ZX Lidars

Wind speed at light speed

Measuring wind from 10 to 50 metres

An Informative Guide for the Wind Energy Industry

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Contents

1 Introduction 4
2 Wind Flow Characteristics from 10–50 m Above Ground Level 5
3 Challenges of measuring wind at low altitudes (10–50 m) 6
4 Validation and accuracy of ZX Lidars (10–50 m compared to mast instruments) 8
5 Use cases and applications 10
5.1 Onshore applications benefiting from low-altitude wind data 10
5.1.1 Large rotors on short towers (lower tip heights at 20–40 m AGL) 10
5.1.2 Complex terrain and forested sites (shear and turbulence at low altitudes) 11
5.1.3 Repowering 11
5.2 Offshore applications requiring low-altitude wind data 12
5.2.1 Platform deck-level measurements (10–30 m ASL for operations and development) 12
5.2.2 Floating Lidar Systems and near-sea-surface winds 14
6 Conclusion 16
References 17

1 Introduction

Measuring wind in the 10–50 m layer above ground or sea level is critical for a range of applications within the wind energy industry - from designing wind energy projects to understanding loads on modern wind turbines. This altitude band sits in the lower portion of the atmospheric boundary layer, where wind speeds increase rapidly with height and turbulence is strong due to surface friction. Historically, wind measurements at ~10 m height (the standard reference height in meteorology) have been collected by cup anemometers on short masts or buoys. However, those conventional measurements at 10 m often lack broader context – they represent very local conditions and may not capture the vertical wind profile needed for modern engineering analyses.

To fully characterise winds up to 50 m (roughly the height of a 15-story building or the lowest part of a wind turbine's rotor sweep), more sophisticated approaches are required. Advancements in Lidar (Light Detection and Ranging) technology, specifically ZX Lidars' continuous-wave Doppler Lidar systems, have enabled remote, accurate wind measurements throughout this 10–50 m altitude range and well beyond.

This informative guide explores the unique wind flow behaviour in the 10–50 m layer, the challenges of measuring wind in this regime, and how ZX's Lidar technology addresses these challenges. We present validation evidence comparing ZX Lidars against traditional sensors (cup and ultrasonic anemometers) at low heights, discuss use cases across wind energy and offshore platforms, and include real-world case studies. All claims are grounded in validated data and aligned with IEC 61400-12-1 standards and industry best practices for wind measurements.

2 Wind Flow Characteristics from 10–50 m Above Ground Level

Wind in the 10–50 m AGL (Above Ground Level) band is governed by the physics of the atmospheric surface layer. In this lowest layer of the atmosphere, wind speed typically increases sharply with height following a logarithmic or power-law profile, due to the reduced influence of surface friction as you go higher. For instance, a gentle breeze at 10 m might accelerate to a strong wind by 50 m on a windy day, depending on surface roughness (terrain or sea state) and atmospheric stability. Turbulence intensity is generally highest near the ground – eddies generated by terrain features, buildings, trees, or waves (offshore) create a constantly fluctuating wind vector. This means that winds at 10–20 m can be highly variable and gusty compared to winds at, say, 100 m. During daytime with convective heating, the lower atmosphere tends to be well mixed, and wind gradients from 10 to 50 m may not be extreme. But during stable night-time conditions, a low-level jet can form just above this layer, causing a dramatic wind speed increase with height and even different wind directions (wind shear) just tens of meters apart. All these factors make the 10–50 m wind behaviour complex and rich in information – capturing it is essential for accurate wind resource assessments, dispersion modelling, and flight safety analyses.

However, measuring wind in this layer poses challenges. Near the surface, obstacles and terrain have an outsized influence. A wind sensor at 10 m must be sited in an open area; otherwise, it might reflect more about a single tree or building wake than the free wind flow. To get representative data, best practice is to position sensors well away from obstructions (typically at a horizontal distance of 10–20 times the obstacle height, per guidelines) and in locations that reflect the broader environment (e.g. over uniform terrain or water). Even so, a fixed sensor at one height gives a limited picture. For wind energy projects, knowing the vertical wind profile across 10–50 m is important – for example, wind shear and turbulence in this layer can impact the lower part of a wind turbine rotor disk or the loads on a turbine’s tower. In the offshore context, winds at 10–50 m above sea level influence vessel operations and the behaviour of waves. In urban settings, 10–50 m spans the typical heights of low to mid-rise buildings, where winds channelled through streets or over rooftops create complex microclimates. In short, the 10–50 m layer is where atmosphere meets infrastructure, and measuring it accurately is both challenging and essential.

