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Supplement of

The CU 2-D-MAX-DOAS instrument – Part 2: Raman scattering probability measurements and retrieval of aerosol optical properties

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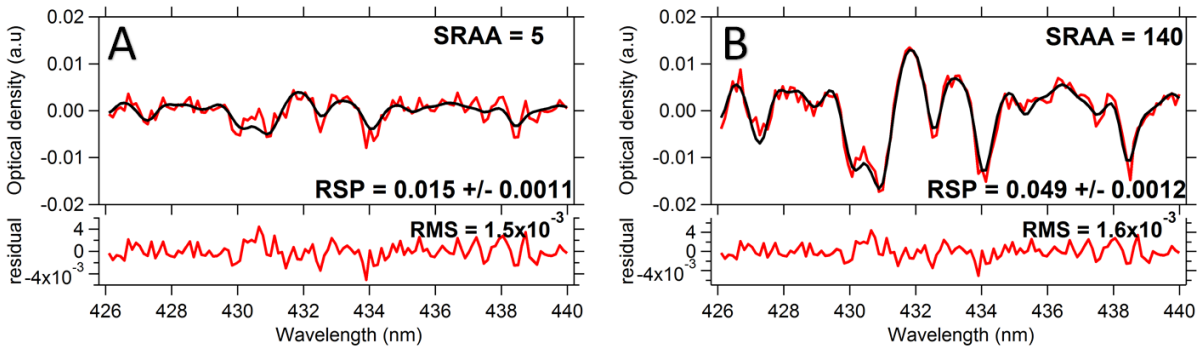

Fig S1. Same as Fig. 2 in the main text but for SRAA of (A) 5˚ and (B) 140˚.

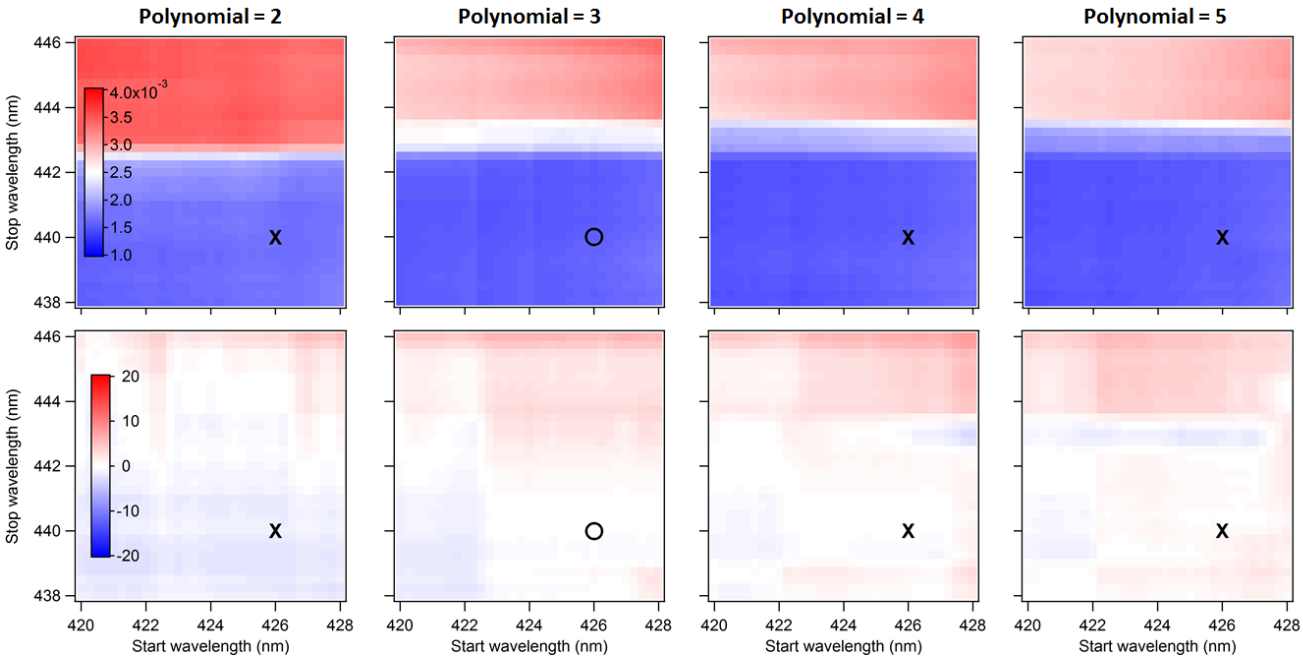

Fig S2. Sensitivity studies of the dRSP fit coefficient as a function of the spectral fit window at visible wavelengths. The example is taken from 22 July 2012 at 8:18 LS (EA = 3˚, AA = 0˚). The top row shows the RMS, and the bottom row shows the dRSP, calculated as the relative difference in percent $\left[\frac{(dRSP - dRSP_0)}{dRSP_0}\right] x100\%$, where $dRSP_0$ is the value obtained with the standard settings (black circle), and $dRSP$ is the value obtained changing the lower, upper limit of the wavelength window, and polynomial order. For comparison with the standard settings an X is shown in the other windows. The theoretical RMS calculated based on photon counting statistics is 0.0013.

