Responses to RC1:

This manuscript presents the calibration algorithms used for the ACDL lidar onboard the DQ-1 satellite, with the analysis of the 532 nm nighttime polarization and high-spectral-resolution channels. This work is of interest to the lidar community. Also, the upcoming launch of EarthCARE with the ATLID lidar in May 2024 will provide opportunity for further comparative studies between these two advanced lidar systems. I appreciate the efforts made in this study and offer some comments for improvement of this manuscript. Additionally, a careful review of the manuscript for English language improvements is advised, as some sections may benefit from further editing for clarity and grammatical accuracy.

AR: We greatly appreciate your valuable time for reviewing our research paper and providing feedback/suggestions.

General comments:

1. Figure 4: The blue dotted line is indistinguishable from other color curves representing iodine vapor absorption. Please enhance the figure's visualization quality for better interpretation.

AR: We feel sorry for our carelessness. The caption below Figure 4 has been corrected to show the **green dotted line** instead of the previously incorrect **blue dotted line**.

2. Figure 7 (a): The large variation in original signals within the SAA region is noticeable, but the overlay of filtered signals obscures the original data in most other regions. Adjusting the transparency level of the filtered data may resolve this issue. This recommendation applies to all subplots in Figure 7.

AR: Thanks for the suggestion. The figure 7 has been reprocessed by changing the line color of the original signal to orange and bold, adjusting color of the filtered data to blue and change the transparency.

