Atmos. Chem. Phys. Discuss., 7, S9109–S9121, 2008
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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Validation of 525 nm and 1020 nm aerosol extinction profiles derived from ACE imager data: comparisons with GOMOS, SAGE II, SAGE III, POAM III, and OSIRIS" *by* F. Vanhellemont et al.

F. Vanhellemont et al.

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The authors would like to thank the comments of both referees. These comments turned out to be very constructive, leading us to make corrections and add extra comments that have improved the paper significantly.

Before we answer the comments of the two referees, we need to point out that in the revised version of the paper, we changed the figures for the SAGE II and SAGE III comparisons. This was necessary after finding out that we made a few mistakes. The error was found because of the comments of referee # 1. Many thanks!

Three things have been changed:

1. by mistake, we used wrong files for the ACE versus SAGE II/SAGE III comparison figures. In the revised paper we use the right ones.

2. a few ACE imager occultations were removed (labeled as "bad" by the ACE algorithm team). For SAGE III, there are now 538 northern hemisphere and 55 southern hemisphere profiles.

3. An outlier removal algorithm was used. The number of data points that were removed is very small; about 99.85 % of the data are kept.

The new results for SAGE II and SAGE III are now much more consistent and are shown in new figures (Fig. 4, Fig. 5, Fig. 6 and Fig. 7). The discussion of the figures remains largely intact, only a few sentences had to be changed:

1. page 12358, line 12, the old text reads: "Below this altitude, the two data sets span similar value ranges, although the mean values differ considerably in the SH. At 1020 nm, profile statistics are very similar in the stratosphere, but SAGE II shows significantly larger mean values below about 18 km." The new text reads: "Below this altitude, the two data sets span similar value ranges taking into account the statistical spread. At 1020 nm, profile statistics are very similar over the entire altitude range".

2. page 12359, line 24: the new paragraph reads: "The resulting statistical distributions are shown in Figure 6. Once again, we observe systematically negative values for ACE at 525 nm above 25 km, and reasonable agreement between the two instruments below this altitude. At 1020 nm, we observe a good resemblance between the profile shapes for ACE and SAGE III, although ACE exhibits larger values over the entire altitude range. The mean and standard deviation of the set of relative differences are presented in Figure 7, clearly showing acceptable agreement at 525 nm within the altitude range from 10 to 25 km, and a positive bias at 1020 nm at all altitudes."

3. At page 12364, line 2: The following text was changed: "For both wavelengths

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there is nearly always a NH/SH discrepancy present (with the exception of the SAGE III comparison) when looking at the median/mean profiles at both wavelengths in the troposphere//lower stratosphere region: NH comparisons are ... This is related to the remark given previously: the variability of aerosol extinction in the troposphere (and lower stratosphere if we take PSCs into account) is very large". The new version reads: "For both wavelengths there is often a NH/SH discrepancy present when looking at the median/mean profiles at both wavelengths in the troposphere/lower stratosphere region: comparisons in the NH are usually better than in the SH."

We also added an extra author: Doug Degenstein.

Finally, we added the data versions for all instruments:

ACE imagers: V2.2

GOMOS: V6.0

SAGE II: V6.2

SAGE III : V4.0

POAM III : V4

OSIRIS : MART_3.0

Reply to comments of:

Anonymous Referee #1

Atmos. Chem. Phys. Discuss., 7, S5605-S5608, 2007 www.atmos-chem-phys-discuss.net/7/S5605/2007/ Received and published: 2 October 2007

REFEREE:

General comments: The paper is generally well written and easy to follow. Although

there are still major issues with the quality of the data product, I believe the paper - viewed as an intermediate status report for these ACE aerosol profiles - has sufficient content to be published as part of the special ACP issue on ACE. I ask the authors, however, to consider the general and specific comments below. I have three more general comments:

1) I think the use of "validation" in the title and several sections of the paper is somewhat inappropriate. A "validation paper" usually serves the purpose of demonstrating that the new data product agrees to with the combined error bars with independent collocated measurements. Once this is established the data product may be used for scientific purposes. But with the obvious problems with the aerosol ACE extinction profiles (low bias and negative values for the VIS channel and also fairly large differences for the NIR channel) we cannot really conclude that the data product is in a good shape. Therefore, I wouldn't consider (and neither would you, probably) this product validated. I suggest replacing "validation" by, e.g., "comparison", particularly in the title, and perhaps speak of "preliminary" ACE aerosol extinction profiles.

