

Assessment of WindCube Data Availability in Cold Climate Environments



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Introduction



- Lidar performance depends on atmospheric aerosols; low aerosol concentration reduces signal, data quality, and range.
- Lower aerosol concentrations, especially in clean/cold air, can weaken the lidar return signal, reducing measurement quality and effective range.



Goal : Evaluating vertical profiling lidars' data availability for wind energy in cold/clean air climate conditions

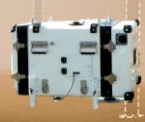


WindCube Technology



Pioneering wind lidar development

02



2006

1.0



2010

2.0



2019

2.1

2025



WindCube 2.1 XP

[Extended Performance]

+500

Organizations using
WindCube products

+3000

Units delivered

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Technical datasheet

WindCube 2.1 vs. WindCube 2.1 XP

Description	WindCube 2.1	WindCube 2.1 XP
Data Availability	Drops in Clean Air	Major improvement
Measurement height	40m to 300m	40m to 400m
Digital platform	Insight Fleet - lidar management	Compass Connect - Lidar management Compass Renewable- Lidar management & advance data postprocessing
Maintenance cycle	3-years maintenance cycle & warranty	5-years maintenance cycle & warranty
Robustness to environment	Sensible to heavy snow and high temperature	Improvement in high temperature environment
Probe length	Constant measuring probe (spatial resolution) : 20 meters	Constant measuring probe (spatial resolution) : 20 meters
Power consumption	45 – 110 W Nominal: 45 W (-5 to +30 °C)	35 – 95 W Nominal: 35 W (-5 to +30 °C)
Connectivity		Addition of local API and Modbus TCP
WS Uncertainty	60m : 2% / 120m : 0.6%	60m : 1.6% / 120m : 0.8% / 200m : 0.35%
IEC Classification	40m to 135m	60m to 200m
IEC Classification	3 sensibilities (on 10)	1 sensibility (on 10)
Measurement Heights	Max 20 heights	Max 20 heights
Customer usage	Input Voltage Range (24.5 – 27 VDC)	Wider voltage range (18 – 32 VDC)
Operating Temperature range	-30 to +50°C	-30 to +55°C
Training	Only face to face training	L1 e-Learning or face to face training

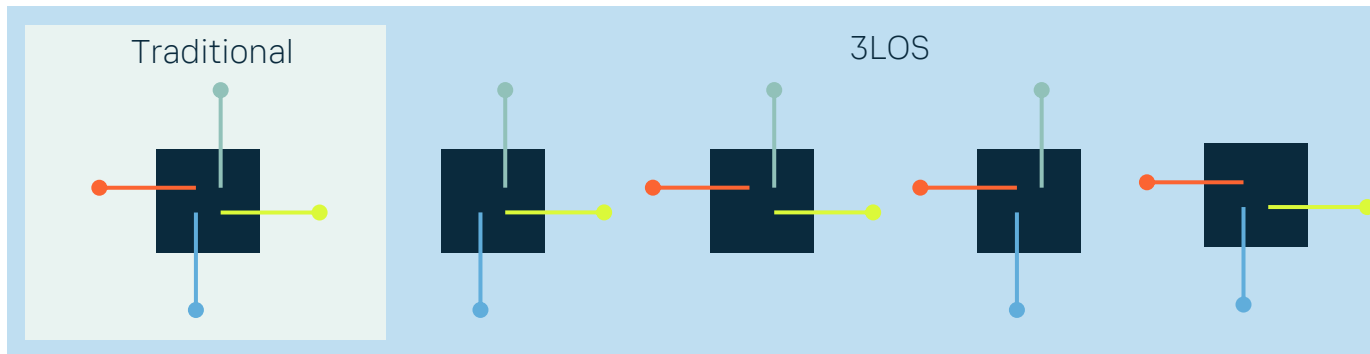
Availability Booster

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3LOS dynamic wind reconstruction

Conventionally windfield is reconstructed by using data from all four beams. But sometimes signal from one of the beams doesn't pass the CNR threshold due to obstructions causing reduced data availability.

