University of Stuttgart
Germany

Lidar-based wake tracking for wind farm control at alpha ventus

Steffen Raach[1], David Schlipf [1], Ines Würth[1], Juan José Trujillo[2], Po Wen Cheng[1]
[1] Stuttgart Wind Energy, University of Stuttgart, Allmandring 5B, 70569 Stuttgart, Germany
[2] Institute of Physics, University of Oldenburg, Ammerländer Heerstr. 136, 26129 Oldenburg, Germany

www.uni-stuttgart.de/windenergie

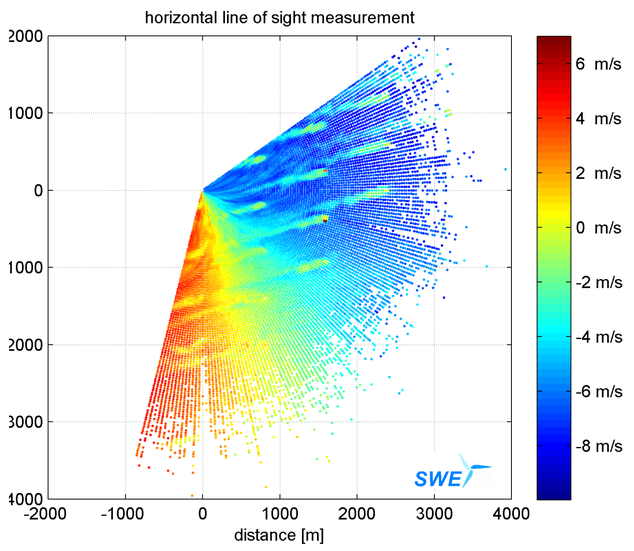
Motivation:

Wake redirecting is a promising approach to

- increase the power output of the wind farm
- decreased the structural loads induced by the wake interactions.

Why using a lidar:

- Using optimized yaw angle is open loop (sufficient in defined simulation conditions).
- A nacelle-based lidar system could close the loop by tracking the wake.



Approach:

full mathematical description of:

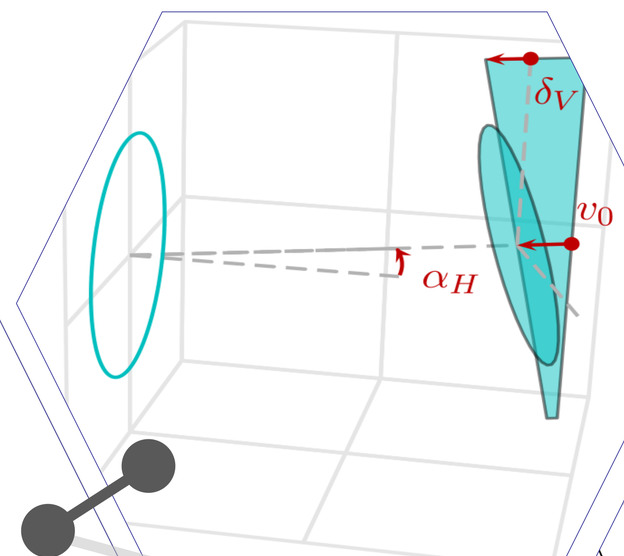
- a lidar measurement
- a wind turbine wake
- a reduced wind field

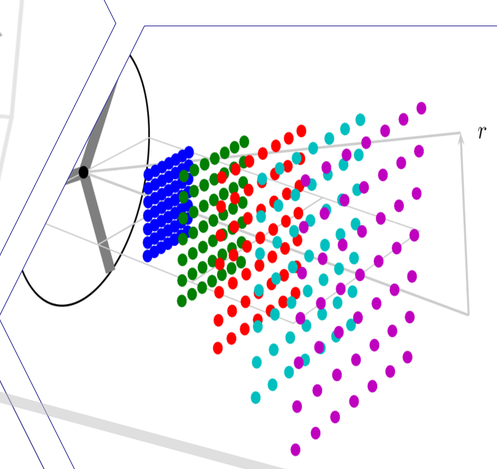
➔ nonlinear model fit for each lidar measurement sequence to obtain the parameters of the models:

