Lidar measurement in extreme winter conditions
Tuomas Jokela¹, Petteri Antikainen¹, Lucile Mussio², Sophie Loac², Matthieu Boquet², Jean-Marc Thevenoud²
(1) VTT Technical Research Centre of Finland (2) LEOSPHERE

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 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.

‘Clean air mode’ Principle

Test set up

Weather conditions and operations

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 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.

‘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.

WINDCUBE measurement results in extreme conditions

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.

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.