Response to Reviewer Comments

Manuscript No.: egusphere-2026-1866

Title: *A Fast Spectral Line-Ratio Algorithm for Mesospheric Airglow Rotational Temperature Retrieval and Validation*

Dear Reviewer,

We sincerely thank you for the careful review of our manuscript and for the constructive comments and suggestions. We greatly appreciate the time and effort invested in evaluating our work. The comments have been very helpful in improving the quality, clarity, and presentation of the manuscript.

We have carefully considered all comments and revised the manuscript accordingly. Detailed responses to each comment are provided below. Reviewer comments are shown in black bold font, our responses are shown in blue font, and the corresponding revised manuscript text is shown in blue italic font.

Sincerely,

Shuqi Niu

on behalf of all authors

Response to Reviewer #1

GENERAL COMMENTS

This manuscript presents the FASLR method for MASP observations by calculating the relationship between spectral line intensity ratio and temperature. The proposed approach provides a potential solution for processing long-duration and high-temporal-resolution observations of MASP datasets in the future. The retrieved temperatures are compared with those derived from the MPII method, lidar observations, satellite measurements, and model simulations, demonstrating the reliability of the proposed retrieval method. In particular, comparisons with the MPII method and co-located lidar observations indicate that, although the absolute temperature values retrieved by the FASLR method show some differences, the temporal variations are generally consistent with those observed by lidar. In addition, spectral analysis is applied to the retrieved temperatures, and atmospheric wave signatures are successfully identified, suggesting that FASLR-retrieved temperatures can be potentially used for atmospheric wave studies.

SPECIFIC COMMENTS:

Comment 1

Section 2.2.1: The MASP datasets used in this study should be clearly described in this section. It appears that two MASP datasets are involved: one collected at Hulunbuir in February 2024 and another collected at Beijing in 2023. This section should provide a comprehensive description of all MASP observations used in the analysis.

Response:

We thank the reviewer for this helpful comment. We agree that the original manuscript did not provide a sufficiently consolidated description of the two MASP observation datasets used in this study. The Beijing dataset was obtained in 2023 using the original single-channel O_2 configuration, whereas the Hulunbuir dataset was obtained in February 2024 using the updated dual-channel configuration with a filter wheel, enabling alternating O_2 and OH observations.

Accordingly, we have renamed Sect. 2.2.1 as ***"2.2.1 MASP observation datasets"*** and revised this section to provide a consolidated description of both datasets, including their observation locations, measurement configurations, and respective roles in the analysis.

The revised text now reads:

"Two MASP observation datasets are used in this study. The first was obtained during coordinated observations of MASP and a sodium fluorescence Doppler lidar at the National Space Science Center, Chinese Academy of Sciences, in Huairou, Beijing (40°N, 116°E), in 2023. MASP was operated in the single-channel configuration described in Sect. 2.1, providing an O_2 rotational-temperature series with a temporal resolution of 3 min. Two nights with high-quality simultaneous observations, 26 April and 23 May 2023, were selected for comparisons among FASLR, MPII, and sodium fluorescence Doppler lidar temperatures.

The second dataset was obtained at the Tulihe Meteorological Observatory, Hulunbuir, Inner Mongolia (50.5°N, 122.6°E; Fig. 1), from 2 to 7 February 2024. MASP was operated in the alternating dual-channel configuration described in Sect. 2.1, providing O_2 and OH rotational-temperature series with an effective temporal resolution of approximately 5.3 min for each channel. This dataset was used for dual-channel temperature retrievals, comparisons with satellite and model temperatures, and analyses of nocturnal variability and wave disturbances."

Comment 2

What is the temporal resolution of the MASP temperature retrievals? Based on Figures 5 and 7, the temporal resolutions of the MASP observations at Beijing and Hulunbuir appear to be different. Please clarify the temporal resolution used for each dataset and explain the reason for the difference, if applicable.

Response:

We thank the reviewer for pointing out that the temporal resolutions of the two MASP datasets were not sufficiently clarified. The temporal resolution of the Beijing O_2 temperature series was 3 min, whereas those of the Hulunbuir O_2 and OH temperature series were approximately 5.3 min. This difference arose from the different single-channel and alternating dual-channel observation configurations.

To clarify this point, we renamed Sect. 2.1 as ***"2.1 MASP instrument and observation configurations"*** and revised it to clarify the two observation configurations and their corresponding temporal resolutions. The revised text reads:

"...The instrument was operated in two configurations for the observations analyzed in this study. In the original single-channel configuration, MASP continuously measured the O_2 (0–1) airglow emission, providing a temporal resolution of 3 min. In the dual-channel configuration, a filter wheel was added to enable alternating measurements of the O_2 (0–1) and OH (6–2) emissions. The exposure times were 3 min for O_2 and 2 min for OH, and successive measurements of each emission band were separated by

approximately 5.3 min. The effective temporal resolution of each retrieved temperature series was therefore approximately 5.3 min. ..."

For consistency, the captions of the relevant figures were also revised accordingly.

Comment 3

Section 2.2.2: When comparing the MASP retrievals with sodium lidar observations, which altitude range of lidar temperature measurements was used for the comparison?

Response:

We thank the reviewer for this helpful comment. The sodium fluorescence Doppler lidar temperatures profiles used for comparison with the MASP O_2 rotational temperatures were weighted and averaged over 92–96 km.

We have therefore revised Sect. 2.2.2 to clarify the lidar temperature processing. The revised text reads:

"*...For comparison with the MASP O_2 rotational temperatures, the lidar temperature profiles were weighted and averaged over 92–96 km to obtain a layer-representative temperature for the MASP O_2 emission layer. ...*"

Comment 4

Lines 116 and 119: The vertically averaged altitude range is 85–89 km for satellite observations, while it is 85–90 km for SD-WACCMX and MSIS model results. Why are different altitude ranges used for these datasets? Please clarify whether this difference is related to the vertical resolution or other characteristics of the datasets.

