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 and constructive review of our manuscript and for the time and effort devoted to evaluating our work. Your comments and suggestions have been very valuable in helping us further examine the methodology, strengthen the quantitative evaluation, and improve the interpretation and presentation of the results. In particular, your comments prompted us to reconsider the comparison between FASLR and MPII, especially regarding their computational characteristics and the interpretation of the observed temperature differences, and to revise the manuscript accordingly.

Based on these revisions, we have also further clarified the scope and contribution of this study. The revised manuscript emphasizes the development of FASLR as a computationally efficient retrieval algorithm for processing continuous, high-temporal-resolution MASP observations. FASLR establishes ratio–temperature relationships using forward-modeled synthetic spectra, derives multiple ratio-based temperature estimates from observed spectra, and combines them through sensitivity-based weighting. This algorithm provides an efficient approach for rotational-temperature retrieval from long-duration airglow observations and facilitates analyses of mesopause temperature variability.

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 #2

GENERAL COMMENTS

Temperature measurement and retrieval are important in atmospheric dynamics and chemistry. In this work, a Fast Airglow Spectral Line-Ratio algorithm (FASLR) is proposed to retrieve temperature from the Mesospheric Airglow Spectrum Photometer (MASP). Compared to the previous algorithm (MPII) of retrieval temperature form MASP, the improvements of FASLR are their efficiency.

However, there are two essential issues should be clarified: (1) What are the computation efficiency or computation cost during each retrieval of MPII and FASLR? (2) How to explain the systematic temperature differences between MPII and FASLR? Some specific comments are listed below for consideration.

SPECIFIC COMMENTS:

Comment 1

L15: Please quantify the terms "computational efficiency"? Please clarify and quantify "occasional anomalies"? Such that one can get the necessary of developing fast algorithm to process the "long-duration, high-temporal-resolution" data.

Response:

We sincerely thank the reviewer for pointing out this issue. We agree that the original descriptions of "computational efficiency" and "occasional anomalies" were too general and were not supported by sufficient quantitative evidence. We have therefore revised the manuscript to clarify the motivation for developing FASLR and to provide a quantitative evaluation of its computational characteristics.

For continuous MASP observations with high temporal resolution, a large number of spectra need to be processed to obtain long temperature time series. The previously developed MPII method retrieves temperature through multi-parameter iterative optimization for each observed spectrum. Although MPII provides a reliable retrieval framework, the iterative adjustment of multiple parameters and repeated forward-model calculations increase the computational cost for processing continuous observations. In contrast, FASLR provides a direct, non-iterative retrieval approach without per-spectrum iterative optimization, thereby reducing the computational cost associated with continuous MASP temperature retrievals.

To quantitatively evaluate the computational characteristics of FASLR and MPII, we performed runtime tests using the complete datasets from the two observation nights shown in Fig. 6 (original Fig. 5). Each method was independently run 10 times under the same computational environment. The timing covered the complete processing procedure from initial data processing to generation of the final temperature time series. For the 132 observations acquired on 26 April 2023, the mean total processing times of FASLR and MPII were **19.0 and 296.7 s,** respectively. For the 120 observations acquired on 23 May 2023, the corresponding processing times were **16.8 and 350.0 s**, respectively. Therefore, MPII required approximately **15.6 and 20.8 times** the total processing time of FASLR for the two tested datasets. These results provide a quantitative assessment of the lower computational cost of FASLR under the tested observational conditions and support its application to continuous MASP observations with high temporal resolution.

Accordingly, the Abstract has been revised to include quantitative information on the computational time of FASLR. The revised sentence reads: The revised manuscript no longer implies that MPII is unsuitable for long-duration, high-temporal-resolution observations; instead, it emphasizes that iterative optimization increases the computational cost, while FASLR provides a direct retrieval approach with reduced computational requirements. The revised Abstract states:

"*…For the two test nights containing 132 and 120 observations, the complete FASLR processing required 19.0 and 16.8 s, respectively. …*"

We also appreciate the reviewer's comment regarding the term **"occasional anomalies"**. After re-examining this description, we found that this wording was not sufficiently defined and could lead to an overinterpretation of the role of the sensitivity-based weighting scheme. Therefore, this term and the related statements have been removed from the revised manuscript. The weighting scheme is now described as determining the relative contributions of multiple ratio-based temperature estimates according to their sensitivities to instrumental-parameter perturbations, rather than identifying or correcting a specific type of anomaly.

