Atmos. Chem. Phys. Discuss., 3, S2672–S2678, 2003
www.atmos-chem-phys.org/acpd/3/S2672/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Saharan dust events at the Jungfraujoch: detection by wavelength dependence of the single scattering albedo and analysis of the events during the years 2001 and 2002" *by* M. Collaud Coen et al.

S. Martin (Editor)

smartin@deas.harvard.edu

Received and published: 22 May 2004

The authors have provided me via e-mail the following responses to the reviews. -Scot Martin, Editor

Answer to the refereeŠs comments on ŞSaharan dust events at the Jungfraujoch: detection by wavelength dependence of the single scattering albedo and analysis of the events during the years 2001 and 2002Ť by M. Collaud Coen et al.

We would like to thank the referees for their helpful comments and we believe that they helped in improving the quality of the paper. Below we describe how we accommo-

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

dated the refereesŠ comments in the revised version.

Common answers to all refereeŠs comments on the calculation of the absorption coefficient and the determination of the C constant

The absorption coefficient was determined at 7 wavelengths by an aethalometer (AE 31, Magee scientific). To calibrate the aethalometer two factors were introduced (Weingartner et al., 2003) 1) The C factor is designed to correct all artefacts caused by the unloaded filter, that is the multiple scattering of the light beam at the filter fibres. It may depend on the nature of the filter and the apparatus used. It was found to be independent on the wavelength, on the filter loading and on the nature of the loading. This C factor was experimentally determined for the aethalometer during a chamber study to be 2.14ś0.21. This value was applied to this field study. 2) The empirical R function accounts for any other effects measuring artifacts caused by the deposited particles, and varies with the amount of aerosol particles embedded in the filter (shadowing effect), and the optical properties of the deposited particles (scattering, which enhances the absorption measurement). This shadowing effect has been found to be negligible for aged particles. Since particles arriving at the Jungfraujoch are always aged aerosols, the R function was set to unity for all aethalometer measurements performed at the Jungfraujoch. The correction of the aethalometer data used in this paper is the best one that is currently available for this instrument. It was deduced in a chamber calibration experiment, using artificially coated soot particles. Indeed it does not necessarily apply also to aged tropospheric aerosols (such as Saharan dust particles). However, at the moment it is not possible to perform a similar calibration experiment (determination of the absorption coefficient as the difference between the extinction coefficient and the scattering coefficient) at the Jungfraujoch due to the low sensitivity of available methods for extinction measurements. An intercomparison between an aethalometer, a particle soot/absorption photometer (PSAP) and a multi angle absorption photometer (MAAP) has been recently done (CLACE 3, February-March 2004) at the Jungfraujoch, and the calibration of the aethalometer will be reviewed in the near future based on a

ACPD

3, S2672–S2678, 2003

Interactive Comment

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

detailed analysis of these data. The scope of this paper is however not to publish real absorption coefficients and single scattering albedo values, but to analyse their wavelength dependences. Since C is only a multiplying factor, it has no influence on the single scattering albedo exponent. A modification of the calibration value C will thus have no effect on the new SDE detection method and will therefore not change the results of this paper. In addition, a small dependence of C on the wavelength will not effect the conclusion of this paper (i.e., a change in the wavelength dependence of the single scattering albedo for Saharan dust episodes). In fact, this conclusion was in the meantime confirmed by other authors (Höller et al., 2003).

Specific answers to Anonymous Referee #1:

- The Bond correction was not applied to the PSAP data. The slope of 1.25 between the PSAP and aethalometer data underlines however the importance of this correction. Since this comparison between both instruments was not the aim of the present study and these data are not further used in the paper, we decided not to perform a more detailed analysis. Such a study will be done for the above mentioned intercomparison with the CLACE 3 data.

- We believe that the detailed description of the meteorology which led to SDE yields important information to characterize and understand Saharan dust events in the Alps. We will therefore keep them in this paper.

Specific answers to Anonymous Referee #2

- Correction of the scattering coefficient for the truncation error: We have done a truncation correction (Anderson and Ogren, 1998) which takes into account the size of the aerosol through the scattering exponent (which is nearly identical to the Angstrom exponent). The applied correction is greater for larger aerosol particles. A correlation between the angular and truncation corrections and the scattering exponent has been studied by Nessler et al. (2003) for a lot of different aerosol size distributions usually found at the Jungfraujoch and for all three wavelengths used by the nephelometer. The

ACPD

3, S2672–S2678, 2003

Interactive Comment

correlation is very good for small particles, but the dispersion of the points becomes important for coarse mode aerosol. The total error on the correction is very low for small particles (95% confidence bound for the total correction = 3%), but becomes larger for Angstrom exponent smaller than 1.5 (95% confidence bound for the total correction = 17%). However, the main uncertainty for coarse aerosol is due to the error on the determination of the Angstrom exponent, which is vanishing. Our new SDE detection method is precisely based on the vanishing of this exponent. The error on the scattering coefficient is therefore maximal for coarse aerosol, but we are interested only on its spectral behavior. Alfaro et al. (2003) take into account the size distribution to compute the scattering coefficient correction. Since they measured separately fine and coarse mode aerosols, they applied a different correction for supermicrometer size range particles. We have no separate measurements for fine and coarse mode aerosols and also no particle size distribution for SDE. Such a different correction for supermicrometer particles is therefore not possible.