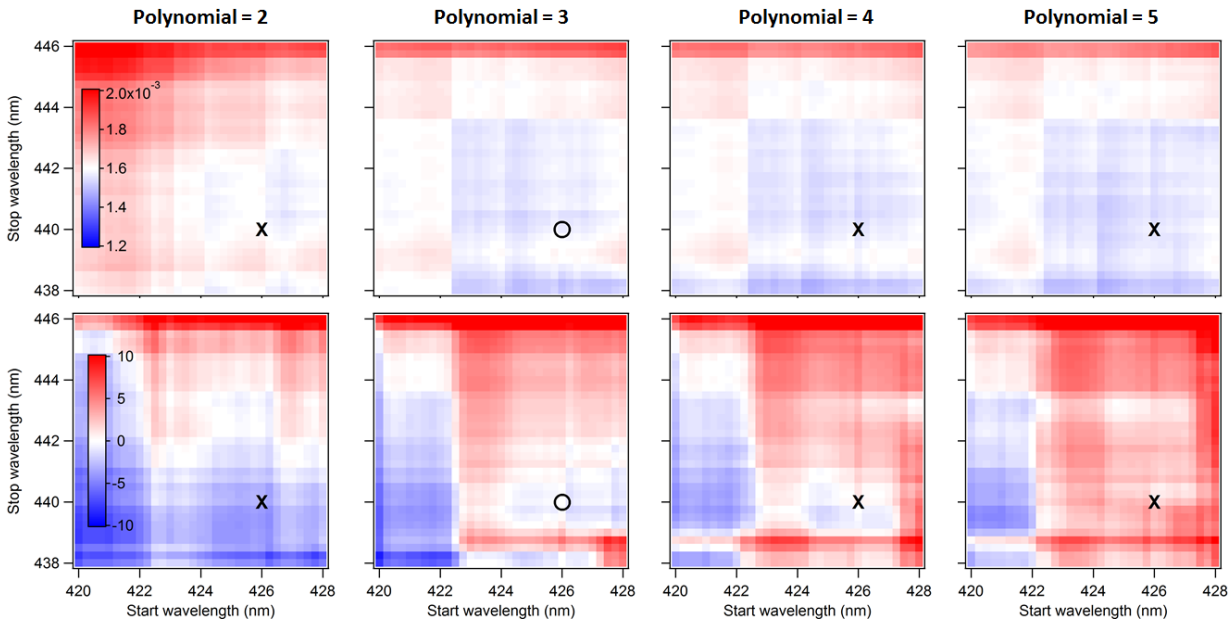

Fig S3. Same as Figure S2 but for SRAA = 5˚ and SZA = 60˚.

