



Netherlands Enterprise Agency

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Measuring offshore wake effects: BeNeWakes

Presented by: Melle Vriesema

“Redoubling the efforts for your project”

11 June 2026

What is BeNeWakes?

- Multi sensor offshore measurement campaign
- Behind Dutch-Belgian 'Borssele cluster' (3.4 GW)
- Measuring wind speed deficit in cluster wake
- December '25 – July '26 (Possibly extended)
- Data publicly available through RVO wind portal
- [Offshorewind RVO](https://offshorewind.rvo.nl) (offshorewind.rvo.nl)



Rijksdienst voor Ondernemend
Nederland

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ACCURASEA

TNO innovation
for life



Royal Netherlands
Meteorological Institute
Ministry of Infrastructure
and Water Management



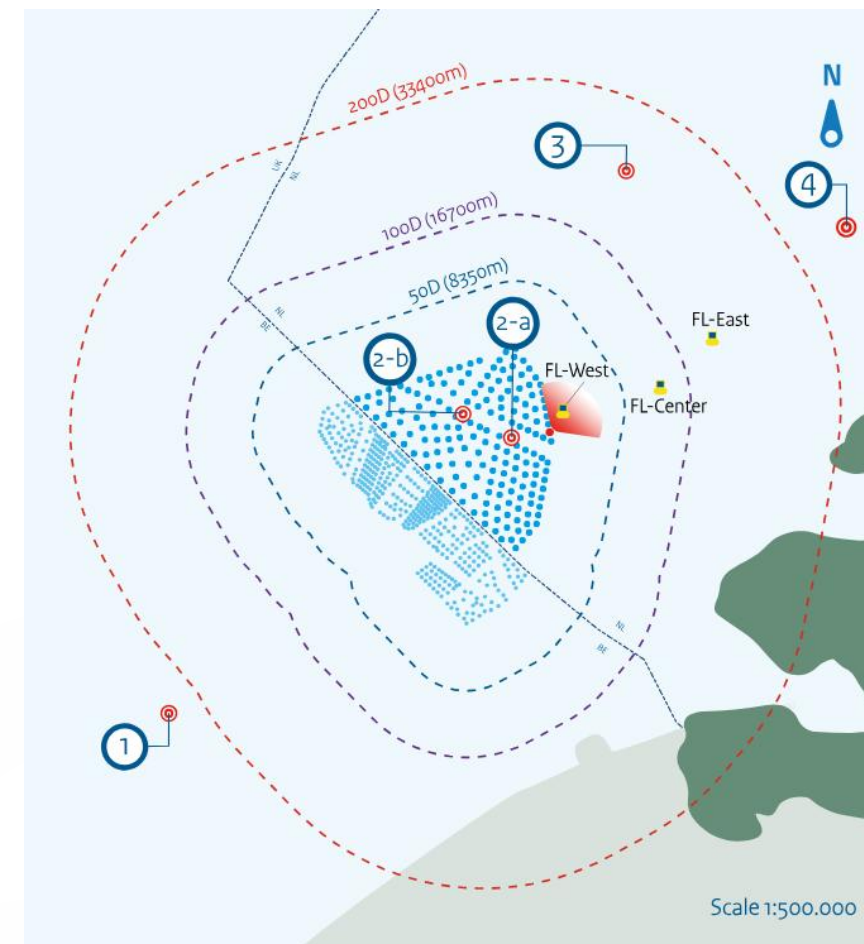
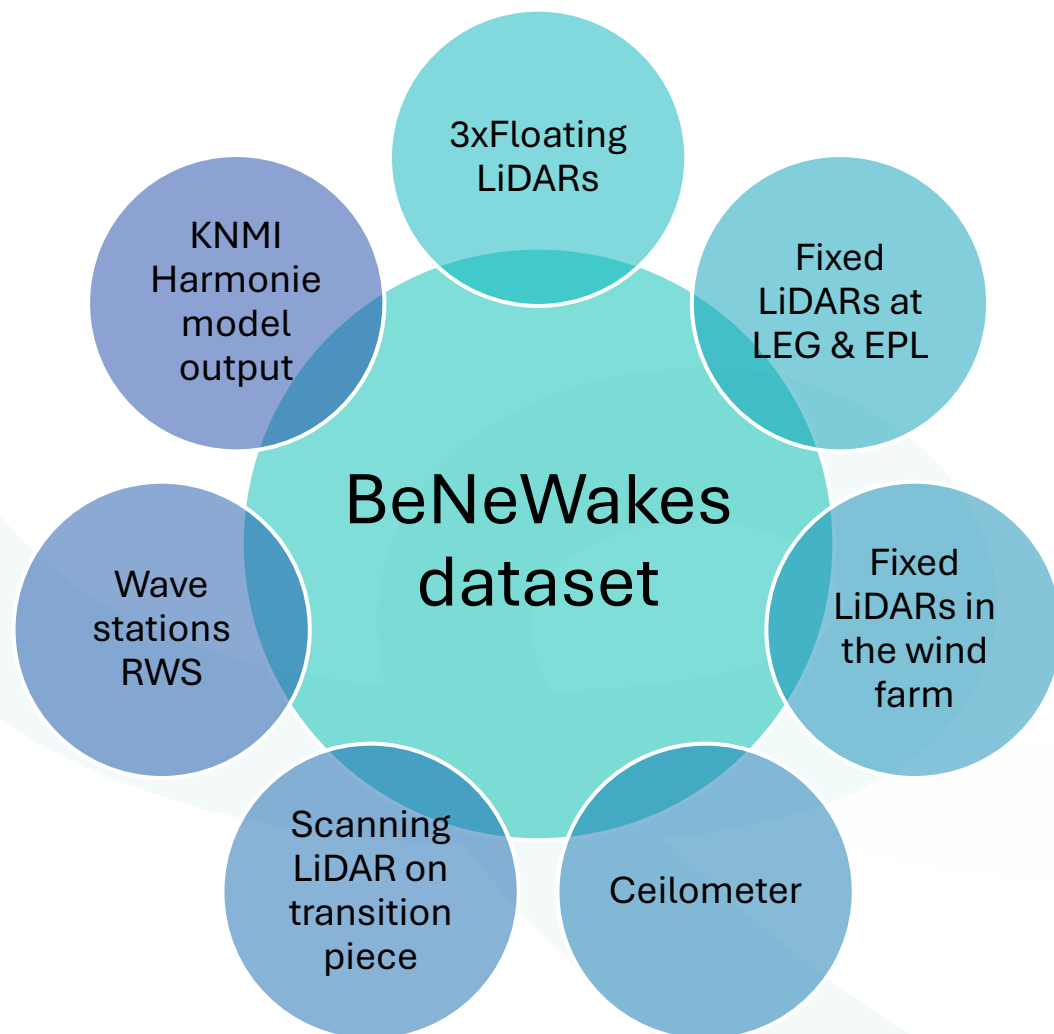
Rijkswaterstaat
Ministry of Infrastructure
and Water Management

