Ship-lidar systems for wake measurements

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EERA-DTOC: Project description

-European Energy Research Alliance –
 Design Tool for Offshore Wind Farm Cluster

-EU funded project within Seventh Framework Program (FP7)
-Project duration: 01/2012 – 06/2015

-“Use and bring together existing models from the partners“
-Wake and far-wake models should be compared to measurements

=> Scanning lidar measurements and Ship-lidar measurements
EERA-DTOC: Ship-lidar measurements

Performed measurements:

1. System test, first wake measurements  27-31 Aug 2013
2. Near and far-wake measurements       4-10 Oct 2013
Ship-lidar development

First **software simulations** of motion correction in 2010

Simulation of motion induced measurements…., Wolken-Möhlmann et. Al., iSARS2010

**Onshore motion test** in 2012

Introduction of a validated and verified floating lidar system, Gottschall, EWEA Offshore 2013

First **ship-based measurement** using a ferry in 2012

Ship based LIDAR measurements, Wolken-Möhlmann, DEWEK 2012

First **ship-based near- and far wake measurements** in 2013

First verification test and wake measurement…., Wolken-Möhlmann, EERA-Deepwind 2014
Motion correction
Motion correction

Radial velocities / Line-of-sight data

Recalculated wind vector

Corrected wind vector

Line-of-Sight correction

Vectorial correction

Corrected time series

Wind speed time series

Statistics

Wake measurements

Different tracks
- Perpendicular to inflow direction
- Different distances to wind turbine

FINO1
alpha ventus
Wake measurements

Different inflow conditions…
Wake measurements: Results!!!

Measurements without corrections

Measurements with corrections

Keep in mind:
1-min lidar turbulence!
Wake measurements: Results!!

- Near-wakes can be detected by wind speed deficit and increased turbulence
- Detection of single and triple wakes
- Far wakes can be detected by turbulence intensity
Ship-lidar verification

Can we verify our method?

⇒ Measurement in **proximity to FINO1**
⇒ Using scanning **patterns similar to wake measurements** with similar ship velocities!
Ship-lidar verification

Overview of performed tracks
Ship-lidar verification

Vessel speeds and Wind speeds
Ship-lidar verification: Results

Uncorrected
Vectorial correction
LoS-correction

LoS-correction, 10-min mean

\[ d < 2000m, m = 1.002; r^2 = 0.984; 333 \text{ MP} \]
\[ d < 1500m, m = 1.001; r^2 = 0.986; 296 \text{ MP} \]
Ship-lidar verification: Results

- Motion correction is mandatory for ship-lidar measurements
- Vectorial correction and LoS-correction show similar results for 10-min-mean speed
- Good correlation to met. mast data!
Résumé and outlook

- Ship-lidar can detect wakes and far wakes
- Comparison for different motion patterns show good correlation!

Next steps:
- Using ship-lidar as ferry box
THANKS FOR YOUR ATTENTION

Questions?

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