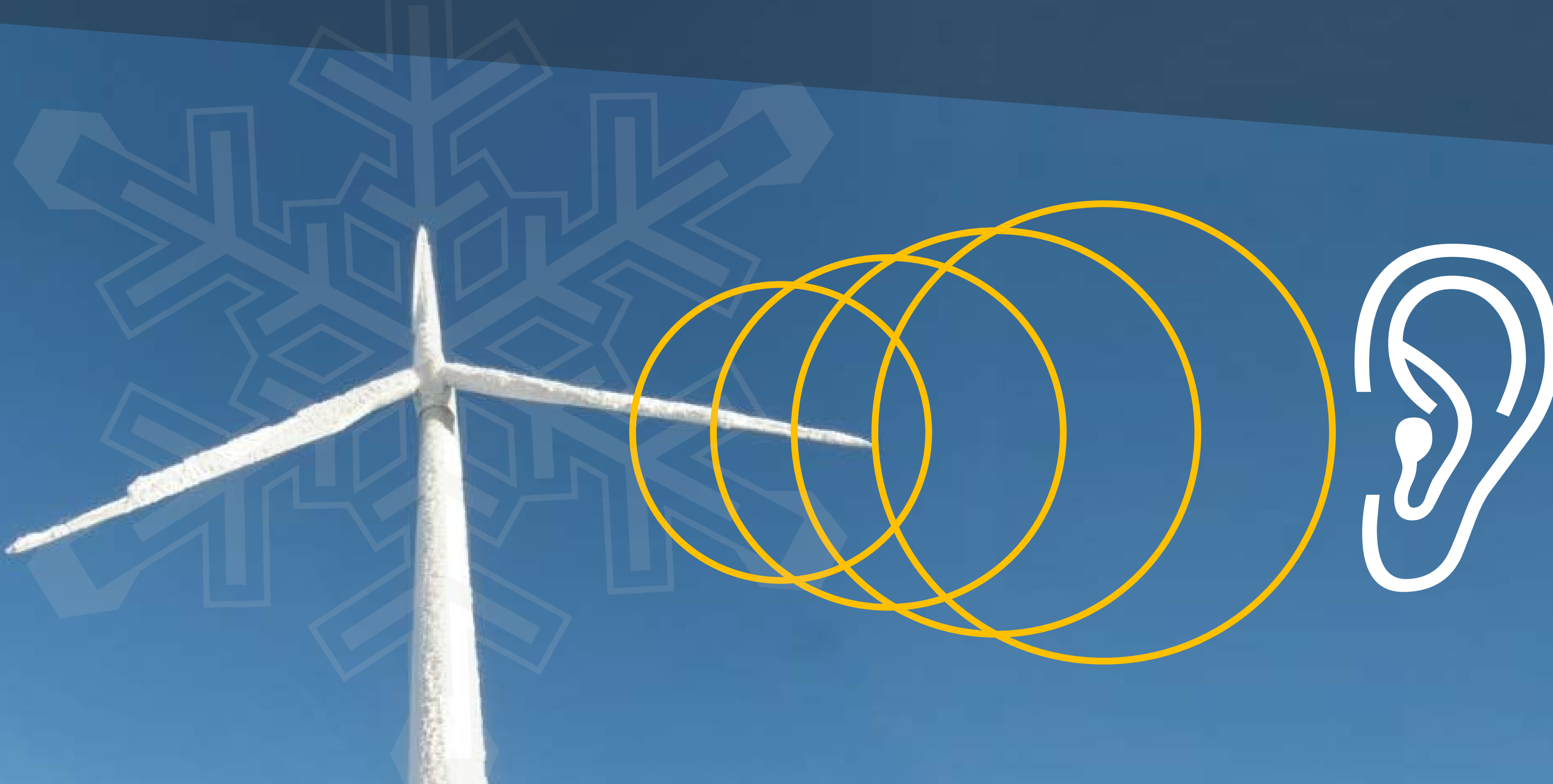
Simulating Iced Wind Turbine Noise

Richard Hann

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

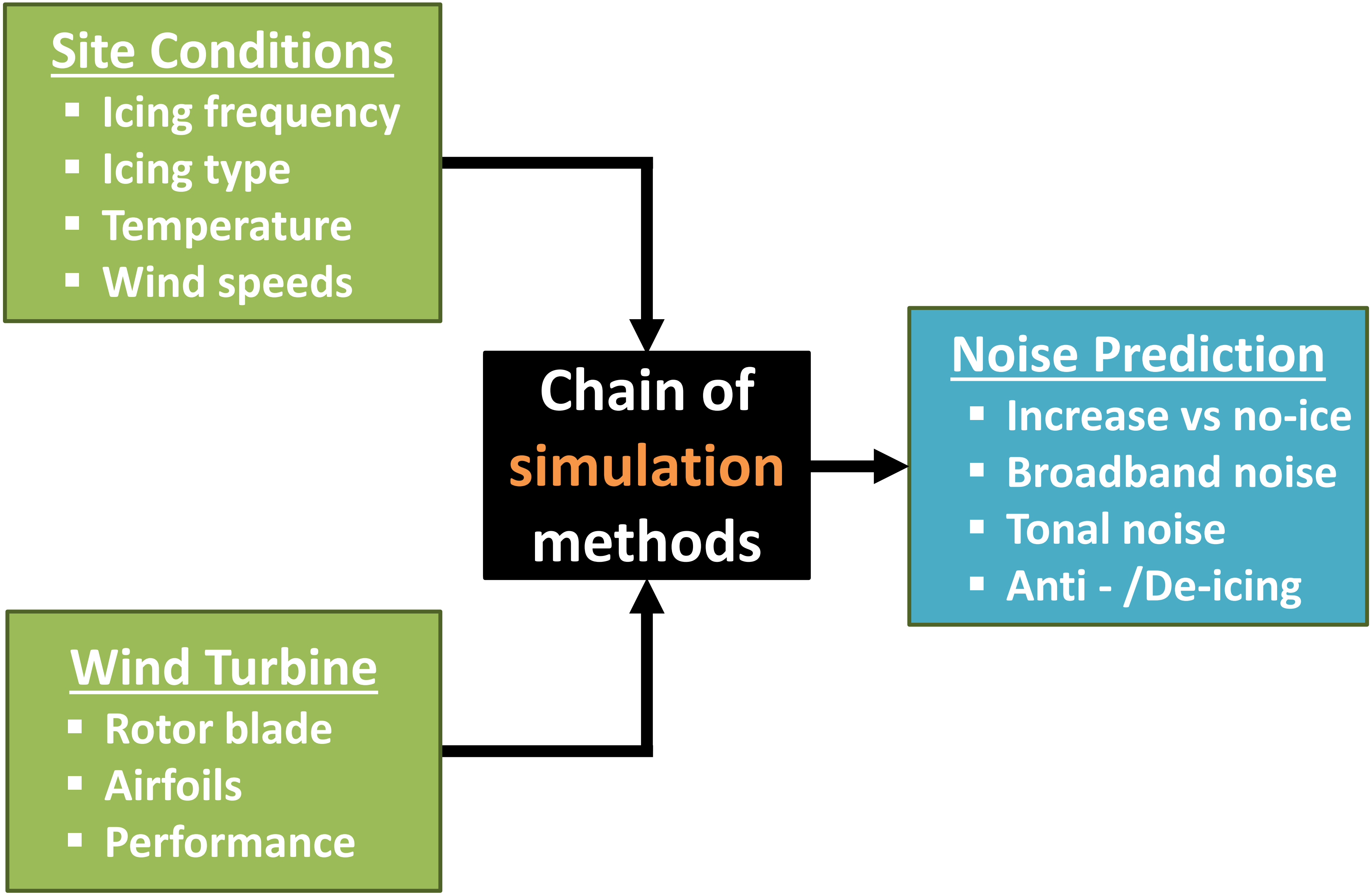


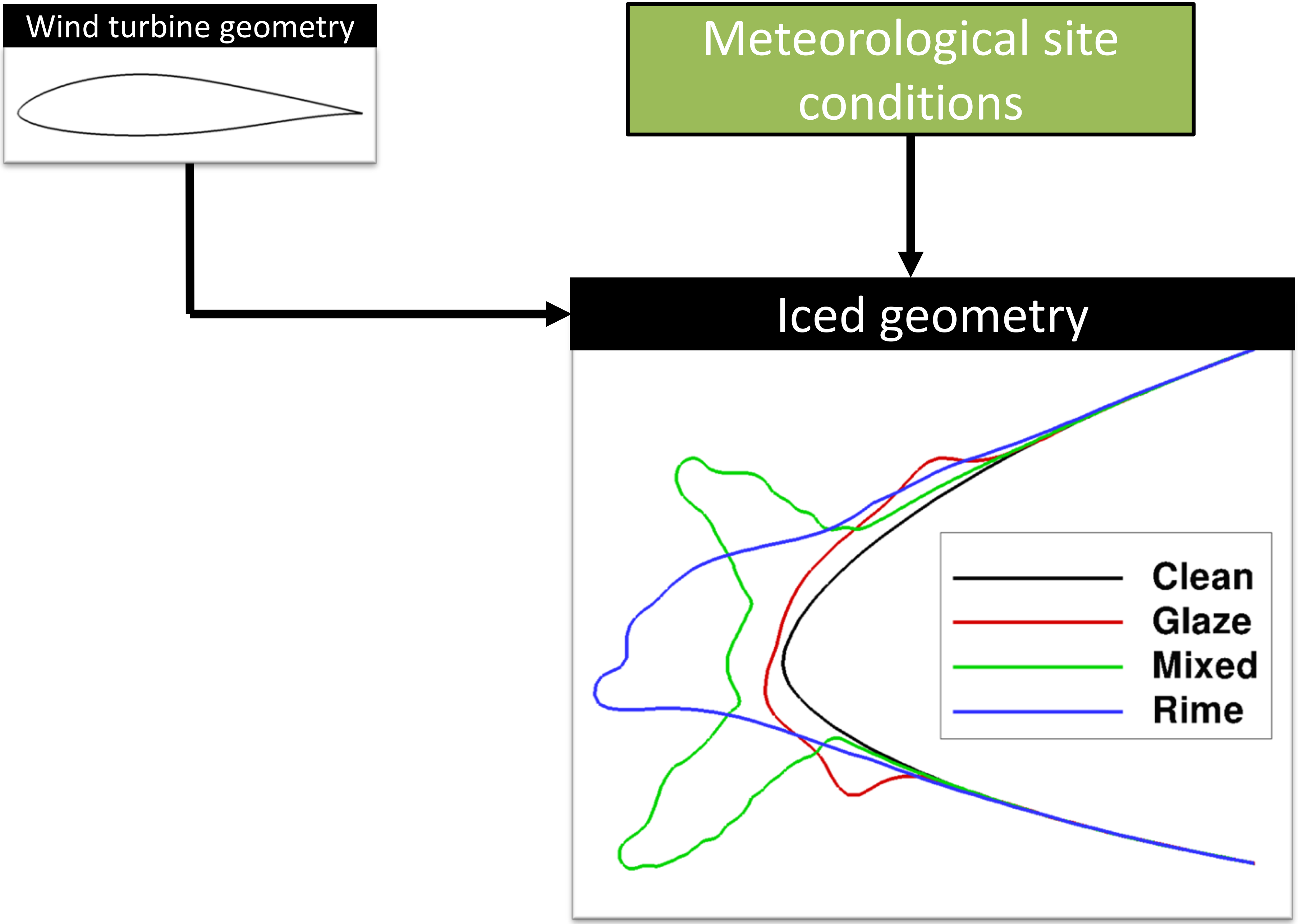
Noise may cause…

… annoyance

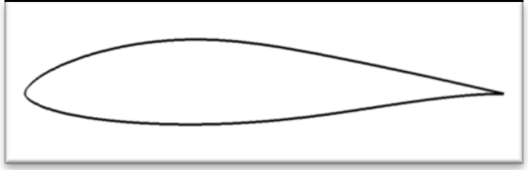
… psychological distress

… insomnia

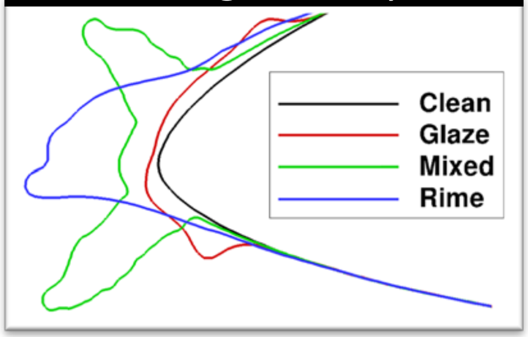

Site Conditions
Icing frequency