Ørsted



BeNeWakes

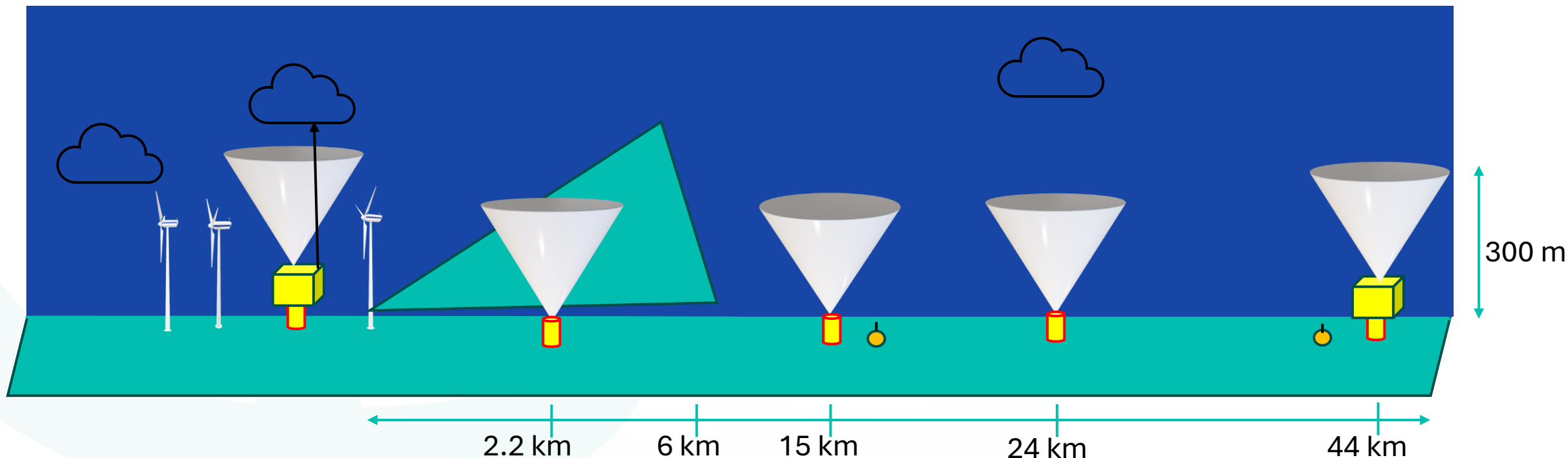
Included Data:



- Floating LiDAR buoy
- Fixed location measurement
- Scanning LiDAR
- Wind turbines
- Scanning LiDAR measurement zone

Number	Name
1	Meetpaal Westhinder (WindCube LiDAR)
2-A	TenneT platform Alpha
2-B	TenneT platform Beta
3	EPL Europlatform (ZX LiDAR)
4	Lichteland Goeree (WindCube LiDAR)

