Response to Reviewer #1

We would like to thank the reviewer for thoroughly examining the manuscript. We gratefully incorporated the reviewer's comments which certainly improved our manuscript. Please find below our replies in italics and indented.

General comments

The present study by Rieger et al. presents an updated tagging algorithm for OH and HO2 which allows for an attribution of HOx to various emission categories. In contrast to the previous version V1.0 the new version takes into account tropospheric as well as stratospheric chemistry. Furthermore, the new scheme considers rest terms to take into account HOx production and loss reactions which are not explicitly tagged.

Since the tagging mechanism does not only consider primary contributions, but also secondary effects via the long-lived species, the paper is rather difficult to read. I am sure for the authors, who are familiar with the tagging approach, it is clear what's going on, but for an unacquainted reader it is difficult to understand why an updated tagging method for HOx results in different contributions of, e.g., biomass burning emissions to ozone. Maybe a schematic would be helpful. Furthermore, the HOx tagging includes several assumptions and special cases. There are several open questions (details see below). My major concern is related to the steady-state assumption and the rest terms. Overall, I think the paper needs a clearer description of the method, a better justification of the assumptions and a more thoroughly explanation of the presented results.

> *We added some further explanation in the introduction about the interaction between short-lived and long-lived species to clarify the relations. As suggested by the reviewers, we also inserted a sketch explaining the interaction between long-lived and short-lived species (Fig. 1). We also restructured the manuscript by merging Section "Steady-state assumption" and "Closure of the budget". We further set the case "tag" as baseline for the manuscript as was suggested by reviewer #2. Moreover, we better justified the introduction of the rest terms in Sect. 3.4. We also tried to present the results in a better and more understandable way. We hope that this improves readability of the manuscript. Details of the changes are described below.*

In the introduction the authors argue that mitigation of climate change requires attribution of certain chemical trace gases to specific emission categories, and therefore propose the tagging approach. I wonder how robust the presented results are. For example, the presented model simulations do not consider direct CH4 emissions. I assume that tagging CH4 from the applied emission categories would have a large impact on the attribution of HOx to certain emissions. In my opinion it is inconsistent to consider CH4 decomposition as one category, while NOx, NMHCs etc. are split into road traffic, non-traffic etc. For an evaluation of the overall climate impact all traffic related emissions have to be tagged in the same manner. Therefore, I have doubts that the method is already applicable.

> *This is a good point. Indeed, it would be desirable to also tag* CH_4*. However, for the current state-of-the-art, this is not possible. Estimates of* CH_4 *lifetime are still quite uncertain. In particular,* CH_4 *lifetime against OH is generally underestimated by chemistry climate models (Jöckel et al., 2016). But* CH_4 *is an important greenhouse gas. Thus, to hold* CH_4 *lifetime on a reasonable level,* CH_4 *emissions are generally prescribed in state-of-the-art chemistry climate models. Therefore, considering the current treatment of* CH_4 *in chemistry climate model, it is not reasonable to tag* CH_4*.*

Considering the tagging of CH_4 would of course change these categories where CH_4 emissions play a role. However, for those categories where CH_4 emissions do not play a major role, no large changes are expected. For example, for road traffic and shipping emissions, direct CH_4 emissions are not important. Consequently, no large changes are expected if the tagging of CH_4 would be included. Hence, the current implementation of the HO_x tagging method enables to determine the contribution of traffic emissions to HO_x.

Note that we do not expect large changes in contributions from methane decomposition since this relies on CH_4 concentrations which are reasonable due to boundary conditions. However, a part of this decomposition will be allocated to other sources.

In the first sentence of Sect. 3.3 the authors state it is crucial that HOx production and loss of the reduced mechanism (almost) equal the complete HOx production and loss. Furthermore, steady state means to me that HOx production equals HOx loss. This is valid for the complete HOx chemistry derived from MECCA, but not or only partly for the reduced system. For example, stratospheric OH production of V1.1 deviates by 9% from the total stratospheric OH production and, maybe even more important, from the stratospheric OH loss of V1.1. Therefore, I do not agree with the conclusion at the end of section 3.3 that the steady-state assumption for the reduced reaction system V1.1 is justified. If the steady-state assumption was fulfilled, the rest terms to close the budget would be needless.

