

PLANETARY RESEARCH

This peer review report contains the editor decisions, reviews, and author rebuttals for each round of peer review. The peer review rounds are ordered chronologically, and the final acceptance decision is not included.

The published manuscript can be found on the journal website: <https://planetary-research.org>.

TITLE

Super-resolution maps of icy moons: Application to the Cassini-VIMS observations of Enceladus with updated navigation and photometric correction

AUTHORS

C. Ntinos, S. Rodriguez, Le Mouélic et al.

DOI

<https://doi.org/10.53480/arz2-gn59>

EDITOR DECISION
round 1

Dear Christos Ntinou,

I would like to thank you for submitting your manuscript "Super-resolution maps of icy moons: Application to the Cassini-VIMS observations of Enceladus with updated navigation and photometric correction" (#349) to Planetary Research. I have now received the reviews and associate editor assessment of your submission, which are included at the bottom of this email. Based on my evaluation of your submission, your manuscript should in principle be suitable for publication after revision.

We ask that you please provide a point-by-point response to all comments and identify what changes you have made to the revised manuscript. In addition to the rebuttal, we ask that you also provide a document that tracks all changes that have been made to your manuscript since its initial submission. Your revisions should be submitted within two months time.

When you have completed your revisions, you can upload the revised manuscript, your response and a tracked changes document from your submission dashboard.

If you have any questions about the recommendations in your review, or if you are unsure how to respond or proceed, please feel free to contact me from your submission dashboard.

Sincerely,

Oded Aharonson
Editor, Planetary Research

Associate editor recommendation

[paste comments here]

The following comments were received from the reviewers.

Reviewer 1:

Recommendation: Revisions Required Without Review

All pre-existing data used in the manuscript are publicly available and sufficient information is provided so that they can be found and accessed.

Yes

All significant data products generated as part of the study have been uploaded to a public repository (or will be at the time of acceptance) and are cited using a persistent identifier (such as a DOI).

Yes

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Yes

All pre-existing software used as part of the study are acknowledged, and sufficient information is provided to find, access, and understand the software. If the software is restricted, the conditions under which it can be accessed are publicly available.

Yes

If you answered no to any of the above questions, please provide supporting information.

I am uploading an annotated version of the manuscript.

No

Comments for the authors

Review of Manuscript „Super-resolution maps of icy moons: Application to the Cassini-VIMS observations of Enceladus with updated navigation and photometric correction” by C. Ntinos et al.

Dear Editor,

the main objective of this study is to develop a general Super-Resolution (SR) mapping method for icy moons, in order to produce surface maps with increased spatial resolution.

The authors use the icy moon Enceladus as example to present the pipeline for producing these hyperspectral Super-Resolution (SR) maps by combining all the overlapping hyperspectral observations for Enceladus acquired by the Visual and Infrared Mapping Spectrometer (VIMS) instrument which was on board the Cassini spacecraft that orbited through the Saturnian system between 2004 and 2017.

The task is challenging, because a high number of VIMS observations have to be combined that dramatically differ with respect to spatial resolution, illumination conditions and SNR of the individual spectra.

The resulting data show an improved version of the spatial pattern of Enceladus’ surface, which is essential for comparing the spectral signatures to the geologic context visible in imaging data, which is essential to resolve the formation mechanisms of the identified spectral compounds.

The method is clearly and sufficiently described. The technique is particularly very useful when dealing with a high number of observations acquired during flybys in a planetary system, such as it was the case for the Cassini mission. However, this will also be the case in the first months of the JUICE mission after arrival in the Jovian system, which starts with flybys at the icy moons Europa, Callisto and Ganymede. It will be interesting to see the application of this technique to these data. Therefore, I strongly recommend this work to be published.

In only have some minor general comments.

P3 LL 76 – just out of curiosity – why did you not include the data of the VIMS-VIS instrument?

The authors should review the references and the citation mode that varies between several different styles. Here are some examples:

Some citations include the initials of the first names, some do not: C. Hansen et al. 2011; Postberg et al. 2011

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spectral maps for the icy moons, and they applied their procedure to Enceladus by exploiting Cassini VIMS dataset of near-infrared spectra. Their main goal is to give new insight into the moon's geomorphology, to improve the understanding of icy moons, and to help prepare future observations by exploiting these super resolution maps. The method is publicly available and provided in a Python pipeline.

This work is of great importance, as increasing the resolution of the spectral maps makes it possible to access information that could not be resolved using more conventional mapping techniques. Applying such method to Enceladus is a good idea, given that this moon shows a quite homogeneous surface, and a higher resolution can allow the detection and analysis of fine spectral features. The developed technique can be applied to other Solar System objects, and the provided pipeline can be used to study the Galilean moons by exploiting the spectral dataset of the JUICE mission.

This paper is well written, and every step of the method is explained and justified in a tremendous amount of details. The resulting super resolution spectral maps are presented, and their quality is undeniable. Validation tests of all the steps performed for the production of the maps are presented, giving confidence in the quality of the results. This paper should be published after minor revisions.

