WindRamp: Observer-based minute-scale power forecasts at the offshore wind farm Nordergründe – Measurement campaign and forecasting methodology

Frauke Theuer, Jörge Schneemann, Marcos Ortensi, Martin Kühn

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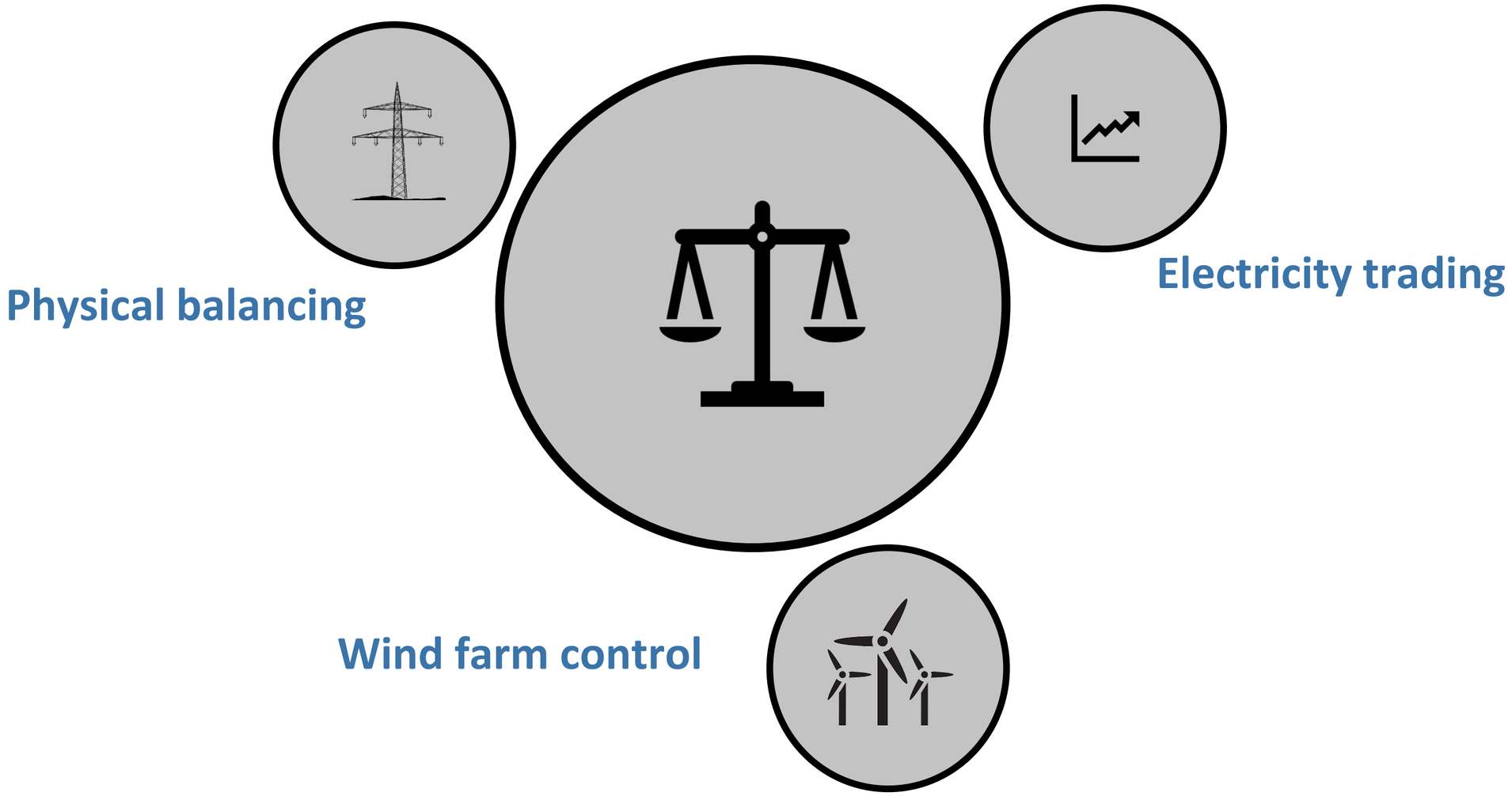
Why minute-scale power forecasts?



BMWK joint research project WindRamp

Objectives:

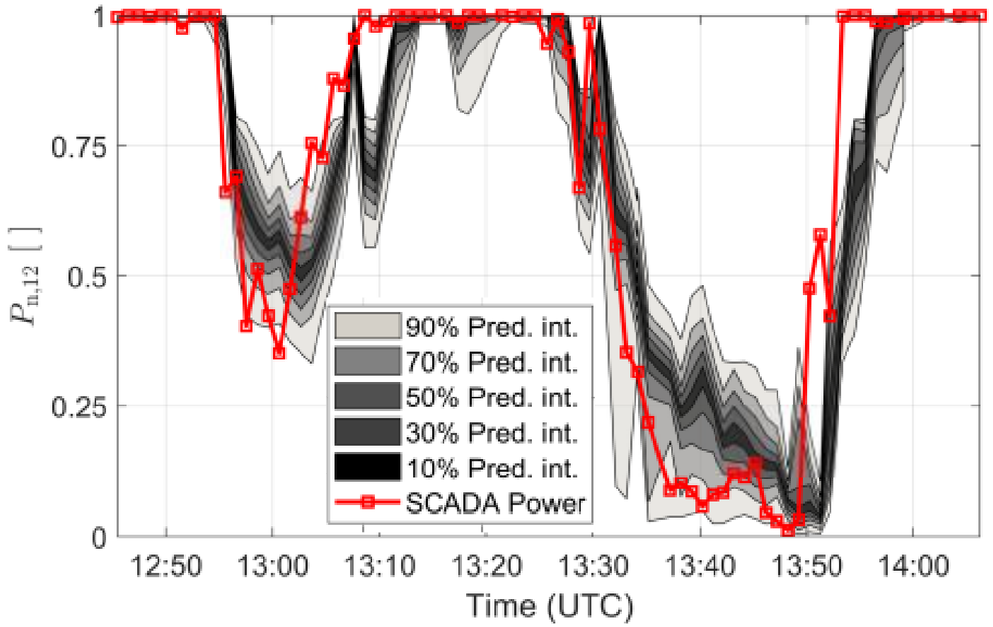
- increase of grid-stability through more accurate forecasting of ramp events
- reduction of curtailment and short-term balancing power
- reduction of uncertainties in electricity trading

Scientific and technical tasks:

- conduction of measurement campaign
- development of forecasting methodologies
- research on new lidar concepts
- analysis of systemic effects
- operational use by end-users

