

Response to Referee 1 :

My main concerns with the current presentation of the manuscript is that the numbered variable (SR_0, 1, etc) names make reading and following the text very difficult, especially in legends and captions. I would strongly suggest that these are renamed to something more easily understandable such as SR_noclouds, SR_detectable, etc. both in the paper and in the code (if applicable).

To improve the readability, the names of the variables have been changed in the text and in the legends of the figures. As the change is difficult to perform in the code, we kept the initial variable names in the code but we added in the paper a table that shows the correspondence between the names of the variables in the text and in the code (Table 1).

My second main concern is that I can't find this code contribution in the COSPv2 codebase linked to in the manuscript. Has this been merged into the code? I would appreciate visibility of the code (the specific files / commit) in order to provide a more detailed review.

Yes, now the code can be found on Zenodo : DOI 10.5281/zenodo.7418199. It will be incorporated in the COSPv2 infrastructure at <https://github.com/CFMIP/COSPv2.0> if the paper is accepted.

We changed the statement on the code availability :

the aerosol lidar simulator presented in this paper is available at <https://doi.org/10.5281/zenodo.7418199> and is incorporated in the COSPv2 infrastructure at <https://github.com/CFMIP/COSPv2.0>.

The only major scientific comment I have is that I seem to remember the CALIOP aerosol detection threshold depends on the presence of cloud. I.e., if there is thin attenuating cloud aloft, or a thick layer of low cloud this would change the detection threshold. As far as I can see this isn't accounted for, which is understandable since it may not be easy to quantify (and models won't suffer from it), but it should be mentioned as a possible source of discrepancy in the combined EXT_3 variable.

The CALIOP aerosol detection threshold indeed depends on the presence of cloud in level 2 NASA data. In this study we use 1.5 level NASA data, in which no aerosol is detected below clouds. Thus the method of comparison is robust in this respect.

While generally well written and structured the introduction is missing some citations and a bit more context (detailed below). Also, the discussion section contains results on the effect of cloud screening, on page 18 through to line 18 on page 21, which should please be moved to the results section (or in an Appendix).

We slightly changed the plan by adding a subsection 4.3 in the Section 4 (Results) : 4.3 Validity of the comparison between CALIOP data and simulator outputs. In this subsection we discuss the effects of cloud screening with different (modeled and observed) clouds. This leads to the conclusion that the differences between observed and simulated SR values are directly attributable to the aerosol representation in the model. In the Section 5 (Discussion) we focus on the potential errors in aerosol modeling.

Minor comments

- *P2L24-25: Please rephrase, perhaps you mean ‘variety of aerosol research questions’.*

Done

- *P2L24-25: Please provide citations rather than a URL.*

We provided two citations rather than the URL : Tian et al., 2017; Ratnam et al., 2021

- *P2L31-35: Citation needed*

Citations have been added : Konsta et a. 2016, Chepfer et al. 2018.

- *P2L35-37: Citation needed*

A citation has been added : Ma et al. 2018

- *P3L6-8: Citation needed*

A citation has been added : Kim et al. 2007.

- *P3L8: This doesn't make sense and needs rephrasing*

We rephrased this sentence as :

Indeed, while the transport by large-scale circulation determines the geographical patterns of aerosol forcing, this aerosol forcing also impacts large-scale circulation. These mechanisms can be studied by making use of aerosol optical depths (AOD) retrieved by MODerate resolution Imaging Spectroradiometer (MODIS) or VIisible Infrared Imaging Radiometer Suite (VIIRS).

- *P3L17: Add a full stop after ‘model’ to break up this long sentence?*

We cut the long sentence by adding a point after : detector.

...to the detector. The calculations also account for the molecular backscatter (i.e. Rayleigh backscatter), calculated from the model's air temperature and pressure profiles.

- *P3L36: “(from the cloud lidar simulator but not only)” -> (from not only the cloud lidar simulator)*

Done

- *P4 Figure 1 caption: Everything after the first sentence should be in the main text rather than the caption.*

Done

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- *P4L18: Please provide citations for the Rayleigh scattering expressions*

Done : Stromatas et al. 2012

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- *P5L19: ‘simple’ -> ‘single’*

Indeed! Done

- *P5L29: Is this every radiation timestep or every model timestep? Please clarify*

We changed ”The process applies to each radiation timestep” to “The process applies to each instantaneous model output. In this study, the model writes out at 1:30 am and 1:30 pm local time, corresponding to the CALIPSO overpass time.”