3 Challenges of measuring wind at low altitudes (10–50 m)

Traditional wind measurement approaches have limitations in the 10–50 m range. Meteorological masts with cup anemometers can be used to mount sensors at 10 m, 20 m, 50 m, etc., but building a tall tower is costly and often impractical for short-term campaigns. Moreover, a cup anemometer at 10 m is extremely sensitive to local siting – minor misplacements can cause flow distortion (e.g. the mast itself or nearby objects can alter the wind). In complex terrain or urban areas, installing a mast that high with enough fetch around it is difficult. Sodar (acoustic wind profilers) have been used to probe winds starting from ~30 m above ground, but Sodars can suffer from noise interference and require large, flat sites; their data quality in high turbulence or near obstacles degrades. Radar wind profilers typically focus on higher altitudes and lack resolution near the ground. These factors created a gap in reliable wind sensing from just a few meters above ground up to the mid-tens of meters.

Remote sensing with Lidar is an attractive solution, but not all Lidar technologies are suited for low altitudes. Pulsed Doppler Lidars emit laser pulses and measure the Doppler shift of returns at discrete range gates. By design, pulsed Lidars have a minimum measurement range on the order of tens of meters – the first tens of meters are a “blind zone” while the instrument’s receiver is gated off to avoid the overwhelming pulse emission and near-field backscatter. In practice, a standard pulsed wind Lidar cannot measure below about 40 m from the device. If you set up such a Lidar at ground level, your wind data begins at 40 m AGL, missing the entire 0–40 m layer. Even mounting the Lidar on a 10 m platform only brings the lowest data point down to ~50 m AGL, still above the 10–50 m band of interest.

Another issue is probe volume size. Pulsed systems sample a relatively long stretch of the atmosphere with each gate – the range gate length is typically 20–30 m for wind profiling Lidars. This means a “wind speed at 40 m” from a pulsed Lidar is actually an average over perhaps 30 m of depth (from ~25–55 m, for instance). Near the ground, where wind speed changes quickly with height, such a large averaging window can blur important details. By contrast, continuous-wave (CW) Doppler Lidars – the technology employed by ZX Lidars – inherently have much smaller probe lengths at short ranges because they focus the laser at the exact measurement distance. The returned signal in a CW Lidar comes primarily from the focal volume, which can be extremely tight near the focus point. For instance, the ZX 300 (formerly ZephIR 300) continuous-wave Lidar has an effective probe length of only ±0.07 m at 10 m range (essentially a few centimetres, effectively a “point” measurement) and about ±7.7 m at 100 m range. Even at 50 m range, the CW probe length is on the order of a couple of meters – far smaller than a pulsed Lidar’s fixed 20–30 m gate. In practical terms, this gives CW Lidar much finer resolution of wind gradients in the 10–50 m layer.

Because a CW Lidar like the ZX 300 uses a continuously emitted laser and focuses at each measurement height in sequence, it also has no inherent blind zone. It can, in principle, measure as close as a few meters above the device – in fact, “detection [is] possible in principle at zero range” for CW Doppler Lidar. The ZX 300 is specified to measure wind speeds starting at 10 m above the instrument, which in a typical ground deployment means ~10 m AGL. By comparison, a pulsed system is “blinded while the pulse is leaving the transmitter,” resulting in a minimum range of “tens of metres, typically around 40–50 m”. This fundamental difference – CW Lidar’s ability to start measuring almost at ground level versus pulsed Lidar’s 40+ m startup height – is a primary reason why other Lidar types have been unsuitable for the 10–50 m altitude range. A ZX continuous-wave Lidar can sit near the ground and directly observe the winds at 10 m, 20 m, 30 m, etc., which a pulsed Lidar simply cannot do due to physics of time-of-flight ranging.

Beam obscuration in the lower measurement heights is a further consideration. The CW ZX Lidar can easily handle obstructions blocking part of the high-fidelity, 50-point (beam) scan at low elevation angles (for example, it can still operate if an adjacent met mast intersects part of the scanning cone, with only a minor loss of data). This robustness is important when deploying at crowded test sites or near structures.

