Remote Sensing Correction

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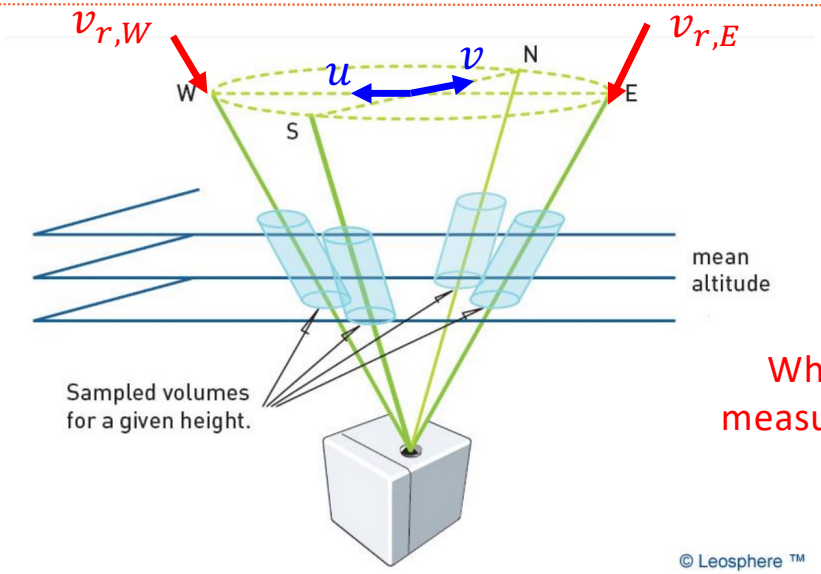
Market

- Market trends
- Multiple devices
- How many devices needs correction?

Theoretical background on LIDAR measurements



$$v_r = u\sin(\theta)\cos(\phi) + v\sin(\theta)\sin(\phi) + w\cos(\theta)$$

θ: beam angle respect to the vertical
ϕ: beam orientation respect to north (azimuth)

What the LIDAR measures (per beam)

What we really want to measure

$v_{r,W}$ $v_{r,E}$ ⇨ u

$v_{r,S}$ $v_{r,N}$ ⇨ v

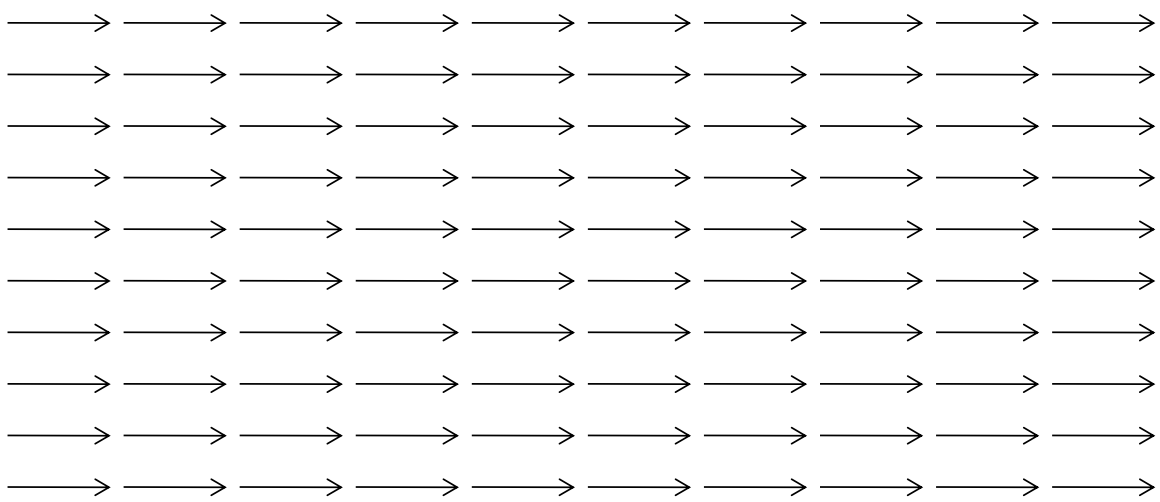
To make this calculation possible certain assumption on the wind flow must be taken:

1. The wind direction is constant
2. The inflow angle is constant

➡ **Homogeneous flow**

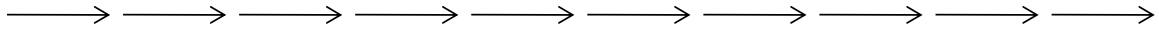
What is the problem?

