

Trade-off between signal coherence and ambient noise (3C) beamforming results in a complex noise environment



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1 Core Questions

- How coherent is the surface wavefield?
- Where do coherent signals come from?
- Of which wavetype are these signals?
- What can be seen at depth?

2 Study area and data set

- Euregio Meuse-Rhine – Maastricht-Liège-Aachen
 - ET candidate site
- Data from 4 geophone surface deployments
 - Including 3C sensors and dedicated array
- Borehole station TERZ.01 and surface station TERZ.00

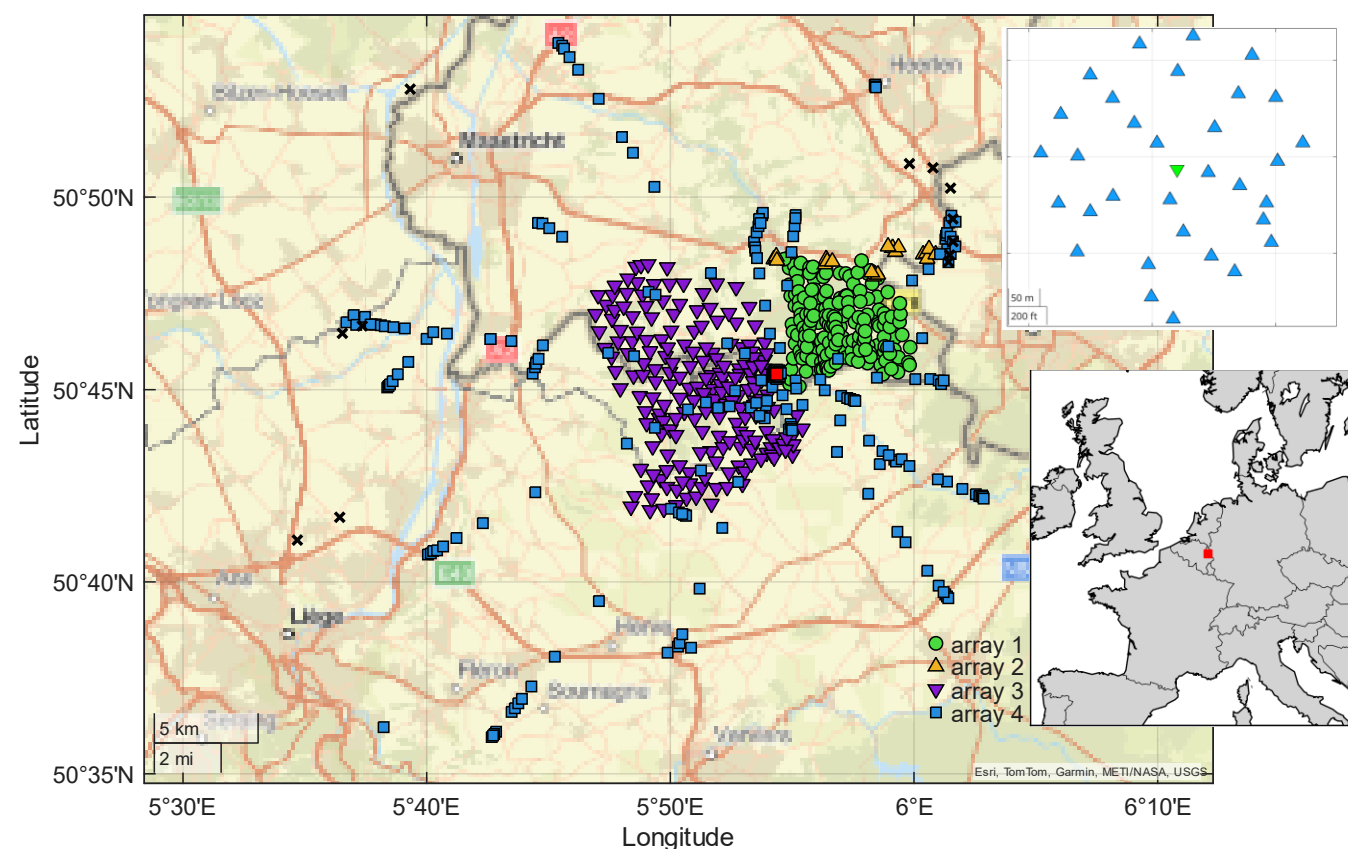


Fig. 1: Study region with four different surface deployments color coded, position of borehole station TERZ (red square) and wind farms (black crosses). Insets show geometry of TERZ subarray and geographic position of study site

