Airborne Wind Lidar Measurements Supporting The Pre-Launch Validation Of ESA's Aeolus Mission

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ABSTRACT

ESA's satellite mission Aeolus carrying the direct-detection Doppler wind lidar instrument ALADIN is scheduled to be ready for launched by end of 2016. DLR operates the ALADIN airborne demonstrator (A2D) from a container on ground and from its Falcon aircraft. Results from the airborne campaign in 2009 will be shown, in particular A2D measurements related to Zero Wind Correction (ZWC). Wind speeds measured during a flight along the east coast of Iceland and derived from the A2D Rayleigh channel are compared against wind measurements which were performed in parallel by a coherent 2-µm Doppler wind lidar.

INTRODUCTION

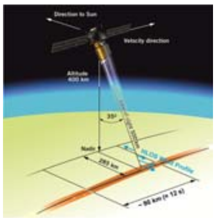

Fig. *Viewing geometry and sampling strategy of the Aeolus satellite for horizontal line-of-sight (LOS) wind speed (adapted from [1]).*

The European Space Agency ESA plans to launch the Aeolus wind lidar satellite by end of 2016 to improve numerical weather prediction and climate studies. By emitting laser pulses at 355 nm and analysing the Doppler shifted light backscattered by the atmosphere, wind speeds between 0-25 km will be provided on a global scale and in near real time [1].

The A2D is a prototype of the satellite instrument and is operated by DLR from ground and as an airborne demonstrator [2], [3]. Two different types of interferometers analyse Rayleigh and Mie scattering from molecules and aerosols or clouds.

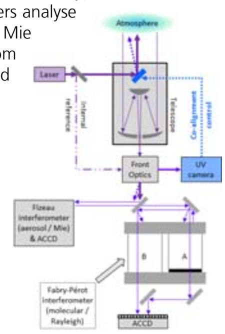

Fig. *Overview of the A2D subsystems. The emitted laser light (violett) is partly reflected by the atmosphere, collected by a telescope and analysed by two spectrometers.*

MAIN OBJECTIVES OF THE AIRBORNE CAMPAIGN

- Development, validation and optimization of retrieval algorithms
- Validation of measurement principle and particularly the calibration strategy
- Validation of wind measurement results & first estimation of errors
- Overall rehearsal for ADM Cal/Val campaign after launch of the satellite

METHODS

As solid ground does not move it constitutes a valuable and perfect target to calibrate the instrument. In case the ground signal shows a speed ≠ 0 m/s, an according correction in the wind retrieval is applied.

Fig. *Top: payload of the DLR Falcon aircraft during the airborne campaign in May 2015. Bottom: DLR Falcon aircraft in front of the NASA DC-8 aircraft in Keflavik, Iceland.*

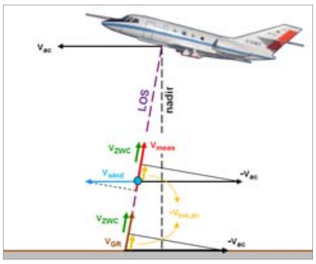

Fig. *Determination of the Zero Wind Correction value v_{ZWC} taking into account the velocities of the aircraft v_{ac} and the ground return v_{GR} as well as the correction of the measured wind speed v_{meas} in order retrieve the true wind speed v_{wind}.*

For the first time worldwide two wind lidar instruments were operated simultaneously on the same aircraft in 2009: The A2D and a well-established coherent reference lidar at 2 µm, the latter being characterized by low random and systematic errors of about 0.1 m/s. During the campaign in 2015 two additional lidar systems also using both detection principles were operated in paralled on a NASA DC-8 aircraft.

RESULTS & DISCUSSION

On September 29th in 2009 the DLR Falcon aircraft performed a 4 hour flight over Iceland. A deliberate misalignment between the optical axis of the A2D telescope and the laser pointing direction imitated an instrumental error which was to induce an offset in the retrieved wind speed. In turn the measured speed of selected ground returns was used to correct for this offset, i.e. a so-called Zero Wind Correction (ZWC) was successfully demonstrated [4].

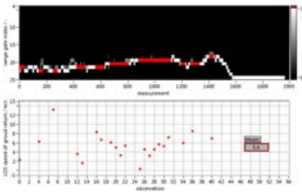

Fig. *Top: Location of ground (white) and cloud (grey) returns over Iceland. Selected ground returns used for the ZWC are in red. Bottom: Line-of-Sight velocities for the selected ground returns with respect to the A2D instrument.*

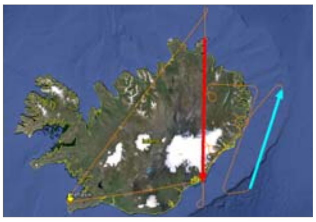

Fig. *Flight tracks of the DLR Falcon aircraft on September 29th in 2009 with a blue and red segment for wind measurement & ZWC respectively.*

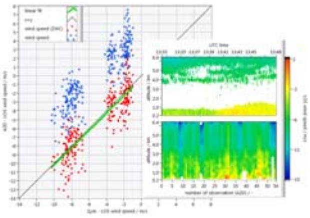

Fig. *Measured (blue) and corrected (red) A2D Rayleigh LOS wind speeds (right bottom) compared to winds from the 2-µm heterodyne reference lidar (right top) in a scatterplot (left).*

CONCLUSION & OUTLOOK

The goal to validate the method of ZWC was achieved. The strong variation in zero winds necessitates the usage of a mean value instead of an application on an observational basis. It was found that the ZWC values are different for the Mie and the Rayleigh channel. In preparation of calibration/validation activities for the Aeolus satellite a new airborne campaign was realised during May 2015 in the North Atlantic region between Iceland and Greenland complementing the data set from 2009 and promising new comparisons, e.g. with respect to the NASA lidar systems & dropsondes.

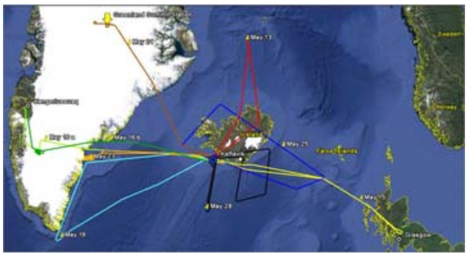

Fig. *Flight tracks of the DLR Falcon aircraft during the campaign in May 2015.*

MAJOR REFERENCES

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[2] **Reitebuch et al.,** "The Airborne Demonstrator for the Direct-Detection Doppler Wind Lidar ALADIN on ADM-Aeolus. Part I: Instrument Design and Comparison to satellite Instrument," JAOT, 26 (2009).

[3] **Paffrath et al.,** "The Airborne Demonstrator for the Direct-Detection Doppler Wind Lidar ALADIN on ADM-Aeolus. Part II: Simulations and Rayleigh Receiver Radiometric Performance," JAOT, 26 (2009).

[4] **Marksteiner, U.,** "Airborne wind lidar observations for the validation of the ADM-Aeolus instrument," PhD thesis, Technische Universität München, (2013).

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