

VAISALA

WindCube[®] Complex Terrain Ready

Expand your possibilities with
world-class technology and
extensive support



Flexible and validated. Bankable and accepted. This is lidar without limits, demonstrated by our commitment to continuous innovation and backed by wind energy leaders worldwide.

The wind industry is expanding, and the need for wind farms located in complex terrains is increasing as land in simpler terrain becomes less available. Considering the wind industry's rapid business growth, this trend is expected to continue over the next decade.

Complex terrain poses a unique wind measurement challenge: the wind flow isn't uniform in these environments. Thankfully there are modeling technologies at hand that account for non-homogeneous wind flow to correct lidar data so it is accurate, reliable and bankable.

WindCube® lidar has been used in moderately complex terrain for many years — made possible by integrated and patented Flow Complexity Recognition (FCR) software. Now, through strategic partnerships, you can use WindCube measurements in even more complex terrains using the proven Computational Fluid Dynamics (CFD) correction method.

The challenge of complex terrain

Wind farm environments range from simple to complex. Wind measurement using lidar in simple, generally flat terrain is relatively straightforward since wind flow is homogenous, with minor variances in wind speed and direction at the 10min average scale.

Complex terrain includes features such as hills, forests, obstacles and varying slopes and roughness. The wind is deflected over and around these features and does not follow a homogeneous linear path. This breakdown in flow homogeneity can lead to errors in lidar measurements. This phenomena is well-known and documented, and solutions based on CFD techniques have been developed and validated over the past several years.

FCR and CFD algorithms

Bankable data (accurate and with known uncertainties) is critical for wind energy development regardless of terrain type, with specific technologies required to provide the best outcomes. For remote sensing devices in complex terrain, a site-dependent correction is required to get precise and reliable wind speed data. The most accurate and historic correction methods are FCR and CFD.

FCR technology — available at no extra charge with every WindCube v2.1 lidar — is essentially an embedded, simplified, real-time CFD model. FCR accounts for the impact of moderate terrain complexity and provides a direct correction to the data. FCR combines hardware and software innovations to enable WindCube to reach accurate measurement in moderately complex terrain.

At some sites, however, FCR's simplifications reduce its accuracy. In these cases, full CFD software is the best post-processing tool for managing more complex terrain-induced error in lidar measurements. Commercial CFD providers and wind energy experts, including Vaisala's strategic partners, offer lidar correction tools and methods for post-treatment of lidar data which was collected using the "normal mode" algorithm without the FCR mode algorithm.

About the bankability of WindCube CFD correction in complex terrain

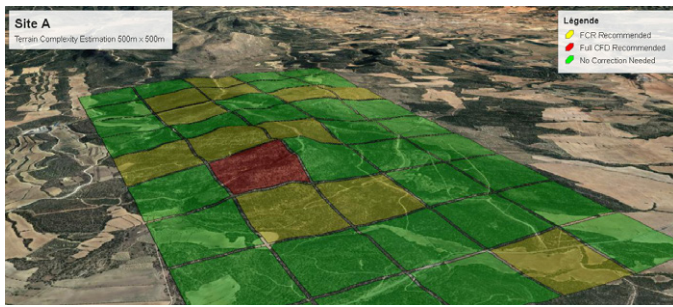
"We have successfully performed energy yield assessment projects with CFD-corrected WindCube data in complex terrain. For example, we did a 12-month campaign with a stand-alone WindCube and the wind farm, now in construction, illustrates plainly the bankability of the data."

Johannes Cordes
Deutsche WindGuard Consulting

"DNV considers that suitably validated CFD-based complex terrain conversion techniques advance the case towards acceptance of the use of WindCube data for pre-construction wind farm development on sites with complex terrain."

Paul Leask
DNV

WindCube for all types of complex terrains



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Companies have leveraged WindCube lidar for more than a decade to solve these challenges in making the invisible visible — and simplify managing wind measurement in complex terrains.

Our solutions include FCR, embedded in WindCube, for moderately complex terrain as well as simplified access to industry-leading CFD correction services for moderately to very complex terrains. Beyond improving the accuracy of WindCube

in complex terrain, our strategic partners can also approve the corrected data, evaluate the resulting measurement uncertainty following industry best practices, and ultimately ensure WindCube bankability in complex terrain.

You could need one layer or a combination of layers to further reinforce your business case with bankable data. We help you make that determination. After more than 200 analysis combinations of most solutions over several sites and various altitudes, the majority of the bias from WindCube corrected data against met masts was less than 1%.

Our methodology begins with our exclusive “Complex Terrain Error Predictor”, an innovative tool that helps you estimate possible complex flow lidar errors at the beginning of your measurement campaign. This first-look information helps you choose the right solution.