Icing type
Temperature
Wind speeds
Wind Turbine
Rotor blade
Airfoils
Performance
Chain of simulation methods
Noise Prediction
Increase vs no-ice
Broadband noise
Tonal noise
Anti - /De-icing


Wind turbine geometry
Meteorological site conditions
Iced geometry
Clean
Glaze
Mixed
Rime

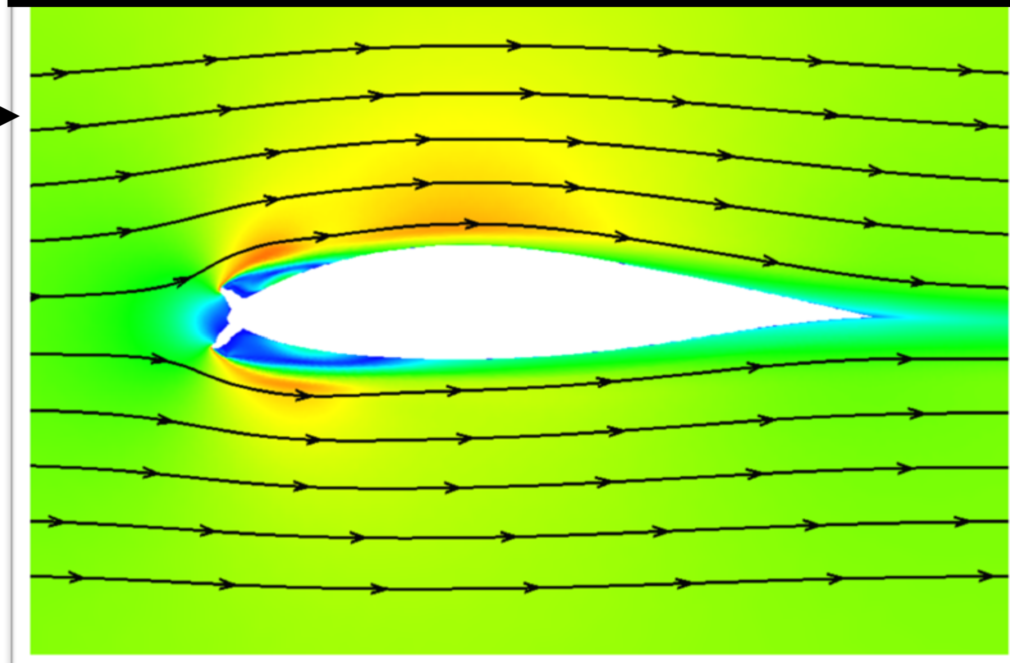
Wind turbine geometry

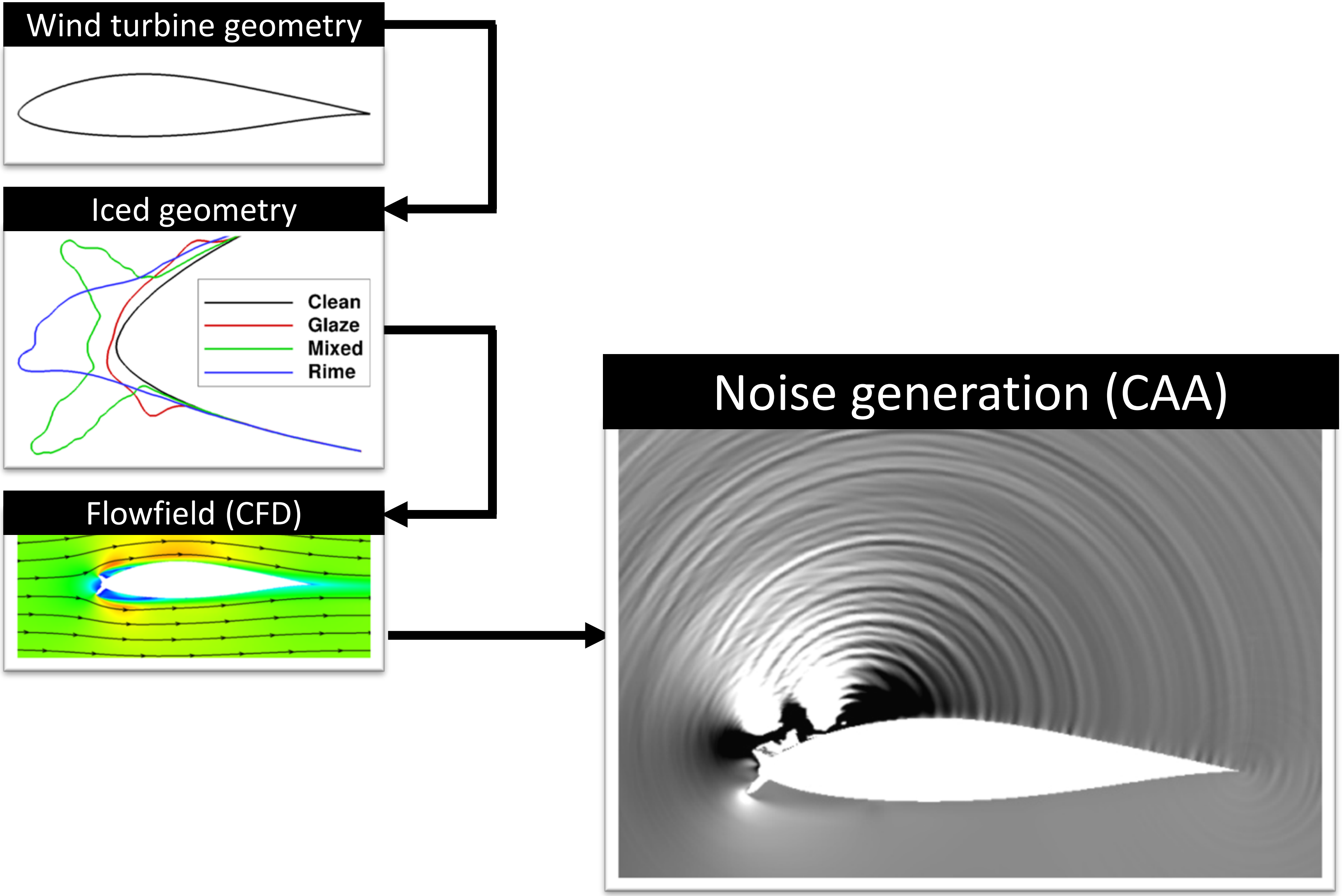


Iced geometry



Flow field (CFD)

