



Numerical Investigation on the Noise Generation of Iced Wind Turbines

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Noise may cause...

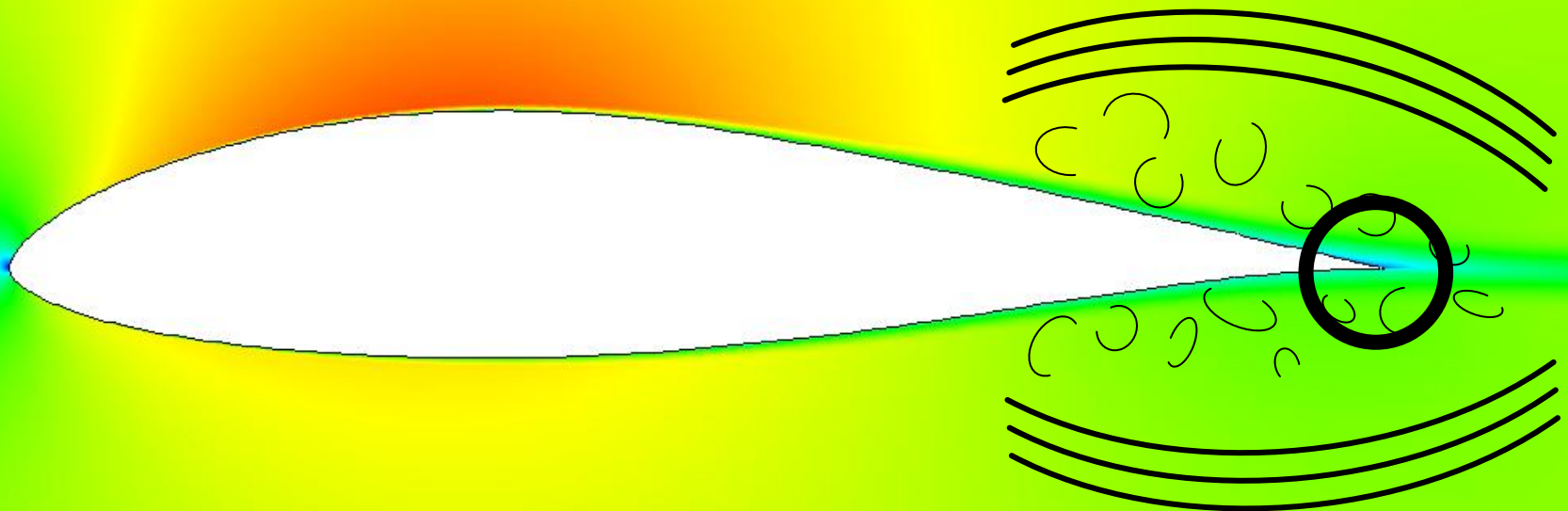
... annoyance

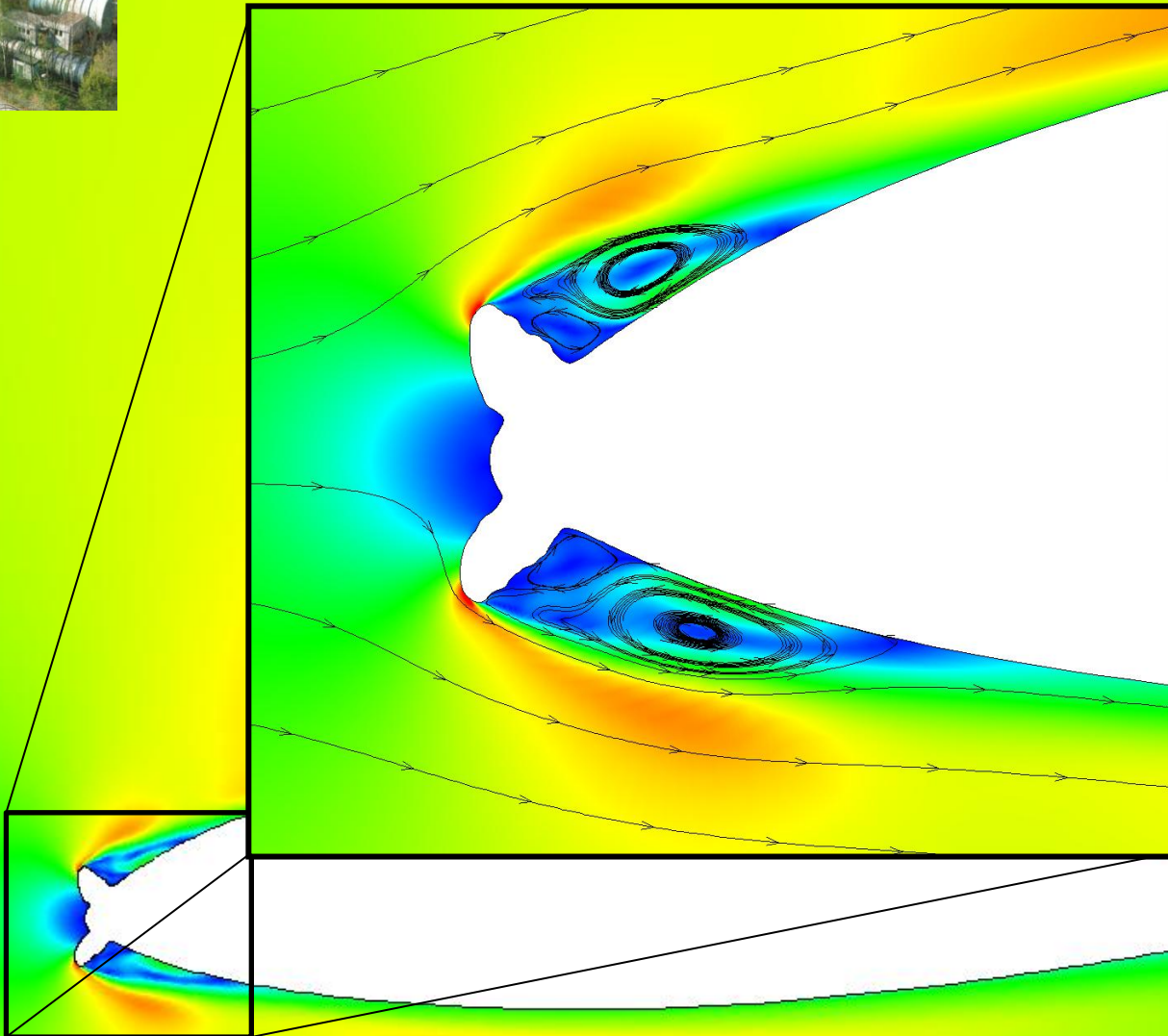
... psychological distress

... insomnia



Trailing-edge (TE) noise is the dominant noise source for modern wind turbines.





Flow separation is a possible noise source at the leading edge (LE).

