Karlsruhe Institute of Technology

Ground motion emissions due to wind turbines: Results from two wind farms on the Swabian Alb

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Inter-Wind project

- Characterization and prediction of wind turbine (WT) emissions
- Psychological surveys of affected residents on the Swabian Alb, SW Germany
- Acoustic, **ground motion** and meteorological **measurements** to support psychological surveys

Inter-Wind project

Key findings:

- Similarities in acoustic and ground motion data
- WT signals are measureable but below human perception thresholds
- Infrasound and ground motion amplitudes do not explain annoyance

Gaßner et al., 2022
(Renewable Energy)

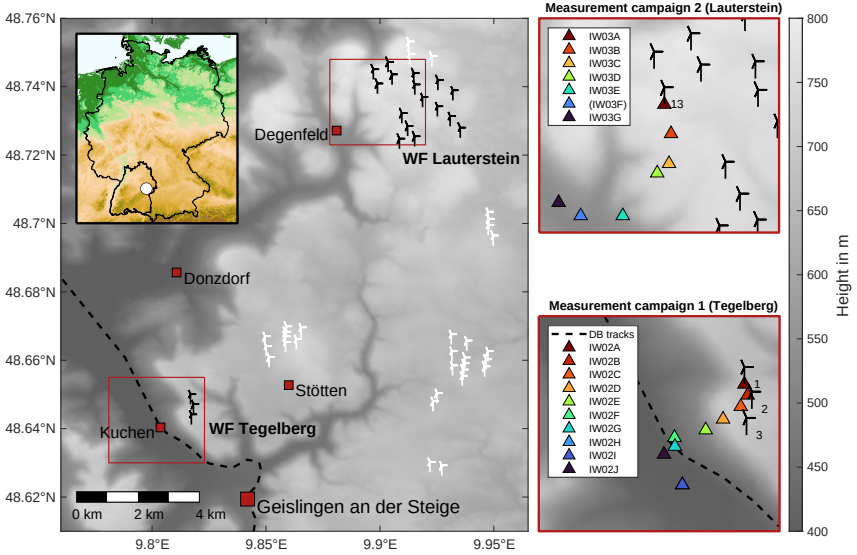
Campaigns

WF Lauterstein:

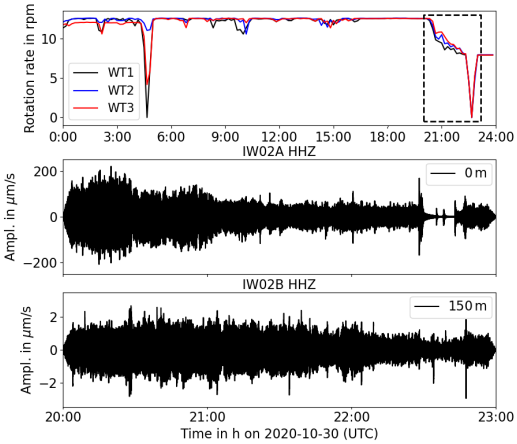
- 8 % annoyed residents
- 7 seismometers (200 Hz sampling)

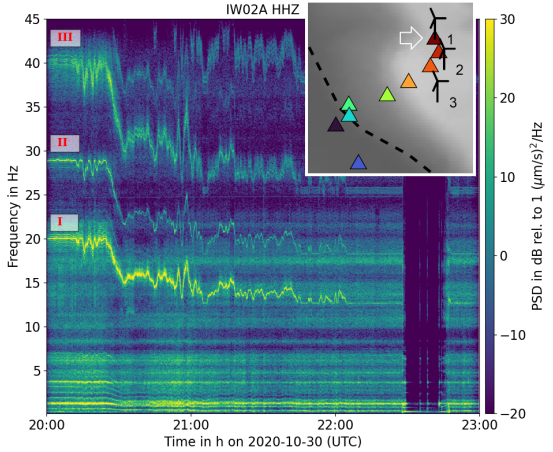
WF Tegelberg:

- 33 % annoyed residents
- 10 seismometers (100 Hz sampling)