ANSWER:

We agree. The word 'validation' has been removed everywhere, and has been replaced by an alternative word. The following corrections have been made:

- Title has been changed to: "Aerosol extinction profiles at 525 nm and 1020 nm derived from ACE imager data: comparisons with GOMOS, SAGE II, SAGE III, POAM III, and OSIRIS."

- Abstract (line 6 and 7): "In this paper, we present first comparison results for these ..."

- Section 1: Introduction (page 12351, line 24 and 25): "The subject of this paper is the comparison of the aerosol and cloud extinction profiles ..."

- Section 4: title has been changed to: "ACE imager comparisons"

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- Section 4.1 (page 12356, line 19): "In this (validation removed) study, we have ..."

Concerning the use of the word "preliminary": we already mention explicitly in the text that the ACE imager data are in a preliminary state (last paragraph of section 2). We don't think it is necessary to repeat this statement over and over again.

REFEREE:

2) Nothing is said about the quality of the aerosol extinction profiles derived from the SAGE, POAM, GOMOS and OSIRIS instruments. It would be good to list the known accuracies and problems of the aerosol data products derived from these instruments, particularly since you describe the retrieval algorithms in some detail.

ANSWER:

Agreed. However, this task is very difficult (not to say very extensive). To give an idea about the quality of the profiles, we added some validation results (where possible) for each instrument:

For GOMOS: At page 12356, line 26, we added: "At present, GOMOS aerosol profiles have not been systematically validated." Besides this, we already mentioned the large range of retrieval accuracies (page 12357, line 5) and the known problems (residual scintillation; page 12356, 16).

For SAGE II: page 12358, line 7: "SAGE II was in operation for a very long time, and many validation studies have been performed, demonstrating that the aerosol extinction profiles are qualitatively very good, and consistent with other measurements. For example, Deshler et al. (2002) present comparisons of SAGE II profiles with results from the HALOE satellite instrument and balloonborne optical particle counters, during the period from 1991 to 1998. The agreement at the 1020 nm and 525 nm wavelengths for altitudes from 15 to 30 km is on average always within 50 % but becomes as small as 20 % in the middle stratosphere."

For SAGE III: page 12359, line 12: "Yue et al. (2005) performed a validation study by

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a comparison with coincident SAGE II profiles for the period from 2002 to 2003. The relative differences at all wavelengths are always less than 30 % at altitudes from 18 to 26 km, but are particularly small at 525 nm, typically within 10 to 15 %."

For POAM III: At page 12361, line 12: "At 1020 nm, however, a direct comparison is possible with the 1018 nm POAM III channel. The validation study of Randall et al (2001) shows that POAM III aerosol extinction profiles at 1018 nm agree on average with SAGE II measurements within 30 % for altitudes from 10 to 22 km. Typically, POAM III extinctions are lower than SAGE II in the NH and higher than SAGE II in the SH. Fundamental radiometric differences between POAM III and SAGE II are likely the cause of the differences".

For OSIRIS: At page 12363, line 1, we added: "A complete comparison and validation study for OSIRIS aerosol profiles has not yet been performed. However, Bourassa et al (2007) present a single 1020 nm profile comparison with SAGE II and SAGE III data. Assuming background aerosol particles, an agreement within 15 % was found for altitudes from 15 to 30 km. At lower altitudes, OSIRIS values were systematically higher, a fact that was explained by a larger smoothing error due to the larger optical depth."

REFEREE:

3) The vertical resolution of the ACE aerosol profiles is not mentioned. It should be explicitly stated in the paper. Except for SAGE II and POAM III the vertical resolution of the other instrument isn't mentioned either. It should be discussed whether differences in vertical resolution between the different instruments affect the comparisons (I don't think so), and whether these differences need to be considered in any way (convolution with averaging kernels) when comparing the profiles.

ANSWER:

Agreed. We have added the following statements:

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For ACE: Page 12354, line 17: "The altitude resolution is determined by the image pixel FOV (less than or equal to 0.7 km) but data are interpolated at a 1 km altitude grid."

For GOMOS: page 12356, line 18: "Star magnitude, temperature and occultation obliquity also determine the vertical resolution of the profiles (which differs from one occultation to the next): typically hundreds of meters to a few kilometers."

For SAGE III: page 12358, line 28: "... allow the retrieval of vertical profiles of ozone, ..., with a vertical resolution of 0.5 km."

For OSIRIS: page 12362, line 27: "After inversion, the extinction coeeficient is calculated from the solution. The profiles have a vertical resolution of about 1 km."

