Correction Factors for Remote Sensing Device Deployed In Complex Terrain

Consortium for Advancement of Remote Sensing
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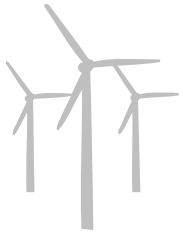
March 27th 2018




INTEGRATED ENERGY SOLUTIONS

Development | Construction | Operations

Outline

- Collection of Data
- Correction Methodology Applied to RSDs
- Results

Relevance

- RSDs (Remote Sensing Device) are becoming an alternative to traditional meteorological masts for wind measurement campaign purposes and most recently during power performance phase. The main reasons RSDs are replacing traditional mast is due the certain advantages they have, such as: ease of deployment, ability to reached large vertical measurement heights without excessive costs, and most importantly RSD can be transfer to other projects once their main task is completed.

- That said, this success has been limited to flat and simply terrains only.

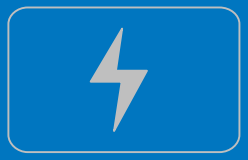
- In complex terrain, there is an uncertainty associated to RSDs.

- To reference one of many examples, Riso National Laboratory carried out a research and wrote an article title "*Conically scanning lidar error in complex terrain."* in April 2009. That shows that in complex terrain, the errors in the horizontal wind speed from RSD (in this case a LiDAR RSD) can be up to 10%. This is due to the lack of horizontal homogeneity of the flow.

- RES research explores a pragmatic solution that generates measurements equivalent to that of a "single point measurement" from a RSD in complex terrain by using the results of flow modelling to correct for the impact of any non-uniform flow.

Collection of Data






Step 1 – RSD Technologies

» Representative sample of the different types Remote Sending Device (RSD) available in the market.

SODAR	LiDAR	LiDAR
Triton	(Continuous - Wave)	(Pulse)
by Vaisala	by ZephIR	by NRG System / Leosphere

Step 2 – Choosing the Right Project

- Project site has to have already had one of the three RSD technologies I listed (Triton, ZephIR 300, and/or Wind Cube V2).
- Or, a project under development to allow RSD deployment.
- Meet the criteria of complex.
- Meteorological r

Disclaimer!!!
Image shown in this slide is not RES' actual project locations.