We agree that end of Sect.3.3 could be confusing. In fact, it referred to the reduced HO_x reaction system taking all 30 reactions into account. For this case, the steady-state is valid for tropospheric OH as well as for tropospheric and stratospheric HO_2. Indeed, for the stratospheric OH, the production and the loss deviates by 9% and thus are not in steady-state. We have rewritten the paragraph and emphasized that the steady-state assumption for the reduced HO_x reaction system V1.1 is not completely fulfilled.

Changes in manuscript:
Summing up, the reduced HO_x reaction system V1.1 represents well the total HO_x production and loss in the troposphere and stratosphere. V1.1 reproduces the HO_x chemistry better than V1.0. However, OH production in troposphere and stratosphere as well as H loss in the stratosphere of V1.1 deviates from the total rates derived by MECCA. Thus, the state-state for the reduced HO_x and H reaction system (Tables 1 and 2) is not completely fulfilled.

Furthermore, it is not clear from the paper that the steady-state assumption for H is valid, as claimed in Sect. 3.4.

We agree with the reviewer that we missed to explain this point. To show that steady-state of H is valid, we have added this information to Table 3 and discussed the steady-state of H in Sect. 3.4.

Changes in manuscript:
The reduced H reaction system in V1.1 (Table 2) represents the total H production and loss in the troposphere very well. However in the stratosphere, H loss in V1.1 deviates by 17 % from the total H loss.

Table 3 presents the “main reactions of H” for the reduced system, but is this reaction system identical to the complete chemical mechanism in MECCA or only a subset?

Table 3 shows a subset of the complete chemical mechanism in MECCA. The compete MECCA mechanism contains 15 reactions concerning H. To clarify the misunderstanding we have added an explanation in the text.

Changes in manuscript:
Table 3 presents the main reactions for H which still constitute a subset of full H chemistry implemented in MECCA.

Section 4 is mainly a description of the presented figures, but lacks explanations, for example for the differences between V1.0 and V1.1. The argumentation is often rather vague, namely that V1.1 considers now more reactions which contributes to the differences. That leaves the impression that the authors themselves do not fully understand the changed patterns. From what is written in the paper it is hard to understand the presented results and differences, but I think this is important to judge the performance and shortcomings of the tagging method.

Thank you for this comment. As you suggested we have replaced Fig. 2-4 in the manuscript by Fig. 1 and 2 from the Supplement. We agree that this makes the comparison between V1.0 and V1.1 easier.
We have stated the given explanations more precisely and hope that this can clarify the presented results. For example, we have merged the examples which are based on the same explanations.

Changes in manuscript:
The contribution of the category "aviation" to HO_2 in V1.1 shows roughly the same pattern compared to V1.0. However, the HO_2 destruction along the flight path is not as pronounced anymore which is caused by the inclusion of reaction (15) and (18) to V1.1. Reaction (15) adds the term ½ R_{15} NO_y^i/NO_y to the HO_2 loss (eq. 12) and reaction (18) adds the term R_{18} NO_y^i/NO_y to the HO_2 production (eq. 11). As reaction rate R_{15} equals the rate R_{18}, this leads to a larger HO_2 production than HO_2 loss ($R_{18}\, NO_y^i/NO_y > \frac{1}{2} R_{15}\, NO_y^i/NO_y$). Consequently, the addition of reaction (15) and (18) to the reduced HO_x reaction system V1.1 constitutes an extra HO_2 source.
Larger values of the categories "N_2O decomposition" and "lightning" to HO_2 in the upper troposphere are explained by a larger HO_2 production in V1.1 compared to V1.0. The H tagging in V1.1 considers all relevant HO_2 sources (reaction (7), (10), (11) and (28)) leading to a larger HO_2 production. Also the addition of reactions (15) and (18) (explanation see above) as well as the addition of reaction (23) which considers more reactions than in V1.0 increase the HO_2 contribution of the categories "N_2O decomposition" and "lightning".
Large changes in pattern are observed for the contributions of "biogenic emissions" and "CH_4 decomposition" to OH and HO_2 as well as for the contributions of "biomass burning" and "anthropogenic non-traffic" to OH. In V1.1, these categories mainly constitute a source of OH and HO_2 in the troposphere. The addition of reaction (24) and (25) to the reduced HO_x reaction system V1.1 presents a HO_2 source increasing OH and HO_2 contributions. Furthermore, reactions of NMHC with OH, HO_2 and NO_y (reaction 21, 22 and 23) are important throughout the whole troposphere. In contrast to V1.0, V1.1 considers all reactions of NMHC with OH, HO_2 and NO_y (see Sect. 3.2) significantly changing the pattern of "biogenic emissions", "CH_4 decomposition", "biomass burning" and "anthropogenic non-traffic".

