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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical Note: Cloud and aerosol effects on rotational Raman scattering: Measurement comparisons and sensitivity studies" *by* A. Kylling et al.

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Response to interactive comment from Referee #2

General comments:

1: The Introduction has been reworked to justify the need for radiative transfer models that include RRS. Section 2 covering the present radiative transfer model, has been reworked and more details have been provided.

2: The revised manuscript has been reorganized.

3: The use of references and the choice of references have been improved.

4: The number of streams used in the calculations was 16. This information is now included in the paper and the equations with $j = \pm 1$ have been corrected to $j = \pm N$.

5: All simulations in the first manuscript were made with the delta-M method. For the revised manuscript all simulations have been repeated with an improved version of the Nakajima et al. (1988) correction method. This improved method has recently been published by Buras et al (2011). These changes are included in the revised manuscript.

6: In the revised manuscript the solution of the RTE has been described in more detail, including the question of degeneration of the substitution method. Please see revised manuscript.

7: For the revised manuscript we have adopted the revised Kurucz solar spectrum, please see the revised manuscript for details. The spectral resolution of the simulations have been outlined in the revised manuscript.

8: In the revised manuscript absorption by ozone has been included and the albedo has been assumed to be constant with wavelength. The aerosol information was taken from independent measurements and no "tuning" was applied. The

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differences when ratioing measurements and model results, Figs. 1b and 2b in the original manuscript, are most likely due to innaccuracies in spectral response functions and wavelength registration. The accuracy of the model results depends on the quality of the extra-terrestrial spectrum that is used. Differences between extra-terrestrial spectra may be larger then the differences seen in Figs. 1b and 2b in the original manuscript, see for example Fig. 2 Skupin et al (2005). The RRS spectral signal is calculated from relative comparisons. As such we have omitted Figs. 1b and 2b from the revised manuscript. The labeling in Figs. 1b in the original manuscript was correct. It is important to notice that the irradiance includes both the direct and the diffuse down-welling radiation. For the cloudless sky the direct radiation, which is not Raman shifted, dominates the signal. The filling-in for the diffuse-downwelling component only is of course larger for the cloudless sky than for the overcast cloud. This issue has been addressed in the manuscript. Undersampling is not an issue as the measurements are oversampled.

9: The inconsistencies between the results in Figs. 4 and 5 in the original manuscript was due to a problem with the Fortran version of the radiative transfer equation solver that was used. For the revised manuscrip a new implementation of the solver in the C computer language has been used. This has resolved the inconsistencies and the results are now in agreement with earlier published works.

10: These issues has been resolved as explained in previous points.

11: The irradiance has been properly defined in the revised manuscript. Figs. 3 and 9 in the original manuscript have been removed.

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Particular comments:

Abstract: References have been removed from the abstract.

22516, L10: The mentioned changes have been made and the ackronym RRS has been introduced and used throughout the paper.

22516, L18: "gase" changed to "gas". Relevant references have been added.

22516,L21: Relevant references have been added.

22516, L22: Since the manuscript is a scientific text and not poetry, "numerous" has been changed to "many".

22517,L4-L5: Sentence has been removed.

22517,L6: "and aerosols" has been added as suggested.

22517,L11-L12: Sentence changed as suggested.

22517,L20-L21: The sentence has been rephrased. Landgraf et al. (2004) state in their summary "this effect is of minor importance for most applications". They do recommend full comprehensive vector radiative transfer simulations for the retrieval of cloud properties from GOME radiance measurements of the filling-in of the Ca II lines.

22517,L22: Sentence removed.

22517,L26: The sentence has been rephrased and numbers provided. The solution methods used by Vountas et al (1998) and Landgraf et al. (2004) are mentioned where appropriate.

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Section 2, general comments The appendix has been moved to section 2 and the description of the RTE and the solution of it has been extended and improved as suggested. The non-physical nature of the "Raman loss" terms have been noted in the revised manuscript.

22518,L22: "Similar" changed to "similarly". Other suggested change also made.

22518,L23: "specie" changed to "species"

22519,L11: "wavelength" changed to "wavelengths"

22519,L12: The section describing the RTE and solution of it has been extended and the Appendix has been moved to this section. Information about how the phase function is handled has been added.

22520,L1-L2: Absorption by O_3 has been included in the calculations presented in the revised manuscript. The text has been changed accordingly.

22520,L3: The sentence has been removed and the paragraph rewritten.

22520,L9: It has been added to text that Eq. (4) applies to radiances as well. We did not calculate DOD from radiances, but, yes, Eq. (5) also apply to radiances.

22521,L5: Our clear sky reference spectrum was recorded during this cloudless period. We find this information to be of importance and prefer to keep the sentence. The sentence has, however, been slightly rephrased.

22521,L17: The direct sun measurements were made by the same instrument. This information has been added to the text.

22522,L6-L9: The aerosol information was derived from direct sun measurements made with the same instrument. This has been clarified in the text. The aerosol information is of importance when doing absolute comparisons between model and measurements, Fig. 2a.

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22522,L23: Change made as suggested.

22522,L24: Change made as suggested.

Section 3: "Heyney" has been correected to "Henyey" throughout the manuscript.

22524,L17: Sentence rephrased as suggested.

22524,L20: "exact" removed as suggested.

22524: The phrase "so-called" has been removed.

22524,L29: The label has been corrected.

22527,L2: Sentence cut as suggested.

22527,L20: Please see answer to note 9.

22528,L11: "as a reflecting surface" changed to "as reflecting surfaces".

22528,L14: References that include OMI results have been added.

22528,L17: Sentence removed as suggested.

22529,L7-11: The sentence starting with "Differences may be attributed. . . " has been removed.

22529,L26: Text changed as suggested. The location of the cloud is indeed between 2 and 3 km. This has been corrected. The definition of the solar principal plane has been included.

22530,L27: "measurements" changed to "retrieval" as suggested.

22531,L9-10: Sentence removed as suggested.

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22531,L13: “As such” changed to “In this context” as suggested.

22531,L19-20: Changes in wording made as suggested.

22532,L12: Sentence changed as suggested.

22532,L16: The Conclusions have been rewritten. The mentioned bullets have been removed.

22532,L19: “levels” changed to “level”.

22523,L22-22534L2: Three sentences have been removed as suggested.

22535,L8: More information has been added on RR spectroscopy.

22535,L12-13: The phase function expansion coefficients have been explained in the revised manuscript.

22535,L15: “The transmission” has been changed to “The solar beam transmission”.

Figures in general: Where appropriate more information has been added in the captions about solar zenith angles etc.

22543,Fig 2: “in” inserted between “shown” and “black”.

22543,Fig 5: “Lambert” changed to “Lambertian” and the value of the albedo has been mentioned.

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