Responses to RC2:

The Aerosol and Carbon Detection Lidar (ACDL) is the first high spectral resolution lidar using an iodine filter in space. This is an important milestone for aerosol and cloud research from space and thus has the opportunity to advance our understanding of aerosols, clouds and their interaction, once the data will hopefully be made publicly. The manuscript describes the data, retrieval and first results of ACDL with focus on the aerosol (cloud) retrieval (ACDL-A). Thus, the paper is very important with respect to future use of the data, especially if viewed as a piece of documentation of the aerosol retrieval for DQ-1. However, for me to accept the paper, revisions are needed, as too many details of the processing are missing. In the block diagram Fig.6 there are some crucial processing steps like 'Wavelet domain denoising' or 'Multi scale local denoising' which are not described at all. There is also no description of the depolarization calibration.

AR: Thanks for the valuable advices. In section 4.1.2 of the revised manuscript, a more detailed description of the chosen filtering and noise reduction scheme is given.

The ACDL system has undergone ground calibration, including depolarization calibration. The calibration module has been specially reserved in the spaceborne ACDL. In this module, a calibration beam with a known polarization state is pre-set. This, in combination with the usage of a half-wave plate, can be used for the on-orbit polarization calibrations. This method has been well introduced in Alvarez et al., 2006 and Freudenthaler, 2016. The science team is currently evaluating and analyzing the system's performance during on-orbit calibration and preparing for on-orbit polarization calibration.

Reference:

Alvarez, J.M., Vaughan, M.A., Hostetler, C.A., Hunt, W.H., and Winker, D.M.: Calibration Technique for Polarization-Sensitive Lidars, J Atmos Ocean Tech, 23, 683-699, https://doi.org/10.1175/JTECH1872.1, 2006.

Freudenthaler, V.: About the effects of polarising optics on lidar signals and the Δ90-calibration, Atmos Meas Tech, 9, 4181-4255, 10.5194/amt-9-4181-2016, 2016.

Specific comments:

P1, l.16: 'two wavelength polarization detection' gives the impression that the depolarization is also detected for the 1064 nm channel. But according to the block diagram this is not the case.

AR: Thanks for the advice. Sentences with ambiguous expressions have been replaced as "The ACDL/DQ-1 is a high-spectral-resolution lidar (HSRL) that separates molecular backscatter signals using an iodine filter, and has 532nm polarization detection and dual wavelength detection at 532nm and 1064nm, which can be utilized to derive aerosol optical properties."

P2, l.39: Please state once for non-lidar specialists what the lidar ratio is.

AR: Thanks for the advice. The corresponding description "Lidar ratio is defined as the ratio of the aerosol extinction coefficient to the backscattering coefficient and is closely related to the physical and optical properties of the particles." has been added.

P2, l.50: It would be good to also include the first papers that proposed the HSRL technique.

AR: Thanks for the advice. Relevant references have been added to the paper: "Taking advantage of the different spectral broadening, high-spectral-resolution lidar (HSRL) can separate the aerosol contribution from the molecular backscatter with a narrow bandwidth optical filter (Fiocco and DeWolf, 1968; Shimizu et al., 1983). Thus, without assuming the lidar ratio, the aerosol backscatter and extinction coefficients could be obtained respectively. HSRL uses several techniques to achieve a clear separation between Mie and Rayleigh scattering spectra, including the Fabry-Pérot interferometer edge technique approach (Garnier and Chanin, 1992; Flesia and Korb, 1999), interferometric fringe imaging techniques (Matthew and James, 1998) and atomic or molecular filter discrimination (She et al., 1992; Liu et al., 1997)."

Reference:

Fiocco, G., and DeWolf, J.B.: Frequency Spectrum of Laser Echoes from Atmospheric Constituents and Determination of the Aerosol Content of Air, Journal of Atmospheric Sciences, 25, 488-496, https://doi.org/10.1175/1520-0469, 1968.

Flesia, C., and Korb, C.L.: Theory of the double-edge molecular technique for Doppler lidar wind measurement, Appl Optics, 38, 432-440, 10.1364/AO.38.000432, 1999.

