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Atmospheric Measurement Techniques Discussions

Interactive comment on "Global stratospheric aerosol extinction profile retrievals from SCIAMACHY limb-scatter observations" *by* F. Ernst et al.

F. Ernst et al.

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Reply to comments by reviewer #1:

We thank the anonymous reviewer for his/her constructive comments. We implemented most of the aspects addressed by the reviewer and believe that the paper has significantly improved, particularly by using a Mie scattering phase function.

Reviewer comment (1): The retrieval algorithm is based on OSIRIS work, and tuned up for OSIRIS available wavelengths. Because of hardware design, OSIRIS has only one available wavelength for aerosol, namely 750 nm (outside of Chappuis and as

long wavelength as possible). SCIAMACHY does not have that limitation and can use a range of wavelengths, which is a very important point since the independent retrieval of aerosol extinction at several wavelengths can yield information on particle size, which in turn can be used to model the aerosol phase function. In LS, all happens in scattering and one needs as much information on the phase function as possible: LS needs size information to help in setting up the phase function.

Reply: Yes, retrieving the aerosol extinction at more - longer - wavelengths would give us the opportunity to gain information about the particle size distribution and relating microphysical aerosol parameters. This information gets lost in the wavelength pairing step of the algorithm. As this is one of the greatest benefits of SCIAMACHY broadband radiance measurements, it will be implemented and published as future work. This paper shows the first version of the retrieval algorithm using wavelengths "approved" for aerosol retrieval. A section "Outlook" is added to the paper briefly discussing planned algorithm improvements including multi-wavelength retrievals of particle size information.

Reviewer comment (2): On the choice of using the 470 nm channel to effectively increase the contrast aerosol vs Rayleigh. OSIRIS is using that channel because at their Single Scattering Angles (SSA=around 90 deg, +- 30), the aerosol scattering is practically invisible at this wavelength. For SCIAMACHY with a Sun-synchronous orbit, SSA varies from backscatter (SSA=155) to forward scatter(SSA=38). While at SSA=155 stratospheric aerosol is practically invisible at wavelengths below 700nm, at SSA=38, one may no longer assume that the 470 nm channel is completely Rayleigh.

Reply: Yes, that's true, but even if we don't assume that the 470 nm channel is completely Rayleigh (we don't and we don't have to), the wavelength pairing still has the effect of strenghtening the aerosol signal vs. the Rayleigh signal, as explained in Section 4. Below 470 nm, the optical depth of the atmosphere could be too large to perform limb retrievals down to the tropopause.

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Reviewer comment (3): The use of the Henyey-Greenstein (HG) approximation for the aerosol phase function is odd. Stratospheric aerosols are known to be mostly spherical particles, sulfates (of known index of refraction) and Mie Scatter theory should be used directly to evaluate the phase function. The problem is complex as it is and we need to use as simple methods as possible. The authors do not provide justification for using HG with "4 water soluble and 8 insoluble aerosol components". Since (a) the authors are very keen on sensitivity studies and (b) the RT model rests on the value/shape of the phase function, how come the authors did not do a sensitivity study on their choice of model for phase function?

Reply: We fully agree with the referee. We used the Henyey-Greenstein approximation for the phase function in our first retrieval version and came to the conclusion that the phase function was most likely the key for dealing with the interhemispheric difference displayed in the comparisons with SAGE II. Therefore, we now added a Section "Retrieval with a Mie phase function" showing Mie phase functions calculated with a standard Mie program for a lognormal size distribution with size parameters assumed to be typical for stratospheric background conditions. A sensitivity study with respect to the median particle radius is shown, followed by a repetition of the SAGE II comparison, now with an appropriate Mie phase function implemented.

Reviewer comment (4): In their sensitivity studies, the authors found "that the parameter with the largest impact is surface albedo". Yet they rely on climatogical values for albedo instead of using the Effective surface albedo which can be retrieved directly by comparing the absolute value of the measured radiances with the modelled ones.

Reply: Yes, using the effective surface albedo retrieved directly from the data surely has the potential to improve the retrieval. This is not implemeted yet and will be part of (near) future improvements. We now mention this at the beginning of Section 6.

Reviewer comment (5): the sensitivity of aerosol product to ozone amount is not necessary since the wavelengths used (470 and 750 nm) are outside the Chappuis band.

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Reply: We agree and mentioned that one could expect this result in section 4.4 (→ 5.4). Nevertheless, we preferred to leave this result in the paper to confirm this expectation.

Reviewer comment (6): the sensitivity of aerosol product to atmospheric density depends on the SSA and may be much larger than the quoted 6%. At large SSA (Southern latitudes), the aerosol phase function is small and aerosol contribution is small compared to Rayleigh: the errors due to atmospheric density on retrieved aerosol would therefore be larger. Conversely at Northern polar latitudes.

Reply: We fully agree with the reviewer and weakened the statement in the abstract by adding "except at high southern latitudes". Table 2 shows the altitudes and latitudes where the error can be higher than 6%.

Reviewer comment (7): 35 km may be low for normalization since there may still be non negligeable aerosol at that altitude

Reply: 35 km is a compromise between potential aerosol load below and straylight contamination above. We made tests with a normalization tangent height of approx. 28 km with no significant impact on the retrieved extinctions. For this reason, we preferred to make sure to prevent straylight contamination by choosing a relatively low normalization TH of 35 km.

Reviewer comment (8): Impact of a priori profile: It may be worthwhile to show the Averaging Kernel matrix. It must be close to unity matrix since the a priori profiles have little effect on retrieved values.

Reply: We added a plot with an exemplary Averaging Kernel matrix in Section 4.1 . The sum of each averaging kernel - the red slashed line in the plot - is approx. 0.6 - 0.8, which means that the a priori profiles have an effect on retrieved values. Since in each iteration step we use as a priori the aerosol extinction calculated in the step before instead of the original a priori profile (see corrected Eq. 6), this influence is reduced in each iteration step. We also note that a unity matrix is only expected if the a priori

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impact is small AND the retrieval altitude grid is close to the tangent height grid. The latter is not the case in our study: The TH grid is a 3.3 km grid, whereas the altitude is a regular 1 km grid in the main retrieval altitude range.

Reviewer comment (9): The aerosol retrieval is going to be more difficult at high SSA (Southern latitudes for SCIA) than at low SSA (Northern latitudes), and that is because of the phase function and therefore the relative contribution of aerosol wrt Rayleigh. Your sensitivity wrt albedo only shows that. The apparent reversal in Southern polar region is due to high zenith angles which reduce effect on albedo

Reply: We fully agree with the referee and we discuss the point in Section 5.2. We expanded this explanation and added a column with the corresponding scattering angle in Table 1.

B. Test editing issues

(1) The introduction is rather long. Suggest breaking off some paragraphs into a section named "Background"

Reply: Done.

(2) May be worthwhile to stress advantage of LS data set wrt to Solar Occultation (SO): large geographical coverage, which can/will allow to be used in global atmospheric model assimilation. SO datsets are very accurate but limited in scope and can be used to "spot validate" LS.

Reply: Yes. We mentioned this in the introduction of the paper, this explanation is now extended.

(3) NPP has changed its name: It is no longer: "NPOESS preparatory mission, where NPOESS stands for National Polarorbiting Operational Environmental Satellite". It is now, much simpler: Suomi National Polar-orbiting Partnership (NPP)

Reply: Thanks. Changed in the paper.

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(4) The one-page rationale on radiance normalization may not be needed and a reference to von Savigny's paper may be sufficient h

Reply: We would like to leave it in the paper for the sake of completeness.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 5993, 2012.