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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Physical and optical aerosol properties at the Dutch North Sea coast" *by* J. Kusmierczyk-Michulec et al.

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First of all we would like to thank the Reviewer#3 for the comments and suggestions. Following the Reviewer's comments the paper was re-organized, as follow:

1. Introduction
2. Experimental data (here is the description of sun photometer and the chemical measurements)
3. Methodology
3.1. The analysis methods for the AERONET data
3.2. The Empirical Orthogonal Function (EOF) method
4. Results
4.1. Aerosol optical depth

4.2. Ångström coefficient versus PM10, BC and wind direction sector.
4.3. Application of the EOF method to the aerosol optical depth measurements in The Hague
5. Interpretation of the EOF results
5.1. The amplitude function
5.2. The physical interpretation of the eigenvectors
5.2.1 NE-SSW sector: off shore wind and continental air masses
5.2.2 SSW-NE sector: onshore wind and maritime air masses
6. Conclusions

The responses for the specific comments are given below.

Specific comments

1) "Ångström coefficient" should be replaced by "Ångström exponent"(AE) throughout the manuscript.
I would like to make a comment on this statement. It is well-known that the aerosol optical depth spectrum $\tau_A(\lambda)$ can be fitted to a power law function and written in a simple form
$\tau_A(\lambda) \sim \lambda^{-\alpha}$
We all agree with this mathematical expression. However, as far as I know, in the literature there is no agreement on the name given to α. I found at least three different names: Ångström parameter, Ångström coefficient and Ångström exponent. Each of them has comparable amount of supporters. I only refer to three publications:

1) Ångström coefficient:
J. R. Miller and N. T. O'Neill, Multialtitude airborne observations of insolation effects of forest fire smoke aerosols at BOREAS: Estimates of aerosol optical parameters, J. Geoph. Res., Vol. 102, D24, pp. 29,729-29,736, 1997.

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2) Ångström parameter:
A. Smirnov, B. N. Holben, O. Dubovik et al., Atmospheric aerosol optical properties in the Persian Gulf, J. Atmos. Sciences, Vol. 59, pp. 620-634, 2002.

3) Ångström exponent.
N. T. O'Neill, O. Dubovik, and T. F. Eck, Modified Ångström exponent for the characterization of submicrometer aerosols, App. Opt. Vol. 40, No.15, pp. 2368-2375, 2001.

To find a compromise I added on page 1560, sentence 15, additional comment and I modified the sentence:
"The Ångström coefficient α(also known as Ångström exponent or Ångström parameter) was obtained from fitting the spectral aerosol optical depth spectrum $\tau_A(\lambda)$ to a power law function".

2) To make clear where the measurements were made the following sentences were modified, p. 1559, line 13-15:
"In this paper we present results from a study on the optical aerosol properties at the North Sea coast, based on sun photometer measurements made in The Hague, on the premises of the TNO, between January 2002 and July 2003."
And also sentences from p. 1561, 8-9 are completed:
"The distance between both locations is approximately 35 km. De Zilk is situated in the NE direction from The Hague. Both stations are situated just east of the dunes, i.e. about 2.5 km from the coastline. "

3) Page 1561, lines 9-12: The following information on the instrumentation used for obtaining the PM10 mass and the black carbon was added:

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Relevant aerosol data available from this station are PM10 (particulate matter with an aerodynamic diameter of less than 10 μm) and black carbon concentrations. Black carbon (particles mostly smaller than 2.5 μm) is available as daily values and PM10 is available on an hourly basis.
RIVM's National Air Quality Monitoring Network in the Netherlands performs continuous PM measurements i.e. PM10 and PM2.5, using an FAG-typeβ-dust monitor (Van Elzakker, 2000). The sampling air is heated (to 50^0C) in order to remove water from aerosol particles (Buringh and Opperhuizen, 2002). The drawback of the heating is a removal of semi-volatile compounds eg. ammonium nitrate which leads to the losses in PM measurements. The correction methods for a systematic underestimation by the sampling equipment are described by Hammingh (2001) and discussed in detail by Buringh and Opperhuizen (2002). The amount of black carbon is estimated based on the PM measurements using the so-called light-reflectance method (Buringh and Opperhuizen, 2002).

