

Authors Response

Dear Mrs Khosrawi,

we would like to thank you very much for the list of technical improvements. Below you find your list with improvements. If the **font** is **green** we applied the improvements as suggested. Please note that this applies to nearly all suggestions with some exceptions mostly related to abbreviations. Please do not hesitate to contact us again, if we misunderstood the suggestions regarding the abbreviations. Our answers are given in *blue below your suggestion*.

Yours sincerely,

Johannes Pletzer

Editor comments on revised version of egusphere-2022-285

Pletzer et al.: The Climate Impact of Hydrogen Powered Hypersonic Transport

P2, L49: I would suggest to write “given by Grewe et al. (2010)” instead of “given in 2010 by Grewe et al.”

P2, L49-50: This sentence is not really helpful. Add the references directly after the given numbers instead of having an additional sentence stating where you get these numbers from. Or if it is better to use two sentences for clarity then add these numbers to the second sentence.

P2, L59: “Polar dehydration within polar stratospheric clouds” sounds quite weird. Write “Polar dehydration caused by the sedimentation of polar stratospheric cloud particles.....”

P3, L73: The “2” should be in subscript.

P3, L76: Same here for NO_x. The x should be in subscript. This should be adjusted throughout the manuscript.

P3, L88: Move “yet” one line up and put it behind “not”, so that it reads “not yet been assessed”.

P3, L88: Move “as well” behind “remains”

P3, L91: add “the” so that it reads “on the impact” and add “atmospheric composition” or “stratospheric composition”.

P3, L92: Move “flying at 30 km” at the end of the sentence and add “altitude” so that it reads “flying at 30 km altitude”.

P4, L95: Add “the” -> “They focus on the sensitivity”

P4, L96: of -> in ? (Not sure which is correct, please check)

Thank you for pointing that out. “for” is the correct choice. Now: “Their estimate for a reduction”

P4, L99: Abbreviation RF has not introduced yet.

The term RF was introduced in line 46. We happily add another introduction, if needed.

P4, L108: Abbreviation “LAPCAT” and “PREPHA-type” has not been introduced. Further, the latter should be written in upright font.

The term LAPCAT was introduced in line 92. We further added the long term for PREPHA, which is “Programme de REcherche et de technologie sur la Propulsion Hypersonique Avancée”

P4, L114: section 4 -> Sect. 4, section 5 -> Sect. 5, section 6 -> Sect. 6 (use the Copernicus style)

P6, L147: Abbreviation MIPAS not introduced.

P6, L148-149: mode -> model? Anyway this is obsolete and should be deleted. Instead of “setup” it should rather read “tool”.

P6, L157: Abbreviation ECHAM not introduced.

The abbreviation was introduced in line

110-111

P6, L159: Abbreviation ECMWF not introduced.

P7, L176: Add “were” so that it reads “chemistry calculations were operated”.

P7, L180: Add “to” so that it reads “and to alter specific humidity”.

P7, L184: Add the link to the MESSy webpage and/or a reference to the latest version of the model.

Added hyperlink to MESSy homepage

P9, L239: Write STS and NAT rather than type I and type II since you are not explaining the different types. Write also what STS and NAT stands for and add the respective compositions.

P9, L240: write “includes sedimentation of the PSC particles and combine with the next sentence and continue with “which affect.....”

P8, L252: Introduce the abbreviation ORCHIDEE and use and an upright font for ORCHIDEE.

ORCHIDEE is now upright. The abbreviation was introduced in line 125.

P9, 259: Add trace gases “long lifetimes of trace gases in the stratosphere”.

P9, L260ff: There are a lot of abbreviation that have not been introduced: IPCC, CMIP6, SSP, RCP CMIP5, SSP3-7.0.

General comment: The model description is quite long. You could consider to shorten it.

Thank you for the proposition. We get your point and would like to keep the full description in the manuscript.

P11, L284: PREHA in upright font.

P12, Figure 2: Increase figure size.

P13, L317: section 5 -> Sect. 5

P14, L329: Abbreviation UTLS has not been introduced.

P15, L336: move the reference of Cohen behind “software”.

P16, L372: Write instead of just sedimentation “sedimentation of particles” or “sedimenting particles”

P16, L373: resolved -> considered?

P18, R1: Use “Eq. 1” instead of “R1” (Thus use the Copernicus style) and use upright font for the chemical reactions.

P19, L416: Two “2” in H₂ should be in subscript.

P19, L418: Same here for the “x” in HO_x

P20, L419: use here the chemical abbreviations since you already have introduced them.

P23, L463: Add “(RF)” after “radiative forcing”.

P23, L465ff and P24, L490ff: units should be written in an upright font.

P25, L524: considerabe -> considerable

P27, L576: Sect. 7.3 title Emission should read Emissions.

P28, L583: add “the” -> than “the” EMAC

P28, L591: Put numbers in subscript.

P28, L595: PREHA in upright font.

P29, L631: Add here the altitude in parenthesis once again.

P29, L631ff: “x” should be in subscript.

P30, L636: in -> at (thus it should read “at lower stratospheric altitudes”.

Appendix.: Consider combining figure A6-A9 to one figure.

We combined Figures A6, A7 and A8, A9 as pairs, since all combined were too large for one page.