Forecasting of ramp events

- wind ramps cause strong gradients in feed-in of offshore wind farms
- hard to predict their amplitude and time of occurence
- statistical methods fail during these situations
- measurements of upstream wind can support the prediction of ramp events



[Valldecabres et al., 2020]

Probabilistic 5-minute ahead power forecast of ramp events using a radar-based forecast

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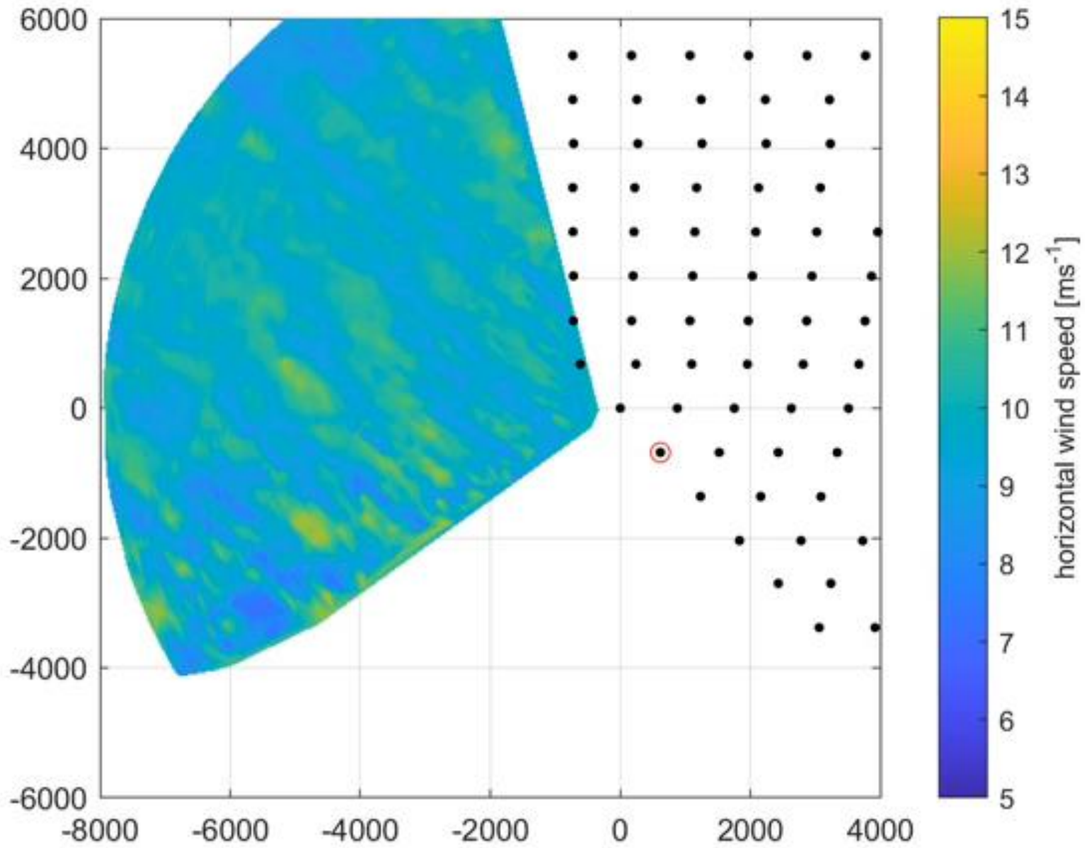
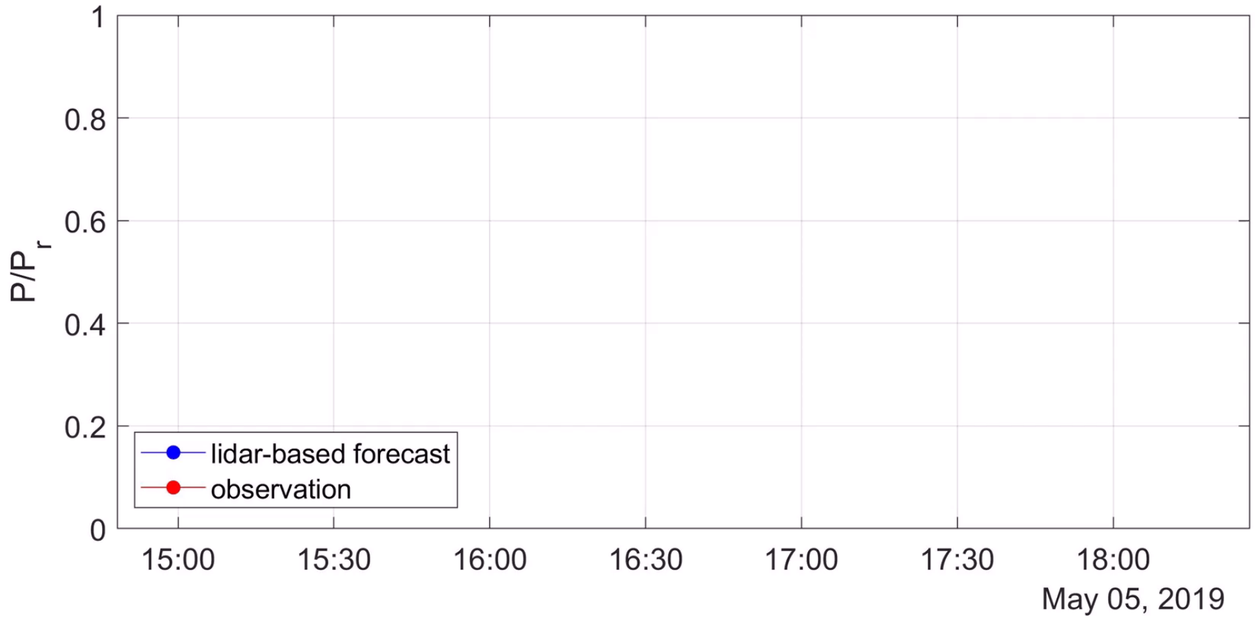
Lidar-based power forecasting



Lidar data and a 5-minute ahead power forecast at the offshore wind farm Global Tech I in May 2019

- lidar measures incoming horizontal wind field
- wind vectors are propagated in space and time using Lagrangian advection
- selection of vectors reaching a target turbine within a targeted time interval