Measurement setup



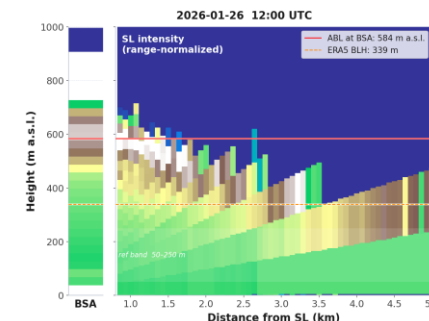
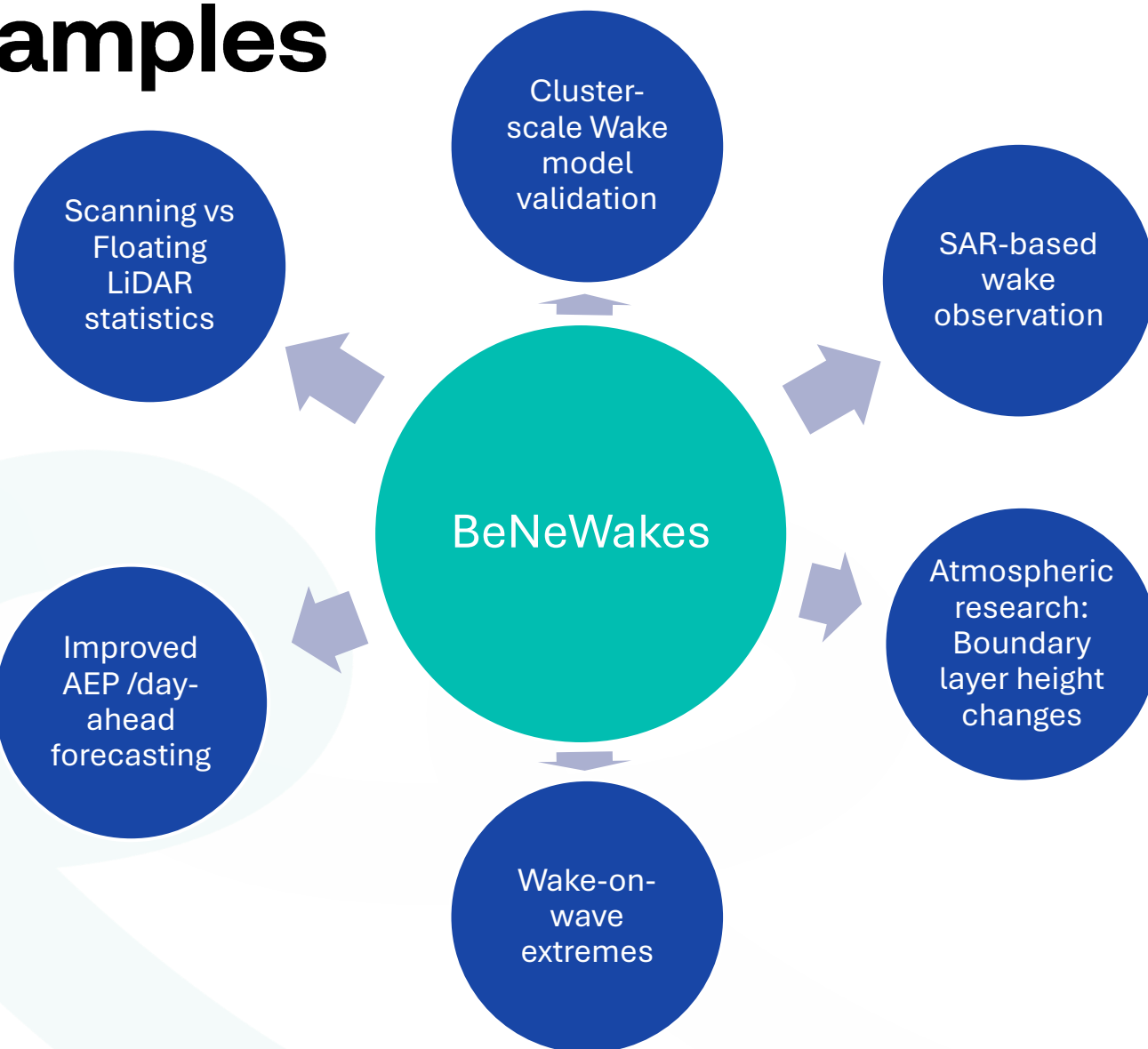
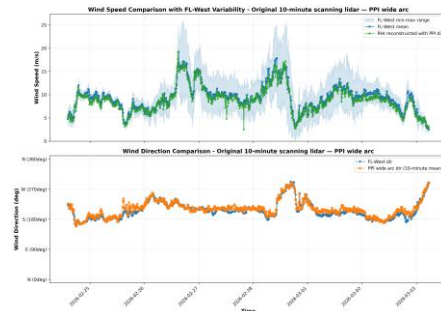
Floating LiDARs: Measure wind speed & direction up to 300 m vertically