For example, what is the reason for the changes in the contribution of stratospheric O3 production to tropospheric OH?

Although the reactions of OH and HO_2 with $O(^3P)$ play only a minor role in the troposphere, their addition to reduced reaction system modifies the contributions to OH. Additionally, the re-establishment of the steady-state also increases the *contribution of stratospheric O_3 production to OH and thus causes the change in pattern.*

Furthermore, I am concerned about the HO2 shipping contribution discussed in Fig. 6. In this case the authors provide a clear explanation, but frankly speaking this example seems to show that the tagging method does not work. Two reactions (production and loss) with the same reaction rate, but only half of the loss is considered???

The addition of new reactions to the reduced HO_x reaction system changes the contribution of these sectors where the new reactions are relevant. For the category shipping, all reactions concerning NO_y are relevant. Thus adding reaction (15) and (18) does change the contribution of shipping emissions to HO_2 significantly. We added further explanations in the text to clarify the change of sign due to addition of reactions (15) and (18).
This example shows that in V1.0 not all relevant reactions concerning NO_y have been considered which leads to errors in the contribution calculations. In comparison, in V1.1, the tagging method overcomes these shortcomings.

Changes in manuscript:
Explanation:
The contribution of the category "aviation" to HO_2 in V1.1 shows roughly the same pattern compared to V1.0. However, the HO_2 destruction along the flight path is not as pronounced anymore which is caused by the inclusion of reaction (15) and (18) to V1.1. Reaction (15) adds the term ½ R_{15} NO_y^i/NO_y to the HO_2 loss (eq. 12) and reaction (18) adds the term R_{18} NO_y^i/NO_y to the HO_2 production (eq. 11). As reaction rate R_{15} equals the rate R_{18}, this leads to a larger HO_2 production than HO_2 loss ($R_{18}\ NO_y^i/NO_y > ½\ R_{15}\ NO_y^i/NO_y$). Consequently, the addition of reaction (15) and (18) to the reduced HO_x reaction system V1.1 constitutes an extra HO_2 source.

Example HO_2 shipping:
The change of sign is caused by the addition of reaction (15) and (18) to the reduced HO_x reaction system V1.1 which constitutes a net HO_2 production leading to positive HO_2 contributions (explanation see above). The comparison shows that HO_2 contributions in V1.0 were systematically and erroneously underestimated.

Specific comments

- P1, L11-14: As mentioned above, at first glance it is hard to understand why the tagging of HOx affects other tagged species. If you do not want to lose your readers right at the beginning, you should consider rewriting the last part of the abstract.

Very good point. We definitely want to avoid losing readers already at the abstract. We added further explanations in the introduction and abstract of how the tagging of short-lived and long-lived species interacts. A detailed description of the tagging of long-lived species is found in Grewe et al. (2017).

Changes in manuscript:
Abstract:
As HO_x reacts with ozone (O_3), carbon monoxide (CO), reactive nitrogen compounds (NO_y), non-methane hydrocarbons (NMHC) and peroxyacyl nitrates (PAN), the contributions to these species are also modified by the advanced HO_x tagging method V1.1.

Introduction:

The contributions to long-lived and short-lived species are closely linked. For example, the reaction
$OH + O_3 \rightarrow HO_2 + O_2$
involves the long-lived species O_3 *and the short-lived species OH and* HO_2*. Hence, this reaction is considered in the implementation of the tagging method for long-lived and short-lived species. The contribution of, for example, shipping emissions to* O_3 *influences the contribution of shipping emissions to* HO_2*: the higher the contribution to* O_3 *is the more* HO_2 *is attributed to shipping emissions. Furthermore, OH from shipping emissions destroys* O_3 *and thus reduces the contribution of shipping emissions to* O_3*.*

- P2, L8: For which specific environments? Please clarify.

Thank you for this hint, we added an example.

Changes in manuscript:
For certain environments, such as marine boundary layer, model studies compare well with measurements.

- P4, L2/3: Why do you use a different time period for the global and the regional simulations (2007/2008 vs. 2009/2010)?

