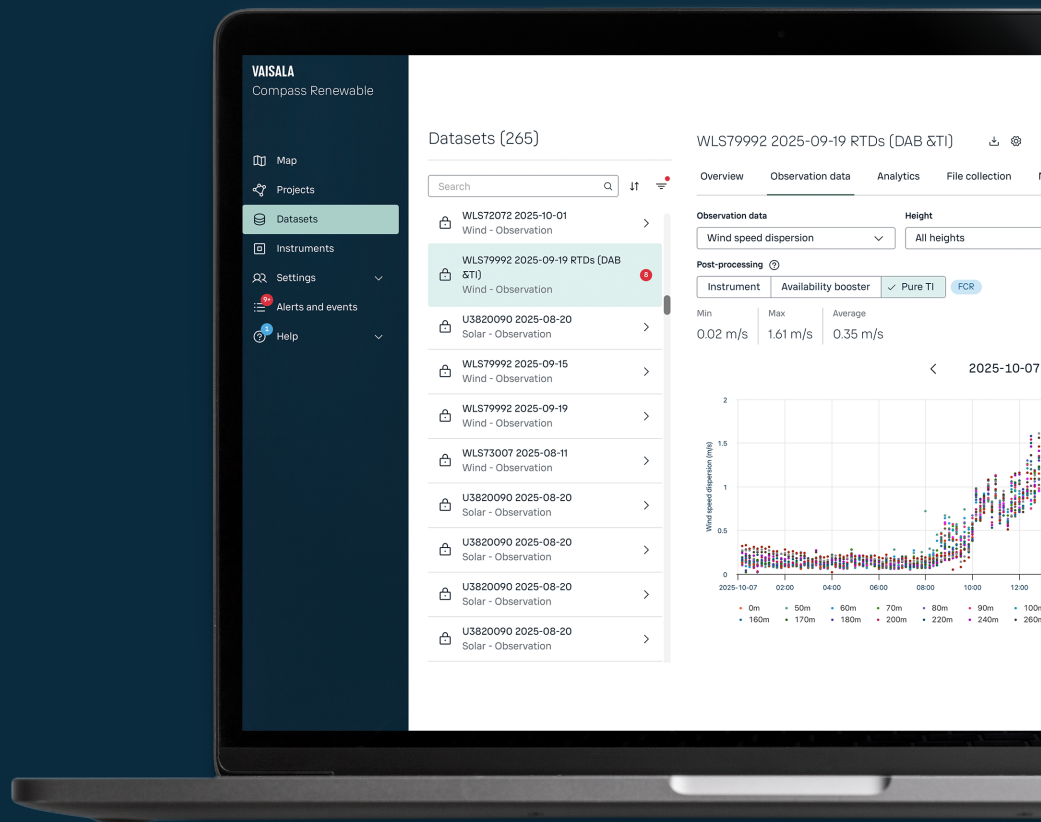


WindCube Pure TI™

Physics-based turbulence intensity reconstruction

Improve your wind measurement campaigns with WindCube® turbulence intensity (TI) data for turbine selection, site suitability and load assessment.



Why turbulence intensity matters

Turbulence Intensity (TI) is a key parameter in wind resource assessment. It describes how much wind speed fluctuates and directly affects structural loads, fatigue, and turbine lifetime. This in turn determines how effectively the selected turbine model can convert the available wind resource into reliable energy yield over its lifetime. Developers today typically rely on met masts and cup anemometers to get trustable TI for IEC-class turbine selection and load calculations.

WindCube Pure TI, available through Vaisala Compass®, changes this by reconstructing TI from WindCube measurements using a physics based algorithm designed specifically for vertical profiling lidar.

Introducing Pure TI

For decades, the wind industry has struggled to get reliable TI from vertical profiling lidar. After years of focused scientific work, Vaisala scientists have solved this lidar TI limitation by testing many candidate algorithms, beyond what has been published in academic literature, including machine learning approaches, and demonstrating that advanced physics-based algorithms deliver the most reliable results.

