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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 #1

Shortcomings:

a): Measurements with scanning spectral spectroradiometers will neccessarily be influenced by changes in the solar zenith angle. It will also affect results derived from the measurements. For the aerosol measurement made at low sun the change in solar zenith angle is 0.44° from 340 to 410 nm. As stated in the

manuscript, the model simulations do include the change in solar zenith angle as for each wavelength the corresponding measurement solar zenith angle is used. Thus, the model results also contain the change in solar zenith angle and is thus directly comparable to the measurement. See also answer to specific comments #14 below.

b): The manuscript has been completely reorganized. The focus of the revised paper is on the description of the implementation of a new first-order RRS discrete-ordinate radiative transfer model. The model is used to calculate Raman scattering effects under cloudy conditions and used to explain the reason for the behaviour of the filling-in of Fraunhofer lines. The introduction and conclusions have be changed accordingly.

Specific comments:

1. The suggested references and a few more have been added.

2. For the revised manuscript we have adopted the revised Kurucz solar spectrum, please see the revised manuscript for details.

3. Ozone absorption has been included using the cross section of Daumont et al (1992). This information has been included in the text.

4. The pathlength itself will depend on altitude, viewing direction, solar zenith angle etc. Thus, the altitude dependence of Raman scattering is included in the

pathlength. The altitude dependence of Raman scattering is discussed in a later section of the manuscript.

5. The albedo was erroneusly set to vary with wavelength. Kylling et al (1998) analysed data for similar conditions and used a constant albedo of 0.03. The calculations have been redone using this value and the manuscript has been updated to reflect this. Concerning the effect of 'reflection' at the water surface, there were no independent effective albedo measurements for the measurement site. To estimate this effect is beyond the scope of the present work. It should be stated though, that what is measured is the irradiance on a horizontal surface. This surface did not directly 'see' the ocean. Increasing the albedo from 0.01 to 0.1 increases the global downwelling irradiance by 3.5% (340 nm) to 2.4% (410 nm) for the conditions presented in the paper. Thus, while the exact value of the albedos may be questioned, their influence on the results presented here are small.

6. That the filling-in depends on the viewing direction of the satellite instrument has been mentioned in the manuscript at the suggested place.

7. As stated in the manuscript the spectral resolution is 0.6 nm (full width at half maximum) and the step width is 0.25 nm. Thus, the measured spectra are more than twofold oversampled and not undersampled.

8. The quoted number of 2.5% is taken from Mayer et al. (1998). They compared a cloudless spectrum with the thunderstorm spectrum. The spectra were recorded at similar solar zenith angles. Hence, there is no solar zenith angle effect

included. This has been clarified in the text.

9. The model spectrum for the thunderstorm was not included because it did not contribute any new information as long as the clear sky model results were present. The model results have now been included for the thunderstorm case. See also answer to next question.

10. The measured and modelled thunderstorm spectra have been scaled by a factor as suggested by referee #3.

11. The legends are correct. Please also see answer to General comment #8 of referee #2.

12. In figure 1b in the original manuscript absolute measurements of UV-radiation are compared with absolute model simulations of the measurements. The uncertainty in absolute UV-measurements are no better than the uncertainty in the absolute calibration standards. A full discussion concerning the uncertainties of absolute UV-measurements are beyond the scope of the manuscript. A detailed description of uncertainties involved in UV measurements have been provided by Bernhard and Seckmeyer (1999). Furthermore, Weele et al. (2000) have discussed uncertainties in model/measurement intercomparisons. We note here that at the time the measurments were made, they were state-of-the art and reflect the uncertainties involved. Obviously, the absolute model results also use a measured extra-terrestrial spectrum as input. This spectrum has uncertainties similar to the spectra measured at the surface. Undersampling is not an issue here as the measured spectra are oversampled.

13. The reason for the structure at 398 nm is not known. The same structure is observed when comparing the cloudless and thunderstorm ratios in Fig. 1b in the original manuscript. As discussed above, the measurements are not undersampled thus that is not a reason.

14. It took about 160 s to record the thunderstorm spectrum from 340 to 410 nm. Concurrent recordings by an illuminance meter shows that the illuminance was stable within $\pm$5% ($\pm 1\sigma$) for the duration of the scan (Mayer et al.,1998). Thus the cloudy conditions were stable during the scan. This information has been included in the revised manuscript. The transmittance of the instrument, including entrance and exit apertures, is called the slit function. The slit width is the width of the slit function and is usually denoted by the full width of the function at half of its maximum (Bernhard and Seckmeyer, 1999). It is not the resolution of the instrument.

15. The sentence has been rephrased.

16. The section has been removed from the revised manuscript.

17. The sentence has been rephrased.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 22515, 2010.