At page 12355, line 14, we have clarified why differences in vertical resolution are not so important, by adding the following text: "In principle, the different vertical resolutions of the instruments can affect the comparisons. However, since we are only considering instruments that have very good vertical resolution (looking sideways at the atmosphere with a small FOV; narrow averaging kernels), this effect will be minimal, and the usual convolution with averaging kernels is unnecessary."

REFEREE:

Specific comments:

1) Page 12350, line 13: ".. while the profiles are systematically too high at 1020 nm." I don't think this conclusion is justified, looking at the comparison with SAGE II and POAM III. Here, the ACE extinction values are larger than the coincident measurements over fairly large altitude ranges.

ANSWER:

We partially agree. With the new SAGE II and SAGE III figures, the conclusion is more clear: the 1020 nm NIR profiles for ACE show larger values, as is the case for the other

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instruments. POAM III is the only exception. But this is too specific to mention in the abstract. Therefore, we have changed the text to: "while the profiles are almost always too high at 1020 nm".

REFEREE:

2) Page 12353, line 5: ".. edge of the main solar disk the contribution is about 5 - 8 %." Later, on page 12364 (lines 24 - 26) you find, that these values are also more or less valid for the pixels used for the retrievals, which are near the centre of the sun. Your results therefore indicate that the 5 - 8 % are not only valid for the edge, but also for the centre of the solar disk, don't they? Perhaps this is worth mentioning.

ANSWER:

Agreed. We have added the following text to section 5 (page 12364, line 26): "However, our value is obtained for the measurements at the solar disk center. We can therefore conclude that the estimates from Gilbert et al.(2007) are also valid for the solar disk center, and perhaps even for the entire solar disk."

REFEREE:

3) Page 12353, line 19: You mention the relative accuracy of the tangent height registration. What is the absolute accuracy?

ANSWER:

Agreed. We added (section 2, page 12353, line 19): "Relative accuracy of the tangent heights is about 150 m, while the absolute accuracy will be 100 m in the worst case."

REFEREE:

4) Page 12357, line 17: "For the NIR channel, GOMOS.. ". I thought there were no NIR comparisons with GOMOS?

ANSWER:

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Agreed, this was a typo in the text. We changed to: "For the SH, GOMOS median ..."

REFEREE:

5) Pages 12372/12373, Figs. 4 and 5: To me these figures are not consistent. Fig. 4 SH NIR shows that the ACE extinction values below 20 km are systematically lower than the SAGE II values. This is not the case in the corresponding panel in Fig. 5. The same applies to the NH NIR plots. The VIS plots seem to be more consistent. Is it possible, that the wrong plots are shown?

ANSWER:

Agreed. By mistake, we used the wrong files to plot the figures. Figs. 4 and 5 have been corrected and the inconsistencies are no longer present.

REFEREE:

6) Pages 12374/12375, Figs. 6 and 7: Fig. 7 SH NIR shows a "singularity" at about 21 km altitude. There are no indications for unusual behaviour in the corresponding panel of Fig. 6. Please clarify.

ANSWER:

Agreed. After checking the data, we found out that several bad ACE imager files (labeled as bad by the ACE algorithm team) had been used for the calculation of the mean profiles and relative differences. We removed these files, and the singularity has disappeared. Figures 6 and 7 have been corrected.

REFEREE:

7) Page 12362, line 2: Is it really true that global coverage is obtained in a few days. Global coverage typically means that all locations were covered by the instrument FOV/swath. Given OSIRIS horizontal (across track) FOV of only 40 km, I doubt that all spots on Earth are really covered within a few days.

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ANSWER:

Agreed, if the word "coverage" is used in its strict sense, it is not true that global coverage is obtained in a few days. We used the word in a more loose sense, to express that for a certain coarse grid on the earth surface, at least one measurement can be found in each grid cell after a period of a few days. However, all this is not important for the purpose of our paper. To avoid unnecessary complications, we decided to remove the sentence: ", and global coverage of the Earth atmosphere is obtained in a few days".

REFEREE:

8) Page 12362, lines 27 - 29: In this case the aerosol extinction profiles at 1020 nm are not measured, but extrapolated from the spectral range used for the OSIRIS aerosol retrievals. This involves the assumption of an aerosol particle size distribution. What is the error introduced into the aerosol extinction values at 1020 nm due to this indirect technique. I think this issue should be addressed in the paper.