Ground motion signals due to WT operation





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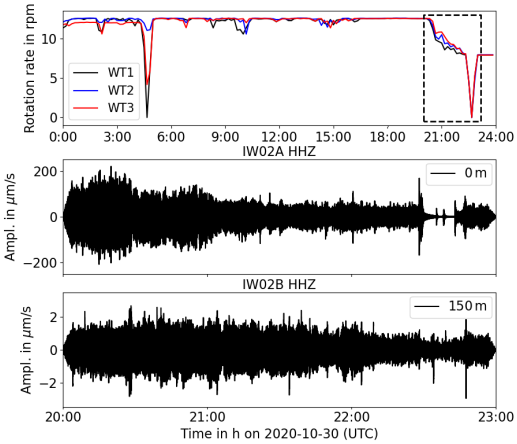

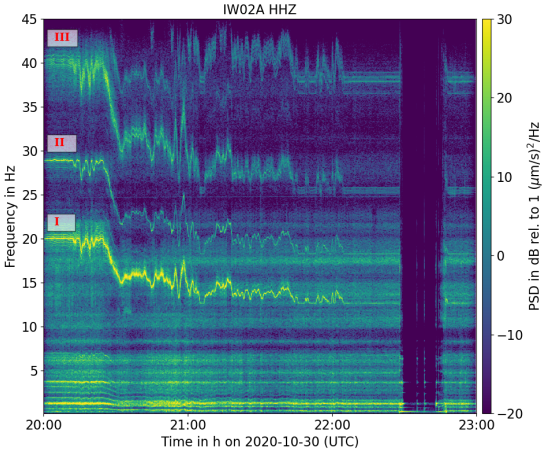

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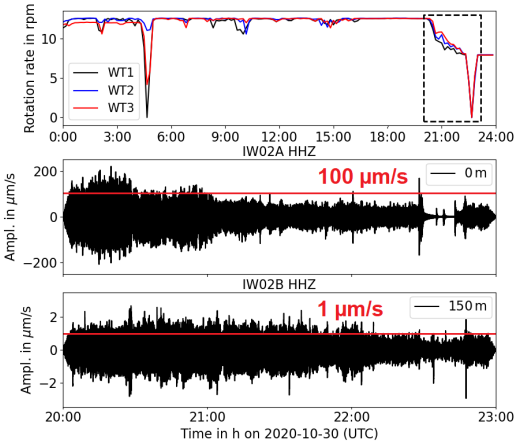
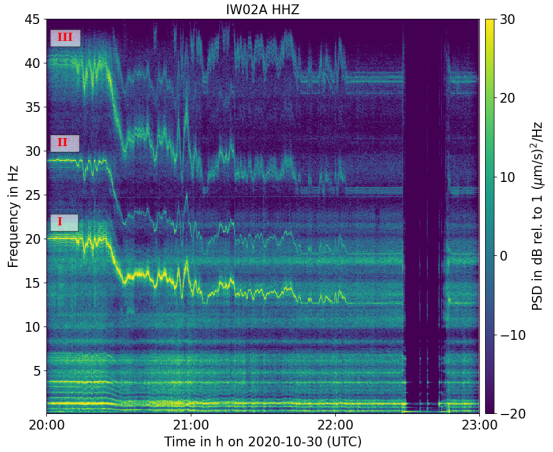
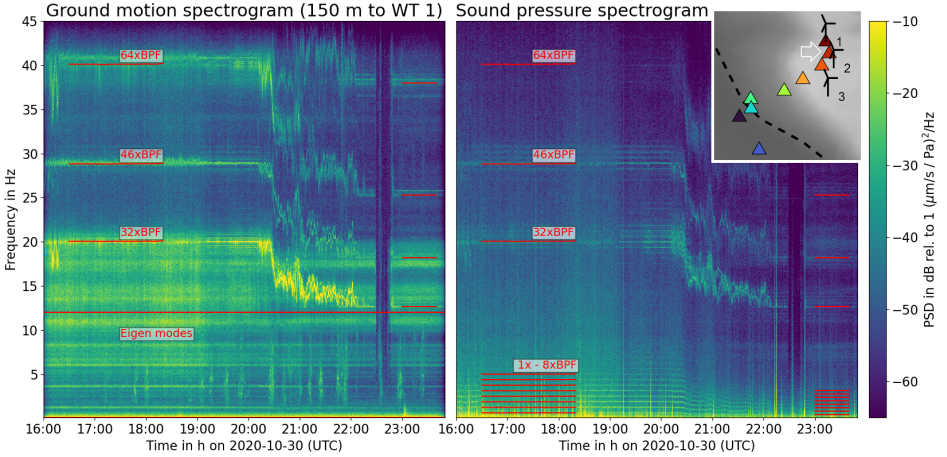




