

TRITON PERFORMANCE UPDATE

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November 13, 2008

On July 22nd, 2008, a Triton was installed at a customer site and has been collecting wind data ever since. At this site, there is a 70 m met tower with anemometers at 30, 50 and 70 m and vanes at 48 and 68 m. The following report is a summary of the overall performance of this Triton including a comparison of the Triton and tower data.

For this analysis, the Triton data were filtered based on quality and vertical wind speed. A minimum quality filter of 90% was implemented. This filter is very effective at removing invalid Triton measurements that may have been affected by an increase in ambient noise or poor atmospheric reflectivity. The second filter was based on vertical wind speed. When it is raining, the Triton interprets the falling raindrops as a strong vertical wind. Filtering based on vertical wind speed is therefore used to identify and remove data affected by precipitation. Triton data with a vertical wind speed greater than +/- 1.5 m/s were removed from the data set.

The resulting performance indicators that are discussed in the report include the following:

- 1) Operational Uptime (percent of time that the Triton was operational and collecting data)
- 2) Time Series Plots of Wind Speed and Direction
- 3) Wind Speed Scatterplots and Correlation Coefficients
- 4) Wind Direction Scatterplot and Correlation Coefficient
- 5) Percent of Valid Triton Data versus Height

When this report was generated, tower data from October 9th to November 9th were available. The following analysis therefore includes data from October 9th to November 9th, 2008.

Operational Uptime

The operational uptime is defined as the percent of time that the Triton was beeping and collecting data. From October 9th to November 9th, 2008, the operational uptime was 96%.

Time Series Plots of Wind Speed and Direction

First, the wind speed and direction as measured by the Triton are compared to the measurements collected at the nearby met tower. As mentioned above, there are anemometers at 30, 50 and 70 m on the tower. The Triton's measurement heights are as follows: 40, 50, 60, 80, 100, 120, ..., 200 m. In the following analysis, the Triton data at 50 m are compared to the anemometer data at 50 m and the 80 m Triton data are compared to the 70 m tower data.

Figure 1 and 2 show the wind speeds measured by the Triton and met tower. Figure 1 shows the 50 m comparison and Figure 2 shows the 70 m tower data plotted with the 80 m Triton data. In both figures, a very consistent agreement is shown between the two data sets.

