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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.

J. Kusmierczyk-Michulec et al.

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First of all we would like to thank the Reviewer #1 for the comments and suggestions. The responses for the specific comments are given below.
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

Specific comments

SECTION 2: Experimental data.

1) "Angstrom coefficient" should be replaced by "Angstrom 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.

2) Ångström parameter:

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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 (in the literature also called as Ångström exponent or Ångström parameter) was obtained from fitting the spectral aerosol optical depth spectrum $\tau_A(\lambda)$ to a power law function."

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AERONET backward trajectories:

To clarify the methods of calculations the following sentences were added:
" The trajectories are based on the National Aeronautics and Space Administration (NASA) Goddard kinematic trajectory model (Schoeberl and Newman, 1995; Pickering et al., 2001). The computed air parcels movements are driven by assimilated meteorological data products obtained from the NASA Goddard Global Modeling and Assimilation Office which supplies the meteorological information in a 1.25 degree longitudinal and 1 degree latitudinal spatial resolution on 55 hybrid sigma-pressure vertical levels (T. Kucsera, personal communication)."

Schoeberl, M.R., and Newman, P.A., A multiple-level trajectory analysis of vortex filaments, J. Geophys. Res., 100, 25, 801-25, 816, 1995.

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Pickering, K.E., Thompson, A. M., Kim, H., DeCaria, A. J., Pfister, L., Kucsera, T.L., Witte, J.C., Avery, M.A., Blake, D.R., Crawford, J.H., Heikes, B.G., Sachse, G.W., Sandholm, S.T., and Talbot, R.W., Trace gas transport and scavenging in PEM-Tropics B South Pacific Covergence Zone convection, J.Geophys. Res., 106, 32, 591-32,602, 2001.

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Backward trajectories

The Reviewer suggested that the AOD values should be grouped with respect to long trajectories (strong winds), short trajectories (stagnant conditions) and trajectories that never were over land (only North Sea from the north).

First of all, I would like to confirm that all information about the backward trajectories was analyzed. It is not true that the trajectories were not taken into account.
The approach suggested by the Reviewer is very interesting. Unfortunately we are not able to apply it to the data set we have. The reason is very simple. In our data set all trajectories were over land, even the trajectories from the North Sea were over land (UK). The only long trajectories were observed in winter. Therefore, I am afraid that this approach would not give more information.

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SECTION 3: Data overview

Figure 2.
Following the Reviewer's suggestion the Figures were changed. Each of them presents the daily mean values (open circles) and the monthly mean values (columns)

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with the standard deviation as error bars for each monthly value.

Table 1.
This Table presents the most probable values of the aerosol optical depth and the Angstrom coefficient for a given month. The Table doesn't present the monthly means and the standard deviation because these values are already presented in Figure 2, and also they are available on the AERONET web page. It would be nothing new to repeat these numbers again.

Figure 4, Table 2 and eq.3

I would like to make a comment here that the meaning of importance is very relative.

Figure 4 as well as the equation 3 and Table 2 demonstrate how based on the Angstrom coefficient values the relative concentration of BC to PM10 (BC/PM10) can be roughly estimated. This relation has a large potential. It is much easier to make optical measurements than chemical ones. The Angstrom coefficient can be determined from sun photometer measurements or even from the satellite measurements. Taking these arguments into account we can see that this kind of relation can have a large application in the first estimate of the relative BC changes.

However, to find a compromise between the Reviewer's comments and our point of view, the following changes were introduced:
Table 2: two columns ($\tau_A(555)$ and PM10) were replaced by the mean values and the standard deviation of BC/PM10.
Eq.3 : The equation is based on the numbers listed in Table 2 therefore following the suggestion of the Reviewer this equation was removed.

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Figure 4: The median values on this Figure were replaced by the mean values and the standard deviation. It is clear that the maximum observed for the median values is also present for the mean values.

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SECTION 5: Application of the EOF method

In response for the Reviewer's suggestion that it would be nice to visualize the time series of h_1, β_{i1} and the deviation from the mean itself for a certain time period, we added a few comments to clarify Eq13.

Important: h_1 is a vector consisting of 4 numbers (one number for one wavelength). The mean spectrum is also a vector consisting of 4 numbers, where each number is a TRUE MEAN VALUE found for a given wavelength.

Example.
If my input data set consists of 50 measurements of the aerosol optical depth τ_A, I can create an input matrix (50x4), where number 4 corresponds to 4 wavelengths: 440nm, 670nm, 870nm and 1020 nm. Equation 13 tells that instead of analyzing 200 numbers I can present the input data in the simpler form by using the eigenvector (4 numbers), the mean spectrum (4 numbers) and the amplitude function β_{i1}. The differences between all my 50 measurements are included in the product: h_1x β_{i1}, where beta is a number (one number for one measurement).

Demonstration of the product h_1x β_{i1} is not very easy because in principle it would require making a 3D plot. I am afraid that the plot could be "too busy" .

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Table 3.
Table 3 was slightly modified. The mean values of the aerosol optical depth at 555 nm were added with their standard deviation. In that way a reader who wants to know the standard deviation at this particular wavelength can also have this information. If I would present all mean values and their standard deviations I would hear that the Table is "too busy".

To reply for the Reviewer's comment what are α and γ, the reference to the equation 1 was added, and the equation 1 was modified to be:
$\tau_A(\lambda) = \gamma\lambda^{-\alpha}$,
where α is the Angstrom coefficient.
In that way, the values of the mean aerosol optical depth and the eigenvectors at a given wavelength can be easily found, using the number from Table 3 and equation 1.

I would like to make a comment that the reason of application of the EOF method was to introduce a new element to the data analysis. Some elements e.g. mean value, in the "classical "approach and in this EOF approach are the same. The classical mean value is still the same mean value, but instead of one single number I can use the "mean vector" consisting of 4 numbers: 4 mean values at 4 wavelengths. Instead of the standard deviation I use the eigenvectors and the amplitude function.

Table 4.
Following the reviewer's comment two columns were deleted, i.e. BC/PM10 and WD (deg).

Figure 7, Figure 9 Figure 10.
Figure 7:

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Following the Reviewer's comment the standard deviation was added to the mean values of the aerosol optical depth. I would like to underline that the mean value of the aerosol optical depth presented in Figure 7 is THE TRUE MEAN VALUE.

That's true that Figure 9 is a continuation of Figure 7. Figure 9 presents the aerosol volume size distribution corresponding to a given aerosol optical depth spectrum. If the amplitude function is close to zero, the input aerosol optical depth (see eq. 13 and Figure 6) is equal to the mean aerosol optical depth. In the same way as the maximum/minimum amplitude identifies the single events corresponding to the maximum/minimum aerosol optical depth, the amplitude close to zero identifies the single events corresponding to the mean aerosol optical depth. Figure 9 illustrate the aerosol volume size distribution corresponding to a given "single event". Figure 9 gives the physical interpretation to the mathematical results. Figure 10 presents the examples of the backward trajectories for these "single events".

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