The revised Abstract now states:

"*…FASLR uses forward-modeled synthetic spectra to establish ratio–temperature relationships, derives temperature estimates from multiple line-intensity ratios, and combines these estimates using weights based on the relative sensitivity of each ratio to instrumental perturbations. …*"

Comment 2

L74-75, L275-276: It is better to specify the computational cost of MPII during each retrieval.

Response:

We sincerely thank the reviewer for suggesting that the computational cost of MPII be quantified more explicitly. In the original manuscript, we described that MPII performs iterative optimization during each temperature retrieval but did not provide a quantitative evaluation of its computational cost. We have therefore revised both the description of MPII in the Introduction and the computational comparison presented in the Results section.

Because MPII independently optimizes multiple parameters for each observed spectrum, the computational time of an individual retrieval varies depending on the convergence process and the number of iterations required. Therefore, a single retrieval time may not fully represent the computational cost associated with processing continuous MASP observations. We therefore evaluated the computational cost of MPII using the total processing time required to generate the complete temperature time series for each observation night, as described in our response to **Comment 1**.

Based on these tests, we added the computational comparison of MPII and FASLR to the revised manuscript. The total processing times for the two observation nights were added to the text corresponding to Fig. 6:

"*...In terms of computational performance, the total processing times for the two observation nights were 16.8 and 19.0 s with FASLR, compared with 350.0 and 296.7 s with MPII, respectively. The computational comparison is discussed further in Sect. 3.4.2. ...*"

We also added a more detailed description of the timing-test procedure and the quantitative comparison in Sect. 3.4.2:

"*...The computational cost of the two methods was evaluated using the two observation nights shown in Fig. 6. Each method was independently tested 10 times in the same computational environment, with the same processing procedures applied to the observational data. The timing covered the complete processing workflow from initial data processing to generation of the final nightly temperature series. For the 132 observations on 26 April 2023, the mean total processing times were 19.0 s for FASLR and 296.7 s for MPII. For the 120 observations on 23 May 2023, the corresponding times were 16.8 and 350.0 s, respectively. ...*"

These quantitative results also prompted us to reconsider the wording in Lines 74–75 of the original manuscript regarding the computational burden of MPII and the motivation for developing FASLR. The revised manuscript no longer implies that MPII is unable to meet the processing requirements of MASP observations. Instead, it clarifies that MPII requires iterative optimization for each observed spectrum, whereas FASLR provides a direct retrieval approach without per-spectrum iterative optimization. The revised text reads:

"...A multi-parameter iterative inversion algorithm (MPII) was previously developed for the Mesospheric Airglow Spectrum Photometer (MASP). In MPII, instrumental parameters are adjusted iteratively together with the forward spectral calculation to reproduce each observed spectrum and retrieve rotational temperature. ... Because each retrieval involves iterative parameter adjustment, computational efficiency becomes an important aspect when processing continuous, high-temporal-resolution observations.

In this study, a fast rotational temperature retrieval algorithm based on airglow line-intensity ratios is developed to provide a direct, non-iterative approach. ... The resulting retrieval does not require per-spectrum iterative optimization, reducing the computational cost of processing continuous observations. ...".

Comment 3

L165: Please provide a short physical description on the term "sensitivity-informed weighting". Otherwise, pleas provide a detailed description on the term "sensitivity-informed weighting" just following this sentence.

Response:

We sincerely thank the reviewer for this helpful suggestion. In the original manuscript, when "sensitivity-informed weighting" was first introduced at Line 165, the specific meaning of "sensitivity" and the way in which the corresponding weights were determined were not explained sufficiently clearly. Following this comment, we reorganized the methodological descriptions in Sects. 3.2 and 3.3 and, to avoid ambiguity, now consistently refer to this approach as "*sensitivity-based weighting*".

In the revised manuscript, the statements related to weighting that previously appeared at the end of Sect. 3.2 have been removed. Sect. 3.2 now focuses only on retrieving the three ratio-based temperature estimates from the selected line-intensity ratios, while their subsequent weighted combination is described entirely in Sect. 3.3.