We agree that this might we confusing. Therefore, we have repeated the EMAC simulation for the same time period 2007/2008 and adjusted the plots, tables and numbers in the paper to represent the year 2008. However, we leave the dates of Fig. 6 to be able to compare it with Grewe et al. (2017).

- P5, L7/8: I am not sure if I understand this statement correctly: In V1.0 the OH loss by the reaction with NMHCs was obtained from the total chemical CO production, no matter if OH was involved or not?

Yes, this is right. The reaction rate of OH + NMHC was determined only by the net CO production. We added some further explanation to clarify the calculation of the reaction rate in V1.0.

Changes in manuscript:
The reaction rate of OH with NMHC (reaction 21, Table 1) was determined via the production rates of CO by assuming that each reaction of OH with NMHC produces one CO molecule. This method neglects all intermediate oxidation reactions of NMHC and considers only these reactions when NMHC is finally oxidized to CO.

- P5, L17/18: Reaction rates depend on the concentrations of the reactants and via the rate coefficient often on temperature, and therefore vary in time and space. So how is the threshold reaction rate of 1e-15 mol/mol/s to interpret? Is that an annual and global mean value?

Thank you, we did not mention this in the text. The threshold is a tropospheric or stratospheric annual mean. We added an explanation in the text.

Changes in manuscript:
We consider only reactions with a tropospheric or stratospheric annual mean reaction rate larger than 10^{-15} *mol* $mol^{-1}s^{-1}$ *(see Table 1).*

- P5, L21-31: What's the point of those two paragraphs? As long as you do not show any numbers, this part is rather vague.

> *Thank you for pointing this out. We added the amounts of relative contributions of the mentioned reactions to the text.*
>
> ***Changes in manuscript:***
> *The reactions which are important in the troposphere are indicated in Table 1. As stated above, reaction (1) of H and O_2 dominates the HO_2 production in the troposphere. It produces 49 % of tropospheric HO_2. In V1.0, only part of this HO_2 source was regarded (see Sect. 3.1). The most important HO_2 loss is the reaction with NO (reaction 14) followed by the reaction with itself producing H_2O_2 (reaction 3) which accounts for 32 % and 12 % of tropospheric HO_2 loss. The production via H2O and $O(^1D)$ produces about 21 % of tropospheric OH (reaction 2). The excited oxygen radical ($O(^1D)$) originates from the photolysis of O_3. Also reaction (14) of NO and HO_2 produces 32 % of tropospheric OH. OH is mostly destroyed by CO (reaction 11, 38 %) followed by NMHC (reaction 21, 25 %).*
> *In the stratosphere different chemical reactions become important. Here, OH is mainly destroyed by O_3, producing 40 % of stratospheric HO_2. The reaction is partly counteracted by the reaction (14) which produces 21 % of OH and destroys 24 % of HO_2. Since large quantities of O3 are found in the stratosphere, O_3 or the excited oxygen radical ($O(^3P)$) destroys about 62 % of HO_2. Reactions with NMHC, CO and CH_4 play only a minor role in the stratosphere.*

- P5, L33: Why are reactions 19, 28 and 30 listed in Table 1, when they are not part of V1.1? That's inconsistent with the table caption.

> *Yes indeed, there is contradicting. We have set the case "tag" as the baseline of the manuscript. Thus, Table 1 now represents only the reduced HO_x reaction system V1.1 as the table caption says. The extra information is deleted and put into the appendix A.*

- Table 1: How are NMHCs treated in the HOx tagging? Is there only one lumped NMHC or are the individual NMHCs treated separately? If it is a lumped NMHC, how often can it react with OH?

> *NMHC represents a chemical family which contains for example CH_3OH, CH_3O_2, CH_3OOH, HCHO, C_2H_6, C_2H_4 and CH_3CO_3. All species included in the chemical family NMHC are given in Table 1 in the Supplement of Grewe et al. (2017). The reaction rate of the reaction NMHC + OH → NMHC is determined by adding up all reaction rates of OH with the species of the family NMHC. We added further explanation to the text.*
> *The number of reactions with OH is an interesting point, which we haven't followed yet. But that is something we might look into in future applications.*
>
> ***Changes in manuscript:***
> *Reactions (21) to (25) involve the chemical family NMHC which contains several species such as formaldehyde (HCHO), ethylene (C_2H_4) and propane (C_3H_8). The rate for reaction (21) is determined by adding up the rates of all reactions of OH with each single species of the family NMHC.*

- Table 2: How exactly are the tropospheric and stratospheric production and loss rates calculated? I assume there is a kind of air mass weighting applied? mol/mol/s is a somehow weird unit, I would usually expect something like Tg(OH)/yr…

The production and loss rates indicate annual means for the tropospheric and stratospheric domain. To calculate the means, each grid box is weighted with the corresponding air mass. We added this information to the table caption.
Concerning chemical reactions in the atmosphere, mol/mol/s is the usual unit for production and loss rates.