- P5L42: Does this interpolation also work for models on pressure levels

Yes.

- P7L20: Please place the Figure 1 caption text here.

Done

- P7L24: 'model+aerosol' -> model and aerosol

Done

- P7L43: Citation
- The citation Ma et al. (2018) was added.

- P9L4-5: Setting the SR=1 is equivalent to setting the aerosol backscatter to zero which may be a reasonable assumption but should be done carefully – particularly when averaging over large regions of tenuous aerosol (see e.g., Watson-Parris et al. 2018). Please make this assumption explicit in the text.

We have changed the text to “We also applied an SR threshold that assume SR=1 when SR is lower than 1.2, which essentially removes the aerosol backscatter signal. While this procedure removes the noise, it can also removes the signal from tenuous aerosol layer (e.g., Watson-Parris et al. 2018).

- In addition to using more descriptive variable names (especially in figure titles), please also use the full model name in the figure legends (e.g. Fig. 10)

Done

- P22L17: -> ...modes has been used interactively for almost two decades...

Done

- P23L16: As a co-author, presumably Nick doesn't need to be acknowledged ï
Yes! Done

Response to Referee 2 :

Major comments

I can't find the aerosol-related additions to COSP on git nor on zenodo. Could the authors be more specific about which routines have changed, perhaps even going as far as providing a diff file?

The word 'aerosol' is effectively already plural, as it refers to the population of particles and not a single particle. Thus 'aerosols' is unnecessary. I suggest correcting throughout the manuscript, but at the same time acknowledge that 'aerosols' is becoming widespread.

Done : we replaced “aerosols” by “aerosol” everywhere in the text.

Readability in many places could be significantly improved with some editing. Many sentences are quite awkward to read and follow.

We hope that the sentences that have been pointed out by Referee 1 and reformulated improve the readability of the text. We also changed sentences in many other places in the text (highlighted in red), mostly in the abstract and in the first three sections, but also in other parts.

Minor comments

Abstract, line 4: The clause ‘and because it has an impact on aerosol-cloud interactions’ seems to be out of place. The sentence in its entirety is hard to follow.

This has been reformulated :

A key variability is in their vertical distribution, because it influences atmospheric heating profiles, aerosol-cloud interactions, aerosols life-time and, as a result, surface concentrations.

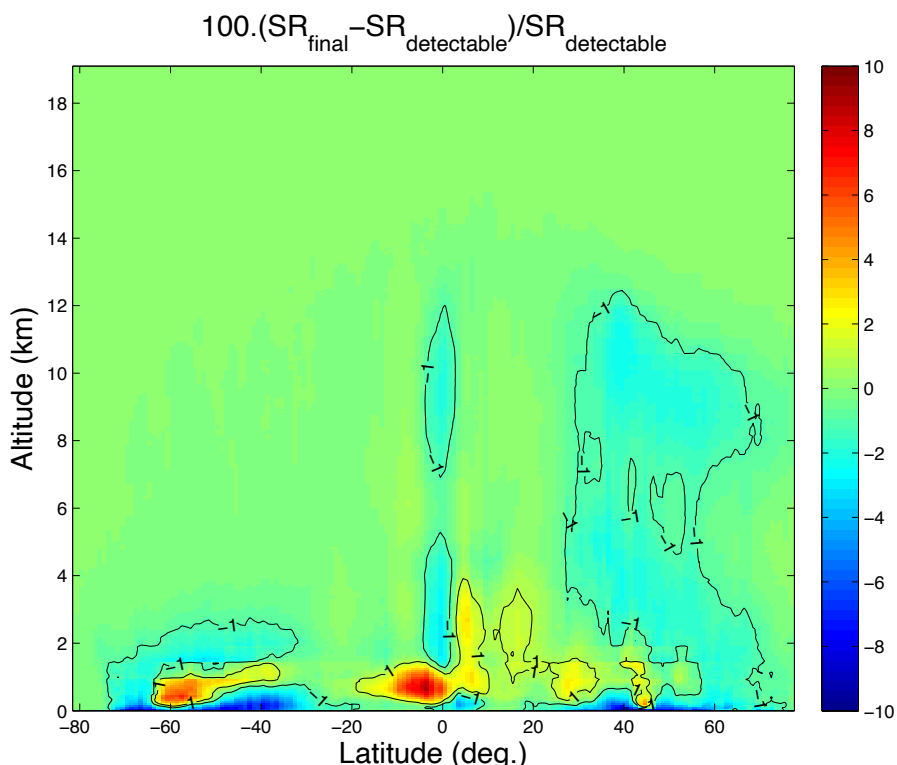
Abstract, sentence starting on line 12: ‘It applies...’, please clarify what ‘it’ is.