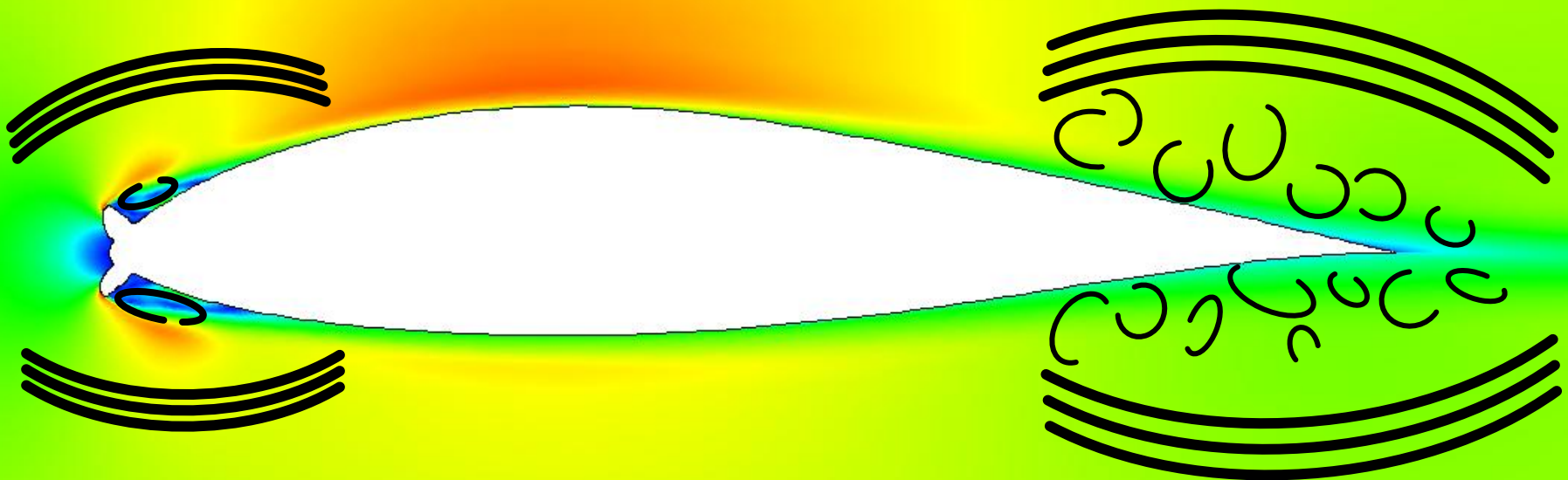


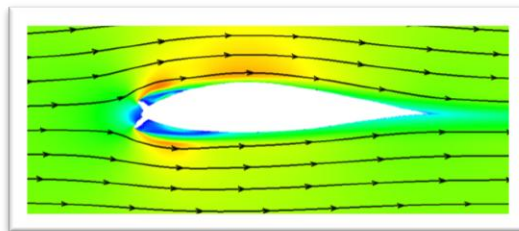
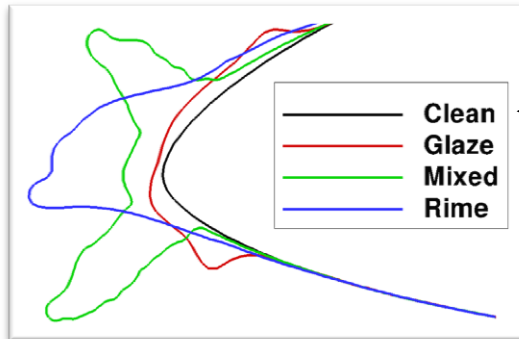
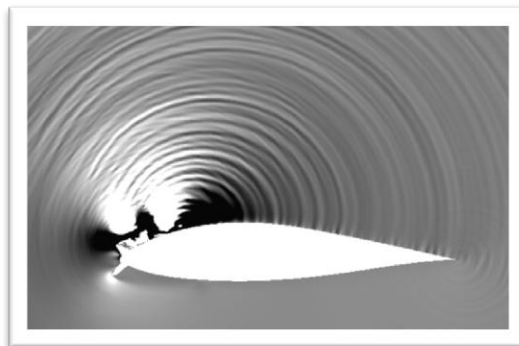
Questions ...

- 1) Increase of trailing-edge noise
- 2) Relevance of leading-edge noise

???