In the revised Sect. 3.3, **"sensitivity" specifically refers to the response of each selected line-intensity ratio to prescribed perturbations in filter temperature and**

optical-system focal length, rather than to observational uncertainty or temperature-retrieval uncertainty in a general sense. Physically, a ratio that exhibits a smaller response to the considered instrumental perturbations is less influenced by these parameter variations and therefore provides a more robust basis for temperature estimation. At each prescribed rotational temperature, this response is quantified by the standard deviation of the corresponding ratio over the specified perturbation range. The resulting sensitivities are then used to construct temperature-dependent weighting functions. Within this framework, ratios with smaller responses to the considered instrumental perturbations are assigned larger relative weights.

Accordingly, the following description has been added and revised in Sect. 3.3:

"*Although FASLR does not iteratively adjust instrumental parameters for each observed spectrum, variations in these parameters can still affect the line intensities and their ratios used for temperature retrieval. To evaluate this effect, the responses of the three selected line-intensity ratios to variations in filter temperature and optical-system focal length were examined using forward-modeled spectra. …*

A sensitivity-based weighting scheme is therefore used to combine the three ratio-based temperature estimates. The relative contribution of each estimate is determined from the response of the corresponding line-intensity ratio to perturbations in filter temperature and optical-system focal length. Ratios that are less affected by these perturbations are assigned larger weights. …"

The revised Sect. 3.3 further provides the quantitative definitions of the sensitivity measures, their normalization and combination, and the resulting temperature-dependent weighting functions.

Comment 4

L182: It is better to provide a figure to show the full-spectrum shape and line-intensity ratios. This is the key difference between MPII and FASLR.

Response:

We sincerely thank the reviewer for this helpful suggestion. Following this comment, we have added a new **Fig. 3** to the revised manuscript to more clearly illustrate the main difference between MPII and FASLR in how temperature is retrieved from the observed spectrum. Since a new Fig. 3 was added, the original Fig. 3 has therefore been renumbered as Fig. 4.

Figure 3a shows the normalized observed spectrum together with the initial and final synthetic spectra in MPII. This panel illustrates that MPII iteratively adjusts multiple parameters in the forward model so that the modeled spectrum matches the observed spectrum over the selected spectral range. Figure 3b identifies the P1(1), P1(2), P1(3), and P1(4) line intensities used in FASLR, together with the three line-intensity ratios constructed from them. This panel shows that FASLR retrieves temperature from selected line-intensity ratios rather than from matching the full spectral shape.

We have also added the following explanation to the main text:

"Figure 3 illustrates the different ways in which MPII and FASLR use the observed spectrum for temperature retrieval. MPII uses the spectral profile over the selected range and iteratively adjusts multiple parameters in the forward model to reproduce the observed spectrum. In contrast, FASLR retrieves temperature from selected line-intensity ratios rather than through iterative spectral-profile matching (Fig. 3b). ..."

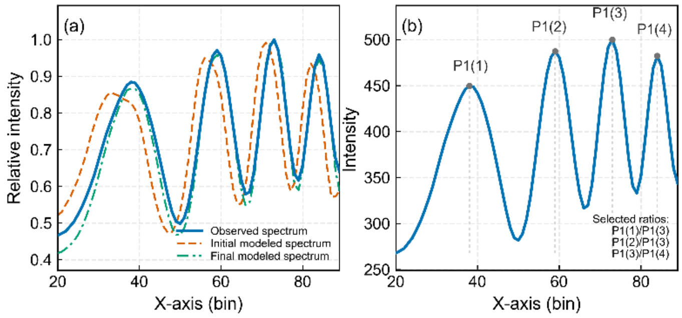

Figure 3. Illustration of the spectra and line-intensity ratios used by MPII and FASLR for temperature retrieval. (a) Normalized observed spectrum together with the initial and final synthetic spectra used in MPII. (b) Observed spectrum showing the P1(1), P1(2), P1(3), and P1(4) lines selected for the three line-intensity ratios used in FASLR."

Comment 5

Equation (4): How about the influence of T_ref on the final temperature T_final?