Garnier, A., and Chanin, M.L.: Description of a Doppler rayleigh LIDAR for measuring winds in the middle atmosphere, Applied Physics B, 55, 35-40, 10.1007/BF00348610, 1992.

Liu, Z.S., Chen, W.B., Zhang, T.L., Hair, J.W., and She, C.Y.: An incoherent Doppler lidar for ground-based atmospheric wind profiling, Applied Physics B, 64, 561-566, 10.1007/s003400050215, 1997.

Matthew, J.M., and James, D.S.: Comparison of two direct-detection Doppler lidar techniques, Opt Eng, 37, 2675-2686, 10.1117/1.601804, 1998.

Shimizu, H., Lee, S.A., and She, C.Y.: High spectral resolution lidar system with atomic blocking filters for measuring atmospheric parameters, Appl Optics, 22, 1373-1381, 10.1364/AO.22.001373, 1983.

She, C.Y., Alvarez, R.J., Caldwell, L.M., and Krueger, D.A.: High-spectral-resolution Rayleigh–Mie lidar measurement of aerosol and atmospheric profiles, Opt Lett, 17, 541-543, 10.1364/OL.17.000541, 1992.

P4, Figure 1: Besides the block diagram a table containing basic system parameters (rep. rate, pulse energy, telescope diameter, detector type, sensitivity, …) should be included. Some are mentioned in the text, but it is best to put them together in one place.

AR: Thanks for the advice. A summary table of system parameters has been added to the paper.

Table 1: Parameters of the ACDL instrument

Parameters	Value
Wavelength	532.024 nm; 1064.490 nm
Pulse Energy	~130 mJ@532 nm; ~180 mJ@1064 nm
Laser frequency stability	<2 MHz (RMS)
Laser divergence Angle	⩽60 μrad@532/1064 nm；
Gain	59.46@parallel; 53.4573@vertical; 32@HSRL
Telescope diameter	1.0 m
Lidar Off-Nadir Angle	2°
Laser Repetition Frequency	20 Hz @ dual-pulse
Sampling rate	50 MHz
Vertical Resolution (raw data)	3 m@<7.5 km; 24 m (8 bin average) @>7.5 km
Horizontal Resolution (raw data)	~ 330 m

P5, l.110: If z is height (altitude), this assumes an exactly nadir pointing lidar. Since this is not the case, there are some terms missing to account for off nadir pointing.

AR: Thanks for your kind reminder. For data processing, we calculated the elevation of each bin, taking into account the Lidar Off-Nadir Angle. We also standardized the vertical height information of the data products to orthometric height for user convenience. The description has been added, as "It is to be pointed out that in the data processing work in this paper, all heights are standardised to the orthometric height, where z is the altitude to the local geodetic level."

P5, l.115: f_a should not depend on temperature and pressure, only f_m

AR: Thanks for the advice. Sentences with ambiguous expressions have been replaced as "The transmittance of iodine filter for molecular scattering is denoted by f_m, which are function of height due to its dependence on atmospheric temperature and pressure. And the transmittance of iodine filter for aerosol scattering is denoted by f_a."

P5, l.119: Can you give a reference, please?

AR: Thanks for the advice. Added the following two references for inversion of aerosol optical parameters by coupled equations:

Hair, J.W., Hostetler, C.A., Cook, A.L., Harper, D.B., Ferrare, R.A., Mack, T.L., Welch, W., Izquierdo, L.R., and Hovis, F.E.: Airborne High Spectral Resolution Lidar for profiling aerosol optical properties, Appl Optics, 47, 6734-6752, 10.1364/AO.47.006734, 2008.

Liu, D., Yang, Y., Cheng, Z., Huang, H., Zhang, B., Ling, T., and Shen, Y.: Retrieval and analysis of a polarized high-spectral-resolution lidar for profiling aerosol optical properties, Opt Express, 21, 13084-13093, 10.1364/OE.21.013084, 2013.

P6, l.1443: Launch = emission?

AR: Thanks for the advice. The word has been replaced with “emission”.

P6, l.146: It is not clear, what is meant here. The two pulses are already separated in time.

AR: The double pulse utilizes a distinctive data acquisition method. The return set of Dual-pulse signals consists of the 1st to 4824th bin of the odd-pulse, the signals for the even-pulse begin with the 4825th to 9152h bin.