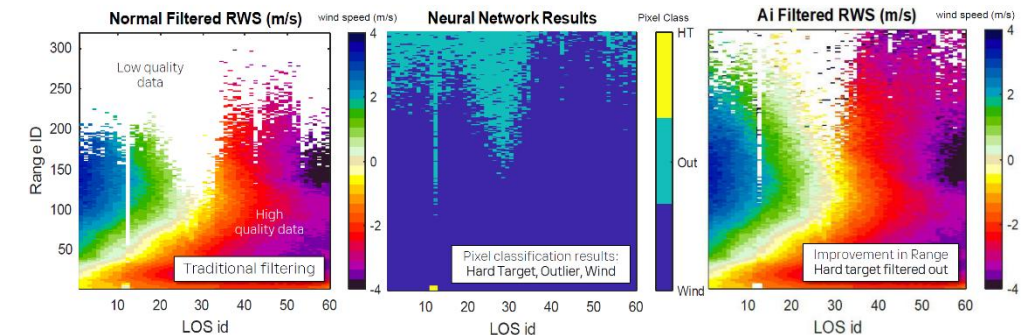
WindCube 2.1 XP has a new 3LOS algorithm that automatically uses the best available 3 or more Lines of Sight reconstruction to avoid losses in data availability.



Neural network filtering

Traditionally WindCubes have used a simple filtering based on CNR signal threshold.

The new algorithm uses proven neural network-trained filtering to effectively remove ambiguities, hard targets and outliers making the profiles cleaner and more reliable without generating any new data.



Reviewed by a trusted 3rd party

"All LiDAR devices were located at PAVANA's 200m IEC-compliant LiDAR validation meteorological mast in Janneby, northern Germany. Our results show that both the 3LOS and RB postprocess datasets show a strong correlation with met mast data, with deviations remaining well within the confidence band"

Data Availability in Cold Climates



Studies presentation

03

Four field studies were conducted to assess WindCube performance under cold-climate and low-aerosol conditions:

- Study 1: 19 November 2024 to 19 March 2025, in the Austrian pre-Alpine region at an altitude of approximately 800 m, using one WindCube V2.1 and one WindCube V2.1XP.
- Study 2: 26 March to 28 May 2025, in the Northern Austrian Alps at an altitude of approximately 1,800 m, using one WindCube V2.1 and one WindCube V2.1XP.
- Study 3: Conducted from January 1st to end of June 2025 at a Swedish site at approximately 62°N latitude, using a WindCube V2.1XP dataset to investigate performance in Nordic conditions.
- Study 4: A broader analysis covering 10 measurement campaigns, 7 WindCube V2.1 systems, and full-year datasets from multiple Nordic and Baltic sites.



Study 1 – Data owner : EWS consulting

Study 1 demonstrates clear technology advantage for the the V2.1XP across all measurement thresholds

Key Performance

- The XP doubles usable data vs V2.1
- Performance gap consistent across ranges

Booster Impact

- The booster adds ~10% availability
- Benefit applied to both systems.