WindCube Pure TI (Physically Unified Reconstruction of TI) is Vaisala's new physics-based reconstruction algorithm that corrects these inter-beam averaging effects. It turns high-frequency WindCube data into 10-minute, cup-equivalent, TI statistics you can use with confidence, transforming wind measurement into high precision averages that accurately capture wind speed variability.

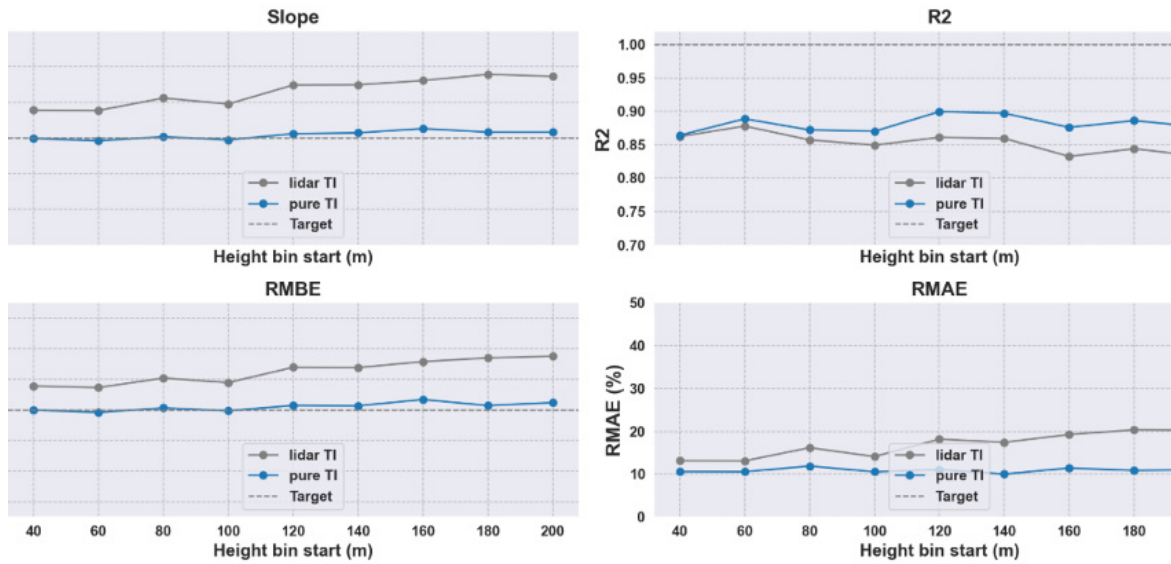
WindCube Pure TI is grounded in the physical laws of turbulent flow and how lidar measures wind, rather than in machine learning models trained on a limited set of sites. Systematic understanding and correction of lidar instrument intrinsic biases one by one enables WindCube Pure TI to close the gap to cup measurements. Because it does not learn from met mast data, it avoids inheriting site-specific and cup imperfections. In contrast to machine learning algorithm, performance is robust in various conditions.

Validated across sites, heights and climates

WindCube Pure TI has been validated on a large database covering multiple terrains, climates and heights. Across the global validation database of more than one million 10-minute records, WindCube Pure TI reduces mean bias in turbulence intensity from 0.014 to just 0.001. Residual bias at individual sites remains tightly constrained within ± 0.01 TI units across all 34 sites with height combinations and all terrain classes - simple, moderately complex, and complex - demonstrating terrain-robust, bankable TI performance. WindCube Pure TI sharply tightens the error spread so that lidar derived TI distributions almost perfectly overlay cup measurements (Wasserstein distance improves from 0.014 to 0.002), while error stays essentially constant with height from 40 m to 200 m. In practical terms, WindCube with Pure TI preserves TI accuracy up to hub height and blade tip, instead of degrading with range as is typical for profilers.

