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Atmospheric Chemistry and Physics Discussions

Interactive comment on "CO at 40–80 km above Kiruna observed by the ground-based microwave radiometer KIMRA and simulated by the whole atmosphere community climate model" *by* C. G. Hoffmann et al.

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General comments

We would like to thank reviewer Hugh Pumphrey for the helpful comments on our manuscript. We answer the comments point by point below in the same order as given.

Answers to specific comments

- Fig. 1: We recognized based on both this comment and the respective comment by Reviewer 2 (Thomas Flury) that the purpose of this figure could be misunderstood. The actual derivation of the KIMRA retrieval characteristics is complex. Therefore, we separated the characterization of the KIMRA dataset and published it in advance in AMT (Hoffmann et al., 2011). This paper is referenced and the major points for the present purpose are summarized in the manuscript. Showing the detailed averaging kernels adequately would also need further explanations in the text, which would be a repetition of larger parts of Hoffmann et al. (2011). In our opinion, this would be a distraction from the intended focus of the paper. The idea of showing this plot was, therefore, not to give detailed information on the KIMRA characteristics, but only to establish the connection between the KIMRA sensitivity discussed by Hoffmann et al. (2011) and the shape of the correlation profiles in this manuscript (Fig. 4). We have changed the figure as suggested by reviewer Thomas Flury to achieve more clarity: the vertical range is now extended to 0-130 km (so that the interested reader can form a rough idea of the KIMRA characteristics over the entire range of altitude). Furthermore we have removed the right panel. The text has been changed accordingly to emphasize the connection to Hoffmann et al. (2011) and to convey the message of the right panel on the basis of the left panel only.

- Fig. 2: This figure is also closely connected to the paper by Hoffmann et al. (2011), where KIMRA is compared to recent satellite observations. The manuscript notes the similarities (p. 570, line 15ff.) between the profile comparisons KIMRA-satellites by Hoffmann et al. (2011) and KIMRA-SDWACCM in the present manuscript. In order to keep this similarities obvious, we presented the comparison in a style similar to the figures in Hoffmann et al. (2011) and, for this reason, we have chosen not to change this figure. A log-scale, as well as normalization of the absolute deviations, were not used in the former paper because the KIMRA profiles exhibit slight negative overshoots and values close to

0. However, we include with this reply the original (not convolved with the KIMRA averaging kernels) MLS and SDWACCM profiles, as requested, to demonstrate the effect of the averaging kernels. The text has been briefly extended accordingly.

- Page 570 line 10: We have decided to remove the objectionable phrase "consistently more curved" completely. The remaining sentence "The KIMRA profile shows less CO increase with altitude below 60 km and a stronger increase with altitude above 60 km" already contains the information we wish to convey.
- Fig. 3: We have included the requested repeats of Fig. 3 for different altitudes. However, instead of plotting the same for 45 km altitude as suggested, we chose 50 km. Although the difference of the behavior at both altitudes is small, the selected altitudes cover then the local correlation maxima (about 50, and 75 km) and the local correlation minimum (60 km).
- Pages 572-3 and Fig. 4: The extension of the correlation profiles to higher altitudes appears reasonable at first sight; however, the interpretation of the correlation coefficients above 80 km is not straightforward, so we decided to keep the figure restricted to the range of KIMRA sensitivity (40-80km): The convolution with the averaging kernels pushes the profiles of MLS and SDWACCM towards the KIMRA a priori above 80 km where the sensitivity drops. The agreement between the single datasets must therefore not get worse above 80 km although there is only little information from the actual measurements. In fact, the correlation coefficients are somewhat smaller than in the sensitive range, but not close to zero above the sensitive region. Showing this coefficients might be misleading, since they might be considered as real when going quickly through the paper even though they are artificially produced by the convolution with the averaging kernels. The behavior described in the review (clear drop of correlation coefficients above 80 km) is only seen when comparing KIMRA to the unconvolved

MLS and SDWACCM datasets, which is, however, not accurate in the sensitive region. Therefore, we decided to leave the vertical range restricted to the sensitive KIMRA range, which is the only range that provides unambiguous information on the model behavior.

- Page 573: We agree that a regression analysis in addition to the presented correlation analysis is interesting and have actually performed such an analysis. If KIMRA is treated as the independent variable and MLS and SDWACCM are dependent variables, we find slopes of 0.8 to 1.2 between 40 and 60 km altitude. Above 60km, the slopes drop to approximately 0.5. The reason why this analysis was not included in the manuscript is that it is not straightforward to separate the effects of the KIMRA measurement characteristics on the profile of the slopes from the effects of the actual model properties. Thus, it is not possible to draw strong conclusions on the pure model behavior from this analysis. This was different for the correlation coefficients, for which the connection to the KIMRA sensitivity is explained in the manuscript. In contrast, the linear regression depends not only on the observed variations, but also on the absolute vmr values, which are known to be not perfect for KIMRA (Fig. 2 and Hoffmann et al., 2011). Thus, this analysis is finally not very illuminating with respect to model characteristics and we think that elaborating on this in the present manuscript might be confusing. If we use MLS as the independent variable and SDWACCM as the dependent variable with the same setup as for the correlation analysis shown in the supplement (no convolution with KIMRA AVK), we find slopes of 0.8 to 1 between 40 and 75 km and a fast drop above and below. We will briefly mention this result of the MLS-SDWACCM regression analysis in the revised manuscript in the context of the MLS-SDWACCM correlation (see next point). However, we do not want to put too much weight on the pure MLS-SDWACCM comparion since, strictly speaking, a convolution with the MLS averaging kernels would be necessary. (See also answer to point "Page 577, line 1" of the anonymous reviewer #3).

- Page 574 and Fig. 5: We have removed Fig. 5, as explained in more detail in the answer to a related comment by Thomas Flury. Furthermore, we have included the figure showing the MLS-SDWACCM correlation from the supplement into the main paper, as requested.

Answers to Technical corrections

- Page 562 line 29: Changed in the revised manuscript.
- Page 562 line 19: Should this be p. 570 line 19? We actually mean “all” other datasets, since we are also referring to the comparisons in Hoffmann et al. (2011), which is mentioned before in the manuscript. This is now clarified.
- Page 574 line 26: Changed in the revised manuscript.

References

Hoffmann, C. G., Raffalski, U., Palm, M., Funke, B., Golchert, S. H. W., Hochschild, G., and Notholt, J.: Observation of strato-mesospheric CO above Kiruna with ground-based microwave radiometry – retrieval and satellite comparison, Atmos. Meas. Tech., 4, 2389–2408, doi:10.5194/amt-4-2389-2011, 2011.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 559, 2012.