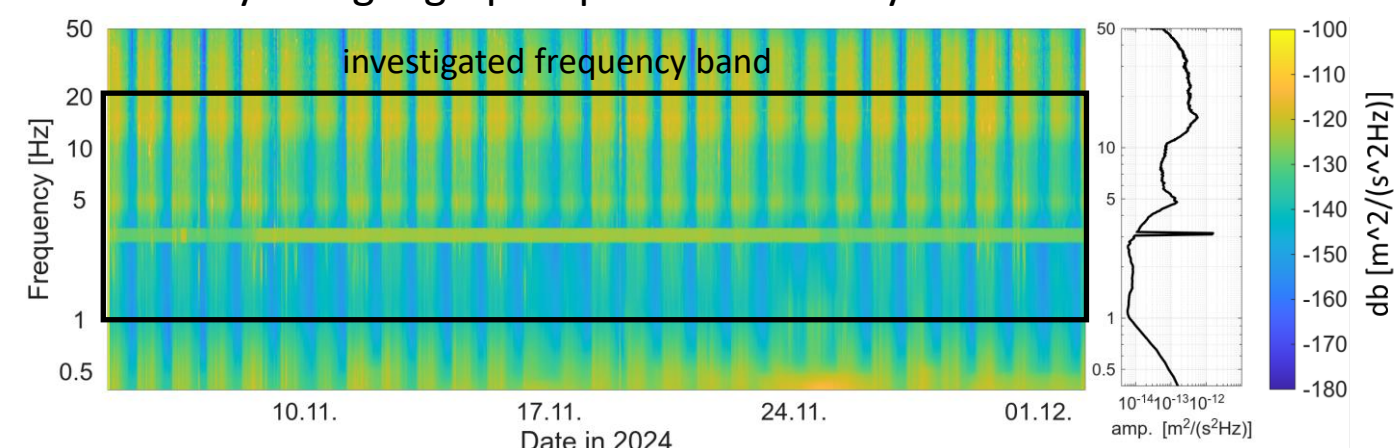


Fig. 2: Vertical component spectrogram and median spectra showing a clear diurnal pattern and an amplitude peak at 3.15 Hz.

