

Reviewer 2

I have reviewed the manuscript “Spectral analyses of lunar regions observed by MAJIS during the JUICE Earth-Moon flyby” by F. Zambon and colleagues. The study presents visible-near-infrared hyperspectral reflectance measurements of several locations on the lunar nearside, acquired with the MAJIS instrument during the JUICE spacecraft’s Earth-Moon flyby on it’s way to the Jovian system. The MAJIS instrument is designed to characterize the composition and physical properties of Jupiter’s atmosphere and the surfaces of its icy moons, with the goal of identifying water ice, minerals, and organic compounds.

Overall, the study is well executed. The authors successfully place the MAJIS observations within the geological context of the Moon and appropriately address the observational challenges. The applied ratioing method is suitable, and the conclusions are generally supported by the data. Although the mineralogical results themselves are not fundamentally novel, the access to mid-infrared wavelengths (and the potential identification of silicate absorption features in this range) is particularly valuable. In this respect, the manuscript provides an insightful demonstration of MAJIS capabilities in preparation for the upcoming JUICE mission.

I recommend publication after addressing the following minor comments:

- While the introduction touches on lunar volcanism, there is room to further connect the results to basaltic mare volcanism. The authors may wish to consider additional context, for example Head et al. (2023): <https://www.degruyterbrill.com/document/doi/10.1515/9781501519895-014/html>

We added a dedicated paragraph in the “*Geological and mineralogical context of the regions covered by MAJIS*” section.

- The authors state that the Lommel–Seeliger law is insufficient for large phase angles. However, other photometric normalization approaches (such as the lunar Lambert model, the Kaasalainen–Shkuratov model, and the Hapke model) have been widely used. Please clarify why these methods were not considered or applied.

We agree with the reviewer that the lack of a dedicated photometric correction represents a limitation of the present analysis. The main issue is that the currently available MAJIS observations were acquired at phase angles around  $\sim 90^\circ$ , and not optimal illumination condition in two of the four cubes, this makes the derivation of a reliable phase function particularly challenging.

In the preliminary stages of the analysis, we tested the Lommel–Seeliger correction, which has also been adopted in previous studies based on M3 observations. However, given the restricted phase-angle coverage of the MAJIS dataset, the application of such a correction did not provide fully satisfactory results.

Moreover, a rigorous photometric correction would require a dedicated and comprehensive investigation, including observations spanning a wider range of illumination geometries. Such an effort is beyond the scope of the present work, whose primary objective is the spectral and compositional characterization of the observed regions.

We added additional explanation in the paper.

• Please note that spectral effects of space weathering are generally thought to saturate within ~1 Gyr. At several points, the manuscript does not clearly reflect this constraint and could be revised for clarity.

We added a paragraph to clarify this aspect in both the “*Geological and Mineralogical Context of the Regions Covered by MAJIS*” and “*Discussion*” sections.

Additional specific comments:

• Line 249: Space weathering causes spectral reddening, but also significant darkening on the Moon. Please include this aspect.

We address this aspect in the manuscript, specifically in the section “*Spectral indices and ratios*”. To better clarify this concept, we have added an additional explanation.

• Line 346: The phrase “lower degrees of space weathering” may be misleading, as it could imply reduced exposure time. It may be more accurate to attribute the observed differences to compositional effects (e.g., higher iron content leading to stronger spectral alteration).

We have modified the paragraph to include these suggestions.

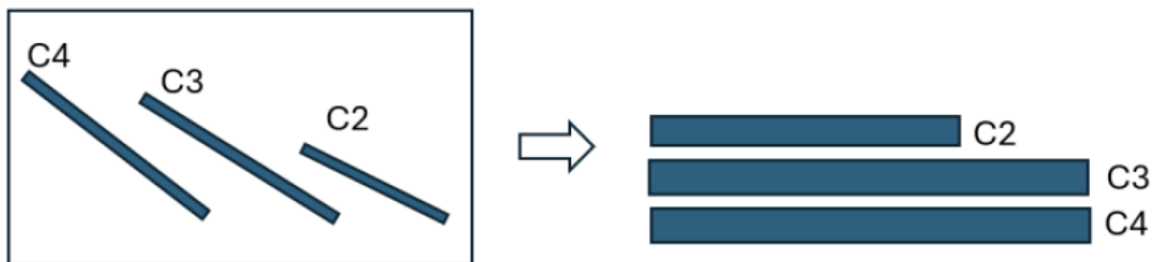
• Line 354: The phrase “with progressive space weathering” suggests an ongoing process. Please consider whether space weathering effects in the region have already saturated (e.g., based on unit ages such as Hiesinger units). If so, terms such as “high maturity” or “strong space weathering” may be more appropriate.

We modified the paragraph as suggested by the reviewer.

• Figure 5 caption: Replace “pink box” with “gray box.”

Done.

• The figures are sometimes difficult to interpret. If possible, consider extracting and reorienting (tilting) the regions of interest to improve readability like this:



All figures showing the maps have been updated and improved.