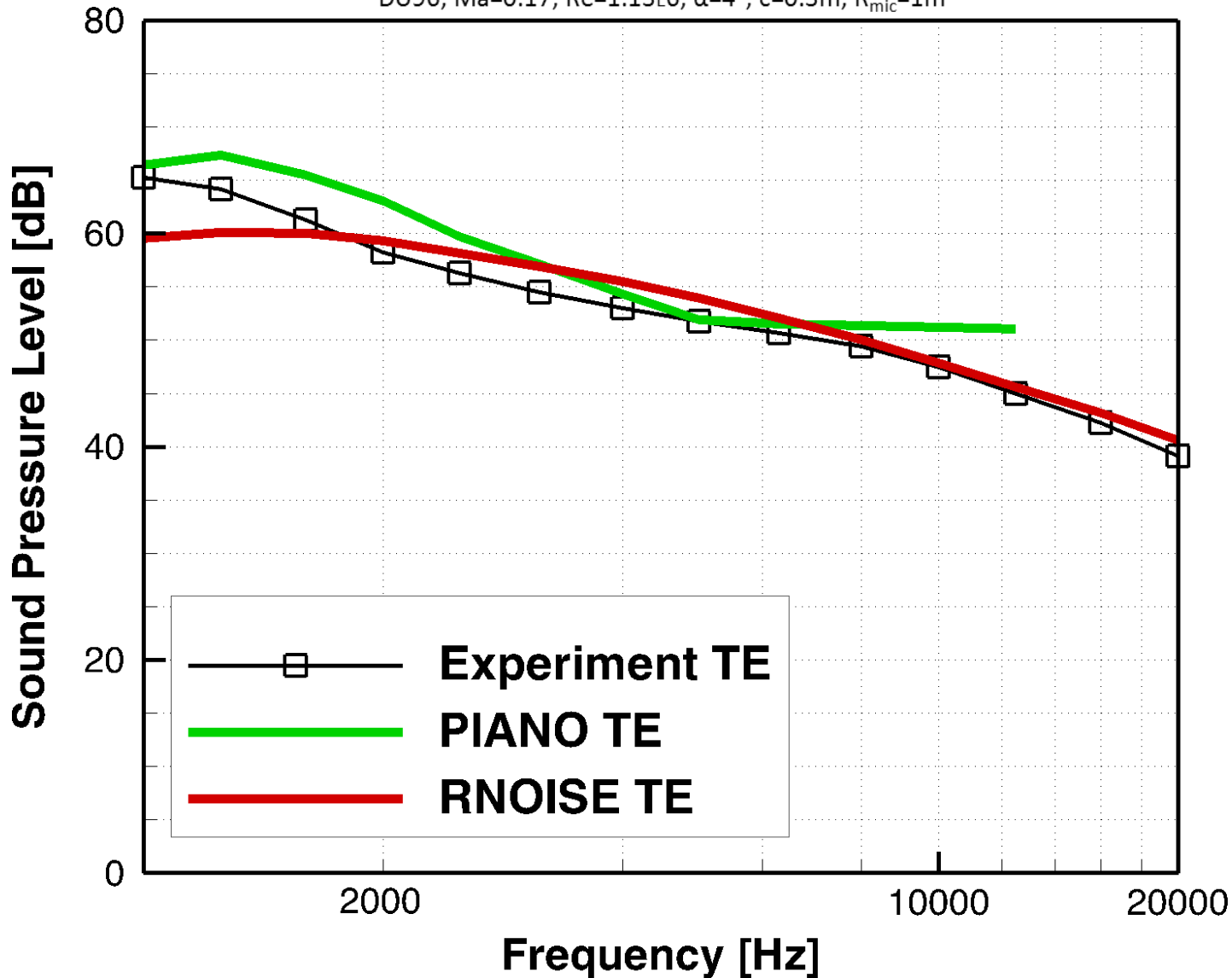
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**Computational Fluid Dynamics (CFD)****Computational Aeroacoustics (CAA)****LEWICE (NASA)****TAU-Code (DLR)****PIANO / RNOISE
(DLR / IAG)****See paper for more
information.**