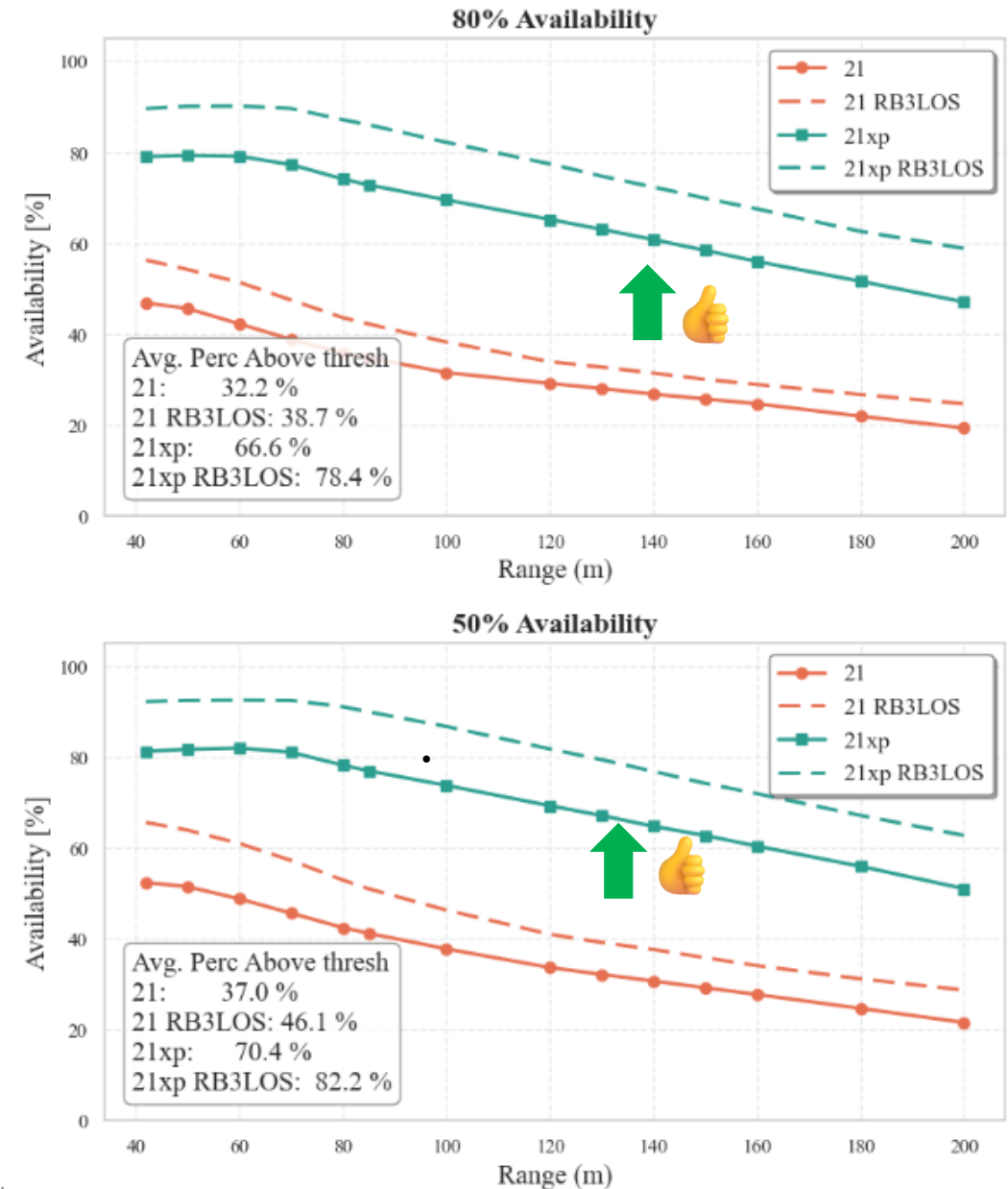
Threshold analysis

- 50% threshold adds 4-5% of data

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Availability Comparison: 21 vs 21xp (with/without RB3LOS)

03



Study 2 – Data owner : EWS consulting

High-altitude testing reveals atmospheric convergence effects effects

Key Performance

- The XP improves data availability
- Convergence at 60-140m range where atmospheric conditions dominate

Booster Impact

- The booster adds ~10% availability
- Benefit applied to both systems.

