

General comments:

The authors present a retrieval algorithm that combines wavelength pairing with the multiplicative algebraic reconstruction technique (MART) and apply it to OMPS-LP L1G data to obtain ozone profiles. The results derived from this algorithm are validated using multiple ozone profile observations. However, wavelength pairing and MART are well-established and commonly used techniques in limb sounding. This study essentially applied these mature methods to a different dataset, thus offering limited novelty. Furthermore, the authors do not clearly articulate the advantages of their algorithm over the official OMPS-LP algorithm. In terms of retrieval accuracy, the presented algorithm does not demonstrate sufficient improvement over the official OMPS-LP retrievals, which diminishes the practical significance of this work.

Response: We thank you for the insightful and critical evaluation of our manuscript. We acknowledge the concerns regarding the novelty and practical significance of our work. Below, we provide a detailed point-by-point response addressing these concerns, clarifying the methodological adaptations, scientific value as an independent validation tool, and practical significance to multi-mission data harmonization.

Point 1: The authors present a retrieval algorithm that combines wavelength pairing with the multiplicative algebraic reconstruction technique (MART) and apply it to OMPS-LP L1G data to obtain ozone profiles. The results derived from this algorithm are validated using multiple ozone profile observations. However, wavelength pairing and MART are well-established and commonly used techniques in limb sounding. This study essentially applied these mature methods to a different dataset, thus offering limited novelty.

Response 1: We thank you for raising this important point regarding the novelty of our work. We agree that the core components of our algorithm—wavelength pairing and MART—are established techniques in atmospheric remote sensing. However, we respectfully argue that the novelty and scientific contribution of this study lie not in the invention of a new fundamental method, but in its tailored adaptation, comprehensive validation, and strategic application to the OMPS Limb Profiler (LP), which presents unique challenges and opportunities. We clarify this contribution in three key aspects:

1. Instrument-Specific Adaptation and Optimization

Porting an algorithm from one satellite instrument (e.g., OSIRIS) to another (OMPS/LP) is non-trivial. The two instruments differ significantly in spectral resolution, wavelength coverage,

sampling geometry, signal-to-noise characteristics, and radiometric calibration. Our work involved substantial re-engineering, including developing a new forward model configuration within SCIATRAN specifically optimized for OMPS/LP's spectral response and limb-viewing geometry, and re-deriving the optimal wavelength triplet (512 nm, 606.3 nm, 675.5 nm) based on OMPS/LP's specific sensitivity and noise properties, which differs from those used for OSIRIS. Moreover, we integrated NASA's v2.6 L1G data with its enhanced stray light and pointing corrections, which required adjustments in the normalization and cloud filtering steps to ensure consistency. Our retrieval workflow had to be adapted to handle these pre-processed inputs correctly. This rigorous adaptation, detailed in Sections 2.2 and 3, represents a significant technical contribution for the OMPS user community and ensures the method is correctly tuned for this specific sensor.

2. Providing an Independent Retrieval Pathway for Validation and Uncertainty Analysis

The existence of an official operational algorithm (NASA OMPS/LP v2.6) does not diminish the value of an independently developed algorithm. In remote sensing, multi-algorithm intercomparison is a fundamental tool for assessing data quality and characterizing structural uncertainties. Our algorithm serves as a completely independent reference for validating the official product. The strong agreement we find with the official product in the 20 – 36 km altitude range (deviations generally $\leq 5\%$) provides robust, independent validation of OMPS/LP data quality in this region. Conversely, the systematic differences we identify (e.g., high biases above 35 km and in the tropical UTLS) are diagnostically valuable. We trace these differences to specific algorithmic choices, such as using visible-only spectra versus a UV-Vis synergy, and different prior constraints and aerosol handling. This analysis, presented in Sections 4.2–4.5, offers crucial insights into the inherent uncertainties of limb-scattering ozone retrievals.

3. Foundational Step Towards Long-Term, Multi-Mission Data Harmonization

A primary motivation stated in our manuscript is to facilitate the creation of long-term, consistent ozone profile records. OSIRIS (launched 2001) and OMPS/LP (launched 2011) are two pivotal limb-sounding missions for stratospheric monitoring. By successfully applying a consistent retrieval core (MART with wavelength pairing) to both instruments, we take a concrete step towards minimizing algorithm-induced discontinuities in combined datasets. This work is therefore a necessary contribution towards building seamless multi-decadal climate data records, which is a high-priority goal for the atmospheric composition community. The novelty here lies in the strategic

cross-platform methodological harmonization. This aligns with the reviewer's perspective that the current work serves as a foundation for future improvements, including the incorporation of UV information and operational aerosol products.