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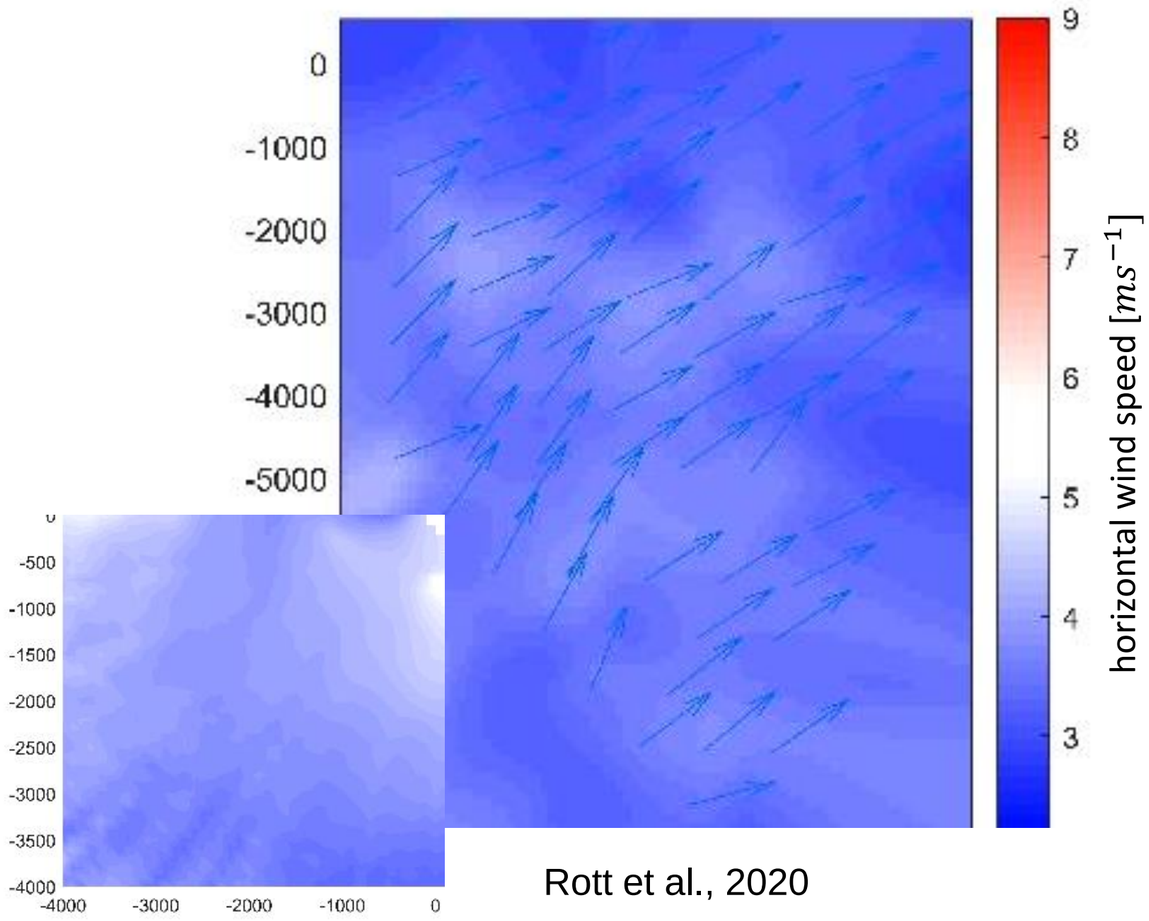
Observer-based power forecasting



Rott et al., 2020

- advection of high-frequency wind turbine operational data in addition to lidar data
- sucessfully implemented at offshore wind farm Global Tech I
- increased forecast availability
- increased forecast skill

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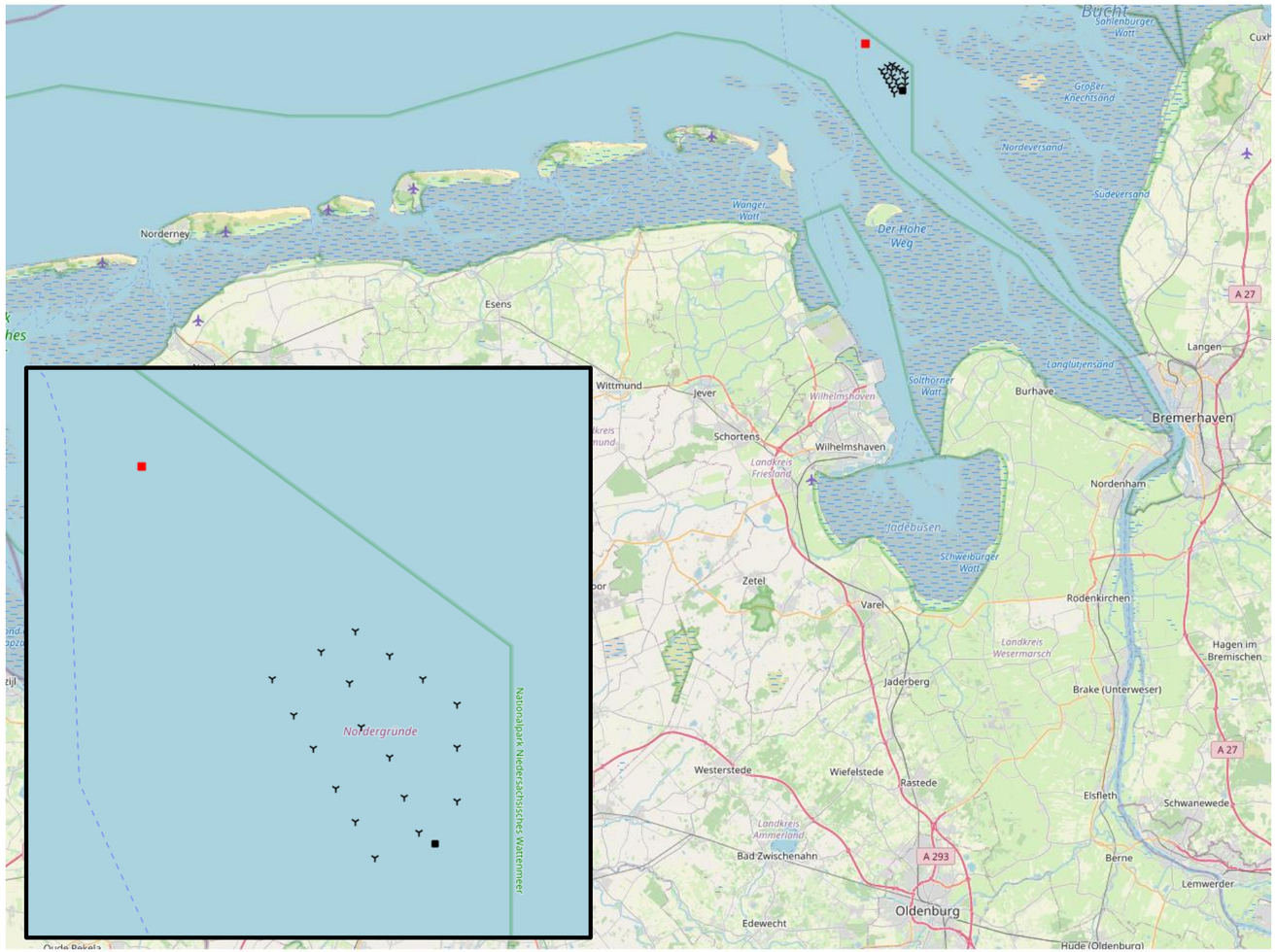
Measurement campaign at the offshore wind farm Nordergründe

