Applications of Iced Wind Turbine Noise Simulations

Richard Hann (2016)

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

Abstract

Applications of Iced Wind Turbine Noise Simulations

Richard Hann

The vast development of wind energy within the last decade has led to increased public awareness of noise pollution. This has resulted in today's strict noise regulations and substantial scientific efforts to understand and decrease wind turbine noise. However, very little work has been performed to investigate the impact of cold climate conditions on wind turbine noise.

A first numerical study introduced a simulative approach to investigate the increased noise generation of iced airfoils and blades for wind turbines [1]. Based on computational fluid dynamic (CFD) and computational aeroacoustic (CAA) methods [2], a 2D simulation process chain was developed to estimate the impact of icing on wind turbine noise. The results clearly indicate that icing leads to amplified turbulences and a significant increase in trailing-edge noise.

However, due to the lack of experimental data for validation of the aforementioned study, significant uncertainties remain. The simulation of iced wind turbine noise combines a broad spectrum of physical phenomena (e.g. high turbulence, early flow separation, increased surface roughness, convex geometries), which are complex and can only be captured by simplification.

This study discusses possible applications of iced wind turbine noise simulations for the industry. Identifying the potential purposes of the simulation results is essential for choosing the degree of detail and appropriate computational methods. The uncertainties in the numerical results need to be addressed specifically of the intended use. In addition, each element of the simulation chain (generation of iced geometry, CFD and CAA) has to be chosen based on an assessment of computational complexity and uncertainty in the results. This highlights the need to further develop a holistic understanding of the interaction between cold climates and wind turbine noise, as well as the potential for further development of numeric simulation tools.

[1] R. Hann, A. Wolf, D. Bekiropoulos, T. Lutz, E. Krämer: Numerical Investigation on the Noise Generation of Iced Wind Turbine Airfoils. Winterwind 2013

[2] T. Lutz, B. Arnold, D. Bekiropoulos, J. Illg, E., A. Wolf, . Hann M. Kamruzzaman: Prediction of flow-induced noise sources of wind turbines and application examples. International Journal of Aeroacoustics ,volume 14, issue 5-6, p. 675-714 2015.

Noise may cause…

… annoyance

… psychological distress

… insomnia

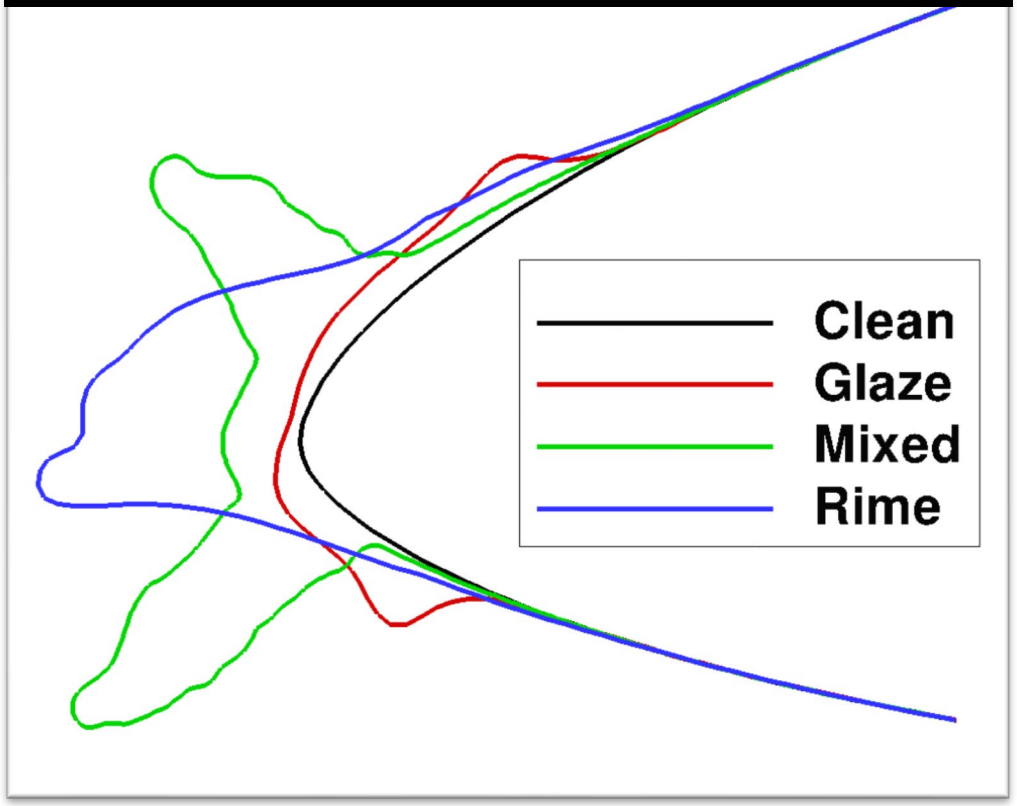
Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

