

Response to reviewer comments

We are sincerely grateful to the editor and reviewers for their valuable time spent on reviewing our manuscript. The comments are very helpful and valuable, and we have addressed the issues raised by the reviewers in the revised manuscript. Please find our point-by-point response (in blue font) to the comments (in black font) raised by the editor and reviewers.

COMMENTS TO THE AUTHOR(S)

General comments:

This work describes a new method for implementing a miniaturized lidar in vehicles, being the system capable of profiling the atmosphere in the first 2-3 km approximately. Authors focused on the intelligent driving technology that could eventually permit the vehicle to operated unattended. This is a very interesting topic by itself and could offer new measurements of aerosol and clouds profiling. However, in its current state the paper need of further improves. The authors focus a lot in the description of the algorithm for autonomous driving capabilities, but this is out of the scope of AMT. I highly recommend to improve the description of the system and the discussion of the cases to demonstrate system capabilities. The authors should consider adding more experimental measurements. Also, the title is confusing because the paper demonstrates the capabilities of the system for low level clouds (Figure 7).

Response: Thank you for the positive feedback from the expert. Your valuable comments have greatly contributed to the improvement of our manuscript. In response to the questions and opinions you raised, our team has carefully discussed and made careful revisions. We have made point-to-point modifications and responses. Please see below for specific feedback. We have conducted preliminary attempts and explorations by combining intelligent driving technology and atmospheric LiDAR detection, solving some common technical problems, and there are still many new problems waiting to be solved. Thank you also for the criticism and encouragement from the reviewing experts. Our team will continue to explore in this direction. Once again, thank you for your help and improvement of our manuscript. We will also continue to conduct more experiments and show more relevant cases in subsequent reports. Regarding Figure 7, the core purpose of Figure 7 is not to conduct specialized research on cloud detection, but to serve as key experimental evidence for verifying the three-dimensional cone-scanning detection capability of the lidar system. Figure 7 is the only result in the main text that demonstrates the system's three-dimensional cone-scanning observation effect, which directly supports the core conclusion that "the system can achieve three-dimensional scanning and positioning tracking of atmospheric aerosols".

Specific comments:

1. Line 37-38: Add references

Response: Thank you for your help and improvement of our manuscript. We have added reference to the manuscript as follows, which can also be seen in line 38 of the revised

manuscript.

The added reference is:

“Rylander L, Lindh CH, Hansson SR, Broberg K, Källén K. Per- and Polyfluoroalkyl Substances in Early Pregnancy and Risk for Preeclampsia: A Case-Control Study in Southern Sweden. *Toxics* 2020;8:43. <https://doi.org/10.3390/toxics8020043>,2020.”

2.Line 40-43: Add references

Response: Thank you for the valuable suggestion. We have supplemented the reference at the corresponding position to support the description of the limitations of ground-based in-situ aerosol observation methods.

The added reference is:

“Garrido C, Toledo F, Diaz M, Rondanelli R. Automated Low-Cost LED-Based Sun Photometer for City Scale Distributed Measurements. *Remote Sensing* 2021;13:4585. <https://doi.org/10.3390/rs13224585>,2021.”

3.Line 49-55: There are not many spacelidar compared to ground based, although the capabilities of spacelidar. Moreover, they face more limitations in SNR.

Response: We fully agree with your viewpoint and apologize for the inaccurate and incomplete expression in the original manuscript. We have revised the corresponding content to clarify that the number of operational space-borne lidars is far less than that of the extensive ground-based lidar network; meanwhile, limited by orbital overpass mode and long slant range, space-borne lidars have obvious shortcomings in signal-to-noise ratio, and cannot realize high-frequency continuous monitoring of regional aerosols. This revision can be found in Lines 59-63 of the revised manuscript.

4.Line 61-62: To my knowledge only a few HSRL systems provide high accuracy of backscattering and extinction. None of them is capable of providing high accuracy of aerosol microphysical properties. Check literature.

Response: Thank you for this professional reminder. We have rechecked the relevant literature and revised the inaccurate description in the original manuscript.

In the revised version, we clarify that high-spectral-resolution lidar (HSRL) can accurately retrieve aerosol backscattering coefficient and extinction coefficient; the depolarization channel can provide supporting information for judging aerosol morphology and analyzing microphysical characteristics, but it cannot directly obtain complete aerosol microphysical parameters with high accuracy. We have also supplemented relevant references to support this statement. The revision is presented in Section 1 of the revised manuscript.

5.Line 64-65: Give reference

Response: Thank you for your valuable suggestion. We have supplemented the corresponding reference at lines 64-65 of the revised manuscript to support the statement that ground-based LiDAR is widely used for aerosol pollution detection.