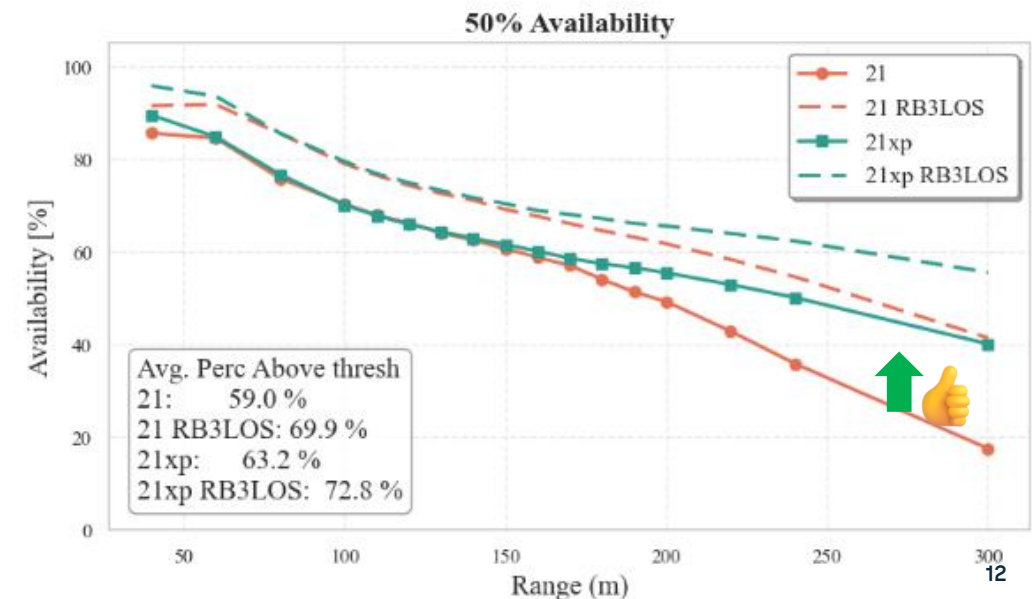
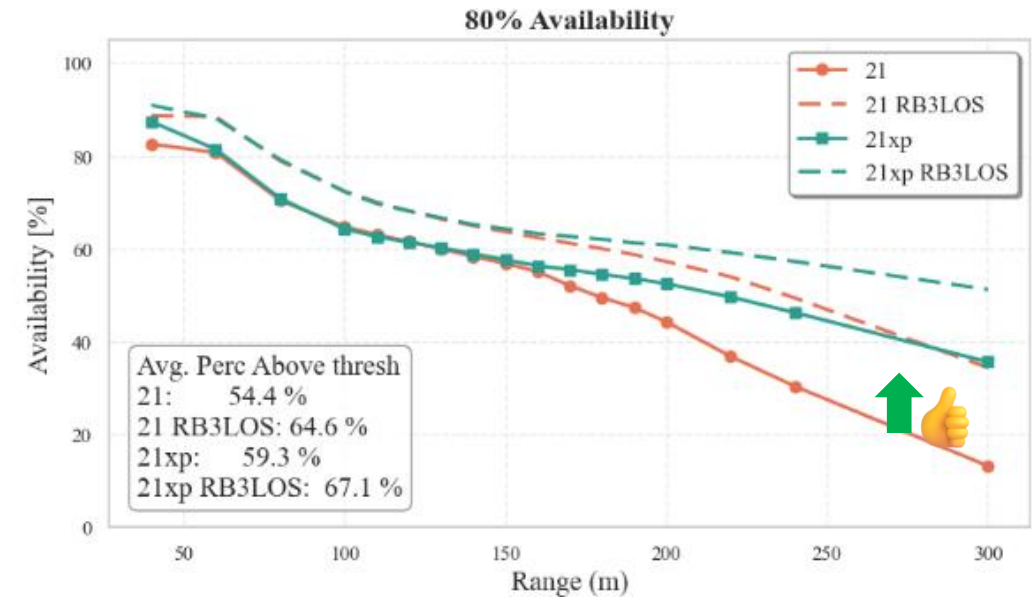
