Response to Reviewers' Comments

Reviewer 2

Overall evaluation

Reviewer comment (in blue)

General Comments:

This manuscript presents a novel approach for cloud layer identification using a Raman lidar network system named CARLNET. The method utilizes multi-channel wavelengths, as well as an anisotropic encoder–decoder architecture, self-supervised pretraining, and traditional algorithm guidance. This approach aligns well with the scope of the AMT journal.
Overall, this paper introduces a new automated method for cloud layer identification, which is acceptable for publication in AMT. However, some clarifications in the representation, as well as minor technical corrections, would enhance the quality of the manuscript, as mentioned in the specific comments and technical corrections section.

Author response (in black)

We thank the reviewer for the positive assessment of the overall value of the manuscript and its suitability for AMT. In response to the specific comments, we clarified the role of the radiosonde-based assessment and added a systematic statistical summary. We also standardized the figures, tables, units, terminology, and technical descriptions in the Appendix.

Location of revision

Revisions were made primarily in Sections 2.5 and 4.3, Tables 2 and 4, Figures 5–8, and Appendix A5.

Specific comment 1 Skew T diagram

Reviewer comment

In section 2.5, as “Radiosonde Observations and Cloud Identification,” the authors utilized a relative humidity thresholding method to define the boundaries of clouds by radiosondes. However, the authors also mentioned that mapping a single-column profile at a specific time is not feasible due to wind drift. Would it be possible to include a Skew-T diagram for one or a few days to validate the results? Specifically, this would help in identifying cloud bases, corresponding not only to relative humidity but also to temperatures and pressure levels.

Author response

We thank the reviewer for this suggestion. We agree that a Skew-T diagram can intuitively display the vertical variations in temperature, dew-point temperature, and pressure and can therefore help illustrate the thermodynamic background of the moist layers identified from radiosonde observations. However, we did not add Skew-T diagrams for individual dates for the following reasons.

First, a Skew-T diagram and the relative-humidity thresholding method used in this study are based on the same radiosonde profile and therefore do not constitute independent sources of validation. A Skew-T diagram primarily identifies near-saturated layers through the proximity of temperature and dew-point temperature, while relative humidity is derived from the same set of thermodynamic observations. Consequently, adding a Skew-T diagram would change the presentation of the information but would not provide evidence independent of the existing radiosonde-based moist-layer identification. Temperature and pressure can characterize the thermodynamic environment of a moist layer, but they cannot independently demonstrate that cloud droplets detectable by lidar are present at the same altitude.

Second, a Skew-T diagram cannot resolve the spatial-sampling mismatch between the two observing systems. The lidar observes a fixed atmospheric column above the site, whereas the radiosonde may drift horizontally by approximately 30 km during ascent. Whether the radiosonde measurements are displayed as a relative-humidity profile or as a Skew-T diagram, they still represent an atmospheric profile sampled along the drifting balloon trajectory. Therefore, moist-layer boundaries derived from an individual sounding should not be treated as strict ground truth for lidar-derived cloud-base and cloud-top heights at the launch time.

Third, Skew-T diagrams for only one or two dates would provide qualitative illustrations at the case level and could be affected by the selected weather conditions and case-selection bias. Such examples would not represent the overall performance across the three independent test sites. To provide more systematic evidence and avoid reliance on selected cases, we instead evaluated 47 valid lidar–radiosonde matched cases from the three test sites. To account for cloud evolution and the spatial mismatch caused by balloon drift, lidar-derived cloud masks within ±1 h of each radiosonde launch were aggregated. We then evaluated the agreement between the two observing systems in terms of layer altitude, continuity, and multilayer structure.

We also further clarified the evidential role of the radiosonde comparison. Radiosonde observations identify moist layers using altitude-dependent relative-humidity thresholds, whereas lidar identifies cloud layers associated with detectable scattering returns. The two methods therefore represent different physical quantities and sampling characteristics. Accordingly, the radiosonde results are used only as an independent reference for structural consistency rather than as ground truth for cloud boundaries. The statistics in Table 4 should likewise be interpreted as measures of structural consistency between the two observing systems rather than as strict cloud-identification accuracy. For these reasons, we consider the systematic analysis of all 47 matched cases more appropriate for the objectives of this study than the addition of a small number of Skew-T examples.