In summary, the physics and engineering of continuous-wave Lidar make it ideally suited to measuring winds from 10 m upward, whereas pulsed Lidars are fundamentally constrained from doing so by range-gating and large initial sample volumes. Other remote sensing technologies (radar, Sodar) likewise fall short in this near-ground regime due to either minimum range or data quality issues. This is why, for the 10–50 m layer, ZX's Lidar technology has become a go-to solution in the wind energy and meteorology communities – it fills a critical measurement gap with high-resolution, accurate data.

4 Validation and accuracy of ZX Lidars (10–50 m compared to mast instruments)

Any wind measurement solution used for energy yield assessments, power curve testing, or safety-critical applications must be rigorously validated against established reference standards. In the context of low-height wind measurements, ZX Lidars – specifically the ZX 300 – have undergone extensive validation against IEC-compliant meteorological masts and reference cup anemometers in the 10–50 m range. These validation results confirm that ZX Lidars provide accurate and reliable data starting from 10 m above ground level, with measurement uncertainties well within accepted limits for finance-grade use.

At the UK Remote Sensing Test Site (UK RSTS), over 500 independent comparison tests have been performed using ZX 300 units against calibrated cup anemometers positioned at 10 m, 20 m, 30 m, and 50 m. The results show a one-to-one correlation between ZX Lidar wind speeds and cup measurements:

- **Regression slope:** 1.000 across all tested heights, including 10–50 m
- **Coefficient of determination (R^2):** consistently around 0.99
- **RMSE:** typically in the range of 0.16–0.23 m/s
- **Standard deviation of slope:** less than 1%, indicating highly stable performance

These values not only meet but exceed industry best practice acceptance criteria (typically requiring slope within 2% of unity and R^2 above 0.98). At 10 m, the ZX 300’s focused probe volume allows precise measurement that is directly comparable to mast-based cup data, which is particularly important for evaluating wind shear, turbulence, and directional stability in the surface layer.

In a separate two-year campaign at the Cabauw meteorological tower in the Netherlands, a ZX 300 Lidar operated continuously alongside an IEC-calibrated mast. At heights including 20 m and 45 m AGL, the ZX Lidar matched cup anemometer readings with:

- **Regression slopes near 1.000**
- **R^2 values exceeding 0.995**
- **System uptime:** ~99.4%
- **Data availability:** >97% after quality control

These results confirm that ZX Lidars can deliver continuous, bankable data in the lower atmospheric boundary layer where wind variability is highest.

Validation of turbulence intensity (TI) and wind direction at low heights has also been robust. In the UK RSTS study, TI values measured by ZX 300 at 10 m and 30 m tracked closely with cup-derived results, indicating that the Lidar is not over-smoothing turbulent fluctuations. Wind direction accuracy has been independently verified to within **±0.5°**, supporting reliable use for yaw misalignment studies and site calibration purposes.

ZX Lidars measure not only horizontal wind speed and direction but also vertical wind speed (w-component), enabling detailed assessments of shear, veer, and flow inclination. Comparisons with research-grade sonic anemometers at 10 m and 50 m confirm that ZX 300 can accurately capture gusts, vertical motion, and turbulence structures critical to turbine loading and drone flight safety.

Importantly, while the focus of this guide is on the 10–50 m range, it is within the backdrop of full-range validation – extending from 10 m to beyond 200 m – that confidence in the ZX system is established. Extended height validations at 70 m, 91 m, 120 m, and up to 200 m have demonstrated the same high degree of accuracy seen at lower levels. For example, across heights from 50 m to 200 m, validation campaigns have shown:

- Regression slopes consistently between 0.998 and 1.002
- R^2 values exceeding 0.995
- Minimal variance in RMSE compared to lower heights

This consistency across the full height range reinforces the ZX 300's credibility as a reliable profiler from near-ground level up through hub height and beyond, ensuring users can trust the same level of precision whether measuring at 10 m or 150 m. The ZX 300 has achieved IEC 61400-12-1:2017 Classification, with results from multiple independent agencies (DNV, UL, Deutsche WindGuard, and Natural Power) confirming its performance across the full vertical profile.