Changes in manuscript:
Annual mean of OH, HO_2 and H production and loss rates (air mass weighted)

- P8, L2: It is true that the OH production for "all" differs only by 2% from the total production, but for "tag" the difference is about the same as for V1.0, namely around 11%. Which quantity is used for the tagging – "all" or "tag"?

We agree that the discussion of the case "tag" and "all" was confusing. In the former version, the case "tag" is finally implemented in EMAC. For the current version, we set the implemented version "tag" as baseline for the paper. We hope this improves the readability of the paper.

- P9, L25: Why are the mentioned species not explicitly tagged? Please explain.

This is a good point. We missed to mention it. Due to limited computational resources, it is unfortunately not possible to tag all relevant species. This is also the reason why we also tag chemical families such as NO_y and NMHC. We added an explanation in the text.

Changes in manuscript:
Due to limited computational resources, other species such as H_2, H_2O_2, CH_4, ClO and BrO are not tagged (as in V1.0).

- P10, L8: I do not understand this sentence. Ratio of what to what?

The sentence refers to the ratio A^i/A. To clarify this, we have rewritten the paragraph.

Changes in manuscript:
In reaction (1), neither H nor O_2 are tagged. To obtain the ratio HO_2^i/HO_2, we set up an extra tagging of H itself.

- P10, L19: Why are H2O2 production and loss not balanced? Please explain. And HOx production and loss of the V1.1 reaction system are also not balanced, but nevertheless steady-state is assumed. This is inconsistent to me.

H_2O_2 is not a radical, so we do not expect that production of H_2O_2 balances the loss of H_2O_2. In contrast, OH and HO_2 as well as H are all radicals which react very fast with many species in the atmosphere. Thus, steady state of OH, HO_2 and H is reached very fast. However, the reduced HO_x reaction system V1.1 is indeed not balanced. Therefore, we introduce the rest terms.

- P11, L14: In my view this is in contradiction to the statement at the end of Sect. 3.3 (-> steady-state assumption justified).

We agree that the formulation at the end of Sect. 3.3 could be misleading. In the former version, end of Sect. 3.3 related to the case "all" which caused this misunderstanding. Since we now changed the manuscript and put the case "tag" as baseline of the manuscript, we modified the statements at the former end of Sect 3.3. So the introduction of the rest terms should be better justified now.

- P11, L28/29: Why are the rest terms equally distributed amongst the source categories (division by n) and not according to the contribution of the individual source categories to the total, e.g. OHi/OH? Couldn't it be that the linear distribution of the rest terms leads to an artificial exaggeration of a minor source category? I would be interested to see the contribution of the rest terms to the individual source categories.

> *For example, a large part of the rest term for OH (resOH) originates from omitting the photolysis of H_2O_2 which produces OH. The question is now: From which source category does H_2O_2 come from? To which sector shall the produced OH attributed to? Since we don't know from which sector OH originates, we split it up equally among the sectors. Indeed, this method weights minor source categories stronger with the rest terms than major categories. However, a linear apportionment would assume that we know the origin of H_2O_2 what we indeed don't know.*
> *We provide figures showing resOH, resHO2 and resH in the supplement.*

- P14, Fig. 2: What is the reason for the different patterns in OH from anthrop. non-traffic, traffic and shipping? All three categories represent surface emissions.

> *Right, emissions of the sector anthropogenic non-traffic, road traffic and shipping are all surface emissions, but their composition and amounts are very different. For example, for the sector "anthropogenic non-traffic" CO emissions are dominating while for shipping, NO_y emissions are dominating. Consequently, these three sectors cause a different response of the atmospheric chemistry and thus also different OH patterns (e.g. Hoor et al., 2009).*
> *Moreover, shipping emissions occur over the ocean where convection is less strong than over the land. This further explains that the contributions of shipping to OH are rather confined to the lower troposphere and do not reach as high into the free troposphere.*
>
> ***Changes to manuscript:***
> *The contributions vary among these categories of surface emissions as not only the amount but also the composition of the emissions differs.*

- P16, L5/6: Please explain how the inclusion of more NMHC reactions leads to the changed pattern. In general, the treatment of NMHCs is not clear to me. Is there one lumped NMHC tracer?