“Since the original signal contains two pulses with different height resolution data, it is necessary to match odd-pulse and even-pulse in altitude separately in the data preparation phase. Based on the time of emission and acquisition, the position of each data point relative to the satellite can be calculated. The latitude and longitude of the laser footprint points corresponding to each set of dual-pulse were determined using spacecraft attitude and ephemeris data. The ellipsoidal heights corresponding to each data point of the odd-pulse and even-pulse are calculated separately by the WGS-84 (Lohmar 1988) coordinate system, then converted to orthometric height using the geoid height. For certain vertical resolution requirements in subsequent processing, the odd and even pulses will be averaged bin by bin by matching them to the appropriate height interval.”

P7, l.155: ‘The mean signals’ would be better, as a contrast to the ‘minimum values’ for the other channels. And only the mean offset can be estimated and subtracted and not the total ‘noise’ as stated in the text.

AR: In certain areas, the maximum detection altitude is only about 35 km, depending on the satellite's orbital altitude and acquisition start time. To obtain background signal values that are free of aerosol signals, each odd pulse was divided into multiple segments from high altitude to the subsurface. The smallest average value of each segment was used as the background signal for this set of dual-pulse signals. This approach was used for all three channels of the 532 nm. The background signal value for 1064nm is determined by averaging the data from the high-altitude segments (average of the 100th~300th acquisition data of the odd-pulse), following conventional practice.

This method extracts the background signal using one of ICESat-2’s calculation methods (Palm et al., 2021). It has been successfully applied in batch processing of both daytime and nighttime data.

Reference:

Palm, S.P., Yang, Y., Herzfeld, U., Hancock, D., Hayes, A., Selmer, P., Hart, W., and Hlavka, D.: ICESat-2 Atmospheric Channel Description, Data Processing and First Results, Earth Space Sci, 8, e1470E-e2020E, https://doi.org/10.1029/2020EA001470, 2021.

P8, l.159: It is not the ‘background noise’ but the ‘background signal’.

AR: Thanks for the advice. All inaccurate expressions in the full paper have been replaced with relevant and precise language.

P9, Figure 5: Font of scale and axis titles are too small

AR: Thanks for the advice, revised.

