Responses to RC2:

The manuscript describes the nighttime calibration of the spaceborne HSR lidar ACDL/DQ-1. It is important to clarify how the signals are calibrated. There is some heritage of the CALIPSO mission, and something to learn for the new EarthCARE mission. At parts the authors present great details, but at others the authors go rather quick over some issues. In general, the paper is good and should be published after major revisions.

AR: Thanks for investing your valuable time in thoroughly reviewing our manuscript and providing us with constructive feedback and suggestions.

Major comments:

1. Please show the calibration of the cross-polarized channel as well. I am not satisfied to state that it is the same except with the polarization gain ratio (PGR). You might provide in the supplement all the figures for the cross-polarized channel which you have provided for the parallel-polarized and HSRL channel in the manuscript.

   AR: Thank you for raising this issue. We have included the results of perpendicular channel background signal and calibration coefficients in Figure 2, Figure 7 and Figure 14.

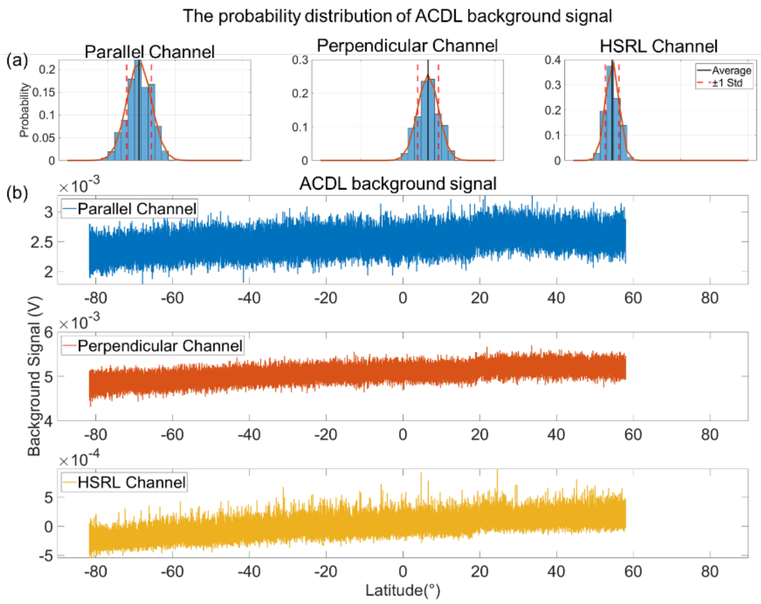


Figure 2: The ACDL collected background signal along latitude and its probability distribution in the parallel, perpendicular and HSRL channels (orbit 9928, for July 1st, 2022). (a) The probability distribution of the background signal in parallel, perpendicular and HSRL channel; (b) The background signal along latitude in parallel, perpendicular and HSRL channel.

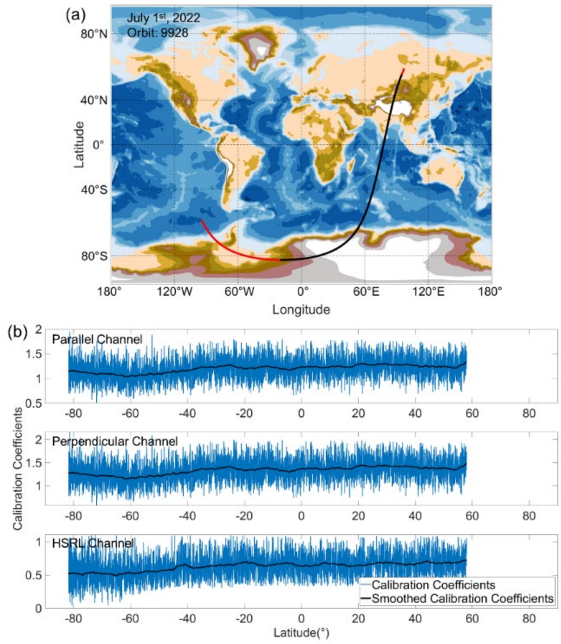


Figure 7: The calibration coefficients for each calibration region, the calibration coefficients for parallel-polarized channel normalized by $4.99*10^{14}$ m^3srJ^{-1}, perpendicular-polarized channel normalized by $1.51*10^{15}$ m^3srJ^{-1} and $1.16*10^{15}$ m^3srJ^{-1} for the HSRL channel. (a) The example orbit 9928 for July 1st, 2022 (red line), and the orbital track segment that corresponds to calibration coefficients (black line); (b) The estimated parallel, perpendicular and HSRL channels calibration coefficients from the 3.6 km average (blue line) and the smoothed calibration coefficient results after 500 km sliding average (black line) are displayed.

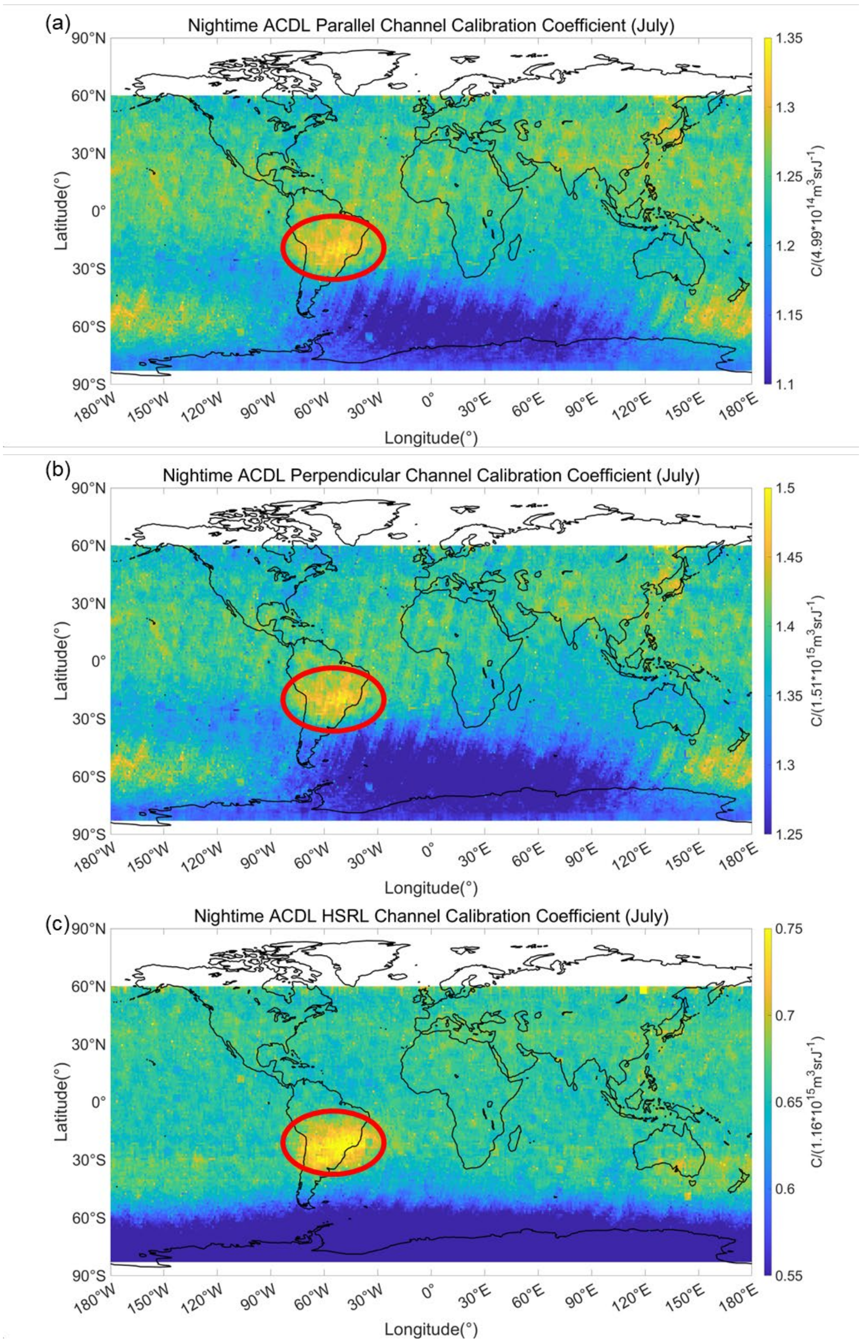
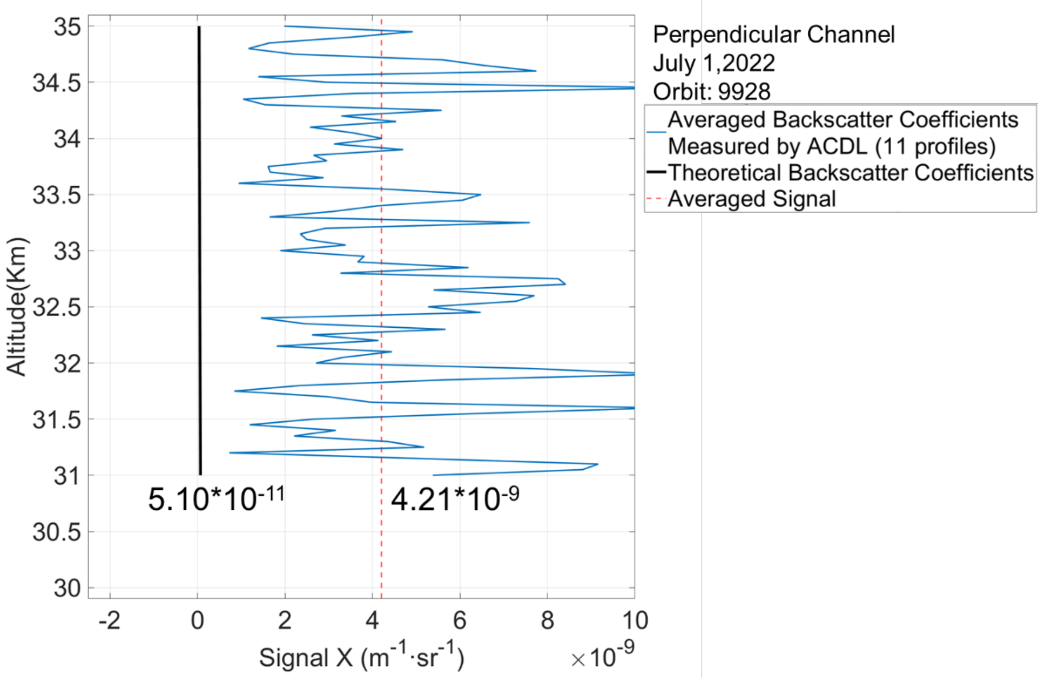


