

Response to Topical Editor's Comments

Dear Editors,

We sincerely appreciate the reviewer's constructive and insightful comments, which have greatly helped us improve the technical completeness, rigor, and readability of this manuscript. We have carefully addressed all comments point by point, revised the manuscript accordingly, and supplemented relevant experiments, analyses and discussions. The detailed responses in egusphere-2025-5121-track-V6.pdf are as follows.

R1) Aligned to the GMD manuscript preparation requirements (e.g. as set out in the manuscript template files) please change all instances of "Fig." to "Figure".

Response: We have replaced all instances of "Fig." with "Figure" in the main text in accordance with the GMD formatting requirements.

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Response: We have removed the word "Stringent" and revised the sentence at lines 154–155 in accordance with your suggestion to read: "**Threshold screening for transmittance achieves numerically secure and accurate atmospheric profile sampling ...**".

R3) Lines 165-167 --> There are a few minor re-wordings needed in this section, to make the text clearer. The equations here seem potentially not well-represented, in the current form (see R3.2, R3.3, R3.4)

R3.1) Line 165 --> The text here refers to "It is defined as:", and the "It" here refers to the error function being minimised, to define the optimal least-squares solution referred to in the preceding sentence. Please change "It is defined as" to "The error function being minimised, for this optimal solution, is:"

Response: The sentence at line 165 is revised to "**The error function being minimised, for this optimal solution, is:**".

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R3.3) Lines 165-166, 171 and 177 --> The use of two different indices for model level (j and m) is unclear.

Assuming indeed d is not required for equations 4 and 5, then this means the integer m is also not needed in these equations, the level index can simply be represented by j , as in equationa 1, 2 and 3. I get that there was the need for separate index, for y being defined from the difference in two integrated optical depths (d_j and d_{j-1}). But if y is not used then stick with just j , without referring to m . Please re-formulate equations 4 and 5 with j used for the level index, and d removed. Specifically, please change the $m=1$ and $m=p$ instead to $j=1$ and $j=p$, set subscript y values with integer j , and use j rather than m also in the parentheses ($j = 1, 2, 3, \dots, p$). Please change m also to j within the addition of equation 10 (line 205 of Track-Changes manuscript).

Consistent with your suggestion, variable d is removed and the definition of optical depth y is simplified.

Response: We would like to clarify that the index m cannot be substituted by j . The symbol m represents the sample index of training profiles, while j indicates vertical atmospheric levels. They correspond to different physical dimensions. Merging them

into one symbol will introduce confusion. Accordingly, m is preserved in Eqs. (4), (5) and Eq. (10), and **we have deleted the expression $y=d_j-d_{j-1}$ at lines 168-170.**

R3.4) Line 177 --> Please also reconcile the upper-index in the Sigma summations in equations 4 and 5. Not a big deal. It's just eq 4 has the upper index includes the indefinite signifier. But in eq 5 it doesn't. Mathematicians would probably prefer that used in equation 5, whilst non-mathematicians would probably prefer that used in equation 4. Either is OK, but pls be consistent.

Response: We have standardized the notation of the upper summation limits in Equations 4 and 5 to maintain consistent mathematical formatting. **Both equations now adopt the original format used in Equation 5.**

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The basic mathematical expression (on line 187) says square-root of the product of τ_j with itself.

From the previous expressions, this $\tau_j * \tau_j$ is not Newton's summation notation (for vectors), and my understanding is that negative transmittance can only occur if a satellite artefact, or so.

Please can you clarify the basis of this square-root of $\tau_j * \tau_j$, and why it isn't simply τ_j .

I can understand applying a weighting to the transmittance, and have seen the new text on line 193, where this now has added some text to explore the sensitivity to using different weighting functions.

There it includes both τ_j and also square-root of $\tau_j * \tau_j$, and then is this simply to screen-out potential non-physical negative transmittance values from noise within the satellite measurements?

If so, please add brief note of this, e.g. “, the approach screening-out non-physical negative transmittance from satellite radiances.”, in place of “on the following physical understanding” (that can be implicit re: the previous text re: physical understanding).

Response: Thank you for your valuable suggestion. As you suspected, the form $\sqrt{\tau_j \cdot \tau_j}$ is used to avoid non-physical negative weight values caused by noise-induced negative transmittance from satellite measurements. We clarify the physical motivation for adopting $\sqrt{\tau_j \cdot \tau_j}$ rather than simple τ_j . This formulation effectively excludes non-physical negative transmittance values induced by noise in satellite radiance observations. Following your suggestion, we have replaced the phrase “on the following physical understanding” with the supplementary description about screening unrealistic negative transmittance “, the approach screening-out non-physical negative transmittance from satellite radiances.” at line 181.

R4.2) Line 187 --> Please add the word “integrated”, before “transmittance from a given layer”

Whilst it may be implicit to satellite retrieval expert readers, the terminology “transmittance” may seem ill-defined to more general GMD readers. Although equ 4 and 5 are clear to be considering the integrated atmospheric column above a given point in the vertical, and the text needs to be accessible, with a term “transmittance” communicated with clarifying precursor word “integrated”. Please also make this change at line 195, i.e. change “total transmittance from the layer to space” to “integrated transmittance” adding also the word “out” before “to space”.

