

# Wind sector management

## - using Parabolic Equations for Sound Propagation

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Why Power optimization of wind turbines:

- Potential electric power without increasing sound levels.
- Pitch regulation, modes.
- 24/7 Surveillance of operations.

Why Parabolic equations:

- Higher heights.
- Complex terrain.
- Sound speed profiles.

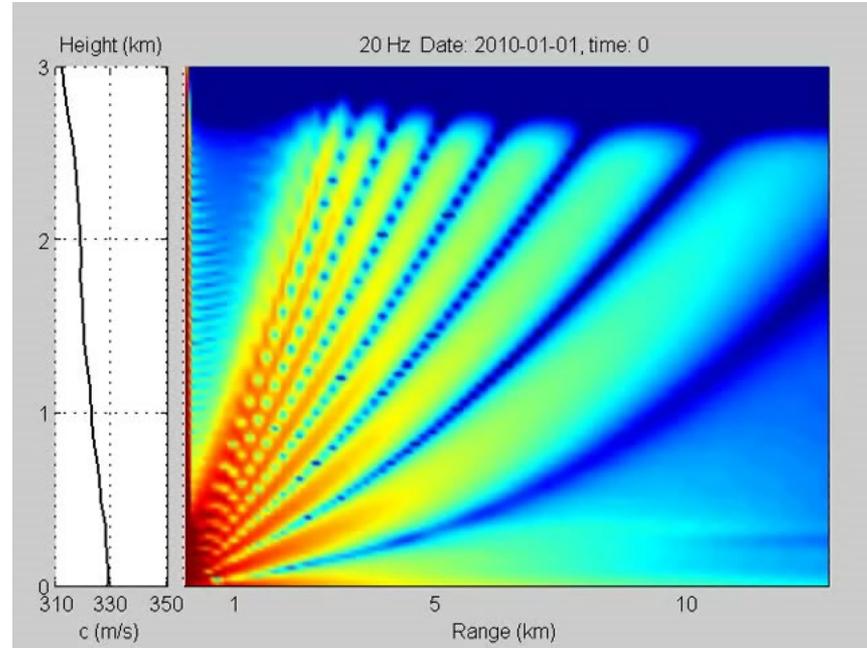


# Sound propagation

- Wave equation:

$$\Delta^2 p - \frac{1}{c} \frac{\partial^2 p}{\partial t^2} = 0$$

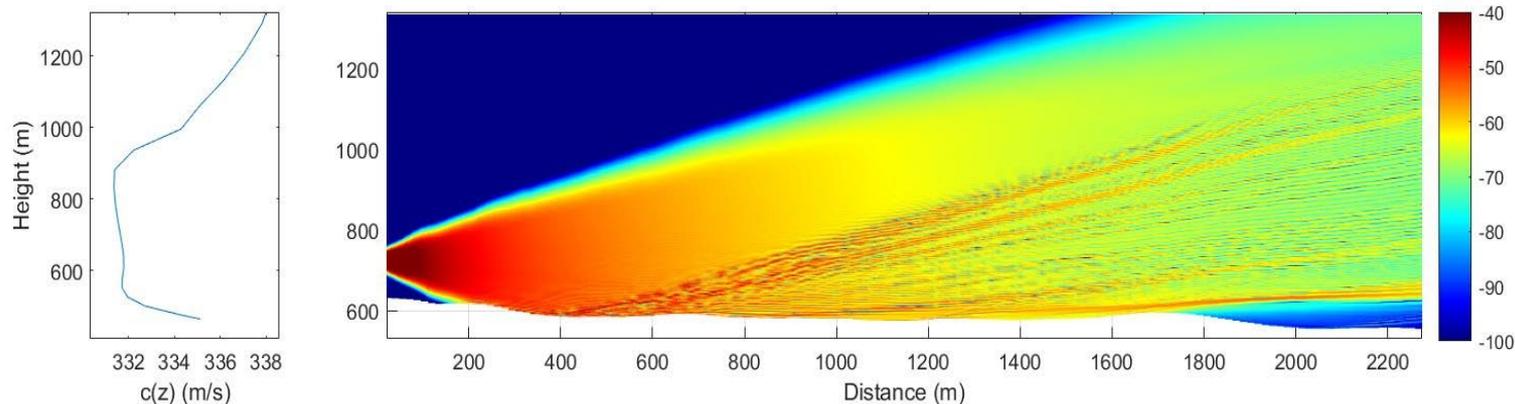
Two differential operators and  $c$



<https://drive.google.com/file/d/1mMbJF-17ULy7eI8MZWFZppgIkmgO58A/view?usp=sharing>

