Radiative impact of thin cirrus clouds in the extratropical lowermost stratosphere and tropopause region egusphere-2023-1234

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1 General remark

We like to thank Blaž Gasparini for reviewing the revised version and for his valuable comments and suggestions which finally improved the manuscript and especially the presentation of the scientific context of the study.

2 Point-by-point reply to the review of the revised version by Blaž Gasparini:

- 1. UTC and climate models

  Abstract: *We followed the reviewer suggestion and replaced the term 'considered' with 'evaluated´ on both criticised text passages.*

  Conclusions: *We followed here the suggestion to delete the following passage:* '... which is so far not included in climate models.'

- 2. Other impacts of UTC

  Discussion: *we followed again the suggestion of the reviewer by adding a short paragraph on the potential influence of ultra thin cirrus on circulation patterns in the discussion section under the new item 4.4.*

  4.4 Possible impact on circulation patterns

  Such optically thin clouds, like those reported above, may be important for the radiation budget of the upper troposphere and lower stratosphere and thus for modifying the mean tropopause temperature. They may thus indirectly control the amount of water vapour entering the stratosphere and influence circulation pattern. Radiative vertical flux profiles could be converted to heating rates (e.g.

Kato et al., 2019), and a large cloud heating rate was shown to strongly modulate circulation patterns (e.g. Voigt et al., 2021; Gasparini et al., 2023). This activity could be the topic of follow-up work of the present study.

Minor points

- 1. Line 12: I suggest mentioning that you extrapolated the results to winter months from your summer results (instead of "in a more limited way")

  we changed the sentence:

  Using sensitivity simulations with different ice effective particle size and shape, we provide an estimate for the uncertainty of the radiative effect of ultra thin cirrus in the extratropical lowermost stratosphere and tropopause region during summer and – by extrapolation of the summer results – for winter.

- 2. Introduction: *We added Sherwood et al. (2020) as suggested.*

- 3. Line 37-39: The text flow is broken at the sentence starting with "Luo et al. (2003)..." and could be fixed.

  We corrected the sentences like presented here:

  The dehydration potential of UTTCs in the tropics was shown by Luo et al. (2003). Cirrus clouds in the tropopause region may have a general and significant imprint on the water vapour amount in the stratosphere, and consequently via radiation effects of the stratospheric water vapour on the surface temperature (Riese et al., 2012).

- 4. Introduction part related to measurements of thin cirrus: the authors could mention a just published ACPD manuscript that also focuses on cirrus, too thin to be detected by CALIPSO (Lesigne et al., 2023).

  We skipped this suggestion, because we don't like to overemphasize in the introduction the difficulties of CALIOP with ultra this cirrus detection.

- 5. Line 106: Avery et al., 2012 is a more appropriate reference for CALIOP.

  We replaced the reference.

- 6. Figure 4: What exactly are the "ALL" lines representing? I don't see that mentioned in text/caption.

  We explained this now in more detail in the caption of Figure 4:

  ... separation in cloud thickness Δz =0.5 km and Δz =2 km in blue and red for spherical/hexagonal/spherical (a-c) (the total of Δz =0.5 and 2.0 km is highlighted in black and labeled with ALL) ...

- 7. The newly written sentence is unclear: A (shortened, but simplified) suggestion you could consider: 'The exact position of the cloud along the limb path (line of sight) remains unknown in limb measurements and is not retrievable.'

  We replaced the sentence with exactly this suggestion.

References

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