RC1

General Comments

- Interesting approach, followed by an interesting and relevant discussion.

We would also like to thank the reviewer for taking the time to review this manuscript and providing useful comments which improved the manuscript. Please note that we have moved the figures to the manuscript text.

- I miss O+ also being cited in the Abstract.

We have modified the text to include O+ ion in line 13 of the abstract. If the reviewer is referring to O^+ mentioned in the second to last line of the abstract, that is because only O^{2+} temperatures are currently available.

Scientific Questions

- Line 27: Explain "stand-off distance", or change it to another word. This may not be obvious to non-native English speakers, like myself, and can cause confusion even within the field of research.

We have removed the "stand-off" and changed the sentence to "*short distance of the bow shock boundary*"

- Lines 89-90: "In deriving Equation 1, effects of generic similarities between time series (constant arrays), singularities, and absolute strength of the fields are also considered." > How are these effects considered exactly?

We wanted to have a quantitative measure of the difference between magnetic fields observed by the spacecraft and the modeled fields at any given time. We began by simply comparing field strengths between the two sets, applied it to initially a small set of events. We noticed this simple difference approach gives small differences for small magnetic fields far away from the crustal fields, while larger differences for events on top of strong crustal fields but with slight deviations. That meant there should be a normalizing factor in the approach/model. We gradually modified the equation (trained the model) and expanded the event sets and monitored the model for robustness for all the events considered.

- Line 95: "The minimum accepted quality flag in LPW data is 50." > What does that mean, considering that the data never reached the density of 50 cm-3? What I interpreter from this is that the whole dataset should not be accepted? Or is it the opposite? Also, write the units after "50".

The LPW density and temperature data are reported with a quality/uncertainty flag which ranges from 0-100, regardless of the actual density and temperature values. This number among other factors depend on the quality of the fitting performed on the I-V curve to determine the density and temperature. This is the text included in each data file (the source may vary):

> *flag_info Integers: The uncertainty of the values with a scale of 0-100. 100 is the best quality. Use data with flag value above 50. # The 5 digit decimal number represent a binary number containing information of specific atticue and sc activities. For all numbers see instrument SIS.*

> *flag_source What is used to evaluate the flag: # MAVEN shadow information # MAVEN wake information # MAVEN thruster information.*

We have removed this sentence from the text as the information is include with the data and to avoid further confusion.

- Figure 1: Are you showing an example of electron depletion that is actually associated to regions of strong crustal magnetic fields? I can see from Panel a that the measurements of Bx and Bz are lower than the predicted (modeled) values. Probably the measured |B| will also be lower than the modeled |B|. How does that relate to your proximity parameter for this event? Is it considered high or low?

This event is a pass. The proximity parameter for this event is 1.16. The proximity parameter for all events considered is in the range of [0.19, 4.92], with a mean value of 2.18 and a median of 1.91. We have added this information to the text in line: 95

- Line 100: "down select": Do you mean you eliminate profiles with proximity parameter less than 5, or the opposite? "Down select" sounds ambiguous here, please use something like "eliminate", or rather "we select only", depending on what you mean.

We've replaced the word down select with, "We kept…".

- It would be interesting to see a map of crustal magnetic fields at Mars overlayed by the locations of the depletion events you analyse. I assume your proximity parameter could also catch events in the Northern hemisphere, far away from intense crustal fields.

That is correct. The crustal fields are strongest in the southern hemisphere. However, models show that there are weaker fields at other regions, and our manuscript is focused on events around any crustal field. The event shown at the bottom of this response letter shows the highest observed latitude event. And we are able to see matching patterns in the field components.

- Figure 2: Are Br, Btheta and Bphi values that are measured by the spacecraft or values from the crustal magnetic field model?

They are in-situ spacecraft measurements. We've added this clarification in line 135.

- Figures 3 and 4: Please insert a scale bar next to the histograms showing number/probability of events. Right now, the histograms are only qualitative.

We have added scale bars to all histograms in Figures 3 and 4.