Scanning LiDAR: Measure wind speed in a line, up to 6 km horizontally

Ceilometers: ABL height

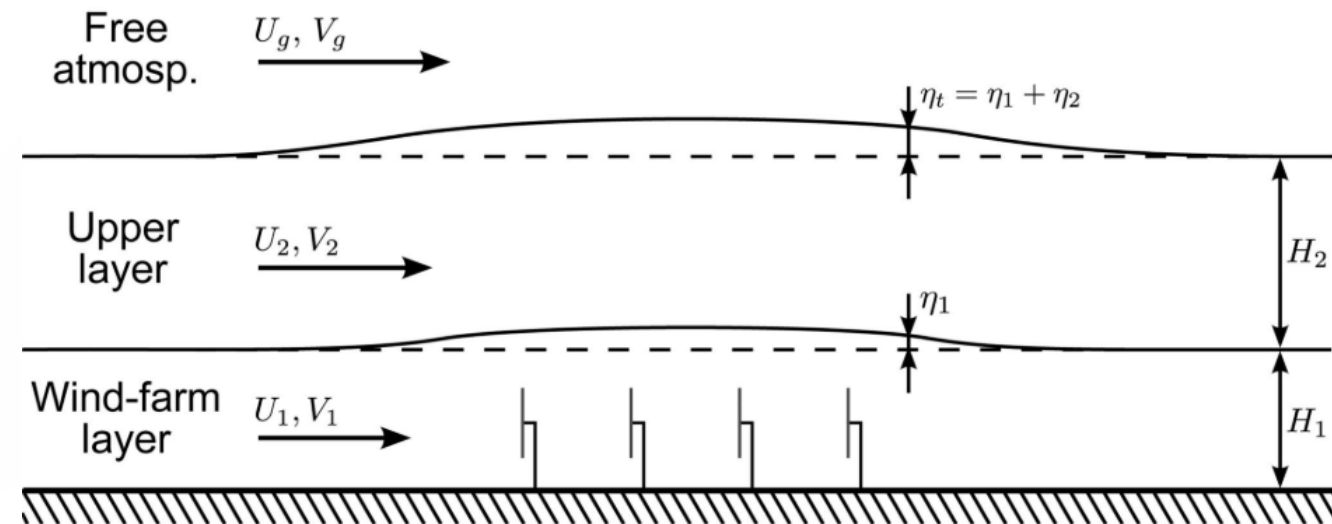
Waveriders: Wave status

Data-use Samples



What is MSC?

- Multi-Scale Coupled Model
 - Reduced order model (Depth Averaged RANS)
 - Mesoscale and microscale coupling
 - Farm-Atmosphere interaction
-
- Why MSC?
 - + Simple set-up
 - + Quick results
 - ? Validity of results



Source: Allaerts & Meyers (2019) J. Fluid Mech.

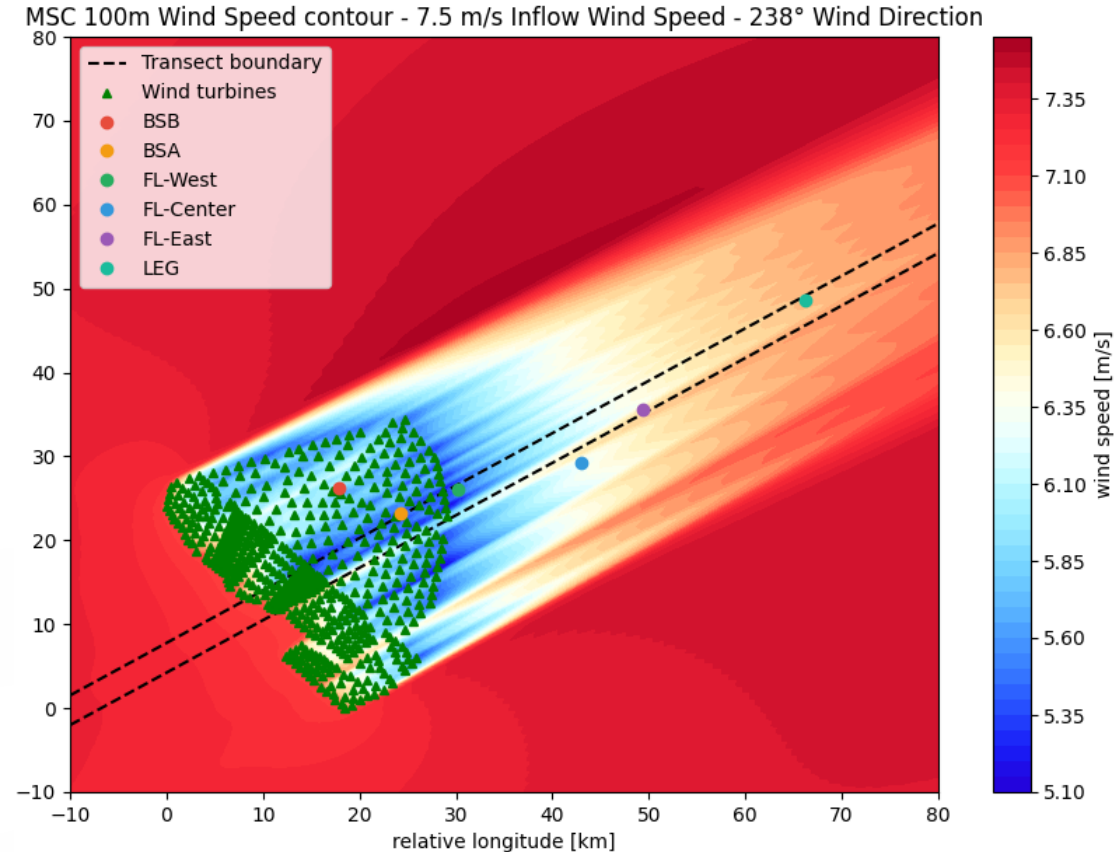
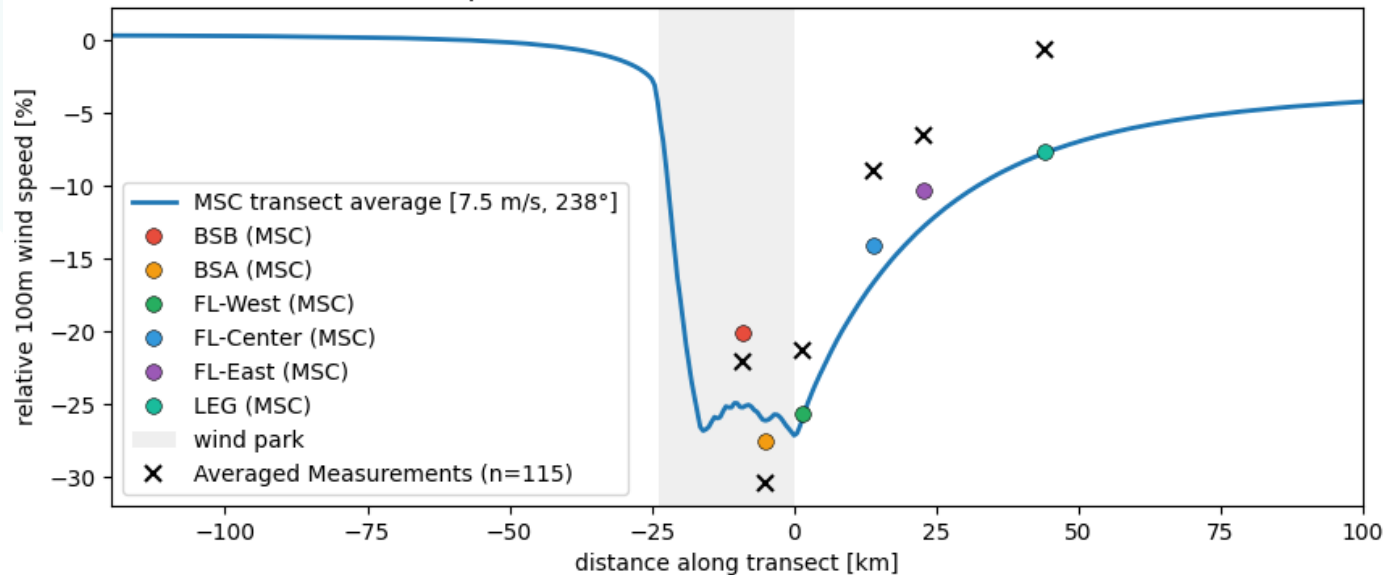
MSC Set-up

