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Atmospheric Measurement Techniques Discussions

Interactive comment on "SAGE version 7.0 algorithm: application to SAGE II" *by* R. P. Damadeo et al.

Anonymous Referee #1

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The paper describes major changes made in version 7.0 of the SAGE retrieval algorithm with respect to the previous version (6.2). Although the paper is very technical and quite difficult to read, it fits well into the scope of AMT and is important for the scientific community. It provides a detailed insight into to the improvements made since the version 6.2 and their influence on the data products. While most issues are discussed with a very high level of details, at some points authors restrict themselves to just a quick overview (e.g. concerning the refractive effects). This gives an impression of an unbalanced level of details. May be these skipped issues are not directly related to the changes between the retrieval versions but they are still important for the general paper flow. This is however rather a minor issue and I think the paper is suitable for publication in AMT after a moderate revision. My detailed comments and suggestions

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are listed below.

Detailed comments:

- A description of the overall paper flow is clearly missing in the introduction. When reading Sec. 1.2 it is not yet clear that a detailed description of all algorithm steps comes later. One tries to understand the single steps which is however not needed at this point.
- Sections 1.1 and 1.2 do not really belong to the introduction and should be indicated as independent sections (or one section containing both subsections).
- page 5106, line 11: Definition of the beta angles should be moved into the previous sentence.
- Fig. 3, figure caption: "(v6.2 left and v7.0 right)" there are no left and right panels in the plot.
- Fig. 4: Figures are hardly readable. The variables must be explained either in the text or in the figure caption.
- Page 5109, lines 6 - 9: "Our refraction algorithm calculates the elevation angle (relative to the local horizontal plane at the position of the spacecraft) of the refracted Sun (where the instrument sees the Sun) and the total refraction angle of the light ray as a function of wavelength (Fig. 4)." - which angles are these in the plot? It is also unclear why you highlight this angles. What you actually need to calculate the optical paths is a refractive ray tracing, i.e. the angles for each altitude layer rather than the angles at satellite position. Please also define the notation "S/C".
- Page 5109, lines 9 - 11: "It also calculates the layer slant-path matrix with which it determines the total number density of the slant-path air column (mass path)

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along the curved path of the light ray." - is the curved path calculated assuming a spherical atmosphere with an effective radius or an oblate atmosphere is considered?

- Page 5109, lines 12 - 13: "The methodology remains largely unchanged from version 6.2 and comes from Chu (1983) and Auer and Standish (2000)." - this statement means for me that there are some changes in the methodology. Please describe the changes and provide the basics of the methodology.
- Page 5109, lines 12 - 13: "After refraction, tangent point altitudes, latitudes, and longitudes are updated, taking an oblate Earth model into account (Fig. 4)." - I guess the right panel of the plot is meant here. However, it is not really clear how this plot illustrates the sentence and what the plot is for. Please describe the plot in more details and establish a clear relation to the sentence.
- Page 5110, Sec 2.4: Aerosol extinction coefficient is also wavelength dependent and should be mentioned in this section.
- Fig, 5: This plot does not contain any useful information and can be skipped (see also next comment).
- Page 5111, lines 5 - 10: A discussion of the relative contribution of different species into the extinction makes no sense if only cross sections are analyzed. These are namely products of cross sections times number densities which are measures of the relative contributions of species.
- Page 5111, line 10: "... and displays little to no structure within these narrow band-passes." - what is the message of this statement? Why does it make difference if O_3 cross section has any structure within band-passes or not? I guess it has a slop anyway.
- Page 5111, line 10: Please provide the wavelength for channel 1.

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- Page 5111, lines 10 - 13: To my opinion the statement about aerosols is in a contradiction with the discussion in Sec. 4.2 where the aerosol extinction coefficient is retrieved at three wavelengths.
- Page 5112, Fig. 8: How the relative difference is defined (new - old)/old, (new - old)/old, or (new - old)/(new + old)? This comment refers also to all plots below showing the relative differences.
- Page 5112, Figs. 9 and 10: The figures can be combined in one plot showing both the old and the new versions for mean profiles. The deviations between mean and median above 40 km are not really worth plotting and can be summarized in words instead.
- Page 5112, Fig. 11: Same as for Figs. 9 and 10.
- Page 5114, Sec. 3: "... less on the order in which they are computed or how these steps may be iterated." - I think it is a quite bad idea. It is really important in which order the corrections are computed and how the steps are (not may be!) iterated. Given the high level of details of the preceeding and following discussion it is unclear why this issue is skipped.
- Page 5114, Fig. 12: What is the reason why the scans become shorter with the time? Is that a sun flattening due to the refraction? Please discuss it in the text.
- Page 5114, lines 21 - 24: "This becomes problematic when the bottom of the Sun is obscured by cloud or is below the limb of the Earth, as the calculated inflection point of the limb-darkening curve no longer correlates to the physical edge of the Sun and the calculated scan rate becomes biased high." - what is done in this case? Is it the same correction as described below? Please clarify if the next paragraph just continues the discussion and thus refers also to the last sentence of the previous one or opens a completely new point.

