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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Nine years of UV aerosol optical depth measurements at Thessaloniki, Greece" *by* S. Kazadzis et al.

S. Kazadzis et al.

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Response to Referee #2 (A. Cede)

General:

We would like to thank the reviewer for the useful comments and suggestions. Most of them have been taken into account. A change in the de-seasonalisation method and the calculation of trends lead to slight changes in the retrieved AOD trends. In addition the use of cloud flagging methodology to derive clear sky scans also for the Brewer MKII direct sun scans eliminated a (small) number of points that were included in the previous version of the manuscript mainly in figure 3. Figures 3, 4 and 8 are changed according to the reviewer's suggestions. All changes in the text according to the reviewer's suggestions are included in this response document together with the

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reviewer's suggestions in order to help understanding easier the manuscript changes.

Specific comments:

Page 540, lines 24-25: The sentence "These measurements . . . (Kerr et al, 1981)" is not needed. Measurements of AOD from both MKIII and MKII Brewers are given, which means both are absolutely calibrated. I claim Langley extrapolation is also an absolute calibration.

Response:

The sentence was deleted as suggested

Page 541, line 26: please state the ozone temperature used in the AOD derivation.

Response:

The sentence was changed to: "the ozone cross sections (for -44 degrees C of temperature) were taken from Bass and Paur (1985)."

It would also be useful to quantify how much (or how little) a variation of the ozone temperature affects the AOD retrieval at 320nm in Thessaloniki.

Response:

Following the referee's comment a text was added: "According to Cheymol and De-Backer (JGR, 2003, already in the paper's references), the sensitivity of the calculated AOD to the effective ozone temperature is -0.065 %/K for 320.1nm. This means that a typical mid-latitude annual variation in the effective ozone temperature in the order of 30-35 degrees will affect the AOD calculation by 1.9-2.3%. Therefore the maximum uncertainty in the AOD introduced by this factor is ś1.1%."

Section 2.2: add a sentence on how often was the calibration repeated for each instrument.

Response:

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A sentence was added in section 2.2 “The absolute calibration of both instruments is maintained by scanning every month a 1000W quartz-halogen tungsten lamp of spectral irradiance, traceable (through Optronic Laboratories Inc.) to the National Institute of Standards and Technology standards. In addition, every six months the relationship of the direct port to the global port is determined (for Brewer MKIII) using the shadowing disk technique as described in Kazadzis et al., 2005.”

Section 2.3: is the CIMEL calibrated at Goddard? How often is it calibrated?

Response:

The instrument was calibrated on June 2005 (just before starting its operation in September 2005) at NASA, Goddard Space flight Center facility. A sentence was added in section 2.3

Section 2.5: How are the samplers calibrated (brief explanation or literature)? How often are they calibrated (what is the long term stability)?

Response:

The following sentence has been added: in section 2.5: “The PM10 analyzers are checked and calibrated on a regular basis to ensure the accuracy of the measurements. Two specific beta gauge tests are made to verify the influence of the Geiger counter noise on the measurement and to measure the surface density of a reference gauge. Calibration is performed each time the filter paper is changed, and every six months to check the analyzer’s response.”

Figure 3: I suggest connecting the dots by a thin line and plotting the two instruments on top of each other (maybe in gray and black).

Response:

The suggestion was taken into account. Figure 3 was changed including also a third line that describes a merged data set as it is mentioned now in the text.

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Section 4 and Figure 3: are the linear trends taken from deseasonalized data as in figure 8? If yes it should be mentioned, if not the data should be deseasonalized either with the method used in figure 8 or simply be making yearly means before calculating the trend. Also report the uncertainty of the linear trend analysis.

Response:

Percentages from figure 3 and data presented in figure 4 were now calculated from diseasonalized data using the formula: 100* (Jx - Mx) / Mx , where Jx is the monthly mean of month x and Mx is the long term (9 year) mean of month x. Due to the fact mentioned above the changes per year has been slightly changed and also the axis labels of figure 8. A sentence was added: “All changes, mentioned above, are calculated from linear trends using diseasonalized data.”

