WLS70: A NEW COMPACT DOPPLER WIND LIDAR FOR BOUNDARY LAYER DYNAMIC STUDIES. VALIDATION RESULTS AND INTERCOMPARISON IN THE FRAME OF THE 8TH CIMO-WMO CAMPAIGN.

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ABSTRACT

To fully understand atmospheric dynamics, climate studies and weather prediction, the wind field is one important atmospheric state variable. Studies indicate that a global determination of the troposphere wind field to an accuracy of 0.3 m/s is critical for improved numerical weather forecasting. Moreover, air quality monitoring relies on the ability to forecast the wind velocity, shear and turbulences several hours in advance and as such would highly benefit from accurate and unattended Boundary Layer wind profiler.

Lidar systems, developed by LEOSPHERE, measuring wind profiles with high accuracy up to 200m are being largely deployed worldwide for applications in the wind energy industry. Based on the accumulated know-how of these ground-based remote sensors, an extended version of them is now available. Such new equipment however needs to be intercompared and validated against usual Boundary Layer profilers. In this paper we present results of measurement campaigns that happened in Europe and the US and in the frame of the 8th CIMO-WMO Intercomparison of High Quality Radiosonde Systems in China, where more than 200 radiosounding fabricants were involved in three weeks intensive campaign together with other remote sensing instruments.

1. Overview

In this paper we present results of the long range Lidar WLS70 for wind velocity measurement within the Boundary Layer. Measurements are shown from several campaigns in which active and passive ground-based remote-sensing systems have also participated.

2. Development Phase

The WindCube70 Lidar is derived from the commercial WindCube7 with some major changes: the optical set up and the embedded software have been modified to increase the measurement range up to the Planetary Boundary Layer height and however maintain wind velocity accuracy better than 0.2 m/s. The WLS70 has been integrated in the same compact casing than the WLS7 WindCube.

Figure 1. Long range wind Lidar pictures during validation campaigns at Cabauw, the Netherlands (close to a 200m met mast) and at LEOSPHERE office in Orsay, France.

First validations of the WindCube70 have been conducted against the WindCube7 whose high accuracy and performances under various weather conditions have been reported by several independent wind energy experts and laboratories (Risø, Deutsche WindGuard, Garrad Hassan…).

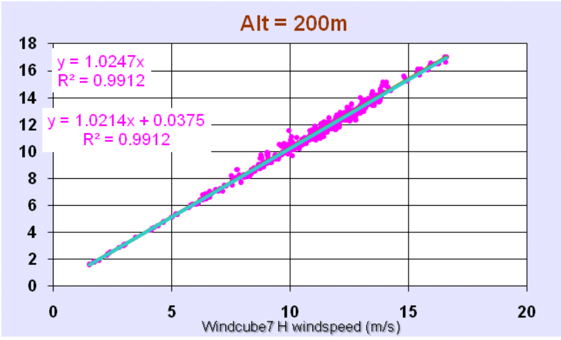


Figure 2. Horizontal wind speed correlation between the short range wind Lidar WindCube7 (1s update) and long range wind Lidar WindCube70 (10s update). 4 days benchmarking of 10min averaged wind profiles showing good agreement between the two Lidars.

Figures below show horizontal wind speed and wind direction profiles time series realized in Orsay, France.

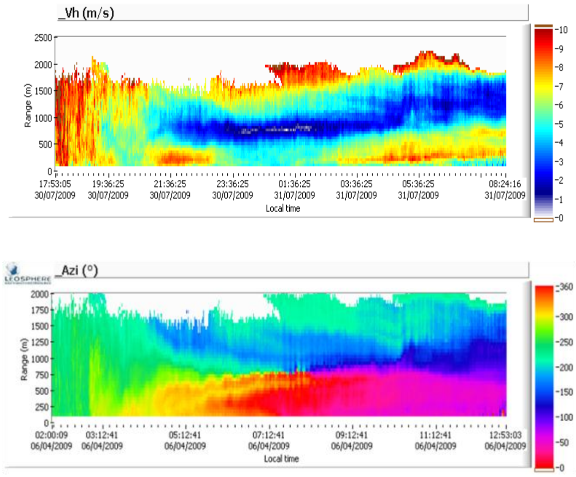


Figure 3. Horizontal and direction wind speed profiles time series. The Lidar puts in evidence the presence of the two separated layers with different wind direction, explaining for the wind speed vertical profiles as seen below.