Validation Results

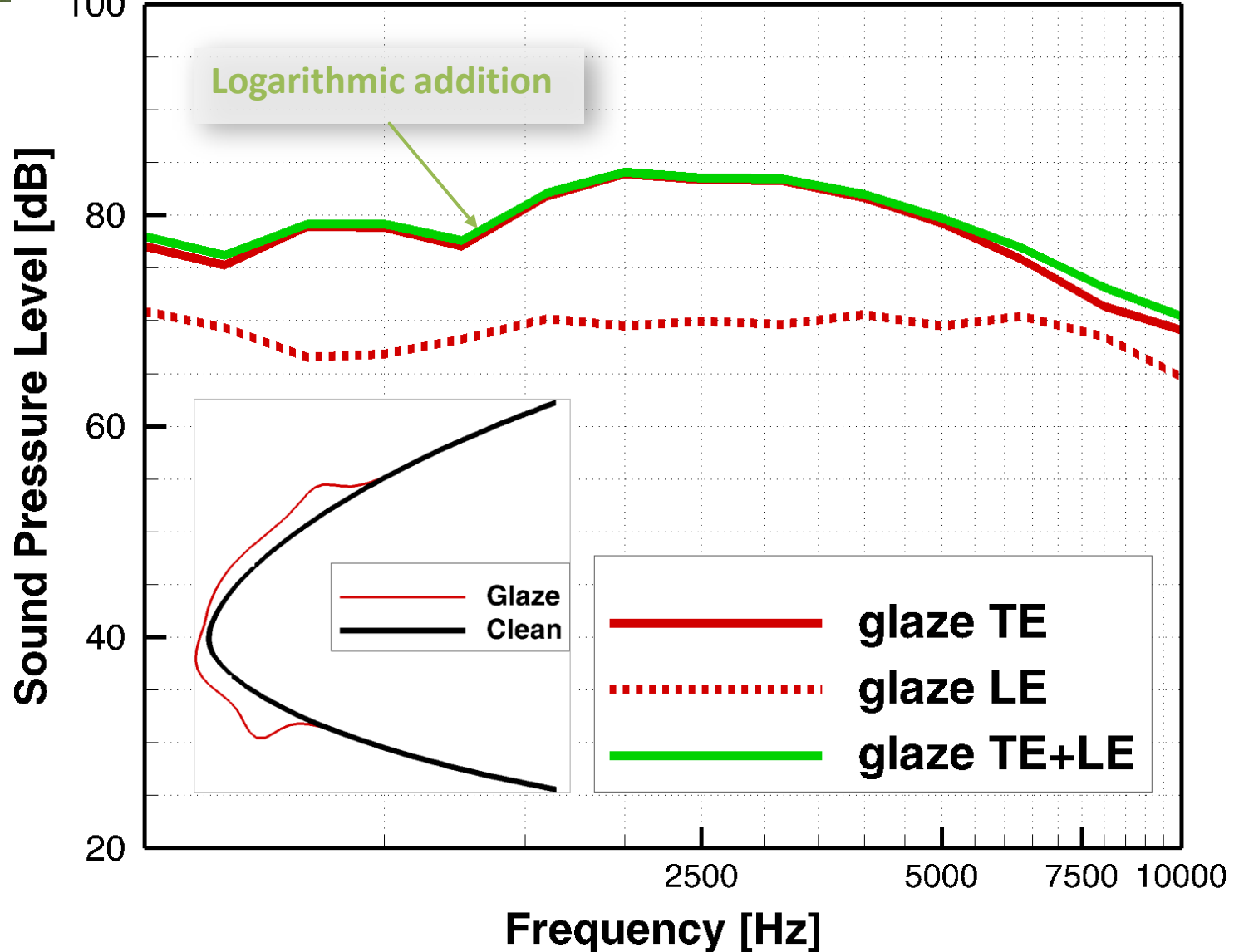
DU96, $Ma=0.17$, $Re=1.13E6$, $\alpha=4^\circ$, $c=0.3m$, $R_{mic}=1m$