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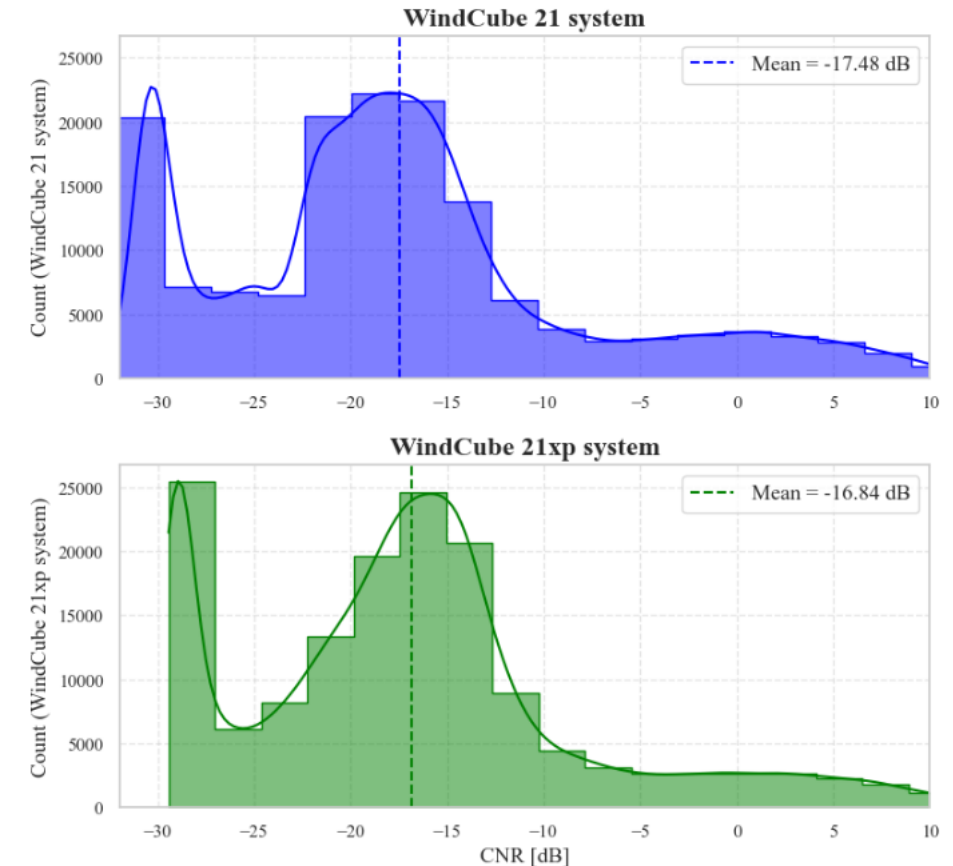
03