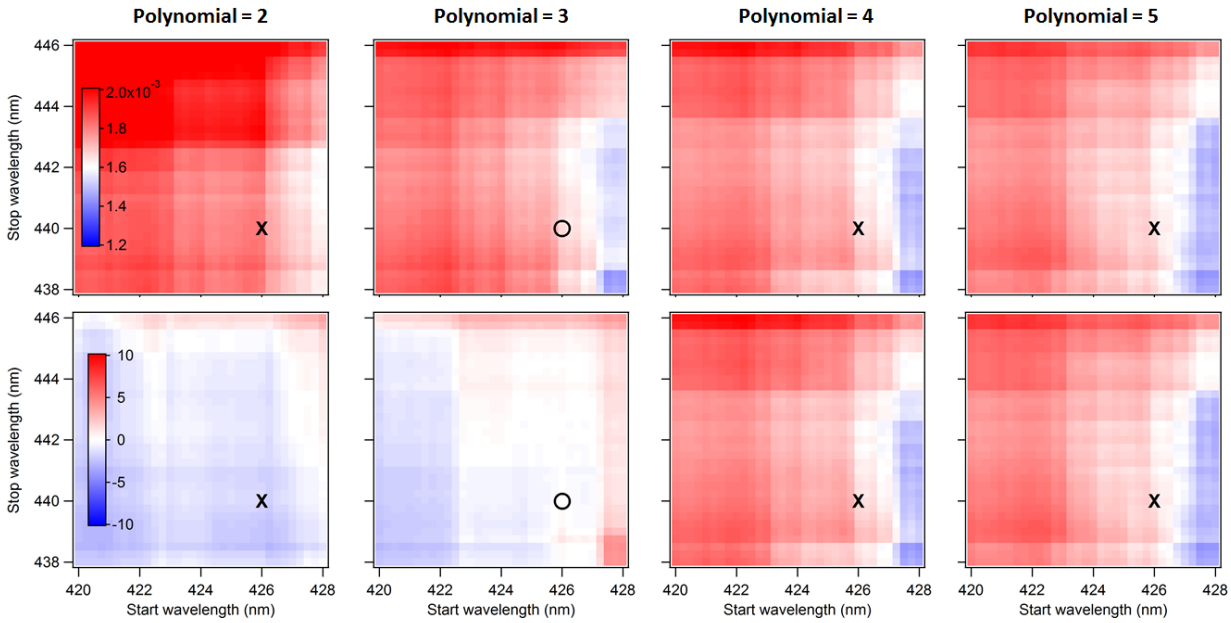

Fig S4. Same as Figure S2 but for SRAA = 140˚ and SZA = 60˚.

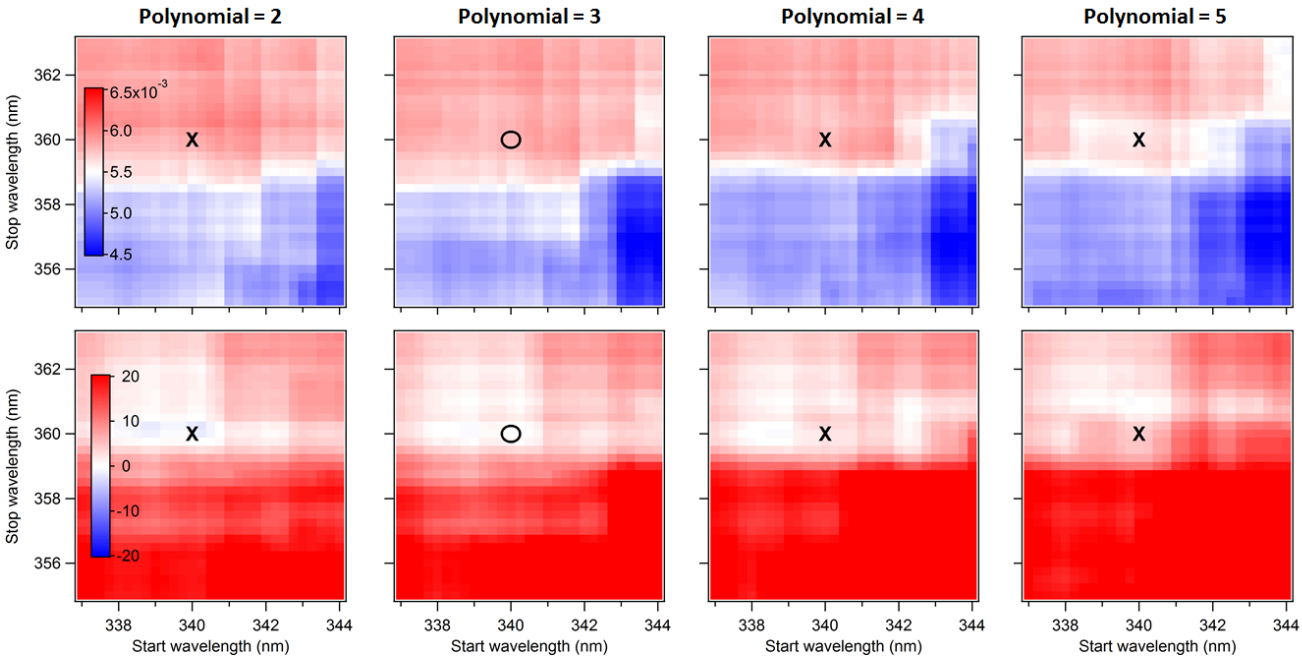

Fig S5. Same as Figure S2, but for evaluation windows at UV wavelengths. The graphs represent multiple analysis of the same spectrum also shown in Fig. S2. As can be seen the retrieval of dRSP in the UV shows more variability and higher RMS in comparison with the visible. The theoretical RMS calculated based on photon counting statistics is 0.0035. The open circle represents the standard setting following Wagner et al. (2009b).