PIANO Results

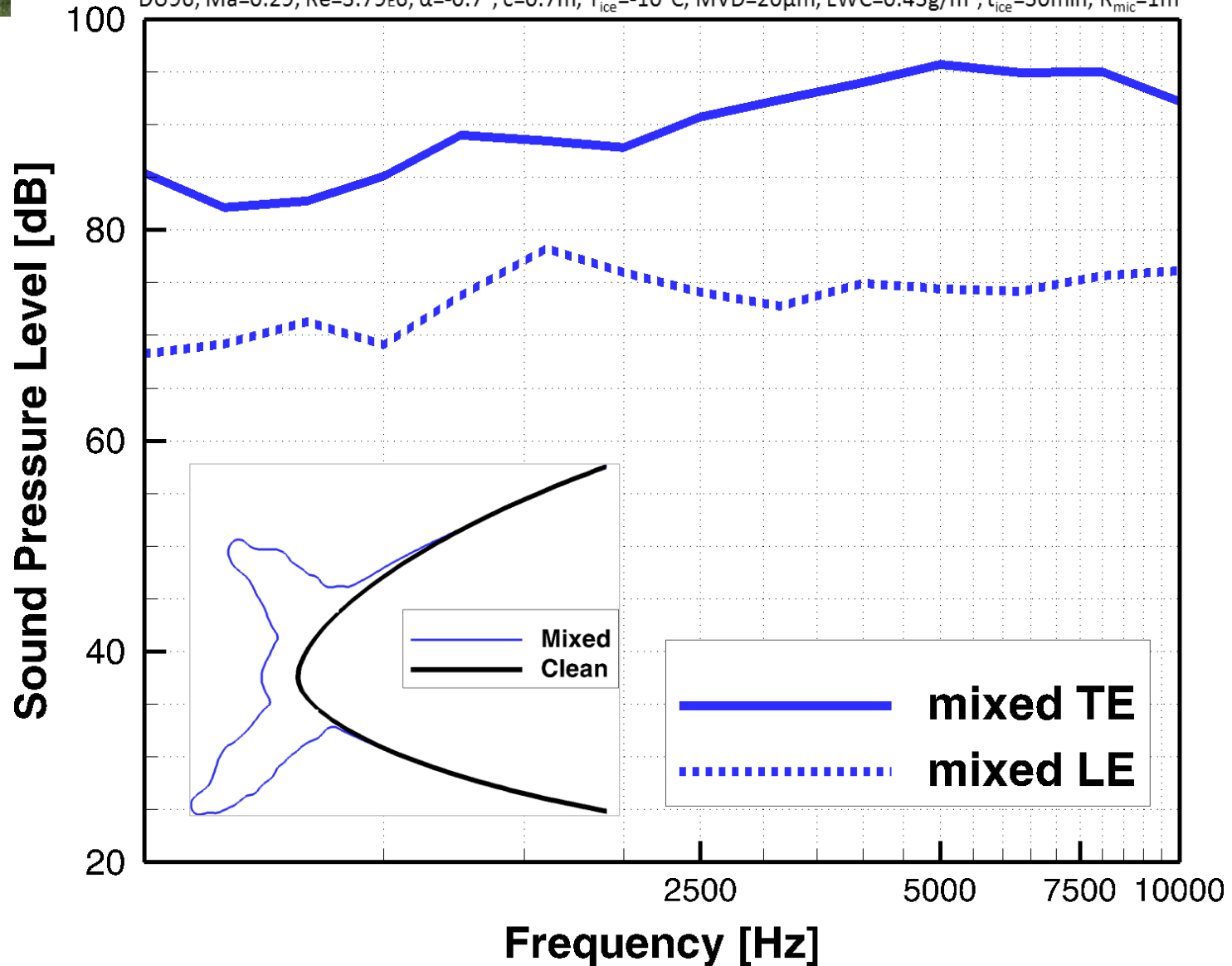
DU96, $Ma=0.29$, $Re=3.79E6$, $\alpha=-0.7^\circ$, $c=0.7m$, $T_{ice}=-2^\circ C$, $MVD=20\mu m$, $LWC=0.59g/m^3$, $t_{ice}=30min$, $R_{mic}=1m$