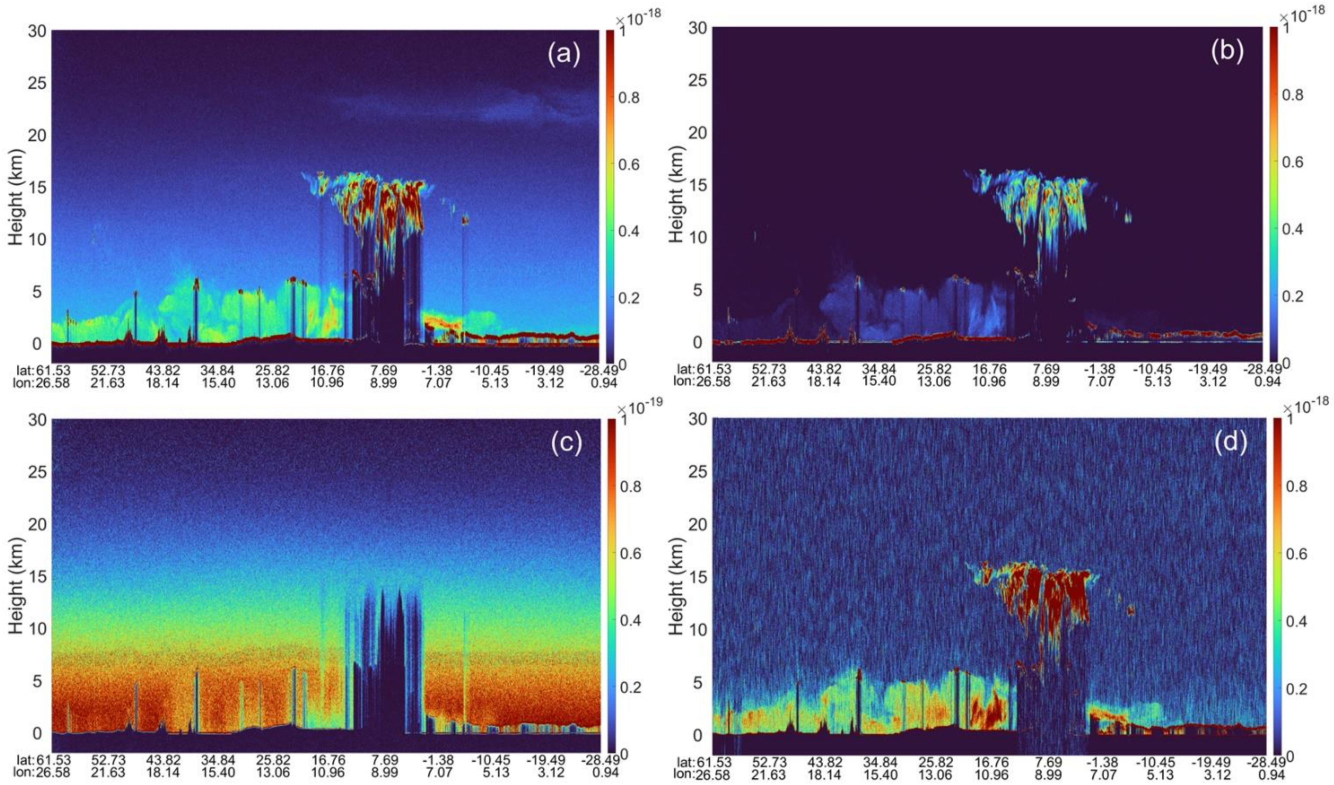

Figure 5: ACDL-A optical power signals in (a) 532 nm parallel polarized channel, (b) 532 nm perpendicular polarized channel, (c) 532 nm molecular channel and (d) 1064 nm channel on 00:45:23 UTC to 01:10:22 UTC on June 27, 2022.

P10, l.228: Median filters are not linear and do not preserve mean values. How large is the window for this? What is the size of the sliding window

AR: The molecular channel profiles along the orbitals exhibit comparable salt-and-pepper noise, which could negatively affect the subsequent optical parameter inversion. To address this issue, the median filter proves to be effective in eliminating the salt-and-pepper noise. “The molecular channel applies a median filter to the signals of the entire orbit using a 5 ×

3 window (250m vertically × 6.6km horizontally).” And using a 20-point sliding window to extracts low-quality signals in the high-altitude, subsurface, and totally attenuated regions. “The sliding window method ensures that occasional spikes in the signal do not interrupt the continuity of data segmentation.”

P11, Equ.8: What numerical scheme is used to calculate the derivative? And in calculating the lidar-ratio, what measures are taken that alpha and beta have the same vertical resolution?

AR: The Equation $\frac{\tau(z)-\tau(z-1)}{\Delta z}$ is used to calculate the total extinction at height z. τ (z) is the optical depth profile and Δz is the vertical resolution of the profile, which is 50m. This paper presents the aerosols and clouds optical properties products of the ACDL/DQ-1, all of which have a uniform resolution of 50 m in the vertical and 3.3 km in the horizontal.

p.12, l.249: This paper gives only the basic algorithm. What values for bulk- and sheer viscosity and thermal conductivity and their temperature dependence are used? Please give a reference!

AR: Thanks for the advice. Added the following two references

Shneider, M.N., Miles, R.B., and Pan, X.: Coherent Rayleigh-Brillouin scattering in molecular gases, Phys Rev a, 69, 33814, 10.1103/PhysRevA.69.033814, 2004.

Gu, Z., Witschas, B., van de Water, W., and Ubachs, W.: Rayleigh–Brillouin scattering profiles of air at different temperatures and pressures, Appl Optics, 52, 4640-4651, 10.1364/AO.52.004640, 2013.

p.13, Figure 8: Fonts are too small.

AR: Thanks for the advice, revised.