Nordergründe:

- 18 x Senvion 6.2M126 on mono piles, 110 MW
- operational since 10/2017
- operator: wpd
- within 12 mile zone, often visible from coast



Map data: Openstreetmap

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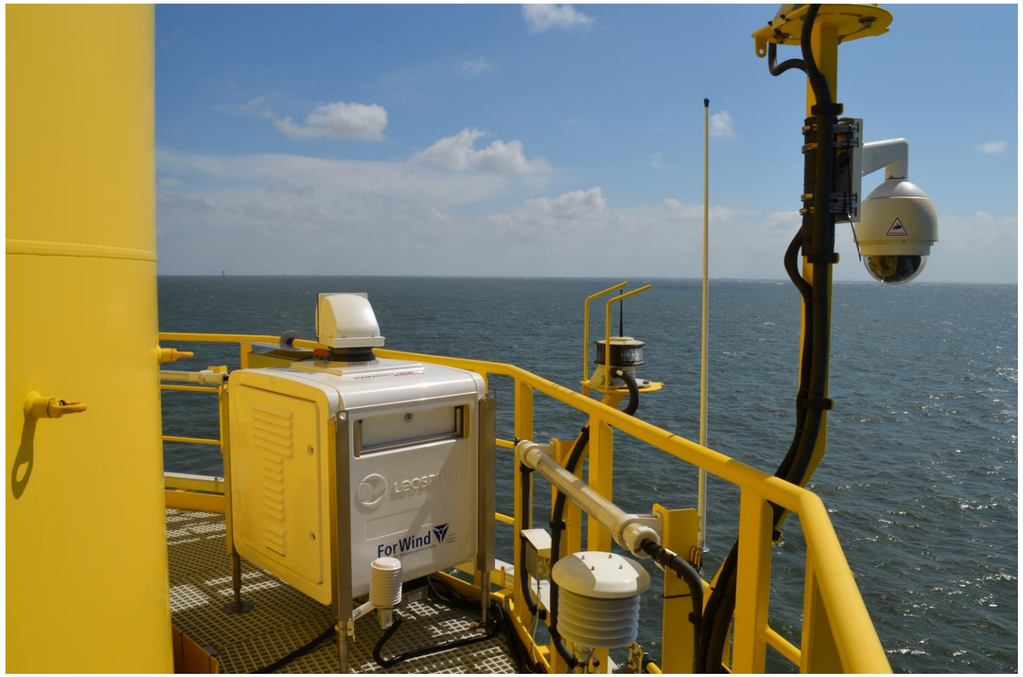
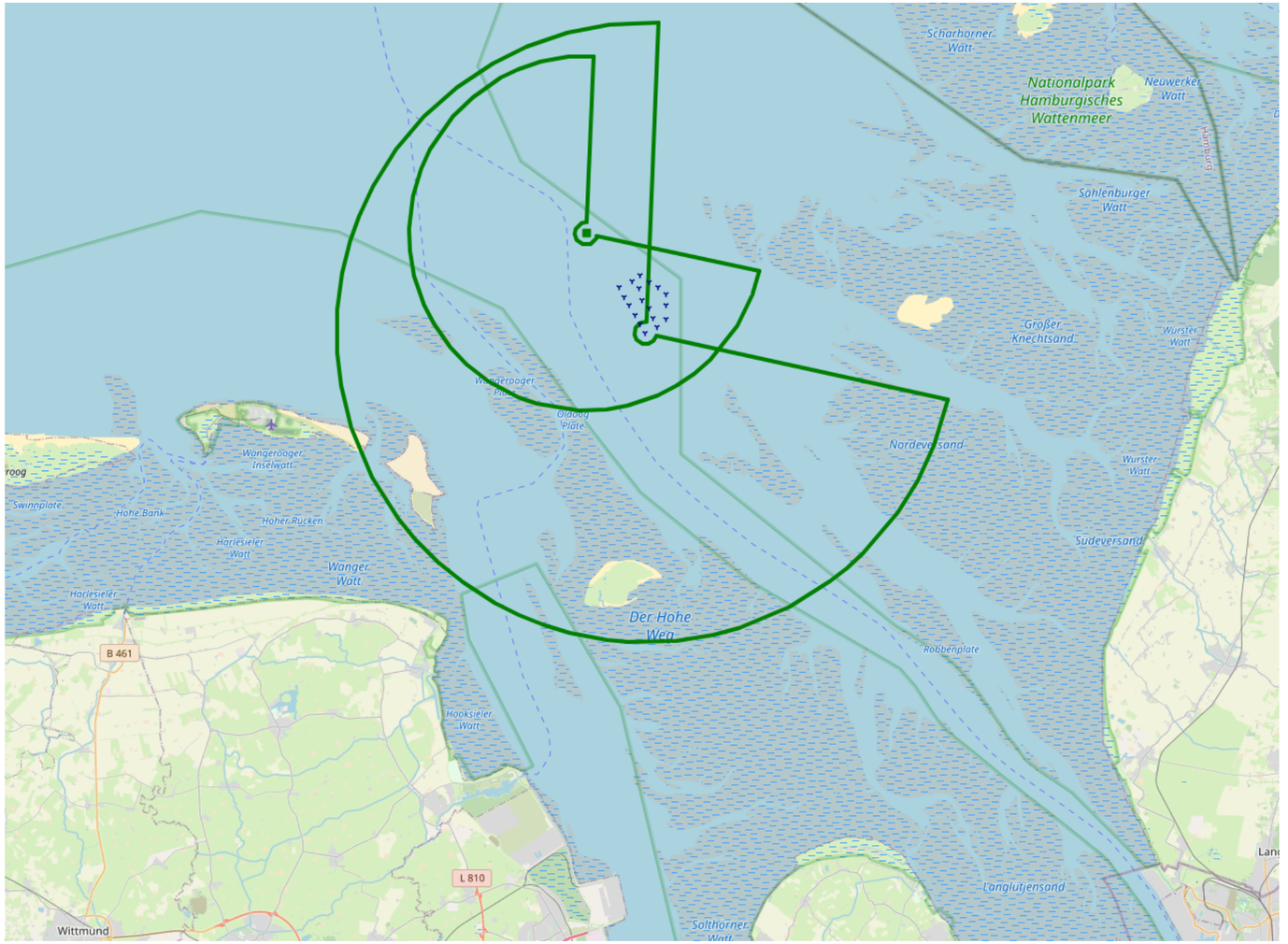
Measurement campaign at the offshore wind farm Nordergründe