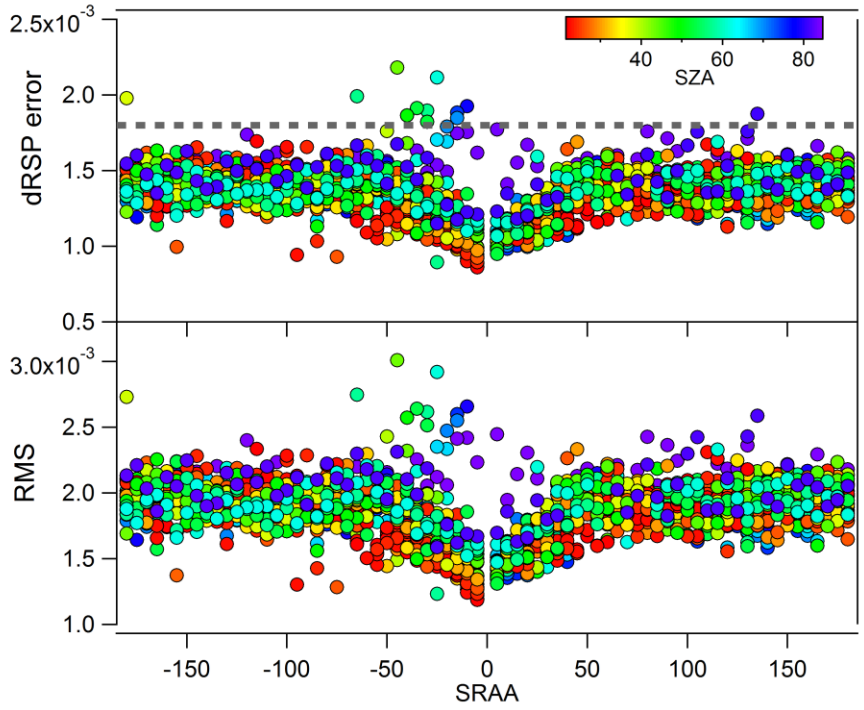

Fig S6. (top) dRSP error and (bottom) RMS vs SRAA on 22 July 2012. The gray horizontal discontinuous line represents the conservative error of 0.0018 reported in the manuscript.