Both CNR distributions show pronounced peaks at low CNR values, suggesting periods with very clean air or fog where backscatter is weak.

Under these conditions, the limiting factor is atmospheric visibility rather than instrument design, which explains why the performance of the two systems converges between 60 m and 140 m.

CNR Distribution Comparison Site 2



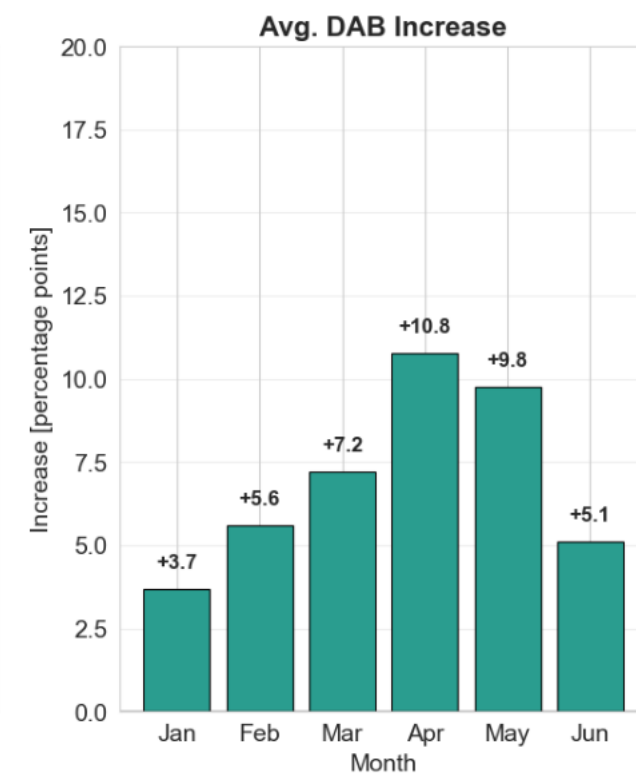
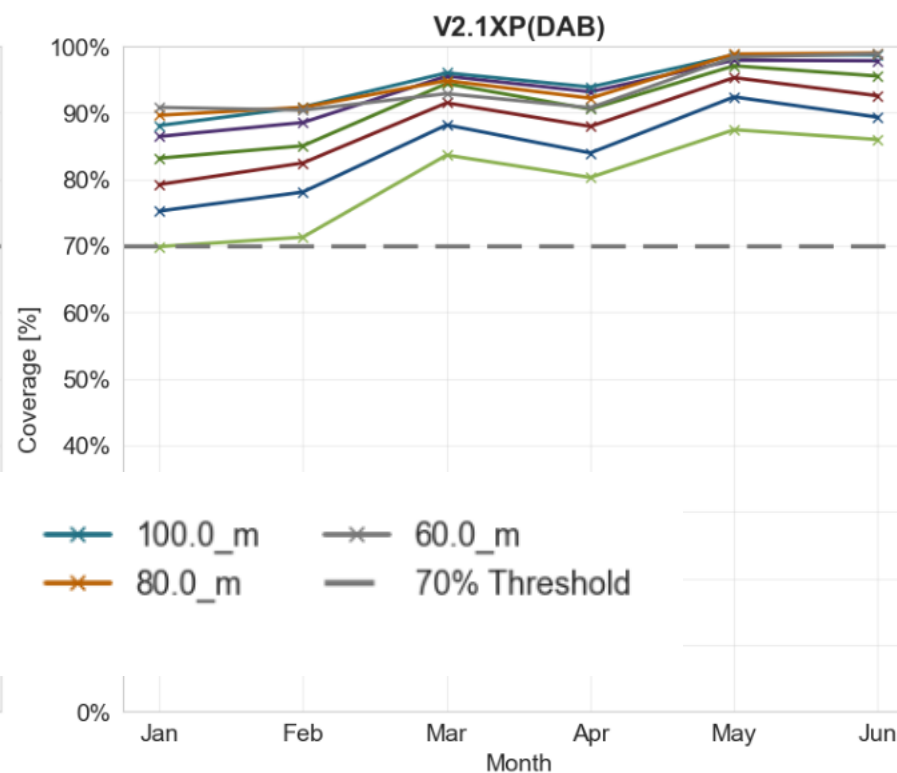
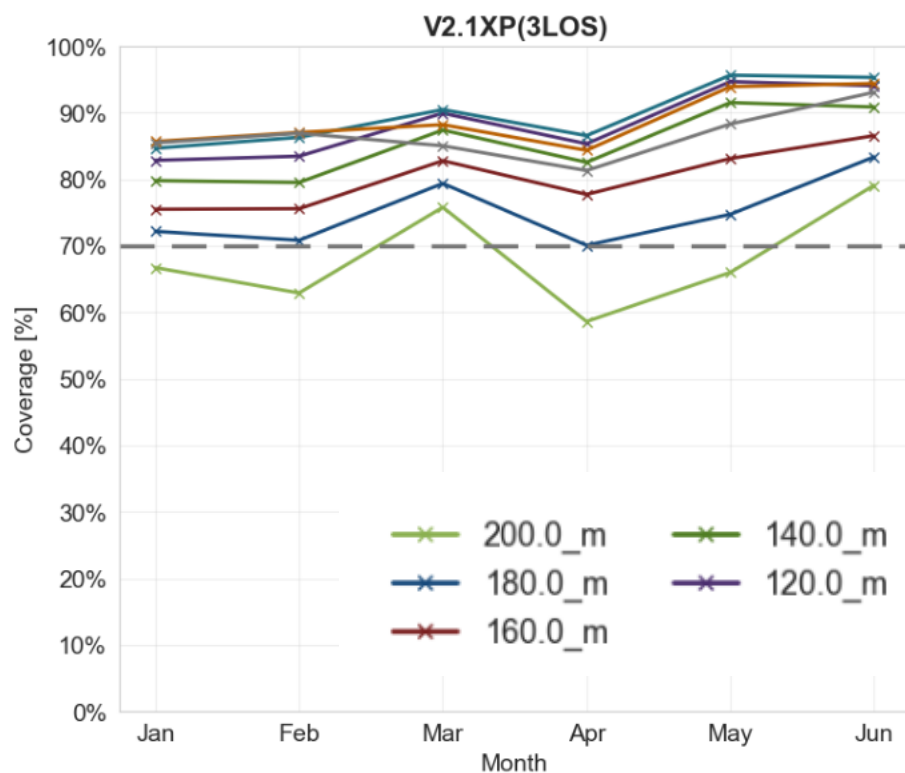
Study 3 – Data owner : RES