PIANO Results

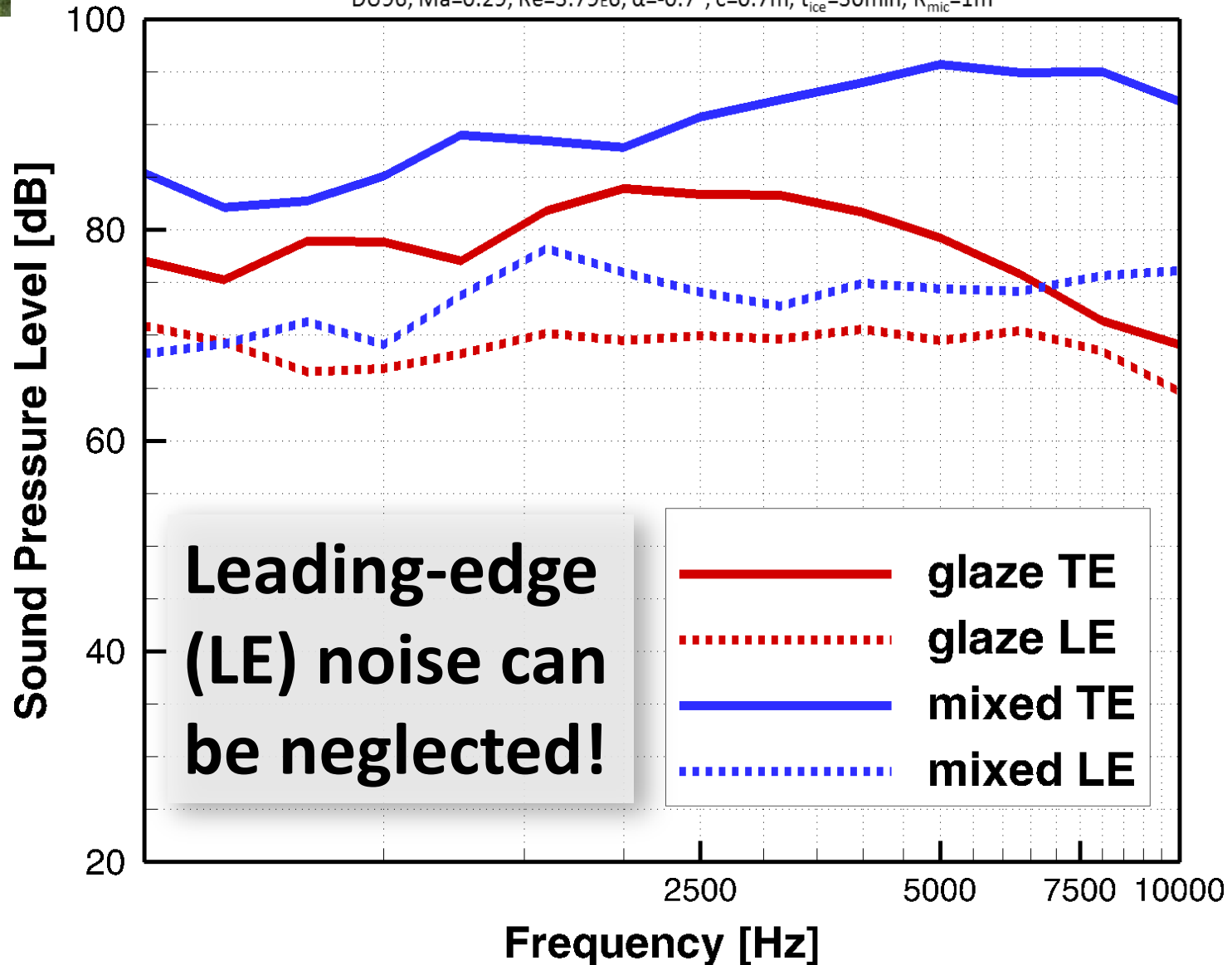
DU96, $Ma=0.29$, $Re=3.79E6$, $\alpha=-0.7^\circ$, $c=0.7m$, $T_{ice}=-10^\circ C$, $MVD=20\mu m$, $LWC=0.43g/m^3$, $t_{ice}=30min$, $R_{mic}=1m$