Figure 14: Result of global calibration coefficient on a 1° latitude × 1° longitude grid for July, 2022. (a) The results of parallel channel, (b) the results of perpendicular channel and (b) the results of HSRL channel. The red circles indicate the SAA region.

The perpendicular channel signal acquisition in the 31-35 km calibration region at high altitude is shown in the figure below. Since the calibration region contains only atmospheric molecules and the atmosphere is thin, and the depolarization ratio of atmospheric molecules is 0.0036, it is hard to accurately acquire signals in the perpendicular channel that are purely supplied by atmospheric molecular depolarization. Under these conditions, the backscattered component of the 532 nm perpendicular polarization calculated using the model will be much smaller than the dynamic range of the detector, so it is hard to directly employ the same molecular normalized calibration technique as the parallel and HSRL channels. As demonstrated in the following example, the averaged theoretical backscatter is $5.10*10^{-11}m^{-1}sr^{-1}$, while the mean value of ACDL measured in the perpendicular channel is $4.21*10^{-9}$ $m^{-1}sr^{-1}$. For these reasons, the current perpendicular channel calibration procedure that we adopt is based on the polarization gain ratio (PGR) (Hostetlar, 2006; Powell, 2009), i.e., $C^{\perp} = C^{\parallel} * PGR$ from the deformation of Eq. 23.



The backscatter coefficients for the theoretical and the perpendicular-polarized channel

2. The PGR is discussed in L264 onwards. However, important points are missing. One point, which is presumably hard to characterize on ground is the angle in the polarization plane between the emitter and the receiver. Further uncertainties might originate from impurities in the laser polarization. These uncertainties are not included in the systematic error assessment in Sect. 3.1. L271 onwards, you state that “based on the statistical analysis of the measured signals over a long time, it can be concluded that the gain of the ACDL is consistent with that of the ground at this stage." Please proof it. Actually, the insertable depolarizer is included to check the PGR in flight. Please make use of it and proof that it is the same as on ground.

AR: Thanks for your kind reminder. As you mentioned, the measurement of PGR is indeed influenced by a various factor, including the laser polarization purity, the transmittance of the polarization beam splitter, and the angle of the polarization plane between the emitter and receiver (Bravo-Aranda, J. A. et al., 2016). During the measurement of the ground experiment, these errors were systematically considered, including the 1000:1 polarization purity of the PBS, the laser outgoing polarization state of 500:1, control of polarization plane angle by using mechanical components, and other relevant factors, which resulted in a final PGR measurement error of ~1%. By ensuring the accuracy of the ground-measured PGR and based on the assumption that the PGR did not change significantly in the short time after launch, the PGR value and its measurement error are used for calibration of the perpendicular channel. And we also realize that using the insertable depolarizer on-board can better demonstrate the actual PGR variation, and we are actively communicating with relevant departments to activate the on-board measures to verify this conclusion. Unfortunately, permission has not yet been granted to complete this on-board calibration process, so we will use the current values until the actual on-board PGR is available. Thank you again for raising this issue. In the absence of on-board PGR data, the description in the manuscript is indeed inaccurate (the stability of the PGR could not be proven just by the stability of the signal strength and the ratio of the two channel signals), and we have revised the description in the text as follows:

L271: "based on the statistical analysis of the measured signals over a long time, it can be concluded that the gain of the ACDL is consistent with that of the ground at this stage." ➔

"Given that the insertable depolarizer had not yet been initiated, the calibration procedure in this study employed the laboratory-calibrated PGR. The ground experiments of the PGR are carried out under the simulation of consistency with the on-board measurement state. "

Reference:

Bravo-Aranda, J. A., Belegante, L., Freudenthaler, V., Alados-Arboledas, L., Nicolae, D., Granados-Muñoz, M. J., Guerrero-Rascado, J. L., Amodeo, A., D'Amico, G., Engelmann, R., Pappalardo, G., Kokkalis, P., Mamouri, R., Papayannis, A., Navas-Guzmán, F., Olmo, F. J., Wandinger, U., Amato, F., and Haeffelin, M.: Assessment of lidar depolarization uncertainty by means of a polarimetric lidar simulator, Atmos. Meas. Tech., 9, 4935–4953, https://doi.org/10.5194/amt-9-4935-2016, 2016.

3. Later, you state that PGR has an uncertainty of 1% (L446). How did you determine it? The same question was asked by the Anonymous Referee #2 to your previous submission and you haven't answered it in the re-submission.

AR: Thank you for raising this issue. As previously indicated, a series of measures were implemented during the laboratory measurement to ensure the accuracy of the PGR measurements. The error of this measurement was defined as 1%. It is important to note that this error may not be an exact match to the true measured PGR error. However, prior to the implementation of the PGR on-board calibration, the ACDL calibration procedure in this study accepted this discrepancy and conducted an error analysis. The following description has been incorporated into the manuscript:

L446: "During the measurement of the ground experiment, various errors were systematically considered, including the 1000:1 polarization purity of the PBS, the laser outgoing polarization state of 500:1, control of the polarization plane angle by using mechanical components, and other relevant factors (Bravo-Aranda, J. A. et al., 2016). "

4. It remains unclear who you combine the parallel and cross-polarized signal to get the total signal for the attenuated backscatter coefficient. Please explain and provide formulas and uncertainties.

AR: We feel sorry for our carelessness. The manuscript has modified Eq. 36 in the article to explain that how to calculate the total attenuation backscatter coefficient, and the error obtained by combining the uncertainties of the two channels separately.

$$R_{CA}(z_{8-12},k)=\frac{\beta'_{total}(z_{8-12},k)}{\beta'_m(z_{8-12},k)}=\frac{\beta'_{\parallel}(z_{8-12},k)+\beta'_{\perp}(z_{8-12},k)}{\beta'_m(z_{8-12},k)}=\frac{\beta_m(z_{8-12},k)+\beta_a(z_{8-12},k)}{\beta_m(z_{8-12},k)}. \quad (36)$$

$\beta'_{total}(z_c)=\beta'_{\parallel}(z_c)+\beta'_{\perp}(z_c)$		
$(\frac{\Delta\beta'_{total}(z_c)}{\beta'_{total}(z_c)})s$	$\frac{\Delta\beta'_{\parallel}(z_c)}{\beta'_{\parallel}(z_c)}$	$\frac{\Delta\beta'_{\perp}(z_c)}{\beta'_{\perp}(z_c)}$
0.07	0.05	0.05

5. You nicely characterize the iodine vapor cell in Fig 6. But how does the Fabry-Perot etalon perform? Please comment on it and add some more details about it.

