Localization and quantification of aeroacoustic noise sources on a scaled and rotating wind turbine.

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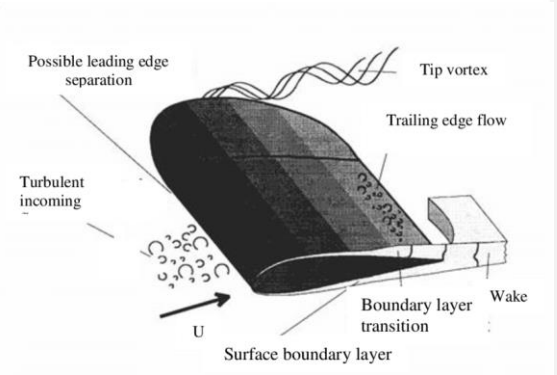
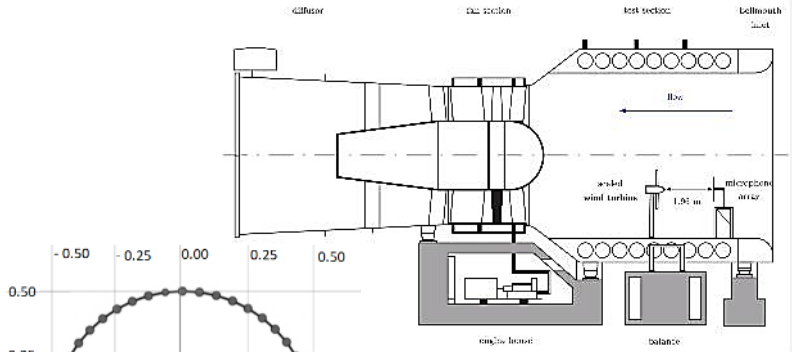
Introduction

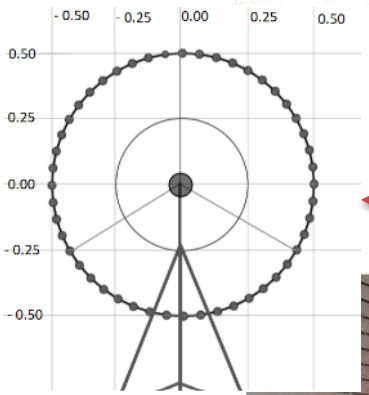
- One of the major environmental concerns with wind energy is an increase in noise levels, both in the atmosphere and the ocean.
- Noise from wind turbines can be either aerodynamical or mechanical.
- Aerodynamical noise is dominated by three main mechanisms:
  - Turbulent inflow
  - Trailing edge
  - Stall noise

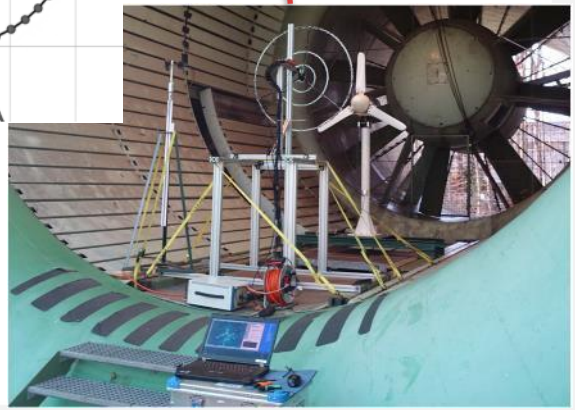


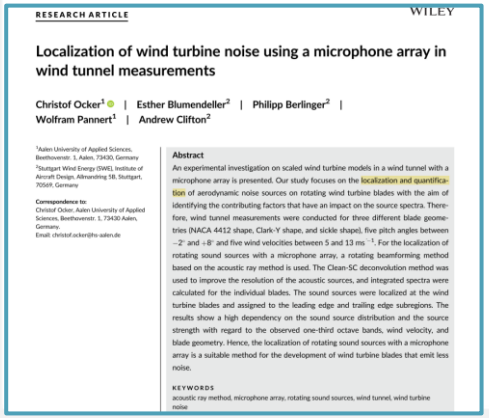
Background for research

- Measurements conducted at the Institute of Aerodynamics and Gas Dynamics, University of Stuttgart, Germany
- Further research based on the findings in the paper by Christof Ocker et.al. on «Localization of wind turbine noise using a microphone array in wind tunnel measurements»









RESEARCH ARTICLE WILEY

Localization of wind turbine noise using a microphone array in wind tunnel measurements

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Abstract

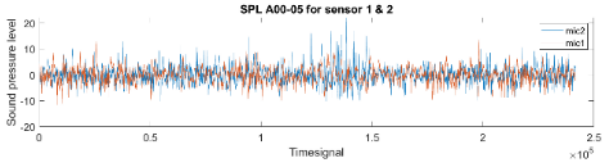
An experimental investigation on scaled wind turbine models in a wind tunnel with a microphone array is presented. Our study focuses on the localization and quantification of aerodynamic noise sources on rotating wind turbine blades with the aim of identifying the contributing factors that have an impact on the source spectra. Therefore, wind tunnel measurements were conducted for three different blade geometries (NACA 4412 shape, Clark-Y shape, and sickle shape), five pitch angles between -2° and $+8^{\circ}$ and five wind velocities between 5 and 13 ms^{-1}. For the localization of rotating sound sources with a microphone array, a rotating beamforming method based on the acoustic ray method is used. The Clean-SC deconvolution method was used to improve the resolution of the acoustic sources, and integrated spectra were calculated for the individual blades. The sound sources were localized at the wind turbine blades and assigned to the leading edge and trailing edge subregions. The results show a high dependency on the sound source distribution and the source strength with regard to the observed one-third octave bands, wind velocity, and blade geometry. Hence, the localization of rotating sound sources with a microphone array is a suitable method for the development of wind turbine blades that emit less noise.