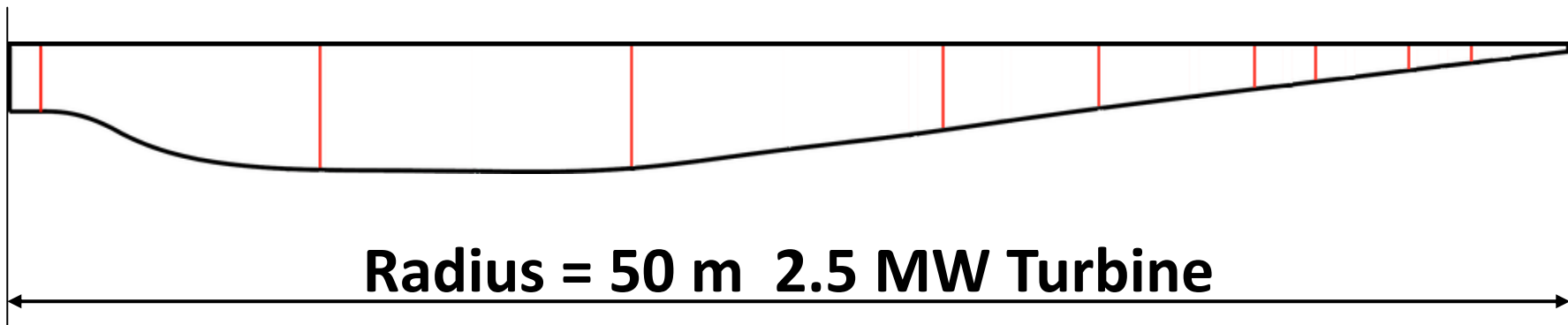


PIANO Results

DU96, $Ma=0.29$, $Re=3.79 \times 10^6$, $\alpha=-0.7^\circ$, $c=0.7m$, $t_{ice}=30min$, $R_{mic}=1m$



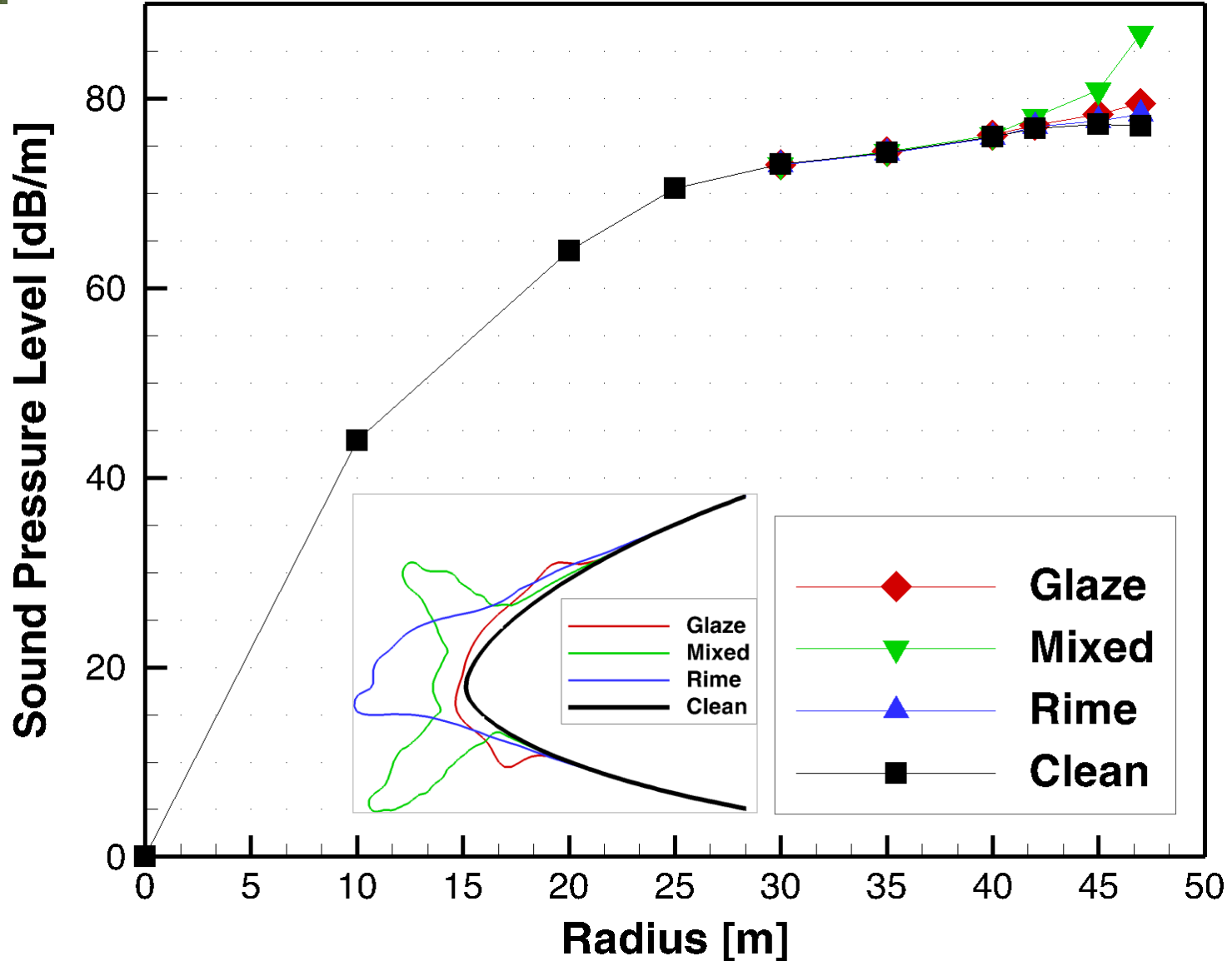
2D simulations of TE-noise with RNOISE on a generic turbine blade.