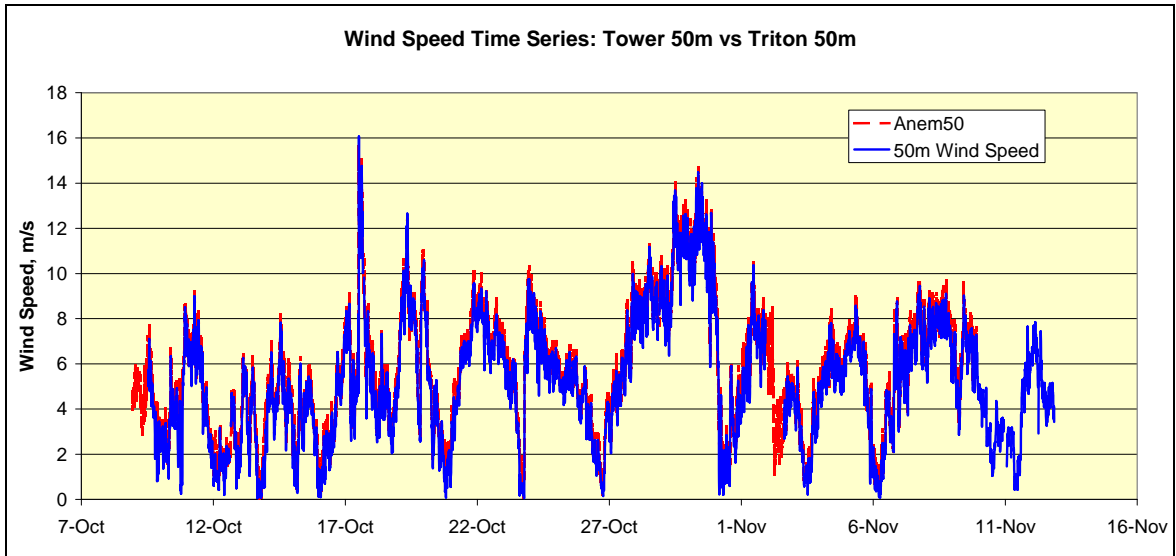


Figure 1: Wind Speed Time Series Tower 50m vs Triton 50m

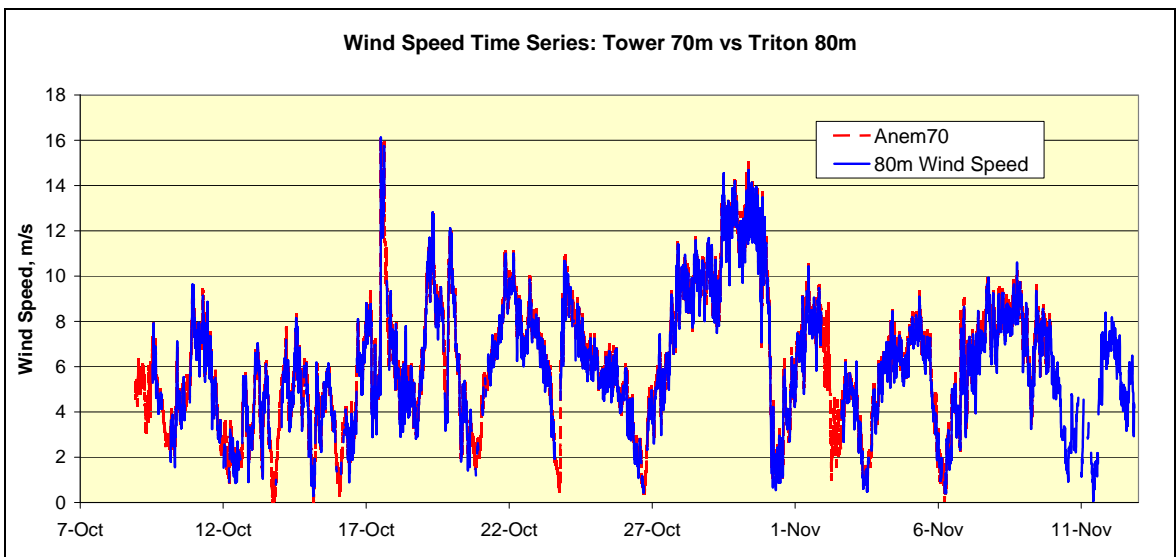


Figure 2: Wind Speed Time Series Tower 70m vs Triton 80m

Next, the wind direction as measured by the Triton at 80 m is compared to the vane data at 68 m. As shown in Figure 3, the two data sets track each other very well. There appears to be a slight offset of approximately 13 degrees. This difference may be attributed to the difference between magnetic and true north. It is also possible that either the vane or the Triton was not properly oriented.

