

Review of “Simulation study for ground-based Ku-band microwave observations of ozone and hydroxyl in the polar middle atmosphere” by Newnham et al.

The authors suggest to use presumably low-cost LNB receivers to observe the O₃ and OH emissions in the mesosphere and lower thermosphere. So far this study is a purely theoretical approach and as such it is well structured and logically sound.

The study will likely be a valuable contribution to the community. It may inspire others to pursue the presented approach further, such as actually measuring O₃ or OH in the suggested way. It is therefore worth publishing in AMT after considering the points below.

General comments

Since this study is purely theoretical, no actual measurements can be presented. However, the authors fall short on describing how feasible actual measurements are in the proposed way. That is, are there any cost limitations and how hard would it be to combine the signals from 40 receivers (for OH) or to cool them to 4 K? Are there any plans to actually carry out such measurements?

Subsection 2.1 describes the model atmosphere and its variation during a sub-storm to great length. This model atmosphere was used to evaluate the retrievals but the authors fail to properly link the rather extensively described ozone and OH model variations to their impact on the retrieval. Does it matter for the current study that “the largest decrease in O₃ occurred between 01:30–07:30 UTC on day 363”? How typical are these values and variations to occur in the real world, are they representative for the general case? All those timing and the discussion can be removed, and subsection 2.1 can be shortened substantially by concentrating on the values that are important for the retrieval simulations. The authors should then provide a better logical connection to the rest of the manuscript, i.e. to the retrieval simulations.

Minor points and detailed comments

Below are some minor points and clarification suggestions.

Page 2

- l. 11: Relative increases of a relative quantity can be misleading and OH has a large diurnal variability. Further, a relevant study should be cited that derives this 1000% increase.
- l. 12: Please provide a reference for the 5–55% ozone loss.
- l. 25: Is “much more” really needed when “abundant” is used? I’d suggest to change to something like “... abundant during night and depleted during day ...”.
- l. 27: “Another instrument” should be removed and the commas adjusted accordingly.
- l. 30: I’d suggest to change to: “helped to elucidate”.

Page 3

- l. 32: Insert “the” before “ Λ -doubling hyperfine structure”.

Page 4

- l. 17: I’d suggest to change to: “are given in Section 2.3.”
- l. 20: I’d suggest to remove the hyphen in front of “ozone”.
- l. 23: I’d suggest to move “from WACCM-D” to before “covering 2000–2009”.
- l. 26: There is something missing, it does not seem to be a complete sentence. Perhaps: “The model data were taken from the ... points closest to ...”.

Page 5

- l. 4: I’d suggest to swap “during a four-day period” and “over the altitude range 68–86 km”.
- l. 5: Insert “the” in front of “number densities”.
- l. 12: How large is the range around 75 km?
- l. 12–14: This is a long and a little convoluted sentence which is hard to understand. Why are the SIC ozone values larger than the SIC ozone values? However, since this discussion seems to be unimportant for the rest of the study, it could just be removed.

Page 6

- l. 1: I’d suggest to insert “taken” after “were”: “... were taken from ...”.
- l. 4–5: I’d suggest to begin the sentence with “As the water vapour ...”, to remove “used was”, and add “was used” after the model version number before the comma.
- l. 5: “separately” can probably be removed.
- l. 7: In my opinion “therefore” would fit a little better than “hence” here, but I leave that decision to the authors.

Page 7

- l. 16: Insert “taken” after “were”: “... were taken from ...”. Why was the older version IGRF-11 used and not the IGRF-12?
- l. 16: What does “renormalized” mean? I’d suggest to use “normalized” to avoid confusion with renormalization as it is known in theoretical physics, e.g. in QED.
- l. 24: What distribution was used for the scaling factor? Was it uniform or a normal distribution around 1? The distribution of the scaling factor may have an impact on how useful the resulting distribution is for evaluating the uncertainties in the retrieval algorithm. Here the authors need to be more specific and more careful about the sampled distribution.
- l. 29: I’d suggest to use “within” instead of “inside”.
- l. 31: I’d suggest to use “for” instead of “over”.

- l. 32: To keep the tenses consistent, “is assumed” should probably be “was assumed”.
- l. 33: I’d suggest to change to: “... fixed to 1.5 ppmv ...”.

Page 8

- l. 1–3: This description is rather convolved and confusing. I’d suggest to restructure: “The off-diagonal elements of ... linearly decrease with a correlation length of one fifth ...”.
- l. 10: I’d suggest to change to “At a zenith angle of 82° the lower transmittance ...”
- l. 12: I’d suggest to change to “... that the different ...”
- l. 17: I’d suggest to use “at a zenith angle of 82°.”