The uncertainty of the linear trend analysis was calculated and more statistical details are now included in the text. The paragraph was changed to: “A linear regression on the MKIII diseasonalized data reveals a change of -2.9 ś 0.92 %, -3.8 ś 0.93 % and -3.5 ś 1.02 % per year for 320, 340 and 355 nm respectively. The statistical significance of this change was found better than 99% using student’s t-test. For Brewer MKII the change of AOD at 320 nm for the same period was calculated to -3.2 ś 0.6 % per year (with statistical significance similar to MKIII), which is similar to the one calculated from the MKIII data.”

Figure 4: The bottom figure is hard to interpret. I suggest making only one figure with 5 lines (no boxes) for the AOD distribution (4 seasons+yearly, as in figure 7). (Also: text refers to left and right panel instead to top and bottom panel).

Response:

Figure 4 was changed according to the reviewer’s recommendation. The text was also was corrected accordingly.

Page 550, lines 10-11, and page 551, line 6: Report the uncertainties of the linear

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trend analysis.

Response:

The uncertainty of the linear trend analysis was calculated and included in the text. The paragraph was changed to: “A negative change is evident at all stations ranging from -2% to -5.6% per year, with an average of -3.8 ś 0.6 % per year. The statistical significance of this average change was calculated to better than 99.9 %, based on the student’s t-test”

Page 550, lines 14-27: I do not fully understand this paragraph. The total pollution load over the city went up from 1989-2003, while in the city the pollution went down? So did the actions to reduce pollution (cleaner crude oil etc.) only affect the center and not the suburbs?

Response:

The paragraph was not clearly written and leads to erroneous conclusions as all reviewers reported. There has not been a significant increase in the pollution load but on the fleet of vehicles. So the correct sentence is: “This remark is of high importance, since during the period 1989-2003 there has been a significant increase in the fleet of the vehicles.” Also, the phrase “this positive development” that existed in the manuscript could be mixed with the positive and negative trends that are discussed in the same paragraph, so it was eliminated.

Section 6: In figure 5 I see a correlation between AOD and the Angstrom exponent. So the average particle size seems to go down when the aerosol loading goes up. Maybe this can be discussed at the end of section 6. The average Angstrom exponent could also be included in table 2 for each cluster.

Response:

Additional text was added at page 547 discussing the Angstrom exponent α seasonality: “In addition, a slight seasonality can be observed in the Angstrom exponent,

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α, monthly means. A summer maximum of 1.6 was found in July and August and a winter minimum of 1.2 in December. This is an indication of the presence of larger aerosol particles during the summer months. However, these variations are well within the 1σ standard deviation, as shown in the lower panel of figure 5." The average Angstom exponent and standard deviation was included also in table 2, as suggested.

Section 6: has a scatterplot of simultaneous PM-10 and AOD 340nm data been done? This could be interesting with respect to the height distribution of the aerosols.

Response:

The scatter plot of the PM10 and AOD values have been produced but not shown in the paper. As it appears there is a weak correlation between the deseasonalized data of AOD and PM10, suggesting that a small part of the observed negative change in the AOD column can be attributed to aerosol change near the surface which can be described by the PM10 measurements. But still the seasonal aerosol vertical profiles that are measured with the LIDAR and referenced in this work (Amiridis et al., 2005) are more appropriate to describe the exact characteristics of the seasonal behavior of the height distribution of the aerosols.

In addition, we have used the daily PM10 data from the closest to the Brewer site ground station, and we produced a scatter plot by selecting only the common days of measurements (daily means). The poor correlation (R squared ˜0.35) is the result of the contribution of the aerosols that are present in higher altitudes, in some cases, and in addition the fact that PM10 stations are directly affected by local and short term emissions of heavy traffic or other ground level emissions. On the other hand, the location of the Brewer site (60 m above surface) is high enough that the instrument is not able to measure completely these local aerosol contributions. For these reasons we believe that this scattered plot does not provide more information (from those presented in Amiridis et al., 2005) concerning the variability in the vertical AOD profiles.

Technical corrections:

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All technical corrections were taken into account and corrected.

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