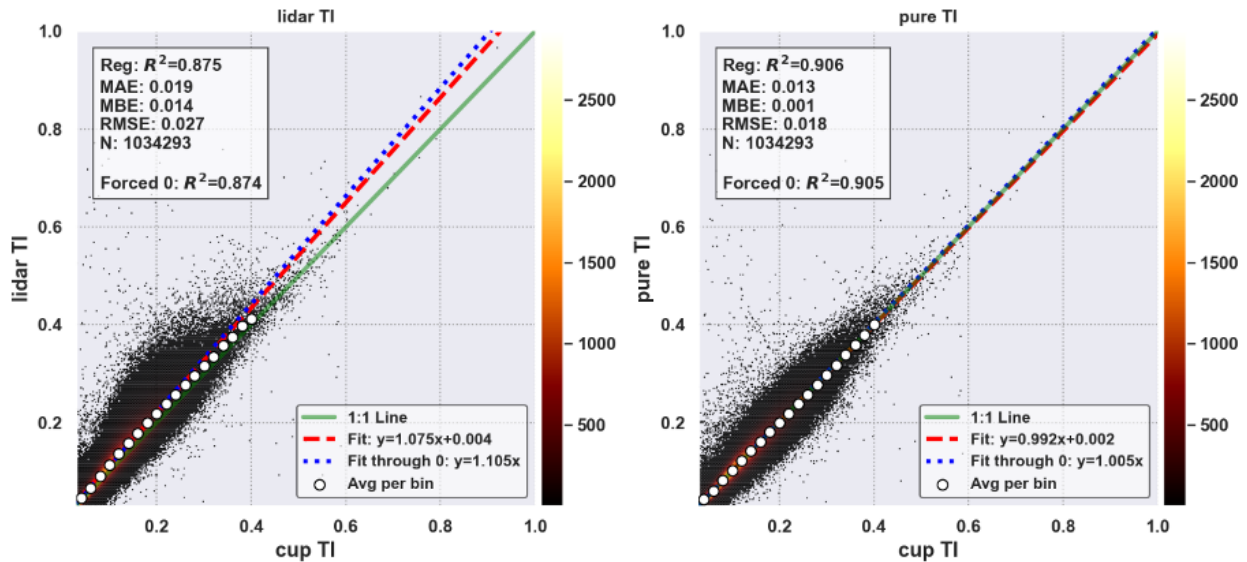


Average performance metrics by height (mean ± 1 standard deviation across sites, forced slope)



A scatter plot offers a simple view of overall performance, comparing lidar derived TI to reference cup TI before (left) and after (right) applying the Pure TI algorithm on over one million points.

With Pure TI, agreement with mast data improves markedly: mean bias is nearly zero, MAE and RMSE are lower, the cloud tightens around the 1:1 line, and the regression slope through the origin is very close to 1, indicating minimal systematic bias across the full TI range.



WindCube Pure TI has been developed and benchmarked against IEC 61400-1 turbine design needs for TI and it meets the KPIs proposed in DNV-RP-0661 for site suitability and load validation. It has also been demonstrated in joint work and research projects with turbine manufacturers and developers.

How developers and turbine OEM's benefit from WindCube Pure TI

Higher confidence, lower uncertainty and better bankability

By reducing lidar-cup TI bias and meeting modern performance KPIs, WindCube Pure TI increases confidence in lidar-based TI for both consultants, developers and turbine OEMs. This strengthens the case for using lidar-based TI in design, site suitability and load validation workflows, opening the door to lidar-only or lidar-dominant campaigns where a mast was previously mandatory. The result is lower overall measurement risk, and more efficient project development.

No met mast required for TI in WRA and site suitability

WindCube Pure TI enables developers to use WindCube as the primary source of turbulence information for turbine class selection, site suitability and load assessment, removing the need to build a dedicated met mast just for TI. This reduces permitting and construction complexity, eliminates mast-climbing risk, and lets campaigns start as soon as the lidar is on site. For turbine OEMs, it means they can base load evaluations on high-quality TI from WindCube.

