

# **Airborne Lidar Observations of Wind, Water Vapor, and Aerosol Profiles During The NASA Aeolus Cal/Val Test Flight Campaign**

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## **Responses To Reviewer 2 Comments**

P35 (here and in the Introduction): This would be my major comment here: I do not think that you provide any comparison of HALO measurements with Aeolus since you are not comparing aerosol/cloud related products (and you provide the reader with a good reason for that). You discuss comparison between DAWN, sondes and Aeolus, and comparison between HALO and DHL, but not comparison between HALO and Aeolus.

The text below was in the original manuscript and discusses the reasoning for not showing the HALO/Aeolus aerosol comparisons. The correlation of the aerosol profiles measured between the two instruments during all of the overpasses was very low and we did not feel it was appropriate to include those results given the preliminary nature of the Aeolus L2A optical properties.

“Comparisons between HALO and Aeolus Level 2A atmospheric optical properties products during this Aeolus Cal/Val campaign are not presented here due to current limitations of Aeolus aerosol/cloud discrimination and low sensitivity to aerosol scattering throughout the troposphere. A comprehensive assessment between the Aeolus and HALO HSRL retrievals will be carried upon the next public release of the Aeolus L2A optical properties product, which is expected in the first quarter of 2021.”

P152: Figures 3 and 10 are the first to be mentioned in the paper..? Figure 14 is also presented before Figure (L289). The figures are not presented in the order they are numbered until Section 3. Please fix that issue.

We recognize that typically the first Figure cited is assigned Figure 1. But in our case, we briefly refer ahead to make a short point related to wind retrieval vertical coverage and issues with the dropsonde important to the methodology. Given the flow of the narrative, where we progress sequentially through the various flights in chronological order, it would not make sense to introduce these Figure panels ahead of all the others, so we choose to keep the Figure numbering as is.

P157: GRIP acronym used before being defined here

This has been corrected.

L206 Does HALO provide range-resolved CH<sub>4</sub> measurements along the line of sight or integrated columns? At what wavelength?

The following text was amended/added:

“Though HALO has successfully flown in several field campaigns in the CH<sub>4</sub> DIAL/HSRL configuration, providing weighted CH<sub>4</sub> columns at 1645 nm in addition to aerosol/cloud profiling, the 2019 Aeolus Cal/Val campaign was the maiden deployment for the H<sub>2</sub>O DIAL/HSRL configuration.”

L226-227: what is the expected penetration depth in clouds and in the water?

The penetration depth in cloud and water is dependent on the cloud/ocean extinction in addition and the instrument noise floor. Cloud extinction is highly variable. Penetration depths can be as large as 3 optical depths which can be as deep as 40-50 m in non-productive open ocean waters. We believe this kind of information is beyond the scope of the paper to warrant inclusion of this point in the text.

L232-236: are the HALO data visualized in real time in the aircraft? What do you use then to compute the dry air number density necessary for mixing ratio retrievals?

The following text was added: “The HALO WV data are calculated in real-time for instrument and flight sampling optimization using a standard atmosphere model to convert the measured DAOD to mass mixing ratio.”

L239 Can you explain how DAOD is optimized through wavelength tuning for the viewing scene? By tuning the wavelength to the side of the absorption line? Do you use a priori knowledge of the water content in the atmosphere to proceed with the adjustment? Is this automatized somehow? Or used induced/controlled?

The reviewer is correct, we tune the transmitted wavelength to the side of the line to either increase or decrease absorption based on the water vapor concentration. Although there is a theoretical basis for optimizing the precision of the WV retrieval through optimization of the measured DAOD (Remsberg and Gordley 1978), in practice, the instrument noise characteristics come into play. The optimization is currently done manually by assessing simultaneously a combination of the measured DAOD and the received signal SNR. No a priori information is required. We are in the process of automating this optimization routine. Given this is a high-level mission overview paper we feel that this information is beyond the scope of the paper. We have added the following text for clarification:

“For the Aeolus Cal/Val campaign, HALO was able to demonstrate a precision of better than 10% with 6 km along track averaging when the WV differential absorption optical depth (DAOD) was optimized by tuning the wavelength along the side of the absorption line for the specific viewing scene.”

L264: can the use of the echo over land still be considered valid over flat terrain? Regarding the use over the ocean, is there a threshold on the wave heights beyond which the echo cannot be used to extend the WV profile?

The text in the manuscript was incorrect. The on/off sampling time is 1 ms which corresponds to ~20 cm translation between the on and off footprints at the surface. The surface height and albedo variations within the laser footprint over this scale is negligible. We have demonstrated surface echo DIAL measurements on the HALO CH4 configuration, and those results are currently in preparation for publication. The following text was added to clarify the lack of land surface echo retrievals in this paper.

“Given the majority of the campaign was over the ocean, the detector gain settings were not optimized to keep the land surface echo on scale and therefore the surface echo retrievals are not employed over land for this study.”

P330 do you mean error on winds  $> 8$  m/s (5 m/s)?

The word winds is included in the existing text, so no edits were made to address this question

We used the “estimated HLOS error” parameter provided in the Aeolus Level 2B product, where it is recommended that Rayleigh clear (Mie cloudy) winds with  $> 8$  m/s ( $> 5$  m/s) be excluded (Rennie and Isaksen 2020).

L341 remove one of the Aeolus

This has been corrected

L348: an -> and

This has been corrected