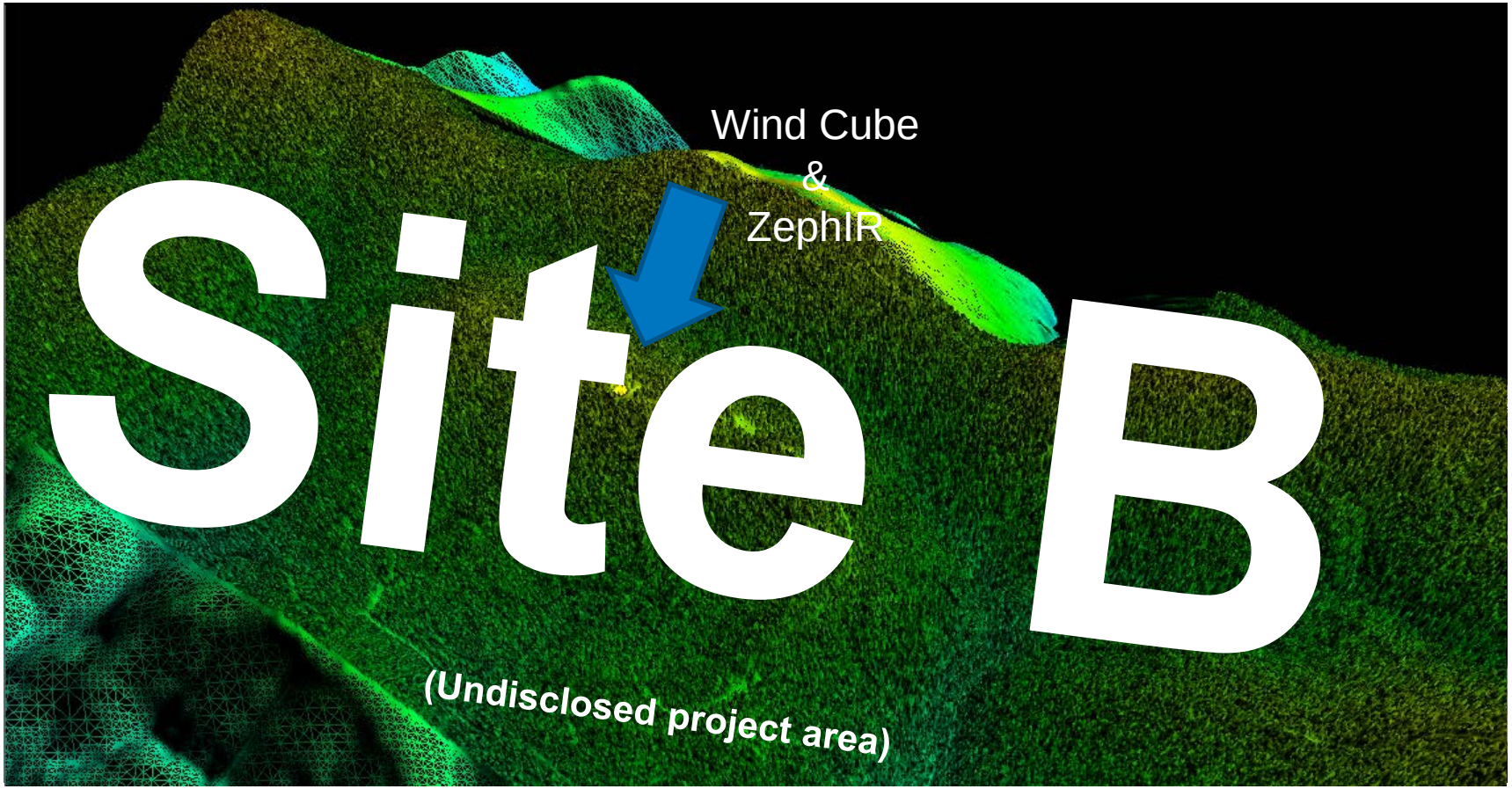
Step 2 – Terrain Characteristic – Site A

- Historical data of SODAR Triton co-located next to a mast of over 22 months.

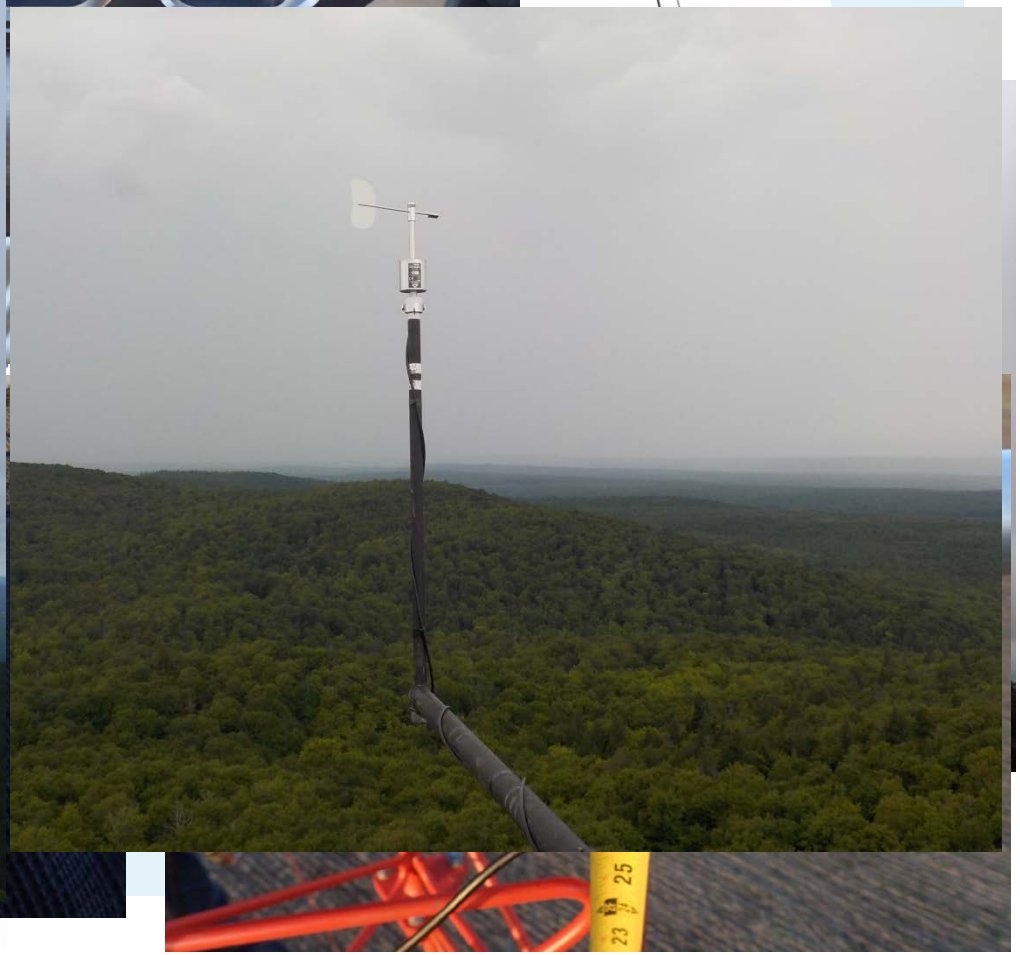
- Complex Terrain Project Sites under development:
  - Ridge top with slopes greater than 10° Slope (~17.6% Slope).
  - Vegetation is dominant in the surrounding with a height of 10m or higher.