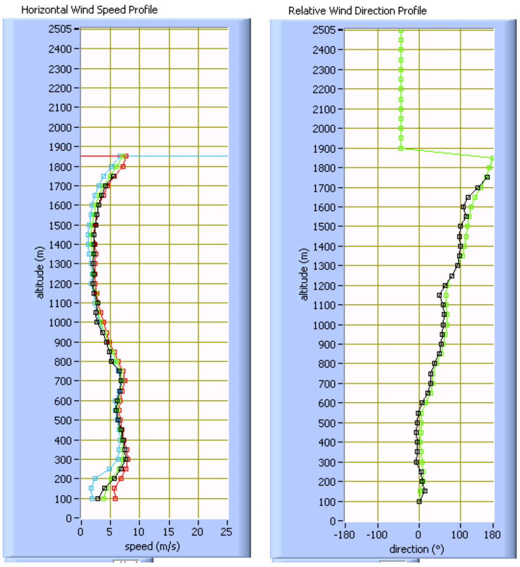


Figure 4. Left graph: non-logarithmic boundary layer horizontal wind speed vertical profile. Right graph: 180° wind direction veer.

3. EUCAARI campaign - KNMI

In May 2008, a prototype started retrieving vertical wind speed profiles during the EUCAARI campaign at KNMI, Cabauw, the Netherlands. Analysis of vertical profiles up to 2km showed high frequency updrafts and downdrafts in the boundary layer.

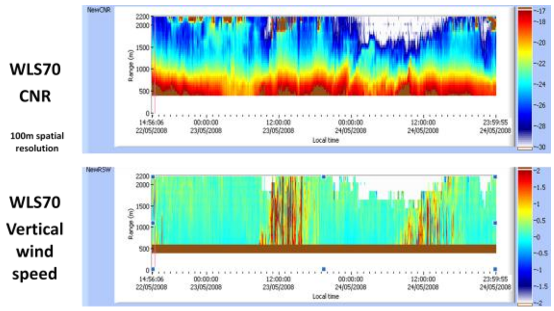


Figure 5. Lidar signal-to-noise ratio and vertical wind speed time series. Large convection phenomena happening around noon.

4. LUAMI campaign - DWD

From November 2008 to January 2009, a second unit has been deployed in Germany in the frame of the LUAMI campaign. During 62 days, the Lidar retrieved 24/24h wind velocity vertical profiles, showing wind shears and veers, gusts and high frequency convective effects with the raise of the mixing layer or incoming rain fronts.

Figure 6 shows a comparison of the horizontal wind speed retrieved by the WLS70 and a Wind Profiler/RASS system

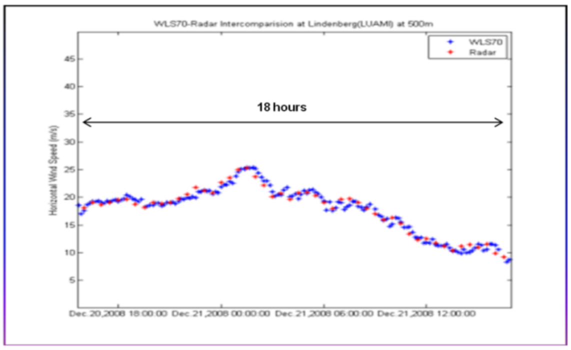


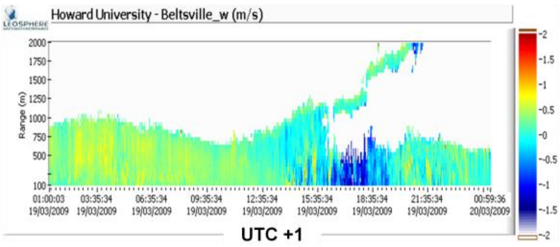
Figure 6. Horizontal wind speed comparison at 500m between a WLS70 and a Wind Profiler/RASS system

5. WAVES campaign - NOAA

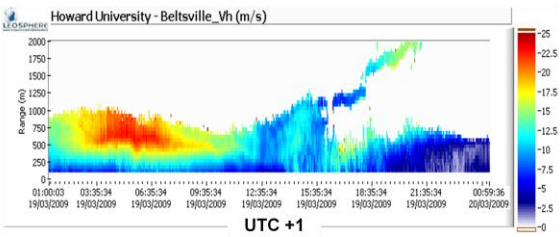
The National Oceanic and Atmospheric Administration (NOAA) held the WAVES from March to May 2009 in Beltsville, Maryland US. The presence of numerous Radars profilers, Lidars and radio soundings was a good opportunity to test the autonomous Lidar. It showed several Low Level Jet phenomena particularly determinant for air quality and production of wind energy monitoring.

