PO.195

Automated yaw misalignment detection based on satellite imagery and numerical weather models

Samuel Davoust, Francois Delaunay

Tipspeed

Yaw misalignment can be assessed within 2.5° using standard 10 min SCADA, and no external sensors.

INTRODUCTION

Yaw misalignment, the average difference between the orientation of a wind turbine rotor and the wind direction, can cause underperformance. Current techniques evaluating yaw misalignment are not fully satisfactory:

- **External sensors** such as lidar are very accurate but hard to scale
- **SCADA-based analytics** do not perform equally well on all types of turbines and sites, and are dependent on input data quality

METHOD

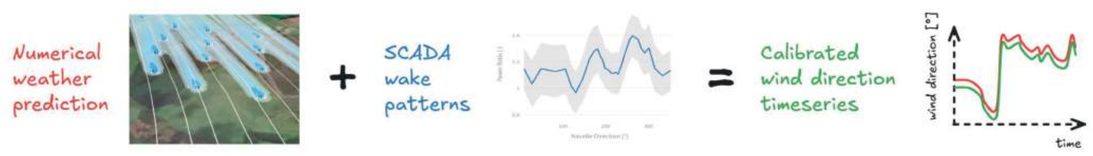
We present a sensor-free method improving upon current data-driven techniques by using high-resolution satellite imagery and numerical weather models:

1. Correct SCADA nacelle direction with satellite imagery

- High-resolution images are used to systematically verify or correct each turbine's SCADA nacelle direction within a few degrees

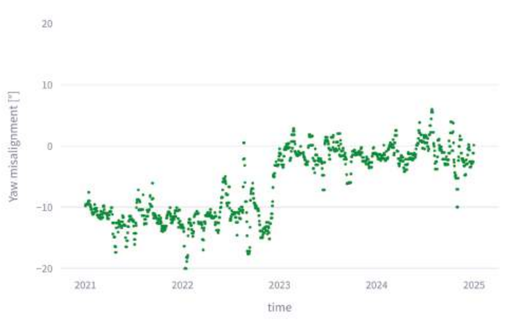
2. Predict wind direction via numerical weather models

- Wind and wake timeseries are generated for each turbine, calibrating wind direction against available observations



3. Compute yaw misalignment

- Calculated as the difference between nacelle direction timeseries (step 1) and wind direction timeseries (step 2)
- Results are available for each turbine (left), including evolution over time (right)

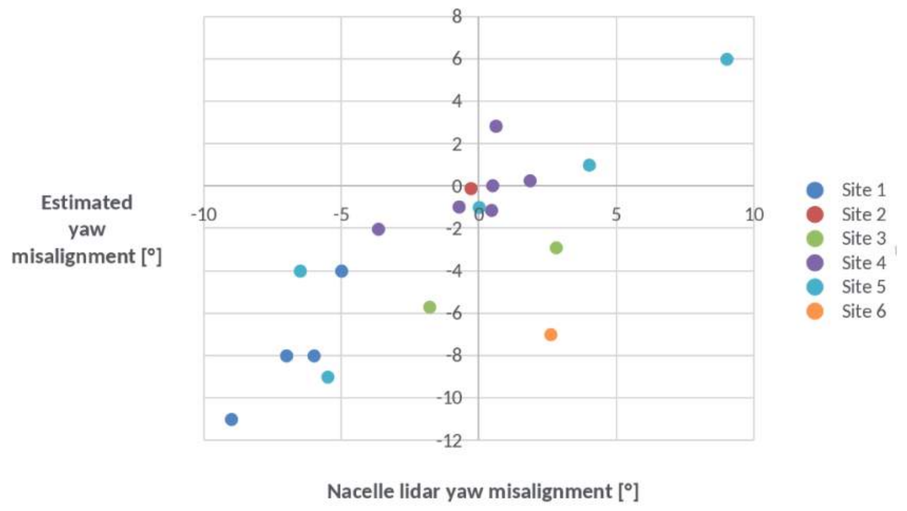


VALIDATION

We conducted **19 blind tests** with several customers across 6 sites on 2 continents, covering varied terrain complexity and turbine models. All turbines were previously tested with nacelle-mounted lidar. After we estimated the yaw misalignment using our method, the lidar results were provided for comparison.

• Average yaw misalignment

Results indicate a good correlation and a **2.5° uncertainty** (mean absolute error) relative to lidar. One site showed a larger deviation, which we plan to investigate further.



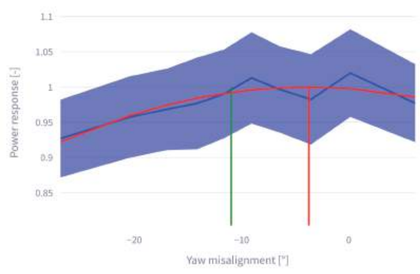
• Detection of changes

In two of the sites, we demonstrated that the method detects changes of yaw misalignment within a few days, indicating potential for monitoring.

OUTLOOK: optimum misalignment

The yaw misalignment that maximizes power output is not necessarily 0°.

By analyzing power response as a function of yaw misalignment, we can determine the optimal setting.



Power response (blue), current (green) and optimum yaw misalignment (red)

Wind EUROPE ANNUAL EVENT 2025 COPENHAGEN 8-10 APRIL

windeurope.org/annual2025
#windeurope2025

Meet us at C2-A50-G

Watch this presentation

Download the poster