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- Fig. 13: The plot is hardly readable.
- Page 5115, lines 10 - 13: “Given the nonlinearity of the problem of combining refraction effects and an oblate Earth model in determining tangent point altitudes, the algorithm uses an iterative scheme optimized for rapid convergence.” - the information content of this sentence equals zero. Please describe the problem, iterative scheme, and optimization in detail.
- Page 5115, line 15: “Lower in the atmosphere, where refraction effects can become large, ...” - please specify the altitude region. Can you provide an estimation of the uncertainty due to meteorological data?
- Secs. 3.1 and 3.2: Please describe how the sun flattening due to the refraction is accounted for when mapping the measured signal to the I-zero curve. The net effect of the sun flattening is that the instrument sees a larger area at the sun when looking through the atmosphere as compared to the exoatmospheric measurements.
- Sec. 3.2: Please provide more details of the time-dependent I-zero correction.
- Sec. 3.2: Please describe which corrections and why need a minimum number of I-zero scans.
- Sec. 3.3: Please provide a short description of the sun spot detection routine and changes made in version 7.
- Sec. 3.3: Please provide a plot illustrating the method to account for the transient during sunrise measurements.
- Sec. 3.4: It is not clear what is iterated when calibrating the mirror.
- Sec. 4.1: Can you estimate the uncertainty related to the removal of the molecular scattering and O_2 - O_2 absorption?

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- Page 5122, lines 12 - 14: “The coefficients for this process (c1 , c2, and c3) are determined using an ensemble of single mode log-normal size distributions of sulfate aerosol at stratospheric temperatures ...” - this statement is a bit confusing. You can determine the coefficients assuming some particle size distribution. What is the purpose of an ensemble? Do you calculate the coefficients for a number of possible size distributions? What do you do then with the resulting ensemble of coefficients? Please clarify.
- Page 5122, lines 15 - 17: “The ensemble of log-normal size distributions spans the observed wavelength-dependence of the aerosol spectra.” - It is unclear to me what you want to say with this sentence.
- Page 5123, lines 14 - 15: “For altitudes below the 5-channel retrieval, there is no longer valid data in the 448 nm channel and thus NO_2 cannot be retrieved.” - please provide typical values (or ranges) for this altitudes.
- Page 5123, lines 15 - 16: “Instead, the NO_2 OD profile from the 5-channel retrieval is inverted to get extinction values ...” - The previous sentence says there is no longer valid data in the 448 nm channel, how can NO_2 OD profile can be inverted? Or you mean higher altitudes where 5-channel retrieval still works? Please rewrite the sentence to make clear what is going on.
- Page 5123, lines 16 - 17: “... assuming the NO_2 mixing ratio is zero. The OD contribution from NO_2 at lower altitudes is then removed from all channels.” - If NO_2 mixing ratio is assumed to be zero, its OD will be zero as well. What is the sense to remove it from all channels? Please rewrite the description.
- Page 5124, lines 23 - 27: “When the fit to the 600 nm aerosol OD drops below a certain threshold, the algorithm subtracts out the fit (which is generally below the “noise level”) and inverts only the remaining 600 nm OD to retrieve ozone.” - It

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seems to be basically the same as “no aerosol” approach in version 6.2 but with dynamically adjusted altitude. Is it the case?

- Page 5126, lines 8 - 9: “Once the algorithm has run through both iterations, ...” - here the reader might be confused by the discussion of the water vapor iterations in the previous paragraph, please state more clearly that you mean iterations from the previous section.
- Page 5126, lines 8 - 9: Once the algorithm has run through both iterations, it has produced vertical water vapor volume mixing ratio and NO_2 number density profiles.” - As far as I understand the vertical water vapor volume mixing ratio is a result of the retrieval mentioned in the first paragraph of the section. It does not results directly from “both iterations”. Furthermore, I cannot find any description of the NO_2 vertical inversion. It is just mentioned in page 5123.
- Page 5127, Fig. 19: please explain the notations “MLR” and “aerosol ozone”.
- Page 5127, lines 18 - 19: “... the changes in the retrieval method make the altitude dependency of the offset more consistent.” - please explain what you mean with “more consistent”. What is a measure of the consistency and what is the reference?
- Page 5127 and 5128, Fig. 20: There are no “a”, “b”, and “c” panels in the figure. You should either insert labels in the plot or refer to left/middle/right panels instead.
- Page 5130, Sec 5.2: How many Fourier terms are used to fit the latitudinal dependence? What are the altitudes of the Singapore wind proxies which are included in the regression and how the proxies measured at different altitudes are combined to approximate the QBO signal at unmatched altitudes? Please define the “EESC” notation.

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- Figs. 24 and 25: The residuals need to be plotted as well (additionally to mean residuals shown in Fig. 26). One additional altitude would be also advantageous.
- Page 5131, lines 3-4: “The effect of the QBO can be seen around 35 km in both versions.” - How it is seen? Is it expected to be seen despite QBO fit term? Does this fact tell us something about fit quality etc.?
- Figs. 27 and 28: Please define what are the correlated and uncorrelated residuals.
- Page 5131, line 11 - 13: “There is a slight signature from the QBO, suggesting perhaps that this element of the fit needs further attention (and/or that an ENSO term is required).” - which signature you mean and how is it related to ENSO?

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 5101, 2013.