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Clean
Glaze
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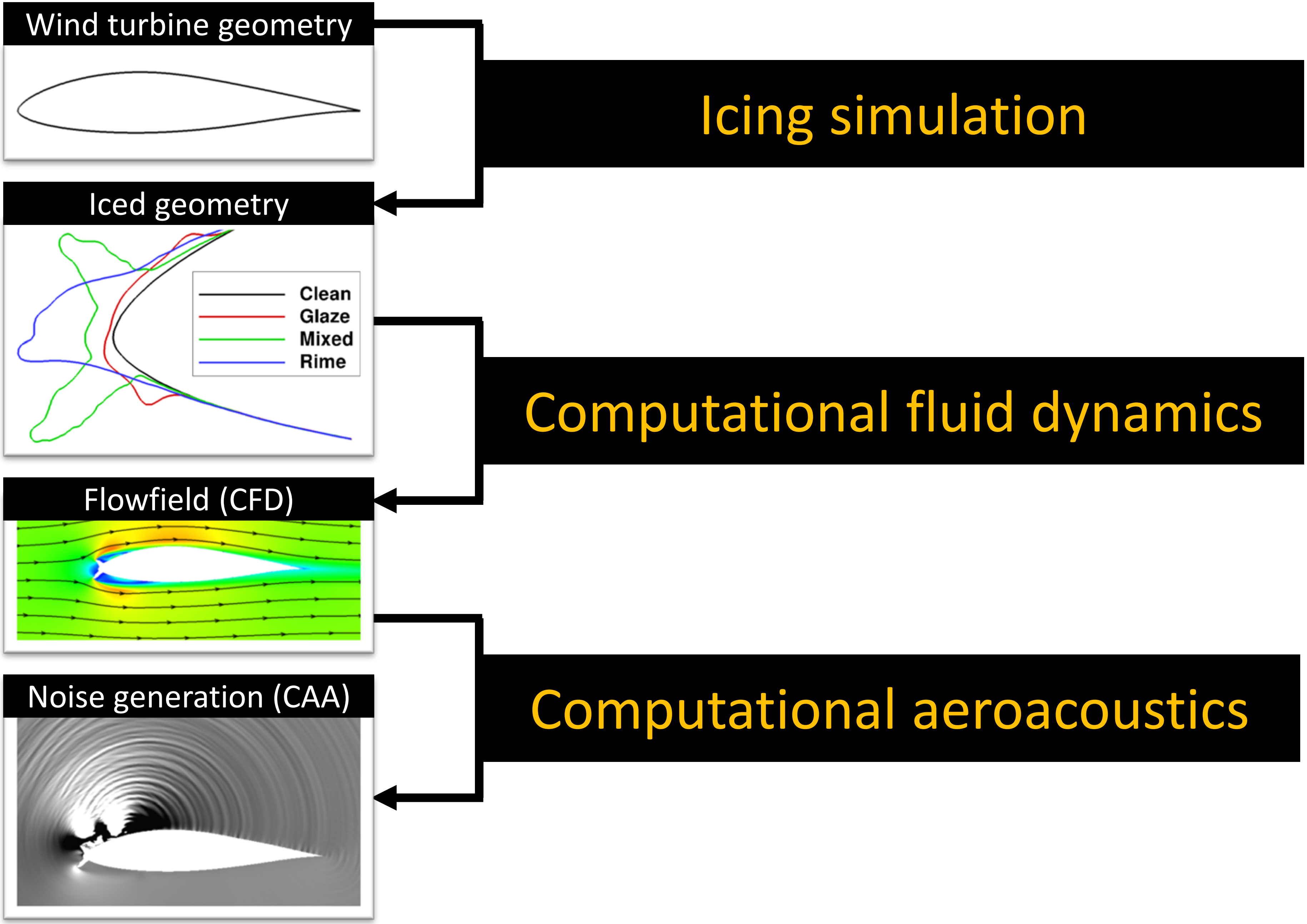
Rime
Flowfield (CFD)
Noise generation (CAA)


Wind turbine geometry
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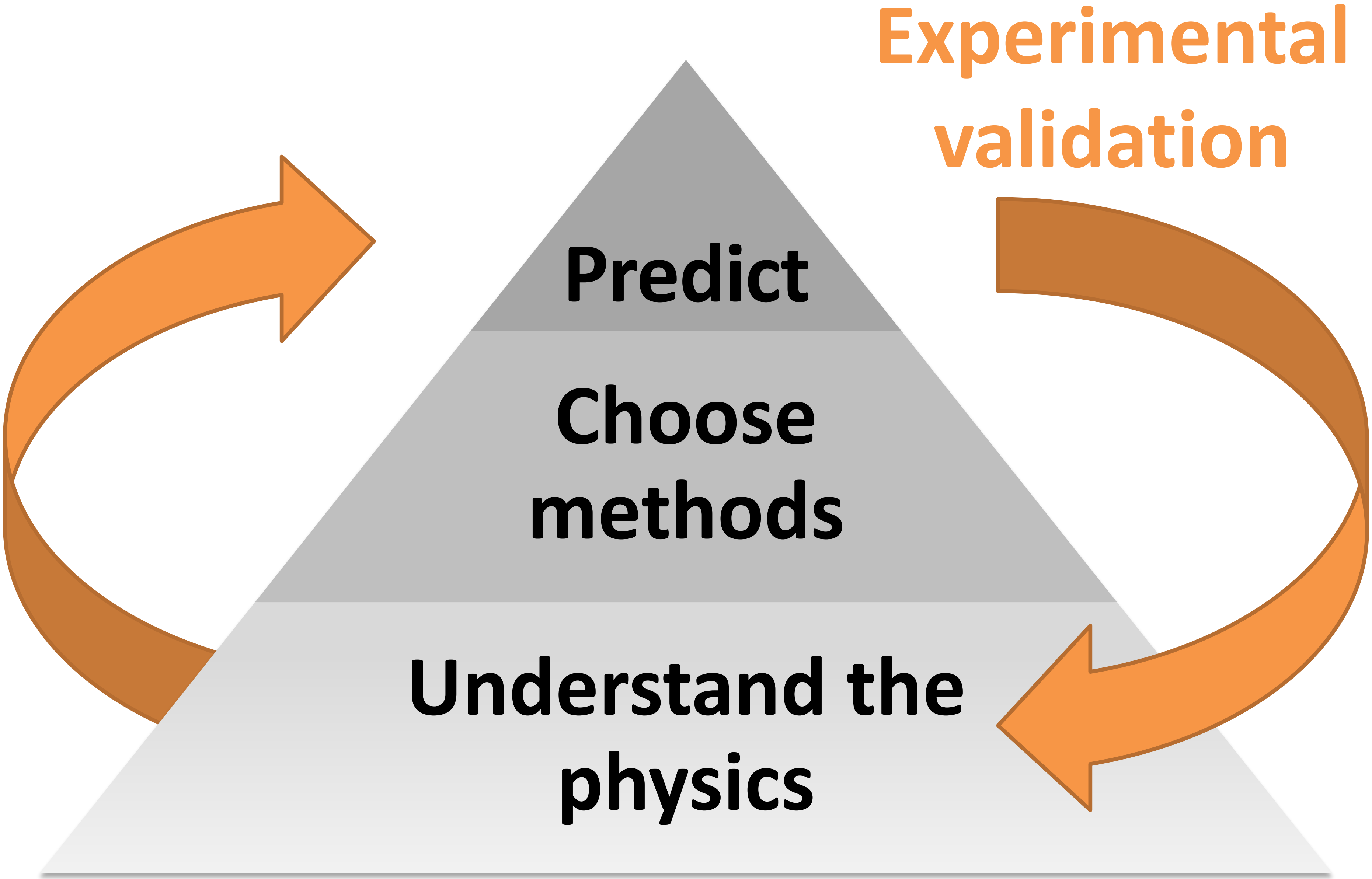
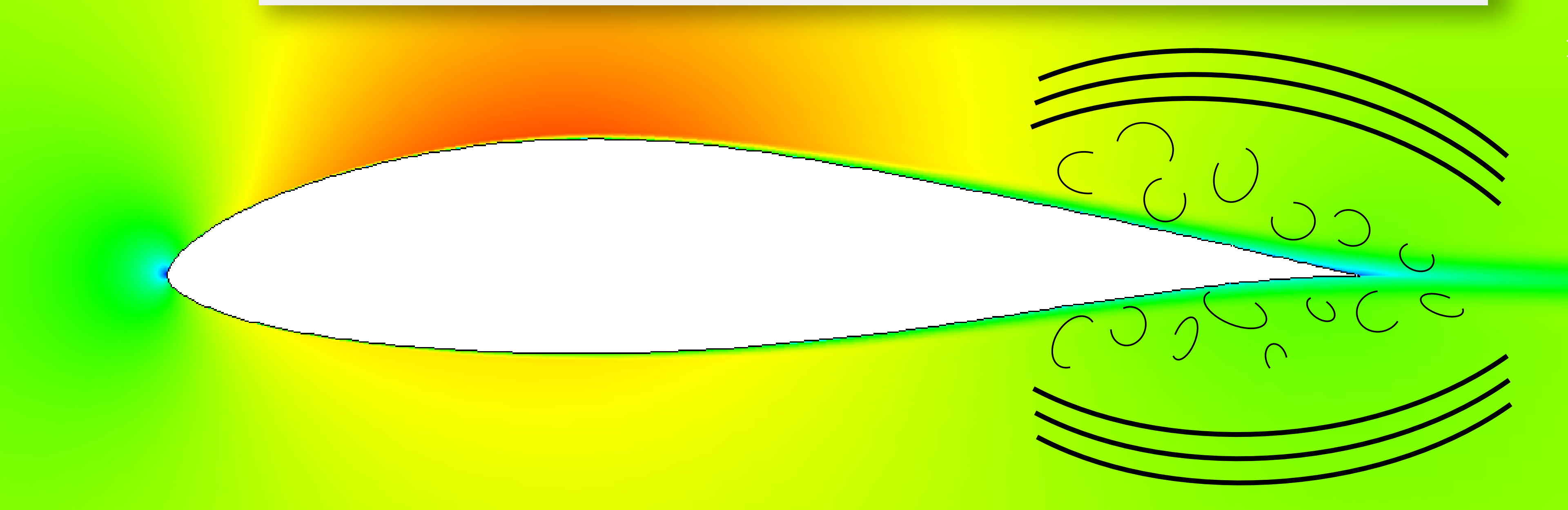
Flowfield (CFD)
Noise generation (CAA)
Icing simulation
Computational fluid dynamics
Computational aeroacoustics

