

PhD proposal, starting in september or october 2026 - Centrale Lyon
Numerical simulation of wind turbine noise propagation in the environment accounting for three-dimensional effects

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Context

The European Green Deal aims to achieve climate neutrality across the continent by 2050. In this context, the development of renewable energy sources represents a major challenge. In particular, wind energy is expected to account for approximately 50

However, noise generated by onshore wind farms remains a significant barrier to their deployment. It is a source of annoyance for nearby residents [1] and can also impact biodiversity [2]. As a result, current regulations may require certain installations to operate at reduced capacity, significantly lowering their efficiency. These constraints also complicate the selection of suitable sites for new wind farms.

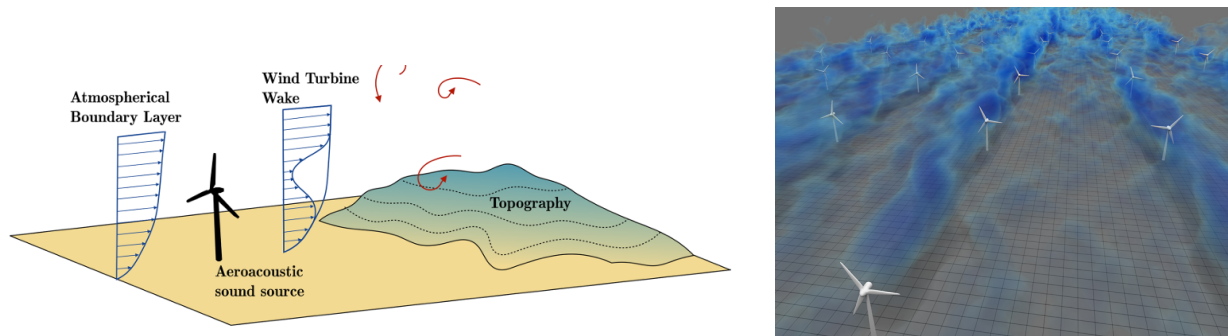


FIGURE 1 – (Left) Schematic of the mechanisms affecting atmospheric flow and the propagation of noise emitted by a wind turbine [3] and (right) flow field simulated using a LES approach in a wind farm, with low-velocity regions [4].

In this context, accurately predicting the propagation of wind turbine noise in the atmosphere is essential to better understand the underlying physical mechanisms and to conduct reliable acoustic impact assessments at the design stage. As illustrated in Fig. 1a, several factors must be considered. Meteorological effects, such as variations in wind, turbulence, and temperature with altitude, have a strong influence on sound propagation. In addition, the presence of the wind turbine alters the atmospheric flow, as shown in Fig. 1b. Furthermore, topography and ground impedance can have a significant impact, both on the flow and on the reflection of acoustic waves at the ground.

Predicting wind turbine noise therefore relies on numerical simulations. Numerous numerical methods have been developed to model acoustic propagation in the atmosphere. The state of the art in wind energy applications [5, 6] is largely based on the parabolic equation, an efficient method for modeling acoustic propagation along a preferred direction. However, existing models are generally limited to a two-dimensional (2D) approach, considering propagation in the vertical plane containing the source and the receiver, to reduce the computational cost of the simulations. This approximation neglects transverse propagation effects, which is a strong assumption given the inherently three-dimensional (3D) nature of the flow around a wind turbine. Recently, we conducted a first study, limited to low frequencies [7], highlighting the importance of three-dimensional effects in the wake of a wind turbine.

Description of the work

The objectives of the PhD are threefold :

1. It aims to develop a reference numerical model for the propagation of wind turbine noise in the atmosphere. This model will be based on a 3D parabolic equation using a formulation adapted

to sound propagation in a moving and inhomogeneous atmosphere recently proposed in the literature [8]. It will incorporate an aeroacoustic source model for the wind turbine [9] and will integrate data from large-eddy simulations for the atmospheric flow [4].

2. Once the model has been validated on test-cases, comparisons will be performed with in situ measurements from a wind farm in collaboration with CEREMA [10].
3. Finally, the model will be applied to investigate three-dimensional propagation effects arising in wind turbine noise context, including the effect of the three-dimensional flow around the wind turbine.

These results will be used to provide recommendations to improve operational models employed in noise assessment studies for wind farms.

Work context / environment

This PhD work is within the French project EOPE (Évaluation des modèles Opérationnels pour la Prévision du bruit des Éoliennes en environnement réaliste) funded by the French agency for ecological transition ADEME. EOPE is a collaborative project between Centrale Lyon, CEREMA, and University of Twente, which aims to develop a reference numerical model for wind turbine noise propagation and to provide recommendations to improve the operational models used in engineering consultancies.

The PhD will be directed by D. Dragna, assistant professor at LMFA, Ecole Centrale de Lyon, and co-supervised by R. J. A. M. Stevens, professor at the University of Twente.

Required skills/qualifications

Diplomas : master's degree or equivalent (engineering diploma) in acoustics, mechanical engineering, physics, or a related field.

Experience : none required.

Knowledge required : background in acoustics, fluid mechanics, aeroacoustics, and numerical methods.

Operational skills : hands-on experience with computing in C/C++, Fortran, Python, or similar programming languages ; excellent written and verbal communication skills in English.

Behavioural skills : autonomy, curiosity, initiative, and ease of interpersonal communication.

How to apply

Applications must be submitted via the website : <https://ecolecentraledelyon.recruitee.com/>. They must include a CV, a cover letter, and transcripts from a Master's (M2) program or an engineering degree.

Références

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- [3] J. Colas, A. Emmanuelli, D. Dragna, P. Blanc-Benon, B. Cotté, and R. J. A. M. Stevens. Impact of a two-dimensional steep hill on wind turbine noise propagation. *Wind Energy Science*, 9(10) :1869–1884, 2024.
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