeling (Five stations)
Average case scenario – Vertical location accuracy



Network Modeling
Worst case scenario – Horizontal location accuracy



Network Modeling
Worst case scenario – Vertical location accuracy