- Wind farm definition using Open European offshore wind turbine database*
- Validated non-waked wind directions
- Analyzed input sensitivity
- Selected wake cases on (either from EPL or ERA5):
 - Wind Direction (223°-253°)
 - Wind Speed (5-10 m/s)
- Planning to filter cases on:
 - Stability Conditions
 - Turbulence Intensity

MSC Results

- Differing results within and behind park
- Similar trend in wake recovery above floating LiDARs
- Full recovery not well modelled
- Large dependency on exact location
 - Wind direction important case filter, small bins preferred
- Further improvement in stability and TI filtering

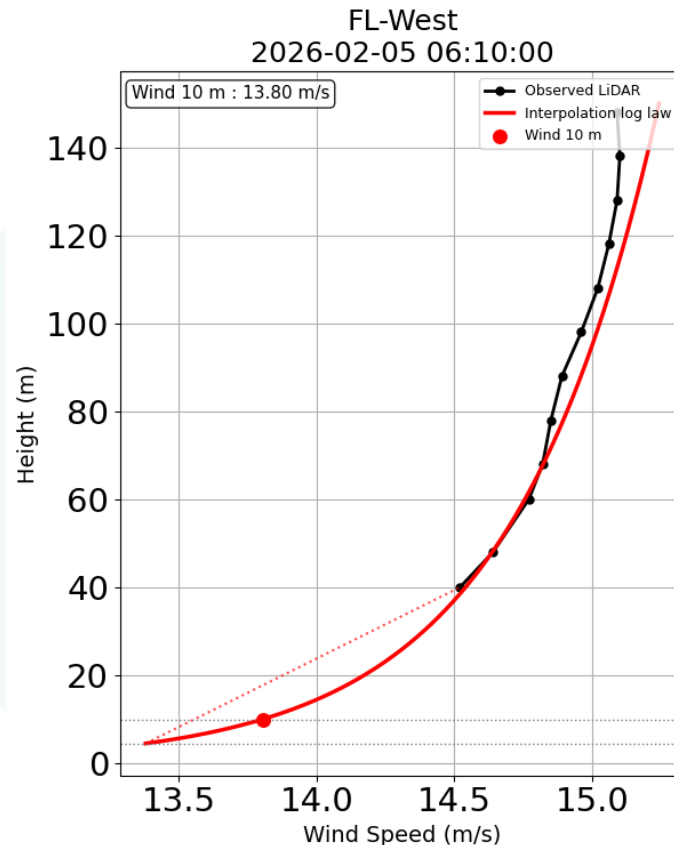
MSC-LiDAR comparison - 5-10 m/s, 233-243° cases (normalized to EPL)



SAR-LiDAR Comparison Set-Up

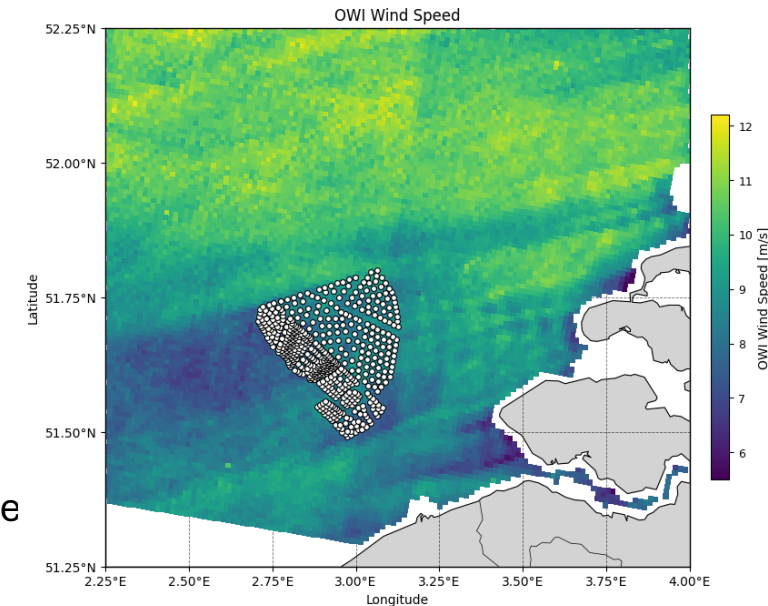
LiDAR & buoy measurements

- Three floating lidars :
 - FL-West
 - FL-Center
 - FL-East
- The wind speed at 10 m derived log-wind law based on measurements at 4.5 m and 40, 48 and 58 m.
- Available dataset :
25.12.2025 – 31.03.2026

