Response to reviewers

R. Larsson et al.

December 1, 2016

1 General

We found one number to be erroneous in our work. The spatial resolution of the Cain etal model should be 130 km. Not the 30 km we originally wrote in the paper.

We also added a discussion on the magnitude of the error and what the consequences of some of our approximations mean for future processing. The 200 nT number is not an end-all error but the error expected after one measurement series of a tangent profile in the span of only a few hours. If the lifetime of the mission is longer than that, then the error can be lowered by good statistical considerations using subsequent measurements. Since both reviewers point at this number we have also changed the abstract to point this out as clear as we can.

2 RC1

> *1. Figure 6 is not very clear in a grey color scale. Would you mind to change it into a color scale and highlight the 4-36% of the surface to be sampled by this technique with a dashed line? This magnetic field map changes with altitude, so would you mind to show in the paper 3-4 panels with this map at different altitudes and with the percentage of surface sampled at each altitude?*

This has been changed. We are now marking the 1000 and 200 nT contours in color in the figure and we additionally have added 20 and 60 km altitude fields. The percentages are about twice as large at 20 km and about half as large at 60 km compared to at 40 km altitude.

> *2. The error in the horizontal magnetic components (∼200 nT) is of the same order of the component strength (Figure 3), and this is after considering ideal conditions for this simulation. I would like to see a larger discussion about this fact and how a different orbit configuration would affect that.*

The errors are on the same order of magnitude everywhere except near the poles. We added text that a sufficiently low inclination will make the errors in the B_v component increase because of the lower azimuthal resolution.

> *3. What's the error of the Cain model at the low altitudes of this paper?*

The short answer is that we do not know how good the Cain or Morschhauser etal models are at low altitude. There is a lack of measurements at low altitudes.

The longer answer is that the Cain etal model reports a fit to about 10 nT with the data of MGS. At lower altitude, there really has not been any measurements so it is not possible to say what the error really is. Compared to the Morschhauser etal model, as we write in the paper, on areas that Cain etal's model do not resolve (e.g., smaller craters) the differences are up to 2000 nT, where one model reports near-zero field and the other reports a much larger value. There are also ideas that the strongest field could be 20000 nT at surface altitudes cf. the 12000 nT in Cain etal. That is an error of over 50% when the field is very strong. All of this is from smoothing errors that are not resolved in the N=90 model. We already discuss this in the paper.

Reviewing this part of the text, we also found that the spatial resolution of the Cain etal model was reported on wrongly. The resolution should be approximately 130 km, not the 30 km we reported on in the paper. (Approximated by $r_m \times \sqrt{4\pi}/(N+1)$, where r_m is the radius of Mars and N is the spherical harmonics order of their model.) We thank the reviewer for pointing this out to us so we found this issue.

> *4. ARTS simulator should be briefly described in the text, despite the references.*

We have added an overview description of ARTS to the theoretical subsection.

> *5. Lines 6-7 of second page: ExoMars 2020 surface platform also plans to carry a magnetometer to the surface of Mars, called: MAIGRET.*

Thanks. I (main author) was not aware of this. This has been added.

> *6. Line 14 of second page: you should add that the Northern Hemisphere is much younger than the Southern Hemisphere.*

Thanks. This has been added.

> *7. Line 25 of page 5: do authors mean "measurements of the measured noise"?*

We changed it to: "the quantitative details of the change of the measurement noise to any specific orbit change"

> *8. Answer given to referee about the JUICE sideband should be added to the paper.*

We added that we got to the 1500 K number by scaling the frequencies.

3 RC2

> *It is said in 2.1, line 18, that "A full sampling of the polarization state of the radiation is thereby the best way to retrieve the magnetic field." On the one hand the statement should be moderated since the works done with previous missions carrying magnetometers have casted better results than this theoretically method.*

Yes, it is only the best way to retrieve the magnetic field using the Zeeman effect. We added some text to the formulation in 2.1 to fix this misunderstanding.

> *Also the success in its application on Mars precisely is very doubtful. (The error is in the order of magnitude of the range). On the other hand, only one component of the polarized radiation is retrieved . Regarding the sources that may contribute to this single component, it is assumed some approximations that constrain these contributions. However, without these approximations, would the final value of 200 nT error in the magnetic field sensitivity be affected? If it is the case what would be the impact on the global coverage ($< 4\%$ or $< 36\%$?). It would be very important to make a connection with the utilization of this methodology in an application with better results. (It can be with atmospheric examples but the discussion would have to be included in the manuscript).*

So long as the azimuthal coverage is good then the errors will be the same over the planet. We show this in the paper. So the error is linear.

Without good azimuthal coverage the errors will be larger. One aspect that seems to be misunderstood here is that the 200 nT/4 km per component is from measurements that can happen within 24 h and not from a lifetime of a mission. We added a longer discussion at the end of section 3.

We have added references to validations of the radiative transfer models used in this work.

> *1) The manuscript should be reviewed to avoid repetitions. For instance: page 2 line 2 and in the same page line 25, and in page 3, line 16. All the paragraph is repeated. Additionally, the question mark might be removed.*

We have revised the text and eliminated unnecessary repetitions.

> *2) Abstract. Lines 1 to 5, Rephrase. Suggestion: "A Mars-orbiting sub-millimeter sensor can be used to retrieve the magnetic field at low altitudes over large areas of significant planetary crustal magnetism of the surface of Mars from measurements of circularly polarized radiation emitted by the 368 GHz ground-state molecular oxygen absorption line".*

We have reworked the abstract. Thank you.

> *3) In 1, page 2, line 25, is repeated what is said in the line 3, and it is repeated in the page 10 line 8. This should be rephrased to avoid repetition.*

See answer to the first point.

> *4) Page 2, line 15, shouldn't have the interrogation at the end of the sentence. Lines 15 to 18 should be rephrased to avoid repetition.*

This has been removed.