Scientifically, this paper is of great quality. The presented method is highly reproducible, even more thanks to the free access to the python pipeline used to produce the super resolution maps, and the figures are informative and well explained in the text. Each step is thoroughly discussed, both the advantages and limitations of the method are clearly presented, which reflects the quality and rigor of the work. However, the level of detail and the current organization of the manuscript can leave the reader somewhat overwhelmed. The paper would benefit from a different organization, perhaps by explaining the methods in a more concise and direct manner and by discussing and validating them in a dedicated section.

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I would recommend re-organizing the paper by separating the methods with their validation and discussion. At present, the justification and discussion of choices made while developing the method are given in the middle of the description of the procedure itself, which interrupts the flow of the explanation and makes the method difficult to grasp on a first reading. All of the suggestions provided in the 'Review Ntinios et al. (2026)' file are to be taken as advice, and the authors can see fit to re-organize information differently, depending on how they wish to pass information.

I recommend creating a Discussion section (or a more global Validation section) after Section 4, where the advantages of the selected methods with respect to others, their limitations, and their validation could be discussed. Alternatively, some of the more detailed information could be moved to the existing appendices, or new appendices could be created, in order to lighten the main body of the text and improve the clarity of the methods on a first reading. In any case, I would like to congratulate the authors for their great work and results.

AUTHOR REBUTTAL
round 1

First and foremost, the authors of the paper would like to acknowledge the contribution of the two reviewers and thank them for their very insightful feedback. We would also like to thank the corresponding editor for a very smooth and efficient submission and review process. We will now address one-by-one the remarks of the reviewers (in red font for clarity). This document is accompanied by the reviewed version of the paper, where the changes to the originally submitted paper are tracked (in red font for information deleted and in blue font for information added).

C. Ntinos on behalf of the authors of this work

Associate editor recommendation

[paste comments here]

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The VIMS-VIS and VIMS-IR are two separate instruments with completely independent navigation and spectral calibration pipelines, different number of pixels, spatial sampling and field-of-view alignments. It is true that the SR method is agnostic to the instrument (the navigation step of course needs to be modified for each different instrument) and can mix any spectral or imaging data acquired in the same wavelength. It is also true that the VIMS-VIS and VIMS-IR have overlapping spectral coverage. However, VIMS-VIS has unresolved spatial and spectral calibration issues, which were not addressed in the context of this work in order to reconcile its data with the data of the VIMS-IR instrument. Therefore this study focuses exclusively on the VIMS-IR data.

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Thank you for noting this issue. All citations have been corrected in accordance with the APA style.

P19 LL 526 – Here is some information missing: "Section ??"

Thank you for tracking this discrepancy. The link to the Introduction section has been fixed.

I also recommend to use letters to label ALL and not only a few (sub)figures and captions.

Thank you for this suggestion. We agree that labeling all subplots will allow for greater clarity. Letter-labels have been added to all subplots missing them and corresponding references in the text and the captions have been updated.

Reviewer 2:

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Thank you very much for your suggestions. We share the reviewer's view that due to the density of the provided information the paper can feel overwhelming at certain points. To address this we have decided to move the following sections to the supplementary material (still important, but not the core of the paper's subject) to the appendices: • "VIMS data wavelength shift and saturation" has been moved from Section 3.1 to

Appendix B

• "Effective sampling" has been moved from Section 4 to Appendix D

These new appendices do not contain information of lesser importance (especially the saturation issue has not been properly addressed before in the way presented in this work), but rather technical details that are not strictly necessary to the reader for understanding the SR methodology presented in our work. The interested reader is directed to the appendices for more details on matters such as VIMS data saturation and SR effective sampling.

Moreover, we have removed Figure 1 (in the original document) containing the pie charts of the data set breakdown, which was deemed redundant, since there is an explicit description of the data set in the main text. We have then added a new figure (Figure 9 in the reviewed document) that presents a schematic illustration of the core idea of our SR methodology, which we believe provides an additional, clear illustration of the description in the main text.

With regards to restructuring the main flow of the paper, we thank the reviewer for the suggestion of a global validation section and we can appreciate the mindset behind it. However we believe that the description of the methodology benefits more by the current structure where each of the three independent steps (1. Navigation, 2. Photometric Correction, 3. SR) is presented in a self-contained way flowing naturally from the description of the implemented method, to the validation, to the resulting cartographic product, each section benefiting from the validation of the preceding sections. We strongly believe that this approach would be less confusing to the reader by concluding each step with its final cartographic product (1. uncorrected, 2. photometrically corrected and 3. SR global mosaic of Enceladus), having solidified its validation in the same section, before moving to the next step.

However, we find the reviewer's suggestion for the addition of a "Discussion" section extremely applicable and we thank you for that. In this new Section 6 we have mostly moved text from the "Navigation" and "Photometric Correction" sections, where we discuss the specific choices and improvements on existing methodologies implemented respectively. Moreover, in the SR paragraph of the "Discussion", we share some additional insight and limitations of the SR step, hinting to future development of the methodology, summarised in the conclusion section.

EDITOR DECISION
round 2

Accept.