Lidar measurement in extreme winter conditions

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Abstract

LiDARs are now widely used in the wind industry in the different steps of wind farm deployment and operation from site assessment and site suitability to power curve measurement with proven data availability in many conditions above 90% at the 200m height. In the addition to the vertical and horizontal uncertainties reductions compared to masts, LiDARs have the unique capability to measure in extreme conditions, whether hot or cold climates.

In addition to the operational constraints of extreme cold sites, the measurements themselves are challenging to retrieve as the concentration of aerosols is often very low, especially in the absence of frozen precipitation droplets. LiDARs most commonly used in the wind industry are based on the Doppler principle and require aerosols to backscatter the signal to measure their displacements and by translation the ambient wind conditions. This poster shows the latest advanced developments towards the improvement of LiDAR performance in sites with extreme low aerosol concentration, by comparing simulated and real measurements done during a winter in Finland at a VTT test site.

Test set up

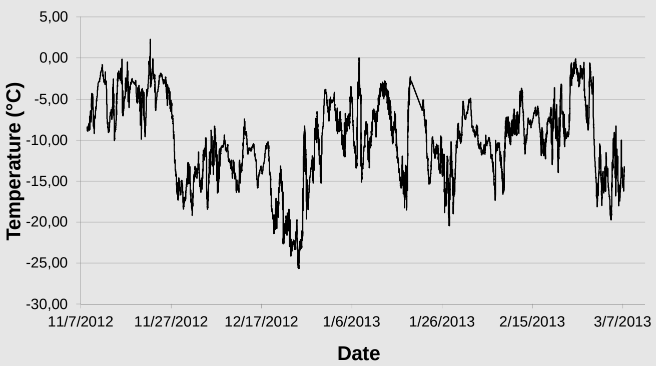
Site location in Finland

LiDARs and Power supply in operation in January at Olostunturi, Finland

The Olostunturi site has been since 1998 in VTT's use for the research purposes. During winter time, long periods of temperatures below -15 degrees to -20 degrees can be observed with large temperature fluctuations and severe winter conditions such as icing and blowing snow.

For the experiment, one WINDCUBE® v1 (previous generation of WINDCUBE) and one WINDCUBE v2 have been deployed during the winter 2012/2013. A winter tent has been installed on the top of the WINDCUBE to mitigate snow accumulation and insulate the device from cold wind.

Weather conditions and operations

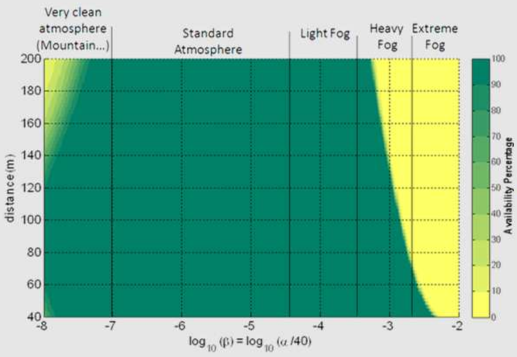


Temperatures during the winter test (November 2012 to March 2013)

As shown on the graph above, during the test the temperature was always below freezing with minimum value of -25 degrees C. There were also several snow storms with snow accumulation of several tens of centimeters. Even with those conditions, both WINDCUBE LiDARs were operating continuously with the exception of one day due to power supply shortage.

The WINDCUBE v2 is equipped with heaters to avoid the freezing of its components and the top surface is also heated to avoid snow accumulation as well as icing. This test has also demonstrated the efficiency of the winter performance kit which was developed for previous campaigns in North America.

'Clean air mode' Principle



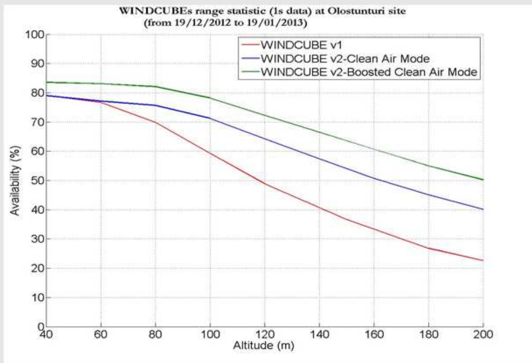
Simulation of availability of WINDCUBE v2 measurement under different atmospheric conditions (by SIMULID™)

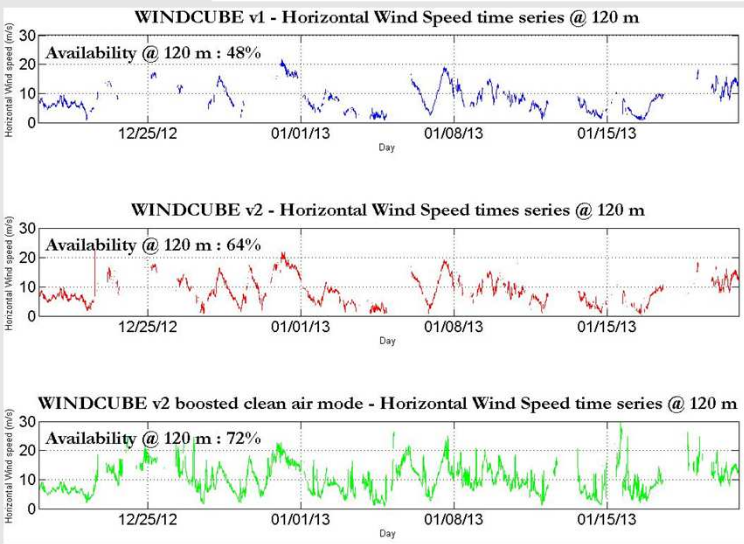
It is observed that data availability depends on concentration of aerosols in the atmosphere. Very high aerosol density from fog for example has a negative impact on measurement range (right part of the graph above shows strong decrease in availability during fog). On the other side, a very low aerosol concentration also negatively affects the measurement range. For that extreme however, it is possible to implement hardware and software solutions to increase the LiDAR sensitivity to lower aerosol concentrations.

Under normal conditions, the WINDCUBE v2 technology has a higher measurement range than WINDCUBE v1. Also specific signal processing can be implemented on WINDCUBE v2, called « clean air mode », to further increase the measurement range. Experimental results are shown below.

WINDCUBEs measurement results in extreme conditions

Right side graph shows the WINDCUBE range statistics on 1Hz measurement data. The graph below shows 10min average wind speed time series for the LiDARs. For WINDCUBE v1, the averaged availability at 120m is 48%, increasing to 64% with WINDCUBE v2 and up to 72% with the "Boosted Clean air mode".





Conclusion

LIDAR technology is the best solution to accurately measure wind components across the full swept area of the wind turbine rotor, even in severe winter environments. The WINDCUBE v2 has already proven good performance and this R&D study shows a higher potential in the near future for even extreme clean air situations.