Figures below show four time series, horizontal and vertical wind speed, wind direction and signal-to-noise ratio. They put in evidence the presence of a Low Level Jet under which high updrafts happen, vanishing in the morning. Incoming rain front is also accompanied with a strong change in the wind direction.

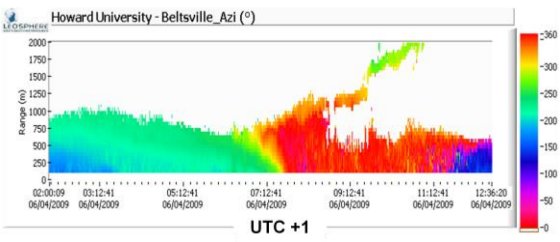
Vertical Wind speed



Horizontal Wind speed



Wind direction



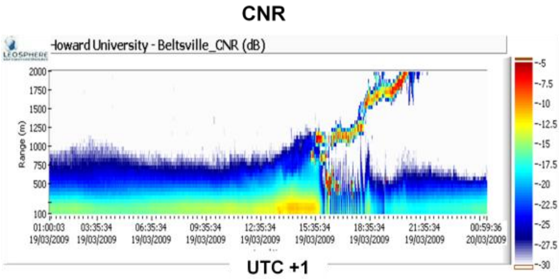


Figure 7. Lidar time series of wind velocity 3 components and system signal-to-noise ratio. From top to bottom: horizontal wind speed, vertical wind speed, wind direction and signal-to-noise ratio.

6. Ash plume detection from Eyjafjallajökull eruption

Eyjafjallajökull volcano eruptions of ash plumes starting on April 2010 paralyzed completely air traffic in Europe for several days. The WLS70 detected the ash plume over South East of Paris from 17 to 21 of April 2010

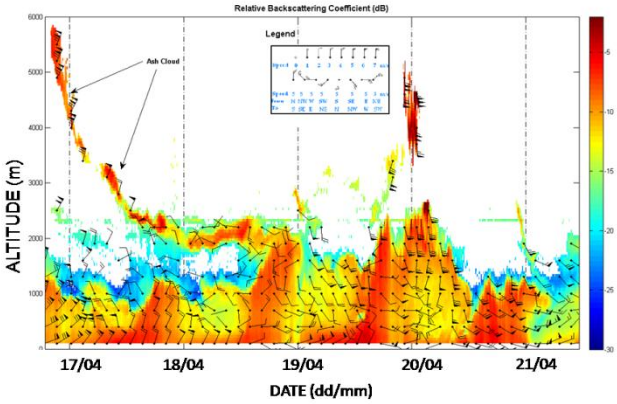


Figure 8 Relative backscattering coefficient (dB) and relative wind speed from 17th to 21st of April 2010 in Orsay, France

7. 8th CIMO-WMO Radiosounding Intercomparison campaign

Radiosondes are small size, light-weight disposable sensors that are launched by a balloon and measure the basic meteorological variable (Pressure, Temperature, Humidity and Wind) and transmit the data by radio signals at 400 MHz to a ground receiving station. The objective of the 8th CIMO-WMO intercomparison campaign was to assess the uncertainty of commercial radiosonde in particular with regards to systematic effect like radiation on temperature by inter-comparison and using reference instrumentation. Another issue was the assessment of the performance and accuracy in sub tropical environment. For this reason the CIMO 2010 campaign took place in July in Yangjiang, China. Among radiosonding manufacturers, the WLS70 Doppler Wind Lidar was deployed to be compared with the radiosondes

During the intensive period (7th Jul – 31st Jul 2010) two launches were carried out each day. The analysis of the remote sensing WLS70 Doppler Wind Lidar data that run unmanned 24/24 is in progress and the intercomparisons will be published soon.

8. Conclusions

During these intensive intercomparison campaigns the wind Lidar has been validated against other Lidars, Radars, Sodars and anemometers. The results show a good agreement between the instruments. Moreover, the good time resolution (8s/profile), range resolution (50m), and velocity accuracy (0.2m/s) make the long range Lidar WLS70 a promising system for applications in weather prediction, air quality monitoring and wind forecasting to increase the power produced by a wind farm and reduce risk of turbine failure.

Further atmospheric parameters like turbulent intensity and turbulent kinetic energy can also be retrieved from Lidar measurements. These turbulence aspects are under study.