Richard Hann

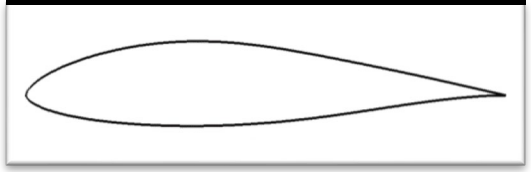
Wind turbine geometry

Metorological icing conditions

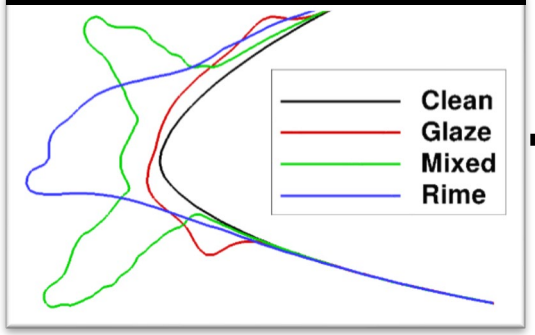
Iced geometry



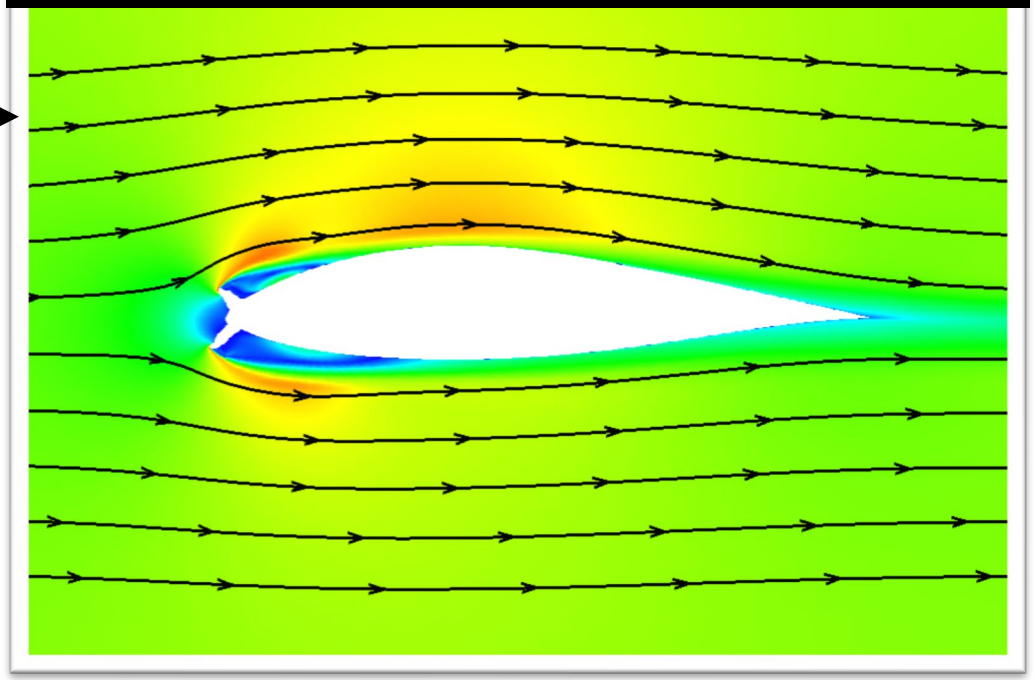
Wind turbine geometry



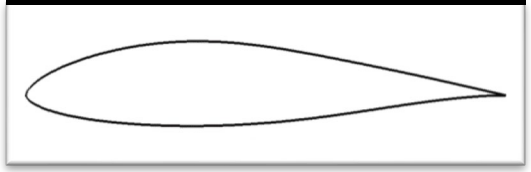
Iced geometry



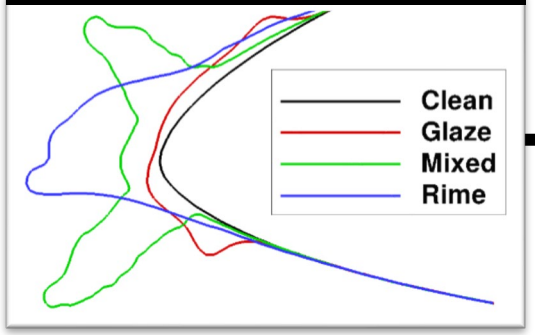
Flow field (CFD)