3 Wavefield coherence

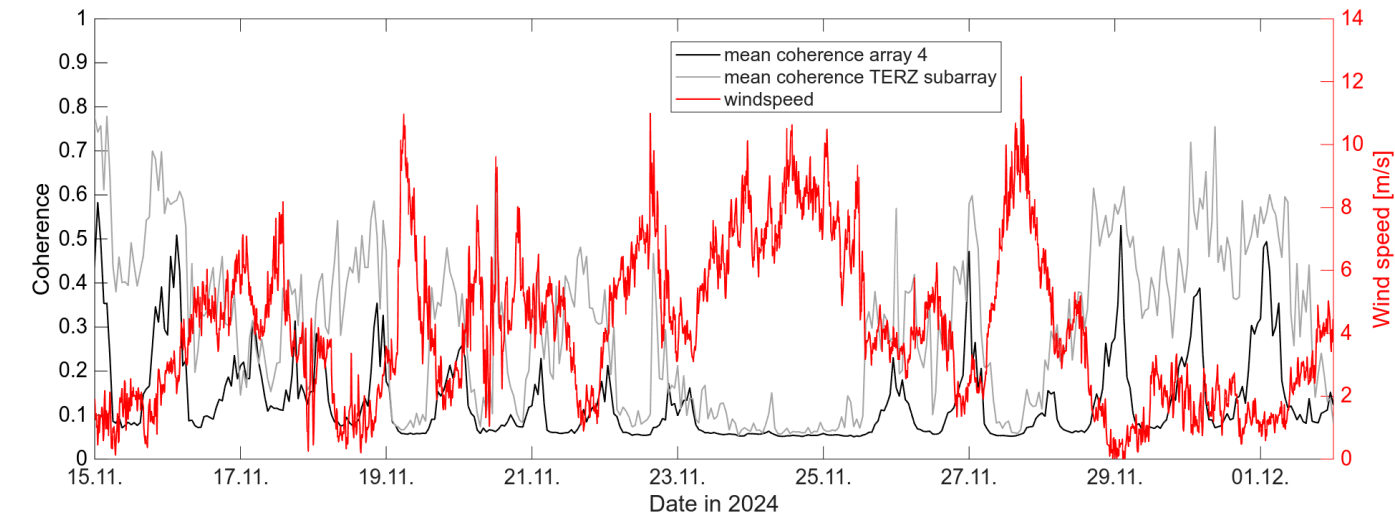


Fig. 3: Hourly surface wavefield coherence for array 4 and the TERZ subarray in the frequency band 2.5-5 Hz. Also shown is the wind speed. Note the diurnal pattern in the coherence for the complete array and the anti-correlation between coherence and windspeed.

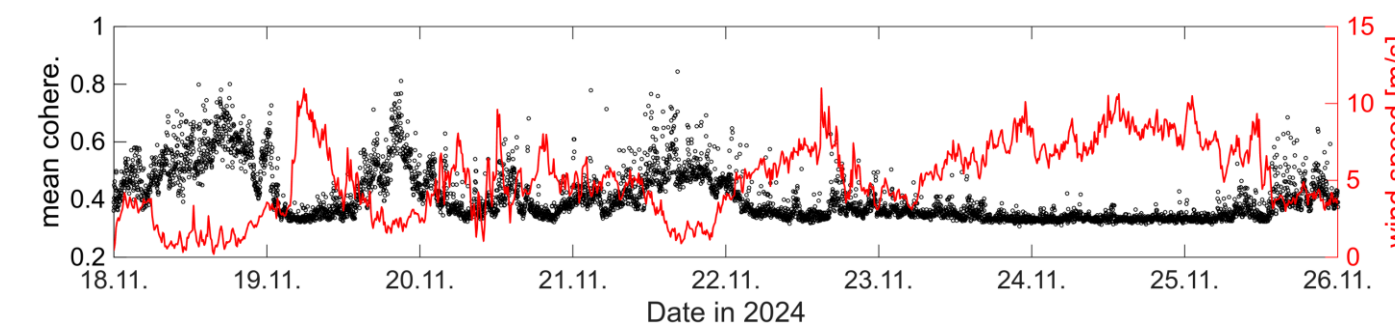


Fig. 4: 2-minute surface wavefield coherence for the TERZ subarray in the frequency band 2.5-5 Hz. Also shown is the wind speed.