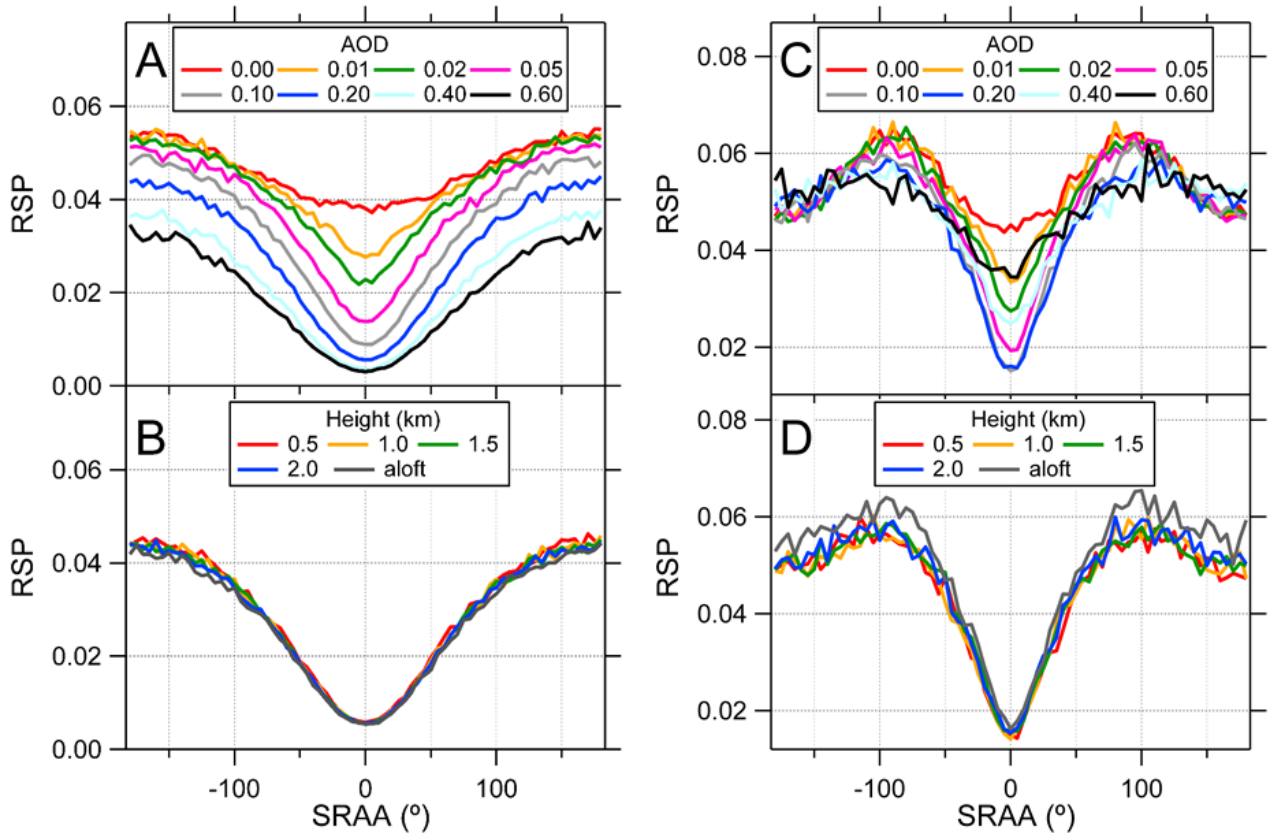

Fig S7. Same as Fig.4 (main text) but for a SZA = 35˚ (A and B) and SZA = 85˚ (C and D).

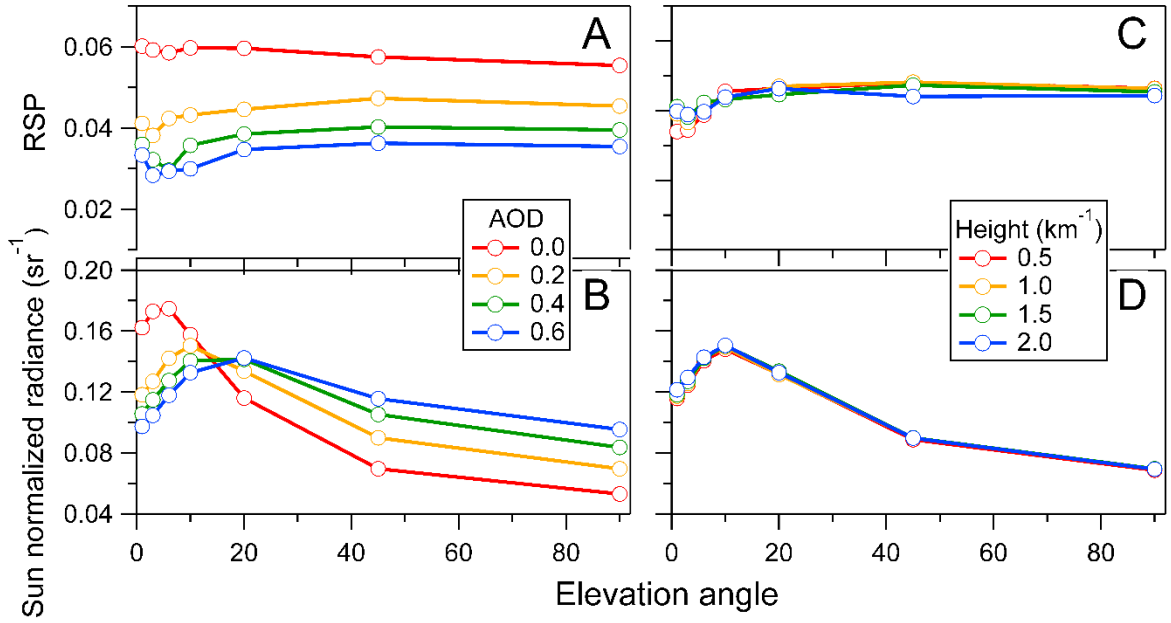

Fig S8. Sensitivity study showing the effect of AOD and aerosol vertical distribution on RSP and sun normalized radiance using the EA scan. The simulation is for SZA = 70˚, SSA = 0.98, g = 0.70, SA = 0.05