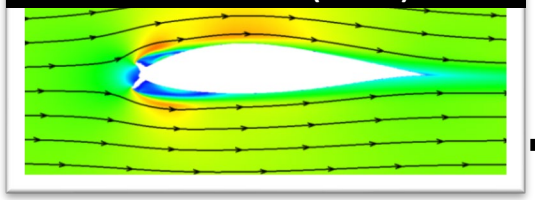
Wind turbine geometry



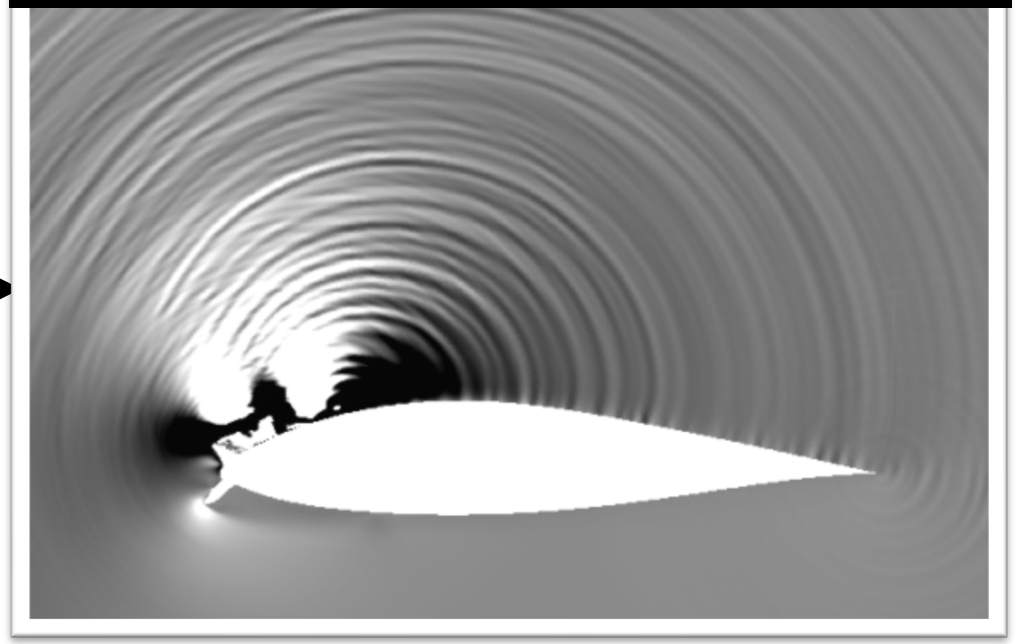
Iced geometry



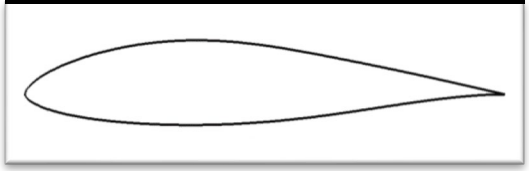
Flowfield (CFD)



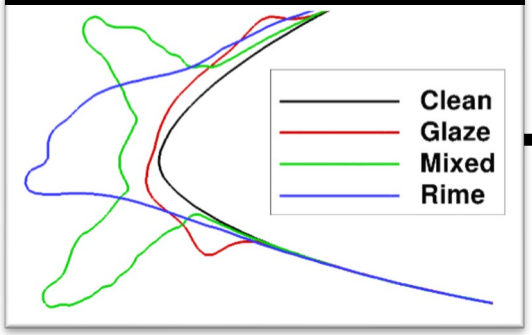
Noise generation (CAA)



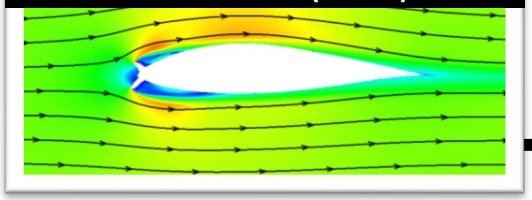
Wind turbine geometry



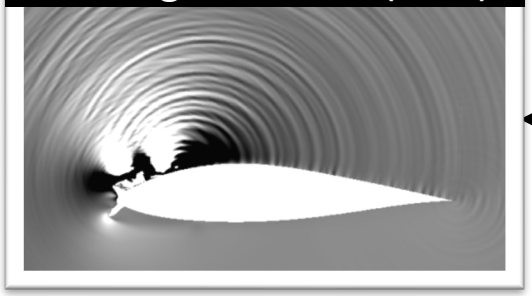
Iced geometry



Flowfield (CFD)



Noise generation (CAA)