Wind Field viewed from above



Not true for complex terrain!

Wind Field viewed from the side



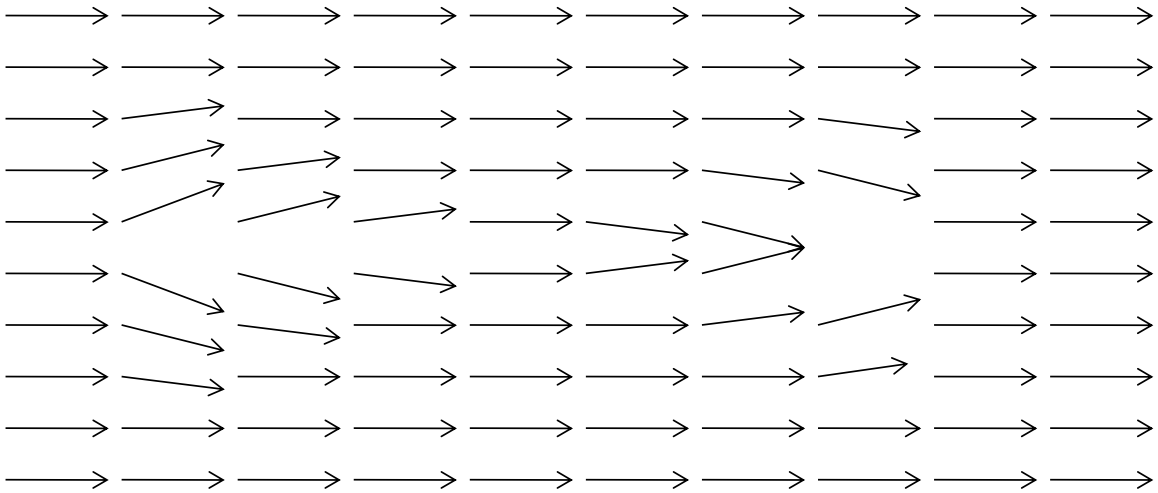
Homogeneous flow

What is the problem?

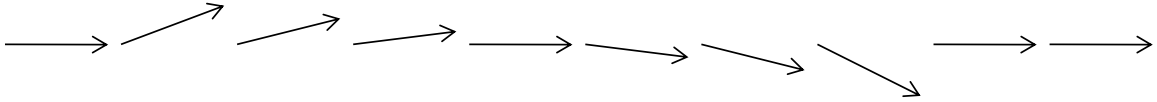
Homogeneous flow

Not true for complex terrain!