Point 2: Furthermore, the authors do not clearly articulate the advantages of their algorithm over the official OMPS-LP algorithm. In terms of retrieval accuracy, the presented algorithm does not demonstrate sufficient improvement over the official OMPS-LP retrievals, which diminishes the practical significance of this work.

Response 2: We thank you for this comment, which allows us to clarify the practical significance of our work. We respectfully submit that the value of an independent algorithm is not solely—or even primarily—defined by its ability to outperform the official product in terms of accuracy. Its significance is multifaceted.

Firstly, our study provides a transparent and comprehensive error analysis (Section 4.1) that is valuable for all users of OMPS/LP data. We explicitly quantify the contributions from the prior profile (~5% error in the tropical lower stratosphere based on a +5% perturbation experiment), aerosol extinction uncertainty (~5% error at 15–25 km), cross-section temperature dependence (localized biases of –3% to –5% in the tropics and Southern Hemisphere), and measurement noise (random uncertainty ranging from <10% in the mid-stratosphere to >20% at high altitudes and in the tropical UTLS, as quantified by Monte Carlo simulations). This detailed error budget helps data users understand the limitations and optimal altitude ranges (e.g., 20–35 km in the tropics) for ozone profiles derived from OMPS/LP's visible channels. This is a practical contribution to the community's understanding of the data. Secondly, the systematic high bias we find above 35 km is a key result with practical implications. We demonstrate that this bias is linked to the inherently reduced sensitivity of visible wavelengths to ozone in the upper stratosphere. This finding objectively validates the design choice of the official algorithm to merge ultraviolet and visible spectral information at high altitudes. Our work, therefore, helps define the reliable altitude boundaries for visible-only retrievals from OMPS/LP, which is valuable for studies focusing on the middle stratosphere or for instrument cross-checks. Last but not least, different retrieval philosophies have different strengths. The official optimal estimation (OE) algorithm is robust and effectively incorporates prior knowledge and constraints. Our MART-based approach, in contrast, has a simpler, more computationally straightforward framework with fewer explicit prior constraints. This makes

its response to the measured radiance more direct and its error characteristics highly transparent. It can thus serve as a useful complementary product for specific research applications, such as in regions where prior information is highly uncertain, or for studies focused on understanding the pure information content of the limb radiances.

To ensure these points are communicated clearly, we have revised the manuscript to better highlight our contributions. We believe these revisions will significantly clarify the novelty and practical importance of our work. We are grateful for your constructive feedback, which has helped us improve the presentation of our study's contributions.

Specific comments:

Point 3: Line 122: Tangent height normalization can reduce absolute calibration errors to some extent. However, the impact of wavelength shifts on retrieval results is unlikely to be eliminated through normalization. This is because wavelength shift affects the calculation of ozone absorption cross-sections.

Response 3: We thank you for this important clarification, which highlights a subtle yet crucial aspect of limb retrieval error analysis. We fully agree that tangent height normalization primarily addresses radiometric calibration errors and surface albedo effects by referencing radiance to a high-altitude measurement where ozone absorption is minimal, but it does not correct for wavelength-dependent errors that affect the spectral shape of the measurement, such as those introduced by wavelength shifts. In response, we have revised the relevant text in the manuscript to more accurately reflect the limitations of normalization and to explicitly acknowledge the potential impact of wavelength shifts on cross-section calculations. The revised text now reads:

“Although radiance normalization cannot completely eliminate the influence of surface reflection and does not correct for spectral errors such as wavelength shifts—which affect the calculation of ozone absorption cross-sections—it significantly reduces the requirements for absolute radiometric calibration accuracy (Flittner et al., 2000).”

We have also added a brief discussion in Section 2.2 regarding the instrument’s wavelength stability and its effect on retrieval. The added text reads::

“...While thermally induced wavelength shifts have negligible impact on height-normalized radiances in ozone retrieval, we note that residual wavelength-dependent errors could affect cross-section matching in regions of strong ozone absorption.”