Page 9

- l. 15: I cannot find a reference *Rodgers, 2004* in the citation list which is presumably a typo and should read “Rodgers, 2000”.
- l. 18: I’d suggest to remove “amount of”.
- l. 20: I’d suggest to change “estimated” to “identified”.
- l. 20: I’d suggest to insert “altitude” before “range”.
- l. 22: I’d suggest to insert an article “the” before “O₃”.
- l. 23: As it is written now, this sentence suggests that “the retrieved O₃” is responsible for smoothing the information. I’d suggest to rewrite that sentence to state what the finite width of an averaging kernel means.
- l. 24: I’d suggest to remove “Thus,” and to start the sentence with “The full-width ...” since “Thus” would need a bit more explanation than simply referring to the smoothing effect of the AVKs. Second, I believe that it should be “widths of the kernels provide” or “width of the kernel provides”.
- l. 25: In my point of view, if the altitude resolution is changing from 10.9 km to 18.4 km, the resolution gets worse and is therefore decreasing.
- l. 29: I’d suggest to introduce a paragraph break before “The OEM ...”.
- l. 30: I’d suggest to change “to give further ... retrieved profiles.” to: “which provide further diagnostic uncertainty estimates of the retrieved profiles.”
- l. 32: Are the stated 0.34 ppmv exact? I’d suggest to insert “around” or “about” before that number.

Page 10

- l. 1: I’d suggest to move “outside the range of the AVK peaks” to the end of that sentence.
- l. 3: I’d suggest to insert “the” in front of “MC”.
- l. 3–5: See the point above about the scaling factor distribution used for the MC samples.

- l. 8: “are dependent” can be shortened to “depend”.
- l. 10: I’d suggest to change “for” to “of”. This sentence is confusing, “should be adequately sampled” by whom? Doesn’t the Jacobian depend on the retrieval setup (forward model) and therefore this adequate sampling should rather refer to that?
- l. 25: I believe it should be “averages and standard deviations” or “average and standard deviation”.
- l. 27: I’d suggest to use “approaches” or “tends to” instead of “converge towards”, at least the singular “converges” should be used.

Page 11

- l. 2–3: I’d suggest to remove “are” at the beginning of line 3 to read “The lowest AVK peaks at ...”
- l. 3: I’d suggest to change to “... where the MR is larger than ...”.
- l. 5: I’d suggest to insert “the” in front of “OH”.
- l. 6–7: As noted above in the ozone section, a resolution that changes to larger numbers means that it gets worse and is therefore decreasing. Secondly, there is not much lower thermosphere left below 90 km, so that expression should probably be removed here.
- l. 10: I’d suggest to change “small” to “smaller”.
- l. 13: I’d suggest to insert “the” before “MC”.
- l. 17: “are dependent” can be shortened to “depend”.
- l. 26–28: This sentence is unclear and confusing, should “to” be “as”? It is confusing which signal changes and how OH relates to ozone, and how that relates to the receiver performance. I’d suggest to not put everything into a single sentence.

Page 12

- l. 3: I’d suggest to remove “seasons”.
- l. 4: I’d suggest to change “differing” to “different”.
- l. 5: I’d suggest to use “performing” instead of “making” and to insert “a” (or “an”) in front of “rms”.
- l. 6: According to the main text, the ozone altitude resolution is closer to 11–18 km.
- l. 18: I’d suggest to remove the commas around “and man-made”.
- l. 19: I’d suggest to change “making observations” to “observing” or “performing observations”.
- l. 19: I believe “or polar” is not needed and can be removed, “high latitude” already includes “polar”.
- l. 20: I’d suggest to change to: “... and by carefully pointing the receiver ...”.

- l. 21–22: I’d suggest to remove “values of the” and to insert “need to be” before “verified”.
- l. 23: I’d suggest to change “that” to “which”.
- l. 24: I’d suggest to change “appropriate” to something like “more appropriate” or “a better approach” or something similar.
- l. 28 (data availability): I’d suggest to be more specific: “The model and simulation datasets used in this study ...”.

Figures

- Fig. 6: It would be helpful to put titles to the panels themselves, “sub-storm” on the left and “background” on the right. The authors may consider swapping the order since “background” has the connotation of being the usual state, i.e. the normal state when nothing happens.
- Fig. 7: I’d suggest to label the panels, i.e. the columns and rows such that is much easier to the cases without reading the rather long figure caption. Similar to Fig. 6 that would mean indicating the columns with “sub-storm” and “background” (consider swapping, see above), and the rows with “both”, “vertical”, and “horizontal”.
- Fig. 9, caption l. 5–6: I believe that the commas after “kernels” and before “are shown” should be removed.
- Fig. 10: The light yellow line is hard to see in prints, please use a different colour.
- Fig. 12, caption l. 6: I believe that the commas after “kernels” and before “are shown” should be removed.
- Fig. 13: The light yellow line is hard to see in prints, please use a different colour.