Done :

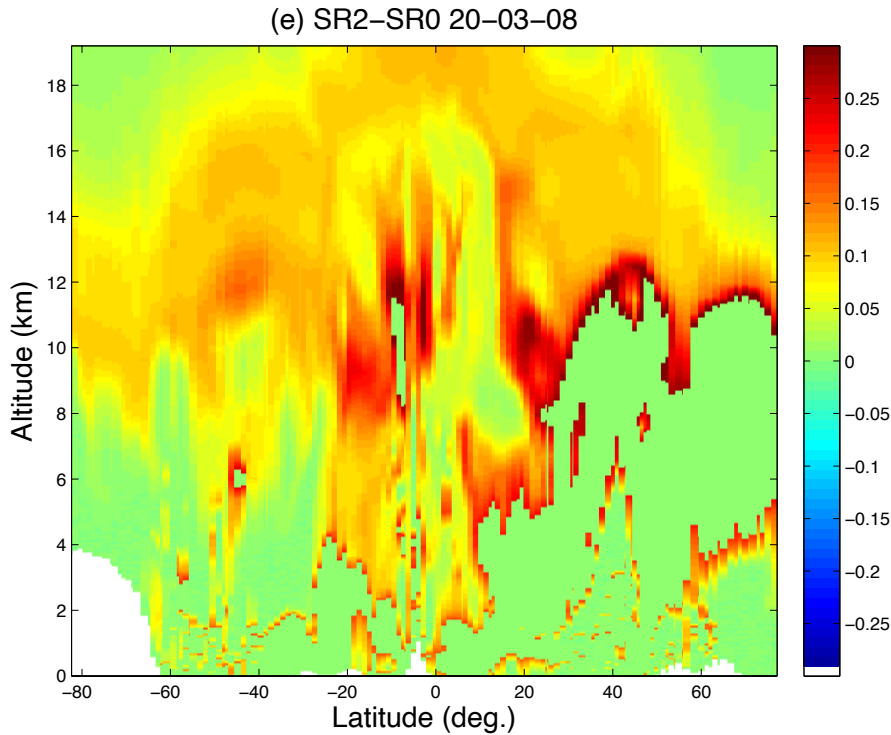
The simulator applies a cloud masking and an aerosol detection threshold, to get the ATB and SR profiles that would be observed above clouds by CALIOP with its actual aerosol detection capability.

Abstract, line 15: ‘discrepancy in the Southern Hemisphere’. Is it possible to be more specific? The Southern Hemisphere is half the globe. Perhaps Southern Ocean is what is being referred to?

Yes indeed ; the change has been made.



New Figure 11



Caption

Page 2, line 5: not all greenhouse gases are long-lived, e.g. ozone. Suggest adding 'long-lived' before greenhouse gases

Done.

Several of the Figures comparing SR0, SR1 etc: It might be easier for the reader to interpret the plots if they were presented as difference plots, e.g. difference to SR0. As presented, the reader finds themselves looking for subtle changes in color in order to derive value from a figure. Additionally the chosen color palette would present difficulties for anyone with color blindness.

Please note that differences between observations and simulations or between different simulated fields are given in Figures 6, 9 and 11. For Figures 4 and 5 : we believe that the message gets through better if we present the SR_initial, SR_detectable etc. figures rather than their differences. An example of the SR_detectable-SR_initial difference field is given above, and we find it quite difficult to interpret.

The two figures that can present the most difficulties to colorblind people are Figure 6 and Figure 11. We added contours (-1% and 1%) on Figure 11 to be more colorblind friendly. For Figure 6, the noise in the Figure makes us difficult to add contours. We hope that the sharper contrast between light green and dark blue and red improves the visibility.