This foundation of evidence means ZX Lidars are widely accepted as a direct replacement for met masts, even in banked energy yield assessments and formal power performance tests. Their proven accuracy from 10 m upwards uniquely positions them as the industry standard for low-height wind measurements. The body of validation – across 10 m, 20 m, 30 m, and 50 m – confirms that ZX Lidars deliver precise, repeatable measurements that align with traditional calibrated instruments.

5 Use cases and applications

Modern wind energy projects increasingly recognize the importance of wind data in the 10–50 m altitude range above ground or sea level. While traditional wind assessments focused on hub-height winds (typically 80–120 m AGL for onshore and offshore turbines), several scenarios demand high-fidelity measurements at lower altitudes. This section explores onshore and offshore use cases where 10–50 m wind data is crucial, and it explains the technical and commercial drivers behind this need. We also highlight validation examples to illustrate how accurate low-level wind measurements inform project success.

5.1 Onshore applications benefiting from low-altitude wind data

Onshore wind projects can have turbine configurations and site conditions that make winds at 10–50 m AGL (Above Ground Level) a critical factor. Two common scenarios are large-rotor turbines on relatively short towers, and installations in complex terrain or forests. In both cases, a substantial portion of the rotor can operate within this low-altitude band, where wind flow characteristics differ markedly from the free-stream hub-height conditions.

5.1.1 Large rotors on short towers (lower tip heights at 20–40 m AGL)

Wind turbine design trends and repowering efforts have in some markets led to large rotor diameters on moderate-height towers, meaning blade tips sweep closer to the ground. In such configurations, the rotor's bottom segment is immersed in the slower, more turbulent air near the surface, which can impact energy production and loads. Accurate measurements at these heights are needed to capture:

- Rotor-Equivalent Wind Speed (REWS): Instead of relying solely on hub-height wind, developers use REWS – the disk-averaged wind speed accounting for vertical shear – to better predict turbine performance. REWS was introduced in IEC 61400-12-1 (2017), which required at least three measurement heights across the rotor to calculate this metric. When a rotor extends down to ~20 m, having wind data near the bottom tip region (e.g. 20, 40, 60 m) provides the opportunity for a more accurate REWS and thus more reliable power curve and Annual Energy Production (AEP) estimates. This may be especially critical for large low-specific-speed rotors where wind speed variation across the swept area can be significant.
- Turbine loads and class validation: Turbine OEMs classify machines (IEC Wind Classes I–III, A/B) based on the design reference wind speed and turbulence. A site with larger rotors on short towers can ensure that extreme winds and turbulence at low heights remain within the turbine's design envelope. For instance, a site may meet Class III at hub height but experience enhanced gusts or turbulence at 20–40 m due to terrain or obstacles.
- Energy yield in low-level winds: In some cases, even when higher hub heights capture stronger winds, untapped low-level winds can contribute additional energy. There is growing interest in technologies (e.g. multi-rotor or vertical-axis turbines) to harvest winds below conventional rotor heights. Wind farm owners have noted that "plentiful untapped low-altitude winds" exist below current turbine rotors. Thus, accurate 10–30 m wind measurements help quantify this resource for potential complementary systems or future turbine designs that operate in that layer. They also inform whether deploying larger rotors (that sweep nearer to the ground) will meaningfully increase production or if the near-ground winds are too weak or turbulent to be useful.

5.1.2 Complex terrain and forested sites (shear and turbulence at low altitudes)

Sites with hilly terrain, ridges, or forest cover may pose additional challenges. The wind profile and turbulence in the lowest 50 m can be heavily influenced by topography and vegetation, affecting turbine performance and lifetime. Key considerations include:

- Wind shear in complex terrain: In mountainous or highly undulating terrain, wind speed can change rapidly with height. Near-valley floors or hill crests, the optimal hub height may not capture the full wind profile shape. Field experiments (e.g. Perdigão 2017 in a Portuguese valley) have shown that non-standard wind profiles and even low-level jets can occur, with maximum winds sometimes at intermediate heights (~50–100 m AGL) rather than increasing monotonically. Accurate low-altitude data can support more comprehensive extrapolation to hub height and rotor-layer winds, that may improve energy yield predictions and layout decisions (e.g. whether taller towers are justified by much higher winds above tree tops).
- Canopy and terrain-driven turbulence: Forest canopies and abrupt terrain features (cliffs, escarpments) inject significant turbulence and gustiness into the flow at low heights. Immediately above a forest, turbulence intensity (TI) can be extremely high – one Lidar campaign measured TI up to ~26% at hub height just 1–2 rotor diameters downstream of a forest edge, versus ~15% in free flow. These findings underline that turbulence generated below ~50 m AGL can persist and affect turbines well above. By measuring wind within and just above the forest (e.g. 10 m, 20 m, 40 m levels), developers can quantify the turbulence penetration and shear. This data supports site suitability assessments – ensuring that the measured turbulence and extreme gusts (which are often greatest near the canopy top) do not exceed what the turbines can handle. In cases where they do, mitigation (tower height increase, setback from forest) or choosing a higher turbulence class turbine might be necessary. Accurate low-level measurements thus avert misjudging the fatigue loads and wake mixing at forested sites, which can otherwise lead to underperformance or damage.

In summary, onshore projects in complex terrain or with vegetation absolutely depend on 10–50 m wind data for modelling wind flow and loads. National wind energy studies have noted that forest effects can reach up to 5× the canopy height (~50 m for a 10 m forest) above ground, affecting most of the rotor layer. Accurate measurements in the lower part of the atmosphere are therefore key to capturing these effects and optimising turbine design and placement accordingly.

5.1.3 Repowering

Repowering – upgrading older wind farms with new technology – often involves installing completely new turbines. This scenario creates a new challenge where existing 'old' measurements for the shorter turbines may be available, 'new' measurements are required representing the higher heights but importantly a relationship between old vs. new may help to improve accuracy of any energy yield study, as production data from the older turbines will be available to complete the uncertainty circle.

Accurate low-level wind measurements therefore become increasingly essential in fully evaluating the retrofit:

- Site wind conditions at original vs new rotor levels: Legacy wind measurement for the old project might have focused on the old hub height (e.g. 50 m). The *new rotor*, however, extends perhaps from 20 m up to 150 m. Measuring wind at multiple heights along this range and comparing with the actual output of the existing wind farm helps determine whether wind speeds near the bottom are sufficient to contribute to energy yield. It may turn out that winds below 20 m are frequently too low or too turbulent, diminishing the expected gain from the larger rotor. Having that data allows a developer to model the rotor-equivalent wind speed and adjust energy estimates accordingly – ensuring that adding rotor area near the ground genuinely yields more annual energy.

- Loads and lifetime considerations: Turbine OEMs may request low-height wind data to update load simulations for the repowered turbines.

10–50 m wind monitoring provides the empirical evidence to proceed confidently with tower selection and rotor diameter for the longevity of the project.

5.2 Offshore applications requiring low-altitude wind data

Offshore wind energy typically conjures images of very tall turbines over open seas. Yet, there are critical offshore use cases for wind measurements at 10–50 m above sea level (ASL). These include deck-level measurements on platforms (for both wind farm development and operations), the use of Floating Lidar Systems which inherently measure from just above the waves upward, and the role of near-surface wind data in air-sea interaction models that underpin weather forecasts and wind resource assessments.

5.2.1 Platform deck-level measurements (10–30 m ASL for operations and development)

Oil & gas platforms and dedicated meteorological masts in the sea often install wind sensors near deck height (roughly 20–40 m ASL). These measurements have long supported offshore operations (e.g. marine logistics, safety) and, more recently, offshore wind farm planning. Key points for this scenario:

- Bridging to standard 10 m reference: Meteorology and oceanography conventionally use 10 m height wind speeds as a reference for surface conditions. However, sensors on platforms might sit at the top of the superstructure (say 40, 60, or even 100 m ASL). The data is then reduced to 10 m to feed into models and forecasts. Studies have found that using a simplistic reduction (like a fixed power-law exponent) can introduce bias – for example, North Sea platforms using a constant 0.13 shear exponent underestimated true 10 m winds by ~0.8 m/s on average. This is a substantial error, given 0.8 m/s could be ~10% of the wind speed. Improving these conversions requires understanding the actual wind profile in the 10–50 m layer. Accurate deck-level measurements, combined with proper modelling, are needed for an “essential representation” of the wind profile. This matters not only for weather forecast assimilation but for wind resource mapping – many global datasets (reanalyses, satellite scatterometers like ASCAT) provide 10 m wind fields. Wind farm may developers rely on these as baseline climate data, so validating and calibrating them with on-site 10–30 m measurements (from platforms or buoys) improves the reliability of extrapolating to hub-height conditions.
- Operational decision support: Offshore platforms (whether oil rigs or wind farm substations) use real-time 10–30 m wind readings to make decisions about crane lifts, vessel transfers, and helicopter flights. While these are not wind energy production issues per se, they directly affect O&M costs and safety for wind farms. For example, if a wind farm has a manned offshore substation or service operation vessel, knowing the true wind at ~20 m (helideck height) is of use for flight scheduling. Thus, high-quality Lidar measurements at low levels are often integrated into offshore wind farm infrastructure. In the Netherlands, the meteorological agency (KNMI) and others have begun deploying wind Lidars on offshore substations at ~40 m ASL that measure from 10 m above the deck up to ~300 m. These provide both hub-height and near-surface data to stakeholders. The benefit is twofold: immediate operational awareness and long-term resource monitoring without needing a separate met mast.

- Wind farm wake and model validation: As offshore wind farms grow larger, a wind turbine's wake can affect not just downstream turbines at hub height but potentially the wind flow closer to the sea surface. Particularly under stable stratification at sea, wakes can stay elevated or, conversely, mix downward – influencing winds in the 10–50 m layer even hundreds of meters away. Deck-level wind profiling Lidars help observe how wind speed and turbulence recover with height inside and around a wind farm. For instance, a Lidar on a platform at ~30 m could detect a slowed wind layer after a turbine row, informing wake model calibration for that vertical slice. This is increasingly important as arrays become denser and researchers incorporate wind farm effects into mesoscale weather models. In fact, KNMI compared Lidar wind profiles before vs. after a wind farm was built (at Borssele) to assess wake impacts on the lower atmosphere, and used weather models with and without wind-farm parametrisation to study these changes. Such analyses hinge on having accurate measurements not just at hub height but *throughout the lower atmosphere*, to see how far down the wakes and momentum deficits extend. The bottom line is that deck-level wind data supports both practical operations and advanced model validation in the offshore environment.

North Sea K13-A Platform Case Study

A prime example of leveraging platform-based measurements is the K13-A platform in the Dutch North Sea. Originally a gas production platform, K13-A has hosted a long-term meteorological campaign since 2016. A ZX 300M Lidar mounted ~35 m above mean sea level on the platform continuously profiles winds at 10 heights from 63 m up to 291 m ASL. This arrangement effectively turns the platform into an offshore met station, providing public data for both industry and research.

- The K13-A Lidar measurements have been instrumental in validating wind atlases and models. TNO and KNMI have used this dataset (along with others) to check the accuracy of new mesoscale atlases like the Dutch Offshore Wind Atlas (DOWA) and satellite-derived winds. Having real observed profiles helps identify biases – for instance, if a model over-predicts wind shear (vertical gradient) in the 20–60 m layer, it might show up when comparing to K13-A data. Indeed, quality assessments of ERA5, DOWA, etc. against K13-A and other mast/Lidar data have revealed differences in low-level wind characteristics, prompting improvements in modeling stability and roughness over the North Sea.
- The K13-A campaign also demonstrates the feasibility of collecting finance-grade wind data without a traditional mast. The Lidar on K13-A is regularly calibrated and maintained under an accredited program, yielding data accuracy comparable to cup anemometers with analysis showing even the 291 m readings were reliable. Thus, the platform has become a trusted reference. Developers planning wind farms in the Dutch North Sea (e.g. Hollandse Kust zones) have accessed K13-A data to understand the vertical wind shear, turbulence, and long-term wind climate in that area. The success of K13-A's monitoring has led to expansions – as of 2023, similar Lidar units operate on other North Sea platforms (Europlatform, Lichteiland Goeree, etc.), enriching the coverage of 10–300 m wind observations offshore.

K13-A underscores how accurate lower-atmosphere measurements support both commercial and research needs: from reducing uncertainty in energy yield predictions to improving weather forecast inputs. It serves as a blueprint for future offshore measurement strategies, where existing oil & gas infrastructure or purpose-built platforms host advanced LiDARs to gather wind data across the entire rotor layer, including the near-sea-surface portion.