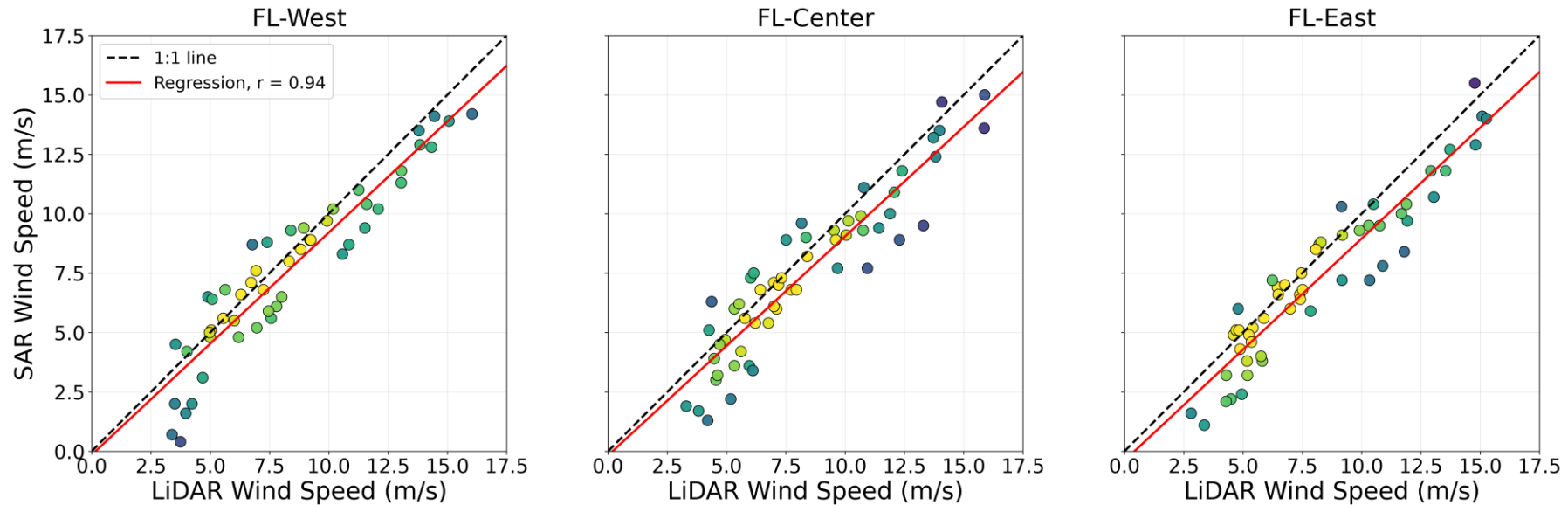


- OWI wind fields: wind speed, wind direction, and quality flags
- 65 SAR images (25.12.2025 – 31.03.2026)
- Four cases with clear wake patterns at the LiDAR locations relative to wind farm