Icing simulation

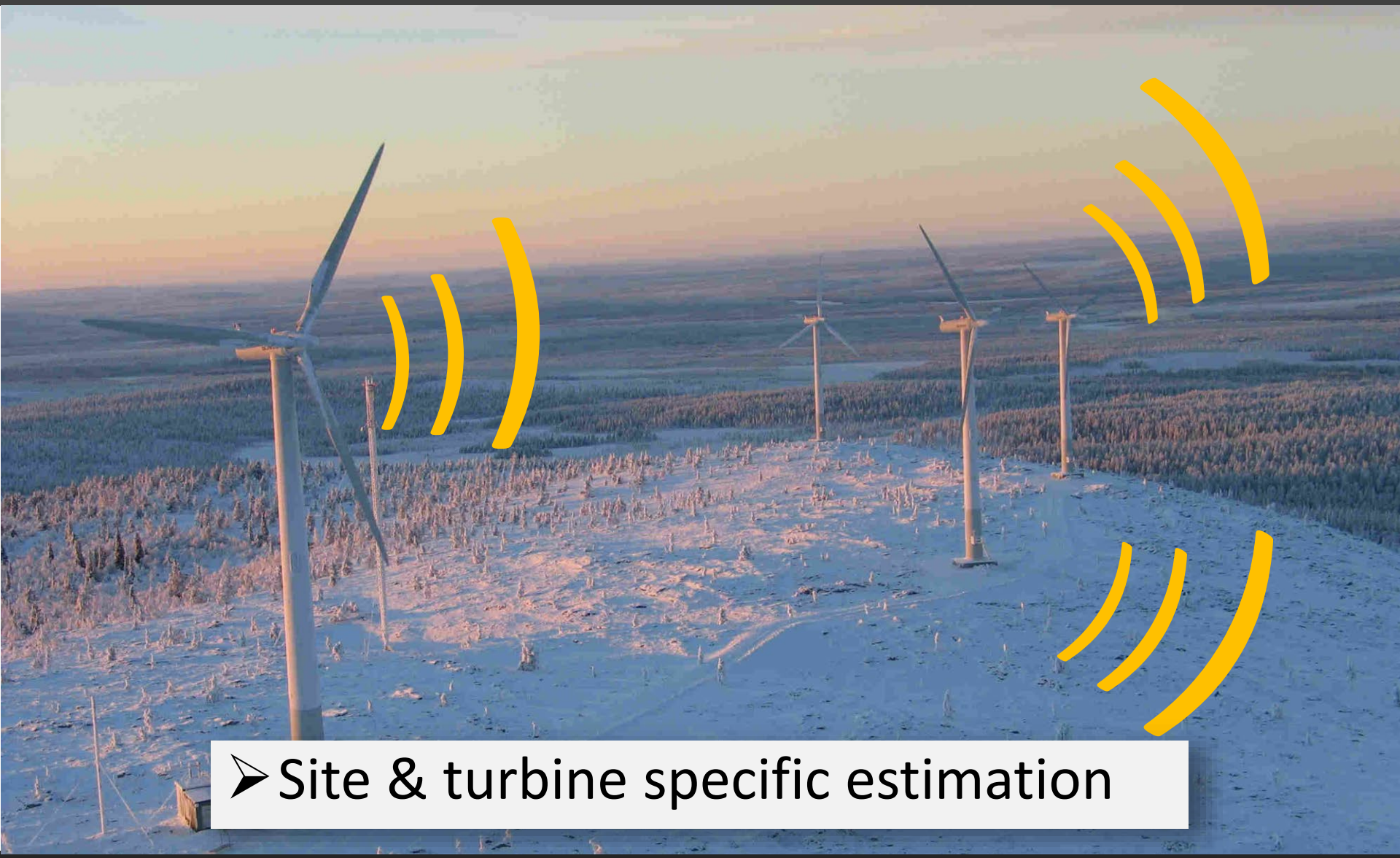
Computational fluid dynamics

Computational aeroacoustics

Understanding the physics

- Leading-edge vs trailing edge noise?
- Performance loss vs noise increase?
- De-icing vs anti-icing?

