

**Review#1 of manuscript "ESA/JUICE encounters Earth/Moon in 2024: overview of the Moons And Jupiter Imaging Spectrometer (MAJIS) observations" by François Poulet et al.**

This manuscript provides a high level overview of MAJIS results from the 2024 flyby of Earth and Moon, highlighting diverse results described in greater detail in accompanying papers. Comparisons are made to previous results where relevant, and implications for instrument performance in the Jupiter system are considered. This material will certainly whet readers' appetites for JUICE's arrival. The paper is well organized and presented and the text is generally well-written and clear. I offer a number of minor suggestions for further clarification, but the manuscript is in very good shape already.

**We really appreciate the effort of the reviewer for its careful reading and for providing helpful comments. Our responses to each comment are listed in bold below.**

Lines 63: the word "shortly" might be better as "briefly".

**Corrected**

Line 72 asserts that this was the very first "combined Lunar-Earth gravitational assist". Given that there have been numerous prior Earth gravity assists, many of which included observations of both Earth and Moon, it would be helpful to provide a little more clarification as to what exactly was unique about this one. Maybe spell out what fraction of the total delta-v came from each body?

**The LEGA maneuver performed by the JUICE mission was really the first time in spaceflight history that a spacecraft used a gravity assist involving both the Moon and the Earth in immediate succession. This information was added in the text.**

Line 109: delete the 2nd instance of "used" so it reads "...techniques used for data processing in this series of papers..."

**Corrected**

Line 134-135: this would be a good place to introduce the terminology pixel<sub>18-μm</sub>, used without definition later (starting line 246).

**This terminology is well defined line 134 and not line 246.**

Line 139: The word "shall" sounds awkward in this context. It sounds like text lifted from a legal document. The word "will" would sound better in its place. Same thing on line 219.

**Corrected**

Line 183: the word "quickly" might be better as "briefly".

**Corrected**

Line 187: delete "a". Also, writing "straylight" as a single word instead of two seems a little odd. But if that's to be done consistently across the mission, I suppose it's acceptable.

**Corrected**

Line 198: change "interferences" to "interference".

**Corrected**

Line 201: The labels on the plot axes and legend need larger font sizes to be readable in the printed edition. This is true for many of the figures. Also the horizontal axis should have a label, like "UTC time".

**Corrected**

Line 224: change "incidences" to "incidence".

**Corrected**

Line 242: change "shall allow to test" to "enables testing".

**Corrected**

Line 265 needs to explain what is meant by 7E1 and GCO500.

**Corrected**

Line 315 describes observations as "acquired in limb geometry", but it's not clear exactly what is

meant by this. Maybe say the limb was in the field of view? Or the field of view extended beyond the limb?

**I added the definition of this pointing: "MAJIS slit in a tangent orientation wrt limb"**

Line 300: This is a really nice figure. It conveys a lot of information in an easily apprehended form. But the axis fonts do need to be much bigger (similar in size to the fonts in the information boxes would be good).

**Figure modified accordingly**

Line 395: change "418 and 2445" to "418 to 2445 to indicate a range".

**I changed as:" covering the 418 and 2445 nm wavelength range"**

Line 400: the empty parentheses suggest a missing literature citation.

**Right ! Corrected, thanks !**

Line 435: change "incidences" to "incidence".

**Corrected**

Line 446: delete the first instance of "5" so it reads "...reduction of the solar radiance at 5 AU".

**Corrected**

Line 506: the "bits/data" should be "bits/datum" if that's the number of bits in a single data point, not plural. Same thing in lines 509, 530 (twice), and 531.

**Corrected**

Line 546: "the last browse spectel" would be clearer as "the longest wavelength browse spectel" (since readers don't know what order the wavelengths are read out).

**Corrected**

In Figure 11, consider making the two curves in the bottom panel be different colors from the 2 curves in the top panel, since having them the same suggests they're the same thing in both panels. At least the font size is good in this plot.

**We keep the figure.**

Line 624: change "are" to "is" since noise (singular) is the subject of the verb.

**Corrected**

Line 672: "upper first" sounds redundant. Maybe just say "uppermost".

**Corrected**

Line 675: change "darken" to "darkens" (or change "reduces" to "reduce").

**Corrected**

The paragraph in lines 750-767 describes 3 methods. The first 2 are introduced as "Method 1" and "Method 2" but the 3rd one doesn't get the same treatment. Could be clearer if they're all given parallel treatment and all three are included in Fig. 14.

**Detailed description and treatment are provided in the paper by Tosi. Here, we prefer to illustrate a few results without being exhaustive.**

Line 789: "this metrics" is strange phrasing. Maybe say "this product".