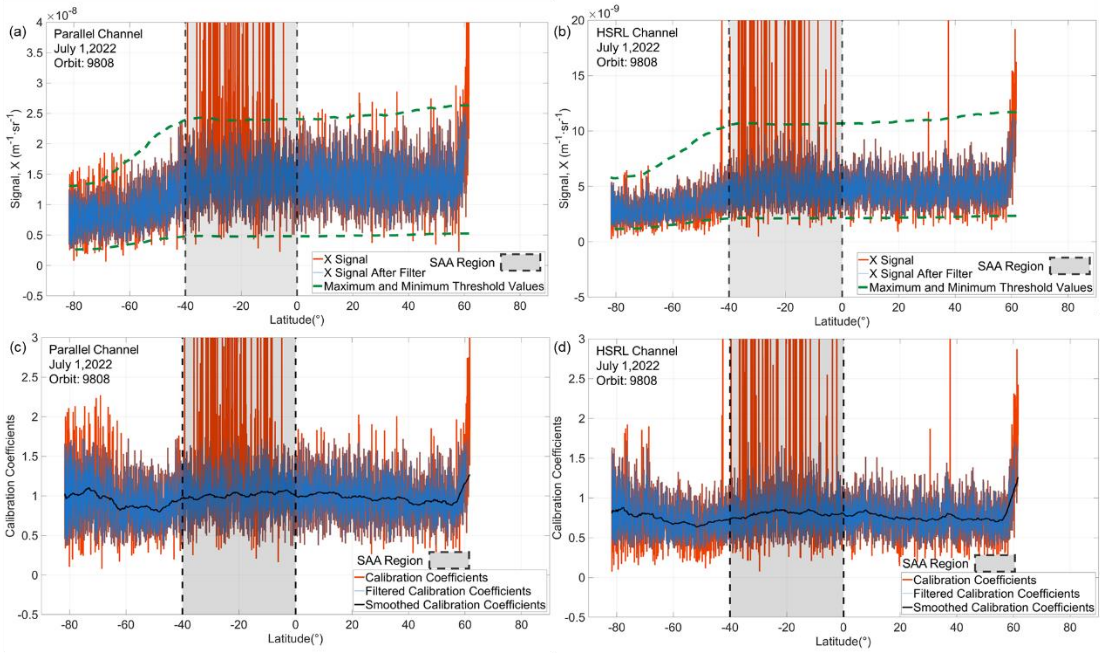


Figure 7: Schematic of the original signal and calibration coefficients after filtering (orbit 9808). (a) The average signal $X^{\parallel}$ as a function of the corresponding latitude for altitudes between 31 and 35 km, 1 July 2022. Within the SAA, there is a significant variation in the original signal, as indicated by the orange lines. The adaptive filter defines the minimum and maximum values with dotted lines, and the blue lines show the signals after filter. And the green dotted lines indicate the range of thresholds; (b) The average signal X^{M} as a function of the corresponding latitude for altitudes between 31 and 35 km, orbit 9808. The lines in Figure 7b have the same meaning as in Figure 7a; (c) The filtered (blue lines) and unfiltered (orange lines) calibration coefficients of the parallel channel. The black line plots the smoothed calibration coefficients; (d) The filtered (blue lines) and unfiltered (orange lines) calibration coefficients of the high-spectral-resolution channel. The black line plots the smoothed calibration coefficients.

3. Figure 7 (c): There appears to be a discrepancy in the upper left legend; it likely should be labeled as "Parallel Channel" rather than "HSRL channel."

AR: We feel sorry for our carelessness. In our resubmitted manuscript, the figure is revised.

4. The error analysis in this manuscript provides a foundation for assessing calibration accuracy. Can the authors discuss how these error metrics compare with those from other missions or standards in atmospheric lidar measurements, which can offer readers a benchmark for assessing ACDL's performance?

AR: Thanks for the suggestion. We focus on the CALIPSO mission, which is also a spaceborne lidar system for cloud and aerosol measurements, as the basis for our error analysis. The calibration procedure used by CALIPSO in version V3 selects a 30-34 km atmosphere as the calibration region, and provides an error impact of 4% for aerosols in this region, combined with an error of 3% for purely molecular backscattering, which leads to a systematic error for calibration algorithm of ~5%. On this basis, CALIPSO has updated the calibration algorithm for latest version V4, which increases the calibration altitude to 36-39 km, which estimated to be 1.6±2.4% (Kar et al., 2018). And the systematic error of ACDL is higher than the calibration algorithm of CALIPSO night V4 version.

We add the text to Line 408 in the manuscript:

Line **408:** The error analysis of the ACDL nighttime calibration procedure refer to the CALIPSO mission, which is also a spaceborne lidar system for cloud and aerosol measurements. The V3 calibration procedure used by CALIPSO provides an error impact of 4% for aerosols, combined with the error of 3% for purely molecular backscatter, which leads to a systematic error for ~5% (Powell et al., 2009). And CALIPSO has updated the calibration algorithm for version V4, which increases the calibration altitude to 36-39 km, which the error estimated to be 1.6±2.4% (Kar et al., 2018). And the systematic error of ACDL is higher than the calibration algorithm of CALIPSO night V4 version

5. The manuscript mentions that ACDL data used in the paper are not publicly available. Given the scientific community's growing emphasis on open data for reproducibility and further analysis, consider discussing plans for data availability or establishing a data repository with access protocols, potentially making a portion of the data available.

AR: Thanks for the advice. We, as the CAL/VAL and Science Application Team, only consider the calibration and validation algorithms from a science application perspective. We're sorry that we can't decide when the data will be released, but we are actively promoting the sharing of the ACDL data. As far as we know, now there is relevant cooperation between ESA and CNSA (China National Space Administration) to promote data sharing mechanisms, and our team is also actively strengthening the cooperation through the Dragon project (between ACDL and EarthCARE). In short, we hope that more people will be able to use ACDL data.

6. The authors mentioned the plans for further validation tests. Can the authors expand on these plans, perhaps by detailing the types of lidar or other atmospheric sensors against which ACDL's data will be validated?

AR: Thanks for your kind reminder. The underflight experiments synchronized with the on-board ACDL are undoubtedly the most effective way to validate the effectiveness of the calibration algorithms. Since the ACDL has not yet carried out these activities, so the content has not been included in this manuscript. The ACDL scientific team is engaged in the targeted development of an airborne lidar that can be utilized for the synchronized experiments. Our CAL/VAL team is monitoring this activity, which will be published in a subsequent paper.

Due to the difficulty of conducting underflight experiments, we have used Raman Lidar from Chinese "The Belt and Road" Lidar Network to carry out the ACDL validation as a supplement. The validation of ACDL has conducted a profile comparison utilizing a dual-wavelength polarization Raman lidar and the CALIPSO satellite. The Total Attenuation Backscatter Coefficient (TABC) and the Volume Depolarization Ratio (VDR) have been validated, respectively, and the validation results are presented in the following table (Liu et al., 2024).