# Parabolic Equation (Beilis Tappert)

- Arbitrary sound speed profiles
- Computational efficiency
- BTPE see Parakkal et al (2012)
- Turbulence

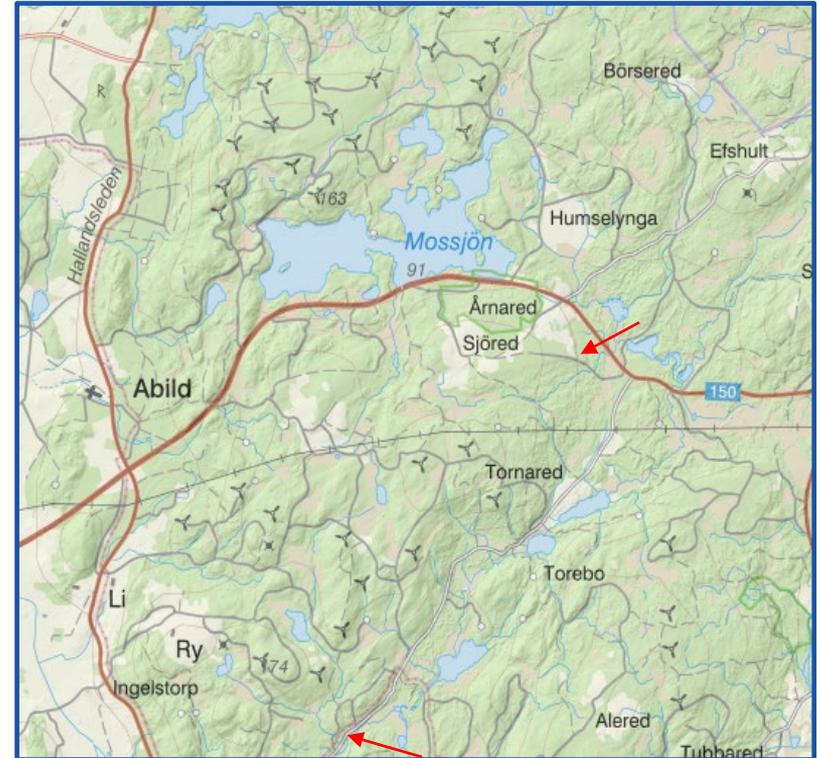


Parakkal, S., Gilbert, K. E., & Di, X. (2012). Application of the Beilis-Tappert parabolic equation method to sound propagation over irregular terrain. *The Journal of the Acoustical Society of America*, 131(2), 1039–1046. <https://doi.org/10.1121/1.3676693>

# Site description

## Wind park in Southern Sweden

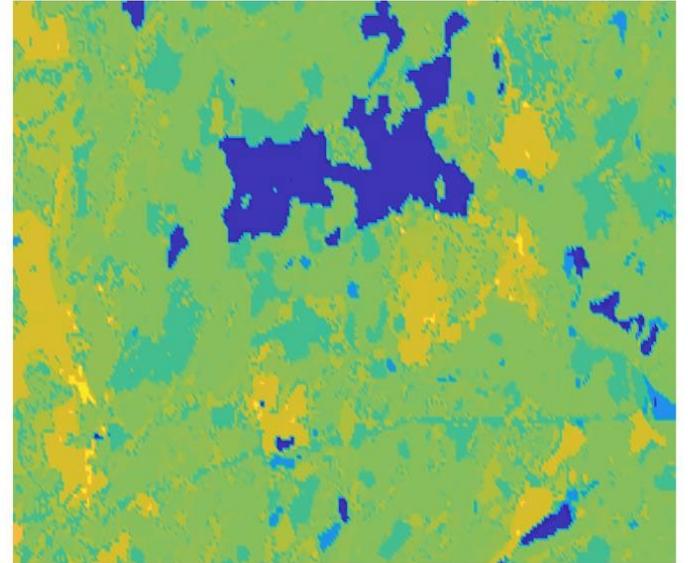
- Complex terrain
  - Hills and valleys
  - Changing ground conditions
  - All downwind conditions improbable
- 34 Wind turbines, 2-3.3 MW.  
Surrounding dwellings around the lake.
- Two reception positions, S and NE of 12 turbines.



