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Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "A user-orientated column modelling framework for efficient analyses of the Martian atmosphere" *by* Mark Paton et al.

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Response to reviewer #1

MP: Thank you for you encouraging and helpful comments. We have hopefully addressed all your comments adequately and look forward to your response. The line numbers we use are those in the revised paper.

1. Do the authors plan to make the presented column modelling framework available?

MP: We have no firm plans for making the entire framework available as it is still under development. We are sharing our results to the community to perhaps inspire the development of other similar tools rather than in preparation to providing any services. The Python code is available by request from Mark Paton.

1. continued: Do the authors plan to provide/share results upon request?

MP: We do not plan to provide or share results of the model at the moment as we have no resources to make this a practical proposition. Also we would prefer not to share the wrapper code as the project is still under development and providing documentation and support would not be realistic. The column model code is available by request from Hannu Savijärvi.

MP: The framework itself is a relatively simple construct in terms of the code. We used the Python software language together with the Pandas software library to develop the framework. Python is an easy to use and a well documented language. Simple wrappers to interface between software tools and data can be developed rather rapidly.

2. Do the authors plan to increase the capabilities of the framework by either calculating new vertical profiles (tau?) or adding new (other than MCS) orbital/ground data sets as inputs?

MP: We have no solid plans to increase the capabilities of the framework although the potential certainly exists.

3. Minor Comments

L2: I suggest clarifying "additional", or using "new" instead.

MP: L2 Agree, corrected.

L8: Please, quantify "higher altitudes". Do the authors mean altitudes between 0 and 28 km?

MP: L8 Added the following clarification: above the height of typical lander meteorological measurements, i.e. above 2 m

L33: "... the lower sections of the Martian atmosphere". Please, quantify.

MP: L35 Added the following clarification: i.e. below the planetary boundary layer or

below 5-10 km altitude.

L63: “which consist of”. I find this line ambiguous. Soundings can be performed using limb or nadir configurations, but vertical profiles are effectively retrieved from limb soundings.

MP: L65 Removed the first two sentences in the discussions paper as they do not really add much to the background section and readers are probably familiar with the profiles uses.

L71: Do the authors mean “limb observation”? Since MCS limb soundings have a vertical resolution of _5 km, nadir sounding’s vertical resolution should be > 5 km. L83: “Surface pressure and temperature...”. And what about atmospheric optical depth?

MP: L65 to L75 Yes limb observations. The paragraph has been updated to reflect this.

L85: Figure 1.

MP: L80 Corrected.

L93: figure 2.

MP: L86 and L91 Corrected

L107-108: More details about Eq. (2) are needed. What reference (Earth, MCD?) is used to choose the analytical form of Eq. (2)?

MP: L132 MCD. Added “see MCD profiles in fig. 9”

L119: I suggest clarifying why these specific heights are selected.

MP: L146 Added the following text: “At these altitudes, which correspond to grid points in the model, the observations diverge the greatest from the model over the winter solstice, e.g. see figure 6 (d).”

L123: “The threshold temperature was set at 3 K”. Is this also the case for the vertical profiles of temperature calculated for the VL-1 and VL-2 sites at Ls = 270, which are

shown in Figs. 4 and 6? It seems that such a threshold is not met by those profiles.

MP: The threshold temperature is for fitting the model to points in figure 8. The model was not fitted to the observations in figures 4 and 6. Figures 4 and 6 are for verification purposes so we did not fit the model to the observations as such, i.e. we are not determining properties here but trying to showing the model can reproduce the observations in a reasonable manner (although it obviously fails in figures 4 (c) and 6 (d) and so this issue is addressed in the discussions section).

MP: L149 Added the following clarification: “This was only used over the winter solstice when the observed temperatures diverged significantly from the model.”

L130: Why are the MCD data used as a reference instead of the EDL data? Is this because MCD results have already been validated? Also, I recommend defining MCD.

MP: Yes, we used the MCD data because it has been verified and has more comprehensive seasonal coverage than EDL profiles. Revised paper line: 107.

L135: The authors need to clarify how tau opacities are handled by the presented framework. Are (column integrated) tau opacity values given to the 1D model as an input? If so, are such values coming from MCD or TES? Are the vertical profiles of tau retrieved by MCS somehow used?

MP: We have not automated the input of the input of the optical depth tau values. The surface column integrated tau opacity is handed to the column model via a hard coded value entered by hand in the wrapper. The value is obtained manually from the MCD web interface. It is then transferred to the model via the model initialisation file (figure 1). The model uses an exponential function in the model to calculate the tau value at each level. The values for the optical depth, and their origin, are mentioned in L162. We have added some text to the methods section to make the process clearer plus extra details in a new Appendix B.

L138: I suggest adding “limb” before “sounding data”.

MP: L170 Agree, however have decided to use “MCS data” as this may be clearer.

L143: “surface temperature and pressure”. And what about atmospheric opacities? Fig. 3, Caption: Do the MCS/T(z) shown in Figs. 3-6 correspond to any specific Martian Year/ Earth date?

MP: Yes these are listed in tables in the appendix. We noted this on L145 (L174 in the revised paper). Martian years have been added to the figure captions. The surface pressure is extrapolated down from the last two points in the profile. The temperature is extrapolated down from the last temperature point in the profile (L109 in the revised paper).

L151: “Meaurement”.

MP: Corrected.

L165: Remove “.” after “year”.

MP: Corrected.

Fig. 7, Caption: Which Ls?

MP: Ls=270°. Added the information to the caption for figure 7.

L203: Replace “section 2.3” by section “3.2”.

MP: Corrected.

L215: “16 km”. Based on the Fig. 9: Axes and legends in Fig. 9 are barely legible (at least on my computer). Please improve the resolution/quality.

MP: Rearranged the figures and enlarged.

