Manuscript number: egusphere-2025-4208
MS type: Research article
Title: Retrievals of vertically resolved aerosol microphysical particle parameters with regularization from spaceborne Aerosol and Carbon dioxide Detection Lidar (ACDL)
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Iteration: Interactive discussion

We would like to express sincere gratitude to the Reviewers for the careful reading and providing comments. The point-to-point replies to the Referee comments are listed below.

Replies to Referee comment:

RC1. This inversion technique is widely used for ground based lidars, but it is really a challenge to use it for satellite measurements. The main problem is to provide high quality of input data, because measurements from space are characterized by high noise. So, anybody, who tries to present such inversion, first of all should demonstrate profiles of aerosol backscattering and extinction coefficients with corresponding uncertainties. This is what I miss in this manuscript. Authors should explain how they calculate backscattering and extinction at 1064 and 1572 nm. I could also provide other comments, but question about input data quality is the main. I think, without it manuscript cannot be published.

Responses:

Thanks for pointing out this. We fully agree that the quality of the input data is necessary and the method that calculate backscattering and extinction at 1064 and 1572 nm should be explained.

First, we provide an explanation of the retrieval methodology for aerosol extinction and backscattering coefficients at 1064 nm and 1572 nm. The ACDL data processing team follows a structed approach to aerosol inversion tasks. The relevant algorithm has undergone cross-validation which shows good consistency and stability, results for this part are currently under preparation and will be detailed in the subsequent work. Following the suggestion, we have added vertical profiles figure of aerosol backscattering and extinction coefficients, along with their corresponding standard deviation estimates.

The relevant revised version will be displayed in blue font in Section 5.1. Once again, we gratefully thank you for your suggestion. The scientific team of ACDL has also been continuously working on the retrievals of raw data and attempting to incorporate emerging methods to provide high-quality optical data. In addition, as you mentioned, the application of regularization in ground-based lidar has been quite mature, and our work is a preliminary attempt to transfer this to the spaceborne lidar system.

The revised version:

In the section 5.1:

"The retrieval methodology for 532 nm channel utilizes the HSRL technique (Dai et al., 2024) and will not be repeated here. For both the 1064 nm and 1572 nm channels, we adopted the Fernald forward integration method. Unlike conventional method, our approach leverages the advantage of the HSRL capability at 532 nm. Specially, the retrieval process first uses the cloud-aerosol classification product retrieved from 532 nm to identify the aerosol type. Then, based on this classification and relevant prior knowledge, an appropriate lidar ratio is selected for the subsequent retrieval. The cross-validation with CALIPSO shows a good consistency and stability as shown in Figure 6. Figure 6 shows the retrieved aerosol extinction coefficients (a) and backscattering coefficients (b). The two sets of profiles are respectively retrieved from ACDL on June 5, 2023 within the latitude of 69.22-70.69, and from CALIPSO on the same day within the latitude of 69.217-70.692. Under the influence of slight temporal and spatial differences, the extinction and backscattering coefficients at the 1064nm obtained from two spaceborne lidar system still have good consistency, and the uncertainty of ACDL is significantly smaller than CALIPSO, which proves the effectiveness of our improved inversion method.

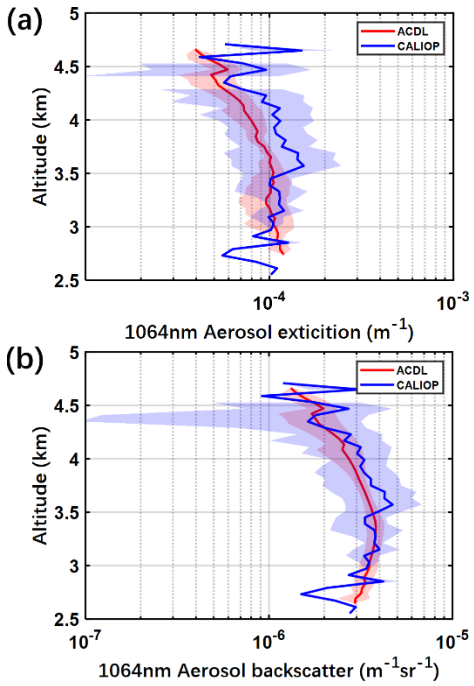

Figure 6: Vertical profiles of aerosol backscattering and extinction coefficients at 1064 nm from ACDL and CALIPSO, along with their corresponding standard deviation estimates.

The vertical profiles aerosol backscattering and extinction coefficients at 532 nm, 1064 nm, 1572 nm obtained from ACDL, along with their corresponding standard deviation estimates, are shown in Figure 7, which selected from ACDL measurements

on March 1st, 2023. Figure 7(a) shows the retrieved aerosol extinction coefficients profile, and Figure 7(b) shows the backscatter coefficients profile. The blue curves represent the 1064 nm signals, and the red curves correspond to 1572 nm. The shaded areas denote the estimated standard deviations. It can be observed that the uncertainty associated with 1572 nm signal is slightly larger than that of the 1064 nm signal. This behavior is physically explainable, the design of the 1572 nm channel is mainly for detecting the column concentration of carbon dioxide, thus, the laser pulse energy at this wavelength is lower compared to which at 532 nm and 1064 nm, leading to the smaller signal-noise ratio. Meanwhile, the reliability of ACDL data has been validated in existing studies (Liu et al., 2024), the deviations of extinction and backscattering coefficients at 532 nm are controlled within approximately 30% and 25% respectively, compared to ground-based lidar. Considering the results of this study and the comparison with CALIPSO in Figure 6, the uncertainty levels presented in Fig.7 are acceptable. These results demonstrate good observational consistency and low systematic errors with ACDL, which provides a solid foundation for the regularization inversion in this work."

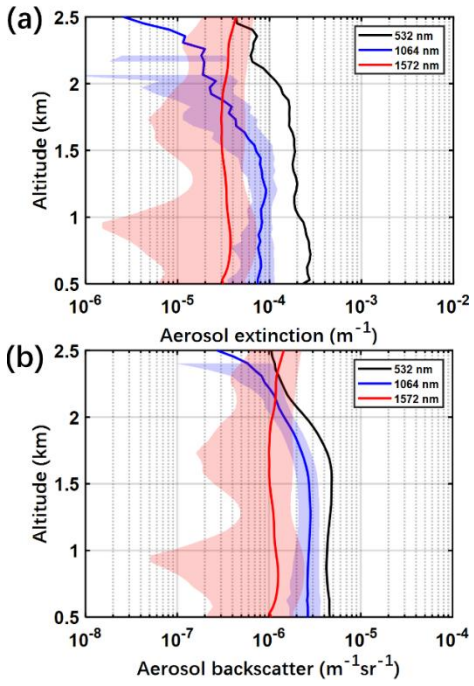

Figure 7: Vertical profiles aerosol backscattering and extinction coefficients at 532 nm, 1064 nm, 1572 nm obtained from ACDL, along with their corresponding standard deviation estimates.

Dai, G., Wu, S., Long, W., Liu, J., Xie, Y., Sun, K., Meng, F., Song, X., Huang, Z., and Chen, W.: Aerosol and cloud data processing and optical property retrieval algorithms for the spaceborne ACDL/DQ-1, Atmospheric Measurement Techniques, 17, 1879-

1890, 10.5194/amt-17-1879-2024, 2024.
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, doi:10.5194/amt-17-1403-2024, 2024.