Dear Franck Montmessin!

Thank you for your comments and improvement ideas! Please find below our responses.
Your comments are in blue and authors' responses are in black.

This article presents a sensitivity study conducted with a 1D-model developed to simulate a column of atmosphere on Mars. The model includes a variety of physical processes intended to represent those to which the column is submitted at various timescales (convection, radiation, exchanges with the regolith).

The main ambition is to address the impact that some parameters have in the predictions of the model; namely temperature, relative humidity and water vapor mixing ratio. As this model has already been applied to interpret data produced by atmospheric sensors on board the Mars Science Laboratory rover (Curiosity), this work should enable the model to be used more effectively in the future, and its main limitations to be better understood.

While this paper represents a solid and valuable effort to explore the behavior of a model used to interpret Curiosity's atmospheric and surface data, it does not answer any particular scientific question and will primarily serve as a reference for the future use of the 1D model.

For this reason, the scientific contribution of the manuscript seems rather weak, while its technical value is beyond doubt.

Parameters whose impact in the predictions were studied were surface temperature and pressure, atmospheric dust and water content. The scientific contribution of this manuscript is to serve as a useful tool for studying the Martian atmosphere as well as surface-atmosphere interactions. This manuscript also describes how these parameters affect the model predictions near the surface and higher up in the atmosphere which is very important for the future studies with the model at other landing sites.

This consideration aside, the article is concise and well-structured, but suffers from several flaws which are listed below:

-It is not clear how the conclusions drawn from this study will impact on the future use of the 1D model. Some conclusions could have been avoided, as they merely confirm things already known and presented in the introduction (the negligible role of sensible and latent heat on surface temperature), while others could have been used to extend the study to arguably more representative cases (MCD). The question that should be addressed is how the findings will change the strategy for the interpretation of MSL data.

This study shows that modifications in the initial surface pressure do not affect the predictions of the model. Therefore, the initial surface pressure can be taken from the other Martian years from the same location or even from the large scale model, for example from the MCD as far as the altitude of the locations is corrected based on hydrostatic adjustment. This study also shows that it is important to initialize the atmospheric water content accurately for the humidity predictions of the model in the future. These results show that the well mixed assumption for the water content may not be the best choice to accurately predict the near surface water content. In addition, the shape of the profile can vary with the season. Therefore, the initial water content for the model should be carefully chosen on the future studies with the model on different locations as well. New model experiments with different initial moisture profile (“low-moist layer” and “high-moist layer”) were performed and they are in the revised version of this manuscript.

Revised manuscript includes 2 additional figures (Figs. 8 and 9) and some text related to new model experiments:

“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.”

Added some text to summary and discussion based on new model experiments:

“**Column model simulations with initial moisture concentrated nearer the surface ("low-moist layer") at Ls 90° and initial moisture concentrated higher in the atmosphere ("high-moist layer") at Ls 271° provided good matches with REMS-H VMR observations and ChemCam-derived VMR values.** This **seasonally varying humidity profile at the MSL site** is likely…”

“The **shape of the** model’s moisture profile **should be adjusted to the location and it** can also…“

-The role of regolith has long been an open question in the Mars water cycle community, since several Martian climate models have successfully reproduced the main features of the Mars water cycle in the absence of regolith. It is understood that the 1D model used here is based on the assumption that regolith plays an active and important role in the concentration of water vapor near the surface, which should deserve some more justification, especially in the context of contradicting results from 3D climate.

Added some text into introduction:

“The main features of the Martian water cycle may be succesfully reproduced by the climate models. However, surface observations at various locations as well as several model simulations have suggested that the near-surface moisture cycle in a diurnal timescale is dominated by the adsorption/desorption and/or salt hydration (e.g. Zent, 2014; Savijärvi et al., 2015, 2016, 2018, 2019a, 2020a; Savijärvi and Harri, 2021; Fischer et al., 2019).“

-Another unquestioned phenomenon concerns condensation and the formation of fogs. This is not mentioned in the manuscript, something that should be clarified by the authors. In particular, it would be interesting whether there is a competition between adsorption and condensation in the early morning

Fogs and boundary layer clouds are allowed to occur. However, they do not occur in any of the present integrations, due to the fairly dry equatorial Gale environment.

Added some text:

“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.”

-half of the graphs show a comparison between various model results as a function of altitude. Yet they should only emphasize the altitude at which the measurements are made (1.6 m) and not show T and VMR profiles up to 5 km while most of the diurnal variations occur in the first hundreds of meters .

Changed the upper limit to 1 km as suggested by the second referee.

Some text was added: “The upper limit of 1 km was selected to see the effect of initialization near the surface.”

Specific comments (numbers refer to line numbers in the text):

26: 1) one of its unique features, compared to Earth, is also its 95% composition.

Added: “Martian atmosphere is mainly composed of CO_2 (>95 %).”

28: 2) sensible heat is negligible for the surface, but not for the atmosphere (matters for the BL)

Changed the sentence: “Since the sensibel heat flux near the surface and latent heat flux troughout the atmosphere on Mars…”

87: “and average of the T” remove of

Removed “the”.

129+: PWC should be expressed in precipitable microns, pr-um.

Changed.

141: the few ChemCam observations could have been expanded by many more data from orbiters

We decided to use ChemCam observations, since these selected sols used in this manuscript had ChemCam observations and are therefore suitable to use here. In addition, ChemCam observations have been used in the previous studies by Savijärvi et al. Thus, we can compare these sensitivity experiments better with earlier studies.

Fig4: 1) is condensation included in the model?

Condensation to fog is allowed in the model but it did not occur.

2) limit altitude axis to below 250 m

See the response above. Added a sentence:

"The upper limit of 1 km was selected to see the effect of initialization near the surface."

3) since the text emphasizes the lack of reliability of VMR for Low RH data; RH plots should be added to let the readers see when VMR should be ignored. Alternatively, the authors could mark points when unreliable.

Very low RH values (<5 %) are now marked as gray in figures. Added a sentence: "These VMR values with very low RH (< 5 %) are shown as gray spheres in Figs. 4–7 (g) and (h)."

Added a sentence into Figure 4 caption: "Unreliable REMS-H-derived VMR values are marked as gray spheres."

202: nighttime H2O VMR for Ls 271° after dusk is not well reproduced at all. Any comment?

Added some text: "However, some disagreement with modeled and REMS-H derived VMRs around 18–24 LTST are visible. This is very likely related to the low RH values, as they have not yet increased enough after the extremely low daytime values. For example after the dusk at Ls 271°, observed RH is only slightly above 5 %. In contrast, observed RH during early morning hours is about 8-11 %."

206: It should be stressed that Chemcam cannot directly measure the H2O VMR at 1.6 m, and its value is essentially an extrapolation based on strong assumptions that the MCD, for instance, could contradict. It is clear from the graphs that H2O vmr deduced from RH measurements are made in a layer marked by a strong yet very shallow gradient. Chemcam has no sensitivity to that region of the atmosphere.

Added some text:

"This ChemCam VMR value is derived from the estimated PWC assuming well-mixed moisture profile."

New model experiments with "low-moist layer" at Ls 90 and "high-moist layer" at Ls 271 are in good agreement with the early morning REMS-H VMR and ChemCam-derived daytime VMR.

216: Since it was already discussed in previous works using the same model, why is it the MCD has not been employed to initialize the moisture profile?

This is considered in the revised version of the manuscript. See also our response to referee#1.

222: "initial" implies these parameters can evolve during the run. "Fixed" parameters see more appropriate

Apart from dust optical depth and surface pressure, these parameters evolve during the model run. We decided to remove "initial".