Response:

We sincerely thank the reviewer for raising this important question. In the original manuscript, the role of T_{ref} and its relationship with T_{final} were not explained sufficiently clearly. Following this comment, we have further clarified the role of T_{ref} in the revised Sect. 3.3 and performed an additional sensitivity test to quantitatively evaluate its influence on the final temperature.

In FASLR, the three selected line-intensity ratios provide three temperature estimates, T_1, T_2 and T_3. Because the sensitivities of these ratios to instrumental-parameter perturbations vary with temperature, the corresponding weights, $w_1(T)$, $w_2(T)$ and $w_3(T)$, are also temperature dependent. If $w_1(T_1)$, $w_2(T_2)$ and $w_3(T_3)$ were selected separately using the three ratio-based temperatures, these weights would belong to three different normalized weight sets evaluated at different temperatures, and their combined value would not necessarily equal unity. They therefore cannot be directly used together for the same weighted temperature estimate. For this reason, a reference temperature, T_{ref}, is introduced so that all three weights are evaluated at the same temperature. In this study, T_{ref} is defined as the median of the three ratio-based temperature estimates for each observation.

T_{ref} is used only to select the set of weights for the current observation and does not enter the retrieval of T_1, T_2 and T_3 itself. Therefore, its influence on T_{final} can occur only through the temperature-dependent weights. To quantify this influence, we performed a sensitivity test in which T_1, T_2 and T_3 were held fixed, while T_{ref} used to evaluate the weights was perturbed by ±10 K and ±20 K. The weights were then recalculated and used to obtain T_{final}.

To illustrate the response of the final temperature to changes in T_{ref} for each observation, we first examined the difference in T_{final} relative to the baseline result for each perturbation. As shown in Fig. R5-1, ΔT_{final} remains close to zero for most observations, indicating a weak dependence of the final temperature on the perturbed T_{ref} values.

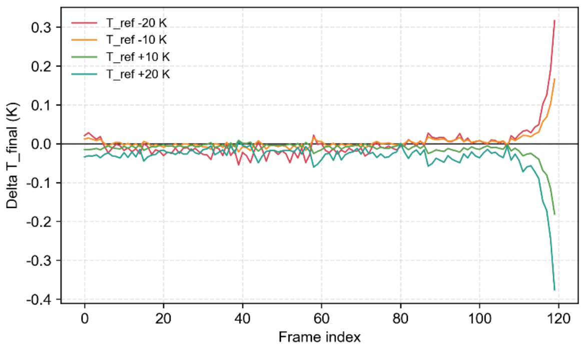

Figure R5-1. Changes in T_{final} relative to the baseline result for each observation when T_{ref} is perturbed by −20, −10, +10, and +20 K. T_1, T_2 and T_3 are kept unchanged in all tests.

To further quantify this effect, we calculated the median and 95th percentile of $|\Delta T_{final}|$ for each T_{ref} perturbation. As shown in Fig. R5-2, for perturbations of −20 and +20 K, the median values of $|\Delta T_{final}|$ are **0.0168 and 0.0267 K**, respectively, while 95% of the absolute changes are smaller than **0.0490 and 0.0722 K**, respectively. The changes are even smaller for the ±10 K perturbations.

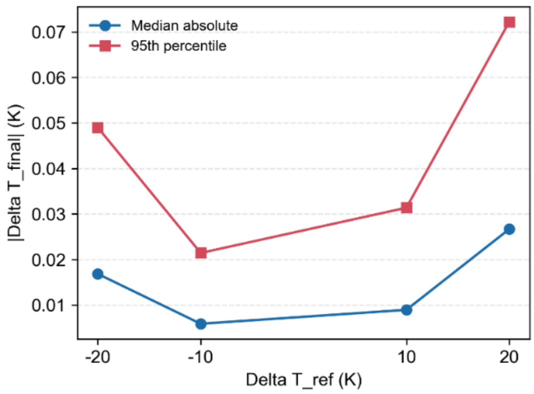

Figure R5-2. Median and 95th percentile of the absolute change in final temperature, |ΔT_{final}|, for T_{ref} perturbations of ±10 K and ±20 K.