TI exactly where it matters – at hub height and beyond

Because many met masts are shorter than modern turbine hub heights, OEMs and developers often rely on conservative extrapolations of TI to hub and tip heights. WindCube Pure TI uses WindCube vertical profiling lidar - measuring up to 400 meters - to provide TI directly at the heights that drive structural loads, with performance that remains stable with height. This gives developers and OEMs a clearer picture of the actual turbulence experienced by tall turbines across the rotor. As pulsed lidar technology removes the trade-off between data availability and accuracy, WindCube Pure TI similarly delivers consistent TI accuracy across height, with up to 20 configurable measurement ranges.

More flexible, efficient measurement campaigns

Lidars are simple to relocate compared to met masts, allowing developers to characterize TI at multiple candidate turbine locations with a single instrument instead of multiple met masts. This supports better-informed turbine siting and layout design, including in and near existing wind farms where wake-driven turbulence is a concern.

"This technology has proven to be highly effective not only in flat terrain, but also in the extremely complex terrain in Japan that we have observed. It is expected to enable further optimization of wind turbine design and improvement in the accuracy of power production estimates."

*Seiya Hasegawa,
Wind Assessment Group
ENEOS Renewable Energy Corporation (ERE)*



Image source: Energiewerkstatt

How WindCube Pure TI works in Compass

Using the high-frequency data generated by the WindCube, Compass determines the intensity of turbulence with unprecedented accuracy.

High-frequency data can be automatically collected by Compass on a daily basis or uploaded manually at any time. As result, Compass establishes a 10-minute average for Turbulence Intensity for each measurement height and provides a statistical analysis of turbulence intensity as a function of wind speed at the determined measurement height with IEC categories.

WindCube Pure TI is available as a post-processing option in [Compass Renewable](#).

1. Measure with WindCube

Deploy WindCube to collect high frequency wind data at multiple heights up to 400 m, including modern hub and tip heights.

2. Upload or stream to Compass

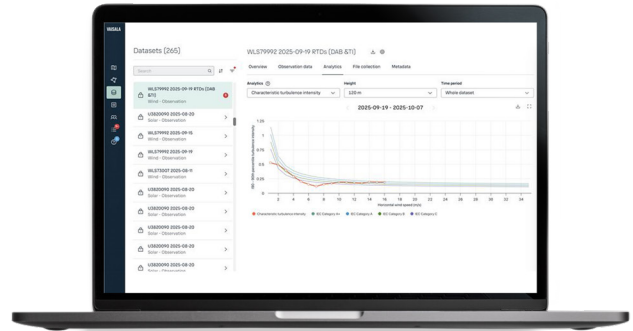
Upload or stream WindCube data into Compass, where instruments, datasets and analytics are managed together.

3. Activate WindCube Pure TI

In Compass Renewable, enable WindCube Pure TI for the selected dataset. Compass runs the algorithm on the 1 Hz (.rtd) data and recomputes new 10 minute TI values at each measurement height.

4. Analyze and export

Compass manages algorithm versions, tags data with WindCube Pure TI metadata and lets users view TI versus wind speed curves or download files processed with WindCube Pure TI for further analysis and reporting.



Get started today

To discuss how WindCube Pure TI can support your current or upcoming WRA projects, or to see a demo of WindCube Pure TI inside Compass, contact Vaisala representative or reach out via your usual Compass support channel.

Why Vaisala?

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 pioneering approach reflects our priorities of thoughtful evolution in a time of change and extending our legacy of leadership.

Vaisala is the only company to offer 360° of weather intelligence for smarter renewable energy, nearly anywhere on the planet. Every solution benefits from our 90+ years of experience, deployments in 170+ countries, and unrivaled thought leadership.

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