Signals at wind farm: ground motion vs. acoustic



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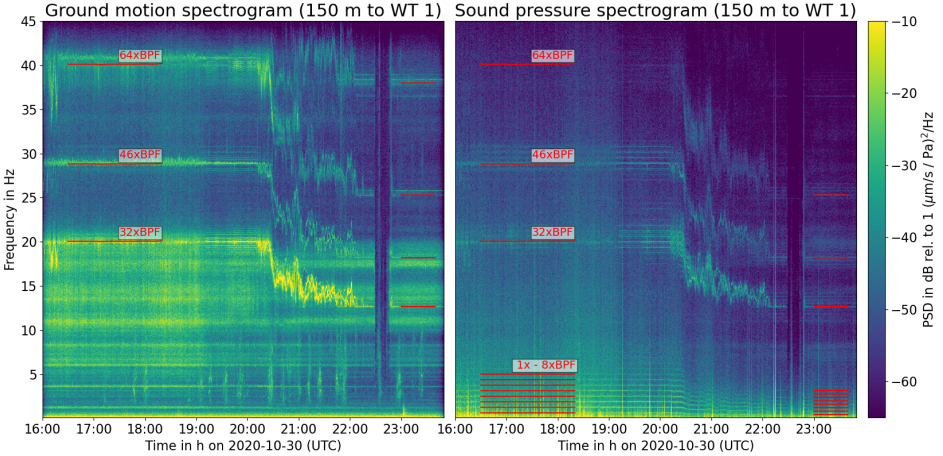
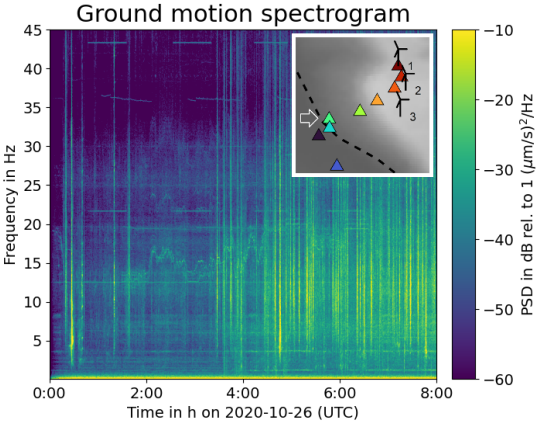
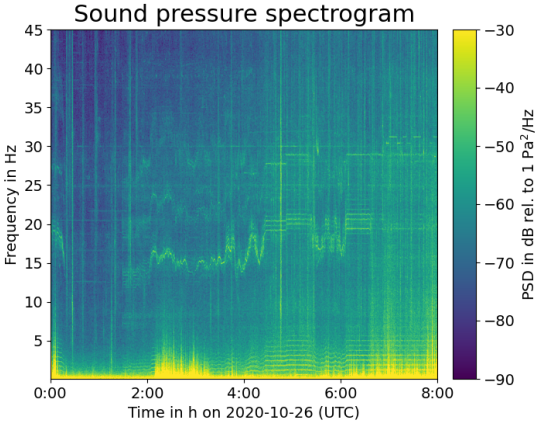