Key Performance

- In cold-climate conditions, WindCube V2.1XP maintains high data coverage across the full 60-200 m range, with most monthly values above the 70% threshold.

Booster Impact

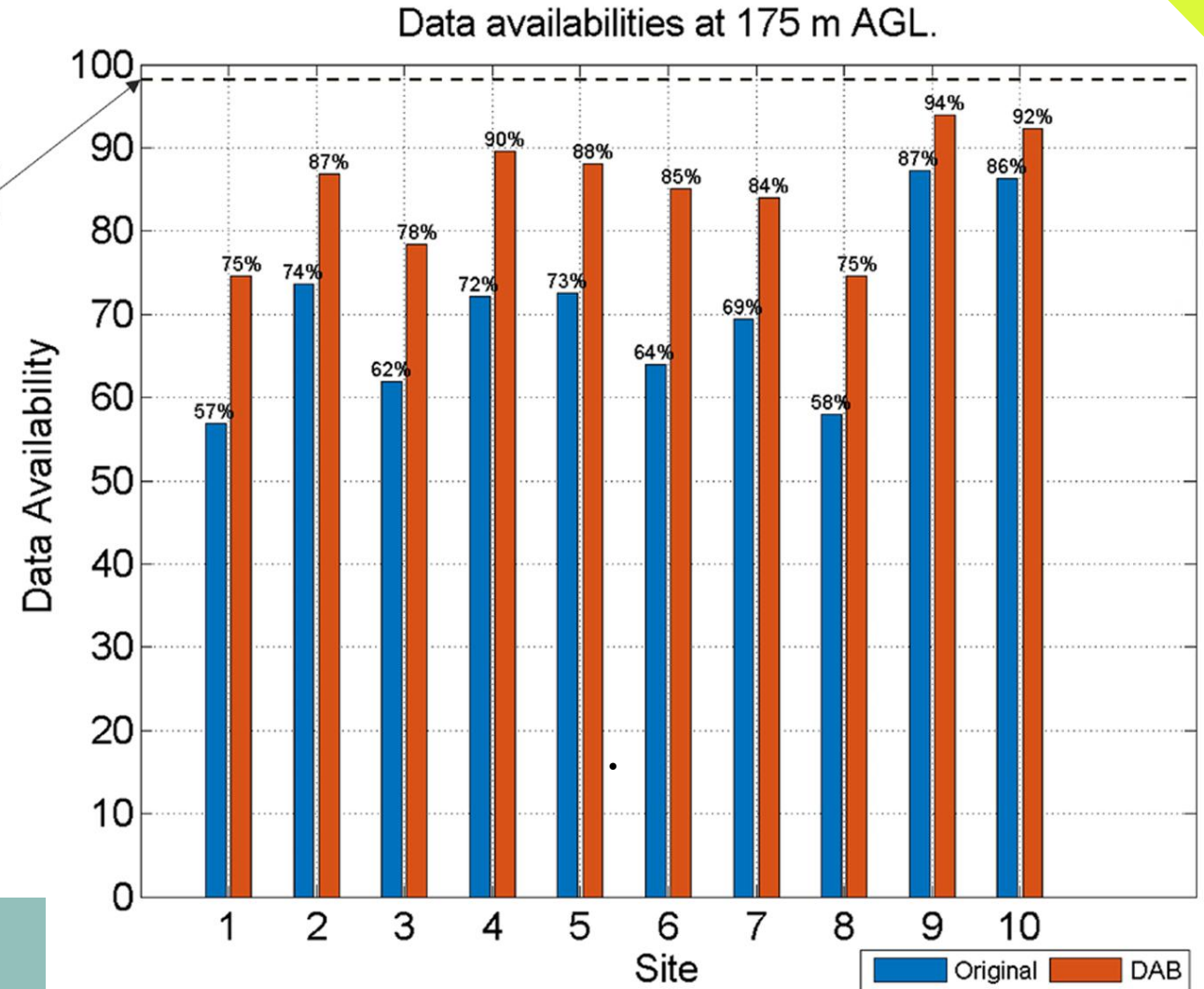
- The Data Availability Booster improves coverage across all months, lifting all range gates comfortably above the 70% threshold.



Average data availability across different sites increases from 70.2% for the original dataset to 84.8% with DAB, representing a +14.6 percentage point improvement.

"We recommend the Availability Booster for all low aerosol sites."

*Pyry Pentikäinen,
Senior Advisor, Wind Energy, Kjeller Vindteknikk*



Independent Validation

Evaluated by Kjeller Vindteknikk across 10 Nordic and Baltic campaigns. Full-year datasets were used to remove seasonal bias and reflect real operating conditions.

Challenging lidar conditions

Sites were mostly flat, forested, and low in aerosols. Original and boosted data were filtered with the same 80% availability criterion for 10-minute averages.

Availability improvement

Gains increased with height: +9% at 100 m rising to +17% at 200 m. Typical site-level boost was +5-20%, with the lowest-availability sites gaining the most.

Uncertainty and AEP impact

IEC verification showed no meaningful uncertainty increase: mean difference 0.00%, worst case 0.06%. Even 75% post-boost availability remained suitable for energy yield assessment, with only about 0.1% AEP uncertainty impact.

Conclusions



The WindCube XP delivers up to 100% data availability improvement over V2.1.

Even in ultra-clean air where atmospheric conditions limit both systems (60-140m convergence), XP maintains superior performance.

The Availability Booster adds 10-15% data with negligible uncertainty impact (mean 0.00%, worst case 0.06%).

Recommended deployment: XP with booster for all low-aerosol sites.

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