> *In the detailed chemistry scheme (MECCA) species are treated individually. For the tagging scheme they are lumped and the total reaction rate is taken as a sum from the detailed scheme. Hence in the tagging method, NMHC is a chemical family and includes species such HCHO, C_2H_4 and C_3H_8. The rates of reactions including NMHC are calculated by adding up all reaction rates from each single species in the family NMHC. Consequently, a change in the reaction rate also changes OH and HO_2 contributions.*
> *We added these explanations to the manuscript.*
>
> ***Changes to manuscript:***
> *Reactions (21) to (25) involve the chemical family NMHC which contains several species such as formaldehyde (HCHO), ethylene (C_2H_4) and propane (C_3H_8). The rate for reaction (21) is determined by adding up the rates of all reactions of OH with each single species of the family NMHC.*

- P17, L2/3: How do NOy emissions contribution to the category "N2O decomposition"?

Thanks, this was unartfully expressed. Decomposition of N_2O is a source of NO_y in the stratosphere. We have thoroughly rewritten the paragraph.

Changes to manuscript:
Larger values of the categories "N_2O decomposition" and "lightning" to HO_2 in the upper troposphere are explained by a larger HO_2 production in V1.1 compared to V1.0. The H tagging in V1.1 considers all relevant HO_2 sources (reaction (7), (10), (11) and (28)) leading to a larger HO_2 production. Also the addition of reactions (15) and (18) (explanation see above) as well as the addition of reaction (23) which considers more reactions than in V1.0 increase the HO_2 contribution of the categories "N_2O decomposition" and "lightning".

- P19, L16/17: How does the HOx tagging affect stratospheric O3 production? Is it that HOx produced from ozone formed in the stratosphere leads to stratospheric ozone formation/destruction via the catalytic HOx cycles? But how would that fit with the family concept?

Ozone produced in the stratosphere does also influence the concentration of OH and HO2. O_3 reacts with OH and HO_2:
$OH + O_3 \rightarrow HO_2 + O_2$
$HO2 + O_3 \rightarrow OH + 2\ O_2$
As these reactions involve long-lived and short-lived species, they are regarded in the implementation of the tagging method for long-lived as well as in the tagging method for short-lived species.
Consequently, if the contribution of the sector "stratospheric O_3 production" to OH and HO_2 changes, this also affects the contribution to O_3.

- Conclusions: The first paragraph has a lot of redundancy and should be shortened. This holds for several parts of the manuscript. And the second paragraph is more a repetition of the abstract than real conclusions.

We have shortened the first part of the conclusion and added some further concluding thoughts.
We tried to avoid redundancy in the manuscript. However, we find it difficult to spot these redundancies because they also lead the reader through the manuscript. We tried to find a balance between redundancy and information necessary to understand the individual parts. We do not expect the reader to have read the whole manuscript, unlike the reviewer. Hence, a certain redundancy is required.

Changes to manuscript:
Please refer to the Sect. 5 Discussion and Conclusion.

- P21, L24-26: I assume that the local maximum around 5 hPa is a secondary effect via ozone?

Thank you for this comment. The photolysis of HOCl becomes important at around 5 hPa. Omitting this reaction from the tagging mechanism V1.1 leads to higher rest terms which are in turn responsible for the local maximum of HO_2 contributions at 5 hPa.
We added an explanation to the text.

Changes to manuscript:
The categories "biogenic emissions", "lightning", "biomass burning", "anthropogenic non-traffic", "road traffic", "shipping" and "aviation" show a local maximum at around 5 hPa which is caused by omitting the photolysis of HOCl (see Appendix A).

- There is no single reference to the supplement in the manuscript. So why are those additional figures shown at all in the supplement? Honestly, I would prefer to see Fig. 1 and 2 from the supplement in the main paper instead of Fig. 2 – 4. That would make the comparison of V1.0 and V1.1 easier.