These results show that T_{ref} mainly serves to determine a mutually consistent and normalized set of temperature-dependent weights for the three ratio-based temperature estimates. Within the range examined here, the tested variations in T_{ref} have only a very small influence on the final weighted temperature. Following the reviewer's suggestion, we have clarified this role of T_{ref} in Sect. 3.3 and added the corresponding quantitative sensitivity analysis. The revised text reads as follows:

"*...Here, T_{ref} serves only as a common temperature at which the three temperature-dependent weighting functions are evaluated. To evaluate the influence of T_{ref} on the final result, an additional sensitivity test was performed by perturbing T_{ref} by ±10 and ±20 K while keeping T_1, T_2, and T_3 unchanged. For perturbations of −20 and +20 K, the median absolute changes in T_{final} were 0.017 and 0.027 K, respectively, and 95% of the absolute changes were smaller than 0.049 and 0.072 K, respectively. The changes were still smaller for ±10 K perturbations. These results indicate that the final weighted temperature is only weakly sensitive to variations in T_{ref} within the tested range. ...*"

Comment 6

L260: "The FASLR temperatures are about 6–10 K higher than the MPII results". Why? What is the accurate temperature? Only after this question is answered, the advantages (L276-283) of FASLR are conceivable.

Response:

We sincerely thank the reviewer for raising this important concern. We agree that the temperature differences between FASLR and MPII shown in Fig. 6 need to be interpreted carefully, particularly before drawing conclusions regarding the absolute temperature performance or advantages of FASLR. This comment prompted us to re-examine the comparison between the two retrieval methods and revise the corresponding statements in the manuscript.

For the two observation nights shown in Fig. 6, the FASLR temperatures were generally higher than the MPII results by approximately 6–10 K. In the original manuscript, this difference was mainly discussed based on these two nights. After further examination, we found that this description was too general and did not fully represent the variability of the differences between the two methods under different observing conditions.

Following the reviewer's suggestion, we added MPII results for the six observation nights and extended the comparison between FASLR and MPII. As shown in the revised comparison (Fig. R6), the differences between the two retrieval methods vary among different nights and also change during individual nights. On some nights, the FASLR and MPII temperatures show generally consistent temperature levels, with differences occurring only during part of the observation period, whereas on other nights, the two retrievals show different temperature levels over most of the observation period. Meanwhile, the major nocturnal temperature variations retrieved by FASLR and MPII are generally similar. Therefore, the approximately 6–10 K difference observed in Fig. 6 is considered a characteristic of the two specific observations rather than a systematic offset between FASLR and MPII.

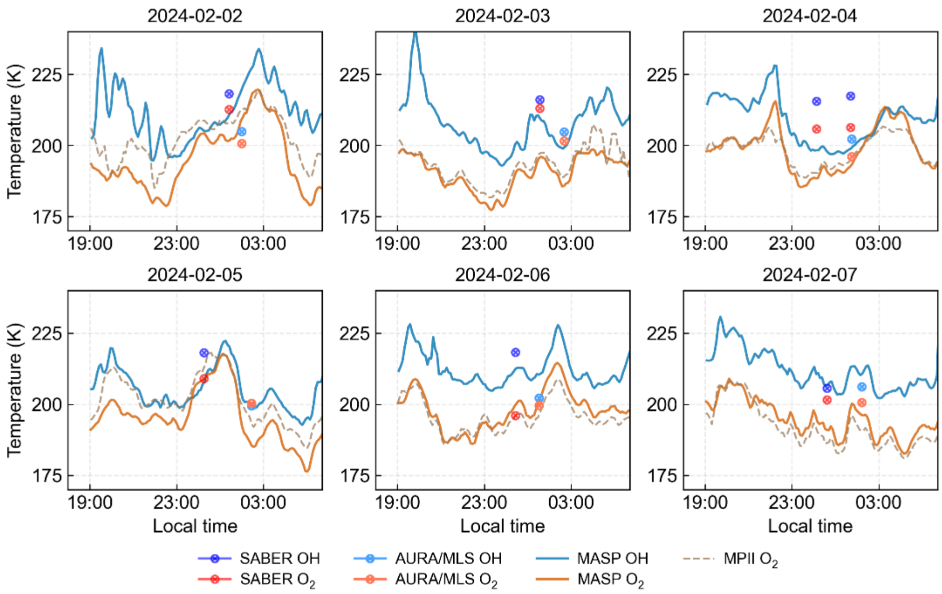

Figure R6. Comparison of temperatures during the six observation nights from 2 to 7 February 2024. The solid blue and orange curves show the OH and O_2 temperatures retrieved from MASP observations using FASLR, respectively, while the dashed brown curve shows the O_2 temperatures retrieved using MPII. Available SABER and Aura/MLS temperatures at the representative OH and O_2 emission-layer altitudes are shown as markers for reference.