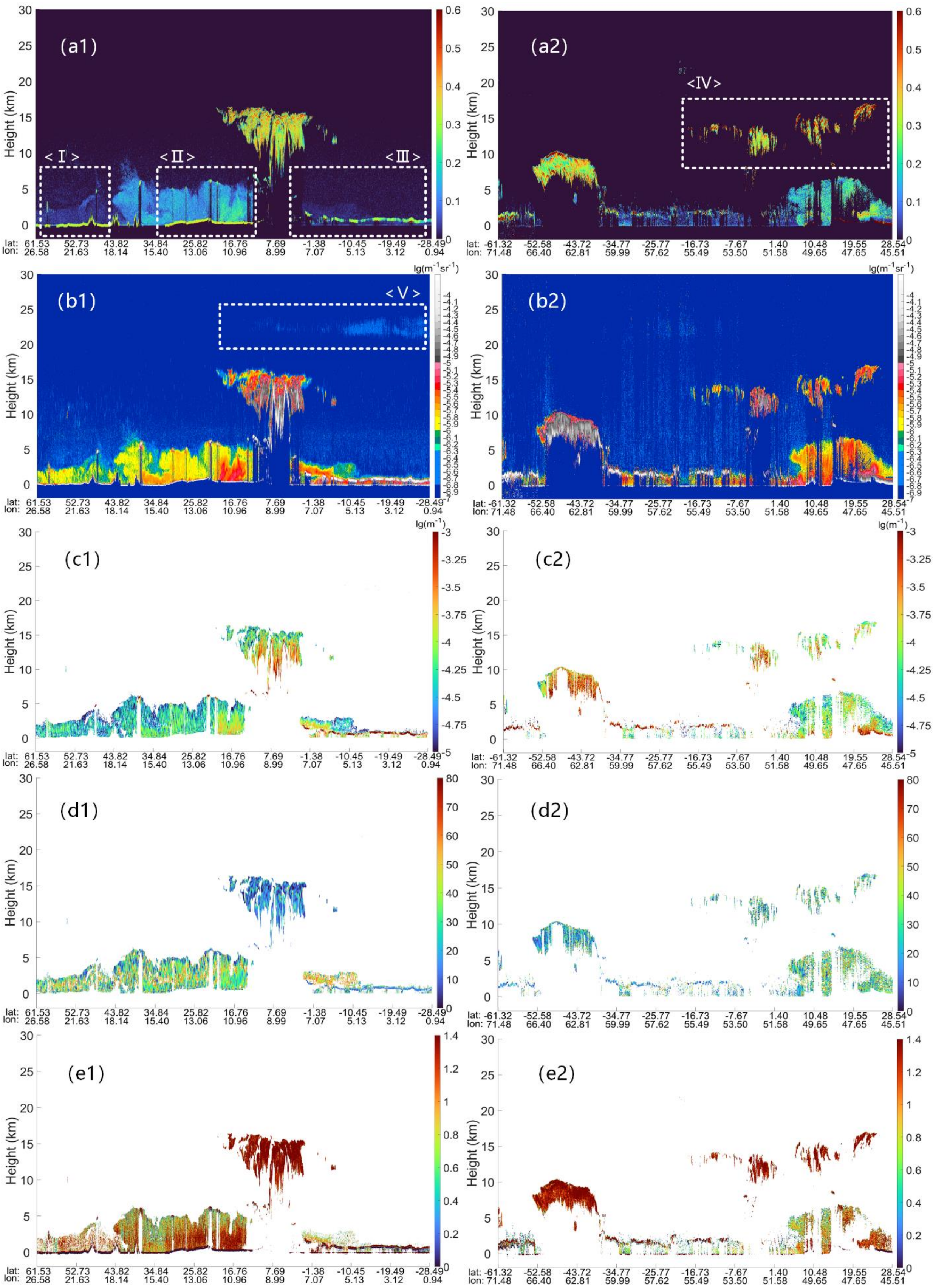

Figure 8: Retrievals from ACDL-A measurements between 00:45:23 and 01:10:22 (nighttime, a1 to e1) and between 09:49:05 and 10:14:05 (daytime, a2 to e2) on June 27, 2022. From top to bottom: The time series of

(a1, a2) total depolarization ratio, (b1, b2) backscattering coefficient, (c1, c2) extinction coefficient, (d1, d2) lidar ratio and (e1, e2) attenuated color ratio.

P14, l281: flied = flew?

AR: Thanks for the advice. The word has been replaced with more commonly used phrases.