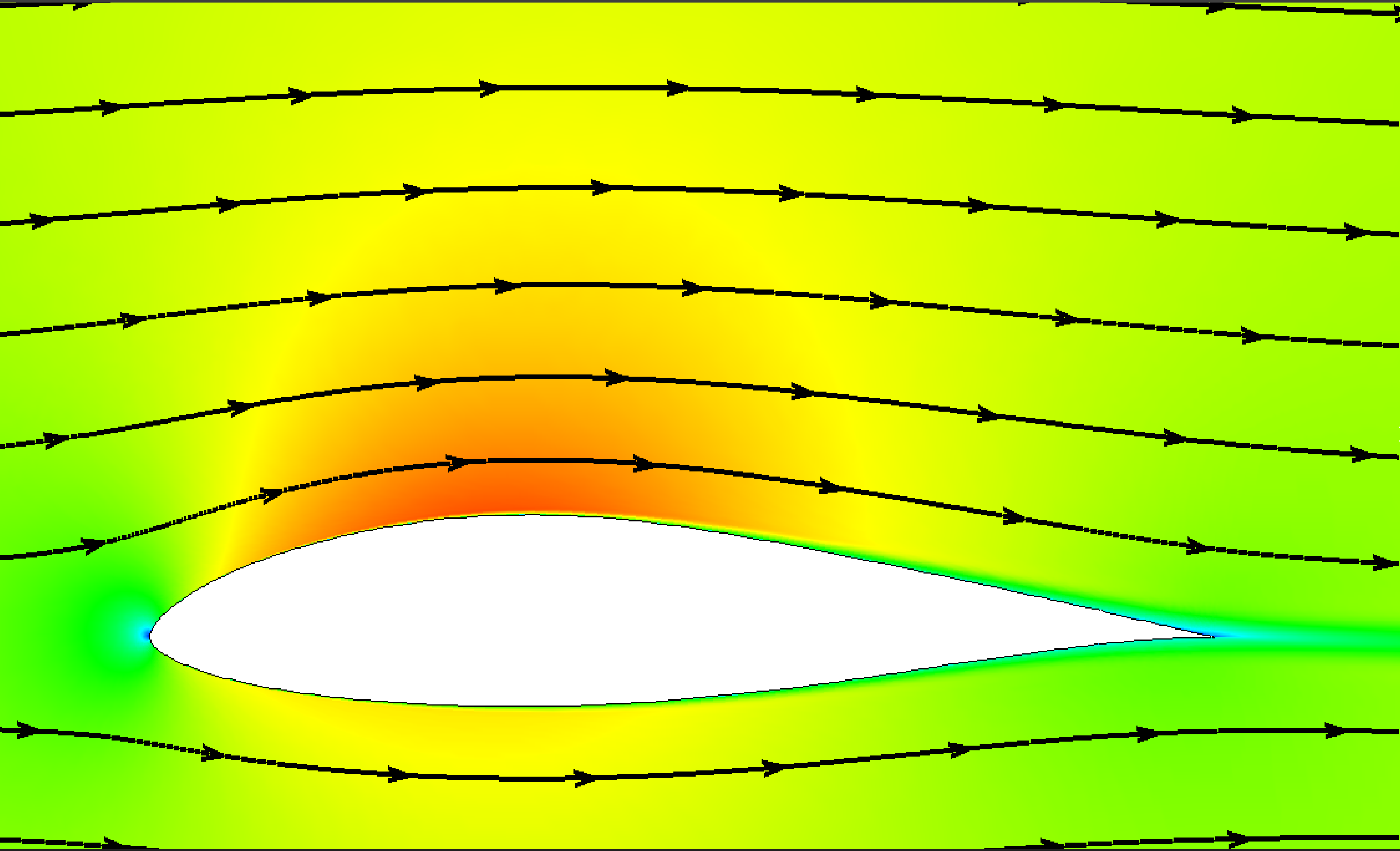

Experimental validation
Predict
Choose methods
Understand the physics

Clean noise generation

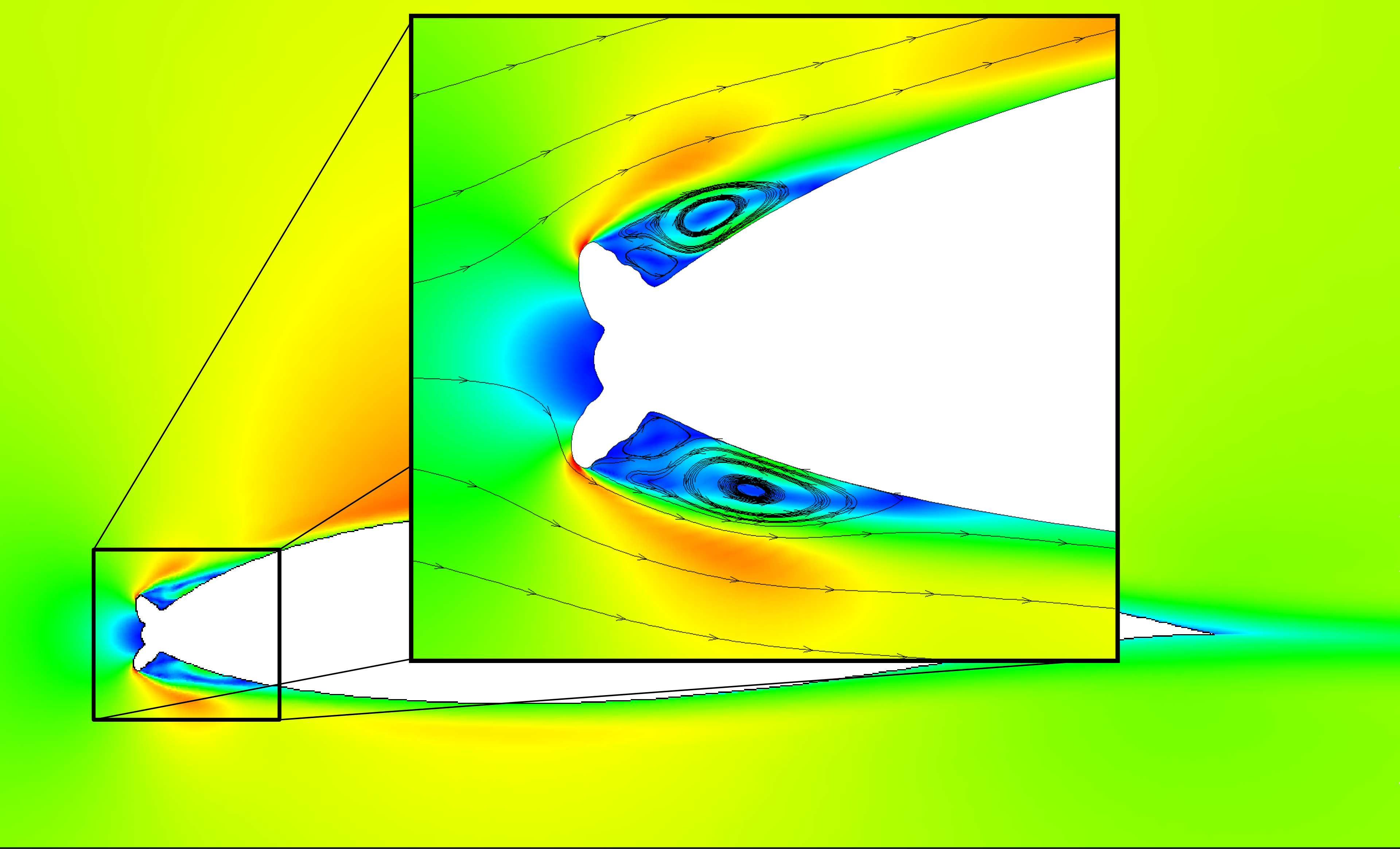
Trailing-edge (TE) noise is the dominant noise source for modern wind turbines.



