Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2021-862, valuable contribution but some inconsistencies

Anonymous Referee #1

Referee comment on "Important role of stratospheric injection height for the distribution and radiative forcing of smoke aerosol from the 2019–2020 Australian wildfires" by Bernd Heinold et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-862-RC1, 2021

The paper presents simulations with an aerosol climate model on forest fire smoke in the stratosphere using lidar observations and the satellite based GFAS inventory. It includes several sensitivity studies on injection height since a pyro-Cb module is still not available in the global model community. The paper demonstrates the importance of wild fires for stratospheric radiative properties and is suitable for ACP after revision since it might be a valuable contribution to a hot topic in atmospheric research.

Major comments

At several places clarificatios are needed, including missing definitions of acronyms.
Figure 7 shows large discrepancies between model results and CALIOP satellite observations concerning the vertical distribution of aerosol extinction. The figure poorly displays the lower stratosphere as the region of interest because of selection of an unphysical linear pressure coordinate. Here log(p) or altitude should be used as in the other figures. As it is, the figure gives the impression that aerosol extinction calculated by the model is severely overestimated almost everywhere, despite averaging, in contrast to the text. The difference is larger than the value mentioned in section 2.3. There appears to be something inconsistent to the results presented in the other parts of section 3.1. It might be worth, to exclude the tropics here and/or look also for other satellite data. For example, OSIRIS sees extinction peaks at 12 and 18km for January to March 2020 averaged over the southern hemisphere.
Figure 8 would be better with satellite observations for AOT included. There are datasets of several instruments available. At least refer to Fig.1 here and use similar color bars with the same units. It looks like that the model overestimates the perturbation at Antarctica. Concerning uncertainties it should be also taken into account that in 2019 the stratosphere was perturbed by volcanic eruptions.

Specific comments

Page 1, line 19: Is the amount of injected smoke from this study or from the literature?
Page 1, line 31: Also the global value should be provided in parentheses.

Page 1, line 32: Provide also the value for all-sky.
Page 2, Figure 1 and line 10ff: Here only Fig 1a is mentioned, part 1b is mentioned first on Page 6. More text is needed or the figure should be split. A definition for AOT is missing, including spellout and altitude range (Page 6 is too late). Why does AOT anomaly in Figure 1 differ from the one in Figure 8 by about a factor of 10?
Page 4, line 5: Why interpolation? The model output should be available at the time and the location of the measurements. Don't rely here on averages, especially not if the meteorology of the model is nudged to observations.
Page 4, line 31: Vertical or horizontal resolution?
Page 4, line 36: Here something is missing. Which aerosol type? Which time? Model results need boundary conditions and cannot be a reference for observations.
Page 5, line 12: Mention tropopause region and reason (Pyro-Cb) already here. Also it should be mentioned how many teragrams of smoke (carbon) were injected in each of the 4 events to enable comparisons with the values of other papers mentioned in the introduction (or the abstract?). More details on the relations betweeen GFAS and estimated injected OC (organic carbon) and BC (black carbon) should be included (here or in an Appendix).
Page 5, line 14: The 47 level version does not have a QBO and has problems with the "H_2O tape recorder", i.e. the vertical transport. It is better to use L90. This should be mentioned as a possible reason for discrepancies. Is nudging applied everywhere (may cause numerical problems) or only in the troposphere and lowermost stratosphere?
Page 6, line 2 or 4: Does this refer to the 8% mentioned on the previous page or in BASE?
Page 6, line 9ff: This paragraph might be better moved to the introduction. Fig. 1b is inconsistent to Fig. 2, please explain why. Or is this just a problem with the range of the colors in the figures?
Page 7, Figure 2 and line 11: Are these values out of the range of the color bar? Please adjust the color bar to accomodate this.
Page 8, line 17: This scenario should be also in section 2.4.1, maybe in parentheses. Or refer at least to Table 1.
Page 9, line 1ff: Caption too short, spell out RMS, normalized against what average(s)?
Figures 4 and 5: Standard units for extinction are "km^{-1}", please convert axes, also to be consistent with Figure 7. I suppose the authors mean 10^6m with Mm.
Figure 5: Please adjust the heights of the panels. It would be also nice to have additional panels with consistent palettes where the lidar ratio is applied for conversion.
Page 11, line 8: Add "(with interaction between radiation and dynamics)"
Page 11, line 11ff and Figure 7: As shown, the agreement is poor (not "well"). The figure has to be improved as mentioned above and more explanation is needed. The disagreement cannot be explained by sampling issues alone (section 2.3). These results are in a strong contrast to Figure 4 where the model at least follows the observed vertical patterns.
Page 12, line 7 and later: Taking the difference of radiative fluxes from 2 simulations is not exactly "instantaneous radiative forcing" since convection or other non-radiative processes might be different. It is, however, an estimate.
Page 12, line 22: Is this number local or some kind of average?
Page 13, line 9: The particle SSA depends strongly on the partitioning between BC and OC. More information on this would be useful here, at least some typical number of the ratio with a range.
Page 13, line 14: This is in contradiction to the large high bias in Figure 7.

Technical corrections
Page 16, line 19: Check abbreviation for journal.
Page 18, line 14: Please separate the 2 references.
Page 19, line 5: Check abbreviation for journal.