AR: Thank you for pointing out this issue. As shown in the figure below, the transmission of the F-P etalon remains above 0.85 near the center wavelength (532.2453 nm), which is able to completely cover the broad range of molecules in the upper atmosphere. And the transmittance of the F-P etalon is calculated by eq. 22. In the revised manuscript, we have modified the Figure 6:

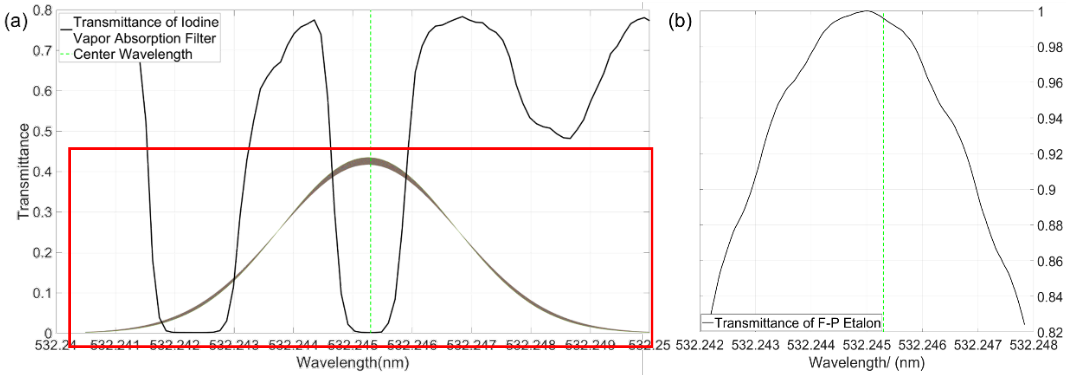


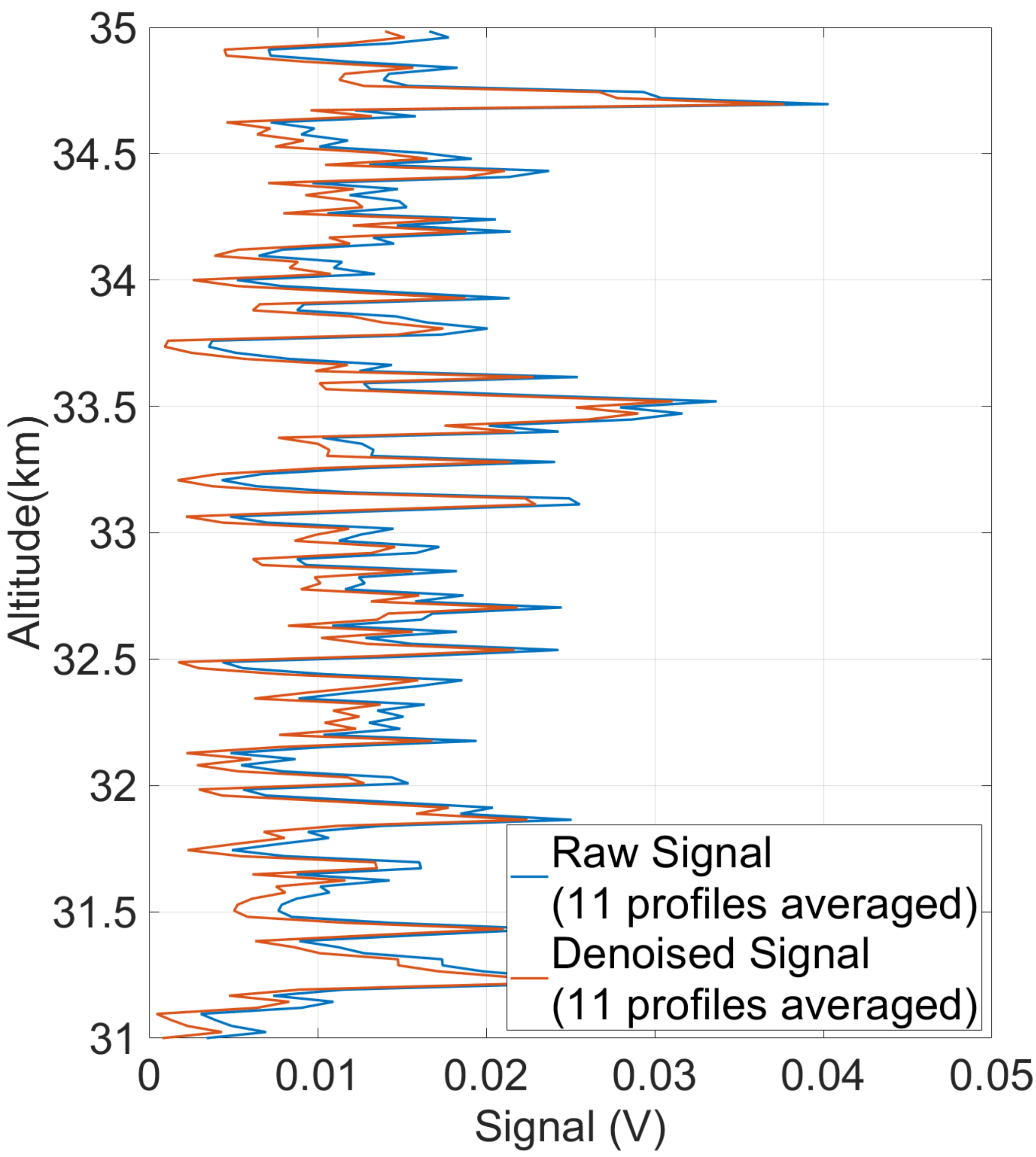
Figure 6: Transmittance function (black line) of (a) the iodine vapor absorption filter (green dotted line means the center wavelength, and multiple color curves means normalized Rayleigh scattering function at 30–40 km) and (b) the F-P etalon.

6. How do you keep the laser frequency stable at the iodine vapor cell wavelength? How do you deal with spectral cross-talk?

AR: Thank you for pointing out this issue. The ACDL receiving system utilizes a narrow-band filter and an F-P etalon to filter the received optical signals. This ensures that signals entering the system are within the vicinity of 532.245 nm. This approach guarantees that the wavelengths of light entering the iodine vapor absorption filter and other optical components are all situated close to the center wavelength of the transmitting laser, thereby preventing spectral crosstalk.

7. You mention the denoised lidar signal (e.g., L136). How do you denoise your signals? Please elaborate on it. And how the denoising might affect the later described filtering.

AR: Thanks for your kind reminder. Subsequent to the acquisition of the background signal (background noise) for each profile across all channels, the background signal is removed by subtractive from the entire profile. This process serves to mitigate the impact of background signals in the raw signal, which is attributable to background signal present in the instrument itself and some environmental factors. Given the existence of the background signal in each bin of the profile, its subtraction is imperative to avoid affecting the overall degree of the data for calibration and the offset in subsequent filtering, thereby ensuring the integrity of the calibration results. As demonstrated in the figure below, a comparison is made between the raw signal and the denoised signal after subtraction of the background. It is evident that the signal undergoes a significant drift.



The comparison between the raw signal and the denoised signal

8. I am a bit puzzled about your low altitude verification. Why do you use the 8 – 12 km height range? In Fig. 12, you mark the red boxes at 26 – 30 km height, because obviously between 8 and 12 km is the huge cirrus cloud. In other words, aerosol particles and clouds are often present in the 8 – 12 km range. So, I would not expect a scattering ratio of 1 in this height range. The 1.03 shown in Fig. 13 seem to be reasonable. However, you cannot conclude on your calibration, because the true value is maybe not 1.0 but a bit higher.

AR: We feel sorry for our carelessness. An error was identified in Figure 12 of the manuscript, which has been revised in the manuscript by adjusting the red box to the correct position. In the 8-12 km, the presence of aerosols and clouds. To ensure the validity of the study, a clear sky area devoid of clouds was selected as the study area, thereby minimizing the impact of cloud effects. Given the uncertainty surrounding the estimation of aerosols, it was assumed that the 8-12 km range does not contain aerosols under clear-sky conditions, thus providing a reference value of 1 (Powell et al., 2009). However, the ACDL measurements indicate that the impact of aerosols in this region, with actual measurements exhibiting fluctuations around 1.03.