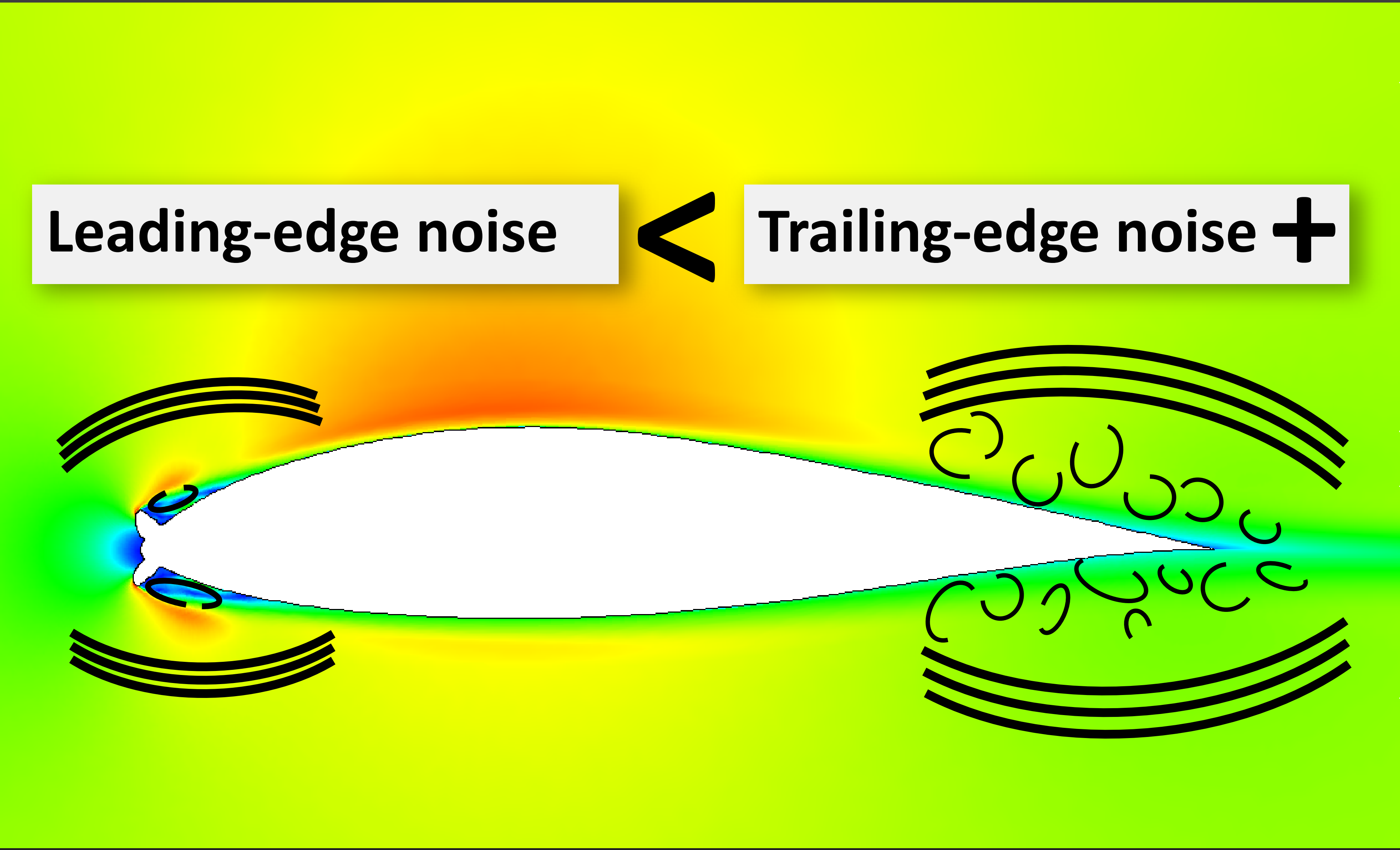
Clean noise generation



Iced noise generation



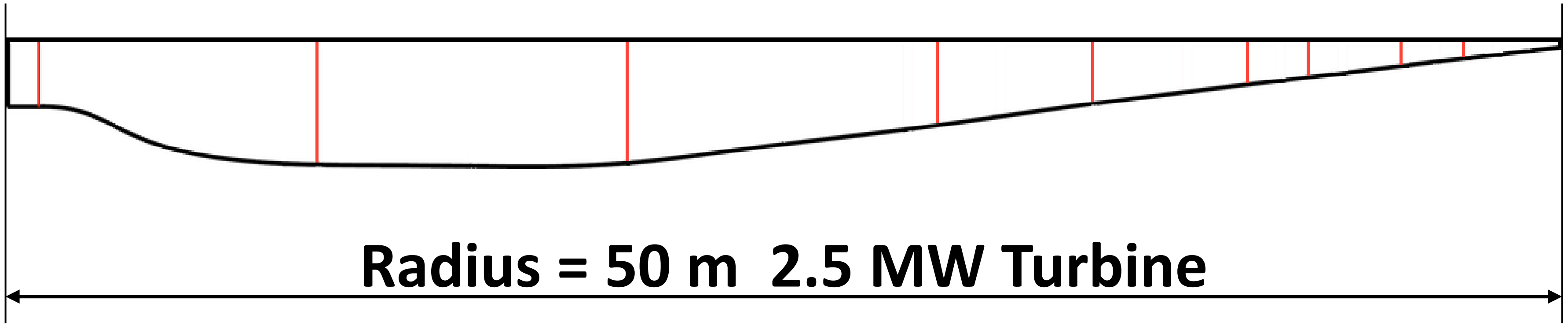
Iced noise generation



Using simpler methods for simulating trailing-edge noise:

R.Hann, A. Wolf, D. Bekirooulos, T. Lutz, E. Krämer: Numerical Investigation on the Noise Generation of Iced Wind Turbines. Winterwind 2012.

Combined simulation results



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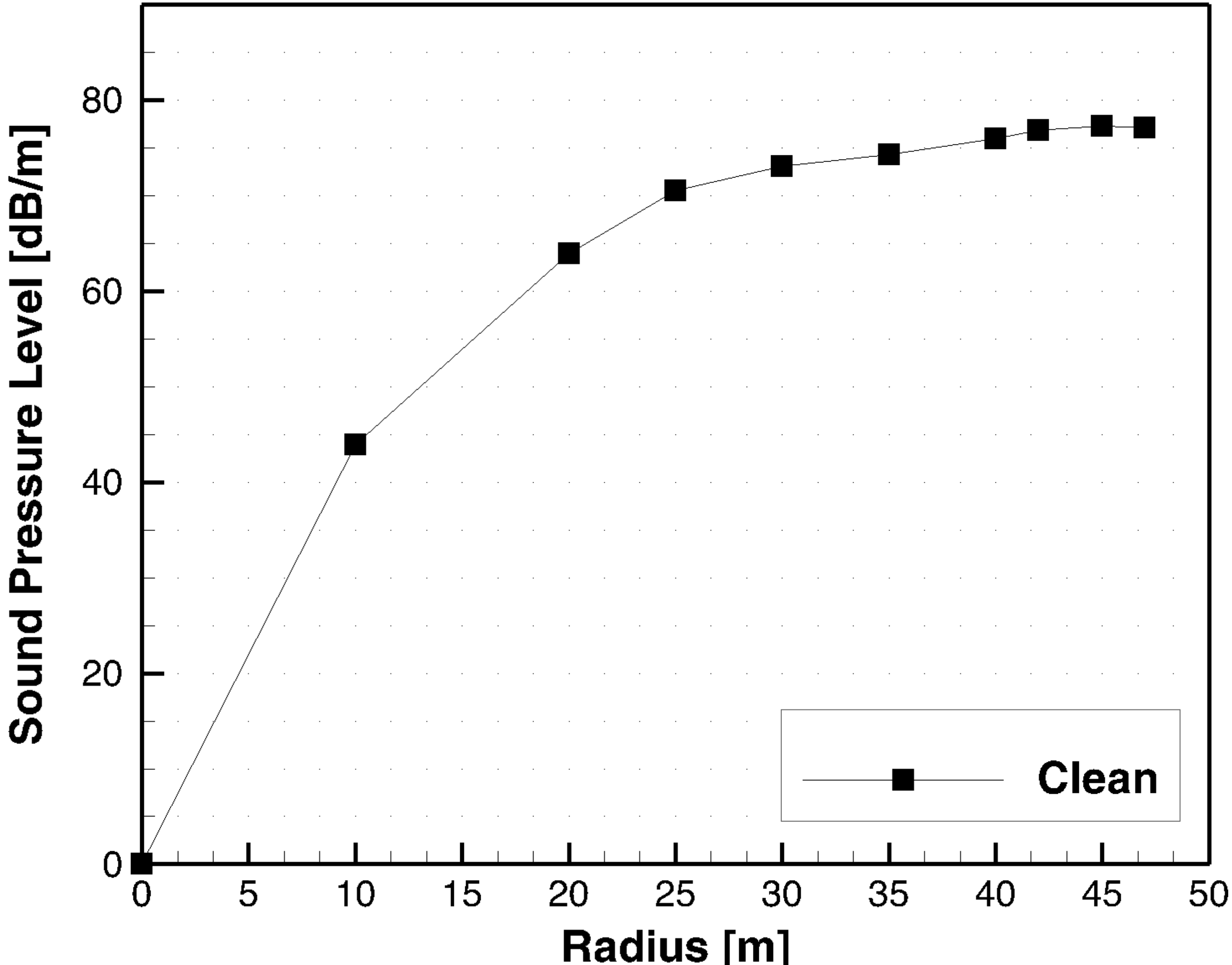