We also examined the possible origin of the differences between FASLR and MPII. Although both methods use the same observed spectra, they utilize the spectral information differently. MPII retrieves temperature through iterative matching between modeled and observed spectral profiles over the selected spectral range, whereas FASLR derives temperature from selected line-intensity ratios. These different retrieval strategies may contribute to the differences between the retrieved temperatures. However, because the magnitude and temporal behavior of the differences vary among the six observation nights, the present observations do not provide sufficient evidence to identify a single dominant cause. Therefore, the origin of the observed differences requires further investigation.

Regarding the reviewer's question of "What is the accurate temperature?", we note that the comparison between FASLR and MPII alone cannot determine which retrieval provides the more accurate absolute temperature, because neither method can serve as an independent reference for the other. Independent sodium fluorescence Doppler lidar observations provide additional information for evaluating the retrievals for the available cases. These comparisons indicate that the MPII temperatures are closer to the lidar measurements for the available observation nights; however, these limited cases are not sufficient to establish the general absolute temperature accuracy of either retrieval method under different observing conditions. A broader assessment requires additional simultaneous comparisons with independent temperature measurements.

In light of these results, we have revised the statements regarding the advantages of FASLR. We no longer present absolute temperature accuracy as an established advantage of FASLR based on the current comparisons.

The discussion associated with Fig. 6 has been revised to focus on the observed temporal variations rather than a general temperature offset:

"…The FASLR and MPII retrievals show generally similar major temporal variations, including the cooling around 23:30, the recovery after midnight, and the gradual warming during the second half of the night. …".

The corresponding discussion of the six individual retrieval results was also revised:

"…The sensitivity-weighted FASLR temperatures again lie between the three individual retrievals and show major temporal variations similar to those of MPII, including the cooling before midnight and the subsequent warming after approximately 01:00. …
For both observation nights, FASLR and MPII show generally similar major temporal variations, although differences remain in their overall temperature levels. …".

In addition, the title of the original Sect. 3.4.2, *"Advantages of FASLR"*, was considered too broad given the available comparison results. It has therefore been changed to *"Computational characteristics and applicability of FASLR"* to more accurately reflect the aspects supported by the present analysis.

Finally, we reviewed the Abstract, main text, and Conclusions to ensure that the interpretation of FASLR performance is consistent with the available evidence. Statements implying that the absolute temperature accuracy of FASLR has already been established have been removed or revised.

Comment 7

Figure 6 and its corresponding descriptions: The sodium fluorescence Doppler lidar temperatures are colder than those retrieved by FASLR? Since temperatures retrieved by MPII are also colder than those retrieved by FASLR, how about the consistence of temperature measured by lidar and retrieved by MPII?

Response:

We sincerely thank the reviewer for pointing out this important issue. Following the reviewer's suggestion, we re-examined the simultaneous observations for the two nights shown in Fig. 7 (original Fig. 6) and carried out a quantitative comparison among the temperatures retrieved by FASLR and MPII and the temperatures obtained from sodium fluorescence Doppler lidar observations.

To quantitatively evaluate the consistency between the retrieval methods and the lidar observations, we compared the FASLR and MPII temperatures with the lidar-derived temperatures at the common observation times. The mean absolute errors (MAEs) between MPII and the lidar-derived temperatures were 2.188 K on 23 May 2023 and 4.555 K on 26 April 2023, whereas the corresponding MAEs between FASLR and the lidar-derived temperatures were 8.717 K and 6.375 K, respectively. These results indicate that, for the two available simultaneous observation nights, the MPII temperatures show smaller MAEs relative to the sodium fluorescence Doppler lidar temperatures than the FASLR temperatures.

At the same time, we believe that a broader assessment of the absolute temperature performance of the two retrieval methods requires additional observations. The six-night comparison between FASLR and MPII further shows that their differences vary among observation nights and over time, suggesting that the results from the two lidar comparison nights should be interpreted as case-specific rather than representative of all observing conditions. Therefore, additional simultaneous comparisons with independent temperature measurements are needed for a more comprehensive evaluation.