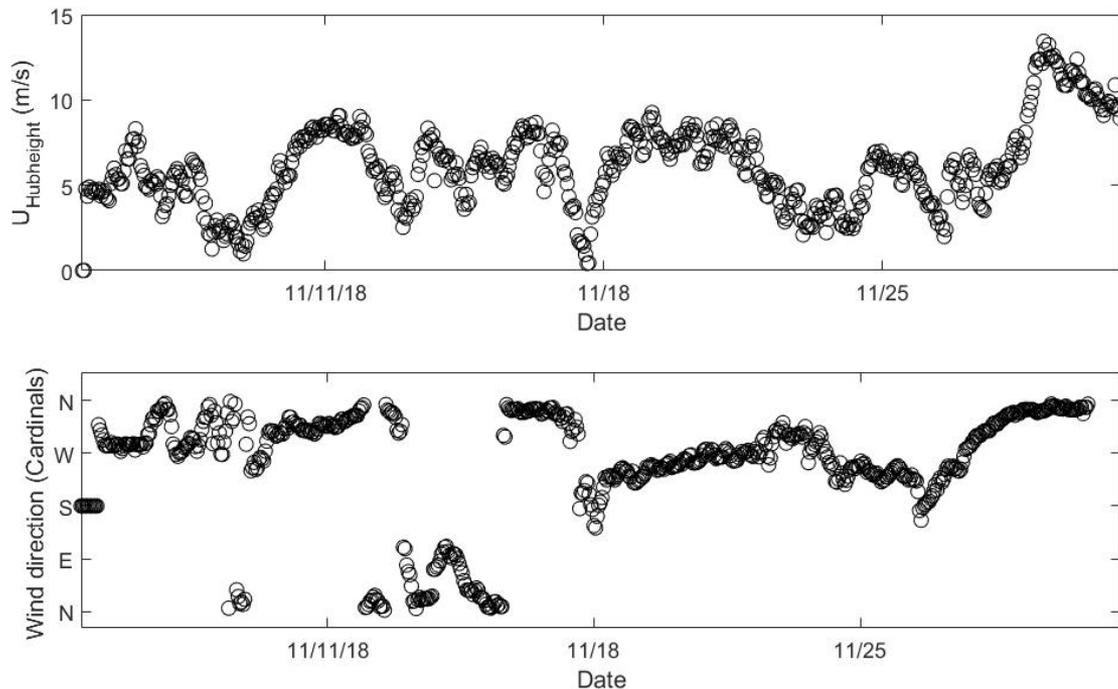
# Environmental parameters

Databases:

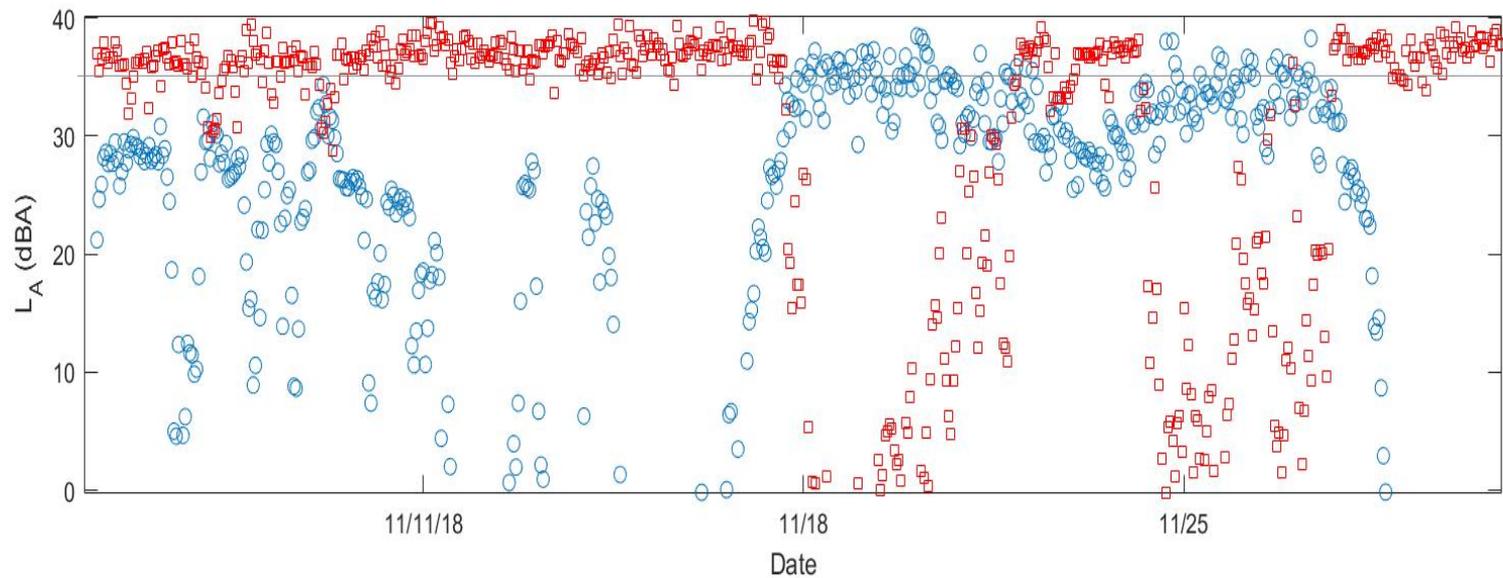
- Altitude alteration
- Ground conditions
  - Ground cover class
  - Corine database, pan-European
  - Ground impedance calculated from Flow resistivity derived measurements.
- Meteorologic conditions
  - AROME-Hirlam Scandinavian forecast
  - 2.5x2.5 km special resolution, hourly data