ANSWER:

Agreed. We have added the following text to page 12363, line 1. "The reader should be aware that the 1020 nm extinction coefficients are in a sense extrapolated from the spectral range used for the OSIRIS aerosol retrievals, and should therefore be treated with caution. It is extremely difficult to assess the error that is introduced by this technique, but under background aerosol conditions the error should be within a factor of 2. A detailed discussion was given by Bourassa et al. (2007)."

REFEREE:

9) Page 12363, line 27: "..(with the notable exception for POAM III below 16 km in the SH).." The same is true (according to Fig. 4) for the SAGE II comparisons in both hemispheres below about 17 km. This is again related to the inconsistency between Figs. 4 and 5.

ANSWER:

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Agreed. However, with the corrected figures for SAGE II (Figs. 4 and 5), the conclusion is now correct.

REFEREE:

Typos etc.

1) Page 12350, line 3: "larg" should read "large"

ANSWER: Agreed, the text has been corrected.

REFEREE: 2) Page 12359, line 1: "extinctions" should be "extinction" ?

ANSWER: Agreed, the text has been corrected.

REFEREE: 3) Page 12361, line 21: The second "I" in "OSIRIS" stands for "Imager", not "Imaging", I believe

ANSWER: Agreed, the text has been corrected.

REFEREE: 4) Page 12363, line 19: "o r" should be "or"

ANSWER: Agreed, the text has been corrected.

Reply to the comments of:

Anonymous Referee #2

Atmos. Chem. Phys. Discuss., 7, S4593–S4594, 2007 Received and published: 3 September 2007

REFEREE:

The paper present an interesting and well documented comparison between ACE, GOMOS, SAGE II, SAGE III, POMA III and OSIRIS vertical extinction of aerosols. The conclusion is that more or less the ACE profiles are promising, but some problems

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Interactive Comment

remains in the data reduction and/or in the instrument. The authors are honest, and this is how a validation paper must be conducted. The paper can be published if the following comments are taken into account:

All the figures containing the Rel. diff (%): Because of the limitation of the x-axis to -150% + 150%, some of the dashed lines are out of the figures. It could be interesting to extend the x-axis, or to add a comment concerning the high value of the uncertainies.

ANSWER:

Agreed. However, we mainly want to visualize the relative differences in the middle and lower stratosphere (main focus of interest for stratospheric aerosols). Extending the x-axis to values larger than 150 % or smaller than -150 % would render these values invisible. We therefore preferred to add a comment to explain the large uncertainty (see below).

REFEREE:

The authors say that the strong differences that can appear in the lower stratosphere and upper stratosphere could be due the high variability of aerosol content in such layers. This is true, but it can be also due to the low signal to noise ratio for the lines of sight at such altitude due to the strong atmospheric attenuation. The authors can tentatively estimate the errors due only to the low signal to noise ratios.

ANSWER:

Agreed. The SN ratio for occultation instruments gradually decreases with decreasing altitude, and below a certain altitude there is even a signal cut-off, where the measurement contains no information. For limb scatter measurements (OSIRIS), the uncertainty at low altitudes is mainly caused by the multiple scatter component in the signal that is very difficult to model in the retrieval algorithm. It is however very difficult to give a simple summary of the errors in the aerosol profiles due to these effects. The error depends on time and latitude (the atmospheric loading of aerosols, ozone and other

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species changes), and the actual light source (an entire catalogue of different stars in the case of GOMOS). Such a summary is really out of the scope of this paper, because it is too extensive. We therefore restricted ourselves to some additional comments to explain the larger uncertainties at low altitudes.

Both requests of the referee can be neatly satisfied by rewriting the paragraph describing the altitude region that is used for the comparisons (page 12355, lines 9-14):

"We will show comparisons from very low tropospheric to very high stratospheric altitudes (from 5 to 40 km). The high altitudes are only presented because some instrumental/retrieval issues become very clear in this region when inspecting the aerosol profiles. However, above 25 to 30 km, aerosol extinction values are extremely small, with large relative errors, and therefore relative differences between ACE and other instruments are always very large. The lower altitude results below the tropopause should also be taken with caution: the troposphere is a very dynamical, complicated area, filled with inhomogeneities and even coincidences may not be very informative. Furthermore, profile uncertainties increase with decreasing altitude: (1) occultation measurements suffer from long atmospheric paths through dense atmospheric layers, leading to strong optical attenuation, and (2) limb scatter measurements contain a multiple scattering component that is difficult to model in the retrieval algorithm."

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 12349, 2007.

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