Table 1. Summary of ACDL passes over the ground-based lidar sites.

Observed time (yyyy.mm.dd, local time)	Overpassed site	Closest distance point	Closest distance (km)	Weather condition	TABC bias (%)	VDR bias (%)
2022.06.10, 14:25	Zhangye	100.5° E, 38.9° N	7.0	Clear	-3.93 ± 13.62	-16.28 ± 35.79
2022.07.24, 14:24	Zhangye	100.5° E, 38.9° N	0.2	Clear	-14.49 ± 12.04	-5.73 ± 30.49
2022.06.29, 03:41	Dunhuang	94.6° E, 40.1° N	17.3	Dust	-25.15 ± 18.84	-18.24 ± 40.79
2022.07.10, 03:16	Zhangye	100.5° E, 38.9° N	28.6	Dust	4.25 ± 32.01	6.27 ± 36.23
2022.05.27, 03:17	Zhangye	100.5° E, 38.9° N	13.0	Cloudy	-8.33 ± 30.53	-9.07 ± 54.96
2022.07.06, 14:48	Dunhuang	94.6° E, 40.1° N	8.4	Cloudy	-4.68 ± 23.59	-6.12 ± 41.57

The aforementioned contents have been revised to the following paragraphs of the manuscript.

Line 482: The underflight experiments synchronized with the on-board ACDL not yet implemented, steady progress is being made. As a supplement, the validation of ACDL profiles have conducted a profile comparison utilizing a dual-wavelength polarization Raman lidar and the CALIPSO satellite. The Total Attenuation Backscatter Coefficient (TABC) and the Volume Depolarization Ratio (VDR) have been validated, respectively (Liu et al., 2024). The validation results further demonstrate the accuracy of the calibration algorithm。

Reference:

Liu, Q., Huang, Z., Liu, J., Chen, W., Dong, Q., Wu, S., Dai, G., Li, M., Li, W., Li, Z., Song, X., and Xie, Y.: Validation of initial observation from the first spaceborne high-spectral-resolution lidar with a *ground-based lidar network, Atmos. Meas. Tech., 17, 1403–1417, https://doi.org/10.5194/amt-17-1403-2024, 2024.*

Technical comments:

Lines 75-76: Simplify “with selected chose the region…” to “chose the region…” to enhance clarity.

AR: Thanks, revised.

Lines 80-82: Include the name of the lidar instrument onboard EarthCARE: the ATLID (Atmospheric Lidar).

AR: Thanks, revised.

Line 81: The upcoming deployment of the ATmospheric LIDAR (Light Detection and Ranging) lidar system, ATLID, is part of the payload of Earth Cloud, Aerosol and Radiation Explorer (Earth-CARE) mission has nearly finished ground-based calibration and performance verifications, with post-launch on-orbit calibrations scheduled to follow (Wehr et al., 2023).

Line 139: Suggest rephrasing for clarity: "Defining the normalized signals is a necessary first step for the different channels including:"

AR: Thanks, revised.

Line 146: Defining the range-scaled energy and gain-normalized signals (hereinafter normalized signal) is a necessary first step for the different channels including:

Line 151: Align the order of terms (molecular, ozone, aerosol) with their presentation in Eq(5).

AR: Thanks, revised.

Line 170: selects 31 -35 km as “the” calibration regions.

AR: Thanks, revised.

Line 171: Clarification needed – replace “subsection” with “the following paragraphs” if subsections are not explicitly defined.

AR: Thanks, revised.

Line 182: This sentence is unclear, please rephrase.

AR: Thanks, we have revised the sentence as follow:

Line 190: The ERA5 dataset provides hourly averaged global atmospheric parameters with 37 barometric pressure levels, and on a 0.25° latitude × 0.25° longitude resolution grid. The ERA5 global data is aligned with the altitude, latitude and longitude of the ACDL profiles.

The aerosol scattering ratio in Eq. 11 is given by the following equation

Line 197: If available, include more recent references regarding this lidar ratio selection.