The added reference is:

“Baars H, Haarig M, König L, Floutsi AA, Basharova E, Hofer J, et al. Validation of

EarthCARE/ATLID aerosol profiling products with ground-based PollyNET lidars – case studies. Atmos Meas Tech 2026;19:3831–64. <https://doi.org/10.5194/amt-19-3831-2026>,2026.”

6.Line 75-76: Give reference

Response: Thank you for your valuable suggestion. We have supplemented the corresponding reference at lines 75 – 76 of the revised manuscript.

The added reference is:

“Sanchez Barrero MF, Popovici IE, Goloub P, Victori S, Hu Q, Torres B, et al. Enhancing mobile aerosol monitoring with CE376 dual-wavelength depolarization lidar. Atmos Meas Tech 2024;17:3121–46. <https://doi.org/10.5194/amt-17-3121-2024>,2024.”

7.Line 80-81: Give reference

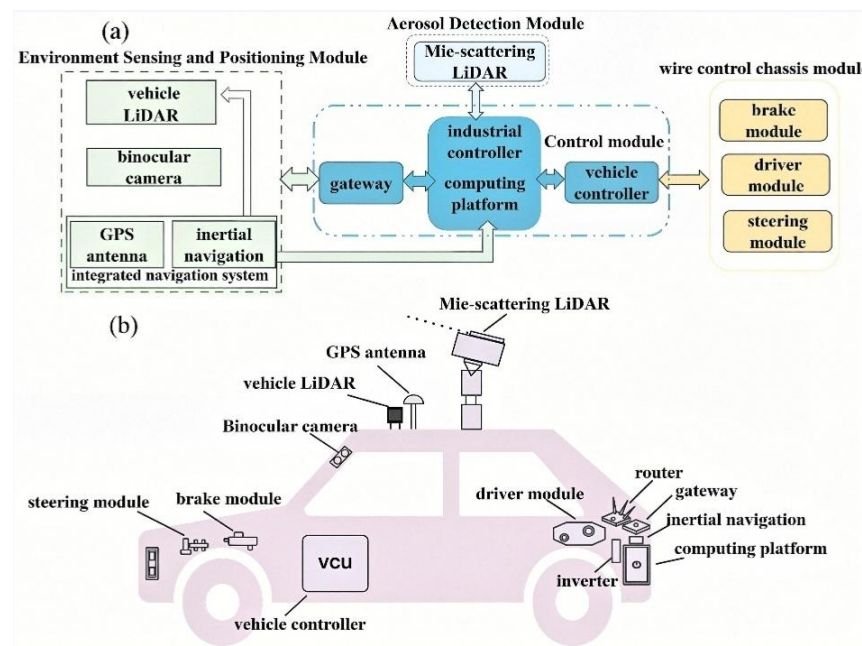
Response: Thank you for your valuable suggestion. We have supplemented the corresponding reference at lines 80-81 of the revised manuscript.

The added reference is:

“Sanchez-Barrero MF, Goloub P, Blarel L, Popovici IE, Torres B, Dubois G, et al. Aerosol variability over oceans using micro-pulse lidar and photometer: insights from TRANSAMA ship-based campaign. Atmos Meas Tech 2026;19:507–28. <https://doi.org/10.5194/amt-19-507-2026>,2026.”

8.Figure 1: Improve the graph quality

Response: Thank you for the suggestion. We have redrawn Figure 1. We optimized the line clarity, text resolution, label specification and overall layout, and improved the overall image quality to meet the publication requirements of the journal.



9.Section 2.1 Systems principle and models: Details of lidar optical module are needed. What wavelengths are you using? The same for the detector module.

Response: Thank you for this valuable suggestion. We have supplemented the detailed

parameters of the lidar optical module and detection module in Section 2.1 of the revised manuscript. An Nd:YAG solid-state laser is adopted, with an output wavelength of 1064 nm, a pulse repetition frequency of 10 kHz, and a single pulse energy of 15 μ J. An avalanche photodiode (APD) is used as the photodetector, with high detection sensitivity and fast response speed. A polarizing prism is integrated in the optical path to realize dual-polarization channel detection, and a narrow-band filter is equipped to suppress ambient background light.

10. Section 2.1 Systems principle and models: Authors use the expression echo lidar signal. To avoid confusions and agree with the lidar community, I highly recommend using 'backscattered lidar signal' instead.

Response: Thank you for the professional suggestion. We have replaced all instances of the expression "echo lidar signal" in the full text with "backscattered lidar signal", the standard term in the lidar academic community, to avoid ambiguity and conform to standard academic expression norms.

11. Section 2.2: To me this section is poor. Only the basis of lidar equation and RCS are introduced. Because of the novelty of the system, details are needed about channels used. This is link with my question of the description of optic/detection modules.

Response: Thank you for this constructive suggestion. We have greatly enriched the content of Section 2.1.