Signals at resident site: ground motion vs. acoustic





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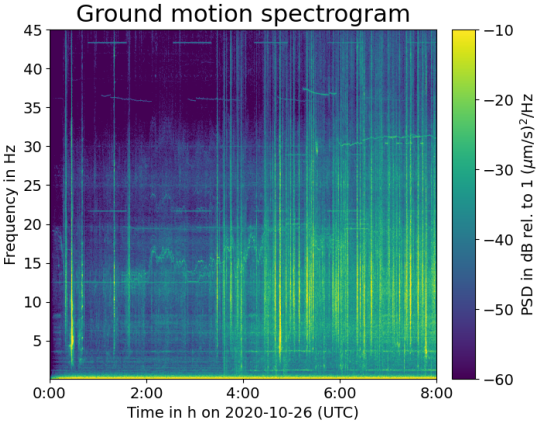
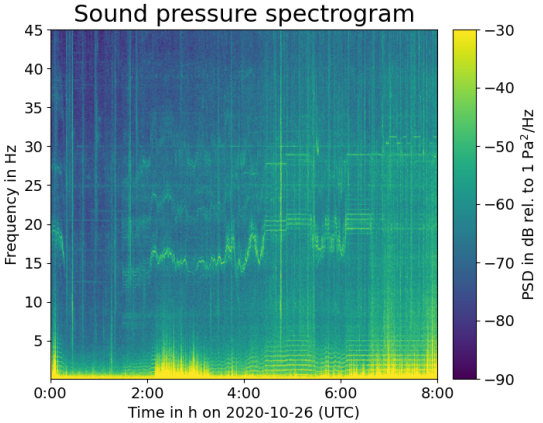
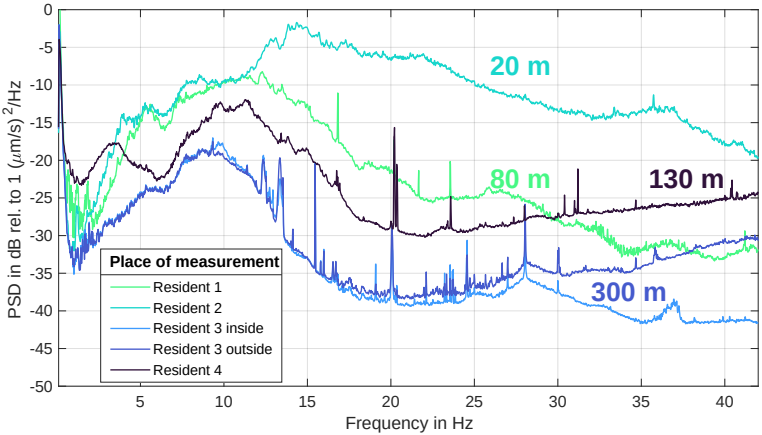




Ground motion spectra

- At residents distance to train tracks determines signal amplitudes



Summary

WT signals include:

- Eigen modes (below 12 Hz) that are only present in ground motion data
- Signals proportional to the BPF above 12 Hz, which are of mechanical origin, e.g., from the WT generator and gears (in ground motion and acoustic data)

Residents:

- Ground motion signals at residents of WF Tegelberg are dominated by train signals
- Annoyance reports from residents name generator and gearing sounds
- Amplitudes in data are very low and below human perception thresholds

Thank you for your attention!

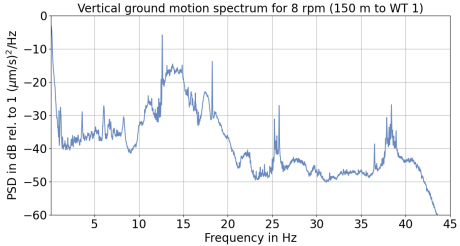
Acknowledgement

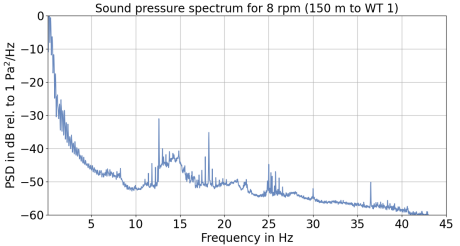
We thank the local authorities of Kuchen and Degenfeld for their support, as well as the Stadtwerke Schwäbisch Hall, the KWA Contracting AG and the wpd windmanager technik GmbH for WT access and data. Furthermore, we acknowledge the support of local residents and thank Esther Blumendeller for providing acoustic data and Florian Müller for providing data on annoyance.