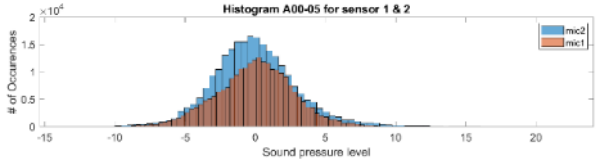
KEYWORDS
acoustic ray method, microphone array, rotating sound sources, wind tunnel, wind turbine noise

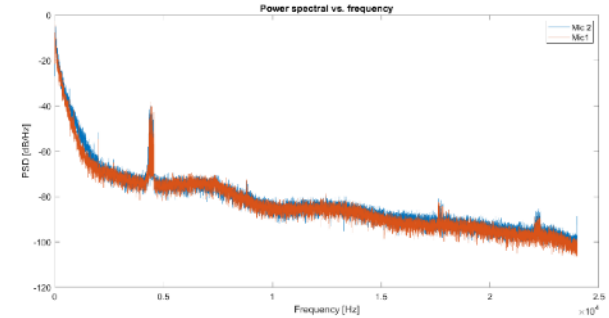
Methods

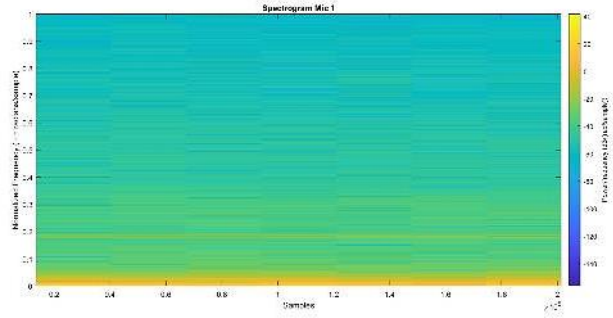
- Develop data processing tools to fully understand all aspects of the dataset provided.
- Power spectra peak at below 500 Hz, mid-frequency range. Typical characteristic «swish» sound.
- Spectrogram: visual representation of the spectrum of frequencies of the signal as it varies with time.

Contact authors and find relevant datasets → Develop signal processing tools → Theoretical work on noise localization → Develop beamforming techniques



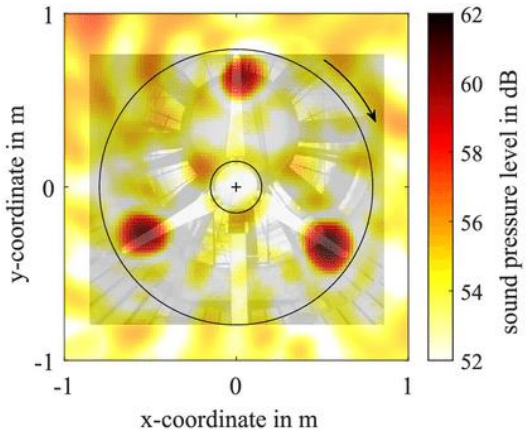


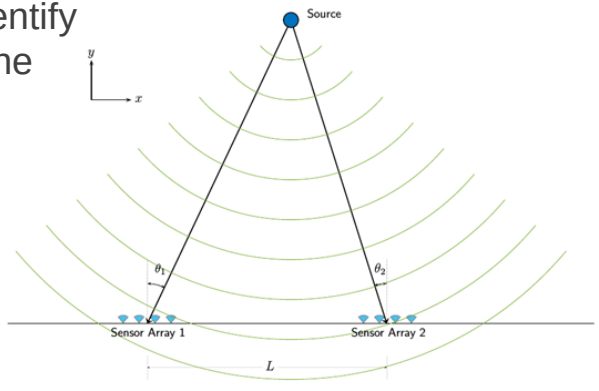


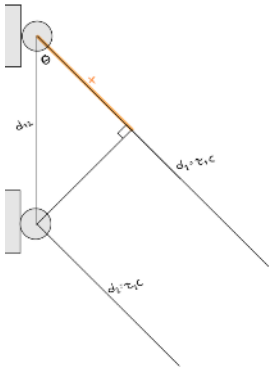


Noise localization

- The noise generation mechanism must be related to the sound source distribution on the wind turbine blade.
- Beamforming - a method for processing microphone array data to produce images that represent the distribution of the acoustic source strength
- Direction of arrival (DOA) – Cross-spectral matrix. Not applicable for high frequency data
- Must develop more sophisticated methods, to identify the detailed acoustic source map in the rotor plane







Thank you for your time.

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