Estimate the overall impact



- Site & turbine specific estimation

Site Conditions

- Icing frequency
- Icing type
- Temperature
- Wind speeds

Wind Turbine

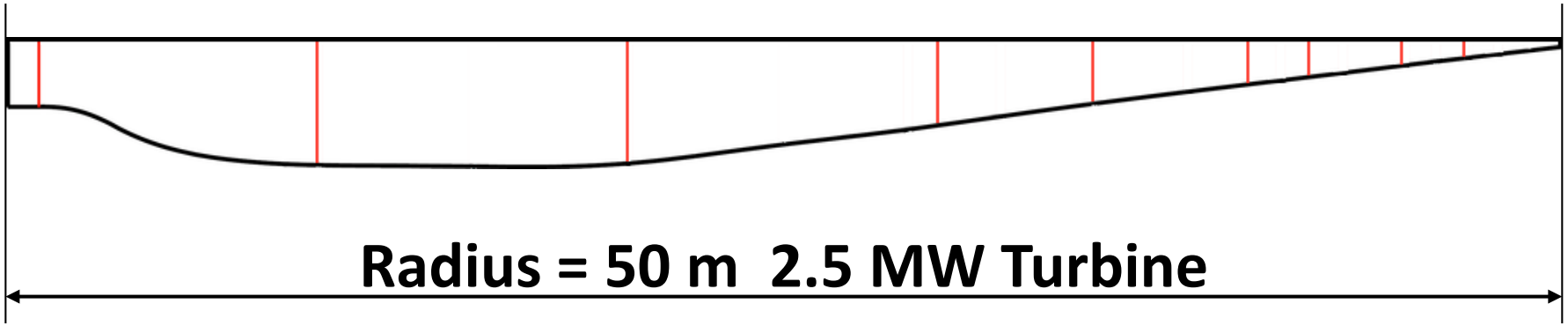
- Rotor blade