AR: Thanks, we have added reference to line 205: Richard B Miles et al., 2001

Line 208: Ensure consistency in the order of terms as previously mentioned.

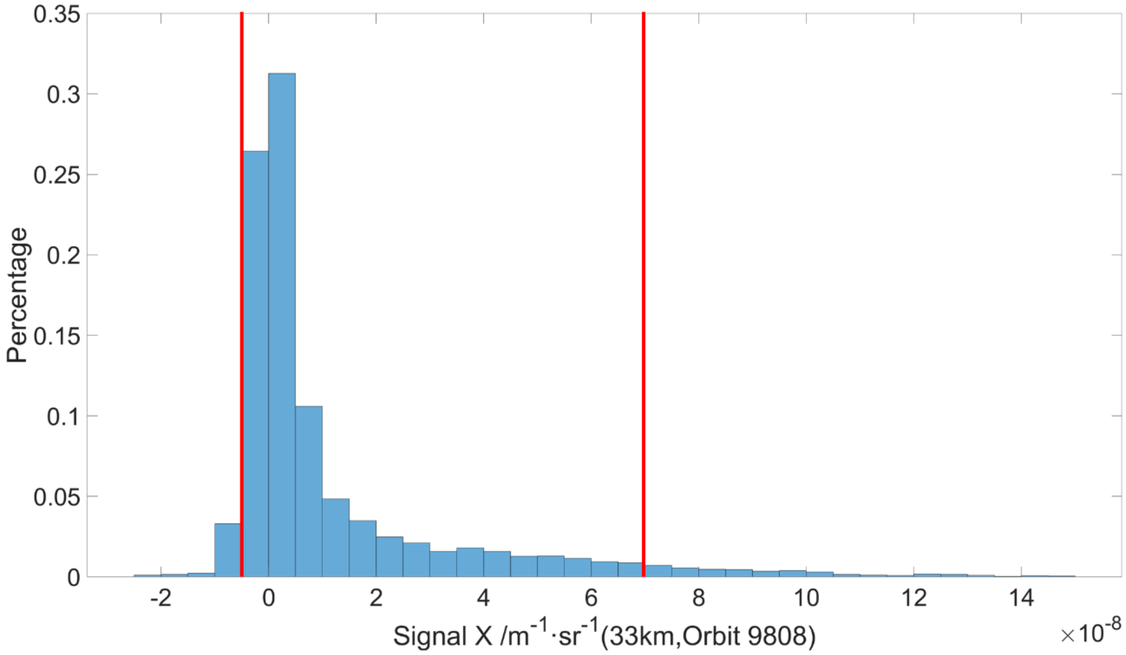
AR: Thanks, revised.

Line 285: Correct to "Eq. (26) is" since only one equation is referenced.

AR: Thanks, revised.

Line 289: Please provide details on defining the empirical scaling factor km, including the specific factor used in this study.

AR: Thanks for pointing these issues. We performed a statistical analysis of the signal intensity distribution of signals (as shown in the figure below). The intensity of signal distributions that are significantly higher (or lower) than the measured values are used as the basis for selecting the scaling factors. In this research, the scale factors are chosen as -0.5 and 1.5.



Signal distribution and filtering scheme for 33 km (Orbit 9808)

Line 321: The selection of the scaling factor is based on the statistical analysis of the signal intensity distribution of the high-energy signals, Since the ACDL signal basically follows the Poisson distribution, with drastic changes in the low value region and smoothness in the high value region, different factors are selected in the high and low value regions to ensure the accuracy of the data. Therefore, in this study, the scaling factors were chosen to be asymmetrical -0.5 and 1.5.

Figure 7: The subfigure labels (a)(b)(c)(d) are missing or unclear.

AR: Thanks, revised.

Line 328: Eqs. (32) and (33) are mentioned prematurely; they are introduced in the subsequent section.

AR: Thanks, revised. “Eqs. (32) and (33)” ➔ “Eqs. (26) - (28)”.

Line 370: A delta symbol is missing before PGR; please verify.

AR: Thanks, revised.

Line 391: Amend to “can also be assessed” for grammatical accuracy.

AR: Thanks, revised.