Reply to the comments of reviewer 3 on the manuscript

Radiative transfer simulations and observations of infrared spectra in the presence of polar stratospheric clouds: Detection and discrimination of cloud types

by C.Kalicinsky et al.

We thank the reviewer for the helpful comments and recommendations. In the following, we discuss the issues addressed by the reviewers and explain our opinions and the modifications of our manuscript.
We enumerate the comments and repeat them in bold face. The modifications of the manuscript are displayed in the marked-up manuscript version as colored text. Deleted parts are shown in red and new or modified text parts in blue.

1 Comments

This paper demonstrates the clear capability of infrared FTS limb sounders to provide detection, discrimination of particle types and particle sizing in polar stratospheric clouds and is an advance on the current state of the art. The paper is acceptable for publication following some minor corrections.
General comments:

1. **I strongly suggest that an attempt is made to make an additional plot that shows the optical depth vs CI for some samples of different PSC cloud types. Likewise the CI vertical gradient is related to the optical thickness gradient.**
   Unfortunately, there is no clear relationship between the optical depth and the CI. Different parameters can influence the CI that leads to different values although the optical depth is the same.
   Spang et al. (2008) already showed that the CI depends on the altitude and that additionally the background atmosphere (e.g. polar winter vs. tropics) can have a large influence. Griessbach et al. (2014) showed that the observed radiance, and thus the CI, also depends on the radius of the particles. In Griessbach et al. (2020) the authors showed that there is some correlation between CI and extinction for ice and volcanic aerosol but a distinct relationship could not be determined. CIs of large particles (r > 5 μm) are more related / show a quite good correlation with the integrated surface area densities along the line of sight or for ice with the ice water path divided by effective radius (Spang et al. (2012, 2015)). We also did some studies with the new simulations and found similar results. Furthermore, the particle type also plays a role as the spectral slope of the extinction is different for the different particle types. Thus, the radiance enhancement in the regions used for the CI can be different although the total extinction and thus the optical depth are the same. As a consequence the CI values can only be related to an optical depth when all influencing parameters (altitude and thickness of cloud, particle type and radius, background atmosphere) are known, which is typically not the case. Therefore, we cannot give numbers in this direction in the paper as there are too many unknowns.

Specific comments and typos

1. **Page 2 L35: "incomplete" rather than "difficult"?**
   changed the term

2. **L37-38: [An] infrared .... build[s]...**
   done

3. **L39: sounder[s]**
   done

4. **L44-45: make distinction between CO2 molecular line emssion and broader continuum like aerosol emission?**
   we rephrased the sentence

5. **L51: color => colour**
   done

6. **Page 3 L64-65: Maybe make clearer that for an airborne instrument the limb tangent moves away from the aircraft for downward looking views.**
   we added information

7. **L72: What about changes with the aspect ration of the particles?**
   We added information that it also depends on shape and radiation scattered from below. See Reviewer 1.

8. **L86: itselves => themselves**
   done

9. **Page 4 L87: JURASSIC is not defined until L106**
   we added the definition

10. **L110: PREMIER IRLS is not defined**
    we added the definition

11. **L111: spectral/ly/**
    done

12. **L115: KOPRA is not defined**
    done

13. **Page 5 L130: What about spectral regions for STS and background binary sulfate aerosols?**
    As STS and the background binary sulfate aerosol have no distinct spectral features like a peak nor a clear slope of the extinction such as ice, there are no special regions for STS and the background aerosol.

14. **L133: al[t]itude**
    done

15. **L139: reference to a rejected ACPD paper?**
    The paper has not been rejected, but the reply to the reviewer comments and the upload of a revised manuscript have not been done. However, it is the best paper describing the atmosphere and it has been cited far more than 100 times.

16. **Page 6 L177: median radius varied in steps of?**
For small particles it has been varied in steps of 0.5 μm, then in steps of 1 μm, and at the end there is one step of 2 μm. Because of the different step sizes all used radii are summarised in Tab. 3.

17. **Page 8 L215: imaginary part/s/**
done

18. **L234-249 and everywhere else including figure captions and tables: Is it possible to give all these spectral regions a distinct short name? e.g. R1, R2, R3 etc Otherwise the reader has to scan the characters and check to see which regions are the same thing rather than seeing that immediately from the short name.**
We added a table for all indices and we marked the regions in Fig. 1 (see Reviewer 2). Additionally, we numbered the micro windows (MW) from 1 to 7 and added the short names like MW1 at the corresponding text positions.

19. **Page 9 L257: an[d]**
done

20. **Page 10 L312: less => fewer**
done

21. **Page 11 L335: mille => thousand**
done

22. **Page 13 L408: extend => extent**
done

23. **Page 15 L463: called [a] hockey-stick**
done

24. **Page 16 L494: What are the detection levels of the new method compared to the old method? e.g. in terms of the minimum volume density um3/cm3.**
The detection level for the small particles is the same as for the old method, as they are detected with the same method. The improvement of our method is that the detection is expanded to larger NAT particle sizes that are not detectable with the old method.

25. **L501: "minimisation" means "reduction"?**
yes, we changed this

26. **L507: "safely" means "always"?**
we removed safely

27. **Figures 3, 6 and 7: Can an approximate optical depth scale be put on the x-axis?**
Unfortunately, there is no distinctive relationship between optical depth and CI (see General comments).

28. **Figure 8: What are the actual optical depths corresponding to these CI values?**

Unfortunately, there is no clear relationship between optical depth and CI (see General comments). As clouds with many different parameters enter this plot, the answer cannot be given.