# **Comparison of dual-Doppler lidar measurements and Large Eddy Simulations of an offshore wind turbine wake**

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#### Wake losses and turbulence inside medium to large size wind farms

- Reductions of power losses and operational risk
- Quantification of interaction of maritim flow with wind farms



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#### Wake losses and turbulence inside medium to large size wind farms

## WP 3: Modelling and validation of flow conditions

Modelling of the wind farm flow with Large Eddy Simulations (LES)



## **Motivation** GW Wakes

Wake losses and turbulence of medium size and large wind farms

WP 3: Modelling and validation of flow conditions

## Validation of LES

- Validation with lidar measurements
- Generation of atmospheric boundary conditions

(Offline Coupling)



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# **Offline Coupling**

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## **Offline Coupling** Models

#### COSMO

#### **Operational weather model**

- Developed and run by DWD
- Horizontal resolution: 2.8 km
- Vertical resolution:  $\sim$  20 40 m
- Resolves weather turbulence
- Domain: Germany
- Hourly Output



#### **LES model**

- Developed by ForWind Hannover
- Horizontal resolution: 5 m
- Vertical resolution: 5 m
- Resolves turbulence on wind turbine scale
- Domain 3.2 km x 3.2 km
- 3 Hz output

## **Offline Coupling** Large Scale Forcing & Nudging<sup>[1]</sup>



# Validation of Wind Simulations

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## Validation of Wind Simulations













## Validation of Wind Simulations

#### Turbulence

Comparison of 10 min TI



#### MuLiWEA<sup>[2]</sup>

- Multiple LiDAR Wind Field Evaluation Algorithm
- Combination of 2 PPI scans

**Measurements** 

- 2D Wind vector evaluation
- 10 min average on 20 m cubes around hub height



Fig: Layout alpha ventus, scan regions LiDARs



### Wind Turbine AV10

- Adwen AD 5 -116
- HH = 90 m, D = 116 m





## Wind turbine model

- Actuator Disc with Rotation (ADMR)<sup>[3]</sup>
- Based on blade element theory
- Speed & pitch controller
- Yaw controller
- New: AD 5 -116

#### **Wake Simulation**

- Atmospheric conditions
- Turbulent flow
- Turbine response



## Horizontal wake



Hub height wind speed between 6:10 and 6:20

- LES: Normalized by mean domain wind speed
- LiDAR: Normalized by FINO1 wind speed

## Conclusion

- Offline coupling with meso-scale model allows for a representation of non-stationary conditions in LES and thus for a direct comparison with measurements
- Wind simulations fit well with FINO1 measurements at the selected day
- Wake simulations show good agreement with LiDAR measurements of the AV10 wake

## Outlook

- Simulation of whole wind farms (alpha ventus, Riffgat)
- Test of control strategies
- Consideration of neighbouring wind farms
- Further coupling with aeroelastic models for load estimations

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Literature

[1] Maronga et al., 2015

[2] v Dooren, 2014

[3] Dörenkämper, 2015



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## Thank you!