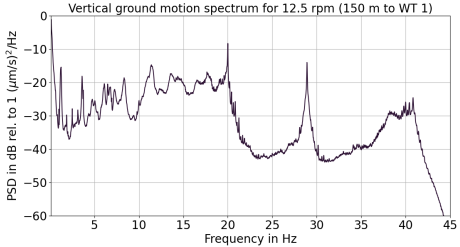
This study is supported by the Federal Ministry for Economic Affairs and Climate Action based on a resolution of the German Bundestag (grant 03EE2023D)

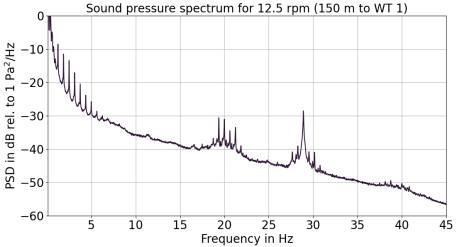
Reference Gaßner, L., Blumendeller, E., Müller, F., Wigger, M., Rettenmeier, A., Cheng, P. W., Hübner, G., Ritter, J., and Pohl, J. (2022). Joint analysis of resident complaints, meteorological, acoustic, and ground motion data to establish a robust annoyance evaluation of wind turbine emissions, Renewable Energy.

Signals at wind farm: ground motion vs. acoustic









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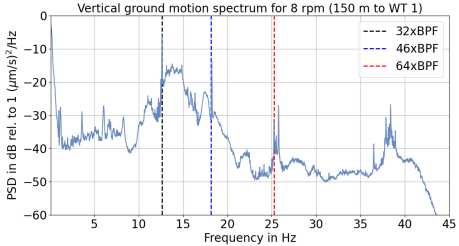
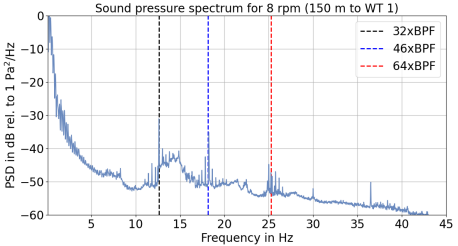
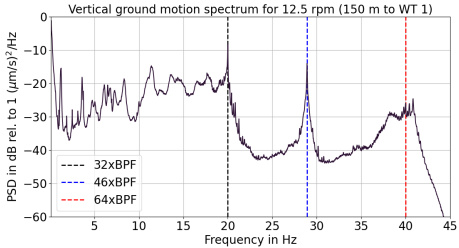
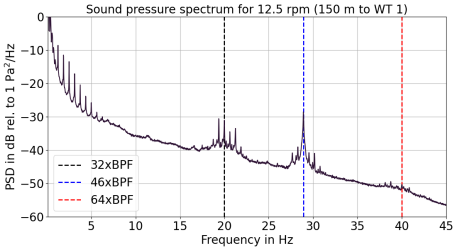
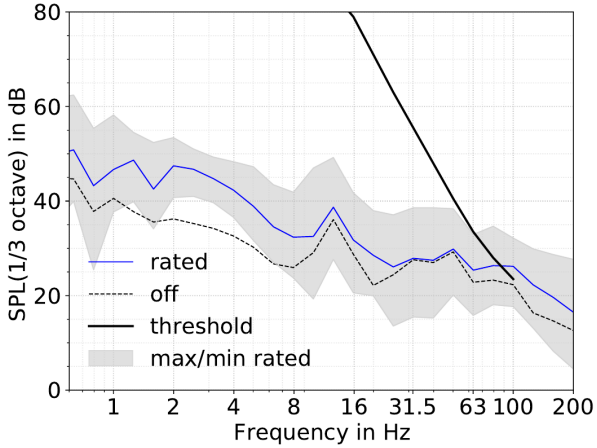








Signals at residents: acoustic sound pressure level



Blumendeller et al., 2022
(personal communication)

WF Lauterstein: Data example

	8 rpm	12.5 rpm
1×BPF	0.4 Hz	0.625 Hz
32×BPF (I)	12.8 Hz	20.00 Hz
46×BPF (II)	18.4 Hz	28.75 Hz
64×BPF (III)	25.6 Hz	40.00 Hz
96×BPF (IV)	38.4 Hz	60.00 Hz
128×BPF (V)	51.2 Hz	80.00 Hz