Response: Thank you for this suggestion to improve readability for general readers of GMD. We have added the word “integrated” before “transmittance from a given layer” at line 182. At line 190, we revised “total transmittance from the layer to space” to “integrated transmittance from the layer out to space” following your comment.

R4.3) Line 188 --> The 2nd sentence says “For such layers, the contribution of their absorption capability to the total atmospheric absorption becomes smaller”.

This wording kind-of works, the sentence following-on from the preceding sentence referring to “from the top of the atmosphere to the surface”, but this clear in referring to the “such layers” being those near the surface.

But this sentence does need to be stand-alone, and it's also not clear what's meant by the word "capability". Please re-word these sentences to clarify what point is being made here.

Response: Thank you for pointing out the ambiguous wording. We have rephrased this sentence. We explicitly write "these near-surface layers" instead of "such layers" to make the statement self-contained, and removed the vague term "absorption capability" to clarify the physical meaning. The revised sentence at line 183 reads: **"For these near-surface layers, their contribution to the total atmospheric absorption decreases."**

R5) Lines 237 and 238 --> Please change "WF" to "W" for weighting function here (equation 10), to be consistent with the other equations. Please clarify also the discretization was used for deriving the log-pressure tau derivative. Was this a two-point calculation (e.g. forward-difference, backward-difference or centred-difference) or a more complex/stable derivation invoking additional points.

Response: We have replaced the symbol "WF" with "W" in Equation (10) for consistency with other equations at line 256. The derivative of τ with respect to log-pressure is computed using the forward-difference two-point discretization scheme, and this detail has been added to the manuscript text at line 227.

R6) Lines 246-247 --> This sentence could be worded better, "builds on" too colloquial for peer-reviewed expert journal, please change to "adapts", then able to delete "by".

Response: We have replaced the colloquial phrase "builds on" with "adapts" and removed the redundant word "by" as suggested.

Line 236: The sentence is revised to **"LSM2 adapts the threshold-based method, incorporating weighted least squares (WLS) for the regression"**.

R7) Line 247 --> Please add comma before "prior".

Response: Following your suggestion, we have inserted a comma before the word **"prior"** in line 237 of the revised manuscript

R8) Table 1 --> The caption needs to give a bit more information than two words, and the term "Experimental Design" and "Remarks content" are both not quite right. I get the idea, each method arguably a model experiment, but that's a bit of a stretch to describe this as "Experimental Design". Maybe return to the terminology "algorithms" used in the title? Suggest replacing "Experimental Design" with "Summary of methodological specifics for the alternate transmittance algorithms", and "Experimental Scheme Abbreviation" with "Algorithm" (that this is an abbreviation can remain implicit). Similarly change "Remarks Content" to "Summary of method" (heading of right-hand column) and "ultimately derived through" to "then derived via" (more appropriate for peer-reviewed journal article). Delete "OLS", there no real benefit from using this three-letter acronym here.

Response: We have expanded the caption of Table 1 to supply more descriptive information. Following your suggestions, we revised the column headers: "Experimental Design" is replaced with **"Summary of methodological specifics for the alternate transmittance algorithms"**, "Experimental Scheme Abbreviation" is changed to **"Algorithm"**, and "Remarks Content" is updated to **"Summary of method"**. We also changed the phrase "ultimately derived through" to **"then derived via"**, and **removed the acronym "OLS"** from Table 1.

R9) Lines 356-362 --> These 3 added sentences require minor edits, and only the 1st of these, with minor mods (R9.1) should in the main article text, to briefly refer to the extra Figures in the Appendix. This 1st sentence is OK in the main article but needs also to be improved. Replace "Figures A1 through A3 in Appendix A present the error comparisons between..." to "Please see Appendix A (Figures A1 to A3) for further comparison errors between..."

The original wording is OK to remain as originally worded, and please have that original wording, with the modified 3rd sentences below (R9.2 and R9.3) as a paragraph of text for Appendix A.

Response: We thank the reviewer for the careful reading and constructive suggestion regarding the organization of the figure descriptions. We agree that the main text should only briefly refer to the supplementary figures, while the detailed descriptions of

subplot arrangements and figure-specific contents are more appropriate in the Appendix. Accordingly, we have revised the manuscript as follows:

1. **In the main article (lines 342-343, replacing the original first sentence, R9.1):**

We have replaced the sentence “**Figures A1 through A3 in Appendix A present the error comparisons between...**” (originally at lines 356-357) with the more concise and directive sentence: “**Please see Appendix A (Figures A1 to A3) for further comparison errors between...**” (now at lines 342-343).