Step 2 – Terrain Characteristic – Site B

- Under development with a meteorological mast on site; this allowed me to deploy LiDARs RSD.
- Complex Terrain [6] Project Sites under development:

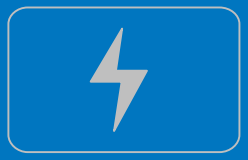


Step 3 – Bench Mark



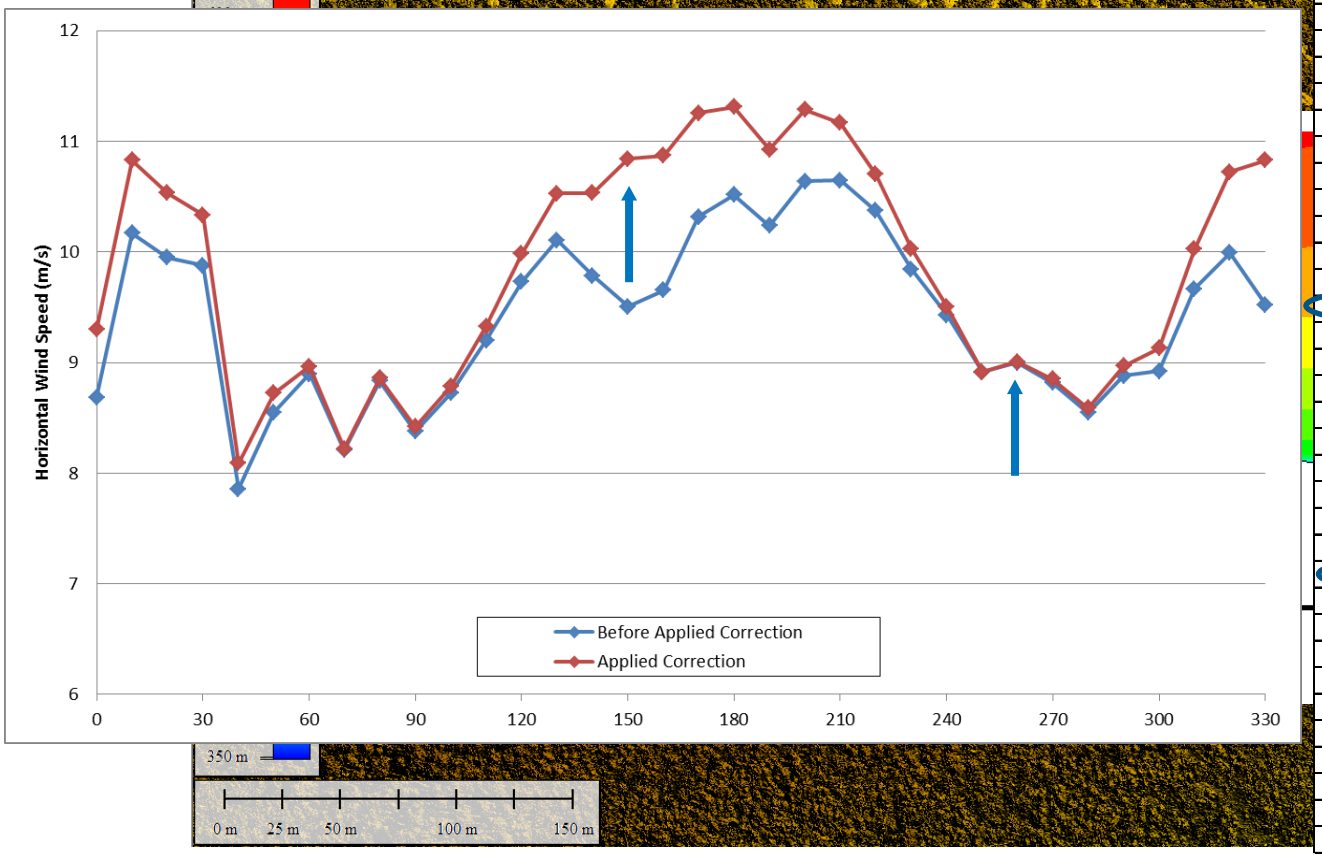
Correction Methodology Applied to RSDs





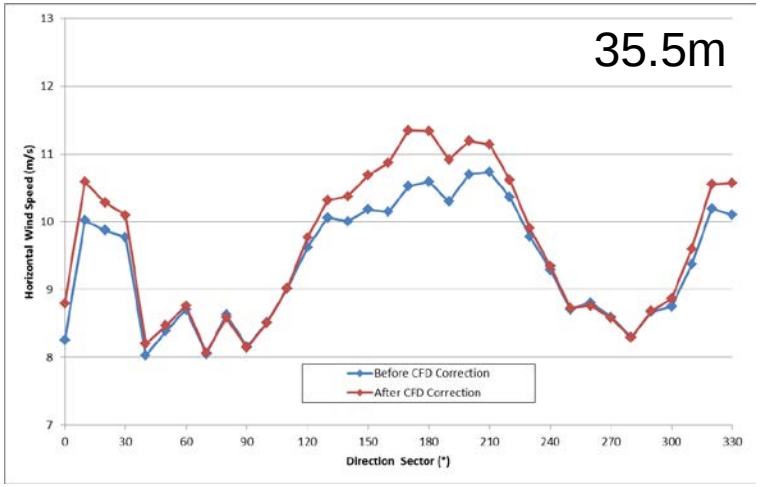

RES Correction Method Applied to the RSDs

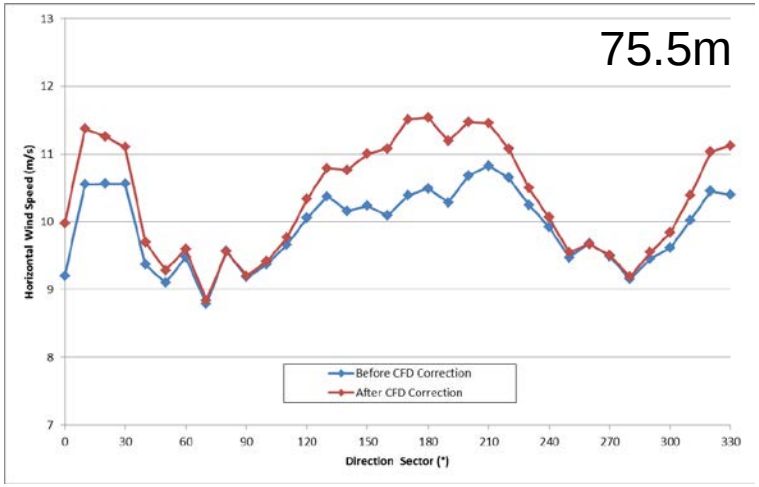
» RES uses VENTOS computational fluid dynamics (CFD) calculations to model the airflow at each RSD location by taking into account direction sector, terrain, measured height to calculate the correction factors.