**I prefer to keep this wording that is familiar in this context.**

Line 799: "red gray" might be better as "pink".

**Corrected**

Line 803: "a series of papers was initiated to detail their analysis" could be better as "additional details are described in a series of papers".

**Corrected**

Line 848: change "clouds top" to "cloud tops".

**Corrected**

Line 870: it could be nice to label the right panel with its wavelength, maybe something like "3.967  $\mu\text{m}$  context image". That would enable the caption to be simplified, too. It might also be useful to mention how the size of the footprints compare to the size of the points in that panel.

**Figure 17 has been modified accordingly**

In Figure 18, it seems like the dynamic range is limited in the densest areas, with blue spots plotted on top of blue spots making it hard to see the structure there. The plot could probably work better by gridding the plot area with a relatively fine grid and then coloring each grid tile according to the number of points that fall into it.

**The main point here is to illustrate the evolution of the  $\Delta TB$  wrt TB at  $3.967 \mu m$  so I'm not sure to understand the request of the reviewer.**

In lines 933-949 the discussion of chemical disequilibrium is good, but it might be worth noting that CO<sub>2</sub> and CH<sub>4</sub> are observed to coexist on Triton, yet nobody attributes that to biological activity.

**In our case this refers to atmospheric signatures, whereas on Triton CO<sub>2</sub> and CH<sub>4</sub> are observed primarily as ices.**

Line 1011: The term "glaciated" seems redundant in the context of ice clouds. And peculiar, too, since the word is normally used in a geological rather than atmospheric context. It is sufficient to call them "ice clouds". This occurs in a number of places in the text.

**Ok glaciated removed in 4 occurrences when associated to ice clouds**

Figure 21 might benefit from a context map showing where each spectrum was taken from. Regardless, the font of the legend labels needs to be bigger.

**Their locations are now indicated on Figure 19. The labels are updated. Captions of Figures 19 and 21 have been updated accordingly.**

Lines 1068-1071: The explanation as to why the more highly reflective liquid clouds appear colder is confusing. If they reflect more light, shouldn't that show up as more signal observed in the channel, and in turn be interpreted as a higher brightness temperature?

**The apparent contradiction comes from mixing radiance and brightness temperature. At  $3.7 \mu m$ , the observed signal during daytime is the sum of thermal emission and reflected solar radiation. When this mixed radiance is converted into a brightness temperature, the conversion assumes the signal is purely thermal. Because reflected solar photons do not follow a Planck distribution, their contribution does not translate linearly into an equivalent thermal temperature. As a result, even though liquid water clouds produce a higher total radiance due to strong reflection, the non-thermal nature of this contribution leads to an artificially depressed brightness temperature when interpreted as emission alone. This effect is strongest for liquid clouds because of their high reflectivity at  $3.7 \mu m$ , whereas ice clouds are much less affected.**

## Review#2

The paper gives a very comprehensive overview of the MAJIS observations during the JUICE LEAG. It summarises the results of a whole set of accompanying papers. This is in general very good, but in some cases makes it difficult to review this paper without reading the accompanying paper at the same time.

All in all the results and the validations of the instrument performance, the compression algorithms, the observation modes, the thermal stability and various details like the browse products are very impressive. The discussion of the straylight effect misses a figure comparable to what is presented for the RIME interference or the thermal stability.

The previews on science results from the various accompanying papers on Moon and Earth observations are well presented and give a good impression of the capabilities of the instrument.

**A big acknowledgment to the reviewer for the careful review and for providing these very useful comments.**

It is not immediately clear what chapter 5.2.2 adds to the paper. All the features have been presented in the previous chapters and the rest is a very brief summary of published literature. It is also placed in a strange position. The chapter before discusses in the end cloud top heights and the following chapter goes into details on the clouds. The Ariel chapter does not fit in that flow.

**This section was placed here because it is related to the identification and analyses of the atmospheric signatures presented in the previous section 5.2.1. Note that after the submission of the paper and its publication on the ANGeo website, I was contacted by the NASA/ExoPAG to discuss a program of observing the Earth during the cruise at different phase angles with MAJIS to support the following finding:**

**<https://science.nasa.gov/astrophysics/programs/exep/exopag/resources/founding-documents-findings/>**

**This supports the relevance of this section.**

The whole discussion of cloud parameters is much more detailed than any of the other parts of the scientific results. While the results are all very interesting it is not entirely clear why there is such a strong emphasis on this topic. In addition the flow of that section could be improved, as the reader is continuously referred back to previous figures.