Accordingly, we also revised the discussion associated with Fig. 7 to more clearly distinguish the similarity in temporal evolution from the differences in absolute temperature level. The revised text now reads:

"*...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 response to this comment and Comment 6, we also revisited the related statements on temperature performance throughout the manuscript, including the Abstract, section titles, main text, and Conclusions, and revised them where appropriate to better reflect the available comparison results.

Comment 8

Figure 7: Please provide temperatures retrieved by MPII, since the main purpose of this work is to retrieve the airglow temperature more efficiently by the proposed method (FASLR).

Response:

We sincerely thank the reviewer for this helpful suggestion. Following this comment, we have added the MPII O_2 temperatures for all six observation nights to the revised Fig. 8 (original Fig. 7), allowing a direct comparison with the O_2 temperatures retrieved by FASLR from the same observations. The corresponding text and figure caption have also been revised accordingly.

As shown in the revised Fig. 8, the O_2 temperatures retrieved by FASLR and MPII generally exhibit similar major nocturnal variations over the six observation nights. This comparison allows a direct assessment of the consistency between the temporal variations retrieved by FASLR and MPII.

With the addition of the MPII temperature series, the number of datasets displayed in the figure has increased. To improve the clarity of the different temperature series and their major nocturnal variations, the revised figure no longer shows error bars at every individual data point. The retrieval uncertainties are unchanged and remain described in the manuscript.

The corresponding text has been revised as follows:

"*Figure 8 shows the nocturnal evolution of O_2 and OH rotational temperatures retrieved using FASLR during the six observation nights, together with the O_2 temperatures retrieved using MPII for comparison. ... Across the six observation* *nights, the FASLR and MPII O_2 temperatures generally show similar major nocturnal variations. ...*

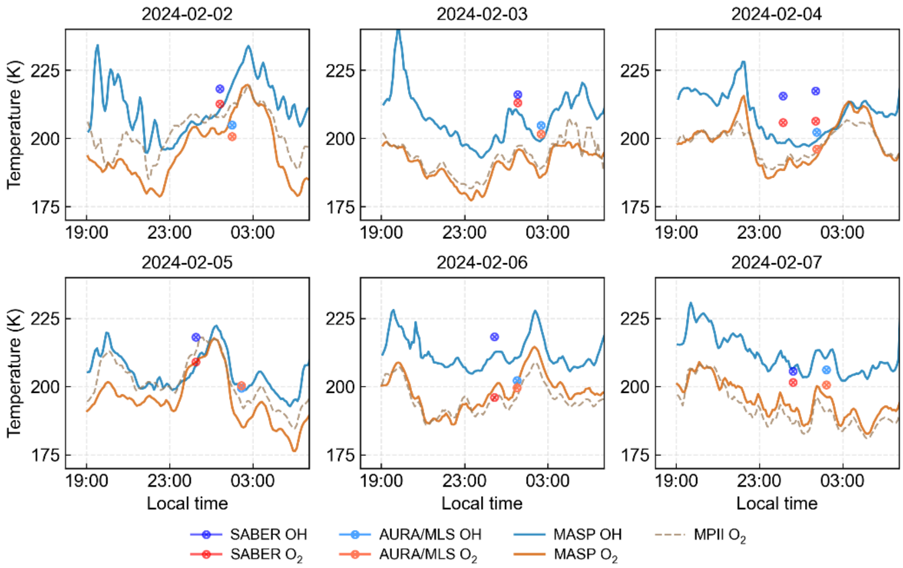

Figure 8: Rotational temperatures retrieved from the six nights of dual-channel MASP observations and comparison with satellite temperatures. The solid blue and orange curves represent the OH (6–2) and O_2 (0–1) rotational temperatures retrieved using FASLR, respectively, while the dashed orange curve represents the corresponding MPII O_2 temperatures. The O_2 and OH temperature series were obtained from alternating measurements, with an effective temporal resolution of approximately 5.3 min for each channel.".

Comment 9

Figure 8: Same comment as that on Figure 7.