4 Signal sources and wave types

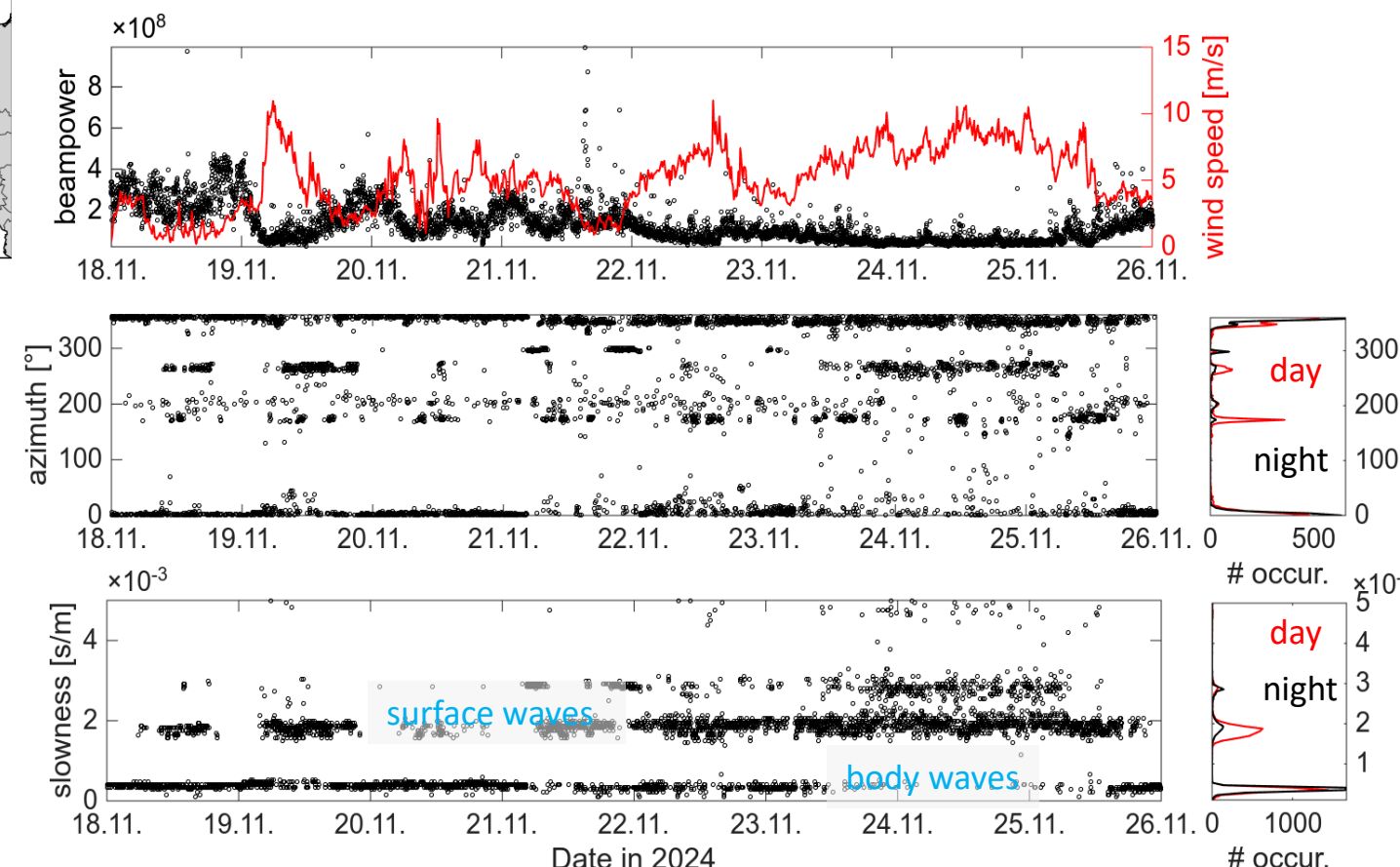


Fig. 5: Results of traditional Z-component beamforming for the frequency band 2 – 3.5 Hz for the TERZ subarray. Shown are maximum beampower (top), and azimuth (middle) and slowness (bottom) corresponding to the maximum beampower value.