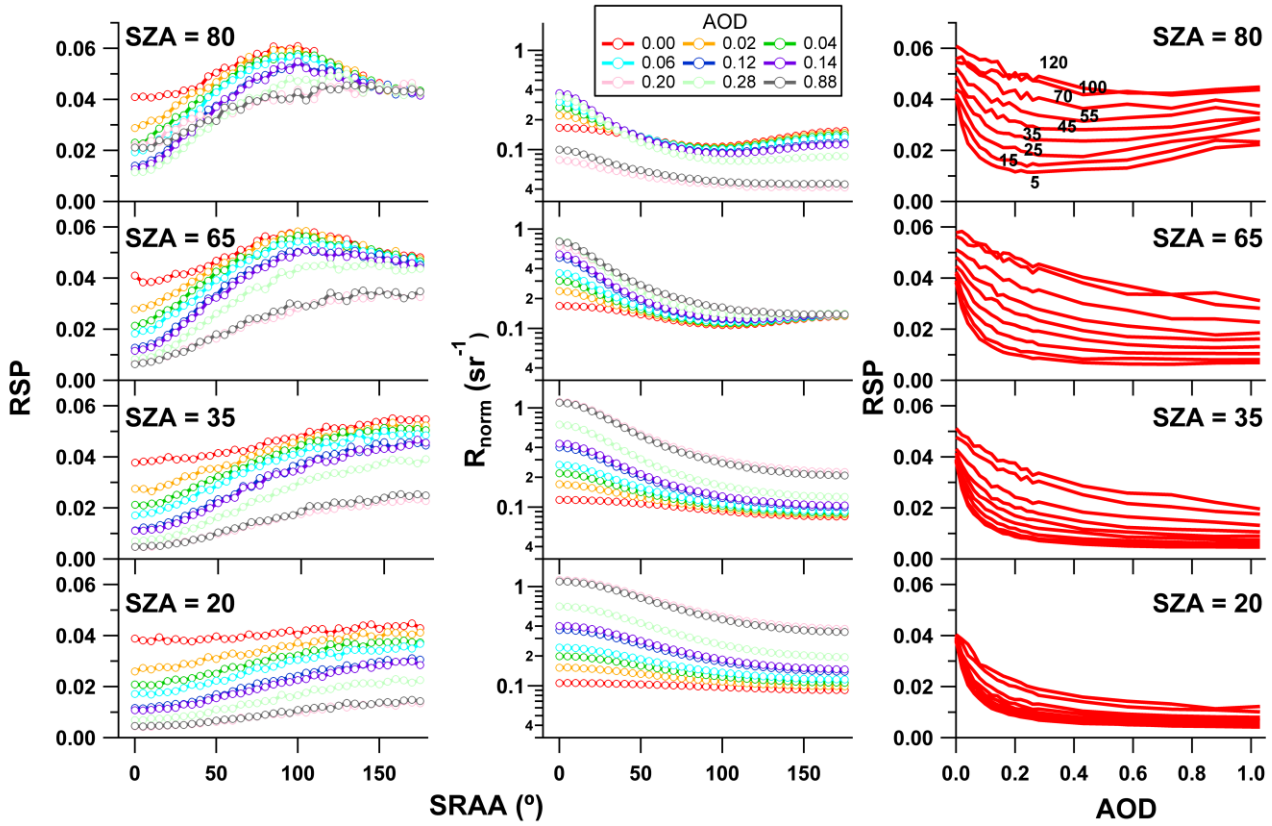

Fig S9. Effect of the AOD in the RSP (left) and R_{norm} (middle) as a function of SRAA for four SZAs (rows). For clarity, the RSP as a function of AOD for the same SZAs is shown in the right column (similar to Fig. 7 in the main text). Additional parameters are g = 0.64, SSA =0.98, SA =0.05.