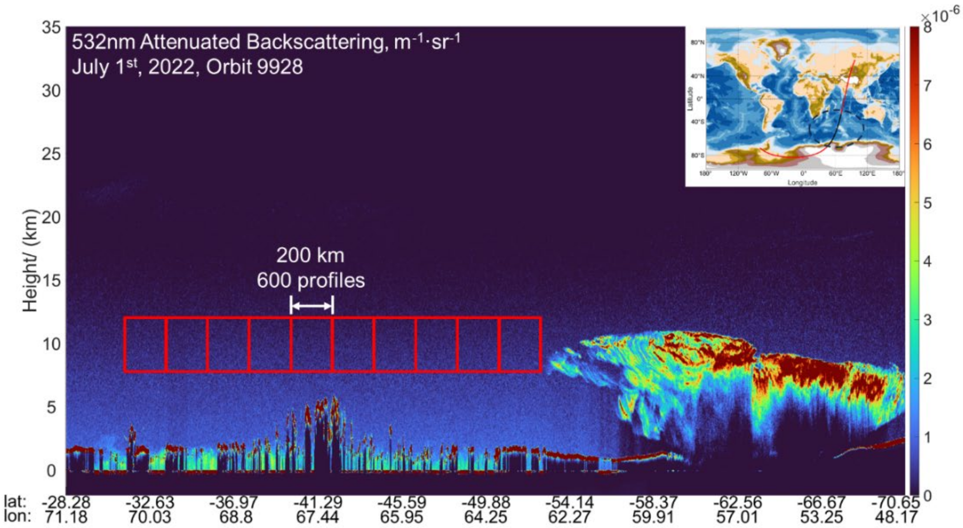


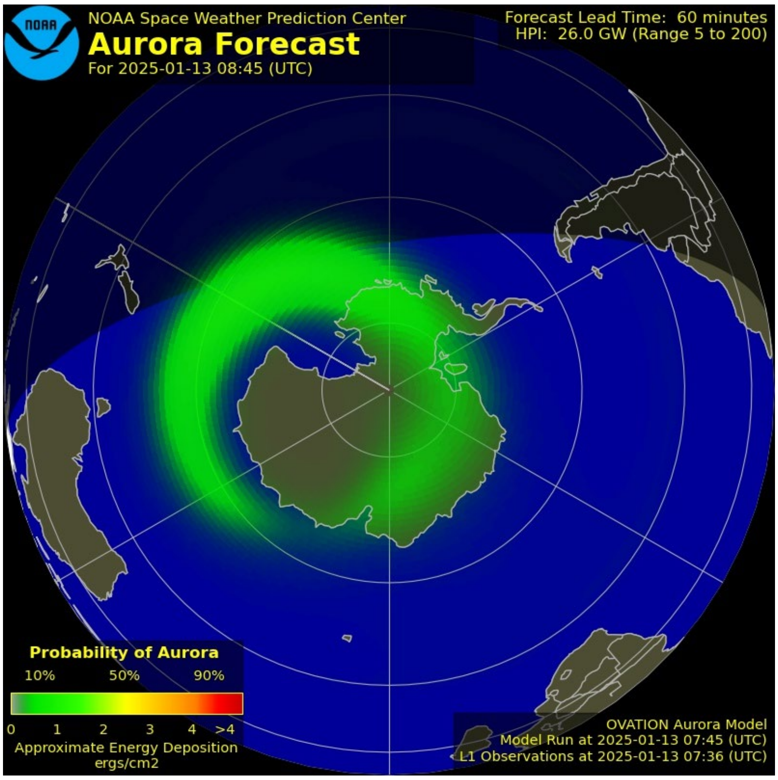
Figure 12: Lidar 532 nm total attenuated backscatter coefficient (m–1sr–1, 1 July 2022). The clear-sky regions are illustrated by red boxes, spanning 200 km in length and ranging from 26 to 30 km in altitude. The upper right figure displays the range of track (black line).

9. The behavior of the calibration constant in Fig. 14 misses any explanation except the SSA. Why does the southern Pacific Ocean behave differently than the same latitudes over the Atlantic and Indian Ocean?

AR: Thanks for your kind reminder. The observed variation in calibration coefficients at a given latitude is near the South Pole attributable to the uneven distribution of auroras within the Antarctic polar night region (as shown in figure below) during July. This phenomenon underscores the inadequacy of prevailing background signal acquisition algorithms in mitigating noise from the aurora in polar regions. Subsequent algorithm updates will address this shortcoming through enhanced analysis and refinement. And the relevant descriptions in the manuscript have been revised:

L529: "In addition, elliptical regions of increased calibration coefficients near the poles can be seen, due to auroras near the poles (Hunt et al., 2009). " ➔

"In addition, elliptical regions (the latitude is near the South Pole) of increased calibration coefficients near the poles can be seen, due to auroras near the poles (Hunt et al., 2009). "



The distribution of the Antarctic Aurora (2025.1.13)

Reference:

https://www.swpc.noaa.gov/products/aurora-30-minute-forecast

10. One should separate between verification and validation. Validation always includes external observations (suborbital or from another satellite), whereas verification can be done with only one's own data. In your case, you present verification and refer to Liu et al., 2024, for validation. Maybe some more comments on the validation presented in the other paper might be helpful at this point.

AR: We are grateful for the valuable advice. We have revised the assessment by using ACDL data to verification in section 3.2, and provided a detailed description of the validation work carried out using ground-based lidar.

L518: “As a supplement, the validation of ACDL profiles have conducted a profile comparison utilizing a dual-wavelength polarization Raman lidar the (Belt and Road lidar network, BR-lidarnet, initiated by Lanzhou University in China) and the CALIPSO satellite. The profiles of the total attenuated backscatter coefficient (TABC) and the volume depolarization ratio (VDR) at 532 nm were compared by three lidar system in six cases. The findings indicate that the relative deviation between the ACDL and ground-based lidar measurements was approximately −10.5 ± 25.4% for the TABC and −6.0 ± 38.5% for the VDR (Liu et al., 2024). The observed discrepancies can be attributed to the presence of systematic errors in the ACDL, as well as measurement errors associated with the ground-based lidar. Additionally, ACDL exhibited a high degree of consistency when compared with the observations made by CALIPSO (Liu et al., 2024; Zha et al., 2024). The validation results further demonstrate the accuracy of the calibration algorithm. “

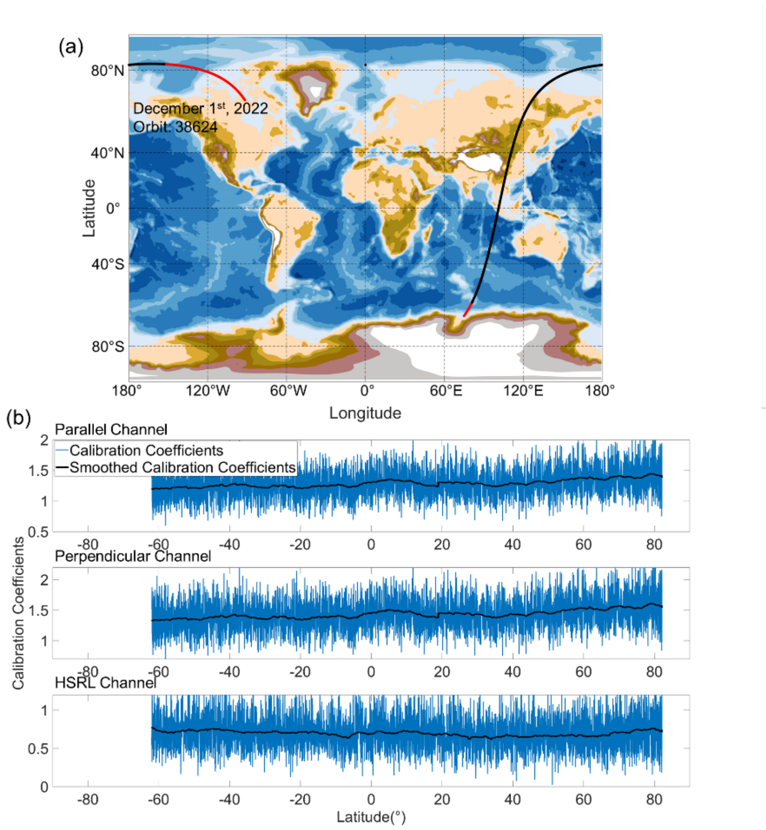
Reference:

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.

Zha, C., Bu, L., Li, Z., Wang, Q., Mubarak, A., Liyanage, P., Liu, J., and Chen, W.: Aerosol optical property measurement using the orbiting high-spectral-resolution lidar on board the DQ-1 satellite: retrieval and validation, Atmos. Meas. Tech., 17, 4425–4443, https://doi.org/10.5194/amt-17-4425-2024, 2024.

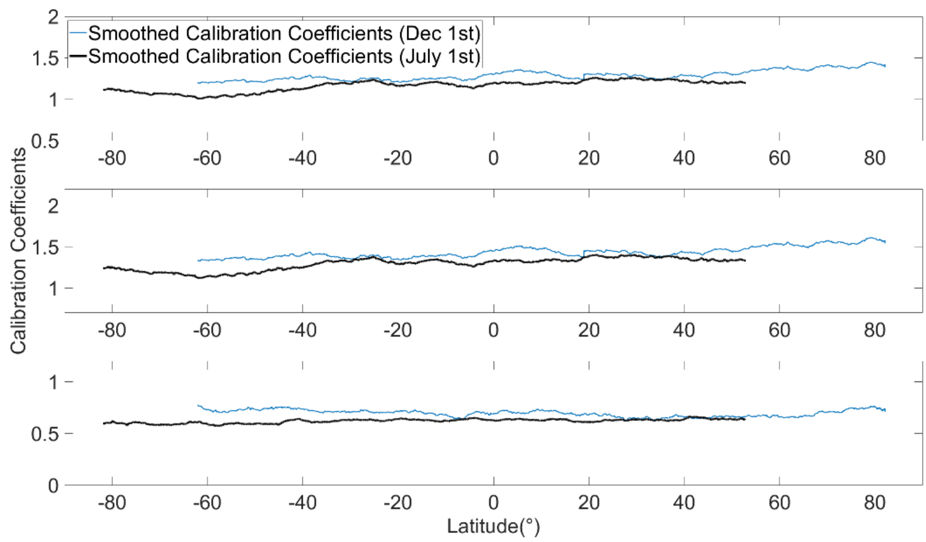
11. The results are shown for observations in 2022. Could you comment on the stability of the calibration constant over the years, e.g., by showing an example from 2024. Does the calibration constant changes with time?