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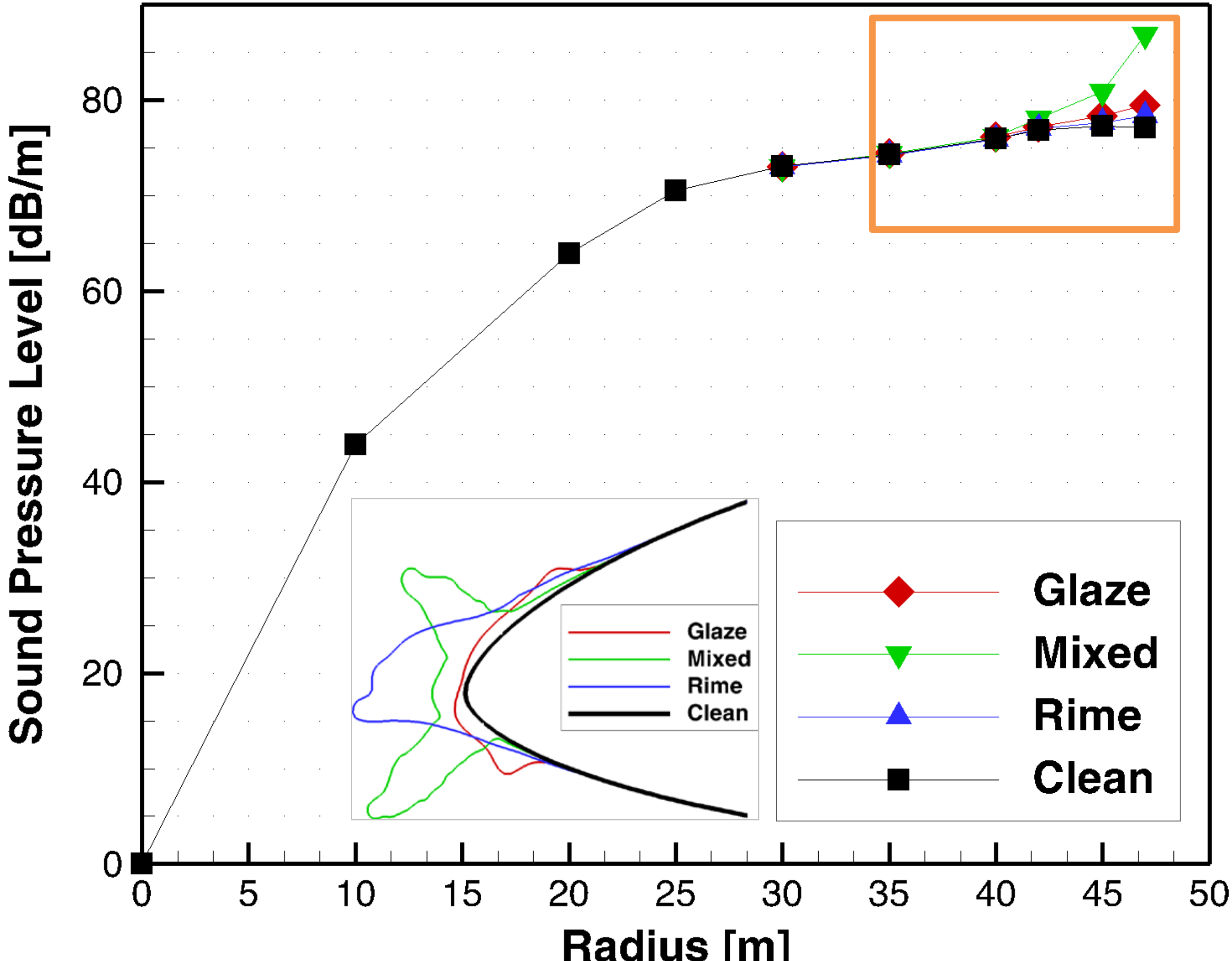
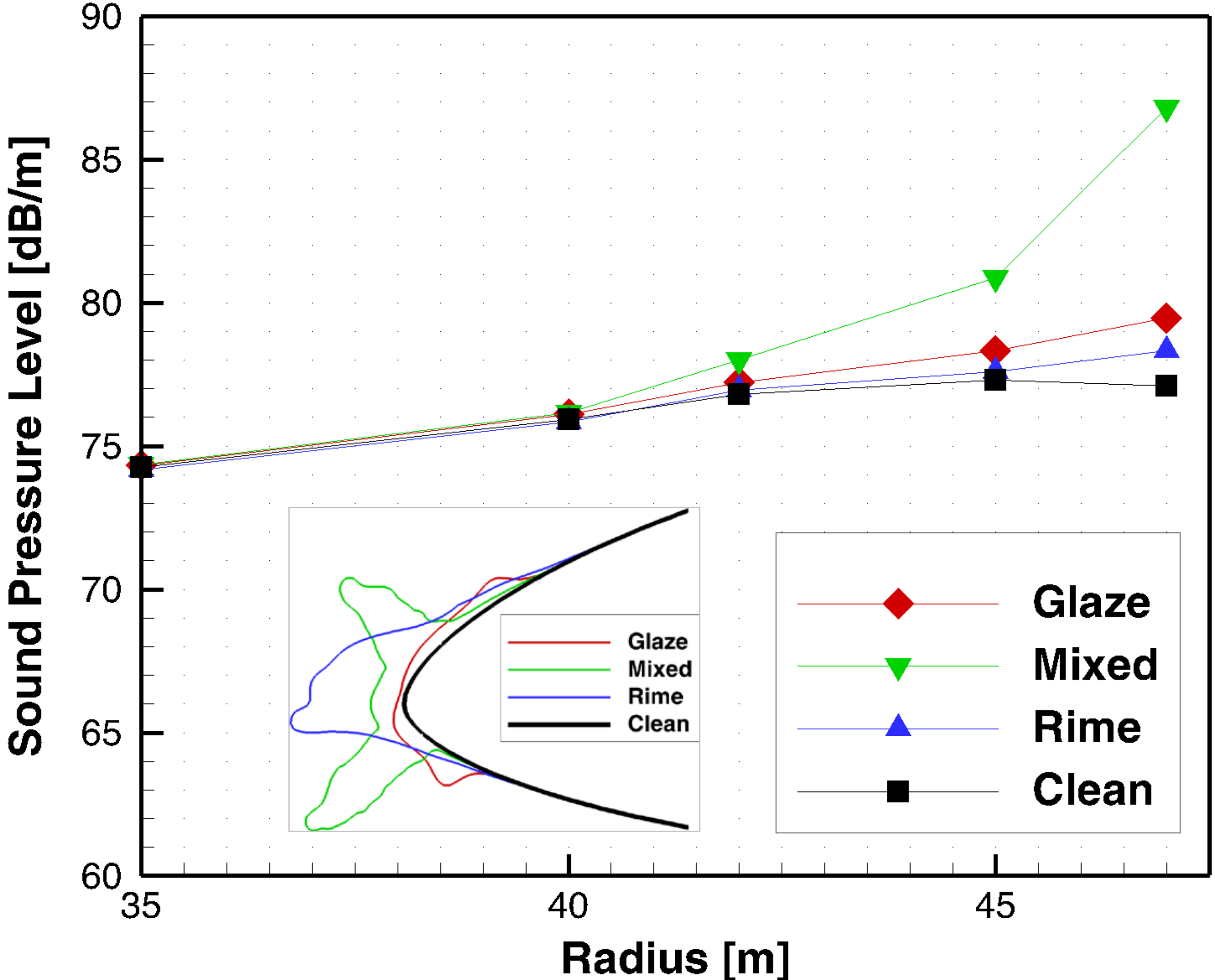
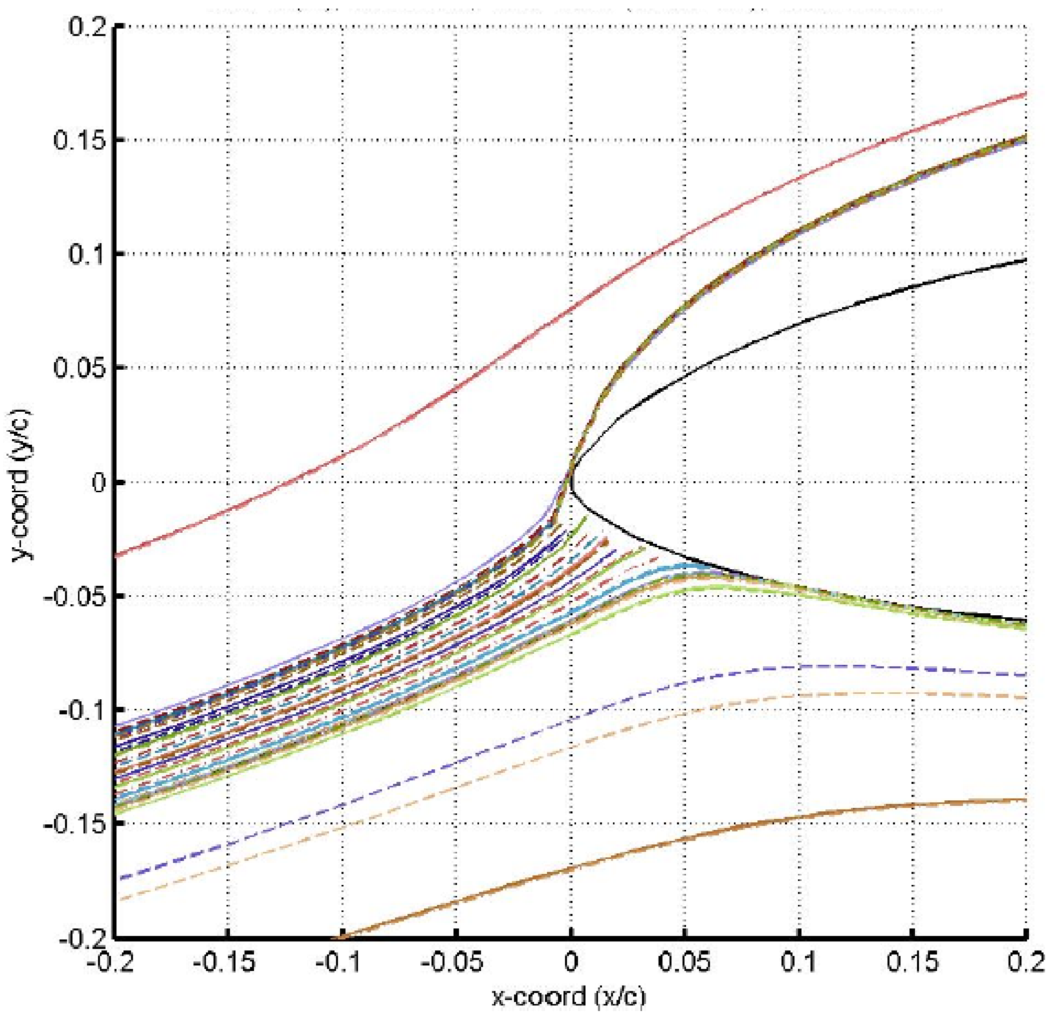