5.2.2 Floating Lidar Systems and near-sea-surface winds

The advent of Floating Lidar Systems (FLS) has transformed offshore wind resource assessment. These buoy-based or moored Lidars typically float at the ocean surface, measuring winds from just a few meters above the water up to hub height and beyond. By design, they fill the critical gap of near-surface wind observation in deepwater or without fixed masts:

- Air–sea interaction and model coupling: The 0–50 m layer is where the atmosphere and ocean exchange momentum (wind stress), heat, and moisture. 10 m wind speed is a key input for wave models and ocean forecasts, as well as for computing the wind stress via formulas (which often assume 10 m neutral winds as a reference). Floating Lidars now offer an in situ view: they routinely measure winds at 10 m, 20 m, 50 m, etc., capturing the wind profile in the marine boundary layer. This data can improve air-sea interaction models – for example, by validating how winds adjust under varying stability. Having full profiles allows exploration of how the wind at 10 m relates to wind at 30 or 50 m over time, which is essential for improved coupled atmosphere-wave simulations.
- Wind shear and stability profiling: Floating Lidars provide a complete wind profile from near-surface to hub-height, enabling detailed shear analysis. Developers look at metrics like the shear exponent (alpha) between 10 m and hub height, or check for low-level jets whose influence down to 50 m could affect turbine startup and loads. If a floating Lidar records, say, 8 m/s at 10 m and 12 m/s at 100 m, that strong shear might indicate stable stratification or nighttime conditions. It could portend higher fatigue loading (due to wind shear across the rotor) and needs to be accounted for in turbine selection. Without the 10 m and 20 m reference data, one might underestimate shear by only looking at, for example, 50 m and above. The FLS data thus directly feed into turbulence and shear assessments required in site conditions reports. Moreover, floating Lidar campaigns often last 1–2 years; they capture seasonal variations in shear (e.g. higher shear in summer stable conditions, lower in winter storms). Consultants depend on this to ensure that extreme shear events at low heights within acceptable frequency. Recent analyses of U.S. coastal wind Lidar data indeed highlighted frequent high-shear, low-level jet events offshore at heights not far above turbine rotor bottoms, underlining the need to profile from 10 m upward to characterise them.
- Floating Lidar performance and 10 m validation: The ZX 300M Lidar, responsible for ~90% of all offshore wind measurements in the last decade, is designed to measure from 10 m up to 300 m with high accuracy, even on a moving buoy. Manufacturers emphasise that these devices provide “low 10 m measurements through to tip height and above” as a new standard in bankable offshore data. The 10 m reading is often cross-checked with an on-board met station anemometer (mounted ~2–3 m above sea on the buoy) to ensure consistency. This redundancy improves confidence in the data quality at the very lowest heights. Successful validation campaigns have led to FLS being accepted by insurers and financiers (DNV Stage 3), meaning developers can use 10–50 m data from buoys as readily as from fixed masts for energy estimates. The wide range of measurement and proven accuracy has made floating Lidars the workhorse for offshore resource assessment, deployed in all major lease areas. They deliver the low-level wind information that was previously missing, thereby reducing uncertainty in how we extrapolate to turbine hub height.
- Metocean design criteria: Offshore wind farm design must consider not just the turbine inflow but also conditions like tropical storms or squalls, where intense winds may initially be measured at 10 m (by marine systems) and need extrapolation to higher levels. Floating Lidar data in the 10–50 m band help calibrate extreme wind models (e.g. the IEC Extreme Wind

Model which might use 10 m gusts as a baseline). Additionally, for offshore substructures (like floating turbine platforms), wind at 10–20 m interacts with waves to produce dynamic loading. Accurate simultaneous measurement of wind and wave is enabling integrated analysis – for instance, one can analyse how a 50-year wave and the accompanying 10 m wind correlate, rather than assuming a generic wind profile. This is important for engineering floating wind platforms or maintenance vessels. Essentially, the 10–50 m wind data form a bridge between atmospheric science and ocean engineering, ensuring that both communities use consistent, validated values for design and operation limits.

