AMTD, 2, 379-438, 2009
Reply to the referee # 4
Cloud sensitivity studies for stratospheric and lower mesospheric ozone profile retrievals from measurements of limb scattered solar radiation

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June 18, 2009

1 General comment

This paper addresses an area of research relevant to Atmospheric Chemistry and Physics Discussions, namely the ozone retrieval error caused by failure to include radiative transfer in cloudy atmospheres realistically in limb scattering retrievals. This topic has not been explored in depth, so the work described is timely. Useful suggestions for a simple correction that does not require full modeling of the cloudy atmosphere are also included. The set of simulations is sufficient to draw meaningful conclusions, and is described carefully to permit the reader to understand the results. The paper is structured well and clearly written. References, figures and tables are sufficient to support the text.

2 Specific comment

Abstract It would be helpful to mention here that the clouds in this study are spherical shell clouds that vary only with height. The lack of horizontal variations may be an important limitation on the applicability of the conclusions to real limb scattered data.
Author: That's a good suggestion, and we now mention this in the abstract already.

Sect. 2, last paragraph: How has the performance of the SCIATRAN model in simulating in-cloud radiative transfer been tested? Several references are given to cite various tests of the SCIATRAN package, but all of them appear to be clear-sky comparisons. I can find no evidence of any comparison that includes radiances within a cloudy atmosphere. The usefulness of this study rests entirely upon the assumption that SCIATRAN accurately computes the radiance in the model atmosphere for both clear and cloudy conditions, so I am uncomfortable with the lack of documentation presented in the literature for the latter case. I doubt that simulating the radiance for each direction as it leaves the cloud with high accuracy is crucial for this study, but a numerical estimate of the SCIATRAN accuracy in simulating the radiation field at the cloud/atmosphere boundary would be useful.
Author: The corresponding reference (Kurosu et al., 1997) is added in the text.

Sect. 8.4, first paragraph: The analysis in this section is incomplete. It seems unreasonable that a perfect estimate of the ground albedo could be obtained for a limb scattering retrieval despite

the presence of a cloud layer. A few calculations to quantify the impact of an imperfect estimate of the ground albedo under various conditions would complete this section nicely.
Author: This is another very good suggestion. We performed several new case studies with different surface albedo values in the (cloudy) forward simulations and the (cloud-free) retrievals. We added 2 new Figures (11 a and b) showing the retrievals errors for a) different albedo values in the forward simulation, but a fixed albedo for the retrievals, and b) the other way around. A new paragraph describing the results has been added to section 8.4.

Appendix A: The Chappuis triplet (as its usually formulated, including in this manuscript) uses two kinds of normalization to limit sensitivity of the measurement vector to factors other than ozone: Tangent height normalization for measurements at each wavelength, followed by grouping the wavelengths into the triplet. In the analysis presented (see Figs. 1-3), the sensitivity of the absolute radiance to clouds is compared to the sensitivity of the Chappuis triplet. A reader who is pondering alternative approaches might be interested to see how much of the reduced sensitivity of the Chappuis triplet arises from the tangent height normalization and how much arises from the wavelength grouping. That analysis might fit comfortably into the Appendix.
Author: We agree with the reviewer, and the corresponding plots for the normalized limb radiance profile at the center wavelength have been added to Figs. 1 - 3. A similar point was also raised by reviewer 2.