Wind Field viewed from above – Hill in the middle

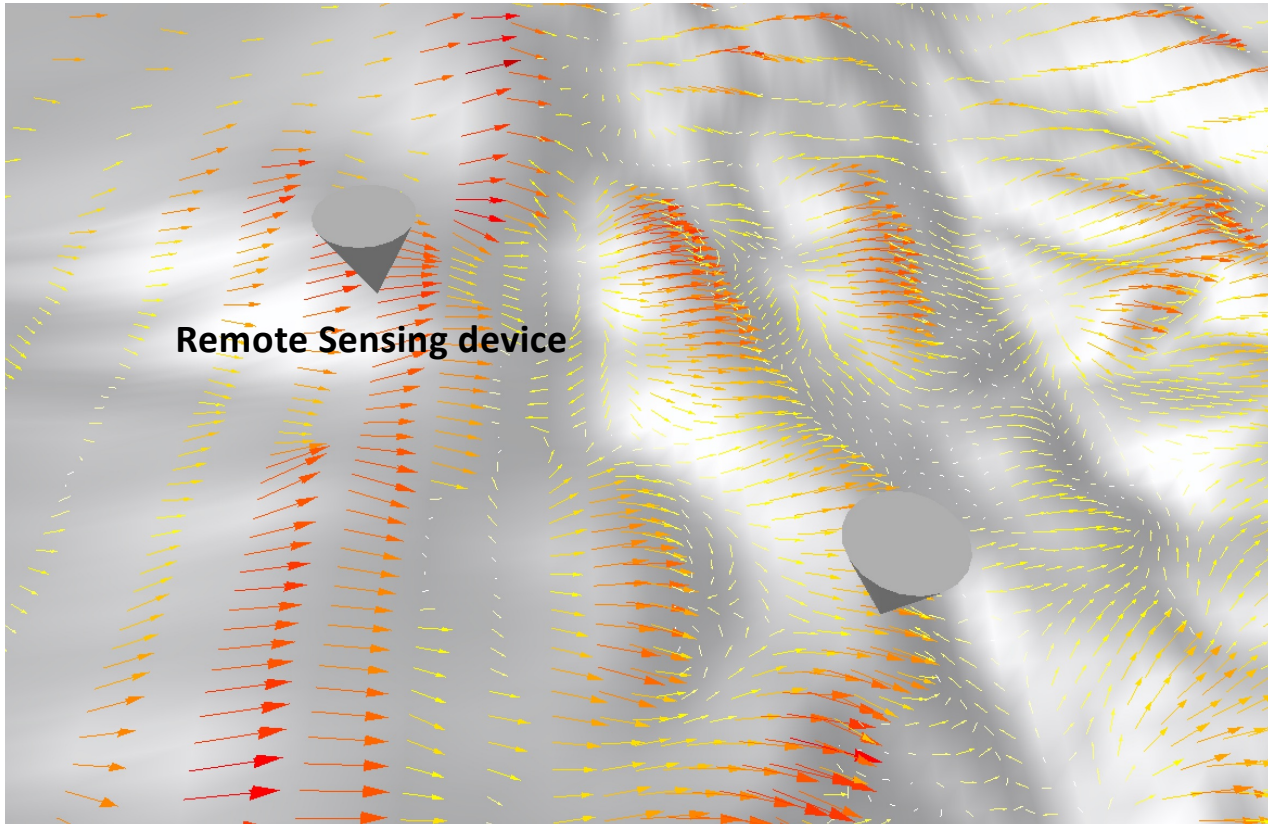


Wind Field viewed from the side – Hill in the middle

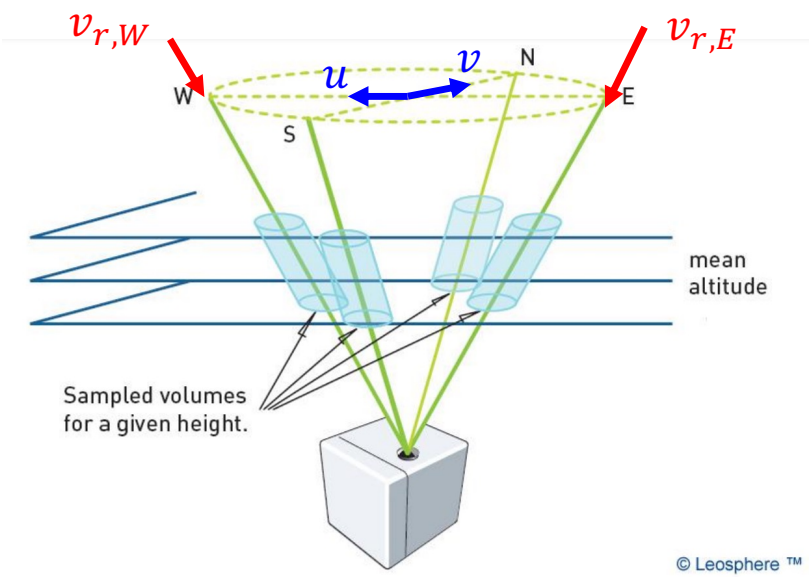


Value proposition

With WindSim's CFD technology we can predict the heterogeneity of the wind flow and correct remote sensing measurements



Remote Sensing Correction Methodology



We extract the CFD results to obtain v_r

$v_r \Rightarrow u, v \Rightarrow s_{RSD}$

Assuming homogenous flow

s_{RSD}

The wind speed the RSD would see

v/s

We compare s_{RSD} with the simulated wind speed at the lidar position

s_{CFD}

Correction factor: $\frac{s_{CFD}}{s_{RSD}}$

What do we need to do the correction?