- Airfoils
- Performance

Simulation Model

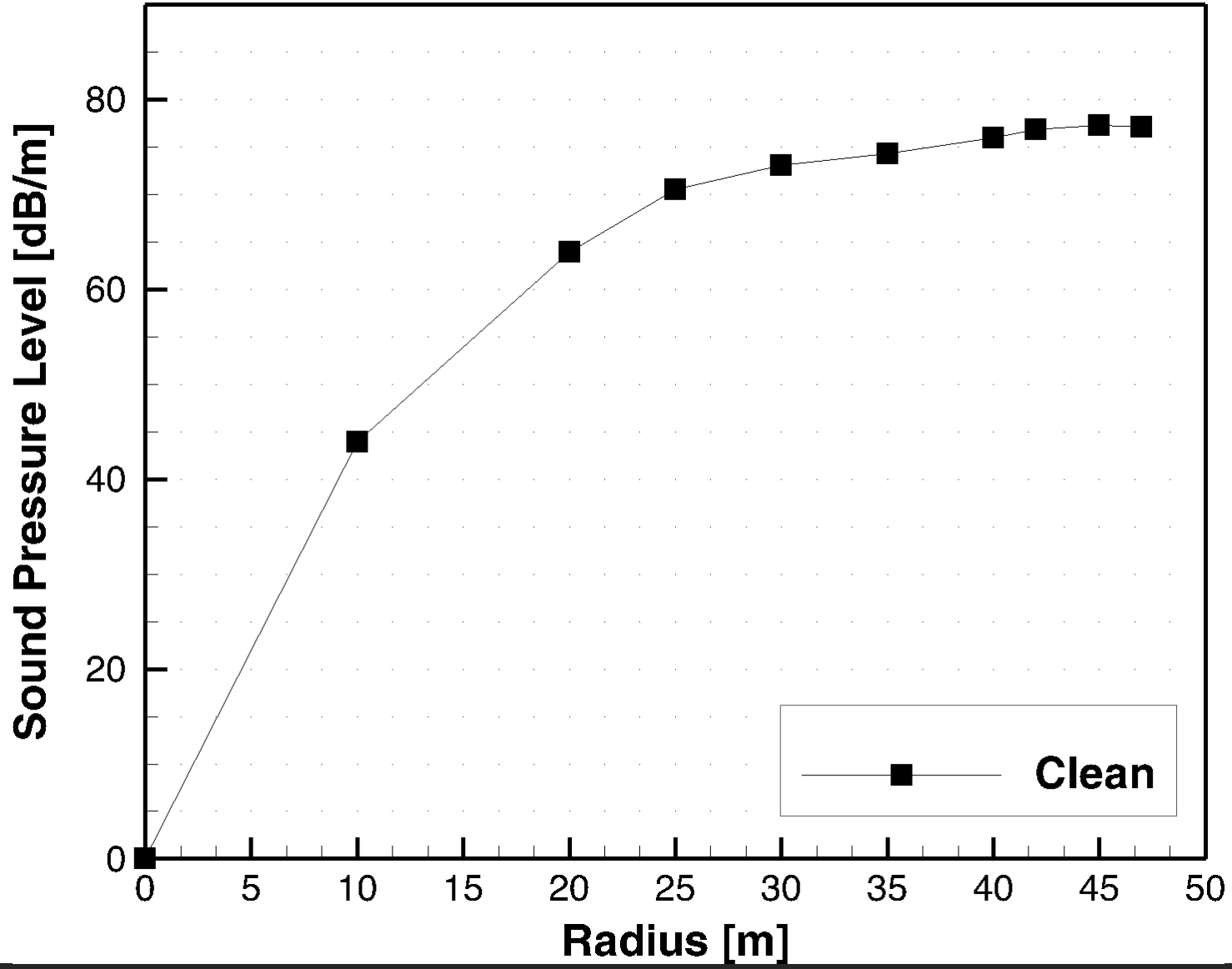
Noise Prediction

- Increase vs no-ice
- Broadband noise
- Tonal noise
- …

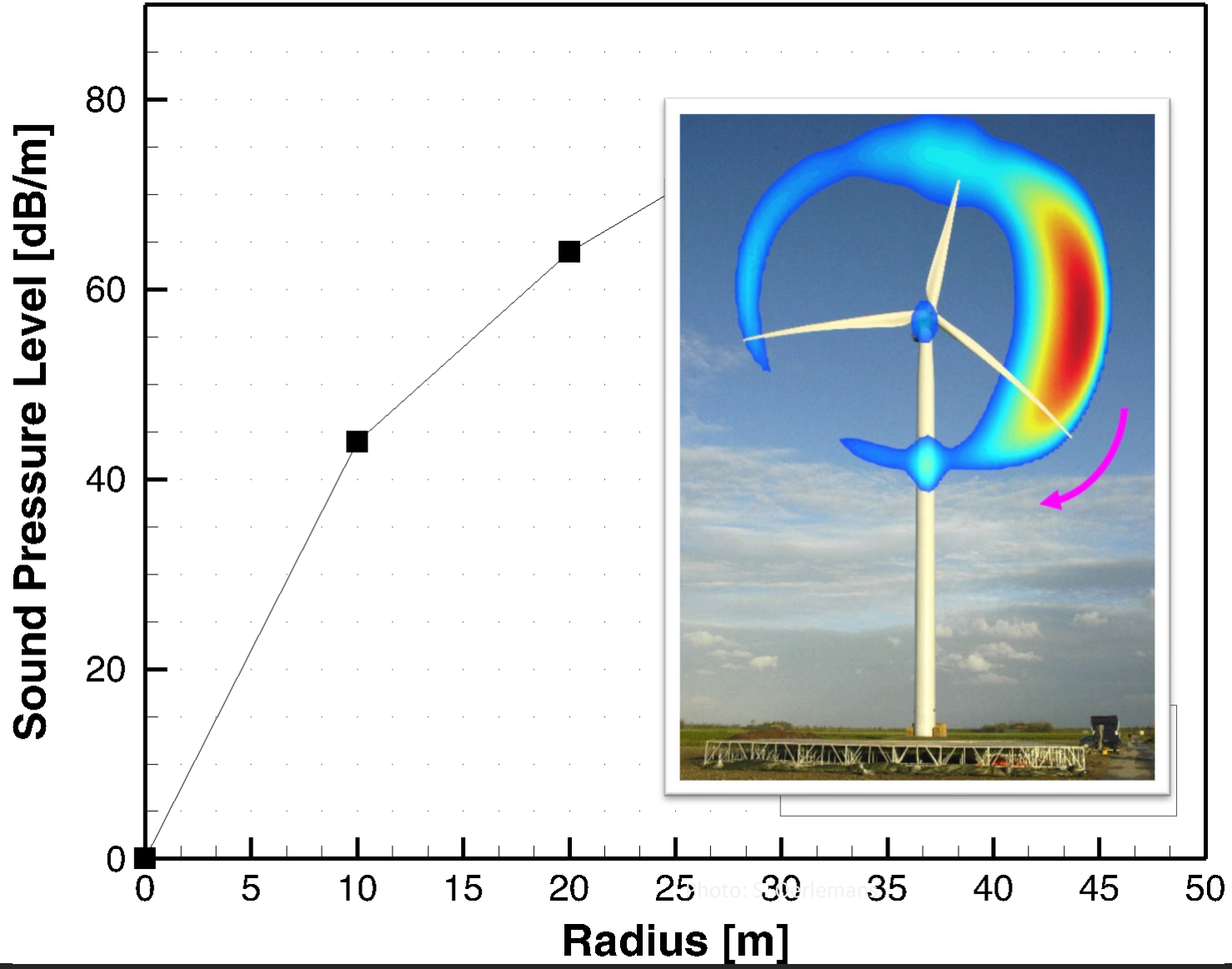