- two long-range lidar devices, second lidar pending
- meteorological sensors at the TP and on the nacelle
- inclination sensors, SST sensor, AIS





Map data: Openstreetmap

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Measurement campaign at the offshore wind farm Nordergründe

Scanning trajectories

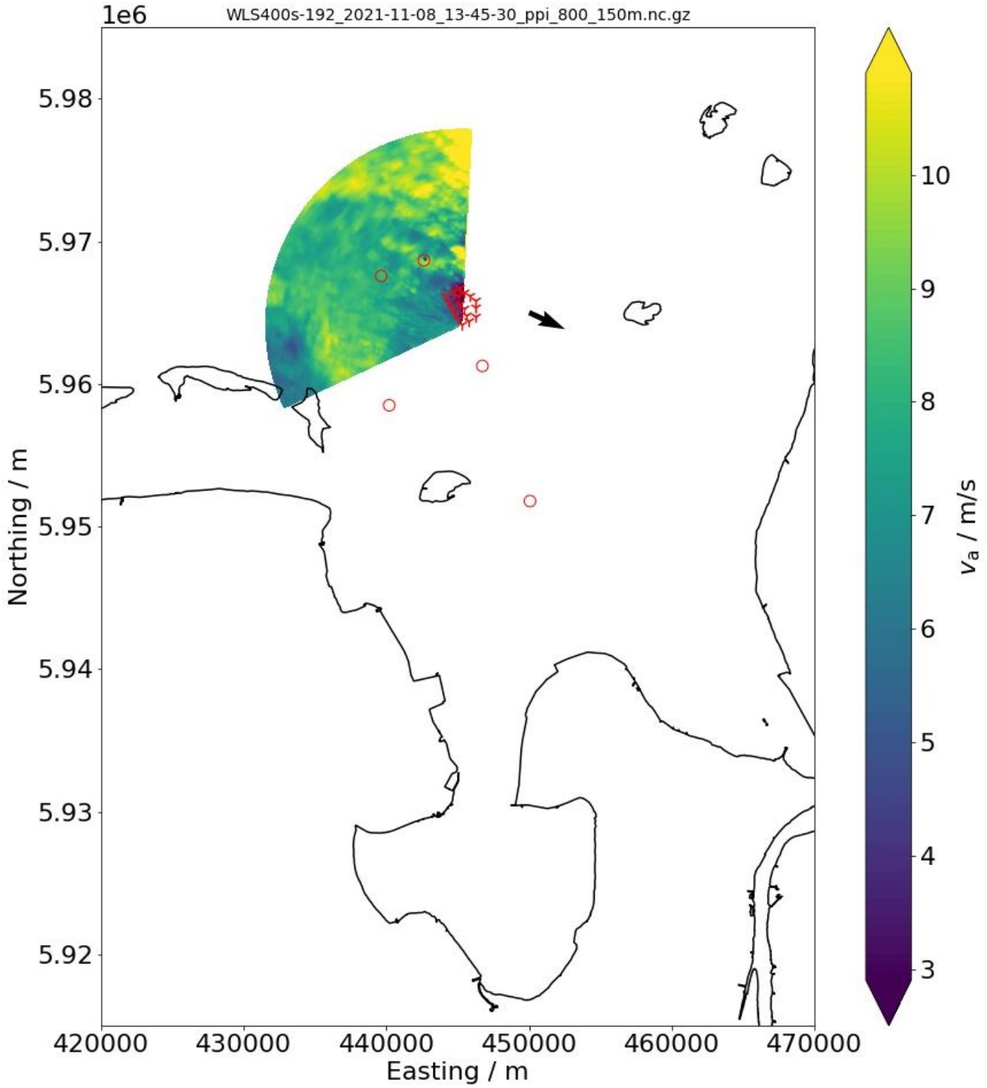
1) Horizontal plan position indicator (PPI) lidar scans

- angular resolution of 2°, spanned azimuth 120°
- range gates from 300 m to 14000 m in 150 m intervals
- scan duration 60 s

2) Multi-elevation PPIs

- 15 elevations between 0.2°and 2.1°
- angular resolution of 2°, spanned azimuth 80°
- range gates from 300 m to 10000 m in 150 m intervals
- scan duration 90 s

- All scans are automatically adapted to wind direction



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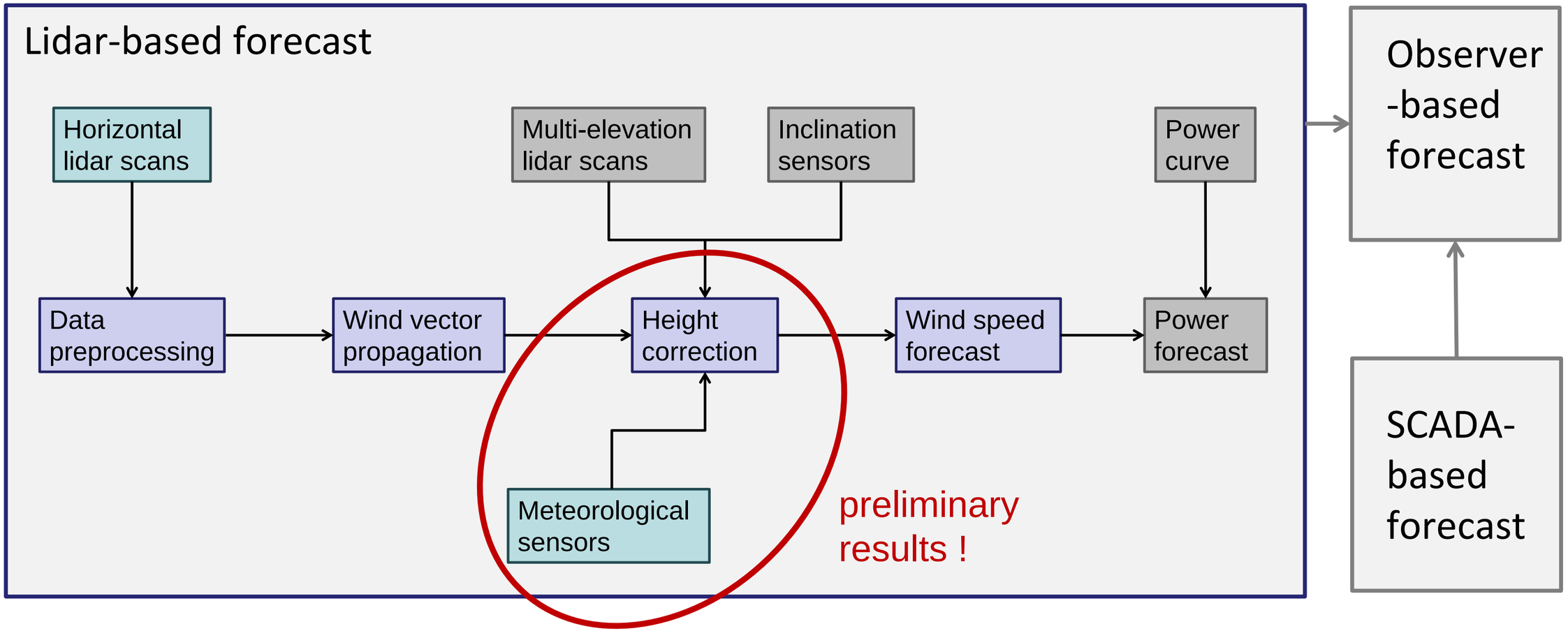
Lidar-based wind speed forecasts at Nordergründe