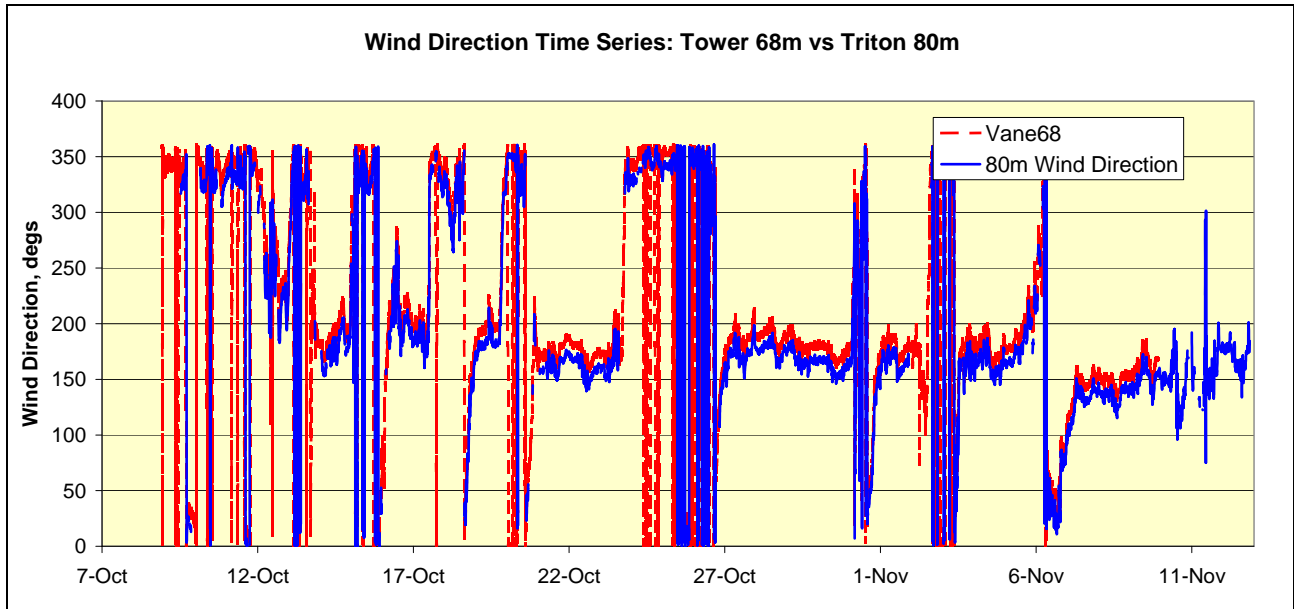


Figure 3: Wind Direction Time Series Tower 68m vs Triton 80m

Wind Speed Scatterplots and Correlation Coefficients

In the next section, the Triton and tower wind speeds are plotted against each other and the correlation coefficients between the data sets are presented. The correlation coefficient can range from -1 to $+1$ where -1 is an indication of completely opposing trends, 0 is an indication of no correlation and $+1$ indicates a perfect correlation.

Figure 4 shows the wind speeds measured by the Triton at 50 m plotted against the 50 m tower data. The scatterplot shows an excellent correlation between the Triton and tower with only a few instances of wind speed underestimation. For this data set, **at 50 m, the correlation coefficient is 0.989.**

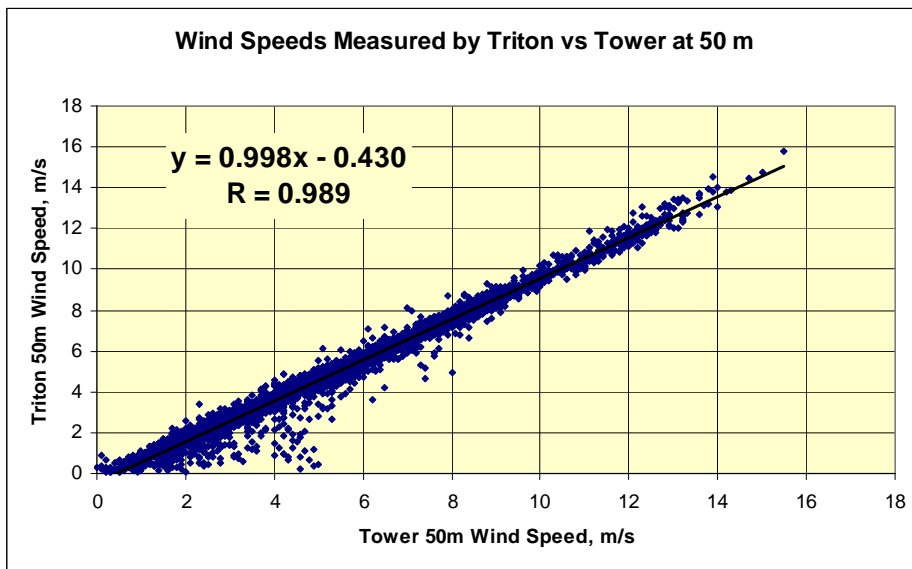


Figure 4: Wind Speed Scatterplot Triton 50m vs Tower 50m

Next, the Triton 80 m data are plotted against the 70 m tower data in Figure 5. The agreement between these two data sets is excellent. There is very little scatter and the distribution is remarkably tight. **The correlation coefficient measured between the 70 m tower and 80 m Triton data is 0.996.**

