Airborne wind lidar observations in the North Atlantic in preparation for the ADM-Aeolus validation

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Fig.: ESA/ATG-Medialab
ADM-Aeolus WindVal

First time with 4 Wind Lidars on 2 aircrafts
ADM-Aeolus WindVal

David and Goliath

Falcon, DLR

DC-8, NASA
Wind lidars on Falcon (DLR) and DC-8 (NASA)
Setup overview
# Wind lidars on Falcon (DLR) and DC-8 (NASA)

## Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DLR A2D</th>
<th>NASA TWiLiTE</th>
<th>DLR 2-µm DWL</th>
<th>NASA 2-µm DAWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>354.9 nm</td>
<td>354.7 nm</td>
<td>2022.5 nm</td>
<td>2053.5 nm</td>
</tr>
<tr>
<td>Laser energy</td>
<td>50-60 mJ</td>
<td>25 mJ</td>
<td>1-2 mJ</td>
<td>100 mJ (nominal 250 mJ)</td>
</tr>
<tr>
<td>Pulse rate</td>
<td>50 Hz</td>
<td>200 Hz</td>
<td>500 Hz</td>
<td>5 Hz (nominal 10 Hz)</td>
</tr>
<tr>
<td>Pulse FWHM</td>
<td>20 ns</td>
<td>15 ns</td>
<td>400-500 ns</td>
<td>180 ns</td>
</tr>
<tr>
<td>Telescope Ø</td>
<td>20 cm</td>
<td>32 cm (eff.)</td>
<td>10.8 cm</td>
<td>15 cm</td>
</tr>
<tr>
<td>Scanner</td>
<td>No, fixed 20° off-nadir</td>
<td>step-stare conical scanning with 45° off-nadir</td>
<td>double wedge, conical scan, fixed LOS and vertical</td>
<td>single wedge, conical scan, fixed 30.12° off-nadir with 5 LOS in fwd. dir.</td>
</tr>
<tr>
<td>Random error</td>
<td>1.5 m/s Mie</td>
<td>2 m/s</td>
<td>&lt; 1 m/s</td>
<td>&lt; 1 m/s</td>
</tr>
<tr>
<td></td>
<td>2 m/s to 2.5 m/s Rayleigh</td>
<td>2 m/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection and Calibration (signal to frequency)</td>
<td>direct; yes, atmosphere and internal</td>
<td>direct; yes, internal</td>
<td>coherent, no need for calibration</td>
<td>coherent, no need for calibration</td>
</tr>
</tbody>
</table>
Greenland summit observations
3216 m asl., 72.6° N

- HALO Photonics 1.55 µm DWL
- MPL lidar
- Radiosondes
- Cloud Radar
- 2 radiosondes per day
- Thanks to support of NSF and ESA

Midnight over Summit on May 21, 2015 seen from DLR Falcon aircraft
Falcon (DLR) and DC-8 (NASA) flight tracks in May 2015
Objectives for ALADIN airborne demonstrator A2D

A2D first direct-detection airborne wind lidar in 2005 [1]
Wind along East Coast of Greenland in 2009 [2]

- Validate instrument and its calibration with real atmospheric signals
- More than 100 recommendations were derived for Aeolus related to alignment, operation, tests, calibration, algorithm and processors => DLR is responsible for end-to-end Simulator, algorithm and operational processors up to L1b
- A2D will be airborne testbed and central validation platform after launch

[1] Reitebuch et al., JTECH, 2009

18th CLRC - Boulder – July 1, 2016
Slightly higher standard deviation (1.5 m/s, 5.2°) for dropsonde/lidar comparison than observed for DLR-NCAR (AVAPS) dropsondes.

Weissmann et al. (2005): 1-1.2 m/s
Chouza et al. (2016): 0.9 m/s
Results
A2D Mie and Rayleigh LOS winds from 25 May 2015

Mie
flight altitude = 10.65 km
cloud layer
sea surface

Rayleigh

South of Iceland
36 minutes 121 observations
Results
Comparison A2D and 2-μm Wind Lidar

A2D Rayleigh

2-μm wind lidar

good comparison with 5% slope error, 1.7 m/s std. and 0.5 m/s systematic difference

Statistical results

corr. coeff. r 0.92
N points 991
slope 1.05
std. dev. 1.66 m/s
avg. Bias 0.46 m/s
Results

Textbook Example of “Iceland”
Low Pressure System

Track of DLR Falcon and NASA DC 8

MSG SEVIRI HRV Image – 18 UTC; from the Icelandic Met Service IMO
Results

Comparison Jet-Stream Winds from ECMWF model vs. 2-μm Lidar

Up to -9.2 m/s

Up to -13.5 %
• First time that 4 wind lidars were operated on 2 aircrafts in parallel
• Most extensive data set of wind profiles in the North Atlantic region
• Comparison of DC-8 dropsondes and DLR 2-μm wind lidar shows no bias and std. dev. of 1.5 m/s and 5° for horizontal wind
• Comparison of DLR direct-detection and coherent wind lidar with std. dev. of 1.7 m/s for LOS wind speed
• Comparison of DLR 2-μm wind lidar with ECMWF model shows overall good agreement except for underestimation of jet stream wind speed by up to 9 m/s (14%)
• Successful rehearsal for future validation of ADM-Aeolus with DLR and NASA airborne wind lidars
OUTLOOK: NAWDEX in September-October 2016

- North Atlantic Waveguide and Downstream Impact Experiment
- Operation center in Keflavik, Iceland from 19 September – 16 October 2016
- Deployment of HALO, DLR Falcon and French Falcon with extensive lidar-radar payload