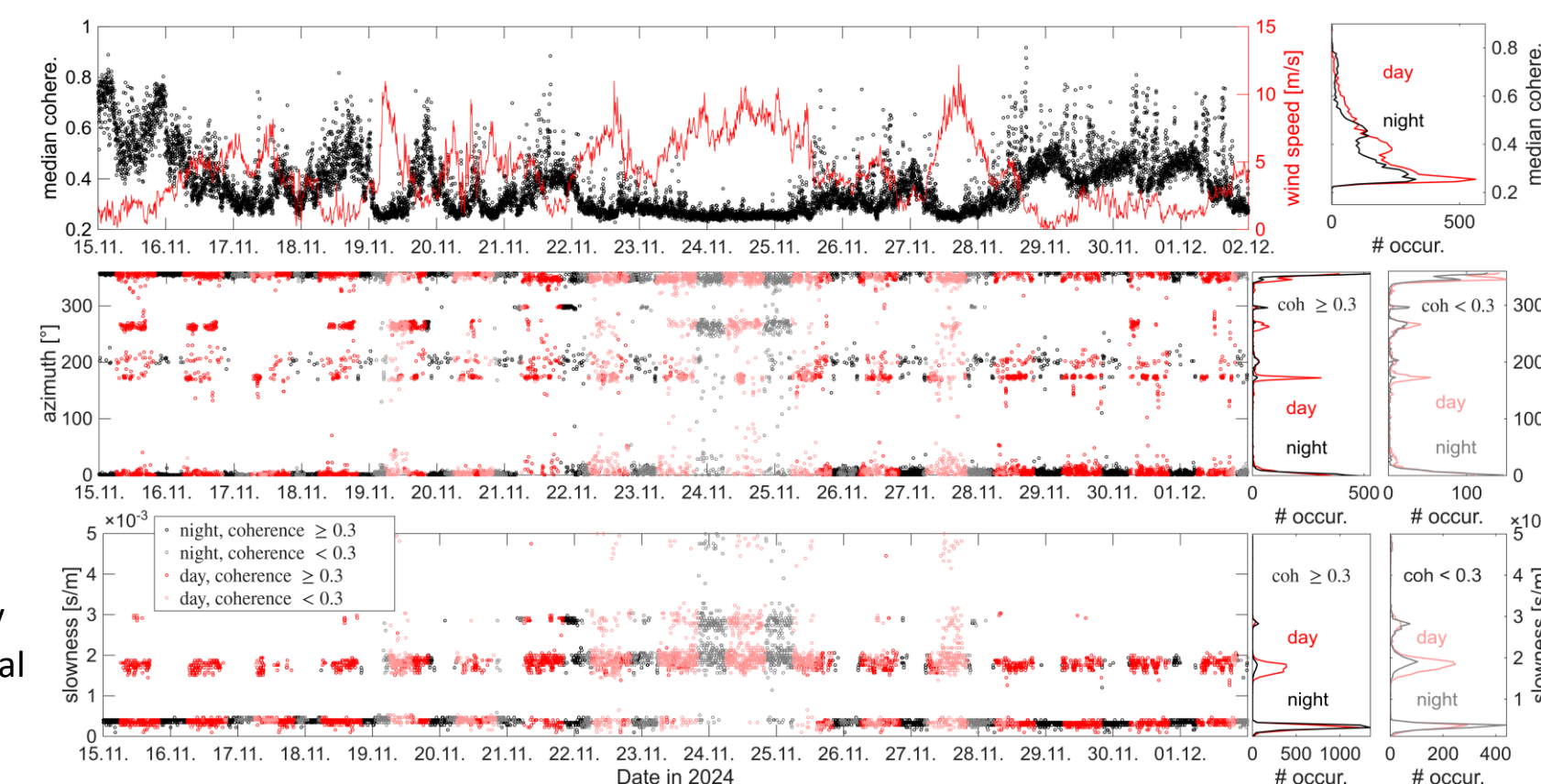


Fig. 6: Traditional Z-component beamforming results for the TERZ subarray for the frequency band 2.8 – 3.4 Hz broken down for day/night and higher/lower coherence values. From inspection of station spectrograms, the day interval was set to 07:00-21:00 local time and the coherence threshold was set to 0.3 was in agreement with the distribution of coherence values.