Combined simulation results



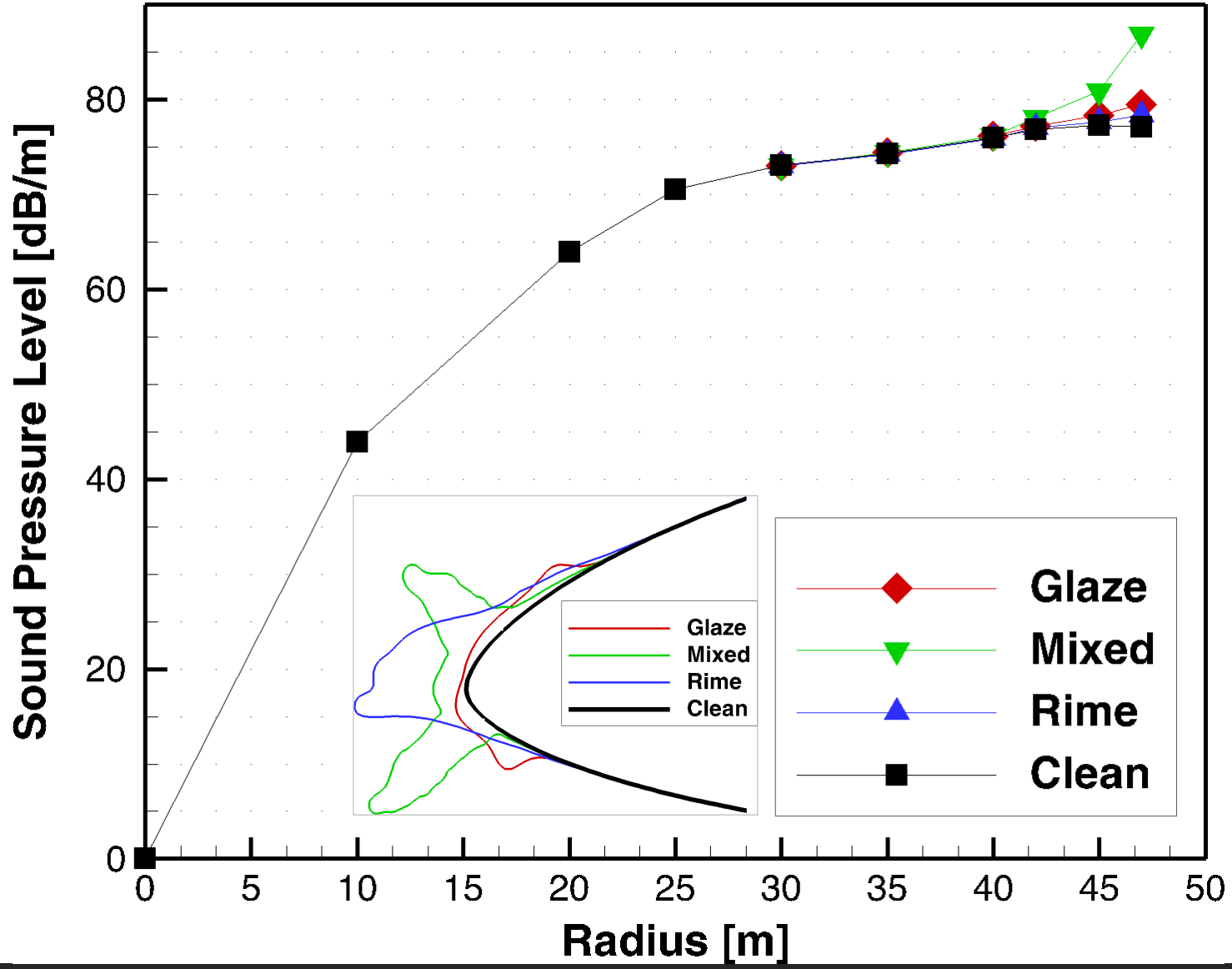
Combined simulation results



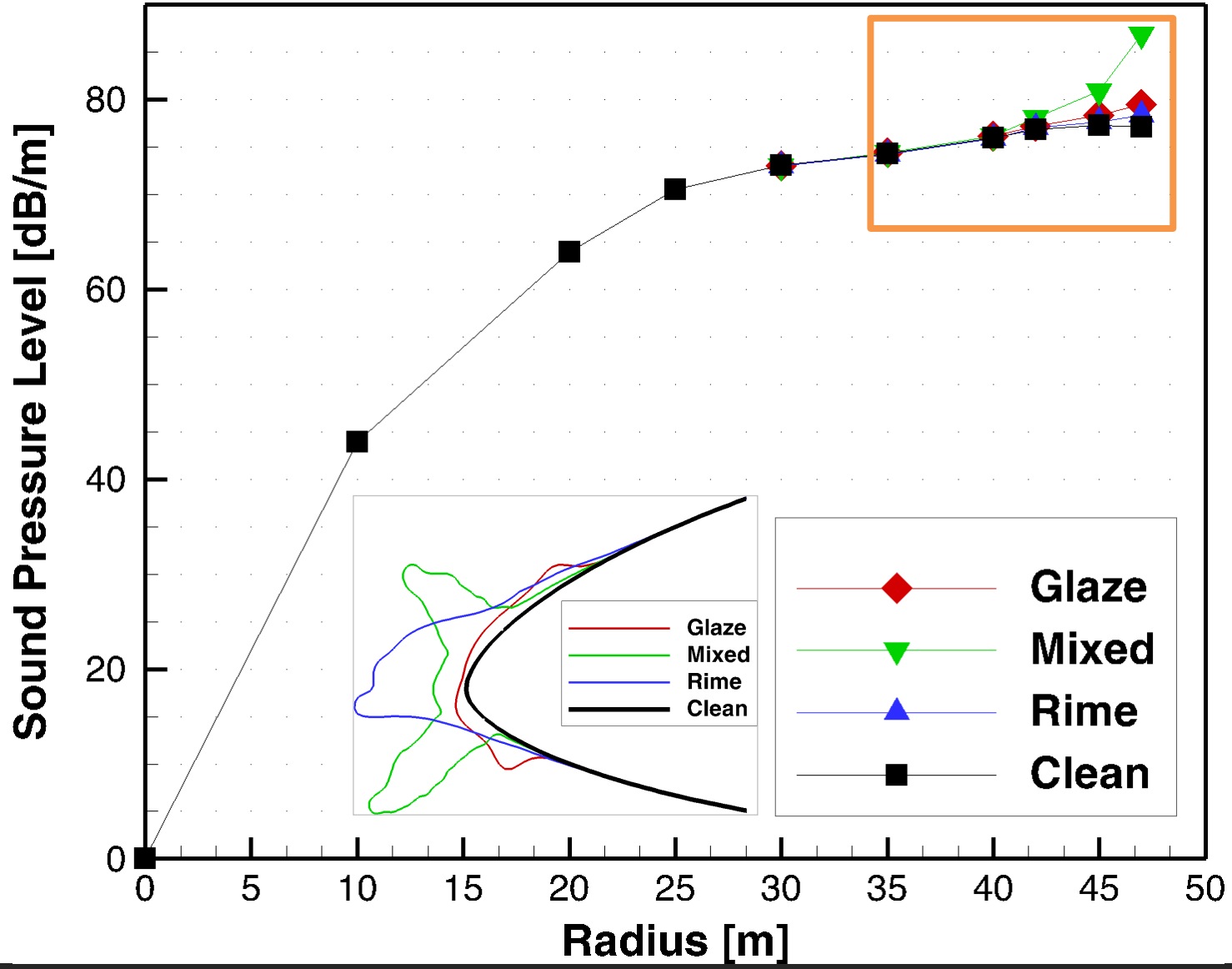
Combined simulation results



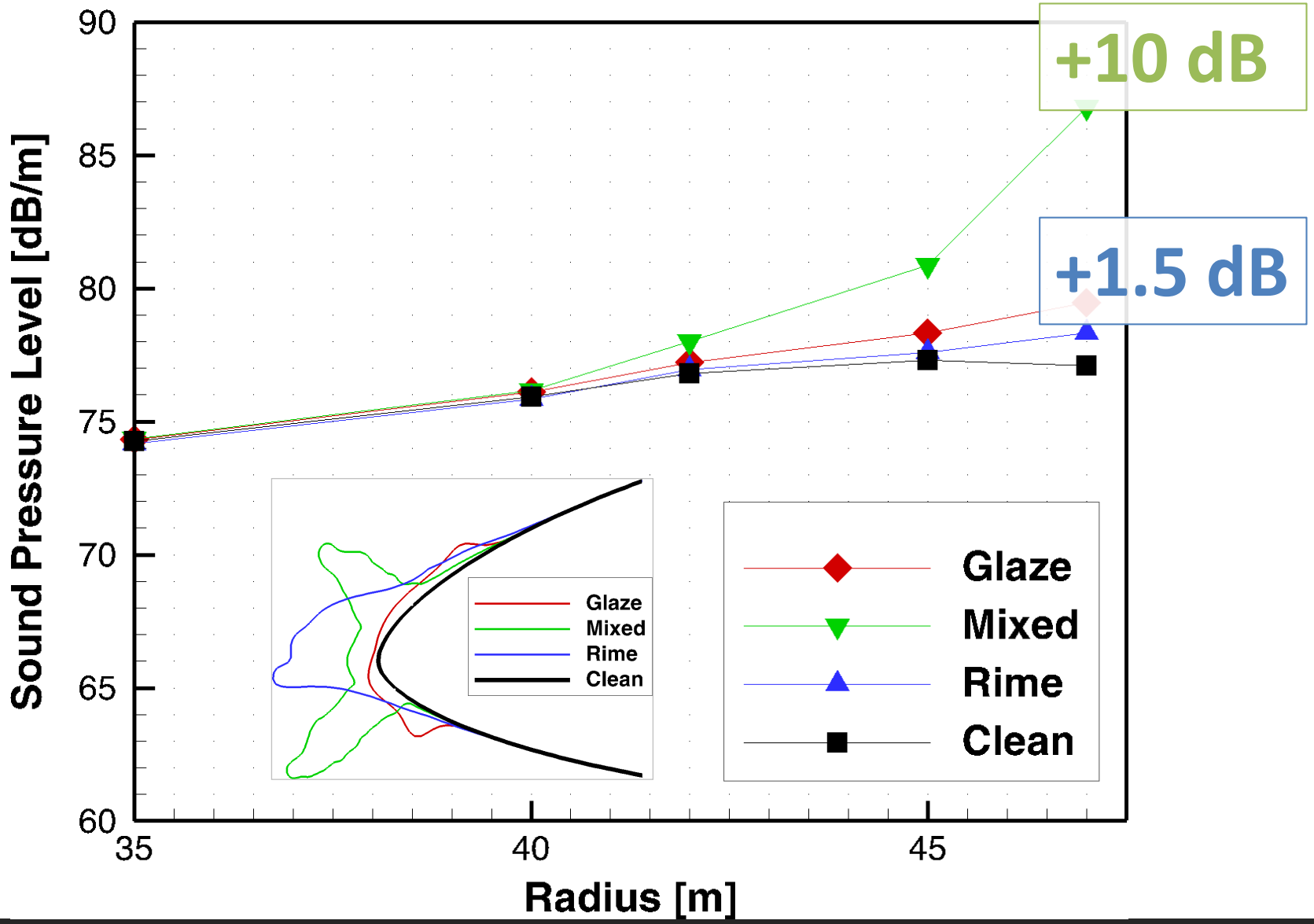
Combined simulation results



Combined simulation results



Combined simulation results



Summary

Photo: VTT

- Simulations are key to CC turbine noise
- Fundamental questions still unanswered
- Experimental validation needed