Response:

We sincerely thank the reviewer for this suggestion. Consistent with the revision made to Fig. 8 (original Fig. 7), we have added the composite O_2 temperature series retrieved using MPII for the six observation nights to the revised Fig. 9a (original Fig. 8a) for comparison with the FASLR O_2 temperatures. With the addition of the MPII results, the revised comparison shows that the FASLR and MPII O_2 temperatures generally exhibit similar major nocturnal variations.

To improve the readability of the composite temperature evolution and the comparison among the different datasets, the gray curves representing the six individual observation nights are no longer shown in the revised Fig. 9.

The model temperatures shown in the revised Fig. 9 were also updated according to the revisions described in response to the related comments regarding the selection and representativeness of the SD-WACCMX and NRLMSIS 2.1 data.

The relevant text has been revised accordingly:

"...The corresponding MPII O_2 temperatures are also included for comparison. ..."

And:

"...For O_2 (0–1), the FASLR and MPII temperatures show a similar composite nocturnal evolution, with a decrease during the first half of the night followed by an increase after approximately 23:00...."

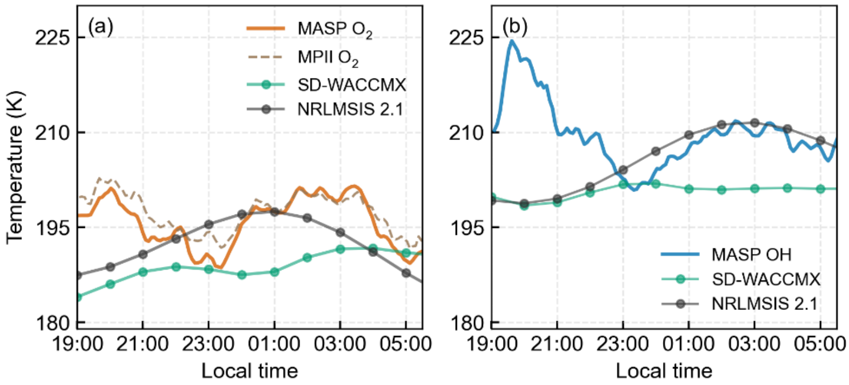

Figure 9: Composite nocturnal evolution of rotational temperatures from six observation nights and comparison with model temperatures. (a) O_2 (0–1) rotational temperature. (b) OH (6–2) rotational temperature. The thick solid orange and blue curves denote the composite mean O_2 and OH rotational temperatures retrieved using FASLR, respectively, while the dashed orange curve in (a) denotes the corresponding MPII O_2 temperature. The green and black curves represent the corresponding temperatures from SD-WACCMX and NRLMSIS 2.1, respectively.

Comment 10

L431-432: How about the window length of moving-average?

Response:

We sincerely thank the reviewer for pointing out that the window length of the moving-average calculation should be specified more clearly. We have added this information to the revised manuscript. The moving-average window used to estimate the slowly varying background contained **29 points**, corresponding to approximately **2.6 h** at the effective sampling interval of **5.3 min**. The corresponding description has been added to the revised manuscript:

"...The moving-average window contained 29 points, corresponding to approximately 2.6 h at the effective sampling interval of 5.3 min. ..."

Comment 11

L471-472: This statement should be caution before the systematic differences of temperatures retrieved by FASLR and MPII are resolved.

Response:

We sincerely thank the reviewer for this important reminder. We agree that statements concerning the temperature performance and advantages of FASLR should be made cautiously while the origin of the differences in absolute temperature levels between FASLR and MPII has not been fully clarified. In this context, the available comparisons do not provide a sufficient basis for making strong statements regarding the absolute temperature accuracy of FASLR.

Following this comment, we revised the relevant statements so that they more closely reflect what is supported by the current results. We no longer use the existing comparisons as direct evidence of the absolute temperature accuracy of FASLR. Instead, the revised manuscript focuses on the computational characteristics of FASLR and the generally similar major temporal variations retrieved by FASLR and MPII, while also acknowledging that differences in their absolute temperature levels remain and require further evaluation.

The corresponding text has been revised as follows:

"*...The present tests show lower computational cost for FASLR than for MPII, while the temperatures retrieved by the two methods exhibit generally similar major temporal variations. Differences in their overall temperature levels, however, remain and require further evaluation. ...*".