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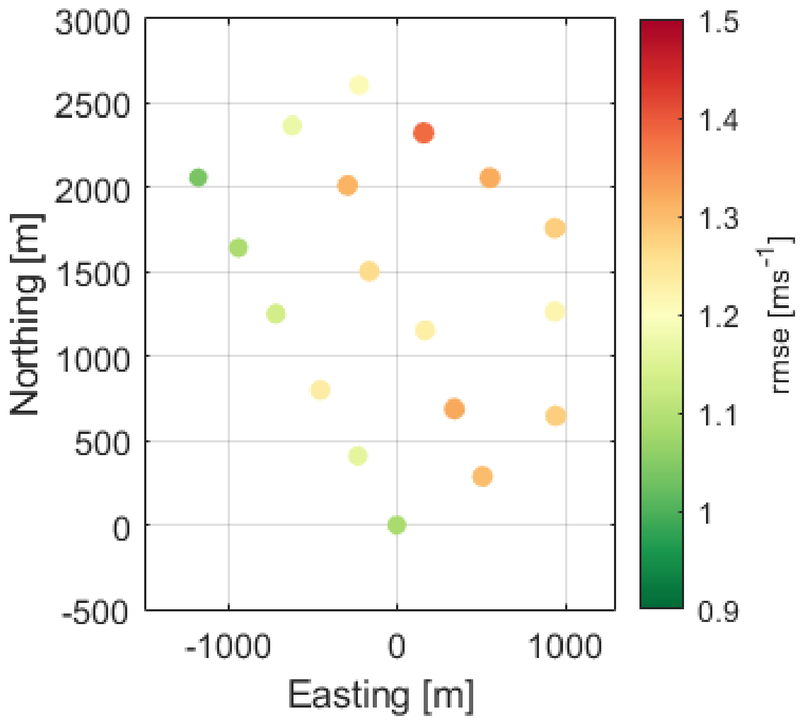
Lidar-based wind speed forecasts at Nordergründe – preliminary results

Deterministic wind speed forecasts – root-mean-squared error (rmse):

unstable



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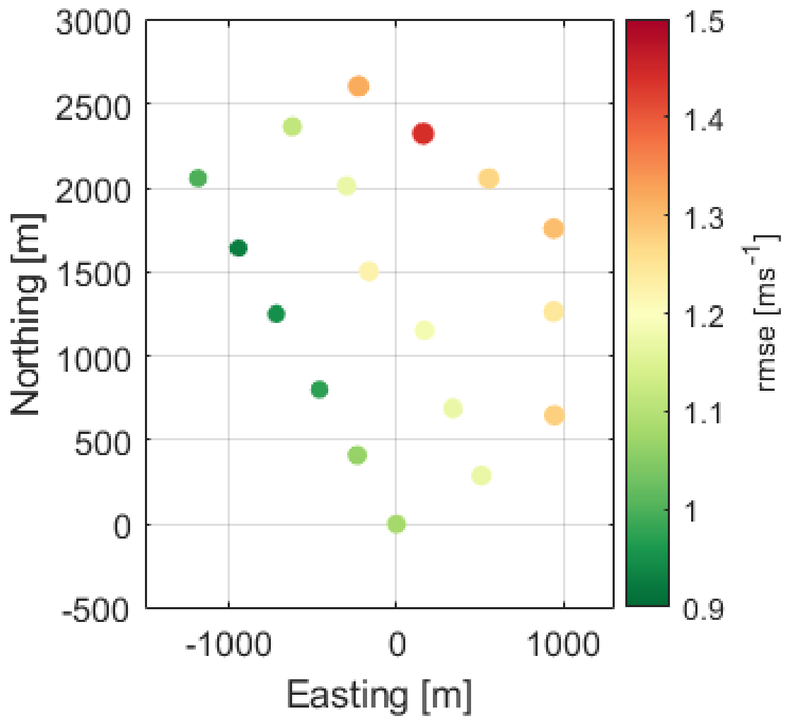

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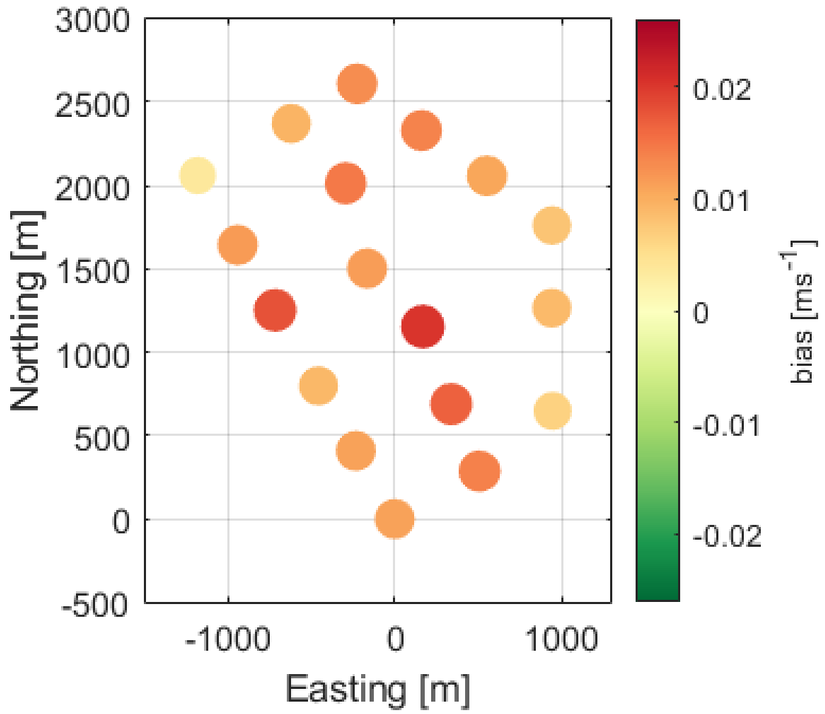
Lidar-based wind speed forecasts at Nordergründe – preliminary results