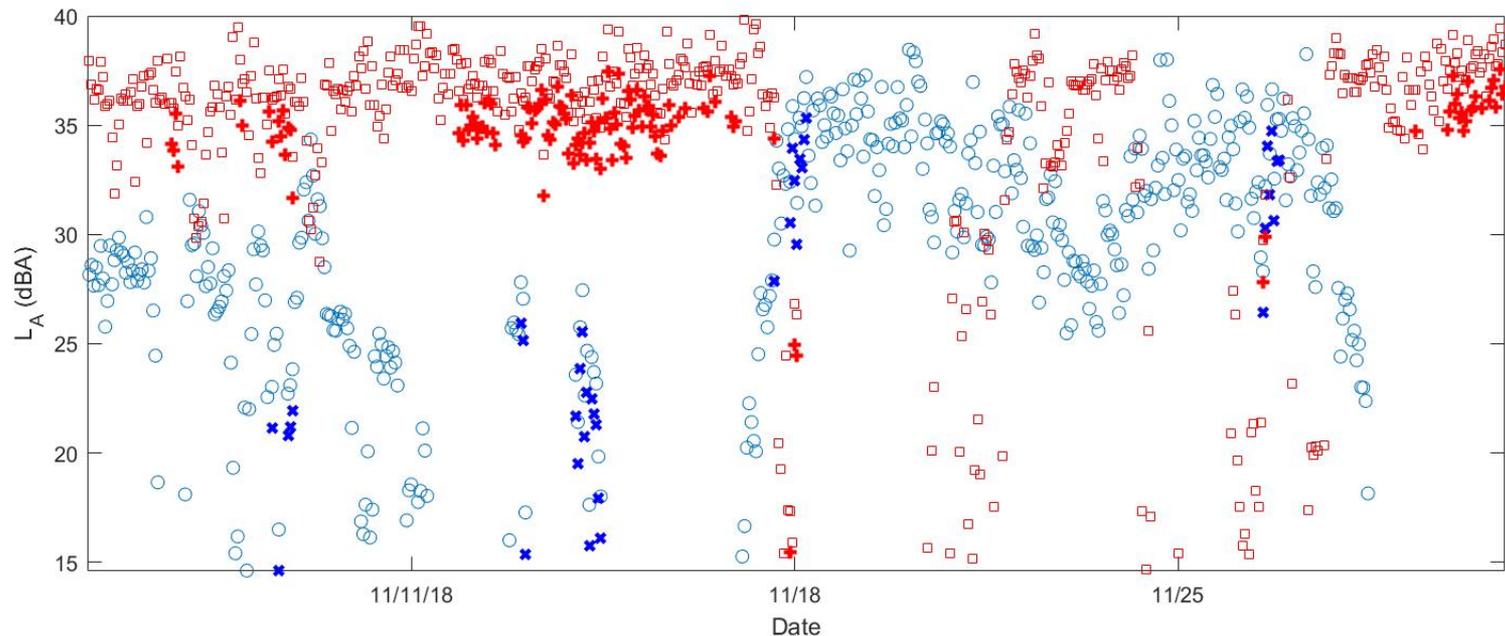
# Wind data



# Sound pressure level



# Sound pressure levels, moded





# Conclusions

- Local sound speed profiles impact as much as modes
- Computational efficiency BTPE sufficient
- Turbulence
- Future studies on more parks and validation to measurements required.



# Thank you!

## Questions & Discussion

Contact:  
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