Triton Remote Sensing Systems: Comparing Accuracy with Collocated Met Towers

IN WIND ENERGY DEVELOPMENT, remote sensing systems have matured to become a viable alternative or complement to the met tower systems traditionally used to measure wind. However, wind developers still want to know: "Are remote sensing systems as accurate as met tower systems?" To answer this question, correlation studies typically compare the measurements of a remote sensing system to those gathered on a nearby met tower. Most of these studies are done with a single remote sensing unit and met tower, in a very controlled manner for a short duration.

The cup anemometer has been the standard and most widely accepted sensor used for wind speed measurement in wind resource assessment. With turbine heights continually climbing, the wind development community has turned to remote sensing systems, including the Vaisala Triton® Wind Profiler, for accurate hub-height data.

Traditional comparison studies are an important first step, but Vaisala wanted to answer this question in a more comprehensive way in order to provide our customers and the wind finance community certainty about the accuracy of Triton in actual wind development projects. To do this, we conducted a far-reaching analysis using Tritons deployed in the field in commercial use. It is the largest comparison study ever conducted between remote sensing systems in the field and met towers.

The Vaisala analysis followed the same rigorous methods employed by leading wind industry certification bodies and independent engineers (as detailed in the full report). Instead of applying the methods to one instrument in a controlled deployment, the analysis was performed on thirty Triton-and-tower pairs located all over the world. The data were voluntarily supplied by eleven leading wind energy developers who are Triton customers. ▶

KEY TAKE-AWAYS

Accuracy: The report demonstrates that Triton is as accurate as a met tower — not just in one carefully controlled test experiment, but over tens of thousands of data-hours in different terrains and climates. Furthermore, Triton was able to cut in half the uncertainty introduced by shear extrapolations from non-hub-height met towers. The findings of the study may point the way to additional applications of Triton that you may not have considered, so please share it with your technical team.

Repeatability: Tritons used in this analysis ranged in age from years to months old. Several of the Tritons studied have been in continuous operation for more than 5 years. Triton is a moveable, reusable asset and you can expect continued, repeatable performance over a long operational lifetime.

Upgradeability: If you have an original Triton (manufactured before 2013) you have an accurate, hub-height wind measurement system. Additionally, all Tritons manufactured after 2013 benefited from an upgraded speaker array that boosts data recovery at higher heights, one of the contributors to greater certainty in a wind resource assessment report. Unlike competing remote sensing systems, Vaisala offers an affordable upgrade path. If you might benefit from an upgrade, contact your Vaisala account representative to learn more. ■

◀ The findings demonstrate that the uncertainty in mean wind speed measured by tower-mounted anemometers and by Triton are indistinguishable from each other. Both are around 1%, (equivalent to the IEC specification for Class 1 anemometry), which supports the practical use of Triton throughout wind development and operations.

TRITON BACKGROUND

Vaisala's Triton Wind Profiler is a trusted remote sensing system that measures wind across the entire blade sweep of today's largest wind turbines. Triton's advanced Sonic Detection and Ranging (SoDAR) technology captures wind speed, direction, and data on anomalous wind events such as shear and turbulence that directly affect wind turbine power output. Since 2008, Triton has been widely used by leading wind developers and wind farm operators in extremely diverse locations around the world. Tritons are successfully used in complex and benign terrain, and across all four major climate zones (tropical, subtropical, temperate, and polar). To date, Tritons have been deployed more than 2500 times in 40 countries on five continents.

STUDY METHODOLOGY

Using data volunteered by our customers, we studied a total of 30 Triton-and-tower pairs, yielding 100 separate anemometer records for validation. Triton deployments that were consistent with our recommended Triton Siting Guidelines were used in the analysis. The sites studied were also mostly located in benign terrain.

Both the met tower data sets and the Triton data sets were quality controlled according to industry-standard practices. All Tritons used for the analysis were operated as shipped from the factory with no special modifications. In no case was any correction or adjustment performed on the Triton data.

RESULTS AND CONCLUSIONS

When the mean wind speed differences at all 100 qualifying anemometer measurement heights are aggregated, the average relative difference is +0.09%, and the percent root mean-square of the differences is 1.27%. The report discusses independent sources of met tower uncertainty and concludes that Triton's uncertainty in measuring mean wind speed is around 1% — identical to well-instrumented met towers.

Vaisala's Triton Wind Profiler has demonstrated consistently high performance across multiple deployments in real, commercial situations all over the world. The analysis of a statistically significant sample of Triton data sets demonstrates that Triton is as accurate as a well-instrumented met tower and supports the use of Triton in many wind resource assessment applications. ■

'TRUTH'

Many correlation studies present a notion of "accuracy" that uses anemometer data to represent true wind speeds: the closer the remote sensing data gets to the anemometer data, the closer it is to "truth."

In this or any comparison study, it is important to recognize that differences between the mean wind speeds measured by Tritons and nearby tower-mounted sensors should not be interpreted solely as errors in the Triton measurement—they result from a combination of errors in both measurement systems.

A few sources of uncertainty with respect to anemometer data include:

- Sensor calibration uncertainty
- Imperfect sensor response to turbulence and off-horizontal flow
- Sensor degradation not detected by QC process
- Tower flow distortion effects not detected by QC process

Both measurement techniques contribute error with respect to "truth," and the determination of how much error each contributes requires knowledge of the error distribution in the other measurement. ■

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