

## ***Interactive comment on “A new method for the simulation of the Ring effect in observations of scattered sun light” by T. Wagner et al.***

**T. Wagner et al.**

Received and published: 7 April 2009

First of all, we want to thank this reviewer for the positive assessment of our manuscript and the constructive comments. We followed them all as described in detail below.

### General comments

The paper fits within the scope of AMT. The paper presents the first (to my knowledge) simulation of 3D cloud effects on the Ring effect using an implementation within a Monte Carlo model. The authors give an example of cloud shadowing that might be observed in the spectrum of a satellite instrument via the Ring effect. The model compares well with two other published models of the Ring effect, providing confidence in its implementation. An efficient method for computing the Ring effect within a limited wavelength band is also presented. The full rotational Raman scattering scattering cal-

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



ulation is done at a single wavelength and a resolution-independent scaling is used for the other wavelengths. The coefficients from a DOAS-type fit may then be physically interpreted.

### Specific Comments

The 3D cloud Ring-effect simulation is a new result and is important for understanding potential errors in UV/VIS cloud retrieval algorithms. I feel that it deserves more emphasis in the abstract and could be the focal point of the paper. This application of the Monte Carlo code appears to be disconnected from the fast computation part of the paper that comes before it. The 3D simulation is accomplished at a single wavelength and has more to do with assets of the Monte Carlo code than the detailed implementation of the Ring effect calculation for a DOAS analysis. This leads to questions about the organization and content of the paper. The authors have chosen to emphasize the fast implementation of the Ring effect calculation. It is given as a general approach with a specific implementation that makes use of a Monte Carlo code. I find this part to be more of a technical implementation issue rather than a new concept as similar approaches have been previously implemented (see comments below). Therefore, I suggest a reorganization of the paper. The description of the Ring effect implementation in the Monte Carlo code, comparisons with other codes, and 3D simulation could be a paper in itself. The fast calculation portion of the paper could be given as a particular implementation/application of the Monte-Carlo code (one that could be applied with other codes as well). The title could be more descriptive. For example, instead of simply "A new method" it could highlight the 3D aspects of the model.

Author response: We agree with the reviewer that the application of the model to the 3D cloud case deserves more attention. Therefore we modified the title, the abstract, conclusion, and also the structure of the paper: we removed the sections on the errors of the method and the DOAS analysis from the main text to an appendix.

We changed the title to: Three-dimensional simulation of the Ring effect in

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



observations of scattered sun light using Monte Carlo radiative transfer models; In the conclusions we added suggestion for future studies.

The first paragraph is very long and could be broken up at line 15 where the discussion of cloud effects comes in.

Author response: We started a new paragraph after line 15.

In the last sentence, I am unsure of what the limitations are in measuring the Ring effect. I would suggest either elaborating here (separate paragraph) or removing this sentence (can also explain the details later).

Author response: We removed this sentence since uncertainties of the Ring effect retrieval are not the focus of the paper.

In the 2nd paragraph: In reference other radiative transfer models of the Ring effect, the following should be included: Spurr, R.J.D., de Haan, J., van Oss, R., Vasilkov, A.P.: Discrete ordinate radiative transfer in a stratified medium with first order rotational Raman scattering, J. Quant. Spectrosc. Radiat. Transfer, 109, No. 3, pp. 404-425, 2008.

Author response: Many thanks for this reference. We included it in our manuscript.

Here it is stated that Monte Carlo models are particularly well suited for the type of approach outlined. While this is certainly true, the approach can be similarly implemented with the other radiative transfer models referred to (e.g. Vountas et al or Spurr et al). Is there any particular advantage of the Monte Carlo model other than that it is well suited for 3D simulations?

Author response: We added the following information to the text: 'can be easily obtained from Monte Carlo simulations, because this fraction can be directly determined by counting photons which have undergone RRS.'

In section 3 it was already stated: While in principle,  $P_{\text{Raman}}(I)$  can be determined

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



from any radiative transfer model, Monte Carlo models are in particular suited for that purpose, because they allow to quantify the relative amount of photons which have undergone RRS in a very direct and simple way. Here we also added more information: and simple way by forming the ratio of the number of rotational Raman scattered photons to all photons.

Do you have any idea how the Monte Carlo code compares to the others in terms of speed?

Author response: Unfortunately, we have no information about such a comparison. However, we added the following information on our computation speed to the text in section 3: The computational speed depends both on the complexity of the modelled scenario and on the required precision. To achieve an precision of 10% for the simulation of a satellite observation for a cloud-free scenario about 20 seconds are required on a state of the art PC (dual core processor, 2.4 GHz). For complex cloud scenarios like that presented in section 6, the computation requires about 20 min.

On p. 95: It should be noted that a similar form was derived by Joiner et al 1995: one term dependent on the solar spectrum and the other on the amount of scattering (independent of resolution).

Author response: We added a sentence with a reference to Joiner et al., 1995 after equation 10. A split into a high-frequent and low-frequent terms was also discussed in Joiner et al. [1995] and Joiner and Vasilkov [2006].

p. 95, paragraph devoted to discussion on various options of solar spectra to use: It should be noted that Joiner et al. 1995 contained a similar discussion and that Liu et al. 2005 (reference below should be included) compared fits using high resolution solar spectra vs measured spectra (the latter giving a significantly better fit). Liu, X., K. Chance, C.E. Sioris, R.J.D. Spurr, T.P. Kurosu, R.V. Martin, M.J. Newchurch, Ozone Profile and Tropospheric Ozone Retrieval from Global Ozone Monitoring Experiment

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

(GOME): Algorithm Description and Validation, J. Geophys. Res., 110(D20), D20307, 10.1029/2005 JD006240, 2005.

Author response: We added the Liu et al. reference to the paper. In the text we added the following sentence: 'Usually, Ring spectra calculated from such spectra lead to smaller residuals in the DOAS retrieval (see also Liu et al. [2005]); We also added a reference to Joiner et al. 1995 in this paragraph.

An approach similar to the one outlined on p. 95-96 has already been implemented in the OMI Raman cloud pressure retrieval algorithm of Joiner and Vasilkov 2006 (though it was not described in as much detail). Their approach was based on table lookup rather than on-line RT, but it is the same basic idea - that the resolution-dependent part of the Ring effect can be decoupled from the resolution-independent part and that the resolution-dependent part can be scaled by the resolution-independent part.

Author response: We added a reference to the Joiner and Vasilkov paper after equation 10: 'A split into a high-frequent and low-frequent terms was also discussed in Joiner et al. [1995] and Joiner and Vasilkov [2006];

p. 102, line 19: Please include Liu et al. 2005 reference here as they also fit higher order Ring effect terms.

Author response: We included the Liu et al. reference

end of section 4: It should be noted that to properly analyze/interpret the fit coefficients, more radiative transfer calculations would have to be performed (e.g., for a 4th order polynomial at least 4 calculations).

Author response: We agree in principle. However, the strongest improvement is already achieved if in addition to the first Ring spectrum a second Ring spectrum is included. We added the following information to the text: 'For DOAS analyses using large wavelength ranges it might be interesting to include additional Ring spectra representing weak wavelength dependencies like e.g. for aerosol scattering';

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



---

Interactive comment on Atmos. Meas. Tech. Discuss., 2, 87, 2009.

**AMTD**

2, S88–S93, 2009

---

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

S93