L232: “16 km”. Based on the abstract, this altitude should be “20 km”.

MP: Yes corrected.

L248: “... and the observed dust properties of the atmosphere...”. The authors have

not previously explained how the presented column modelling framework handles tau values (see previous comments).

MP: Made the sentence clearer. The dust optical depth was obtained directly from the MCD web interface.

L278: “The optical depth, tau, of the atmosphere at the time of the soundings was obtained from the MCD.”

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Response to reviewer #2

MP: Thank you for your helpful comments, especially regarding the clarity of our approach, which was definitely lacking. Hopefully we have addressed this and other issues in a satisfactory manner and we look forward to your response. The line numbers we use are those in the revised paper.

Some of the choices of approach are not justified very clearly, and a few more details concerning the user experience would also be beneficial. I am surprised, for example, that the paper does not illustrate the GUI that is used to run the model and perform the observational fitting?

MP: Section 3.1, Description and operation of the framework, was lacking in details and proper structure. This issue has now hopefully been addressed. Section 3.1 has been rewritten.

MP: A screen capture of the GUI has also been added to the methods section to make things clearer. Some less important details of working environment, such as the output style in the Python console, have been relegated to the appendix, section B.

The VL sites are probably quite strongly affected by horizontal advection which is not represented in the column model - so inferring a vertical wind from temperature anomalies is actually misleading!

MP: Agreed. We have edited the abstract to highlight this limitation. See lines 13 to 21.

Moreover, the adiabatic warming term does not seem to be necessary at the MSL site.

MP: We do not use the adiabatic term at all in the results section which includes the MSL site. We use the adiabatic term in the column model to obtain fits at the VL-1 and VL-2 sites in the discussions section. We do not fit the model with the adiabatic term to the profiles at the MSL site as this is not needed.

Why not choose (in addition?) a couple of cases where adiabatic warming effects are likely to be substantial - such as at a high latitude site e.g. the Phoenix landing site at 68 degrees N?

MP: We have added some more profiles into a new appendix B as a way to illustrate the working environment for the framework. The MCS profiles at the Phoenix site, which we have looked into, start at an altitude that is a bit too high to be a good comparison/example. We have included profiles a little to the south of the landing site. The Phoenix site may be worth investigating in the future though as it looks quite interesting.

Line 24 “increasing”

MP: Corrected.

Lines 33-34 What is meant by “lower sections” or “lower parts” of the atmosphere? Why restrict coverage to the lowest 30 km of the atmosphere? This should be explained, perhaps with references to the original model.

MP: L35 Added some text to clarify: “i.e. below the planetary boundary layer or below 5-10 km altitude.”

MP: L122 The following text has been added: Extra grid points can be added of adjusted in principle. However we use this configuration of the model as it has been used in previous work and its operation is well known.

Line 41 “in the descending” instead of “of”

MP: Corrected.

Line 69 What is a “frozen orbit”? Explain?

MP: L69 Changed ‘frozen’ to ‘polar’.

Line 85 Should be Figure 1. Perhaps also illustrate the GUI here or at some point?

MP: We have now included the GUI as figure 2.

Line 93 Should be Figure 2. Figure 2 is a bit sparse - not sure what it adds to the discussion?

MP: Figure 2 has been removed as the main text describes the same information.

Line 99 “compute” or “predict” would be better than “provide”

MP: L124 Edited the sentence to read: “Column models do not as such include vertical motion in their calculations.”

Line 103 (Eq (1)) “Q” should be “T” (temperature) in “@Q/@t”

MP: Corrected.

Line 104 “t” should be upper case “T” in “dt/dz”

MP: Corrected.

Lines 107-114 Why choose these particular functions for the fitted w for adiabatic warming? They look pretty arbitrary but presumably reflect the expected shape of w over the altitude range. But this should be discussed and justified.

MP: L132 Added the following text: “The assumed structure used to represent a typical profile of the vertical wind is based on the MCD profiles, e.g. see Fig. 9, with a parabolic function for the upper part and the formula for a circle on the lower section.”

Line 132 “within” instead of “with”

MP: Corrected.

Line 133 Subscript S in L_S

MP: Corrected.

Figures 3-6 Although there is a legend in Fig. 3(a) to indicate the column model and MCD data, it would be helpful to state which symbol represents which data in the figure caption.

MP: Added legend to the other figures.

Line 152 Why “perhaps” in this context? What else could it be?

MP: It could be topography or thermal property variations of the surface.

Figure 7 caption - So does w > 0 imply downward motion? If so, is this consistent with Eq (1)?

MP: No, we use an opposite convention in the column model. The caption has been updated to point this out.

Line 200 (and elsewhere?) Make clear the “advected” means “horizontally advected” since the adiabatic warming term is also a (vertical) advection term.

MP: Included “horizontal” before advected in all places where it appears in the text.

Line 206 “periodicity”

MP: Corrected.

Lines 208-213 Why show zonally averaged profiles when the observations are from particular longitudes? Also, are the sol averaged profiles shown here also taken from MCD? If so, please state.

MP: We showed average profiles to indicate what the average vertical wind speed is, i.e. what order of magnitude to expect at that latitude.

Line 221 “an intense”

MP: Corrected.

Line 235 “Again horizontal advection is probably playing: : :.”

MP: Corrected.

Line 238 “jet streams”?

MP: L268 Corrected. Added a reference just to be clear that we are talking about jets arising from the Western Boundary Current.

Line 316 Showman et al. reference is incomplete. Where is it published? (Presumably the University of Arizona Press book Comparative Climatology of Terrestrial Planets Edited by Stephen J. Mackwell, Amy A. Simon-Miller, Jerald W. Harder, and Mark A. Bullock?).

MP: L350 Yes the University of Arizona Press book. Corrected the reference.

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