- wind speed, shear, misalignment
- wake characteristics displacement, dissipation rate, extracted power

Wind Field Model

- effective wind speed
- vertical shear
- horizontal misalignment
- Taylor‘s frozen tyrbulence hypothesis
- superposition of the wake deficit





Experimental Setup

- SWE Lidar scanner nacelle-mounted on AV 7 facing downwind
- 7x7 measurement grid in 5 distances
- from March 11 to July 11

Lidar Model

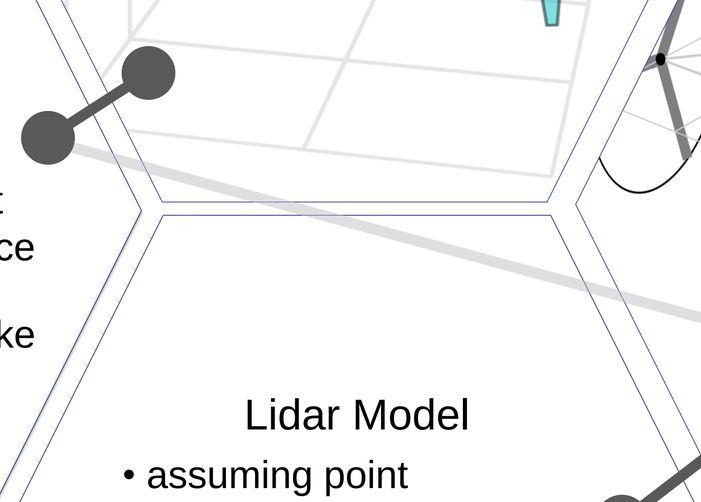
- assuming point measurements
- line-of-sight wind speed extracted from wind field

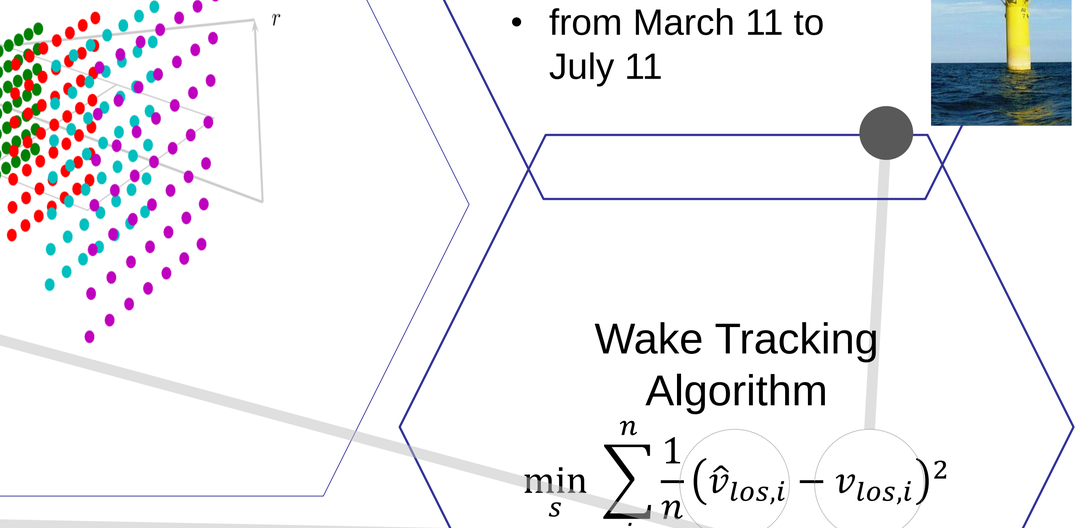
Wake Tracking Algorithm

$$\min_s \sum_i^n \frac{1}{n} \left(\hat{v}_{los,i} - v_{los,i}\right)^2$$

Wake Model

- initial wake deficit based on the power coefficient of the turbine
- energy dissipation modeled by a 2D filter with dissipation rate





Stuttgart Wind Energy
@ Institute of Aircraft Design

Conclusion:

- The approach enables the tracking of the wake center.
- This can be a necessary step towards a field testing of wake redirecting.

Outlook:

- Currently implementing wake tracking algorithm in SOWFA.
- Feedback controller design to redirect the wake based on lidar measurements.