These revisions clarify that while normalization is effective for mitigating certain types of errors, it is not a comprehensive solution for all spectral calibration issues. We thank you for prompting this important clarification, which strengthens the error discussion in our manuscript.

Point 4: Line 221: SCIATRAN v2.2 is a relatively old version. Has the new version made improvements in computational accuracy?

Response 4: We thank you for raising this point. Indeed, newer versions of SCIATRAN (e.g., v4.6) offer enhancements in computational efficiency, support for additional physical processes (such as rotational Raman scattering), and updated absorption cross-section databases. However, for limb-scattering radiative transfer simulations in the visible Chappuis–Wulf band—the spectral range used in this study—the core physics of multiple scattering and ozone absorption are already well-established and sufficiently represented in SCIATRAN v2.2 for the purpose of this study.

Our sensitivity analysis (Section 4.1) indicates that the primary sources of uncertainty in the retrieved ozone profiles stem from the prior profile, aerosol extinction, and measurement noise—not from radiative transfer modeling errors. Any potential differences in simulated radiances between v2.2 and newer versions are expected to be minor in the context of ozone retrieval in this spectral region, and well within the estimated error budget of the retrieval.

We appreciate your attention to this technical detail and agree that future work could benefit from adopting the latest model version, particularly for studies focusing on ultraviolet wavelengths or requiring advanced treatment of inelastic scattering. However, for the present study, the use of v2.2 does not compromise the validity or accuracy of our results, as demonstrated by the good agreement with multiple independent datasets presented in Section 4.

Point 5: Line 512: How significant is the impact of a priori profiles on retrieval accuracy in the official OMPS-LP algorithm? The current algorithm appears to be highly dependent on the a priori profile, which raises concerns regarding the credibility of the retrieval results.

Response 5: We appreciate your attention to the role of a priori information in both the official OMPS-LP retrieval and our proposed algorithm. Below, we clarify the influence of a priori constraints in each case.

The official OMPS/LP retrieval employs an optimal estimation (OE) framework, which indeed incorporates a priori ozone profiles as part of its regularization strategy. However, the algorithm's dependence on the a priori is highly altitude- and latitude-dependent. As noted by Kramarova et al.

(2024), “The LP ozone retrieval algorithm is very insensitive to a priori between 17 and 52 km in mid-latitudes and about 22–52 km in the tropics (Arosio et al., 2022). Sensitivity to a priori increases at the upper (above 52 km) and lower portion (below 17 km in mid-latitudes and 22 km in the tropics) of the profile where sensitivity of the LP measurements to ozone sharply declines.” This indicates that within the core stratospheric altitude range ($\approx 20 - 35$ km) where limb-scattering measurements exhibit strong sensitivity, the retrieval is largely observation-driven, and a priori influence is minimal. Therefore, the credibility of the official product remains high in this scientifically critical region.

In contrast to the OE approach, the multiplicative algebraic reconstruction technique (MART) used in our study does not rely on an explicit a priori constraint term in its objective function. Instead, the retrieval is initiated from a first-guess profile, but the iterative update is driven directly by the normalized radiance gradients. As shown in our sensitivity analysis (Section 4.1, Fig. 5), the impact of the initial profile on the final retrieval is largely confined to altitudes below 20 km in the tropics, where measurement sensitivity declines. Above this altitude, the retrieval is dominated by the measurement signal. Unlike the official algorithm based on optimal estimation, which relies on explicit a priori constraints particularly at extreme altitudes, our MART retrieval is less affected by the a priori. This design makes our algorithm particularly useful for diagnosing prior-induced biases in regions where independent validation is needed.

Nevertheless, both retrievals show strong consistency in the 20–35 km range, where satellite limb measurements are most sensitive and prior dependence is low. The cited studies confirm that the official OMPS-LP retrieval is not “highly dependent” on the a priori in the altitude range where most scientific analyses are conducted, which supports the credibility of the product within its well-validated vertical domain. Our independent retrieval further corroborates this by showing close agreement in that same region.

Thank you again for raising this important methodological issue. The cited studies confirm that the official OMPS-LP retrieval is not “highly dependent” on the a priori in the altitude range where most scientific analyses are conducted, which supports the credibility of the product within its well-validated vertical domain. Our independent retrieval further corroborates this by showing close agreement in that same region.