Combined simulation results

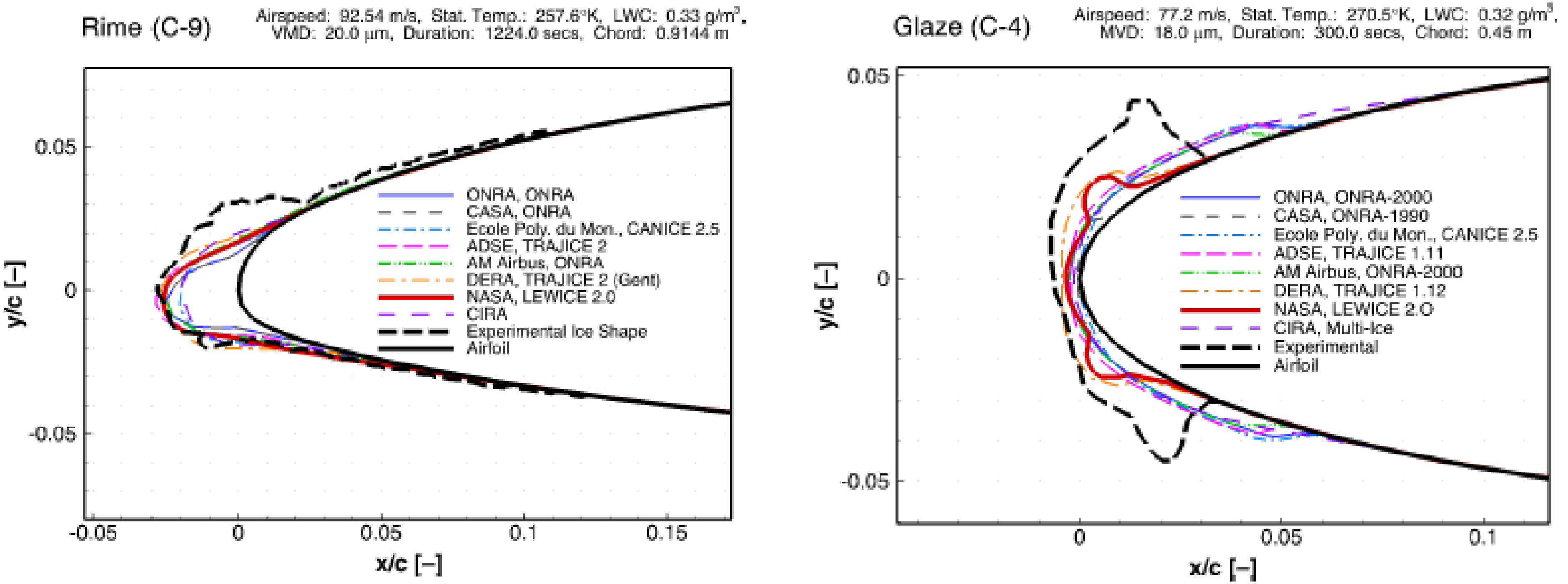


Iced geometry & metrological conditions have a major impact on noise increase.

Icing simulation

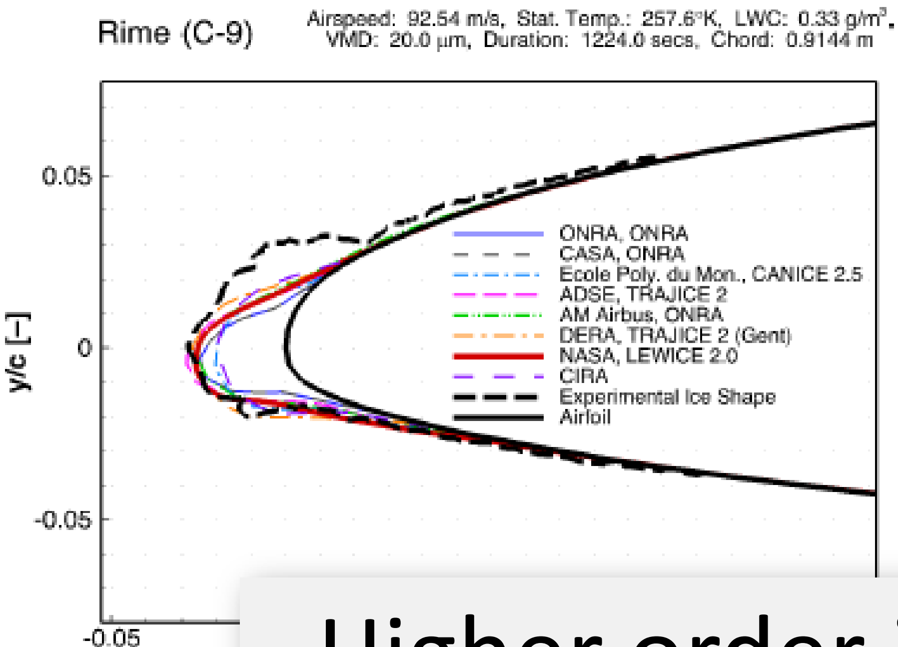


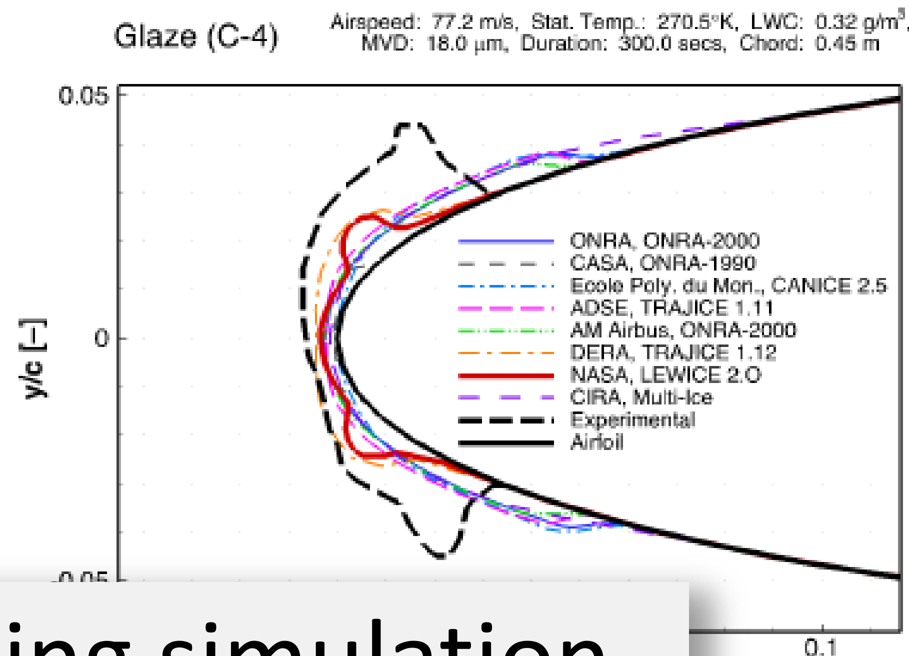
$$\dot{m}_{ice} = \eta_1 \times \eta_2 \times \eta_3 \times LWC \times A \times U_\infty$$



Ref: RTO-TR-038: *Ice Accretion Simulation Evaluation Test.* tech. rep., North Atlantic Treaty Organisation (NATO), 2001.

Icing simulation

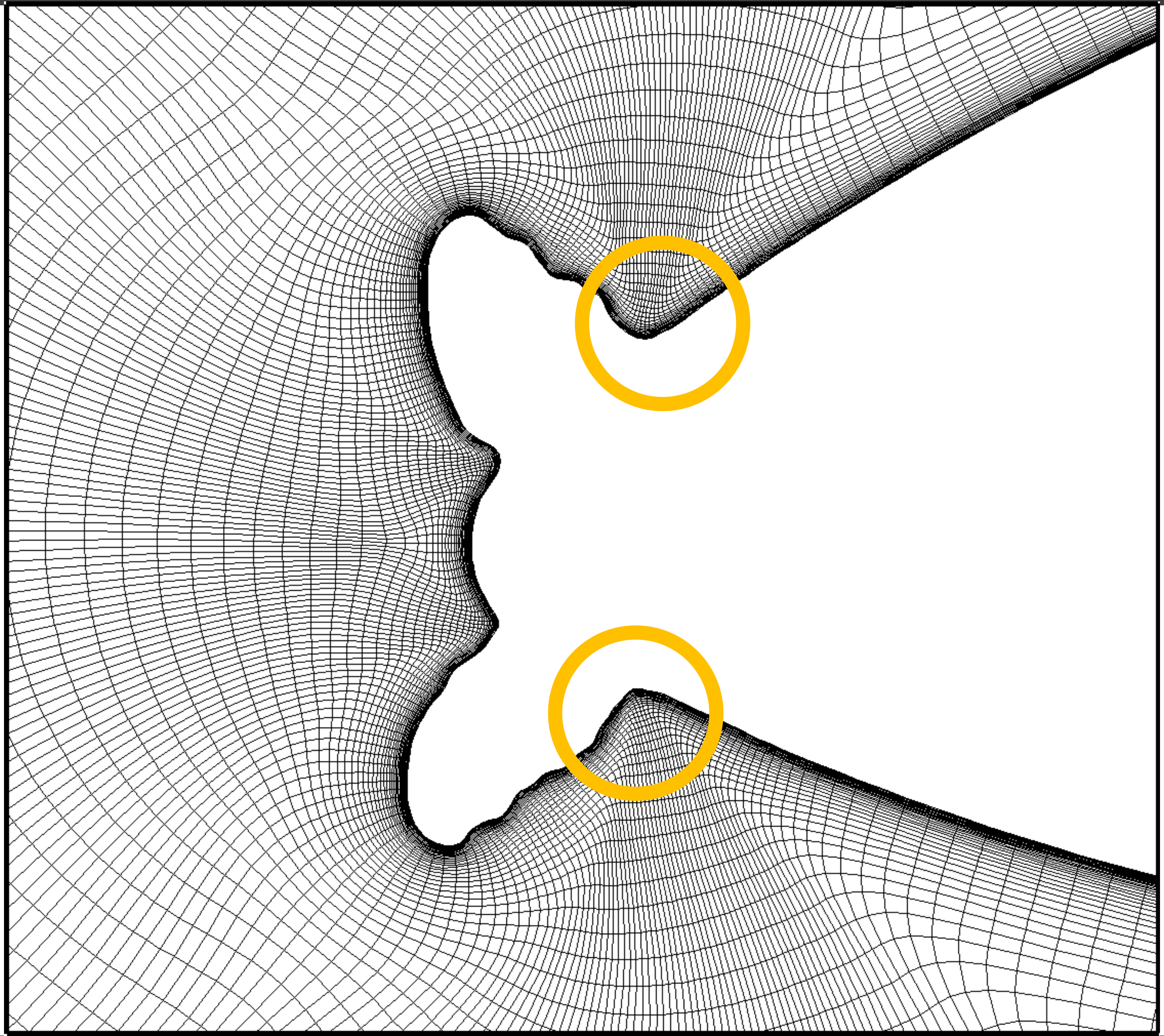




Higher order icing simulation might be necessary.