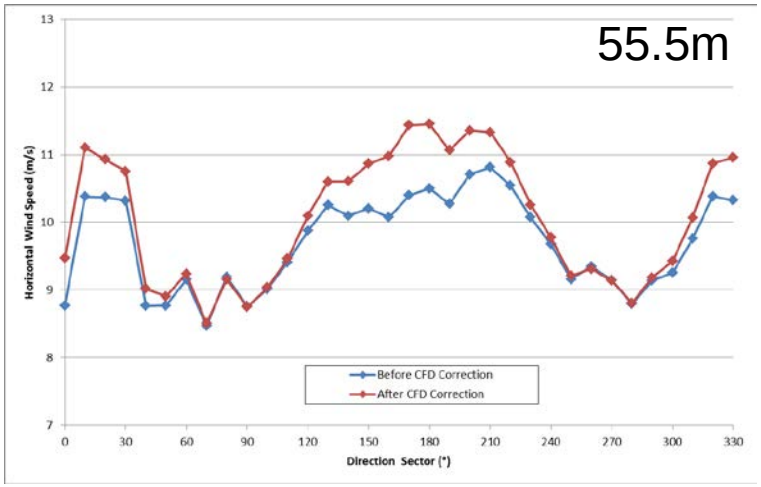


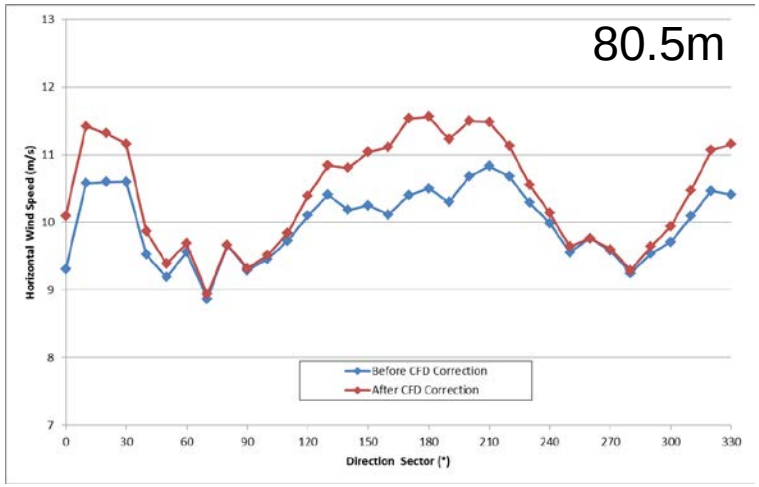
Correction Factors	
Dir (deg)	Correction
0	1.0705
10	1.0649
20	1.0585
30	1.0459
40	1.0294
50	1.0203
60	1.0077
70	1.0016
80	1.0025
90	1.0049
100	1.0068
110	1.0137
120	1.0259
130	1.0419
140	1.0765
150	1.1408
160	1.1263
170	1.0910
180	1.0758
190	1.0674
200	1.0609
210	1.0485
220	1.0319
230	1.0188
240	1.0081
250	0.9997
260	1.0011
270	1.0036
280	1.0048
290	1.0096
300	1.0231
310	1.0374
320	1.0732
330	1.1370
340	1.1228
350	1.0856

RES Correction Method Applied to the RSDs









Second Correction Method Applied to the RSDs

» In addition RES CFD correction method I searched for publically available RSD corrections and reached out to the to RSD manufacturers to use the RSD complex terrain correction application they apply.