    AR: Thanks for your kind reminder. The calibration coefficients are known to undergo changes over time due to alterations in on-orbit operational status. These changes are currently under observation and analysis. The figure below shows the results of the calibration coefficients for the example orbit in December 1st, 2022.



The calibration coefficients for each calibration region (orbit 38624 for December 1st, 2022)

As demonstrated in the following figure, there is a slight increase in the December calibration coefficients compared to the July data.



Comparison of the calibration coefficients (July 1st and December 1st)

12. The manuscript has been previously submitted as https://doi.org/10.5194/egusphere-2024-588 and was not accepted. Especially, the Anonymous Referee #2 provided valuable comments on the manuscript. Many of his/her comments were included in the current version to improve the manuscript, but some are still missing, e.g., the determination of the PGR or a clear discussion about the variations in the calibration constant (Fig. 14). As a reviewer, I feel disappointed that not all comments from a previous review process were carefully included in the manuscript. Please take again his/her comments and improve the manuscript accordingly. I will try to check it while reading the revised version.

AR: Thanks for your kind reminder.

The thorough re-examination of the constructive feedback provided by Anonymous Referee #2 has been conducted, the missing comments have been revised. The revise includes the calibration coefficient units, which pertain to the neglect of sensitivity and optical efficiency of each channel. The aforementioned clarifications have been incorporated into Figures 7 and 9. Concurrently, modifications have been made to the background signal acquisition algorithm, which have led to the exclusion of certain previously encountered issues, such as anomalous changes in the calibration coefficients within the strong backscatter region. An explanation was also provided for the reduction of the calibration factor in the Antarctic region. If there are still problems that have not been explained in the manuscript, please continue to point them out, and we will make further revise in the manuscript.

L549: "Concurrently, it is observed that the ACDL calibration coefficients demonstrate a downward trend in all three channels within the Antarctic region and its adjacent areas. This phenomenon can be attributed to the reduced signals resulting from the thin atmosphere at polar regions, in conjunction with the absorption of high-latitude trace gases into the laser."

The ACDL scientific team is currently engaged in communication with the satellite control department to arrange for an on-board PGR calibration experiment. This initiative aims to validate the effectiveness of the PGR and further refine the calibration algorithm. Pending the execution of this experiment, the calibration algorithm will persist in its utilization of the prevailing laboratory-provided PGR values and errors.

As July 2022 is the closest month to the launch of the satellite with complete data, this paper elects to present the calibration coefficients using data from July 2022 instead of March or September, as referenced in Anonymous Referee #2. Following the implementation of corrections to the background signal algorithm, the calibration coefficients exhibited a substantial reduction in the variations initially observed in regions of significant backscatter (e.g., polar ice, etc., as shown in Figure 14).

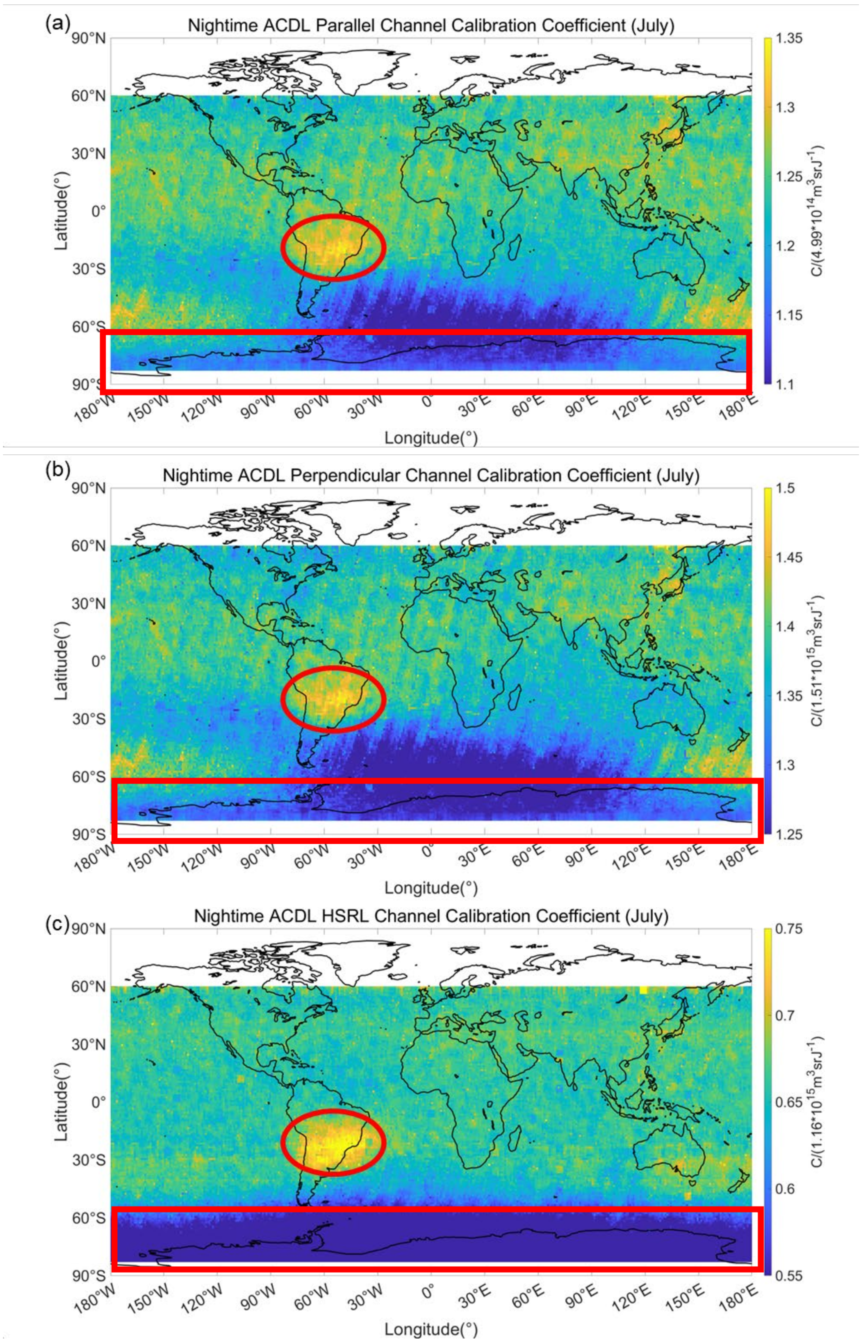


Figure 14: Result of global calibration coefficient on a 1° latitude × 1° longitude grid for July, 2022. (a) The results of parallel channel, (b) the results of perpendicular channel and (b) the results of HSRL channel. The red circles indicate the SAA region.

13. Unfortunately, the data are not publicly available which hampers the validation support by suborbital measurements from various lidar groups. And as a consequence, it hampers the validation of ACDL with data from different geographic regions.

AR: Thanks for your kind reminder. The ACDL scientific team is making every effort to push for the data publicly available, while our team is actively strengthening the collaboration through the Dragon project (between ACDL and EarthCARE). In the future we will cross-validate with EarthCARE. Data underlying the results presented in this paper are not publicly available at this time but may be obtained from the authors upon reasonable request.

Specific comments

1. I welcome, that the title just contains the abbreviation of the satellite's name and the description is given in the first lines of the abstract. Sometimes, the journal requests to not use abbreviations in the title, but here I support the authors and prefer the way as they have done it.

AR: Thanks for your kind reminder.

2. L44 I would not call it particle backscatter if you include both aerosol and molecules.

AR: Thanks, revised. L44 "particle (include both molecules and aerosol)" ➔ "molecular and aerosol"

3. The introduction consists of 3 blocks which are consistent within each block, but are loosely linked to each other. Block 1 (L31-55) describes the satellite, block 2 (L56-86) presents the history of lidar in space and block 3 (L89-99) outlines the optical setup of the receiver. I would move block 3 out of the introduction and to Section 2. And then, you can ponder how to arrange the introduction best. Maybe a general introduction, then the history (block 2) and then presenting your satellite (block 1)? However, it is just a suggestion, and not a recommendation.

AR: Thanks, revised. The revised manuscript has relocated block 3 from the introduction to Section 2.

4. In Fig. 2 – Could you provide a date for the orbit? And please already state a bit earlier, that during summertime there is daylight north of 60°N.