SAR Sentinel 1 A & C level 2 OCN



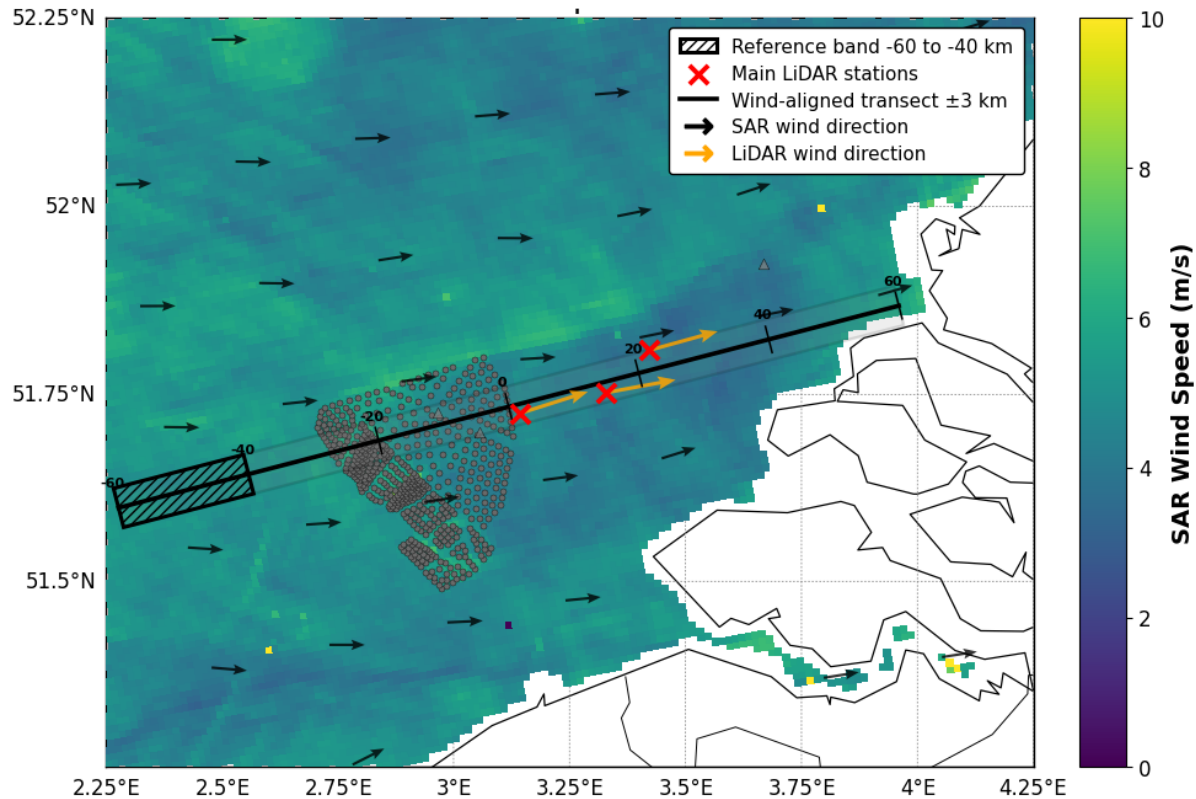
SAR-LiDAR Validation



Lidar	N	R	RMSE	MAE	Bias	Slope
FL-West	53	0.94	1.40	1.14	-0.68	0.94
FL-Center	55	0.92	1.54	1.24	-0.82	0.92
FL-East	53	0.94	1.48	1.21	-0.93	0.93

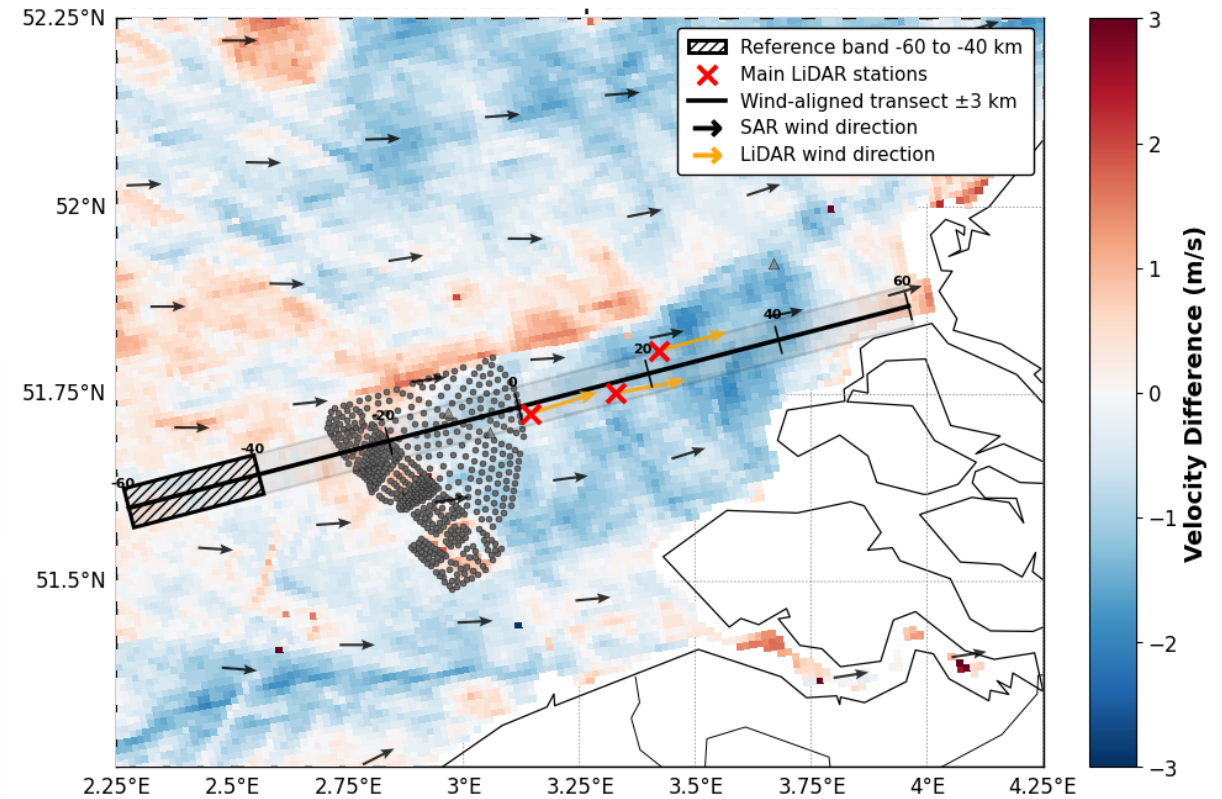
Case on 11 March 2026 (Wake condition on LiDAR)