In contrast the lightning discussion which is a very exciting result is discussed rather briefly, some more details here would be highly appreciated.

**The difference in the level of detail between the various science topics reflects the fact that some of them are extensively described in companion papers, whereas others are not addressed elsewhere and are therefore presented in greater depth here. The following sentence is included in the revised version line 811:**

**"Note that some science topics are discussed in greater detail than others because they are not covered or only partly in the associated companion papers, whereas results such as lightning observations are described more concisely here and expanded upon elsewhere."**

Finally the Data availability is concerning - it seems like all the data discussed here and in the accompanying papers will not be available to the community for at least another 3 years. That seems to be an unusually long proprietary phase.

**This statement reflects the formal contractual agreement between the JUICE mission and the PI instruments for the data acquired during the cruise phase. The main reason is due to the fact that the data are not yet compliant with PDS4 format and since it takes a lot of time and effort to develop the pipeline to generate dataset in line with the numerous requirements of PDS4 data formatting, we (both the instrument teams and the JUICE project) are not ready to distribute official data products before a few years.**

**The agreement is obviously different during the nominal science phase with a usual agreement of 6-months proprietary phase.**

Two general comments about the paper:

1) The use of future and past tense in the paper is a bit mixed. It looks like some passages might actually originate from planning documents for the LEAG phase. The authors should check this for consistency. I highlighted a few examples below.

2) The level of detail and explanation is a bit uneven especially for readers that are not intimately familiar with instrument design and operation. I highlight as an example the discussion of compression below, but it shows up in several places. Again a check that an informed but casual reader can understand the sections would be helpful.

Specific comments:

lines 73-75: I would be helpful for the reader to list also the distance to Earth and Moon during the respective flybys.

**Information added: "This occurred during the closest approach (C/A) to the Moon at 23:15 UTC on August 19, at a distance of 750 km, and to the Earth at 23:56 UTC the following day, August 20, 2024, at a distance of 6,840 km"**

lines 141-143: It is not immediately evident why a window readout enables shorter integration times. Can you expand on this a bit more. Based on later explanations the 1MHz readout mode is also an important factor.

**The integration time depends on several factors, including the readout mode and the conversion and transfer of the data to the proximity electronics. Reducing the number of lines read allows the integration time to be decreased. I added the following wording to the sentence "...by reducing the conversion and transfer of data from the detector electronics to the proximity electronics"**

line 193: "LEAG was thus" - LEAG has already happened

**Corrected**

Line 400: something is missing in the brackets after "CNES"

**Corrected**

line 418: TROPOMI has 5 very narrow bands that could **potentially** be used...

**Corrected**

Figure 7: please add a legend in the figures

**The text to be inserted in the figure is unfortunately too long for these small figures.**

line 495-496: "shifting to the right" is unclear for someone not familiar with compression algorithms. Can you clarify what the shifting means and implies.

**This consists in moving all bits of a binary number to the right by N positions. I added a reference paper such that the reader can have a look of the meaning of this compression algorithm.**

line 515: "We wish to ..." this has been done as explained in the following text, so please rephrase

**Changed to: "LEGA data provided the opportunity to validate the browse..."**

lines 568-570: Somehow this statement is not very clear. Is it possible that it should be "with" instead of "while" in line 568?

**Replace by "when"**

Section 3.4 would benefit from a figure with an example of the straylight effect to illustrate what is written in the text.

**I would prefer to avoid to add such a plot in this paper. The straylight is discussed in more detail in Langevin et al. (submitted to the special issue) as stated in the first sentence of this subsection.**

Figure 10: Changing in the figure "RIME no TX" to "RIME passive mode" would make it easier to understand and match the figure caption

**Figure 10 corrected**

Figure 11: same comment as for Figure 10

**Figure 11 corrected**

Figure 13 might benefit from a LROC image of the region to give context.

**We did not find any good quality image for the crater in the highland.**

Figure 17: the green and blue dots on the right panel are extremely difficult to see

**Corrected**

Figure 22: It would be good to use another color than white to represent the saturate data, because white is already used for the background

**We tested different colors but eventually we found it was the most appropriate.**

line 1038: Use Figure 22 instead of COT figure

**Corrected**

Line 1080: "(red areas in right panel of Figure 5)" is supposed to be "(red areas in right panel of Figure 23)"

**Corrected**

Figure 25: it might be helpful to show as comparison also a spectrum outside of the lightning region to highlight the differences.