- Problem of the non-sphericity of the mineral aerosol: The truncation correction is very good for small particles, but becomes more uncertain for coarse mode aerosol (scattering exponent smaller than one). The error due to the non-sphericity of the particles is therefore probably far smaller than the found dispersion. Moreover, Anderson and Ogren (1998) declare that, because the angular correction factor arises mostly due to near-forward scattering which is quite insensitive to shape effects, the additional uncertainty due to the non-sphericity should be small. For all these reasons, we found that the applied correction for the truncation is the best one considering the state of the studies in this area.

- Accuracy of SSA calculation: We are aware that a detailed and complete analysis of the accuracy of the single scattering albedo would support our new detection method for SDE. The main error that is not corrected in this paper is due to the drying of the aerosol before the measurements. As explained in the paper, we are well aware that corrections for the influence of relative humidity (see Nessler et al., 2003) are

ACPD

3, S2672–S2678, 2003

Interactive Comment

of prime necessity to obtain real scattering coefficients. Similarly, a statistical error on the aethalometer measurements can be mentioned, but the main uncertainty is hidden in the determination of the C calibration factor. As explained above, it is actually not possible to give a better value for this C factor, since a check of the instrument calibration is a difficult task at this remote site. An estimation of the uncertainty on the single scattering albedo would presently not take into account the main sources of uncertainty that are still under study. However, the purpose of this article is not to publish the real values, but to correlate the inversion of the spectral behavior of the single scattering albedo with the presence of Saharan dust. As explained in the paper, we are convinced that the inversion of the single scattering albedo is a real phenomenon due to the presence of mineral dust. It can be justified by theoretical considerations (Bergstrom et al., 2002), numerical simulations (Sokolik et al., 1999) and similar behaviour that have been found or suspected by other authors (Höller et al., 2003, Dubovik et al., 2002) . A serious estimation of the error on the single scattering albedo would actually delay the publication of this paper by several months without affecting the conclusions concerning the spectral behavior. We therefore propose not to include such an estimation in this paper.

Specific answers to Anonymous Referee #3

- We agree, the title is too long. We shorten it in the revised version: ŞSaharan dust events at the Jungfraujoch: detection by wavelength dependence of the single scattering albedo and a first climatology analysis.Ť

- The required change in the abstract was done.

- We introduced 3 recent references on the influence of mineral dust on climate forcing and precipitation in the introduction.

- Calculation of the absorption coefficient: see above.

- We included the missing reference (Holben at al., 2001) and also introduced the one of Dubovik et al. (2002), since his study lead to similar results as ours concerning the single scattering albedo wavelength dependence of mineral dust, based on an analysis of AERONET data.

- The chemical analysis was performed in total on 23 filters. In 25 % of these cases, Saharan dust events were detected by the inversion of the wavelength dependence of the single scattering albedo. The presence of mineral dust in the sample was determined by our new detection method and the differences in chemical composition were analysed according to this discrimination. A sentence clarifying this point will be added in the revised manuscript.

References

Alfaro, S.C., Gomes, L., Rajot, J.L., Lafon, S., Gaudichet, A., Chatenet, B., Maille, M., Cautenet, G., Lasserre, F., Cachier, H., and Zhang, X.Y.: Chemical and optical characterization of aerosols measured in spring 2002 at the ACE-Asia supersite, Zhenbeitai, China, J. Geophys. Res., 108, 8641, doi:10.1029/2002JD003214, December 2003.

Anderson, T.L., and Ogren, J.A.: Determining aerosol radiative properties using the TSI 3563 Integrating Nephelometer, Aerosol Sci. Technol. 29, 57-69, 1998.

Bergstrom, R.W., Russel, P.B., and Hignet, P.: Wavelength dependence of the absorption of black carbon particles: predictions and results from the TARFOX experiment and implications for the aerosol single scattering albedo, J. Atmos. Sci., 59, 567-577, 2002.

Dubovik, O., Holben, B., Eck, T.F., Smirnov, A., Kaufman, Y.J., King, M.D., Tanré, D. and Slutsker, I.: Variability of Absorption and Optical Properties of Key Aerosol Types Observed in Worldwide Locations, J. Atmos. Sci., 59, 590-608, 2002.

Höller, R., Ito, K., Tohno, S., and Kasahara, M.: Wavelength-dependent aerosol single-scattering albedo: Measurements and model calculations for a coastal site near the Sea of Japan during ACE_Asia, J. Geophys. Res., 108, 8648,

ACPD

3, S2672–S2678, 2003

Interactive Comment

doi:10.1029/2002JD003250, December 2003.

Nessler, R., Weingartner, E., and Baltensperger, U.: Adaptation of dry nephelometer measurements to ambient conditions at the Jungfraujoch: a theoretical study, submitted to Environ. Sci. Technol., December 2003.

Sokolik, I.N., and Toon, O.B.: Incorporation of mineralogical composition into models of the radiative properties of mineral aerosol from UV to IR wavelengths, J. Geophys. Res., 104, 9423-9444, 1999.

Weingartner, E., Saathof, H., Schnaiter, M., Streit, N., Bitnar, B., and Baltensperger, U.: Absorption of light by soot particles: Determination of the absorption coefficient by means of aethalometers, J. Aerosol Sci., 34, 1445-1463, 2003.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 5547, 2003.