WindCube for complex terrain: applications and layers of support

	Description	Terrain	What's provided	Need to know	Provider
Layer 1, FCR	Vaisala's patented tool for complex terrain measurement corrections	Moderately complex terrains	Embedded in WindCube	<ul style="list-style-type: none"> Free and immediate Proven and accepted by customers and independent experts 	Vaisala
Layer 2, CFD	Independent CFD implementation for complex terrain measurement corrections	Moderate to very complex terrains	Site-dependent wind correction factors	<ul style="list-style-type: none"> Suitable for companies with current or developing in-house complex terrain expertise Requires expert statements confirming viability 	Partner organizations <ul style="list-style-type: none"> Meteodyn WindSim
Layer 3, Consultant expertise	Consultant-led CFD implementation for complex terrain measurement corrections	Moderate to very complex terrains	In-depth consultation	<ul style="list-style-type: none"> Suitable for companies without in-house complex terrain expertise and need expert consultation to implement the solution and interpret the data Corrected data approved by third parties 	Partner organizations <ul style="list-style-type: none"> ArcVera DNV DWG Fraunhofer UL



WindCube: A recognized, proven innovator in complex terrain

- More affordable, safer and easier to deploy and maintain than met masts.
- Fast becoming the preferred solution for accurate, bankable wind resource and energy yield assessment.
- Complex terrain induces additional vertical wind speed and vertical turbulence, which can be directly measured thanks to WindCube's vertical beam.
- Proven hybrid reconstruction algorithm reduces sensitivity to turbulence — a common issue in complex terrain. Hybrid method + FCR and CFD is a perfect combination to reach inimitable performances in complex terrain.
- Easily repurposed for new locations and campaigns.

Partnerships

Through strategic partnerships with other industry leaders, WindCube works with CFD technologies to provide precise wind measurement in moderate to very complex terrains.



Meteodyn provides a lidar data correction file, built using the GPS position of your WindCube and a CFD calculation using terrain roughness and orography data. Generated factors are distributed across 36 wind sectors and across your lidar-measured altitude gates. Please contact Meteodyn to request a quote at lidar@meteodyn.com.



WindSim Global Consulting Team supplies CFD correction factors for your WindCube and a tool to apply these factors directly to your WindCube STA wind speed files. WindSim's CFD correction is tailored for WindCube devices and considers the lidar GPS location as well as the orientation of the lidar beams. Please contact WindSim for further information and requesting a quote at consulting@windsim.com.



ArcVera Renewables, a US-based technically-leading renewable energy consultancy, generates a customized report with the correction factors derived from WindSim CFD model simulations, using the orientation of the fielded WindCube and high-resolution elevation and land use data specific to the site. ArcVera's wind analysis team experts assess the CFD analysis results and compare them to the local topography to ensure the reconstructed wind flow consistency. ArcVera provides an additional service to validate the flow curvature correction results to a co-located met tower. For further information and to request a proposal, please contact ArcVera Renewables at RemoteSensingCFD@arcvera.com.



Using in-house CFD software, DNV can demonstrably reduce energy assessment measurement uncertainty for projects in complex terrain. Supported by a systematic validation, the outputs of the DNV service include the directional conversion factors to be applied to the WindCube data and estimates of measurement uncertainty with and without the DNV adjustments. For further information, see the DNV website or contact DNV for an analysis at WindCubeCFD@dnv.com.



Teaming up with CFD correction software ZephyScience, Wind consultant Deutsche WindGuard provides correction factors for lidar measurement data measured in complex flow situations. The organization provides a lidar correction report that includes topography as well as a detailed description of the methodology with corresponding results. DWG also proposes an in-depth analysis of the results (the DWG approval) and a comparison of both FCR and CFD corrected data. Please contact DWG for requesting a quote at WindCubeCFS@windguard.de.



Fraunhofer Institute for Energy Economics and Energy System Technology IEE offers a full wind measurement campaign service. Their expertise also extends to complex terrain with the use of the Meteodyn WT CFD solution combined with WindCube measurements. Please contact Fraunhofer at paul.kuehn@iee.fraunhofer.de for requesting additional information on the services available.



As a global Wind Energy consultant, UL offers a wide variety of wind resource assessment services including the use of remote sensing devices such as WindCube. Within the scope of an Energy Yield Assessment in Complex Terrain, UL has developed its own CFD tools to correct the WindCube data, taking into account the local flow curvature, and reduce the final uncertainty over the measurement campaign. Please contact UL at the Sales.REN.Germany@ul.com for enquiry on resource assessment projects in complex terrain.

Learn more about WindCube Complex Terrain Ready solutions and bring your projects closer to realization.

Why Vaisala for renewable energy?

We are innovators, scientists, and discoverers who are helping fundamentally change how the world is powered. Vaisala elevates wind and solar customers around the globe so they can meet the greatest energy challenges of our time.

Our renewable energy solutions are guided by several key priorities:



Thoughtful evolution

Remain a pioneer in renewable energy, always providing sensible, trusted solutions at the leading edge of R&D.



Smarter at every stage

Provide end-to-end weather and environment solutions and critical insights throughout the renewable energy life cycle.



Legacy of leadership

Extend our proven track record and global trust to reach more customers in more ways.

Vaisala is the only company to offer 360-degree renewable energy solutions — from sensors and systems to digital services and actionable intelligence — nearly anywhere on the planet (and even on Mars). Every Vaisala solution benefits from our 85+ years of experience, pioneering deployments in 170+ countries, and unrivaled thought leadership.

Our innovation story, like the renewable energy story, continues.

WindCube®

The gold standard

WindCube® is the iconic and trusted gold standard in wind lidar. The turnkey product suite offers innovative, reliable, and highly accurate solutions for thousands of customers across the globe. Borne from a passion to advance the field, WindCube continues to take wind energy ever higher through a commitment to four guiding principles:



Trustworthy, superior metrology



Innovative lidars from a one-stop shop



Unrivaled thought leadership



Easy, reliable global solution

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