2. **In Appendix A (preserving the original wording and the revised R9.2 and R9.3):**

We have moved the original first sentence (with the original wording, as suggested by the reviewer) together with the second and third sentences (R9.2 and R9.3) to the beginning of Appendix A, serving as a unified paragraph that describes the layout and contents of Figures A1–A3. The revised paragraph now reads: **Response to Topical Editor’s Comments**

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The original wording is OK to remain as originally worded, and please have that original wording, with the modified 3rd sentences below (R9.2 and R9.3) as a paragraph of text for Appendix A.

Response: We thank the reviewer for the careful reading and constructive suggestion regarding the organization of the figure descriptions. We agree that the main text should only briefly refer to the supplementary figures, while the detailed descriptions of subplot arrangements and figure-specific contents are more appropriate in the Appendix. Accordingly, we have revised the manuscript as follows:

1. **In the main article (lines 342-343, replacing the original first sentence, R9.1):**

We have replaced the sentence “**Figures A1 through A3 in Appendix A present the error comparisons between...**” (originally at lines 356-357) with the more concise and directive sentence: “**Please see Appendix A (Figures A1 to A3) for further comparison errors between...**” (now at lines 342-343).

2. **In Appendix A (preserving the original wording and the revised R9.2 and R9.3):**

We have moved the original first sentence (with the original wording, as suggested by the reviewer) together with the second and third sentences (R9.2 and R9.3) to the beginning of Appendix A, serving as a unified paragraph that describes the layout and contents of Figures A1–A3. The revised paragraph now reads:

“**Figures A1 through A3 in Appendix A present the error comparisons between the LSM series models (LSM1, LSM1.1, LSM1.2) with varying thresholds and the LBL line-by-line model (true value) under typical layer, full atmospheric column, and strong absorption channel conditions, respectively. In the figures, the subplots are arranged as follows: the left panel corresponds to the LSM1 model with a threshold of 10^{-4} , the middle panel corresponds to the LSM1.1 model with a threshold of 5×10^{-5} , and the right panel corresponds to the LSM1.2 model with a threshold of 10^{-5} . Specifically, Figure A1 compares the spectral transmittance at the typical layer (atmospheric layer 56); Figure A2 illustrates the vertical profiles of level-to-space transmittance across the full atmospheric column; and Figure A3 provides statistical errors for transmittance and brightness temperature difference (K) over the strong absorption channel range of $1300\text{--}1900\text{ cm}^{-1}$.**”

R10) Line 471 --> Please replace “is conducted over the region from 60°S to 60°N...” to “has near-global coverage, extending from 60°S to 60°N”.

Response: We thank the reviewer for the suggestion. We have revised the sentence at line 456 as recommended. The original phrasing “is conducted over the region from 60°S to 60°N...” has been replaced with “**has near-global coverage, extending from 60°S to 60°N...**” to more concisely and accurately describe the spatial coverage of our analysis.

R11) Line 547 --> Delete “kelvins”, and add a space between “0.5” and “K”.

Response: We have deleted the word “kelvins” and added a space between “0.5” and “K” (now written as “0.5 K”) at line 533.

R12) Line 550 --> Add hyphen to “preprocessing” “pre-processing”.

Response: We have changed “preprocessing” to “**pre-processing**” by inserting a hyphen at line 536, in accordance with the reviewer’s suggestion.

R13) Line 552, and line 543 --> delete comma after “(i.e.” & “(e.g.” ◊ should just be space, no comma.

Response: We have removed the commas immediately after “(i.e.” and “(e.g.”, so the corrected forms are now “(i.e.” at line 529 and “(e.g.” followed by a space (without a comma) at line 538. This aligns with the standard usage requested.

R14) Line 634 --> Delete “: Figures” within “Appendix A: Figures”, just state this “Appendix A”.

Response: We have revised the appendix heading from “Appendix A: Figures” to simply “**Appendix A**”, as recommended.

R15) Line 650 --> Delete “reflects”, and the sentence works OK if deleting “and” and “fluctuation”.

Response: We thank the reviewer for the suggestion. We have revised the sentence accordingly at line 644. Specifically, we have deleted the word “reflects” as well as “and” and “fluctuation” from the original sentence. To maintain clarity and grammatical correctness, we have split the original compound sentence into two separate sentences and used “shows” in the second clause. The revised sentence now reads: “**The blue line denotes Standard Deviation (Std). The gray scattered background shows the range.**”

We thank the editorial office for this notification. We have carefully revised the color schemes of all figures to ensure accessibility for readers with colour vision deficiencies. Specifically:

- All line colours and map markers have been replaced with the colourblind-friendly palette, avoiding any red–green combinations.
- The filled distribution maps (the OMB distribution maps) now use the perceptually uniform, colourblind-safe diverging colormap balance from the cmocool package, instead of the previous rainbow-like scheme.
- Where multiple curves or categories appear in one panel, color encoding is now additionally supported by redundant visual cues (distinct line styles and markers), so that the information remains accessible even in greyscale.

We have made the following revisions to the manuscript (version 7). We believe these revisions fully address your concerns and significantly improve the clarity and precision of the manuscript, especially for readers of a specialist journal.

We have uploaded the revised manuscript with these changes clearly marked.

Thank you again for your guidance and for handling our manuscript.

Sincerely,

The Authors