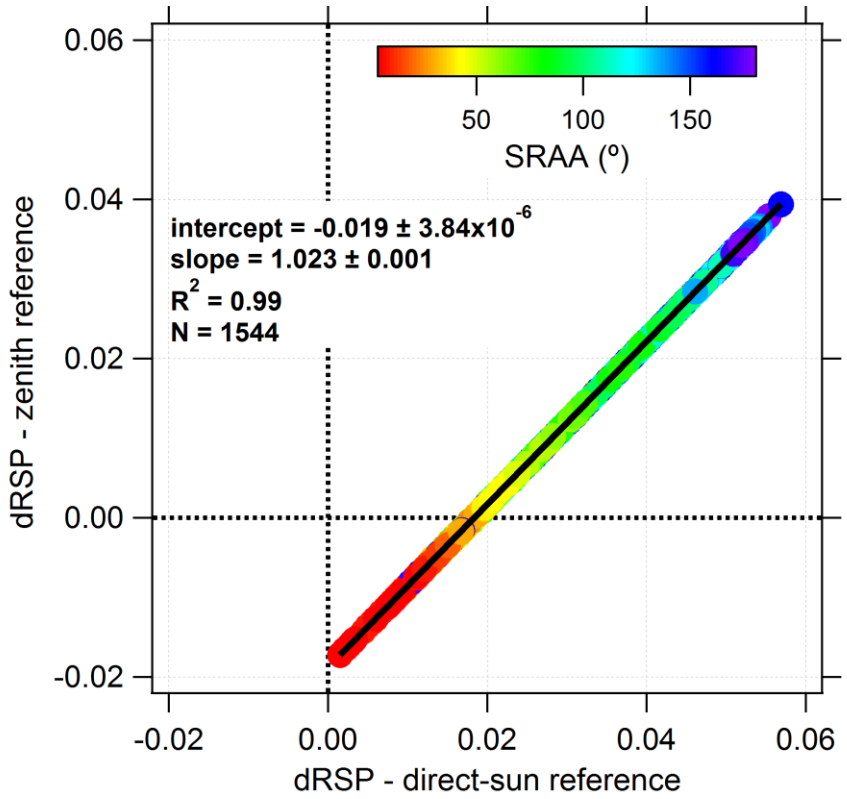

Fig S10. Comparison between the dRSP retrieved using a direct-sun (x-axis) and zenith sky (y-axis) spectrum as reference spectrum in the DOAS analysis. All spectra recorded with the solar almucantar scan on 22 July 2012 (SZA < 75˚) are shown. The dRSP values are color coded by the absolute SRAA. The intercept is negative because of the higher RSP contained in the zenith sky direction. The direct sun reference spectrum has a lower, but non-zero RSP (see main text for details).

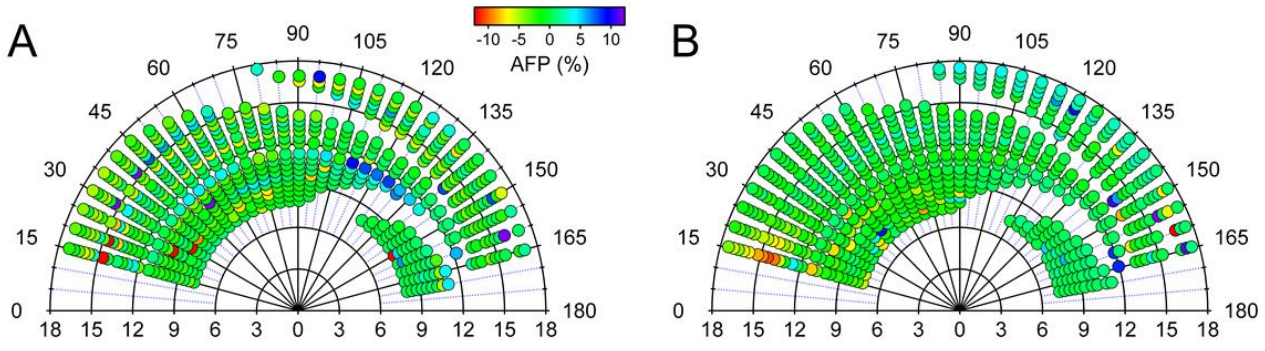

Fig S11. Asymmetry Factor Parameter ($AFP_{I_{norm}}$) in percentage (color code) on (A) 17 July and (B) 22 July 2012. The radii of the polar plot represents the local time, the angles are the absolute SRAA (see main text for details).