Deterministic wind speed forecasts - bias:

unstable



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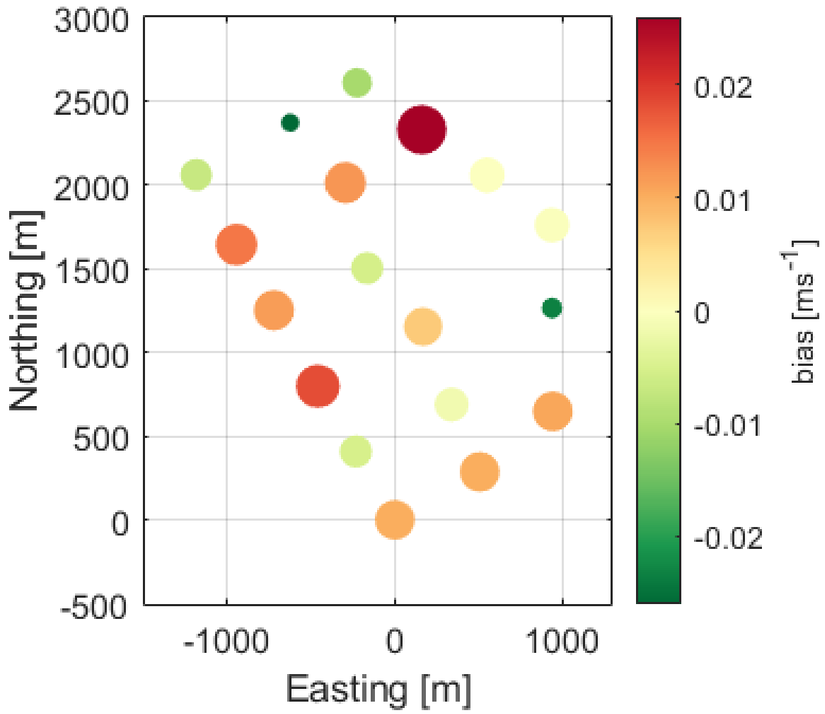

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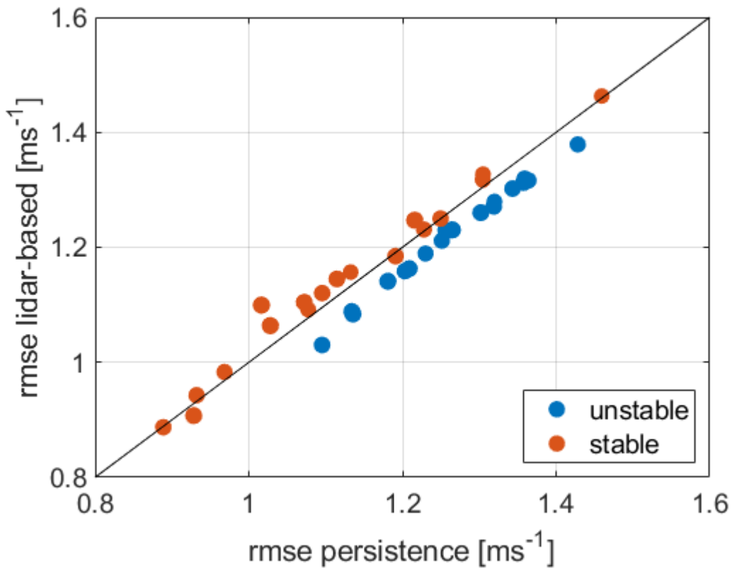
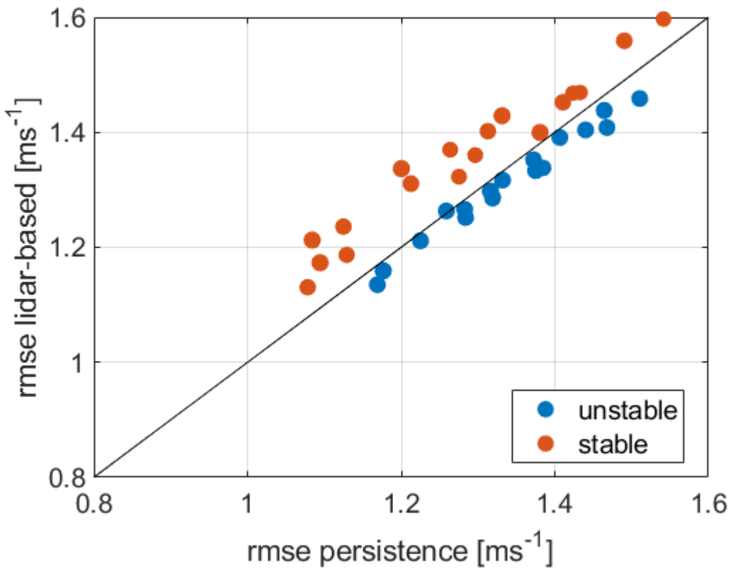
Lidar-based wind speed forecasts at Nordergründe – preliminary results

Comparison with benchmark persistence:

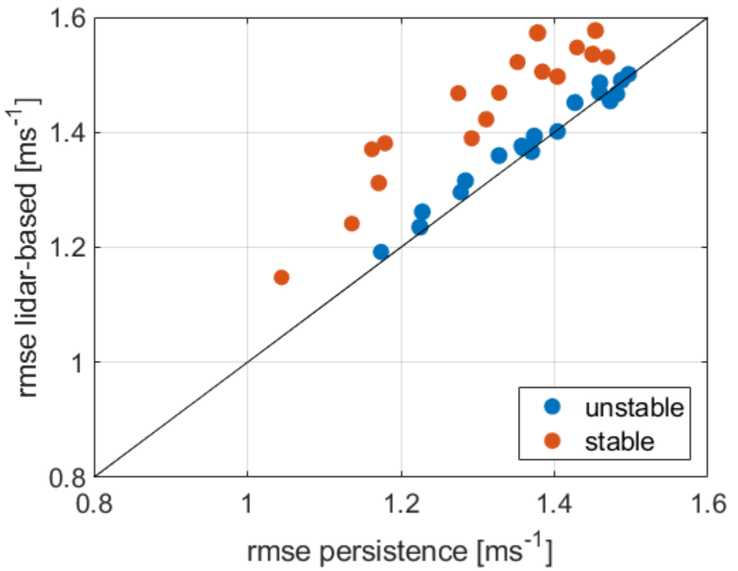
5-minute ahead



10-minute ahead



15-minute ahead



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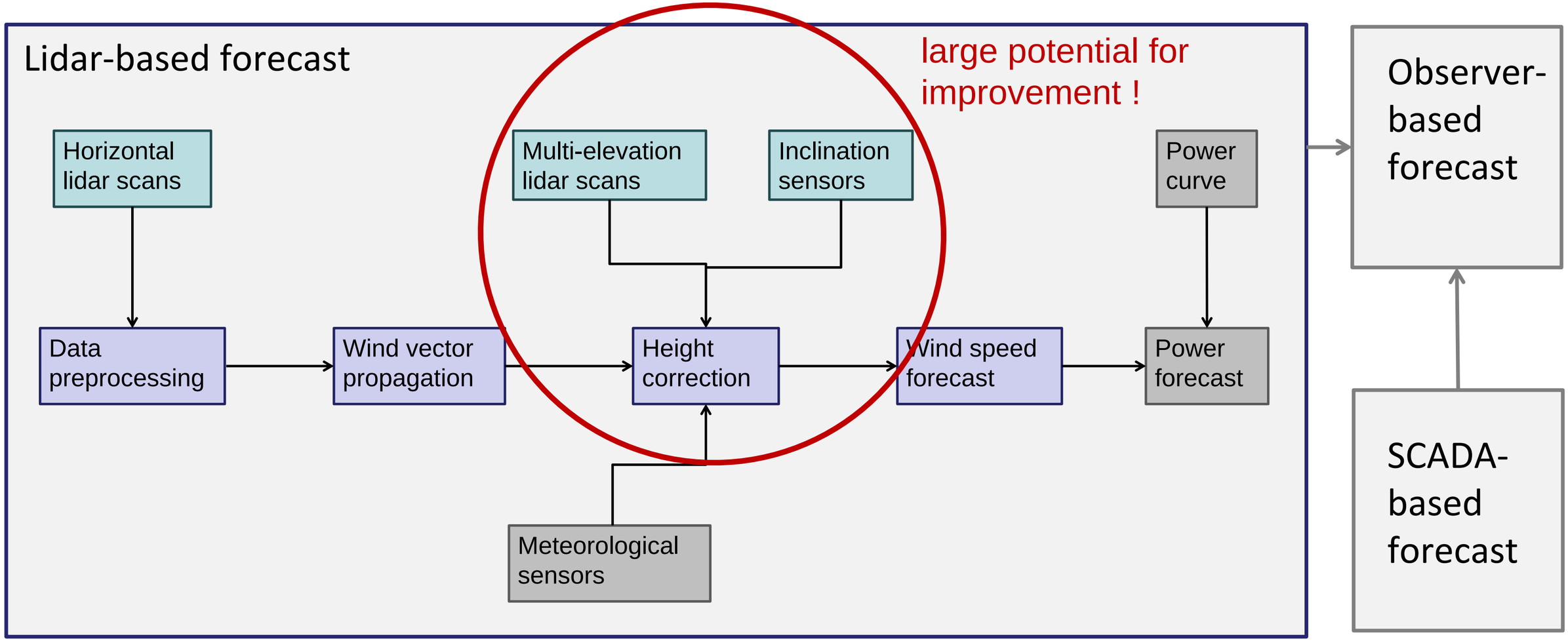
Conclusions

- free-stream turbines can be forecasted more accurately than wake-influenced turbines
- the mean wake-effect can be forecasted well
- during stable atmospheric conditions persistence cannot be outperformed
- the lidar-based forecast has the potential to forecast ramp events more accurately than persistence also for large lead times

Next steps



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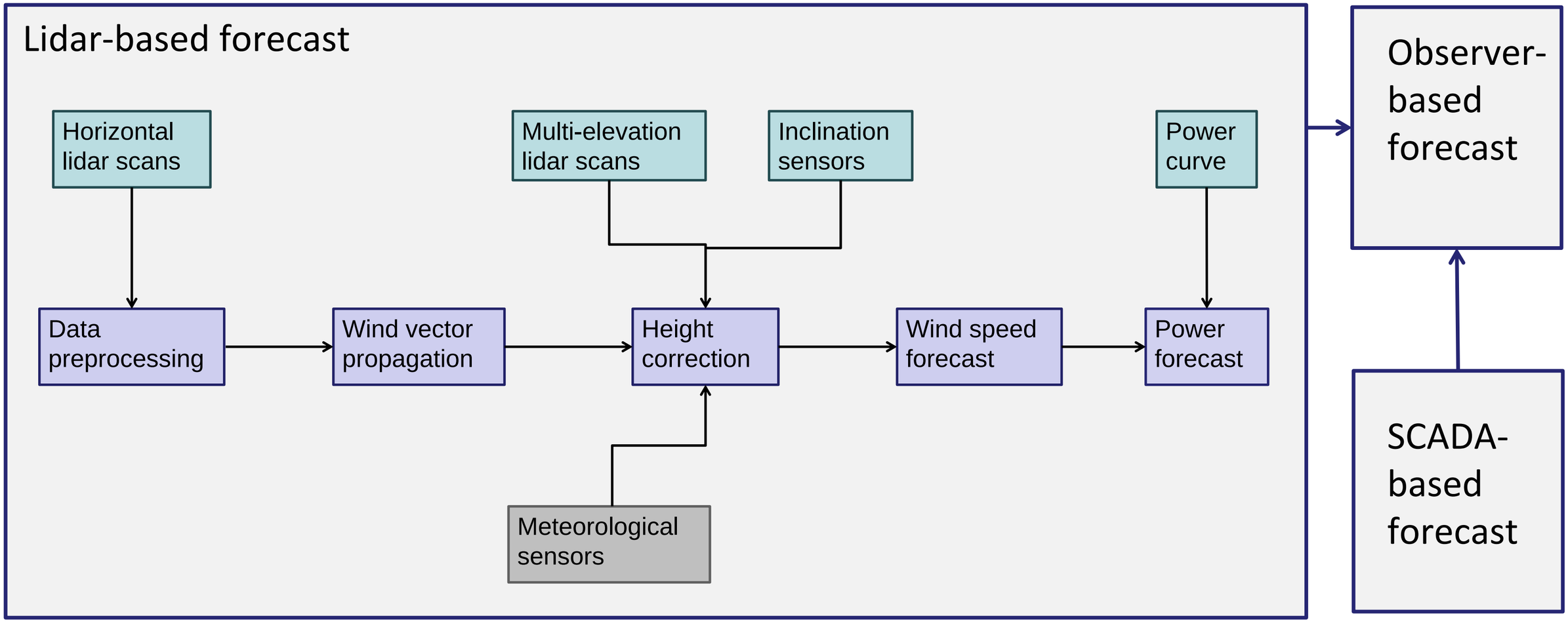
Next steps



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Acknowledgements

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Thanks for your attention! Do you have questions?