New generation compact pulsed infrared coherent Doppler Lidars validation against Wind Profiler Radar and Radiosonde measurements at the Lindenberg GRUAN site

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⇒ Campaign Structure and Methods

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Accurate knowledge of wind fields is crucial for the improvement of Numerical Weather Prediction (NWP) models.

DWD (German National Meteorological Service) prepares Low Level Wind Shear Alert Systems (LLWAS) for the Frankfurt and Munich, Germany airports. The systems will consist of a METEOR 50DX Dual Polarisation Weather Radar, and a WindTracer Doppler Lidar (Lockheed Martin Coherent Technologies).

Scientists of the Lindenberg GRUAN site are included in LLWAS-project as experts of remote sensing and prepare verification campaigns of LLWAS-sensors currently.
Three different Doppler Wind Lidar systems, developed by Leosphere and Halo Photonics, respectively, were deployed in two independent campaigns at Lindenberg Observatory during April/May 2011 and August-December 2011 within the framework of the European COST action ES 0702 (EG-CLIMET).

Lidar instruments were validated against the 482 MHz Wind Profiler, daily Radio Soundings, and NWP model output in order to be used operationally.
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GRUAN = GCOS Reference Upper Air Network

The Richard Aßmann Observatory is located about 65 km south-east of Berlin.

Latitude: 52.21 °N
Longitude: 14.12 °E
Altitude: 98 m
Lindenberg Meteorological Observatory – Richard Aßmann Observatory (2012)

**482 MHz Radar Wind Profiler (stationary)**

behind the berm

**Windlidar (temporary)**

StreamlineLidar HaloPhotonics (KIT)

Windcube WLS200S Leosphere

**Windcube WLS200 Leosphere**
## Windlidar Inter Comparison Campaign 2011
**Performance (operational availability)**

<table>
<thead>
<tr>
<th>2011</th>
<th>March</th>
<th>April</th>
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- **StreamLineLidar (HaloPhotonics)**: Operational since 23/11/2011.
- **Software bugs at midnight**:
  - **WLS200 (Leosphere)**: Operational since 20/12/2011.
  - **WLS70 (Leosphere)**: Operational since 13/1/2012.
- **Insufficient air conditioning**: The problem is now fixed.

### Operational Availability

- **>98%**
- **<70%**
Campaign Intercomparison Methods

- compare / assess operational availability
- compare against the 482 Mhz Windprofiler, 4 times daily launched radiosoundings, and NWP models output
- … measurements as time series
- … profiles at a certain time
- … differences for longer periods
- … different elements
  (horizontal wind speed, direction, components u, v, w, root mean square differences)
- compare lidar ranges to meteorological conditions
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(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings

Examples →
Inter-Comparison Time Series Wind speed Profiler – Model – Balloon

- Altitude (Windprofiler): 552,000 m asl
- Altitude (Model): 540,300 m asl
- Altitude (Windcube): 554,000 m asl

Mean values
10 min

482 MHz profiler

NWP Modeloutput

Windcube WLS200 Leosphere

Radiosounding

00:00 Nov 30 2011 12:00 Nov 30 2011 00:00
0 5 10 15 20 25 30
Wind speed [m/s]
Inter-Comparison Time Series: Wind Speed Profiler - Model - Balloon

- Altitude (Wind Profiler): 552.000 m asl
- Altitude (Model): 540.300 m asl
- Altitude (Halo): 544.482 m asl

482 MHz profiler

NWP Model output

StreamlineLidar HaloPhotonics

3 min Scan!!
(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings
- There are sometimes differences to NWP model output

Examples ➔
Advantages of two independent wind profiling systems:

- NWP (Cosmo-EU)
- Measurements (Windcube and Profiler)
- Balloon, interpolated
(Preliminary) Results

- All wind lidars are close to 482 MHz Windprofiler and radiosoundings
- There are sometimes differences to NWP model output
- In April/May there was a bias in windcube WLS70 wind speed (0.4 .. 0.5 m/s) with Windprofiler as reference, in November/December no bias were found for wind lidars

Examples →
Lindenberg Meteorological Observatory – Richard Aßmann Observatory (2012)

Windcube WLS200 (10 min !) compared to Windprofiler

Windprofiler – Windcube (10 min)
Windcube – Aero
Windcube – LME

Diff ≤ ± 0.2 m/s

RMS-Difference 0.8 m/s

nine days

Year: 2011 DOY: 356–364
StreamLineLidar Halo Photonics (3 min!) compared to Windprofiler

RMS-difference 1.0 m/s

Diff $\leq \pm 0.2$ m/s

nine days

Year: 2011 DOY: 356–364
(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings
- There are some times differences to NWP model output
- In April/May there was a bias in windcube WLS70 wind speed (0.4 .. 0.5 m/s) with Windprofiler as reference, in November/December no bias were found for wind lidars
- Comparisons show ground clutter effects of Windprofiler?