Van Elzakker, B.G.: Monitoring activities in the Dutch National Air Quality Monitoring Network in 2000, report 723101055, Rijksinstituut voor volksgezondheid en Milieu (RIVM), Bilthoven, The Netherlands, 2000.

Hammingh, P. (editor): Air Quality. Annual Survey 1998 and 1999 (in Dutch), National Institute of Public Health and the Environment, report 725301006, Bilthoven, the Netherlands, 2001.

Buringh, E., and Opperhuizen, A., (editors): On health risks of ambient PM in the Netherlands, RIVM report 650010032, pp. 380, 2002. (http://www.mnp.nl/bibliotheek/rapporten/650010032.pdf)

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4) In my opinion it is not fair to say that “frequency of occurrence” or “the most probable values” is an obscure terminology. Maybe there should be an additional sentence with an explanation, but these terms are often used when the AERONET results (e.g. aerosol optical depth or Angstrom parameter) are presented (e.g. Smirnov et al. 2002). **Therefore the sentences, line 9-12, p. 1562, were modified**:

“Based on the frequency histograms of $\tau_A(555)$, the most probable values i.e. the values at which the probability distribution of $\tau_A(555)$ has its maximum, can be determined. These values, for each month, are reported in Table 1. The wavelength 555 nm was selected because it is representative for the visual range which is often used as a reference.The values were obtained by interpolation between 440 nm and 670 nm, using the Ångström coefficients. The most probable values of the aerosol optical depth at 555 nm are between 0.1 and 0.2, although excursions to both lower and higher values are frequently observed.
Figure 2b shows the Ångström coefficients during the study period. The values vary from close to 0 to about 2, indicating large variability of the shape of the aerosol particle size distributions. Based on the frequency histograms of α, the most probable values i.e. the values at which the probability distribution of α has its maximum, were determined for each month. The results are presented in Table 1. “

Smirnov, A. et al.: Atmospheric aerosol optical properties in the Persian Gulf, J. Atmos. Sciences, Vol 59., pp.620-634, 2002.

5) The type of relation i.e. BC/PM10 versus α, or α versus BC/PM10, depends on the eventual application. In my opinion it is much easier to get information about α e.g. from sun photometer measurements or from satellite retrievals, therefore the relation between BC/PM10 and α, would be more interesting.

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6) The sentences on page 1563, lines 11-14 were modified:
“This maximum suggests that the further increase of PM10 is not caused by increase of BC, but by other species. However, because no other measurements are available this cannot be further interpreted. “

7) The sentence on p. 1563, line 23, gives only a possible explanation:
“Likely production of sea-spray and the enhanced deposition of fine particles worked together to change the ratio between fine and coarse particles.” In my opinion it is not in contradiction with the reviewer’s statement that “changes in air mass origin (and thus in aerosol sources) caused these changes”. The reviewer’s statement is more general.

8) To make clear the relationship between Fig 10 and Fig 9, the sentence from p. 1569, line 24 was modified to read:
“Figures 9a -b show the pronounced maximum in the “fine particles” range”.

9) The sentences from p. 1571, lines 10-15 were modified:
“Examples of the aerosol size distributions corresponding to the EOF results for the maritime (SSW-NE) wind direction sector and for two seasons (summer and winter) are presented in Figures 9c-d. The similar aerosol size distribution, as in summer, was observed for this wind direction sector also in spring and autumn. The characteristic feature of these aerosol size distributions is that they are dominated by fine particles with the fine mode radius between 0.05 and 0.19 μm. The Ångström coefficients are typical for industrial aerosol. The aerosol volume size distribution for winter (Fig 9d) is completely different because of its strong peak in the coarse mode with mode radius between 3 and 5μm.”

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10 and 11: The references were checked and completed.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 1557, 2007.