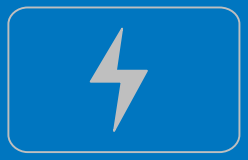
ZephIR 300 → meteodyn meteorology & dynamics

Wind Cube V2 → FCR (Flow Complexity Recognition) → Leosphere

Triton → windsim

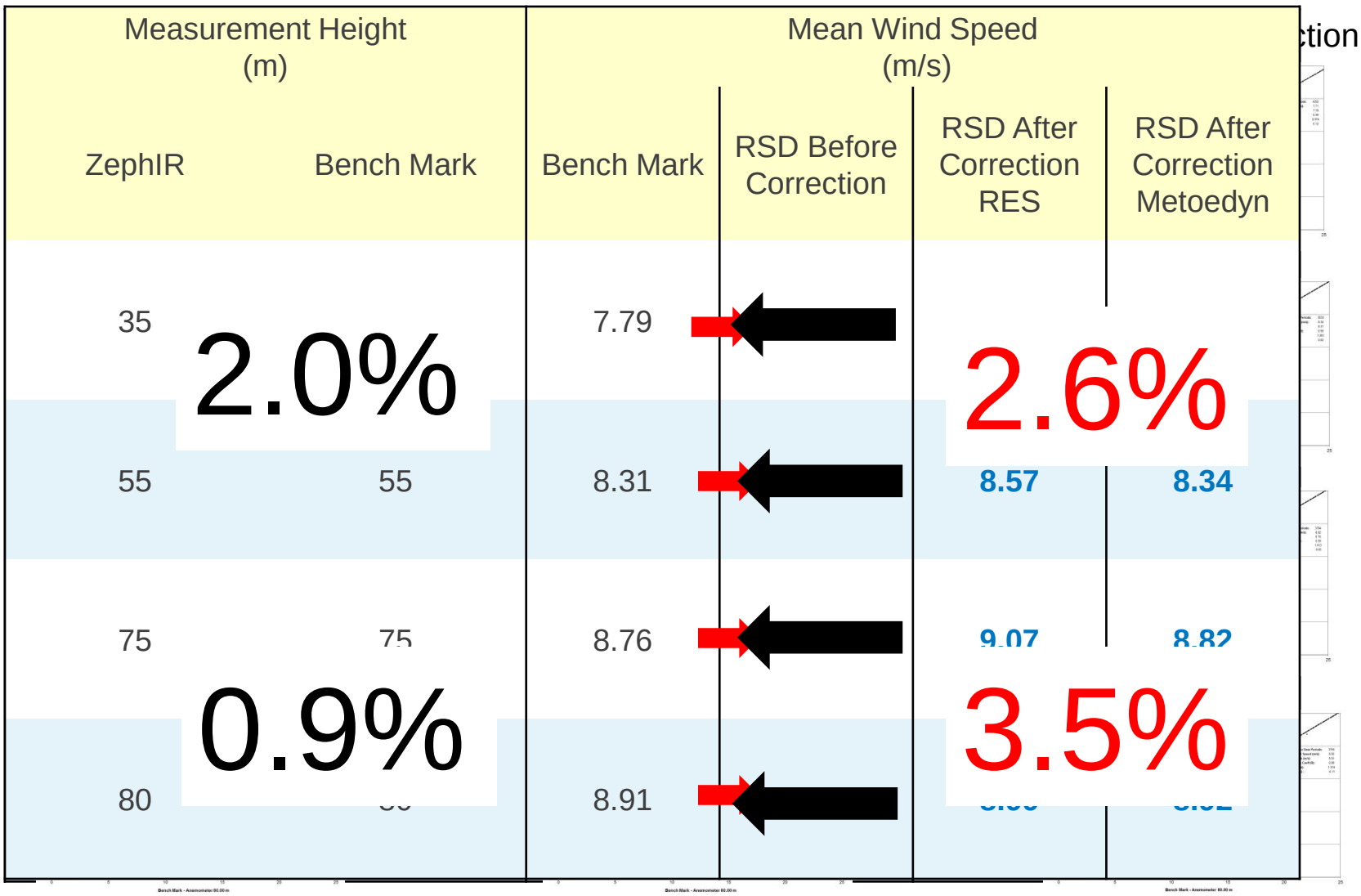
Results






LiDAR Continuous Wave, ZephIR300 -Results