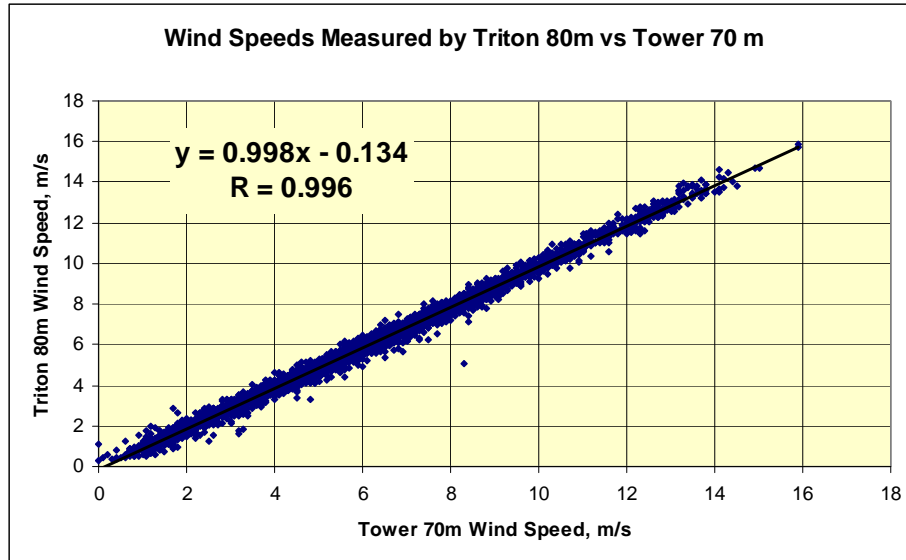


Figure 5: Wind Speed Scatterplot Triton 80m vs Tower 70m

Wind Direction Scatterplot and Correlation Coefficient

In the following section, the Triton wind direction data at 80 m are compared to the tower vane data at 68 m. Figure 6 shows a scatterplot of the two data sets. When the wind is from the north, the wind direction transitions between 0 and 360 and this can cause problems when creating a scatterplot and calculating the correlation coefficient. For this reason, at this transition point, 360 degrees was subtracted from the Triton wind direction data. This resulted in some negative wind direction values and allowed for the correlation coefficient to be calculated and for the scatterplot to be representative.

As shown in Figure 6, the Triton wind direction data agree exceptionally well with the vane data. There are few outliers and the distribution is very narrow. **The correlation coefficient measured between the Triton and tower wind direction data sets is 0.997.**