Response:

We thank the reviewer for this helpful comment. After re-examining the treatment of the reference datasets, we found that the different altitude ranges resulted from differences in their original vertical sampling and extraction procedures. To ensure a consistent comparison, we revised the altitude treatment of the model reference temperatures.

In the original analysis, the vertical treatment of the model reference temperatures was not fully consistent among the datasets. For SD-WACCMX, model levels falling within the prescribed altitude ranges were directly selected, while the NRLMSIS 2.1 temperatures were originally evaluated at a coarser 2 km vertical interval. In the revised analysis, the SD-WACCMX temperature profiles are first interpolated to fixed altitude levels at 1 km intervals, and the NRLMSIS 2.1 temperatures are recalculated directly at the corresponding fixed levels. For the OH comparison, the reference temperatures are now calculated over 85–89 km at 1 km intervals, consistent with the altitude range used for the satellite observations. The same treatment was also applied to the O_2 comparison over 92 – 96 km at 1 km intervals.

The model comparisons were updated using the revised altitude treatment. The corresponding results in Fig. 8 and Sect. 4.2.2, together with the related statements in the Abstract and Conclusions sections, were revised accordingly.

The following revisions have been made:

1. **Section 2.2.3:** The extraction procedure for the SD-WACCMX and NRLMSIS 2.1 reference temperatures was revised to clarify the use of fixed altitude ranges.
2. **Figure 9:** The SD-WACCMX and NRLMSIS 2.1 temperature curves were updated using the revised altitude treatment.
3. **Section 4.2.2:** The comparison with SD-WACCMX and NRLMSIS 2.1 was revised according to the updated results.
4. **Abstract and Conclusions sections:** The corresponding descriptions were updated to reflect the revised model comparison.

The revised text in Sect. 2.2.3 now reads:

"…Temperature estimates from SD-WACCMX and NRLMSIS 2.1 are extracted near the observation site and calculated over fixed altitude ranges of 85–89 km for OH and 92–96 km for O_2. The SD-WACCMX profiles are interpolated to fixed altitude levels to ensure consistent vertical sampling. The NRLMSIS 2.1 temperatures are calculated directly at the same fixed altitude levels. …"

Comment 5

Lines 290-291: The statement "This offset may reflect differences in measurement principle and atmospheric representativeness between the two instruments." may not be appropriate in this context. According to the comparison between the MPII method and sodium lidar observations in Niu et al., 2024, the temperature differences between them are relatively small. Therefore, the observed offset is likely introduced by the FASLR retrieval method itself rather than by differences in measurement principles or atmospheric representativeness. The authors should reconsider this explanation and provide a more reasonable interpretation of the temperature bias.

Response:

We thank the reviewer for pointing out this issue. Considering the relatively small temperature differences between MPII and the sodium fluorescence Doppler lidar reported in Niu et al. (2024), we agree that the original explanation attributing the

FASLR–lidar temperature difference to differences in measurement principle and atmospheric representativeness was not sufficiently supported by the available evidence. The reviewer also suggests that the FASLR retrieval procedure may contribute to the observed difference. We have therefore removed this interpretation and revised the discussion accordingly.

For the two simultaneous observation nights shown in Fig. 7 (original Fig.6), the FASLR retrieval procedure may contribute to the observed difference; however, the present comparisons do not provide sufficient information to distinguish its contribution from other possible factors or to establish the generality of the observed differences. Therefore, we revised the corresponding discussion to focus on the observed comparison rather than assigning a specific cause to the temperature differences.

The corresponding text has been revised as follows:

"... Overall, the FASLR and lidar temperatures show generally similar major nocturnal variations on both observation nights, although differences remain in their absolute temperature levels. These comparisons therefore mainly characterize the similarity in temporal evolution between the FASLR and lidar temperatures. A broader assessment of the absolute temperature accuracy of FASLR would benefit from additional simultaneous comparisons with independent temperature measurements over more observation periods. ..."

In addition, we reviewed the corresponding statements in the Abstract, main text, and Conclusions and revised those that could imply a stronger assessment of the absolute temperature accuracy of FASLR than is supported by the available independent comparisons. The revised manuscript therefore uses these two lidar cases primarily to assess the consistency of the temporal temperature variations, while a broader evaluation of absolute temperature accuracy would require additional simultaneous independent observations.

TECHNICAL CORRECTIONS:

Comment 1

Line 119: "T To ..." appears to be a typographical error. Please check and correct it.

Response:

We thank the reviewer for pointing out this typographical error. It has been corrected in the revised manuscript.

The revised text reads: *"...To characterize the ..."*

Comment 2

Line 183: "Fig. 3c and d" should be corrected to "Fig. 3c and 3d".

Response:

We thank the reviewer for this correction. The figure citation has been revised accordingly. Because an additional figure was added during the revision, the corresponding figure number is now Fig. 4c and 4d in the revised manuscript.

The revised text reads: *"...Fig. 4c and 4d, ..."*

Comment 3

Line 210: The second equation in Equation (5) seems to be missing an equal sign. Please carefully check and revise the equation accordingly.

Response:

We thank the reviewer for identifying this issue. During the revision of Sect. 3.3, the sensitivity-based weighting scheme was reformulated to improve the clarity of the derivation. Therefore, the original Equation (5) referred to in the comment is no longer present in the revised manuscript. The corresponding formulation has been replaced by the revised equations in Sect. 3.3, and the revised equations have been carefully checked for mathematical consistency.