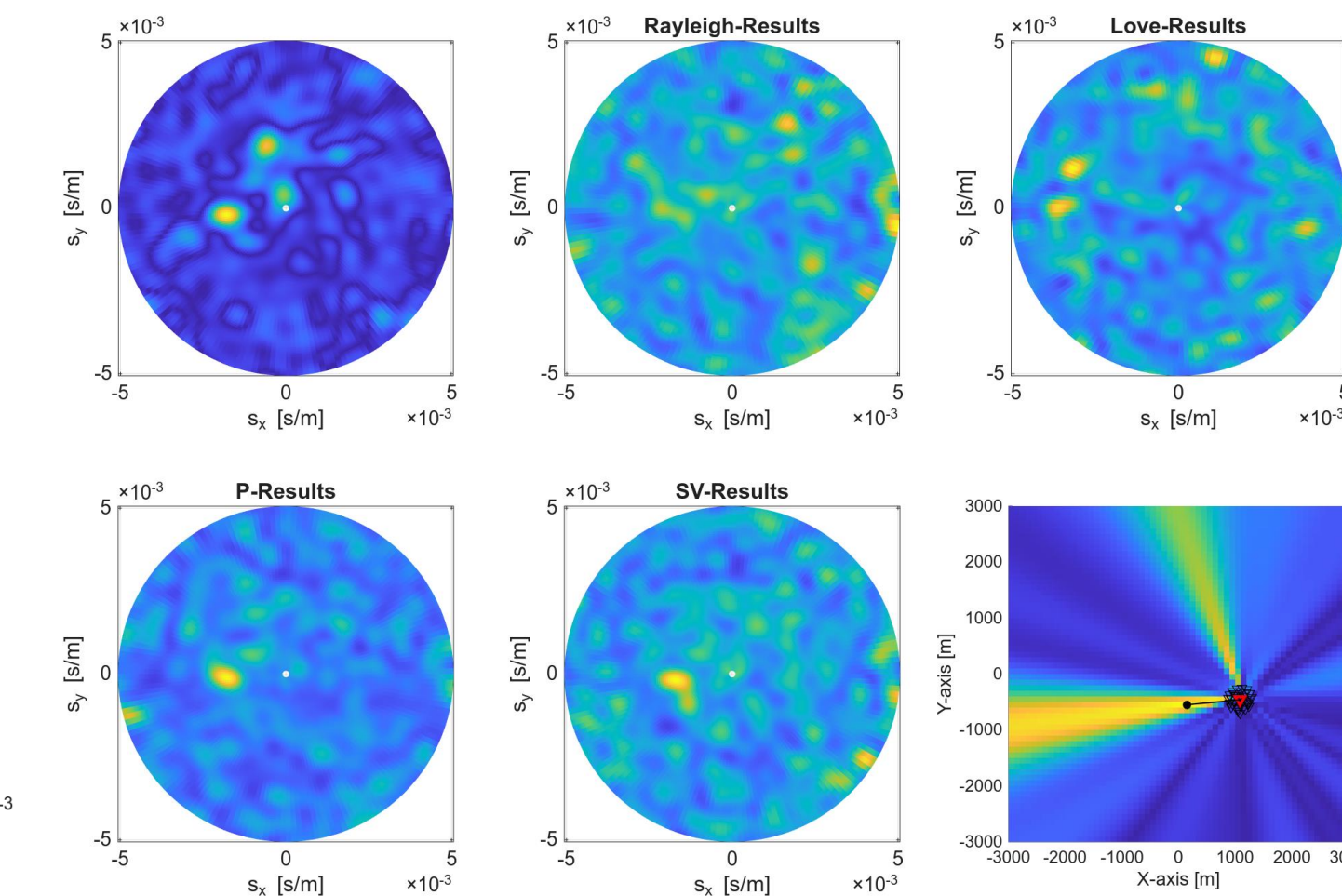


Fig. 7: Traditional z-component beamforming, polarization analysis with 3C beamforming for different wave types and MFP with velocity information from beamforming. Evaluated for a 2-min time slice on 19.11.2024 at 18:00 UTC for the TERZ subarray.