Authors Response

Dear Reviewer,

we would like to thank you very much for your second review and your list with minor suggestions. Below you find your text with suggestions below "Referee's comments". We applied most suggestions and our answers are given in *blue below the comments*.

Yours sincerely,

Johannes Pletzer

Referee's comments

General comments

I see that the authors have invested substantial effort in improving the papers taking into account the comments received from all three referees.

Thank you for your kind words.

I still have a few wording clarification suggestions (see below). Should these minor points be addressed I recommend publication of the paper.

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P. 1, l. 13: "leading to an increase in H₂O concentrations." --> increase compared to what?

I suggest two sentences here:

...methane and nitric acid depletion. These processes lead to an increase in H₂O concentrations compared to a case with no emissions from hypersonic aircraft.

P. 1 l. 14: increase --> increase with altitude (correct?)

p.1: l 16: suggest: 8-22%

p.1: l 17: suggest: 78-92%

We applied all of the few wording clarification suggestions. Thank you very much for the propositions

The paper now contains the following text:

New: "The photochemical depletion of H₂O and shift to H₂ concentrations (e.g. Fig. 5.23, p. 312, Brasseur, 2005) clearly has no large effect at these emission altitudes. So instead to the expected removal of emitted H₂O by photochemical depletion, we found a before unknown importance of the reaction rates of the net-recombination of H₂O based on HO_x recombination and an increased methane and nitric acid oxidation. Both models show an increase in H₂O perturbation lifetime and H₂O perturbation at the higher altitude, which is further increased by the net-recombination, i.e. overcompensation of photochemical depletion. Our finding is robust with good agreement between the two models."

First: do you want to be explicit about the mechanisms of H₂O by photochemical depletion? You could add the main chmeical processes or provide a citation.

We added the most important reactions and referenced them in the text.

Second, I am not sure what "net-recombination of H₂O based on HO_x recombination" means. I could imagine that what is meant net production of water vaour based on the (radical recombination) reaction HO₂ + OH and an increased methane (CH₄+OH) and nitric acid oxidation (HNO₃+OH) ...

We restructured the description of the process.

Now: "The photochemical depletion of H₂O and shift to H₂ concentrations (e.g. Fig. 5.23, p. 312, Brasseur, 2005) is clearly not limiting the water vapour perturbation lifetime at these emission altitudes. So instead to the expected removal of emitted H₂O by photochemical depletion, we found a before unknown importance of water vapour recombination for hypersonic emissions. Several reactions including the hydroxyl radical actually overcompensate the photochemical depletion of H₂O perturbations. The overcompensation results in a net-recombination (recombination-depletion > 0), that is driven by HO_x recombination (mainly Eq. 4), an increased methane (Eqs. 5 and 6) and nitric acid oxidation (Eqs. 7 and 8). Both models show an increase in H₂O perturbation lifetime and H₂O perturbation at the higher altitude, which is further increased by the net-recombination. Our finding is robust with good agreement between the two models."

as it stands the text is confusing and I think that adding the actual reactions that are most relevant here helps.

(I think the issue is actually better described and discussed in the abstract)

The following text was added to the paper:

"The middle atmospheric balance of water vapour is determined by methane oxidation, photochemical lifetimes of HO_x compounds and tropical upward transport, which is limited by the coldpoint temperature (LeTexier et al, 1998; Brasseur, 2005; Frank et al, 2018). Polar dehydration by polar stratospheric clouds and the sedimentation of the particles contribute to the balance."

First, it is good that the current papers are cited (Frank et al., 2018; Winterstein & Jöckel, 2021). But I do not understand why/how tropical upward transport is limited by the coldpoint temperature. Isn't it the temperature in the lower stratosphere which is relevant here rather than the temperature at one particular point? Alternatively, do you mean that stratospheric water vapour is influenced strongly by the entry value of water vapour? This entry value is indeed influenced by the cold point temperature. But then another wording/explanation is required (see also the cited papers).

Thank you for pointing that out. We changed our choice of words accordingly (underlined).

Now: "The middle atmospheric balance of water vapour is determined by methane oxidation, photochemical lifetimes of HO_x compounds and upward transport through the tropical upper troposphere lower stratosphere, which is limited by the cold temperatures (LeTexier et al, 1998; Brasseur, 2005; Frank et al, 2018). Polar dehydration by polar stratospheric clouds and the sedimentation of the particles contribute to the balance."

References

Brasseur and Solomon, 2005.

-- you cite two editions of this book in the paper
but I think you need only one citation

Since the last revision our draft should only contain the 2005 version of Brasseur's book. If you would be so kind to explicitly state the line we will correct the citations gladly.

Frank, F., Jöckel, P., Gromov, S., & Dameris, M.: Investigating the yield of H₂O and H₂ from methane oxidation in the stratosphere, Atmospheric Chemistry and Physics, 18, 9955–9973, doi: 10.5194/acp-18-9955-2018, URL <https://www.atmos-chem-phys.net/18/9955/2018/> (2018)

Winterstein, F. & Jöckel, P.: Methane chemistry in a nutshell – the new submodels CH4 (v1.0) and TRSYNC (v1.0) in MESSy (v2.54.0), Geoscientific Model Development, 14, 661–674, doi: 10.5194/gmd-14-661-2021, URL <https://gmd.copernicus.org/articles/14/661/2021/> (2021)