

## Author response to Referee #1

We would like to thank Referee #1 for the valuable comments. We have included the comments one by one, in bold text, along with our answers. If lines are given in the answers they refer to the original manuscript. The blue colour indicates text added in the revised manuscript.

### General comments:

**The manuscript describes an evaluation of limb radiance measurements of the O<sub>2</sub> atmospheric band near 760 nm taken with the multi-channel imager of the MATS satellite launched in November 2022. The data are compared with spectra of the limb profiler OSIRIS on the Odin satellite (launched in February 2001) in the same wavelength range. Only a small sample of 20 dayglow and 16 nightglow coincidences with sufficient agreement in time and location could be selected. On average, the O<sub>2</sub> limb radiance is about 20% higher than in the case of OSIRIS. It is assumed that differences in the absolute calibration are the most likely explanation for the discrepancies. However, the impact of stray light remains uncertain for both instruments, even with radiative transfer calculations with SASKTRAN.**

**For research in the Earth's mesosphere and lower thermosphere, MATS is a promising mission. Therefore, I appreciate the submission of the manuscript by Linder et al. to AMT as it allows insights in the performance of MATS. Nevertheless, I would like to see some improvements before the start of the publication process. In particular, the design of the investigation could be better motivated. Some clarifications might be provided by another MATS-related manuscript submitted by Megner et al.. However, the present manuscript should be sufficiently self-explanatory.**

### Specific comments:

- Sect.1:** The introduction only describes MATS and OSIRIS in a rather technical way. For a better understanding of the goals of these airglow-observing instruments and the importance of tackling the calibration issues, it would be helpful to discuss them in a broader context. There is no information on other satellite missions (or maybe ground-based observations, although the A-band cannot directly be accessed) that could contribute to solve the calibration issues. As MATS and OSIRIS data appear to have calibration and stray light

issues, it would be important to understand why the study was designed in the described way.

We agree that the manuscript did miss some motivation as to why the evaluation was designed as it was. We have now included a part motivating the design of the study in Section 1. We have also added a short note on atmospheric band airglow in the introduction.

- Fig.1: The rough extent of the images in horizontal direction could also be provided in the caption and not only in the text where it is more difficult to find.**

This is a good suggestion. We have now updated the figure caption to include the across-track extent.

Two examples of IR measurements made by MATS in the studied period. The purple lines are tangent heights in meters. Note that the instrument settings have changed between the two dates, indicated by the different number of rows (horizontal axes) and columns (vertical axes) between the images, and the slight change in pointing of the instrument. **The across-track extent is roughly 200 km at tangent point.**

- L.147: "MATS background channels, ..., which do not include airglow emissions": This statement is not fully correct as there are faint emissions of other O<sub>2</sub> bands, bands of OH, and airglow (pseudo-)continua. Nevertheless, the related measurement errors for the A-band should be very small.**

This is correct. The manuscript has been updated accordingly:

L146: To avoid this, limb scans are simulated in the spectral regions of the MATS background channels, IR3 and IR4, which **only** include **weak** airglow emissions and **mainly** observe Rayleigh scattered light (see Fig. 3).

- Fig.5: The red, orange, and green lines are hard to distinguish. A remark in the caption could be helpful here. Moreover, the orange lines are difficult to see on a orange/pink background ("red shaded area" in the text), which is not explained in the caption. Would it be possible to use a different line colour or to change the colour of the shaded areas?**

Fig. 5 has been updated and the orange line is now black, which stands out more. References to the orange line in text have been updated. The red shaded area is now explained in the caption. The figures in the appendix have been updated to have the same colours.

- Fig.7: Similar to Fig. 5, it is difficult to recognise the individual lines. Again, the orange lines are most challenging.**

Fig. 7 has been updated with new colours and the orange line is now black. The text has been changed accordingly. The lines of the figures in the appendix now have the same colours.

- Sect.6: As the manuscript appears to describe the first study that actually evaluates real MATS data, it would be interesting know more about the performance of the satellite/instrument compared to the expectations before the launch. At least for the calibration of the airglow radiance and stray light issues (i.e. the topic of the study), more information would be helpful. In this context: where does the statement "is reported as 3-4%" come from?**

The calibration paper is at the time of writing also under review (finalising response). While this is one of the two first studies that evaluates MATS data, these questions are treated in greater detail in the calibration paper. The 3-4% is from this calibration paper (Megner et al.), which is now cited alongside the statement. From mission requirements, an absolute error within 10% was required - this is included in the updated manuscript.

As for the expectation with regards to stray light, in short, the suppression of stray light was prioritised during the development of the limb imager and the presence of any such light is unfortunate for the mission. Nonetheless, it was anticipated that some stray light would be detected in the measurements and its characterisation was scheduled already prior to the mission launch. The exact magnitude of the stray light and its behaviour is the focus of ongoing work.

#### **Technical corrections:**

- Inconsistent spelling: "stray light" and "straylight" are used.**

We have replaced "straylight" with "stray light" throughout the manuscript.

- Fig.8: In "(SZA > 100°), panel a)", the parentheses are not consistent with "(SZA < 90°, panel b)".**

Corrected.