Response to Reviewer Comments

General Comment:

Accurate simulation of microwave oxygen ("O" _2) absorption is critical for upper-atmospheric remote sensing. However, traditional radiative transfer models exhibit systematic biases due to simplified Zeeman splitting calculations relying on the Hund case (b) assumption. In this manuscript, the authors present a simulation analysis of upper-atmosphere temperature-sounding channels for the proposed Hyperspectral Microwave Atmospheric Sounder (HMAS). Using an updated Line-by-Line (LBL) model with the updated Zeeman coefficients from Larsson et al. (2019), this study demonstrates certain improvements in simulated brightness temperatures across several upper microwave frequencies. Furthermore, the authors conducted a retrieval experiment about vertical temperature profiles using an improved back-propagation (BP) neural network enhanced with dual residual blocks and a squeeze-and-excitation (SE) attention mechanism based on simulated brightness temperatures from both HMAS and SSMIS corresponding channels. The results show that HMAS can yield a little superior vertical temperature profiling retrieval capability compared to the Special Sensor Microwave Imager/Sounder (SSMIS) upper-atmospheric sounder (UAS) channels. The methodology and findings presented here are of clear value to the satellite microwave remote sensing community, and the manuscript is well organized and clearly written. I recommend publication following minor revisions.

Below are my detailed comments and suggestions for further refining the manuscript prior to publication:

We thank the reviewer for the positive assessment and constructive comments. We have revised the manuscript accordingly. Our responses are provided below.

Comment 1:

In Section 'Introduction', the author only mentioned Section 4. How about other Sections? Suggest updating the last paragraph to have a complete structure briefing of the manuscript.

Responses:

Thank you for this suggestion! We have revised the last paragraph of the Introduction to provide a complete outline of Sections 2-5, covering the methodology, oxygen absorption line characteristics, sounder channel design and evaluation, and conclusions.

Changes: Introduction, page 3, lines 76-81.

Comment 2:

it is understandable that the manuscript only studied the impact of the Zeeman effect at the upper temepratur4e sounding channels with weighting heights above 40 km. However, I am wondering whether the effect is entirely negligible for the upper channels with weighting heights below but close to 40 km. If this is not the case, consider revising 'Microwave oxygen (O2) absorption channel observations and simulations above 40 km are affected by Earth's magnetic field.' In line # 60 to 'Microwave oxygen (O2) absorption channel observations and simulations close to and above 40 km are affected by Earth's magnetic field.'

Responses:

Thank you for this comment. The influence of the Zeeman effect is not entirely negligible below, but close to, 40 km. Following the reviewer's suggestion, we changed "above 40 km" to "close to and above 40 km" in the Introduction. We also clarified in Section 2.2 that approximately 40 km is used as a practical transition between scalar and polarized radiative transfer treatments. This is a computational approximation reflecting the increasing dominance of pressure broadening at lower altitudes, rather than a physical boundary below which the Zeeman effect is absent.

Changes: Introduction, page 2, lines 63-66; Section 2.2, page 6, lines 149-153.

Comment 3:

It is my understanding that Eq. (3) in the manuscript was not derived in Larsson et al. 2019. Please verify and correct if needed.

Response:

Thank you for identifying this issue. The previous form of Eq. (3) did not correctly represent the expressions given by Larsson et al. (2019). We replaced it with the three fine-structure branches following their Eq. (12), and have explicitly identified this source in Section 2.1. For direct comparison, Eq. (2) now presents the corresponding three branches under the simplified Hund's case (b) approximation. We also clarified the definition of the mixing angle and the applicable range of the equations.

These corrections concern the theoretical expressions presented in the manuscript. The simulations used the Zeeman coefficients implemented in the radiative transfer model, rather than the previous written form of Eq. (3), so the numerical results are unchanged.

Change: Section 2.1, page 4, lines 102-117, including Eqs. (2) and (3) and the mixing-angle definition; page 5, lines 125-127, for the applicable range and limiting relationship between the equations.

Comment 4:

Following the above comment in 4), I don't think Larsson etal. (2019) derived the following parameters, i.e., gs, gr, and g (see the descriptions in line103). Please verify and correct it as needed.

Response:

Thank you for this correction. We corrected the description following Eq. (3) to identify g_S as the effective molecular electron spin g-factor, g_r as the rotational g-factor, and g_l^e as the parameter describing the anisotropic spin Zeeman interaction.

The revised manuscript attributes the adopted values to the earlier molecular spectroscopy studies of Bowers et al. (1959) and Christensen and Veseth (1978), using the sign convention presented by Larsson et al. (2019). We also clarify that their Table 1 summarizes these adopted parameters, whereas Table 2 provides the calculated level-specific Zeeman coefficients. The two earlier studies have been added to the reference list.

Changes: Section 2.1, page 5, lines 119-125; References, page 27, lines 613-616.

Comment 5:

for the MAS (Line # 330) is it a typo or a new instrument? Suddenly changing to MAS seems not consistent with other discussions in the manuscript. However, the author mentioned 'both Hyperspectral Microwave Atmospheric Sounder (HMAS) and Microwave Atmospheric Sounder (MAS) are comparable' in lines from 510 to 511. Please clarify this.

Response:

Thank you for pointing out this unclear description. MAS refers to the conventional Microwave Atmospheric Sounder proposed in this study, not a typo. MAS has 21 channels, whereas HMAS has 150 original channels combined into 39 composite channels. Both configurations use the same three oxygen absorption line combinations. MAS uses progressively broader channels away from the line centers, while HMAS uses more narrow channels for finer frequency sampling.

We also clarified the distinction at the first occurrence of MAS in Section 4.2 and in the Conclusions. Tables 1 and 2 provide the HMAS and MAS channel configurations, respectively.

Changes: Section 4.2, page 16, lines 350-360; Conclusions, page 25, lines 535-539. The HMAS channel combination is described on page 13, lines 329-330, and the channel configurations are provided in Table 1 on pages 14-15 and Table 2 on pages 16-17.

Comment 6:

the link of https://cetemps.aquila.infn.it/mwrnet/lblmrt_ns.html in both the line 546 and its reference is not working. Please verify and correct it.

Response:

Thank you for pointing out the inaccessible link. We removed the link from the manuscript and revised the Code availability statement to identify the source of the code and explain how to obtain the version used in this study. The revised statement reads: The microwave LBL code used in this article was obtained from MWRnet. The version used in this study is available from the corresponding author upon request.

Changes: Code availability, page 26, lines 570-571.

We sincerely thank the reviewer for these detailed and insightful comments, which have significantly improved the scientific rigor and clarity of our manuscript.