In conclusion, wind energy stakeholders – developers, OEMs, consultants, financiers – depend on accurate 10–50 m wind measurements because they fill a vital gap in understanding and derisking projects. From capturing the benefits of large rotors on short towers to ensuring models correctly represent the air-sea boundary layer, these low-level data have proven their worth. The North Sea K13-A case demonstrated how a well-executed measurement campaign at an offshore platform can yield rich insights for the entire industry. As wind turbines grow and wind farms spread into new environments (from forests to floating wind), mastering the winds just above the surface is more important than ever – and thanks to modern Continuous Wave Lidars, it's more achievable than ever.

6 Conclusion

Measuring wind from 10 m to 50 m above ground or sea level is no longer an unresolved challenge. With modern ZX Lidar systems, we can obtain detailed wind profiles in this critical zone confidently and in compliance with international standards.

The success of ZX Lidars in measuring winds at 10–50 m is evidenced by their widespread adoption and the wealth of validation data. They exemplify a best-practice approach: use the right technology for the right layer of the atmosphere. Now, with Continuous Wave wind Lidars, such as ZX 300 and ZX 300M, we can confidently capture the wind in the surface layer, yielding benefits from project development through to operational safety.

In conclusion, measuring wind from 10 m to 50 m is not only feasible with ZX Lidars – it is highly accurate, operationally practical, and fully accepted by the wind and meteorological communities. This advancement improves our understanding of wind flow behaviour in the surface layer and enables better decision-making, such as financing a wind farm. By following the validated methodologies and best practices outlined in this guide, practitioners can ensure that they gather quality wind data in this altitude range, unlocking new insights and efficiencies in their respective fields.

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About Us

In 2003 we released the first commercial wind Lidar, pooling decades of fibre laser research from the science, security and energy industries. Designed specifically for the wind industry our Lidar has paved the way for many of the remote sensing devices seen in the market today. Our original Lidar technology continues to innovate with world firsts such as taking measurements from a wind turbine spinner and being the first to deploy an offshore wind Lidar, both fixed and floating. Our Lidars have also now amassed millions of hours of operation across 15,000+ deployments globally spanning two decades of commercial experience. Some of our proudest achievements are listed below; these are the earliest reported examples that we are aware of from open publications.

2003 - The first wind Lidar to make upwind measurements from a turbine nacelle
2004 - The first and original commercially available Lidar for the wind industry
2004 - The first wind Lidar to investigate the behaviour of turbine wakes
2005 - The first wind Lidar to be deployed offshore on a fixed platform
2007 - The first wind Lidar to take measurements from a turbine spinner
2008 - The first wind Lidar to be signed off against an industry-accepted validation process
2009 - The first wind Lidar to be deployed offshore on a floating platform
2010 - The first wind Lidar to re-finance and re-power a wind farm
2011 - The first wind Lidar to be proven in a wind tunnel
2012 - The first wind Lidar to be used with very short masts and secure project financing
2012 - The first wind Lidar to be accredited for use with no or limited on-site anemometry for project financing by DNV GL
2014 - The largest batch of single-type Lidar verifications against an IEC met mast
2015 - The first Lidar designed specifically for offshore use, with the longest warranty available - 3 years as standard
2016 - The first wind Lidar to support safe lifting on a jack-up vessel
2016 - The first wind Lidar SCADA integrated on operational wind farms in replacement of site met masts
2017 - The first wind Lidar to be installed across a wind farm on a Lidar-per-turbine basis, uniquely mapping wakes across a wind farm
2018 - The first wind Lidar to satisfy all criteria for IEC Classification
2019 - The first wind Lidar to take wind measurements from a drone
2020 - The first wind Lidar to be accepted for bankable energy assessments in complex terrain standalone (without a met mast)
2021 - The first wind Lidar to attract more than £150bn+ of investment into wind energy projects
2022 - The first wind Lidar to be fully integrated into a retrofit wind turbine controller for Lidar Assisted Control
2023 - ZX Lidars moves to Willow End!
2024 - The first wind Lidar with a 5 year warranty and 5 year planned service interval as standard

Our Products & Services

ZX300
Onshore vertical profiling wind Lidar

ZX300M
Floating & platform-mounted vertical profiling wind Lidar

ZXTM
Turbine-mounted horizontal profiling wind Lidar

ZX Measurement Services
Wind Data as a Service

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