Examples ➔
Radar influenced by ground clutter in the lowest heights
(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings
- There are sometimes differences to NWP model output
- In April/May there was a bias in windcube WLS70 wind speed (0.4 .. 0.5 m/s) with Windprofiler as reference, in November/December no bias were found for wind lidars
- Comparisons show ground clutter effects of Windprofiler?
- The scanning lidars show similar performance ....

Examples ➔
Halo Intercomp. Campaign 2011 - Level 19 = 904.107 m (Gate: 936.000 m)

Date Time: 16.12.2011 00:08:25

Halo (00:08 Z) 257° 17.6 m/s

WLS200S (00:09 Z) 256° 17.4 m/s
Lidar ranges compare to meteorological conditions

WLS200S: November 23 to December 20 2011
Frequency of maximal range

WLS200S

November 23 to December 20 2011

Height [m] above ground
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Intercomparison campaign provided a comprehensive data set over different seasons

All wind lidars are close to 482 Mhz windprofiler and radiosoundings ($\leq \pm 0.2$ m/s and $< 0.8..1.0$ m/s in RMS-diff)

Comparison campaigns useful for new instrumentation, some bugs/problems could be identified and fixed

Data coverage of wind lidars more than 90% up to 500 m height (even in fall) and complement the wind profile monitoring from ground to LS (lowest level 482 MHz RWP: 448 m)
Thanks for attention
For discussion ....
<table>
<thead>
<tr>
<th></th>
<th>StreamlineLidar HaloPhotonics (KIT)</th>
<th>Windcube WLS200 Leosphere</th>
<th>Windcube WLS200S Leosphere</th>
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<tbody>
<tr>
<td>Manufactured by</td>
<td>Halo photonics</td>
<td>Leosphere</td>
<td>Leosphere</td>
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<tr>
<td>Provided by</td>
<td>Karlsruhe Institute of Technology (KIT)</td>
<td>GWU-Umwelttechnik GmbH</td>
<td>Leosphere</td>
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<tr>
<td>Wavelength</td>
<td>1.5 µm</td>
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<td>1.55 µm</td>
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<td>Max. range (of the provided Lidar)</td>
<td>3 km</td>
<td>6 km</td>
<td>6 km</td>
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<tr>
<td>Beams configuration</td>
<td>LOS mapping</td>
<td>Four beams</td>
<td>LOS mapping</td>
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<tr>
<td>Scan modes</td>
<td>Stare, VAD, RHI, DBS</td>
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<td>Stare, VAD, PPI</td>
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Windlidar Inter Comparison Campaign 2011
Performance (meteorological availability)

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28/04/11
Up to 6 km

18/11/11
no windlidar measurements due to low clouds/fog
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- **Halo (8/8/11)**: VAD 7 min
- **Halo (13/9/11)**: DBS 15 sec
- **Halo (3/1/11)**: VAD 3 min

### Observations:
- **WLS200 (20/4/11)**: VAD 7 min
- **WLS200**: DBS 15 sec
- **WLS200S (23/11/11)**: VAD 3 min

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*The table represents a comparison of windlidar measurements at various observatories during the Windlidar Inter Comparison Campaign 2011.*
## Windlidar Inter Comparison Campaign 2011

<table>
<thead>
<tr>
<th>Date</th>
<th>Halo (VAD 3 min)</th>
<th>WLS200 (DBS Averag. 10 min)</th>
<th>WLS200S Installation</th>
<th>DBS</th>
<th>VAD</th>
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**Leosphere**

- **VAD** - Velocity Azimuth Display (more than four directions)
- **DBS** - Doppler-Beam Swinging (four beams)

**PPI**

**VAD**
Frequency of maximal range

WLS200
October 20 2011 to January 9 2012

Probabilité de portée

Height [m] above ground

Probabilité cumulée de portée

Height [m] above ground