AR: We feel sorry for our carelessness. In the revised manuscript, we have incorporated orbital dates into the caption of Figure 2, updated the normal distribution curves, and included the following description:

L124: "The data from July 1, 2022 (orbit 9928), was selected for the subsequent background signal illustration, encompassing a latitude range from -80°S to 58°N, comprise only the nighttime data. "

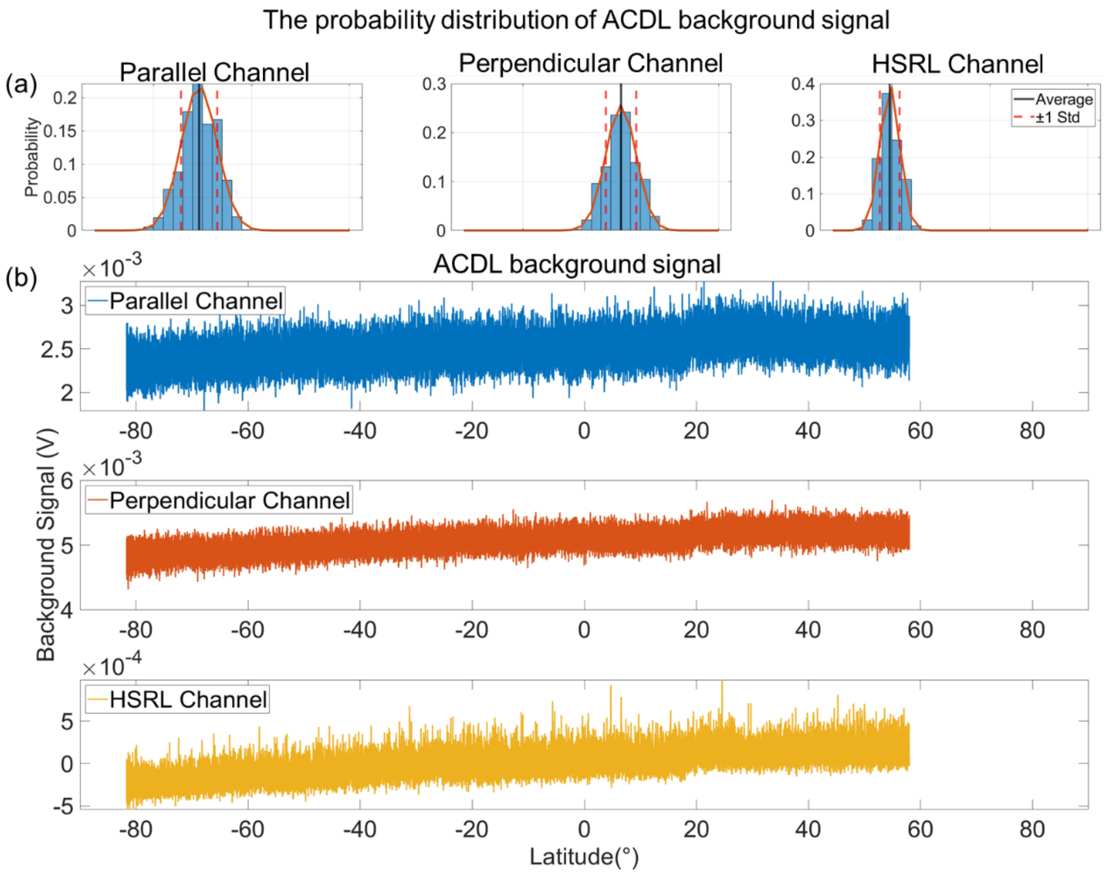


Figure 2: The ACDL collected background signal along latitude and its probability distribution in the parallel, perpendicular and HSRL channels (orbit 9928, for July 1st, 2022). (a) The probability distribution of the background signal in parallel, perpendicular and HSRL channel; (b) The background signal along latitude in parallel, perpendicular and HSRL channel.

5. L130 onwards: You describe the 6 steps quite short here. Please mention, that you'll describe them in greater detail later on.

AR: Thanks for your kind reminder. We have added detailed descriptions for each step in the manuscript, revised as follows:

L130: "Step 1: Removes the background signal from the ACDL raw signal to provide a background-free signal for subsequent calculations. Subsequent to the acquisition of the background signal for each profile through the implementation of the background signal acquisition algorithm, the background value is subtracted from each profile. This process yields a denoised signal, which can then be utilized for the subsequent filtration of data;

Step 2: The molecular transmittance and ozone absorption at 532 nm within the calibration regions are computed using the ERA5 atmospheric prediction model data provided by ECMWF. Additionally, the molecular backscattering at the corresponding location is calculated based on its pressure and temperature data. Then the transmittance effects due to the Fabry-Pérot etalon (F-P etalon) and the iodine vapor absorption filter following the ACDL system design are computed. Match the denoised lidar signal with the above calculated molecular and ozone transmittance, molecular backscatter coefficients and lidar instrument transmittance in elevation and geographic coordinates. And then compute the range-scaled energy and gain-normalized signal;

Step 3: Evaluate the signal quality and atmospheric aerosol distribution, determine calibration range and horizontal average distance, and screen the signals for calibration procedure. The parallel-polarized channel and HSRL channel of the ACDL use molecular normalization technique, which requires that as much as possible purely molecular atmospheric regions within the data frame be selected for calibration. After balancing the signal quality and atmospheric environment, 31-35 km is adopted as the calibration region for ACDL. To minimize the effect of random errors, the raw signal is first averaged over 11 profiles. Subsequently, a three-step adaptive data filter is implemented to obtain valid data that can be used for subsequent calibrations;

Step 4: Calculate the calibration coefficients for the parallel and high-spectral-resolution channels, and then determine the calibration coefficients for the perpendicular-polarized channel based on the polarization gain ratio. The calibration coefficients for the three channels are calculated using the formulas in Section 2, and the initial usable calibration coefficients are obtained by sliding averaging along the track over 500 km;

Step 5: Obtain the global calibration coefficients by sliding averages in the along-track and adjacent-track directions using valid data. The full-month global calibration coefficients are obtained through a process of further adjacent-track averaging and data accumulation. The adjacent-track averaging involves the calculation of all valid data available for calibration over the entire 500 km (along track) * 500 km (adjacent-track) range of the month. This process yields the global calibration coefficient results for the entire month;

Step 6: Compute the attenuated backscatter coefficient profiles. The raw profiles were calibrated using the global calibration coefficients to obtain the attenuated backscatter coefficient profiles for subsequent use in product inversion."

6. L203: How do you align ERA5 to your ACDL profiles? Interpolation? Nearest-neighbor?

   AR: We feel sorry for our carelessness. The study used cubic spline interpolation when align the ERA5 to ACDL profiles, which is described in the documentation as follows:

   L205: "The ERA5 global data is aligned with the altitude, latitude and longitude of the ACDL profiles. " ➔

   "The ERA5 global data has been aligned with the altitude, latitude, and longitude of the ACDL profiles through the implementation of cubic spline interpolation. "

7. L222: "backscatter as the central Cabannes line" – unclear formulation, maybe something like "backscatter because only the central Cabannes line"

   AR: Thanks, revised. L222 "backscatter as the central Cabannes line" ➔ "backscatter because only the central Cabannes line"

8. L258-260: Unclear formulation. What do you mean with additional schema in Fig. 6? The F-P etalon? Please discuss the F-P etalon in greater detail (see major comment above).

   AR: Thank you for pointing out this issue. The additional schema in Fig. 6 (red box in figure below) means normalized Rayleigh scattering function at 30–40 km. And the transmittance of the F-P etalon has added in the Figure 6:

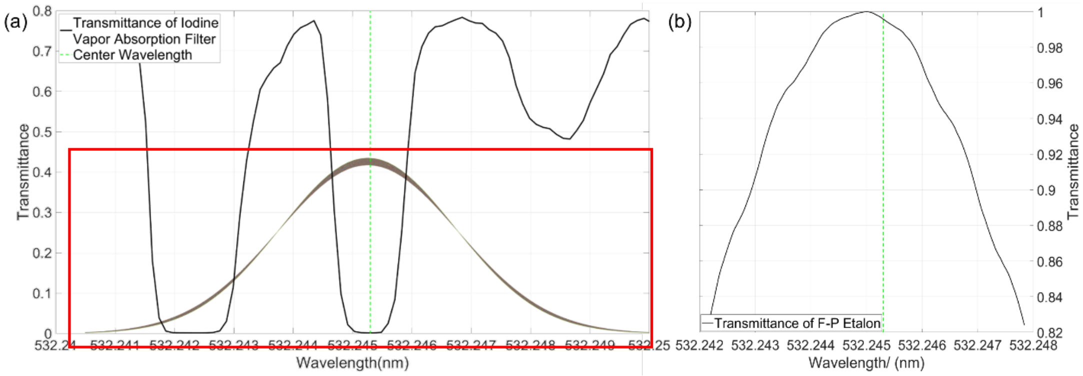


Figure 6: Transmittance function (black line) of (a) the iodine vapor absorption filter (green dotted line means the center wavelength, and multiple color curves means normalized Rayleigh scattering function at 30–40 km) and (b) the F-P etalon.

9. L280: Unclear formulation. Does it mean what the calibration module in Fig. 1 emits an additional laser beam? Please explain the module in greater detail.

   AR: We feel sorry for the misunderstanding. This description has been removed from the revised manuscript.

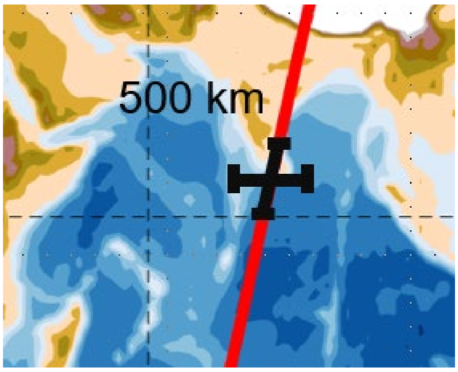
10. L305: C is not shown as a function of C~, but as a function of latitude.