RNOISE Results

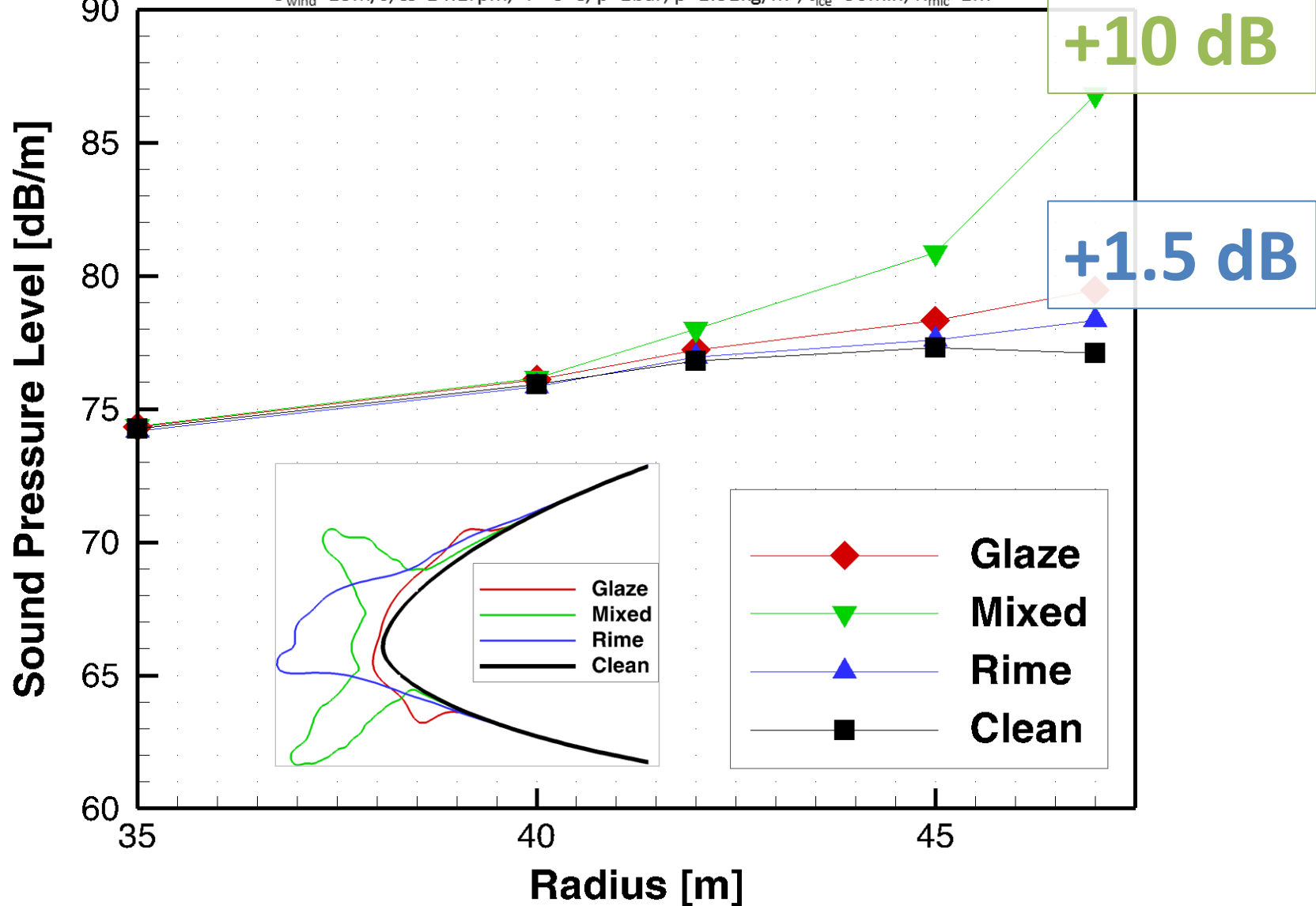
$U_{wind}=13\text{m/s}$, $\Omega=14.1\text{rpm}$, $T=-5^\circ\text{C}$, $p=1\text{bar}$, $\rho=1.31\text{kg/m}^3$, $t_{ice}=30\text{min}$, $R_{mic}=1\text{m}$





RNOISE Results

$U_{wind}=13\text{m/s}$, $\Omega=14.1\text{rpm}$, $T=-5^\circ\text{C}$, $p=1\text{bar}$, $\rho=1.31\text{kg/m}^3$, $t_{ice}=30\text{min}$, $R_{mic}=1\text{m}$





Summary

- Icing increases noise
- Trailing-edge noise is dominating
- More work needs to be done!





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