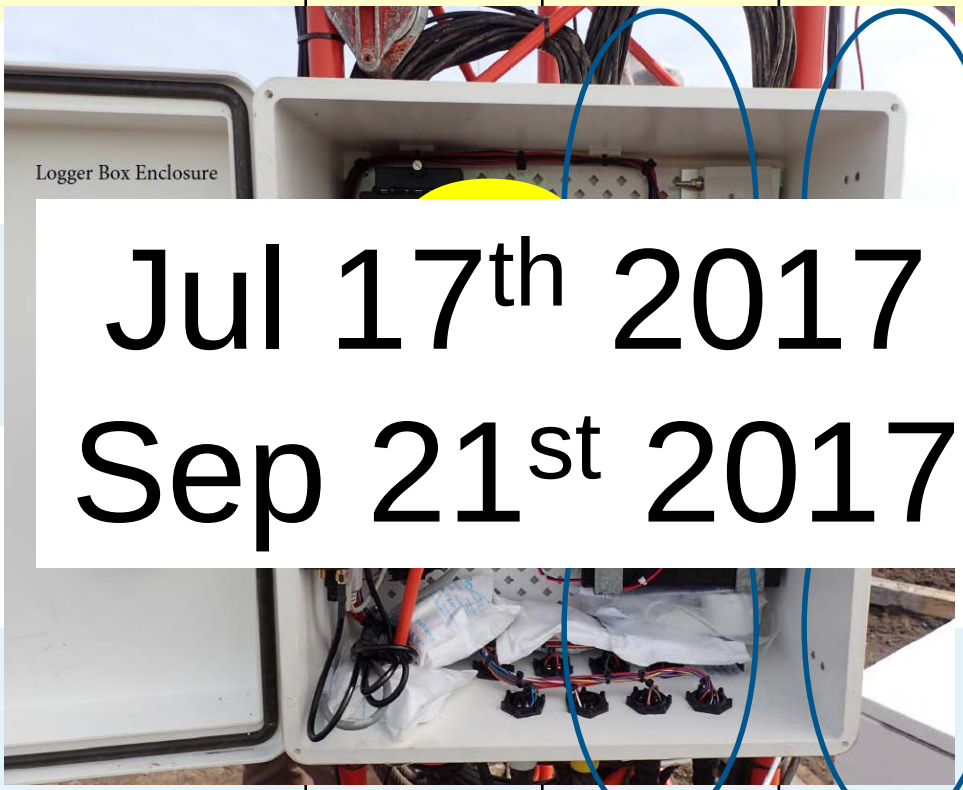
Measurement Height (m)		Mean Wind Speed (m/s)			
ZephIR	Bench Mark	Bench Mark	RSD Before Correction	RSD After Correction RES	RSD After Correction Metoedyn
35		7.79			
			2.0%	2.6%	
55	55	8.31		8.57	8.34
75	75	8.76		9.07	8.82
			0.9%	3.5%	
80		8.91			