- You provide us the coordinates of your device and some additional information about its configuration. With this we can fetch terrain datasets of the surrounding areas which are used as an input in our CFD simulations.

Device information			
Device	□ Triton	□ AQ System	□ ZX LIDAR
Latitude (decimal degrees)			
Longitude (decimal degrees)			
Scan angle (°)			
Direction offset (°)*			
Measured heights (m)			

Scan angle: Angle between a vertical line and the beams of the Lidar.

Direction offset: Angle between the front of the device and the geographical north.

- To generate the correction table we do not need any wind data.
- For the delivery of the complete corrected time series, the time series measurement data for the site is required.

Output

- Correction table

645012.5	223012.5											
	000	030	060	090	120	150	180	210	240	270	300	330
40.000	1.002	1.002	1.001	0.997	0.997	1.001	1.003	1.003	1.001	1.000	1.000	1.001
60.000	1.002	1.003	1.001	0.996	0.997	1.002	1.005	1.004	1.001	0.999	0.999	1.001
80.000	1.003	1.003	1.001	0.995	0.997	1.003	1.006	1.005	1.002	0.998	0.999	1.002
100.000	1.003	1.003	1.001	0.994	0.996	1.003	1.007	1.006	1.001	0.997	0.999	1.002
110.000	1.003	1.003	1.001	0.993	0.996	1.003	1.006	1.006	1.001	0.997	0.998	1.001
120.000	1.003	1.003	1.001	0.993	0.995	1.003	1.007	1.006	1.001	0.996	0.998	1.001
140.000	1.002	1.003	1.000	0.991	0.994	1.002	1.006	1.006	1.001	0.996	0.997	1.001

- Our procedure complies with IEC61400-12-1

Experience

- WindSim Service
- Over 100 corrections
- More than 10 years

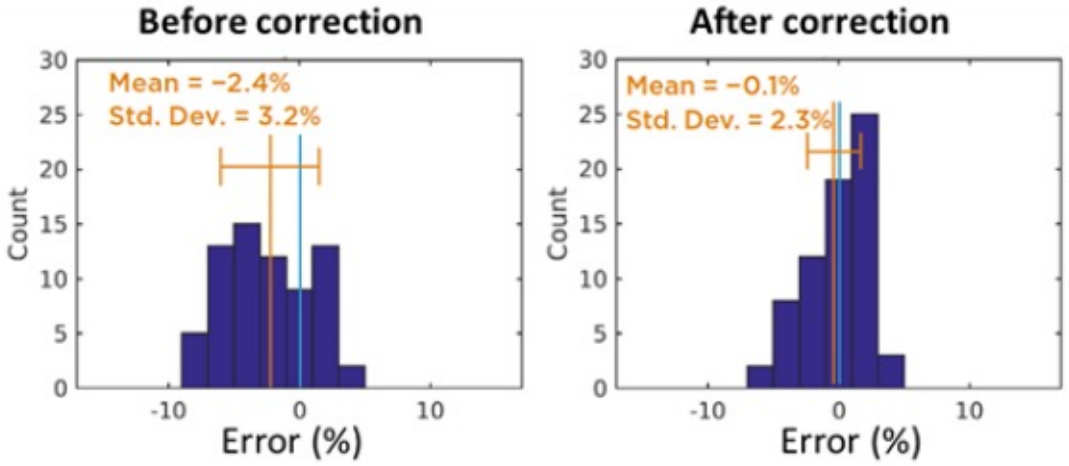


Figure 2: Error comparison before and after WindSim CFD correction of Triton SODARs at 26 sites [2]

[1] Meissner C., Boquet M. "Correction of LIDAR remote sensing measurements by CFD simulations", 2011, EWEA Brussels

[2] Stoelinga M., LaWhite N. "Validation of Triton Wind Profiler Measurements in Complex Terrain, Using WindSim CFD-Based Flow Curvature Correction", 2018, whitepaper

Advantages & Benefits

- Support multiple devices
- No need to share sensitive wind data
- Lower uncertainty
- Low cost/high value