5 Signals at depth

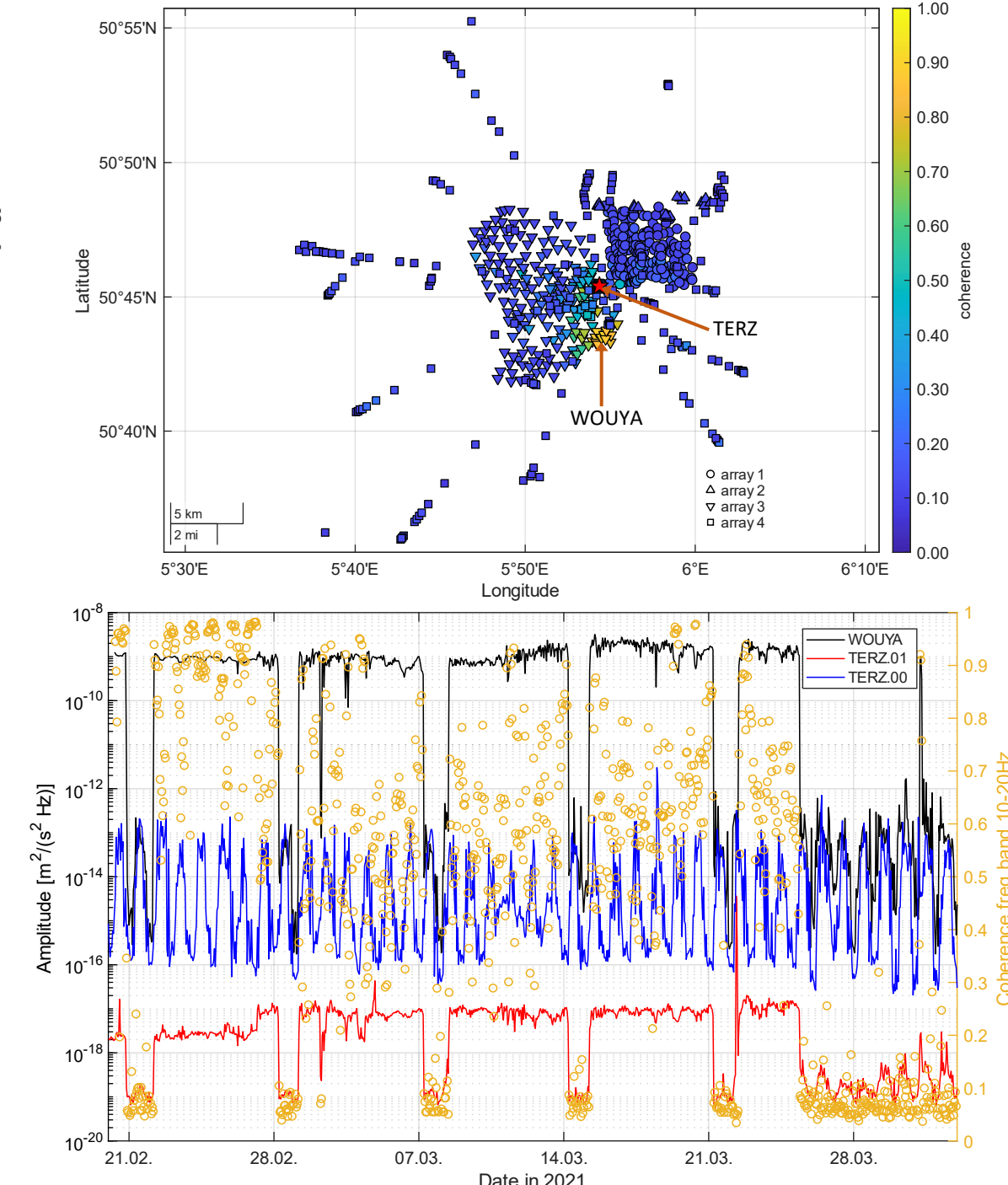


Fig. 8 top: 90th percentile of hourly coherence values for the vertical component of surface stations in comparison with TERZ.01 in the frequency band 10-20 Hz. **bottom:** Temporal spectral amplitude comparison of vertical component data of surface stations WOUYA and TERZ.00 and downhole station TERZ.01downhole station at frequency 12.5 Hz.

6. Takeaway

- Coherence strongly wind/distance dependent
- Signals with diurnal azimuth patterns
- Surface and body wave are present
- Distinct sources recorded at depth