Dear Referee!

Thank you for your comments and improvement ideas! Please find below our responses.

Referee' comments are in blue and authors' responses are in black.

This paper reports a number of sensitivity analyses conducted using a one-dimensional atmospheric column model and comparisons with data acquired by REMS: pressure, near-surface temperature, and VMR at 1.6 m. The authors investigated the impact of dust optical depth, precipitable water content (PWC), surface temperature, and surface pressure values on the model results by varying these parameters in different ranges chosen based on observations. The comparison is conducted for two Ls values: 90° and 271°. Although the manuscript is generally well-written and provides new and valuable information for column model simulations on Mars, further analyses and comparison (listed below) are needed before publication.

Major comments:

-Vertical profiles of Figures 4-7: In the discussion, the authors refer to altitudes that are not shown (e.g., lines 175-182) and that are key to understanding the performance of the model. Additionally, as the comparison is with near-surface data, I would like to see the model results near the surface. If the authors want to keep the sensitivity analysis up to an altitude of 5km, then additional figures focused on the 0-1000 m range should be added as it is hard to distinguish the different curves in that range.

We decied to change the altitude from 5 km to 1 km as suggested.

-The manuscripts states that one of the most sensitive initial parameters for the column model temperature profile are the dust opacity and surface temperature. Here, I would like to see a comparison with the MCD. Also, what would be the effect if part of the aerosol opacity is due to water ice? For Ls=90° simulations, a notable % of the total opacity should be ice whose single scattering albedo is close to 1. Would it be possible to add in the model a diurnal cycle of the aerosol opacity?

The 1-D column model can only take into account local conditions. Condensation to fog and boundary layer clouds are allowed but they did not occur in any of the present integrations, due to the fairly dry equatorial Gale environment. At the moment, it is not possible to add a diurnal cycle of the aerosol opacity to the column model.

-Conclusions section: 'An earlier study by Savijärvi et al. (2019a), large-scale model moisture profile from the MCD (Fig. 8 in Savijärvi et al. (2019a)) and our sensitivity experiments (Figs. 5g and 5h) suggest that the model's initial humidity profile at the MSL site should vary with the season to provide a better moisture prediction near the surface.'. I think the authors should address this in this study. Why not taking the MCD profiles and see if the simulations improve with those model profiles? I don't think that "…the model's initial humidity profile at the MSL site should vary with the season to provide a better moisture prediction near the surface.." is demonstrated in this work, and it is not clear what this study contributes beyond the cited work. This point is also mentioned at

the end of the abstract but again no demonstration of how the humidity profile can affect is given. Please use MCD profiles and see of results change.

Added new model experoments (Figures 8 and 9) and the following text:

“To test these hypotheses, column model simulations with "low-moist layer" initialization at Ls 90°, and "high-moist layer" initialization at Ls 271° were performed. These initialization profiles are shown in Fig. 8 so that the "low/high moist layer" PWC is the same as the PWC for the corresponding well-mixed profile. This "low-moist layer" assumption is based on GCM aphelion season results (e.g. Montmessin et al., 2017, Fig. 11.18), which suggests that the moisture is concentrated nearer the surface at the equatorial latitudes. However, GCM-based MCD suggests the moisture to be more well-mixed at low altitudes during the warm season (Ls 271°), and peaking at about 35 km. Hence, out "high-moist layer" assumption is based on the MCD moisture profile. “

“Figure 9 shows the simulated 1.6 m VMR cycles for Ls 90° (left panel) and Ls 271° (right panel) with REMS-H-derived VMR values (spheres) and ChemCam-derived VMR values (marked by x). Simulated cycles include "well-mixed" assumptions (red) and "low/high moist layer" assumptions. Figure 9 indeed shows that these tuned assumptions perform better compared to the "well-mixed" assumption. At Ls 90°, the "low-moist layer" initialization now matches with the REMS-H derived VMR at about 05 LTST, as well as with the ChemCam-derived VMR. Similar matches at about 06 LTST REMS-H VMR and daytime ChemCam VMR for Ls 271° is visible when using "high-moist layer" initialization.”

Changed the last sentence of the abstract:

“Our additional model experiments with different shape of the model's initial humidity profile yielded better results compared to the well-mixed assumption in the predicted water vapor volume mixing ratios at 1.6 m.”

-Conclusions section: The authors basically summarize the findings in the sensitivity analysis (some previously reported in previous works) but they discuss vaguely the reasons behind and do not detail the impact of their results. For instance, page 14: “We found that the initial value of surface temperature affects the entire temperature profile with a slightly larger effect at Ls 90.”. Why is that? Also, is this the case at all altitudes? It is complicated to say below 1000 m from the figures.

Changed the upper limit to 1 km and added some text: “This seems to be the case at all altitudes and it is propably related to the smaller variations in the diurnal temperature cycles during the cold season compared to the warm season.”

-I believe the manuscript would benefit from the addition of more data from other Ls in the comparison.

We chose 2 opposite seasons to study the sensitivity of the model as comprehensively as possible. Ls 90 is dry and cold while Ls 271 is wet and warm. Therefore, we think that these two seasons are enough to study the model’s sensitivity.

General comments:

-Why the authors are not included in the comparison data from MEDA??

MEDA is not used since this would require additional acceptance from the MEDA team and the main purpose of this study is to study the sensitivity of the model. With the help of this study, we can then use the model at the Perseverance landing site in the future studies.

-Include the errors in the observations, as otherwise, it is hard to figure out how well the model reproduces the data.

Uncertainties for these data are not currently available (see https://atmos.nmsu.edu/data_and_services/atmospheres_data/MARS/curiosity/rems_humidity.html). We decided to mark VMR values with very low RH (< 5 %) as gray spheres in Figs. 4–7 (g) and (h).

-It is confusing to use in the paper terms like ‘profile initialized…’ for parameters that do not change during the run. For the model parameters that do not change during run, please just use ‘fixed profile…’ or ‘fix values of …’

Done.

-Section 2.2: please add information about the sampling when describing the REMS data.

Changed sentence: “The REMS instrument, onboard MSL, measures pressure (P), relative humidity (RH) and temperature (T) **at the rate of one sample per second** for 5 first minutes of each hour, at an altitude of about 1.6 m.”