Collection of Data | Correction Applied Methodology | Results

LiDAR Pulse, Wind Cube V2 - Results

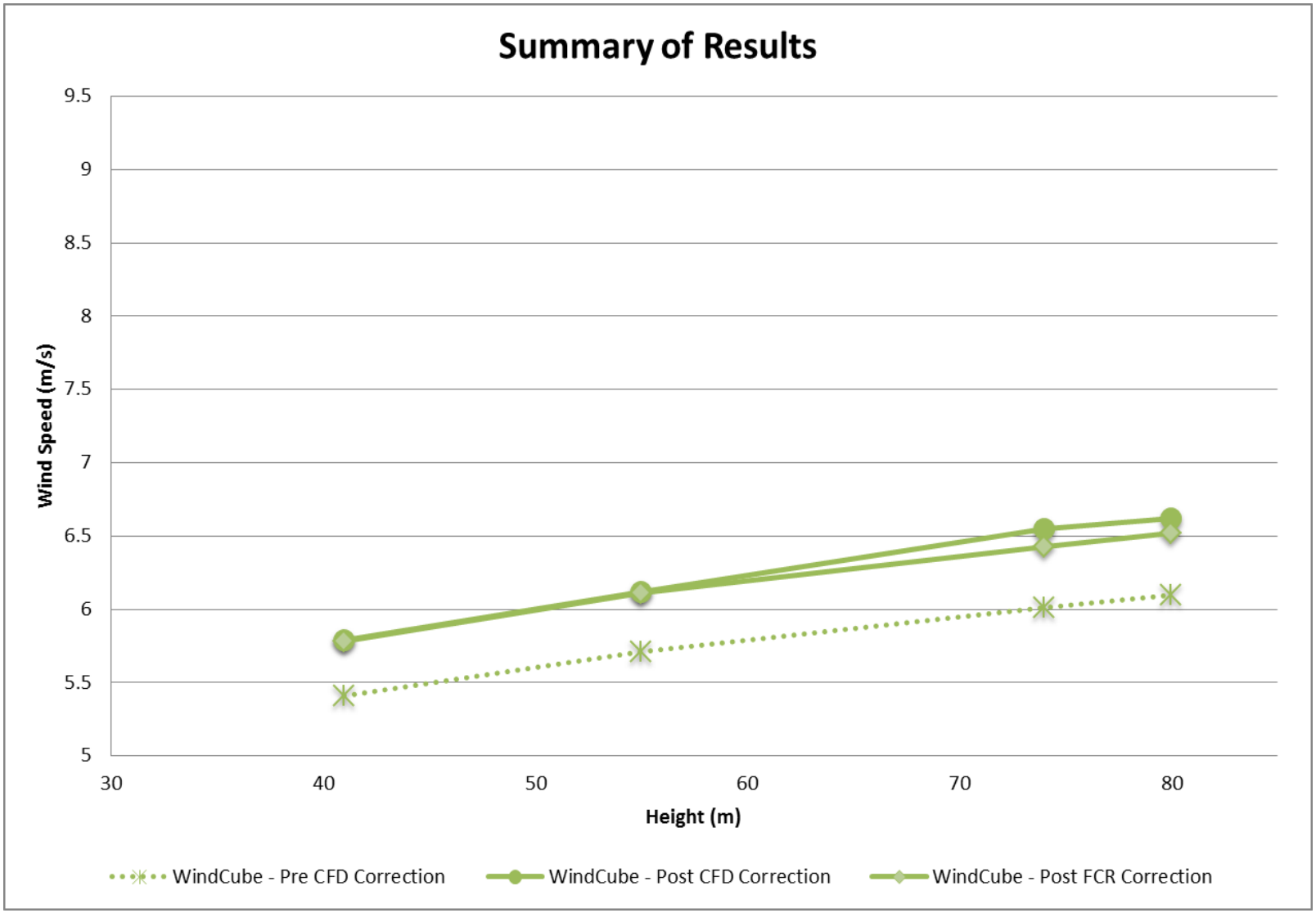
Measurement Height (m)		Mean Wind Speed (m/s)				
Wind Cube V2	Bench Mark	Bench Mark	RSD Before Correction	RSD After Correction RES	RSD After Correction FCR	
41					5.78	6.9%
55					6.11	7.1%
74					6.43	8.8%
80					6.52	8.6%



Jul 17th 2017

Sep 21st 2017

Summary Graph

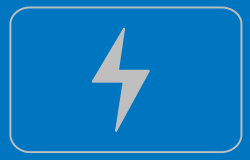


CONCLUSION

1.) Improvement to RSD horizontal mean wind speed (to closer reflect a meteorological mast) can be achieved by applying a computational fluid dynamic (CFD) correction, independent of the RSD technology type.

2.) The data used in this study demonstrate a closer alignment between the bench mark and the RSD corrected wind speed with increasing vertical height; however, further studies are required to either prove or bound this secondary observation.






Next Steps

- Correction factors per time stamp, not overall.
  - Seasonal, diurnal, hourly, 10min…
- Apply unique RSD correction per region.
  - With density as variable, wind speed range, or temperature.
- Incorporate CFD corrected RSD into energy assessment.

Thank you!

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