> *Thank you, this is a good point. We added references to the supplement. As you recommend, we also replaced Fig. 2-4 in manuscript by Fig. 1 and 2 from the supplement to enable a better comparison of V1.1 and V1.0.*

Technical comments

- Avoid overusing the definite article, e.g. P1, L21: “HOx impacts global warming and local air quality: : :” or P2, L4: “: : :human impact on climate and air quality: : :.”

> *Thank you. Where possible, we tried to avoid the usage of “the”.*

- Caption Table 1, 3: “In the column “tropos.” (“stratos.”) reactions which are : : :.”

> *Changed.*

- P7, L2: Do you mean Sect. 3.3 instead of 3.4?

> *We actually wanted to refer to points 4. and 5. in Sect. 3.4. However, since we have restructured the manuscript, this is obsolete.*

- Eqn. 5: There is a mistake. For a unimolecular reaction, there is no LossBi, rather a ProdBi. And the reaction rate is reduced to R=kA, right? Should be mentioned.

> *Thank you for the correction. We added the adjusted reaction rate.*

- Eqns. 8 and 9: Is it possible that ProdHi and LossHi are swapped?

> *Thank you. We switched the labelling.*

- Eqn. 18: I assume the third term on the right side should read -LHO2 instead of -PHO2

> *Thank you for the correction. We changed it.*

- Eqns. 23 and 24: Why are the rest terms includes in Ai and Bi? Doesn’t that lead to a double-counting of the rest terms in eqn. 17 and 18?

> *Thank you for this correction. This is a mistake. As the rest term are already mentioned in eqs. (17) and (18), they must not be repeated in eq. (23) and (24). We deleted them.*

- P14, L26: “This overall shift: : :”

> *Changed.*

- P21, L22: “large negative minimum” is a rather sloppy expression, please rephrase.

> *We modified the wording.*

Changes to manuscript:
The large OH loss in the lower stratosphere

- Fig. 1: The reddish and pinkish lines are hard to distinguish, at least when printed. And I suggest to change the y-axis to 1.e-14 or 1.e-13 mol/mol/s to be consistent with the numbers given in the text.

We deleted the figure 1 from the manuscript as the basic information is contained in Table 3 where we also included the production and loss rates of H tagging.

- Caption Fig. 1: “(a) and (b) show the rates for the troposphere, : : :”

Changed.

- Caption Fig. 2, 3, 6, A1, A2: “Zonal means : : : are shown.” Simluation -> Simulation

Changed.

- Caption Fig. 4, 5: consisted -> consistent

Changed.

References:

Grewe, V., Tsati, E., Mertens, M., Frömming, C., and Jöckel, P.: Contribution of emissions to concentrations: the TAGGING 1.0 submodel based on the Modular Earth Submodel System (MESSy 2.52), Geosci. Model Dev., 10, 2615-2633, https://doi.org/10.5194/gmd-10-2615-2017, 2017.

Hoor, P., Borken-Kleefeld, J., Caro, D., Dessens, O., Endresen, O., Gauss, M., Grewe, V., Hauglustaine, D., Isaksen, I. S. A., Jöckel, P., Lelieveld, J., Myhre, G., Meijer, E., Olivie, D., Prather, M., Schnadt Poberaj, C., Shine, K. P., Staehelin, J., Tang, Q., van Aardenne, J., van Velthoven, P., and Sausen, R.: The impact of traffic emissions on atmospheric ozone and OH: results from QUANTIFY, Atmos. Chem. Phys., 9, 3113-3136, https://doi.org/10.5194/acp-9-3113-2009, 2009.

Jöckel, P., Tost, H., Pozzer, A., Kunze, M., Kirner, O., Brenninkmeijer, C. A. M., Brinkop, S., Cai, D. S., Dyroff, C., Eckstein, J., Frank, F., Garny, H., Gottschaldt, K.-D., Graf, P., Grewe, V., Kerkweg, A., Kern, B., Matthes, S., Mertens, M., Meul, S., Neumaier, M., Nützel, M., Oberländer-Hayn, S., Ruhnke, R., Runde, T., Sander, R., Scharffe, D., and Zahn, A.: Earth System Chemistry integrated Modelling (ESCiMo) with the Modular Earth Submodel System (MESSy) version 2.51, Geosci. Model Dev., 9, 1153-1200, https://doi.org/10.5194/gmd-9-1153-2016, 2016.