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Comment on acp-2021-969

Anonymous Referee #1

Referee comment on "Tropospheric warming over the northern Indian Ocean caused by South Asian anthropogenic aerosols: possible impact on the upper troposphere and lower stratosphere" by Suvarna Fadnavis et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-969-RC1, 2021

Fadnavis et al. present simulations with the chemistry-climate model ECHAM6-HAMMOZ to investigate the transport pathways and impacts of anthropogenic aerosols during spring. They perform five model simulations, one control run and four sensitivity runs. From their simulation results, they find that the carbonaceous aerosols cause an increase in heating rates and an increase in water vapour.

General comments:

The manuscript is generally well written and structured, but leaves several questions open. For example, the title states “possible implications”. What exactly do you mean with that? The society, the atmosphere or a specific process? This is not answered throughout the paper (or if it is answered the message does not come across).

I have difficulties to understand the connection between the heating rates and the increases in water vapour as well as the connection between aerosols and convection. Both seems to be essential for this study, but the underlying processes are not really explained. Thus, this needs definitely to be elaborated in more detail.

Additionally, I have the feeling that the connections between these specific processes and the according changes in heating and water vapour are overrated. Since the numbers are quite low.

Are the AODs only used for model evaluation? If yes, this could be provided in the supplement. How good are the heating rates, aerosol distributions etc. simulated in the

model? Are the model simulations reliable? Wouldn't it be worth to generally compare the model simulations with observations?

Specific comments:

Title: "possible implications" what do you mean with that? Implications on what? The atmosphere? The society? This is also not at all explained/discussed throughout the paper.

P2, L32 and 35: The numbers alone are not helpful without any further explanations. Are these changes severe or negligible?

P2, L37: Please clarify and state more precisely if these increases in heating are due to heating or due to transport.

P4, L70: Are the here mentioned increases based on observations or model simulations? Please add.

P5, Figure 1: Where is the data shown coming from? Inventory, model simulation or observation?

P6, L115: Add here some references. There are some studies that have investigated the impact of increases in water vapour on the polar stratosphere (e.g. Khosrawi et al., 2016; Thölix et al. 2016; Thölix et al., 2018).

P6, L116: Add some sentences on the structure on the paper and what you are going to do in this paper? Especially since you keep this kind of information quite short in the abstract and introduction it would be worth to give here some more details.

P6, L124: Why seven? Either skip this information or provide more details.

P6, L125: Same here. What does M7 mean? Either skip this information or provide more details on what this module does or is.

P7, L140ff: Here definitely a motivation for your experiments is missing. Why are you

switching of the aerosols? What kind of insights you can get from each simulation experiment?

P9, L170: That you use the satellite data sets for model evaluation should be mentioned already in the beginning of the section.

P9, L182: Is AOD a unitless number? What is the typical range of AOD? What do these numbers tell me? How strong is the over-/underestimation? Something the reader should worry about? I would suggest to add differences in percent so that it is easier to follow if this is a large or small over-/underestimation.

P9, L190: Give more information on the uncertainties of the satellite data. I guess there are validation studies that provide some uncertainty estimations so that you could provide some numbers for errors or biases of the satellite data.

P10, L195: How reliable is the ECHAM6-HAMMOZ simulation? Is the model good enough for the here anticipated study?

P10, Figure 2: The differences between model and observations are quite large. For me it looks like that there are serious problems in deriving AOD correctly in the model. Could provide this figure once again changing the scale of the mode so that it is possible to check if there is a qualitative agreement (thus to see if the model at least gets the AOD generally right).

P12, L249: Why significant? What is the measure for rating a change significant or not significant?

P15, L320: To my opinion it is misleading to talk about convection. I think from the CNDC and ICNC distribution you see where you have clouds.

P15, L327-328: This is not clear at all. How do aerosols induce a circulation? This relationship needs to be better elaborated.

P17, L367: Compared to heating rates in the tropics that reach several K d-1 these changes are quite low. I cannot follow why this should be a severe or significant change in heating rates.

P18, L392: As stated above. This is really difficult to believe since the numbers are so low. It would be worth to give the changes additionally in percent so that is is easier to follow what this means.

P18, L412: Same holds for water vapour. Please add also changes in percent.

P20, L444 and Figure 8: I do not see a connection between aerosols in the LS and water vapour entry into the LS. The entry usually appears where you have overshooting convection. Why have you then such a huge amount of aerosols in the LS, but much less water vapour entering in the LS? Have you taken into account that there are also natural processes for aerosols? Especially sulfate aersols are formed naturally in the UTLS (Brock et al., 1995). What kind of aerosols are left if you switch of all aerosols? The natural ones? Unfortunately, it is not clear what exactly is shown in this figure since it is nowhere clearly stated what you derive when you switch of certain aerosols in your model experiments.

P20, L445: References should be added here.

P21, L464: A correlation of 0.57 is not that good. It seems the correlation is generally higher for the Antarctic than the Arctic. Why?

P21, L464: Only because there is a correlation it does not mean that there is necessarily a connection.

P21, L466: transported □ increase in aerosols?

P21, L467: It not good to cite only the own papers. Here, definitely also some independent studies should be cited.