    AR: Thanks, revised.

11. L315: What do you mean by the adjacent-track distances? Do you use it already to derive global calibration constants? Please show it. Or do you just use the 500 km sliding average? It is not clear from your text.

    AR: We feel sorry for the misunderstanding. This description has been modified in the revised manuscript.

    L330: "Therefore, the final calibration coefficients for each position are obtained by averaging over a range of 500 km (along track) and 500 km (adjacent-track)."



Average range of the calibration coefficients

12. L344: How do you select the different factors. Please give a reasoning for the selection. Ideally would be to show how they are selected. Based on which criteria?

    AR: Thank you for raising the issue. Since ΔX represents the standard deviation of the difference between measured and theoretical values, the selection of k_m varies between ±3 according to the 3σ principle.

13. Fig. 8+9 Please show the cross polar channel as well (or in the supplement).

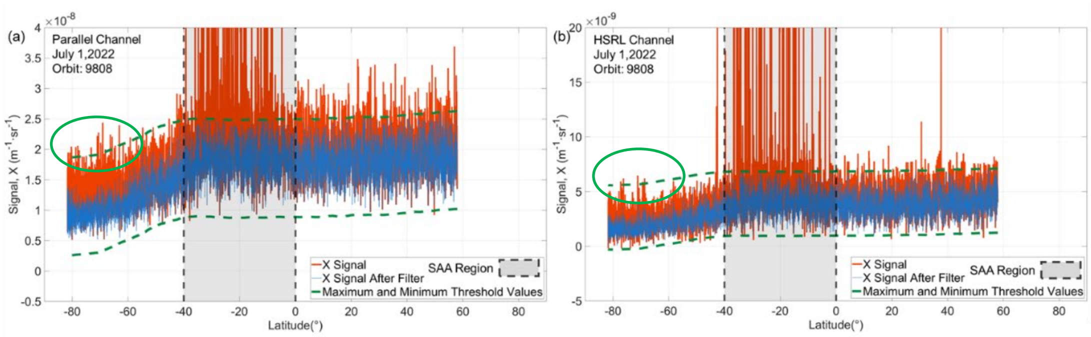
    AR: Thanks for your kind reminder. The research was utilized the Eq. 23 to calculate the calibration coefficients of the perpendicular channel. It should be noted that the perpendicular channel signals do not undergo the data filter described in the algorithm. Consequently, only the diagrams for the parallel and HSRL channels are provided in the manuscript (see Figures 8 and 9).

14. L395 What do you mean by negative spikes?

    AR: We feel sorry for our carelessness, this is a clerical mistake, which has been deleted in the revised manuscript.

15. Fig. 10. What are the differences between the parallel channel and the HSRL channel and why? What is the difference in this figure compared to the one shown in your response to reviewer #2 from the previous submission? What happened to the high values above Antarctica?

    AR: Thank you for pointing out this issue. As demonstrated in Figure 10, the probability of filtered data is less than 10% for both the parallel and HSRL channels. However, the latitudinal extent near the South Pole effectively filters out a greater number of profiles in the parallel channel. This phenomenon is attributed to the observation that the HSRL channel exhibits a diminished received signal for high-energy events within this particular region when compared to the parallel channel. Consequently, the HSRL channel signal within this region is found to be less filtered (as shown in Figure 9a and 9b).



In the revised manuscript, the high filtering in the Antarctic has been eliminated due to the modification of the background acquisition algorithm. This modification represents the most significant difference between this submission of Figure 10 and the previous manuscript.

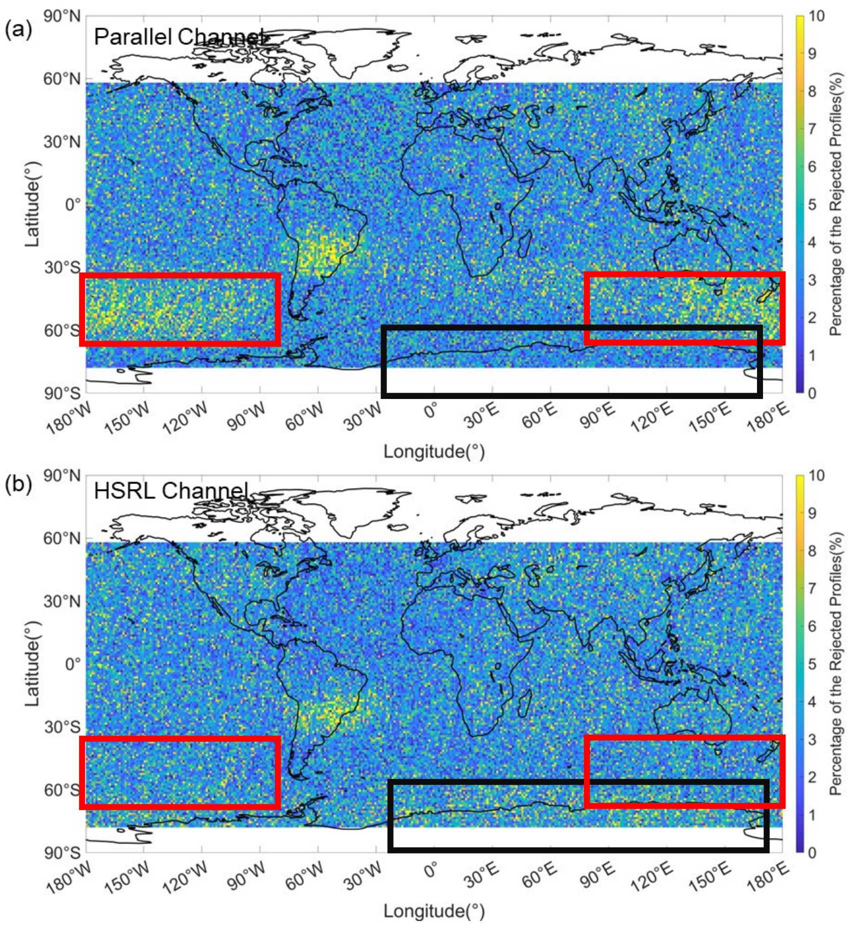


Figure 10: The percentage of rejected profiles for ACDL nighttime calibration (July). (a) Parallel-polarized channel, and (b) HSRL channel

16. Maybe I missed it, but in eq 31 and 32, there appears an E(z_c). What does it stand for?

    AR: We feel sorry for our carelessness. The *E* denotes lidar energy and is not a function of altitude, and has been revised accordingly in the manuscript by modifying $E(z_c)$ to *E*.

17. From Section 3.2 onwards, you switch the naming of the channels. Previously, you speak about the parallel and the HSRL channel, now you state polarization channel and HSRL channel. Usually, polarization channel refers to the cross-polarized channel. I would suggest a different naming for the non-HSRL channel. What about Mie channel, elastic channel or still parallel-polarized. Also, the name "total polarization signal" is misleading and should be removed.

    AR: We feel sorry for the misunderstanding. In Section 3.2, the term "polarization channel" is employed to denote the total attenuated backscatter coefficient of both the parallel and perpendicular channels. We have revised the manuscript to replace this term with " total attenuated backscatter coefficients", and replace the "HSRL signal" with "molecular attenuated backscatter coefficient"

18. In Fig. 11 it is hard to spot the yellow line. The orbits (c+d) are not necessary to understand the figure.

    AR: Thank you for raising the issue. The Figure 11 has been updated in the revised manuscript as follows:

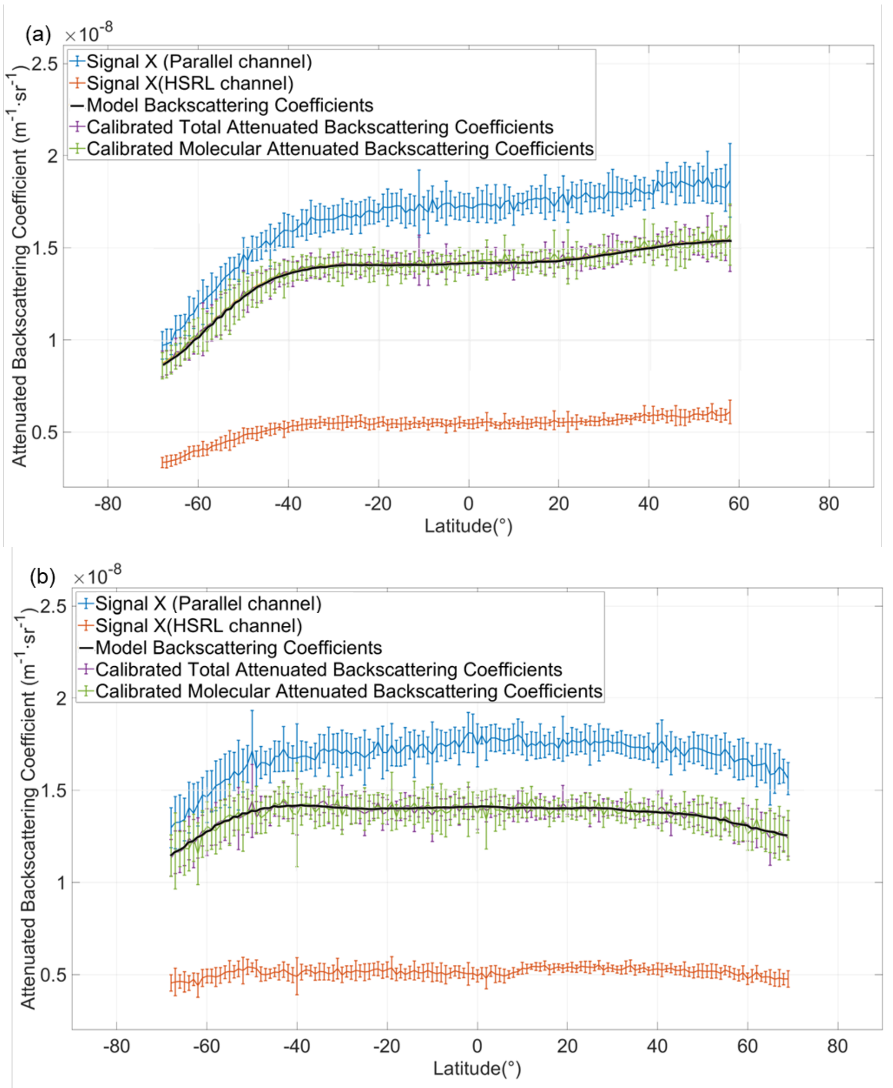


Figure 11: Average for the measured total and molecular attenuated backscatter coefficient (m-1sr-1, blue and orange line), model estimates (m-1sr-1, black line), and calibrated total and molecular attenuated backscatter coefficient (m-1sr-1, purple and green line) along the latitude. (a) and (b): These values on August 1st and October 31st; (c) and (d): The orbits of DQ-1 nighttime measurement for August 1st and October 31st, 2022. The estimated average values were calculated over a vertical distance of 31–35 km and a horizontal sliding average of 1°.

19. Why are you doing such complicated calculations in eq. 37? If you define the total backscatter coefficient as the sum of molecular and aerosol part, the result is obvious from eq. 36.

AR: Thanks for your kind reminder. The revised manuscript contains the following changes to Eq. 36 and delete of Eq. 37

$$R_{CA}(z_{8-12},k) = \frac{\beta'_{total}(z_{8-12},k)}{\beta'_m(z_{8-12},k)} == \frac{\beta'_{\parallel}(z_{8-12},k)+\beta'_{\perp}(z_{8-12},k)}{\beta'_m(z_{8-12},k)} = \frac{\beta_m(z_{8-12},k)+\beta_a(z_{8-12},k)}{\beta_m(z_{8-12},k)}. \quad (36)$$

20. In the text and caption of Fig. 13 you swapped the naming of "dashed" and "solid" lines. Furthermore, the scales in Fig. 13 could be improved. In a) it would be sufficient to show the x-axis between 0 and 2. In b) you could zoom in the y-axis and provide some more minor ticks.

AR: We feel sorry for our carelessness. The Figure 13 has been updated in the revised manuscript as follows:

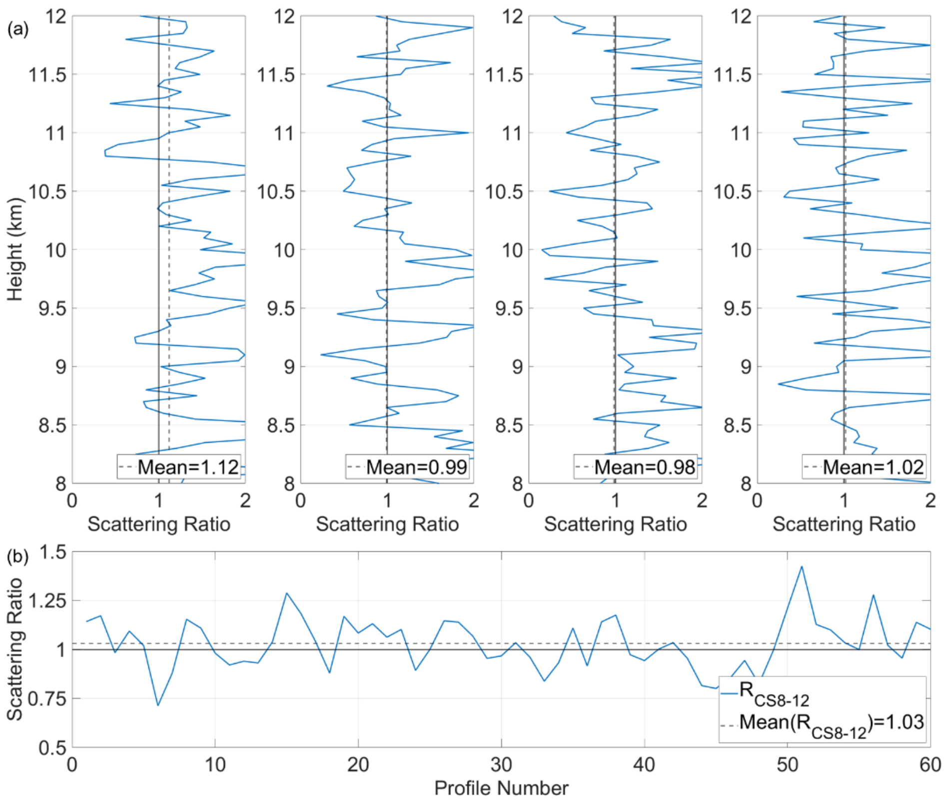


Figure 13: The averaged clear-air scattering ratio from July 1st, 2022. (a) Four consecutive clear-air scattering ratio profiles (3.3-km horizontal resolution, 8–12 km); (b) The mean of the averaged clear-air scattering ratio for 60-profiles (~200 km segment, blue line). The mean of averaged clear-air scattering ratio (black dotted line), and the expected value of 1.0 (black solid line).

21. L 513: Where were the suborbital validation measurements performed? With which instrumentation? Airborne or ground-based.

AR: Thank you for pointing out the issue. To assess the performance of the newly launched satellite lidar, the ACDL-retrieved observations were compared with ground-based lidar measurements of atmospheric aerosol and cloud over northwest China from May to July 2022 using the Belt and Road lidar network (BR-lidarnet) initiated by Lanzhou University in China and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) lidar observations (Liu et al., 2024).

22. L519: Dark noise is mentioned here for the first time.

AR: We feel sorry for our carelessness. Dark noise in this context actually means background signal. We have revised in the manuscript: L519 “Dark noise” ➔ “background signal”.

23. L528: [28] – is probably a reference which does not show up correctly. It does not happen if you prepare the manuscript in latex.

AR: We feel sorry for our carelessness. We have revised in the manuscript: L528 “[28]” ➔ “(Hunt et al., 2009)”.

24. The summary is rather short. I think you should emphasize at some point what is a legacy of CALIPSO and what you developed newly for ACDL.

AR: Thanks for your kind reminder. We have revised summary in the manuscript:

L565: "As the lidar system utilized for cloud and aerosol monitoring within the atmosphere, the ACDL follows the molecular normalization calibration technique and PGR calibration method adopted by CALIPSO in the calibration procedure for parallel and perpendicular polarization channels, Furthermore, ACDL develops calibration algorithms for spaceborne HSRL in accordance with the characteristics of the signal. "

25. L545: You have not validated your results, just verified. See my previous comment.

AR: Thank you for raising the issue. We have revised the assessment by using ACDL data to verification in section 3.2, and provided a detailed description of the validation work carried out using ground-based lidar.

L518: “As a supplement, the validation of ACDL profiles have conducted a profile comparison utilizing a dual-wavelength polarization Raman lidar the (Belt and Road lidar network, BR-lidarnet, initiated by Lanzhou University in China) and the CALIPSO satellite. The profiles of the total attenuated backscatter coefficient (TABC) and the volume depolarization ratio (VDR) at 532 nm were compared by three lidar system in six cases. The findings indicate that the relative deviation between the ACDL and ground-based lidar measurements was approximately −10.5 ± 25.4% for the TABC and −6.0 ± 38.5% for the VDR (Liu et al., 2024). Additionally, ACDL exhibited a high degree of consistency when compared with the observations made by CALIPSO. The observed discrepancies can be attributed to the presence of systematic errors in the ACDL, as well as measurement errors associated with the ground-based lidar. The validation results further demonstrate the accuracy of the calibration algorithm. “

Technical corrections

Most of my technical corrections were already spotted by the anonymous reviewer #1. In general the language might be improved in some parts.

L270: which is defined

AR: Thanks, revised. L270 “which defined” ➔ “which is defined”.

L328: It is shown in the upper left corner.

AR: Thanks, revised.

L356: subscript “valid” should not be italic.

AR: Thanks, revised.

Fig. 9 There are no orange lines, but red lines.

AR: Thanks, revised.