Location of revision

Section 2.5, Lines 252–272; Section 4.3, Lines 598–640; Table 4, Lines 649–650.

> **Relevant revised text**
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> *"Consequently, radiosonde observations are not treated as a strict quantitative ground truth for lidar cloud-layer identification. Instead, they provide an independent atmospheric reference for evaluating the consistency of identified cloud-layer structures, including layer altitude, continuity, and multilayer occurrence."*

Specific comment 2 Systematic radiosonde results

Reviewer comment

In Section 4.3, as "Independent Validation with Radiosonde Observations," it is recommended that the results be presented more clearly and systematically. In particular, it is suggested to include a table summarizing the results for improved clarity and ease of comparison.

Author response

We rewrote Section 4.3 and added Table 4. The table summarizes the number of matched cases, structural consistency rate, cloud-base MAE, and detectable cloud-top MAE for expert annotations, the proposed model, and VDE across the 47 matched cases.

Location of revision

Section 4.3, Lines 598–640; Table 4, Lines 649–650.

> **Relevant revised text**
>
> *"Because radiosonde-based identification is affected by humidity thresholds, ascent sampling, and spatial drift, these statistics are interpreted as structural consistency indicators rather than strict accuracy measurements. The proposed model achieves a structural consistency rate of 38.3%, higher than VDE (34.0%) and expert annotation (27.7%)."*

Technical correction 1 Figure and section abbreviations

Reviewer comment

The terms (e.g., Figure/Fig., Section/Sect.) should follow the Copernicus manuscript guidelines and be used consistently throughout the manuscript.

Author response

Following the Copernicus manuscript conventions, we standardized the in-text abbreviations as "Fig." and "Sect." throughout the manuscript.

Location of revision

Terminology was standardized throughout the manuscript, including Sections 2–4 and all figure captions.

Technical correction 2 Units and mathematical notation

Reviewer comment

Lines 156–157 and 217, 220: Please use standard distances for units and mathematical signs, and ensure consistency throughout the manuscript.

Author response

We systematically checked and standardized the notation of wavelength, distance, altitude, resolution, and percentage units throughout the manuscript. Mathematical symbols and interval notation were also standardized.

Location of revision

Section 2.2, Lines 155–174; Section 2.4, Lines 219–247; Appendix A1–A7, Lines 719–854.

Technical correction 3 Table 2 structure

Reviewer comment

In Table 2, it is recommended to reform the table using abbreviations for better structure.

Author response

We reorganized the column headings in Table 2 and separately indicated whether unlabeled test-site observations were used during pretraining and whether test-site annotations were used during fine-tuning. To avoid introducing unfamiliar abbreviations, the strategy names are retained in full, but the table structure has been made more compact and consistent with the main text.

Location of revision

Section 4.2.1, Lines 482–500; Table 2.

Technical correction 4 Figure 5 caption

Reviewer comment

In Figure 5, it is recommended to include every annotation used in the figure within the caption as well.

Author response

The caption of Fig. 5 now identifies the method corresponding to each panel and defines GT, N, MAE, bias, RMSE, R, and the dashed 1:1 line.

Location of revision

Figure 5 caption, Lines 559–564.

Technical correction 5 Figure 6 wording and contour

Reviewer comment

In Figure 6b, in terms of "noise misclassified as ..." is something missing after "as"? Please also define the green dashed contour, as it is not visible on the plot.

Author response

We completed the description of the misclassification shown in the figure and removed the reference to green dashed contours, which was inconsistent with the actual figure. The revised caption defines only the elements that are present: the black solid lines, black dotted lines, and black boxes.

Location of revision

Figure 6 and its caption, Lines 593–596.

Technical correction 6 Typographical error

Reviewer comment

In A5, line 665: replace "hile" with "while".

Author response

The typographical error has been corrected.

Location of revision

Appendix A5, Lines 808–821.