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Validation of the Aeolus wind observations in the tropics using the ALADIN Airborne Demonstrator and 2-µm Doppler wind lidar

Oliver Lux[1], Benjamin Witschas[1], Christian Lemmerz[1], Fabian Weiler[1,2], Uwe Marksteiner[1], Stephan Rahm[1], Alexander Geiß[3], Andreas Schäfler[1], Michael Rennie[4], and Oliver Reitebuch[1]
[1]Institute of Atmospheric Physics, German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V., DLR), Oberpfaffenhofen, Germany
[2]Joby Aviation, Munich, Germany
[3]Meteorological Institute, Ludwig-Maximilians-Universität München, Munich, Germany
[4]European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom

The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) conducted four airborne campaigns for the validation of the Aeolus L2B wind product during the first three years of ESA's wind lidar mission between 2018 and 2021. After three campaigns in Europe, the *Aeolus VAlidation Through Airborne LidaRs in the Tropics* (AVATAR-T) campaign was performed around the Cabo Verde archipelago in September 2021 as part of the Joint Aeolus Tropical Atlantic Campaign (JATAC). AVATAR-T employed the DLR Falcon aircraft which carried two Doppler wind lidar (DWL) instruments: the heterodyne-detection 2-µm DWL acting as a high-accuracy reference and the ALADIN Airborne Demonstrator (A2D), representing a prototype of the direct-detection DWL on-board Aeolus with a high degree of commonality in terms of design and measurement principle.

In the framework of AVATAR-T, 11 coordinated flights along the Aeolus track were performed covering nearly 11,000 km of the satellite's measurement swath. The research flights yielded a comprehensive set of A2D and 2-µm DWL wind observations to validate the Aeolus wind product under the influence of the Saharan Air Layer (SAL), the African Easterly Jet, the Subtropical Jet and the Intertropical Convergence Zone. In particular, the campaign results give insight into the impact of atmospheric aerosols onto the operational Rayleigh-clear and Mie-cloudy horizontal line-of-sight (HLOS) winds regarding potential errors that arise from crosstalk between the two complementary receiver channels and their respective wind data coverage in the troposphere.

Validation of the Aeolus wind product based on 2-µm DWL data shows that the systematic error almost fulfills the mission requirement of being below 0.7 m/s (HLOS) for both Rayleigh-clear and Mie-cloudy winds. The random error, however, is larger than specified (2.5 m/s HLOS), being close to 3 m/s for Mie-cloudy winds and as high as 7 m/s for Rayleigh-clear winds. A more detailed investigation reveals that the Rayleigh-clear random error is increased at lower altitudes in case of signal extinction due to aerosols.

The collocated A2D wind observations provide valuable information on the potential optimization

of the Aeolus wind retrieval and related quality control (QC) algorithms. For instance, the A2D, unlike ALADIN, delivered a broad vertical and horizontal coverage of Mie winds across the SAL, whereas A2D Rayleigh winds measured in this region, which are affected by Mie contamination through crosstalk and signal extinction, are effectively filtered out. Preliminary studies suggest that a refinement of the Aeolus wind retrieval may improve the Mie wind data coverage in aerosol regions.

In addition, we studied the influence of different QC schemes on the validation results and developed a two-step QC approach that ensures effective outlier removal and compliance with the Aeolus mission requirements document. The QC scheme also improves the comparability of different validation studies and thus helps to facilitate the consolidation of the Aeolus error evaluation from different Cal/Val teams.

The contribution presents comparative wind observations of Aeolus and the two DLR airborne wind lidar instruments from the JATAC with a focus on the error assessment and a potential improvement of the Aeolus wind data product.