P22, L489 and 491: References should be given for these statements. Why do South Asian aerosols enhance water vapour globally?

P23, L518-519: For me these increases in heating seem to be not that strong. Is this really a severe change? From where do you got these numbers? From your study or from the literature. A 2% change in cloud cover anomalies seems to be negligible for me, however, the 12% are rather non-negligible. Here, it also needs to be elaborated more when the changes are significant and when not.

P23, L524: What is the process behind that? Give also here a short explanation.

P23, L527: How do aerosols increase evaporation? Can they also have an effect on condensation? If they affect heating I would rather expect a connection to condensation than evaporation.

P23, L531: Until the end it is not really explained why BC or other aerosol increase water vapour.

Technical corrections:

P2, L29: Abbreviation TOA not introduced.

P3, L51: Abbreviation BC not introduced.

P3, L63 and throughout the manuscript: south Asia or South Asia? You should choose one way of writing and use this consequently throughout the manuscript.

P4, L68: Abbreviation OC not introduced.

P4, L76: compared to rest of the Indian region -> compared to "the" rest of the Indian region

P4, L82: below what? Do you mean in the troposphere?

P5, Fig. 1 caption: of year 2016 -> for the year 2016

P5, L105: Based -> based

P5, L110: delete "the" so that it reads "by convection"

P6, L119: Change sentences as follows: “We use the state of the art aerosol-chemistry-climate model ECHAM6-HAMMOZ.”

P6, L127: Instead of just ice-nucleating particles, I would suggest to write (to be more precise) “as kernel for ice-nucleating particles”

P7, L134: replace “the” by “a” ☐ the model simulations are performed with a T63 spectral resolution…..

P7, L137: at a time step ☐ with a time step

P7, L140 and throughout the manuscript: Control is usually abbreviated “CTRL”

P7, L148: 31 December? Since you give for the start date the day, you should do the same for the end date.

P8, L162: add “are used” at the end of the sentence.

P8, L163: add “a” twice ☐ …….measures a radiance…….at a spectral resolution……

P9, L173: add “a” and “of” ☐ at a spatial resolution of 0.5° x 0.5°

P9, L178: add “the” ☐ We evaluate the model performance…….

P9, L188: rephrase sentence as follows: The differences are due to uncertainties in the model transport processes, the emission inventory, and the parameterizations.

P9, L190: add “the” ☐ uncertainties in the satellite measurements

P11, Figure 3: Figure size should be increased, so that the scale is better readable.

P11, Figure 3 caption: during ☐ “for the years” or “for the time period from”…..

P11, L231: in ☐ of

P12, L246: “and at the surface” or “and the surface”

P12, L249: add “the” and “a“ ☐ show that the aerosols have produced a significant cooling

P12, L254: add “an” ☐ an atmospheric warming

P12, L261: add “the” twice ☐ at the TOA (…) and the surface

P13, L267: add “a” ☐ lead to a heating

P13, L269: Analyses of the ☐ The analyses of the

P14, Figure 4 caption: replace twice “during” by “for the years” or “for the time period”

P15, L318: add “from” ☐ from north India

P15, L320: Abbreviations CDNC and ICNC have not been introduced.

P16, Figure 5: Increase figure size.

P17, L383: also North is sometimes written with a capital “N” and sometimes with a “small” n. One way of writing should be used consequently. I would suggest to use small letter (“n”) since this is then to my knowledge according to the Copernicus style.

P18, L409: add “the” ☐ on the water vapor distribution

P18, L417: abortion ☐ absorption

P19, L432: add “the” ☐ over “the” Arabian Sea

P19, L432: add “over” ☐ averaged over

P19, L433: during ☐ “for the years” or “for the time period”

P20, L448: it ☐ This figure

P20, L449: add “the” ☐ during spring and the monsoon seasons

P20, L458: averaged ☐ averages, further average appears here twice. One obsolete?

P21, Figure 21: add “in the” ☐ “in the UTLS”

References:

Brock, C. A., Hamill, P., Wilson, J. C., Jonsson, H. H., and Chan, K. R.: Particle formation in the upper tropical troposphere: A source of nuclei for the stratospheric aerosol, Science, 270, 1650–1653, 1995.

Khosrawi, F., Urban, J., Lossow, S., Stiller, G., Weigel, K., Braesicke, P., Pitts, M. C., Rozanov, A., Burrows, J. P., and Murtagh, D.: Sensitivity of polar stratospheric cloud formation to changes in water vapour and temperature, Atmos. Chem. Phys., 16, 101–121, https://doi.org/10.5194/acp-16-101-2016, 2016.

Thölix, L., Backman, L., Kivi, R., and Karpechko, A. Yu.: Variability of water vapour in the Arctic stratosphere, Atmos. Chem. Phys., 16, 4307–4321, https://doi.org/10.5194/acp-16-4307-2016, 2016.

Thölix, L., Karpechko, A., Backman, L., and Kivi, R.: Linking uncertainty in simulated

Arctic ozone loss to uncertainties in modelled tropical stratospheric water vapour, Atmos. Chem. Phys., 18, 15047–15067, https://doi.org/10.5194/acp-18-15047-2018, 2018.