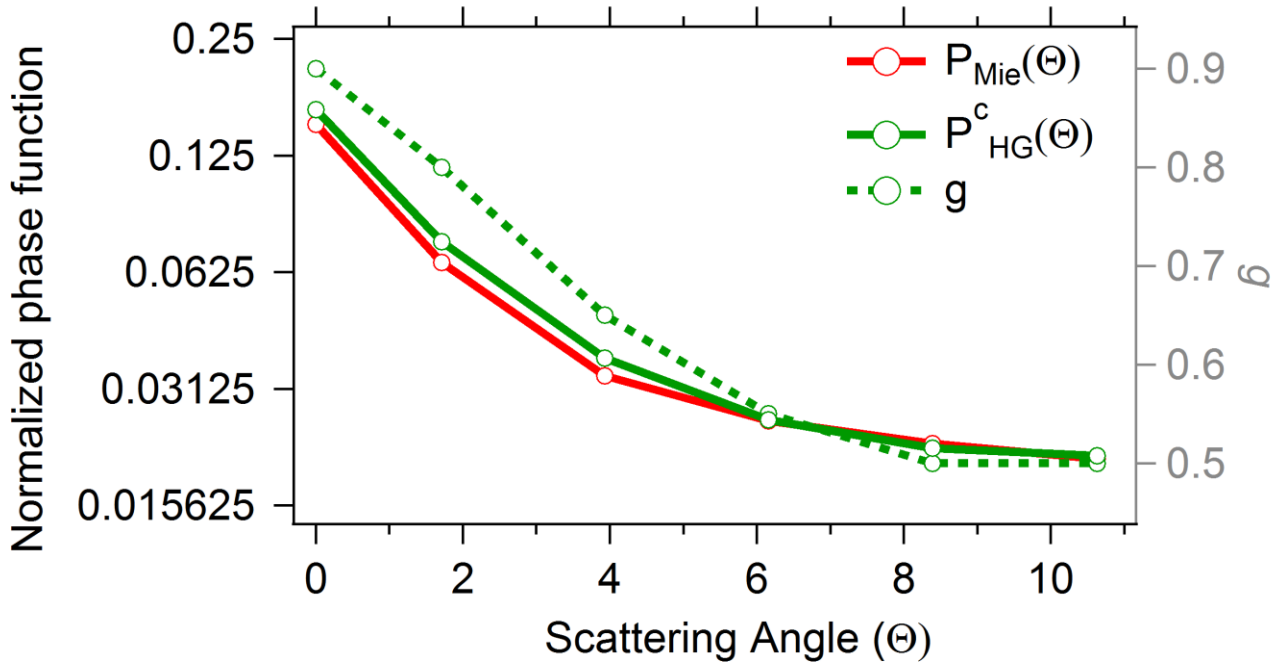

Fig S12. Comparison of area normalized phase functions calculated with a combination of g ($P^{c}_{HG}(\Theta)$) and $P_{Mie}(\Theta)$ by AERONET. Scattering angles below 11˚ are shown. For each phase function, the normalization was achieved using the full angular range (0-180˚).

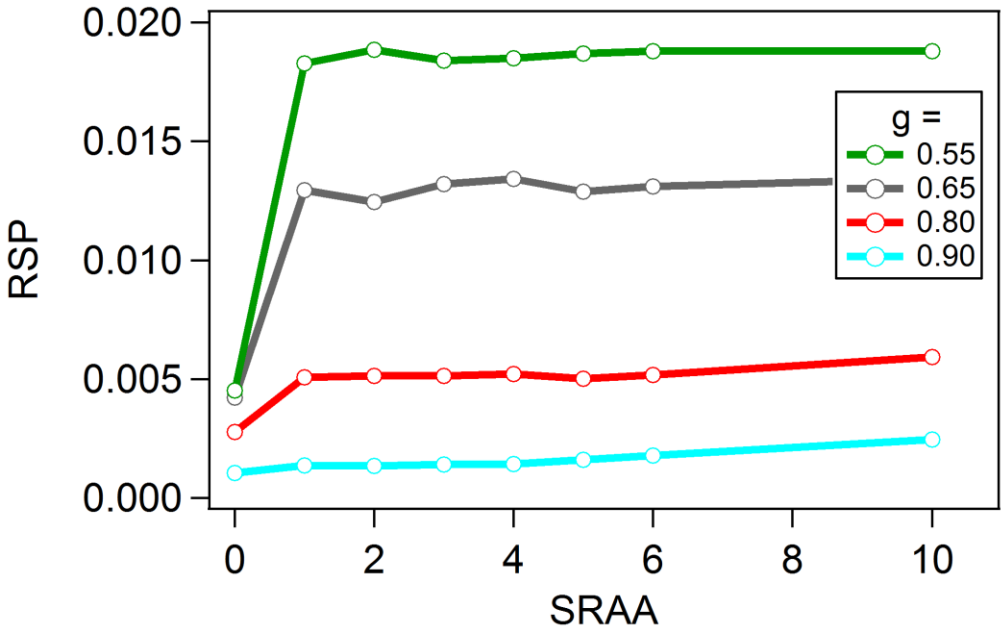

Fig S13. RSP simulated for SRAA smaller than 11˚ and the effective RSP resulted in the direct sun geometry for several *g* (AOD = 0.1).

Table S1. Simulation of the RSP in the reference following method three described in section 3.1 (SZA = 28˚; SSA = 0.95).

Run #	AOD	g	RSP
1	0.01	0.68	0.0047
2	0.09	0.68	0.0040
3 (22 July conditions)	0.1	0.68	0.0038
4	0.1	0.70	0.0037
5	0.1	0.80	0.0028
6	0.1	0.90	0.0011
7	0.11	0.68	0.0037
8	0.2	0.68	0.0033

Table S2. Results of the linear correlation between RSP = f(AOD) for a subset of AODs using the SRAA of 5˚. The results in the table are the slope/intercept of the equation RSP = slope·AOD + intercept.

Subset of AOD	SZA = 80˚	SZA = 65˚	SZA = 35˚	SZA = 20˚
0 – 0.1	-0.240/0.036	-0.225/0.034	-0.232/0.034	-0.235/0.034
0.1 – 0.2	-0.038/0.019	-0.048/0.019	-0.046/0.018	-0.043/0.017
0.2 – 0.4	0.0039/0.011	-0.013/0.012	-0.012/0.011	-0.013/0.011
0.4 – 1.0	0.018/0.004	0.0002/0.006	-0.002/0.006	-0.002/0.007