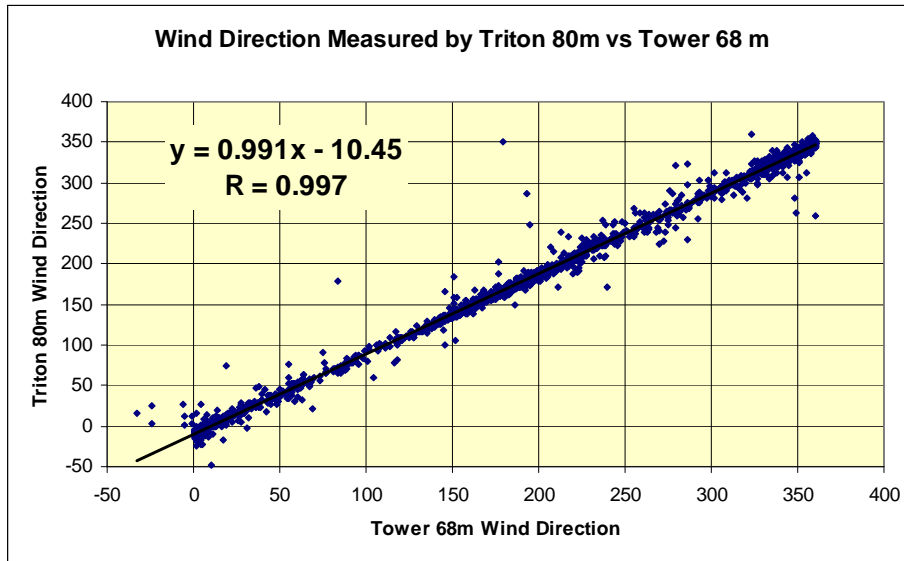


Figure 6: Wind Direction Scatterplot Triton 80m vs Tower 70m

Percent of Valid Triton Data versus Height

In this final section, the Triton performance as a function of height is examined. In this analysis, valid data is defined as a ten-minute average with a quality greater than 90%. The quality is a function of signal-to-noise ratio (SNR) as well as the number of valid data points collected during the ten-minute interval. It has been shown that, by implementing a minimum quality of 90%, the Triton data correlate very well with tower data.

The percent of valid data measured at each height was calculated and are shown below in Table 1 and Figure 7. As shown, at a typical hub height of 80 m, valid data were recorded 90% of the time. At 120 m, a typical blade tip height, the percent of valid data measured was 73%.

Table 1: Percent of Valid Data

Height, m	% of Valid Data
40	99.9%
50	99.2%
60	95.1%
80	90.3%
100	83.4%
120	73.0%
140	59.5%
160	44.1%
180	30.4%
200	19.4%

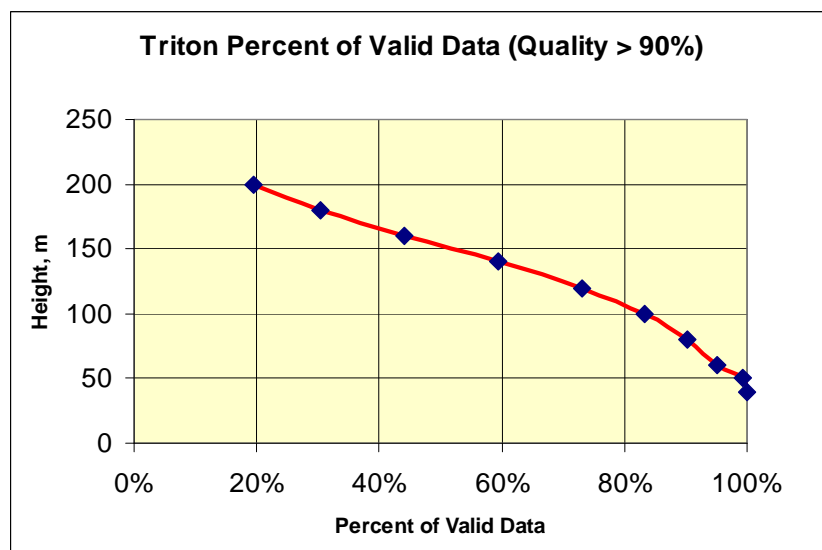


Figure 7: Percent of Valid Data vs. Height

Summary of Performance Evaluation

In summary, this Triton is performing exceptionally well. The operational uptime was 96%, which can be attributed to the Triton's very low power consumption. The time series plots showed that the Triton tracked the tower wind speed and direction data very well. At 80 m, the correlation coefficient calculated between the Triton and tower wind speeds was 0.996. The 80 m wind direction data showed similarly excellent agreement with a correlation coefficient of 0.997. Finally, the data recovery at higher heights was found to be very good. At 120 m, the Triton recorded valid data 73% of the time. Overall, the results are excellent and, while we will continue to monitor the Triton's performance, we expect such high quality data to continue.