SAR wind speed



Stability : Stable Boundary Layer
Wind Direction : 255.5°

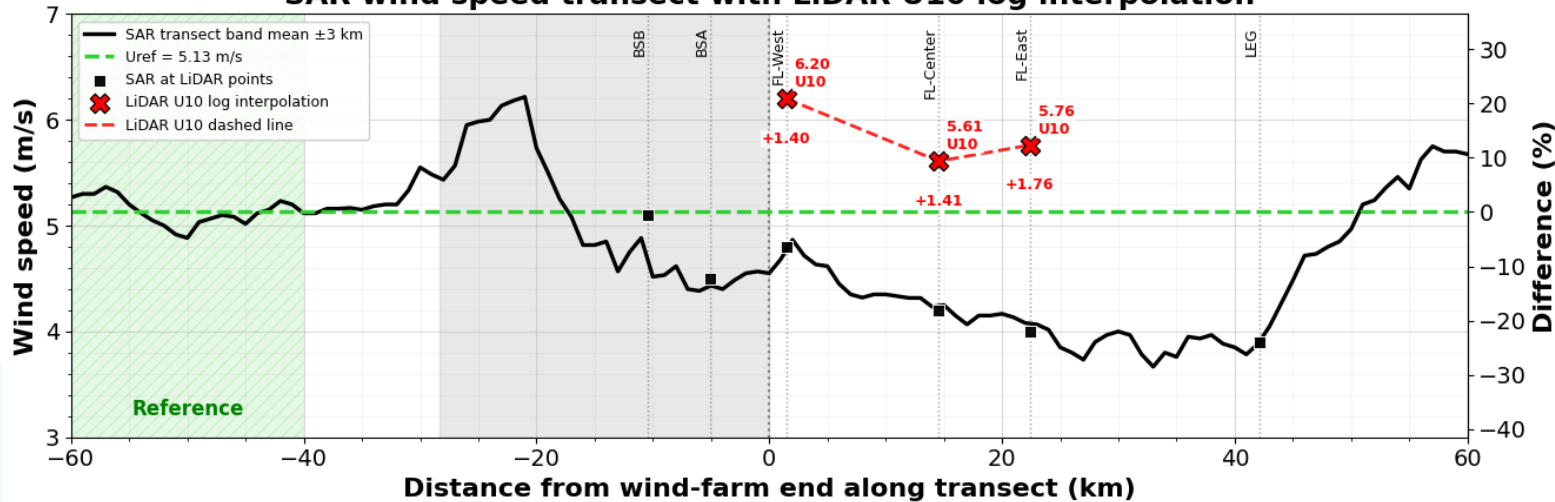
SAR Velocity Difference from reference



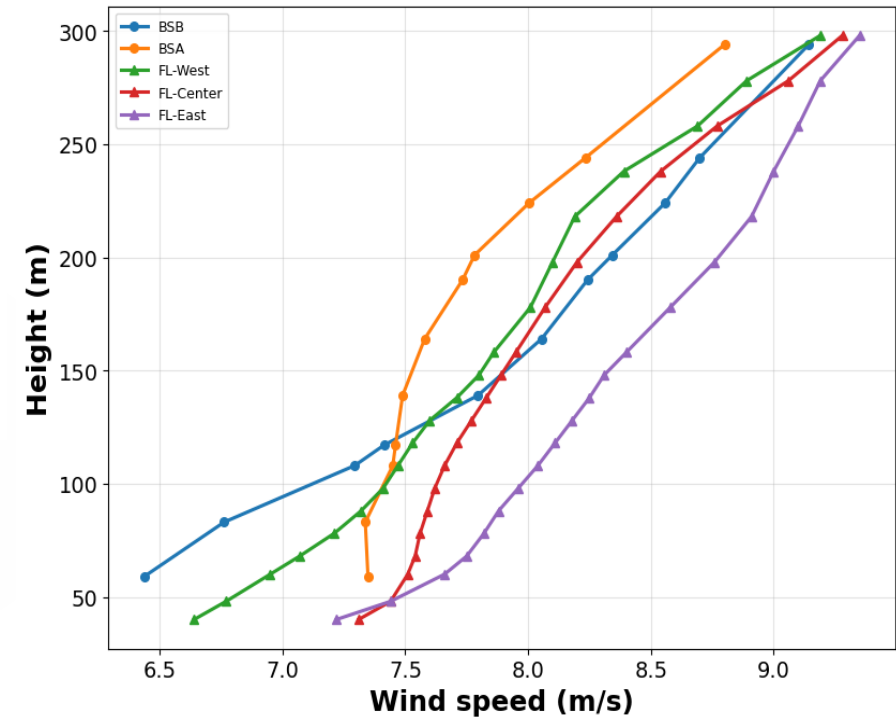
Research performed by: Muhammad Ramadhan

Case on 11 March 2026

SAR wind speed transect with LiDAR U10 log interpolation



LiDAR wind profiles
2026-03-11 17:40:00



- Stable Boundary Layer (Richardson Bulk ERA-5)
- the wake persisted up to 50 km
- velocity difference of -1 m/s, corresponding to a 28.5% velocity deficit.
- SAR underestimated the wind speed compared to LiDAR at 10m

Conclusions

- MSC-measurement comparison
 - Results highly location and wind direction dependent
 - Reasonable agreement in wake recovery trend up to 40 km
 - Further improvement needed in case filtering
- SAR-measurement comparison
 - **SAR performance:** RMSE ranges from 1.40 to 1.48, with a negative bias of -0.37 to -0.55 across floating LiDARs.
 - **Validation limitations:** SAR observations during wake conditions are limited and may be affected by weather, bathymetry, and retrieval issues.
 - **Interpretation:** SAR can identify wind-farm wake patterns, but the wakes-condition wind-speed values are likely underestimated and should be treated with caution.
- BeNeWakes
 - Dataset with high potential for wake analysis



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Thanks for your attention!

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