We supplemented the working principle of the dual-polarization detection channel, and described in detail the optical path flow of the transmitting system, receiving system, beam splitting module and data acquisition unit, which corresponds to the optical module parameters in Section 2.1. We supplemented the physical meaning of the range-corrected signal (RCS), clarifying that it includes both Rayleigh backscattering from atmospheric molecules and Mie backscattering from aerosol particles, and explained the calibration method of the signal unit ($W \cdot km^2$) based on the lidar constant and molecular scattering calibration. We added the complete signal processing flow of the system to make the description of the detection principle more rigorous and complete.

12. Section 3 Experimental Results: The experimental site is not described. This makes a very poor sensation.

Response: Thank you for pointing out this deficiency. We have added a detailed description of the experimental sites at the beginning of each subsection in Section 3. All experiments were carried out in Hefei, Anhui Province, China. We supplemented the geographical coordinates and basic meteorological conditions of the experimental sites to improve the completeness and credibility of the experimental description.

13. Line 251 – 252: Which aerosol property are you referring to? Attenuated backscatter? RCS also include backscattering my molecules. I got lost after continuing reading because you are giving measurements in W/km^2 . How do you calibrate to obtain physical units?

Response: Thank you for this careful comment. We apologize for the ambiguous expression in the original manuscript. We have supplemented complete explanatory text in Section 2.2 of the revised manuscript to fully clarify this issue.

Based on the Mie scattering lidar equation, the raw signal received by the lidar system is weak atmospheric backscattered light, which is converted into electrical power signals by the APD detector. The raw backscattered signal itself has no standardized physical unit and features extremely low signal intensity, making it difficult to distinguish layered aerosol structural details directly. To visually highlight vertical aerosol variation features, we perform range-squared correction on the raw received signal $P(z)$ to calculate the Range-Corrected Signal (RCS) via the formula:

$$X(z) = P(z) \cdot z^2$$

This transformation unifies the signal magnitude evaluation standard for signals at different detection heights.

As pointed out by the reviewer, RCS is a composite physical quantity that simultaneously contains Rayleigh backscattering from atmospheric molecules and Mie backscattering from aerosol particles, rather than a single pure aerosol optical parameter such as attenuated backscatter coefficient. Regarding the unit $W \cdot km^2$ of RCS: The detector outputs original electrical power values with the unit of Watt (W). After multiplying by the square of detection distance z (in km), the unit of the final RCS is unified as $W \cdot km^2$.

14. Line 269 – 270: You can use MERRA-2 for validation when you have a large dataset. For one particular day it could be just a lucky shoot. Please, reconsider the use of MERRA-2 appropriately

Response:

We fully agree with your viewpoint. The single-day observation sample is limited, and it is inappropriate to take MERRA-2 data as the gold standard for accuracy verification.

In the revised manuscript, we have adjusted the relevant expression: MERRA-2 reanalysis data is used only as a large-scale atmospheric background reference to confirm the physical rationality of the lidar observation results. We also clearly stated that this study only carried out observation on a single day, and more multi-period and multi-scenario observations will be carried out in follow-up research for systematic cross-validation and accuracy evaluation.

15. Section 3.2 Cone Scanning Detection: Very interesting measurements but very poor analyses. Cone Scanning capabilities were poorly introduced previously.

Response: Thank you for the recognition of the measurement results and the valuable suggestions. We have revised the content in two parts.

In Section 2.1, we supplemented the introduction of the cone-scanning mode, including the working principle, core scanning parameters (azimuth range 0–360°, elevation angle 75°, angular step 1°), and effective detection radius, to explain the technical basis of the scanning capability.

In Section 3.2, we expanded the result analysis. We compared the spatial distribution characteristics of aerosols and clouds under three typical weather conditions (cloudy day, polluted day and clean day), analyzed the difference of aerosol concentration in different azimuths, and fully demonstrated the three-dimensional spatial detection capability of the system.

16. Section 3.3 Unmanned intelligent cruise detection: Very poor description and discussion of the experimental data.

Response: Thank you for this suggestion. We have greatly enriched the content of Section 3.3.

We supplemented the detailed information of the cruise path, the background air quality data during the experiment, and the specific operation parameter settings of the unmanned vehicle. We analyzed in detail the spatial variation characteristics of the vertical distribution of aerosols during the cruise, and compared the pollution load differences of different concentration sections along the path. We added a targeted discussion part to explain the advantages of the unmanned cruise detection system compared with traditional fixed-point lidar, and discussed its application potential in regional pollution monitoring and pollution source tracing.

17. Figure 9: Improve quality (resolution)

Response: Thank you for the suggestion. We have reprocessed and optimized Figure 9. We improved the image resolution and color contrast, and optimized the clarity of the superimposed map base map to meet the journal's publication standards.