**There is no signature at all because it is a nighttime image. We had this kind of information "night observation" in the caption.**

### Review #3

This paper provides a comprehensive introduction to a journal special issue detailing the results of observations made by JUICE/MAJIS during a flyby of the Earth and the Moon. With the detailed investigations in other dedicated papers, this paper focusses on spacecraft operations, tests and intercomparisons with other EO satellites.

**Thanks a lot to the reviewer for the careful review and for providing very valuable comments. Please find in bold our reply to each comment.**

I realize that many comments have already been made by the other two reviewers, so I have just a few additional points:

Line 200: The HGA is orientated towards the Sun to protect the spacecraft, but it is not stated if this affects the instrument temperature and therefore expected performance? Later it says that "extrapolation to Jupiter's distance yields temperatures of about 82 K for the IR FPA and 129 K for the OH", but wouldn't this also depend on the spacecraft orientation?

**This is correct, even though we expect the variation to be minor due to the solar flux being lower by a factor of 25. We added the following clarification in line 652: "...by assuming the same spacecraft attitude..."**

Figure 2: In the centre of the timeline for the LGA, there is a "service mode" between switch on and acquisitions. I assume this is what is described in the caption, but it's not clear, and there is no reference made to a service mode anywhere in the text.

**This mode is an instrumental stable mode ready to acquire science data (basically all sub-systems are ON waiting for the TC "start science"). We introduced a definition of this mode in the caption of Figure 2 as following: " MAJIS was switched on several minutes before the start of the first frame acquisition and was then kept in the so-called service mode, an instrumental stable mode that is ready to switch to science mode "**

Line 460-465: I don't understand the reference to integration time in this paragraph. From figure 7, the expected signal at Europa is around 10x lower than the Pacific observations at 11ms integration time (the same colors are used, but the two y-axes are shifted). If Europa measurements are nominally made with a 100 ms integration time, doesn't that mean that the expected signal would be 100x less, and therefore the SNR may not be representative? Please clarify this part.

**The radiances plotted in Fig. 7 are intrinsic scene radiances and are therefore independent of integration time. Integration time affects the number of detected photons, which scales linearly with exposure time. Although the Europa radiance is about an order of magnitude lower than the Earth Pacific radiance at high solar incidence, this is largely compensated by the longer nominal integration time for Jupiter system observations (100 ms versus 11 ms), together with the much lower solar incidence angle (10° versus 65°) and the high surface albedo of Europa. As a result, the photon counts (and thus SNR) are of the same order of magnitude in both cases.**

Figure 10: why does the noise continue slightly beyond 7:06, when RIME TX mode is off?

**The green line was approximate and is now correctly placed.**

Line 618: "These spikes degraded the SNR from the nominal level to approximately  $160e^{-}$  " - do you mean that the noise was increased from  $120e^{-}$  to  $160e^{-}$  therefore the SNR decreased by 1.3?

**Correct. Specifically, the noise goes from  $\sqrt{40^2+120^2}$  to  $\sqrt{40^2+160^2}$  leading to a loss of 1.3 in SNR.**

Line 637: please indicate the duration of the LGA operations here so the reader than make a rough approximation of the FPA heating rate. It seems to be around 8-10 minutes based on table 1, but I don't see the total duration given in the text.

**Correct as also shown on Fig.2. We added this information line 640 of the revised MS.**

Figure 12: it is difficult to see that the observations were made before the increase in temperature occurs, especially on the FPA plot, as the figures are too narrow. Please increase the widths, ideally placing the two plots in the centre of the page on top of one another, with x-axes spread to cover the full page width.

**Figure 12 modified accordingly**

This is merely a suggestion, but I think that the conclusions section should contain more specific examples of how the LEGA campaign results will contribute to changes/improvements in future observations; as this was the primary purpose of this campaign. For example, you could add a sentence about how the results can improve data compression selection, browse product wavelengths(?), straylight (VISNIR read-out window shift) etc. Also, it seems that the interference with RIME is significant, especially when observing low-signal scenes: was RIME expected to be operating simultaneously with MAJIS IR during the science phase? Will this have a major impact on planning going forward? I think a reader would expect this to be addressed, even with just a list of potential mitigations, if it isn't done so in a companion paper.

**We added the following text to address some lessons learned: “*Among the lessons learned from an operational point of view, we can list: 1) Observations of the Earth with windows extending beyond the edge of the FOV were acquired in order to reliably evaluate VISNIR straylight from the signal outside the FOV; this procedure shall be applied during the science phase. 2) The interference tests with RIME were well representative of the satellite flybys during the pushbroom phase (corresponding to a spacecraft altitude below ~1000 km). An operational mitigation strategy between RIME and MAJIS should be implemented.*”**