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Interactive comment on "Determination of aerosol properties from satellite observations of the Ring effect" *by* T. Wagner et al.

Anonymous Referee #2

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General comments

The manuscript presents results of a study of the aerosol effects on atmospheric Raman scattering and oxygen absorption in the UV and Vis. The study is based on both radiative transfer simulations using a Monte-Carlo model and satellite observations by SCIAMACHY. The subject of the manuscript is appropriate to AMT. The paper contains original material that has not been published. Earlier work is adequately recognized and credited. The paper is well organized and clearly written. However, the paper needs major revisions. The paper can be recommended for final publication provided the authors are able to address to all the following specific comments.

Specific comments

(1) The title does not properly represent the content of the paper. The paper deals mostly with studying the aerosol effects on Raman scattering and oxygen absorption for different geometries and geophysical conditions. The paper has a little with actual retrieving aerosol properties (i.e. aerosol height, aerosol optical thickness, and single scattering albedo) from satellite observations. The retrieval of aerosol optical properties implies the use of an inverse model. This study uses forward modeling only.

(2) The choice of SCIAMACHY for analyzing the satellite observations is quite questionable. The authors correctly mention that "the probability for cloud contamination is rather high" due to coarse spatial resolution of SCIAMACHY and "OMI would be the most suitable for the analysis of the Ring effect". According to the title, the oxygen absorption is not a focus of the paper. Therefore, the analysis of the O2 absorption band can be easily dropped out and the use of OMI will provide more appropriate data for the analysis. An additional argument for the use of OMI data is that the SCIAMACHY instrument is sensitive to polarization. This hampers the Ring effect analysis as the authors state in Conclusions.

(3) The aerosol effects on Raman scattering are computed in terms of Raman scattering probability. The existing Raman codes provide the spectral dependence of elastic and total radiances. It is not straightforward to compare the authors' results with other Raman codes. Moreover, the paper lacks any comparison with literature results. That is why the authors should provide information that facilitates the reproducibility of their results with other Raman codes.

(4) Section 2.2.4. The normalized radiance in Eq. 2 is defined without the cosine of the solar zenith angle. In this case, authors' statement of Section 2.2.4 that says "for a perfectly scattering atmosphere and reflecting earth surface the normalized radiance is unity" is incorrect.

(5) Section 4.3. The explanation of the dependence of Raman scattering on surface albedo is unclear, particularly the statement "with increasing surface albedo the prob-

AMTD

3, C1694–C1697, 2010

Interactive Comment

ability of the observed photons to be scattered by molecules slightly decreases". In reality, the dependence of Raman scattering on surface albedo has a minimum at some value of surface albedo. This value depends on wavelength. For instance, this value is about 0.2 for wavelength of 335 nm (it can be seen in Fig.14). For longer wavelengths, the minimum occurs at higher values of surface albedo. This can be seen by plotting the data for higher albedos.

(6) Section 4.4. Extrapolation of aerosol optical depth into the UV using measurements in the Vis is quite unreliable [Krotkov et al., Opt. Engineering, 2005] particularly for the AERONET station 'Beijing" where the presence of UV-absorbing aerosols is common.

(7) Section 4.4. I did not find information about aerosol height used in the simulations which data are presented in Fig. 15 and Fig.16. This is important for absorbing aerosol because TOA radiance noticeably depends on the aerosol height in this case.

(8) Section 4.5. There is a strong need of an explanation of the result shown in Fig. 17 for 335 nm that the Ring effect is larger for non-absorbing aerosol with optical thickness of 4 than for the same aerosol with optical thickness of 1. For this wavelength band the dependence of the Ring effect on surface albedo is quite weak (see Fig. 14), so the aerosol albedo effect on Raman scattering can be considered to be negligible. This leads to a question: why the aerosol shielding effect is not seen.

(9) Section 4.6. Figure 22 (O_2 AMF at 630 nm panel) shows a strange result that the oxygen AMF does not depend on aerosol optical depth and aerosol height in the case of non-absorbing aerosol. The result should be explained. Also, information about surface albedo used in computations is missing.

(10) Section 4.7. Figure 24 shows a relatively strong dependence of the O_4 AMF on the aerosol asymmetry parameter that is qualitatively different from the O_2 AMF dependence on the asymmetry parameter. Please provide an explanation.

(11) Section 5. Conclusions listed in this section should be substantially revised. -

second main conclusion. I did not find any discussion in the text that would support the conclusion of the dependence of the Ring effect mainly on aerosol height and single scattering albedo at shorter wavelengths and mainly on aerosol optical depth at longer wavelengths. Please remove the conclusion if you are unable to support it quantitatively. - third main conclusion. The conclusion of the weak dependence of the Ring effect on surface albedo is questionable. It is well known that surface albedo is low in the UV and blue Vis [see e.g. Herman and Celarier, JGR, 1997; Kleipool et al., JGR, 2008]. For low values of surface albedo (A<0.1), the Ring effect significantly depends on surface albedo, except for shortest wavelengths (< 340 nm) where the Ring effect varies with surface albedo less than 10% in the range A=0-0.1. - fourth main conclusion. I agree that the SCIAMACHY data are not appropriate for the Ring analysis because of the instrument polarization sensitivity (see also comment 2). However, this statement cannot serve as a conclusion. - fifth main conclusion. I disagree that the interpretation of oxygen absorption observations for aerosol retrieval "is rather ambiguous" as compared with the interpretation of the Ring effect. For instance, Dubuisson et al. [Remote Sens. Environ, 2009] have successfully demonstrated estimating the aerosol altitude from satellite measurements in the oxygen A-band. The interpretation of the Ring effect may also show possible ambiguity from albedo and shielding effects (see Fig. 17 data for 335 nm).

(12) The authors show their results in 31 figures, most of them have 6 to 12 panels. Too many illustrations may distract a potential reader from main findings of the paper. I recommend reducing the number of figures and leaving those which illustrate and highlight the main findings. For instance, I do not see much added value in 6 figures of Appendices A and B. They can be eliminated without losing significant information.

(13) The quality of some figures should be improved by increasing the size of characters. For instance, it is hard to see the legends in Fig. 15 and 16.

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