- Line 129/Figure 3: "depletions are found more likely around crustal magnetic fields pointing eastward". What is the physical explanation for that? Does it have to do with the preferential direction of the solar wind magnetic field, perhaps?

The solar wind IMF, and the motional electric field could play a role. However, we don't have an upstream solar wind monitor to determine that. Additionaly, we did not restrict the events to a certain field orientation, or a specific region which could introduce a bias to the analysis. Except requiring proximity to crustal fields. We note that these structures are indeed intriguing and demand more attention from the community. For instance, one area that we will focus on in a follow up work is to identify areas of elongated stagnation.

- Line 131/Figure 4: "(i.e., exiting the Martian surface)". Why do you think we do not see as many events for $B_r/|B| = -1$, i.e., when the field is entering the surface?

Similar to the comment above, we think it is worth noting what the analysis shows which is based on observations. We are however, unaware of a physical mechanism that gives preference to the field polarity.

- Line 161/Figure 6: "There is a shift towards higher O2+ variations with increase in Δne,s (the Colorbar)." What shift? Do you mean density variations of O2+ are larger than of O+? The sentence is confusing. Also, you say Δne,s but the colorbar shows Δne,c.

The figure label is correct and we have modified the text to "Δne,C". We have also reworded the confusing sentence to: "*There are higher variations in O2+ at lower altitudes with increasing Δne,C (shown with the color scale). That is because O2+ is the dominant ion species at low altitudes and has a shorter scale height compared to O+.*"

- Line 195: It lacks a sentence saying why we do not see even stronger variations in ion temperatures at altitudes higher than 400 km. Is it because the abundance of neutrals decreases? Or simply because there are not as many depletion events above 400 km?

Yes, indeed as you noted one reason is that there are not enough neutrals at higher altitudes. Another aspect to note here is that we focused on events around crustal fields. Magnetic fields act as conduit for electric potential. If there is frictional heating and an electric field driving ions at lower altitudes, such effects can "map" along the field lines and continue to impact ions at higher altitudes, although there could be other drivers in play as well. As the ion-neutral drift increases, the ion temperature also increases.

Technical Corrections

The manuscript contains several typos. Please, carefully proofread it and fix them.

Yes, thank you. We went through the entire text and made correction to the typos and a few sentence structures as necessary. These changes are marked up in the revised manuscript.

- Line 12: "crustal magnetic fields are..."

Fixed

- Line 24: "~200 km"

Fixed

- Line 27: "make"

Fixed

- Line 54: "night"

Fixed

- Line 54: (Cao et al., 2022) should be an inline citation.

Fixed

- Line 72: " in Section 2"

Fixed

- Line 79: "time series"

We think timeseries is a legitimate word and we made a change to use "timeseries" consistently throughout.

- Lines 78-79: "As such, we identified these events visually and when the density measurements exhibit sharp depletions both in timeseries and altitude profile data." > You identified the events both visually **and** when the density measurements exhibit sharp depletions? Is this correctly phrased?

We visually inspected both the timeseries and altitude profile for each event to make a selection. We have rephrased this sentence to clarify this point: "*As such, through visual inspection we identify events that exhibit sharp depletions in both the timeseries and altitude profile.*"

- Lines 91, 93, 96: You write Panel (a), Panel b, Panel c, and Panel d. Please, be consistent.

We have changed all instances to Panel a… etc.

- Line 94: "UTC"

Fixed

- Figure 1: The texts of X, Y, Z, and hhmm are not corresponding to the label rows.

We regenerated the figure with proper label spacing

- Line 125: "Figure 3"

Fixed

- Line 126: "... are shown below each plot."

Added "are shown". Thank you.

- Line 144: "electron"

Fixed

- Line 184: "ions and neutrals"

Added s to "neutral".

- Line 208: "due to"

Removed the redundancy.

- Line 209: "are listed"

Fixed

- Line 230: "removes caused"?

We have modified that sentence to: "*Electron-ion recombination removes both electrons and ions creating a density depression in the plasma.*"