Ref: RTO-TR-038: *Ice Accretion Simulation Evaluation Test.* tech. rep., North Atlantic Treaty Organisation (NATO), 2001.

Computational fluid dynamics (CFD)



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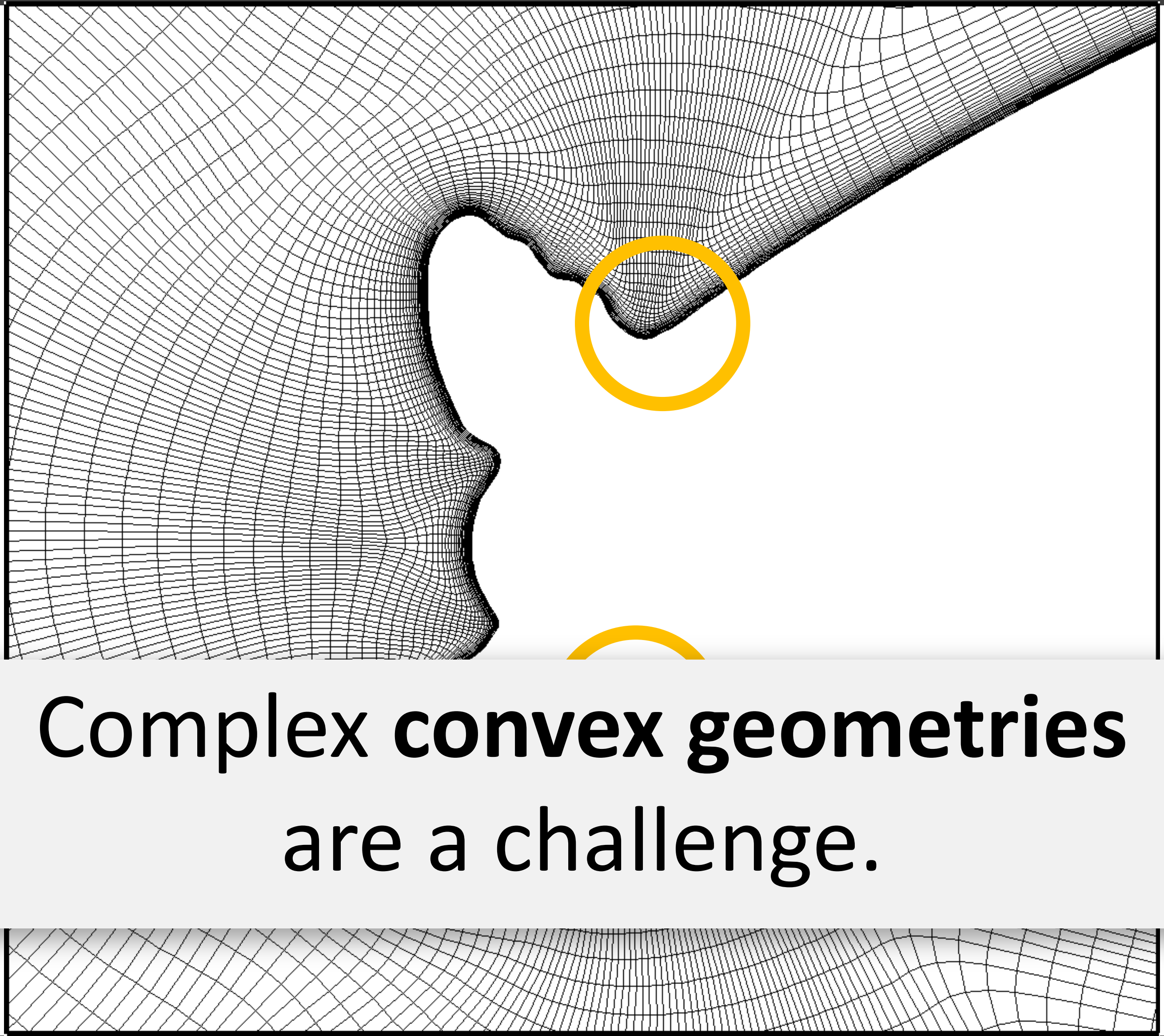

Complex **convex geometries** are a challenge.

Computational fluid dynamics (CFD)

A.G. Kraj und E.L. Bibeau: *Phases of icing on win*... *ice accumulation.* Renewable Energy, Vol. 35, S. 966–927 ... *rized by*

Impact of small scale surface roughness needs to be investigated.

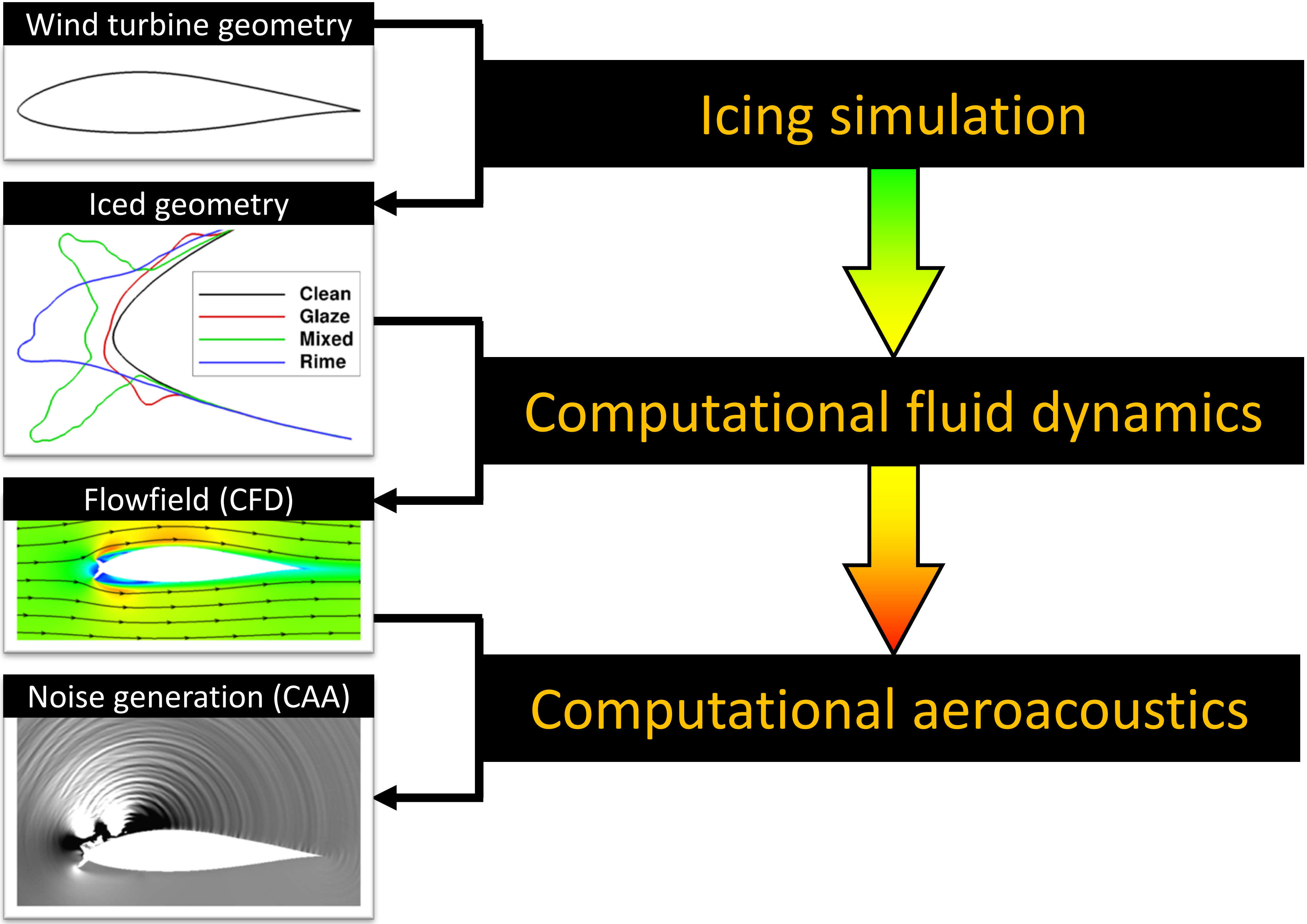
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Photo: VTT

Summary

- Iced wind turbine noise can be simulated.
- Physics must be understood.
- Methods must be chosen carefully.
- Experimental validation is key.

Photo: VTT

Questions?

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Photo: VTT