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Atmospheric Chemistry and Physics Discussions

Interactive comment on "SAWA experiment – properties of mineral dust aerosol as seen by synergic lidar and sun-photometer measurements" *by* A. E. Kardas et al.

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In reply to Interactive comment on "SAWA experiment - properties of mineral dust aerosol as seen by synergic lidar and sun-photometer measurements"

Thank you for pointing out many useful references. We are examining some of them now. We are happy to find, that some of our results are comparable with the ones show in Muller et al. (2003) and Dubovik et al. (2006) (e.g. the desert dust aspect ratios). We regret that the latter was published shortly before our submitting the paper on SAWA to ACPD (September 2006) and we had not the occasion to study it then. We will account for them in the revised version. We agree that our paper lacks error analysis. This will be corrected in the revised version of the article.

Replies to specific comments:

1.Page 12156, 15:

The explanation of the abbreviation SAWA is Sahara Aerosol over Warsaw. We are sorry for not including it in the paper.

2.Page 12157, 9-12:

The Hysplit backward trajectories, not mentioned in the paper, has been calculated. They clearly show the dust advection from the northern part of Arabian desert as well as from Sahara in the middle troposphere over Warsaw. These informations may be included in the revised version of the article.

3.Page 12157, 13-17:

The Microtops sun-photometer has the accuracy of 1-2 per cent (http://www.solar.com/sunphoto.htm). The comparison of the data collected at our observational site and at the AERONET station in Belsk (about 50 km south of Warsaw) gave satisfactory results. The advantage of the measurements taken during the campaign over the AERONET data is that the former were made only in the cloud free conditions, therefore no automatic filtering procedure (which sometimes fails) was necessary.

4.Page 12157, 18-28:

The parameters of the lidar used in our experiment and relevant to the effect of geometrical compression can be summarized as follows:

Laser:

1) beam diameter at the out put: 6 mm

2) beam full-divergence for the 532 nm wavelength (measured in a far field): 0.0015 rad

3) inclination between the laser and the receiver axes: adjustable maximal 0.3 rad

4) displacement between the laser and the receiver axes: 170 mm

Receiver:

1) Telescope primary parabolic mirror diameter: 200 mm

2) Telescope secondary elliptic mirror diameter (ang. of turn 40): minor axis 45 mm

3) Primary mirror focal length: 800mm

4) Field-stop diameter (the field stop is placed in the focal plane of the mirror): 2 mm

Using the above parameters and assuming the laser beam and the telescope axes were parallel the region of the incomplete overlap in our experiment was restricted to approximately 550 m above the lidar i.e. much less than expected by the reviewer. This distance was further reduced by introducing a small inclination angle between the telescope and the laser axes. The method of suppressing the geometrical compression by the laser beam tilt is in details described in (Stelmaszczyk, 2005). It requires that the laser beam stays completely inside the telescope's filed-of-view, which is a case providing the inclination angles not exceeding half of the difference between the telescope's field-of-view and the laser beam divergence. In our experiment the receiver and transmitter axes were arranged exactly in this way.

With the method describe above the region of the geometrical compression can be reduced to the half of the one typical for a typical lidar arrangement (parallel axes of the receiver and the laser beam), meaning that the uncertainties introduced by the incomplete overlap are limited to the heights of 260- 280 m.

The appropriate correction is performed on the signal, therefore the modification of the aerosol optical depth measured by a sun-photometer is not necessary. The details may be added to the revised version of the article.

5. Page 12158, 1-9 and page 12163, 1-11:

Depolarization of light scattered in the pure molecular atmosphere results from the air anisotropy. The measured value of the depolarization of this type depends strongly on the bandpass characteristics of filters used in the lidar detection unit. In case of ultra-narrow bandwidths light depolarization can be practically neglected, as the depolarization in case of elastic Cabannes scattering is typically in a sub-percent range. For example, for 532 nm wavelength used in our experiment the expected depolarization would be equal to 0.36 per cent (She, 2001). If spectrally broader filters are used the Rayleigh scattering (Cabannes plus rotational Raman scattering) characteristic depolarization cannot be neglected. Again for 532 nm wavelength the scattering of this type would lead to the depolarization of 1.44 per cent (Biele et al., 2000). This is also an expected molecular depolarization value for our lidar, in which a commercial 1 nm FWHM interference filter is used.

Much larger objects of non-spherical shape e.g. dust or ice cloud particles depolarize light much more efficiently compared to air molecules. For example, Platt et al. (1987) have reported the depolarization of 15-50 per cent for thin cirrus clouds (Platt et al., 1987). For such strong depolarizing objects a 1 or 2 per cent error resulting from Rayleigh scattering can be neglected. It is true, however, that the precise estimation of the aerosol depolarization requires taking into account the molecular contribution.

With a typical value of the scattering ratio recently reported for desert dust aerosols (Iwasaka et al., 2003; Zhaoyan et al., 2004) and the molecular depolarization ratio of 1.44 per cent we can estimate that the molecular depolarization correction for the Sahara dust observed in our experiment the (volume depolarization 10-16 per cent) is in the order of 9-15 per cent (Liu et al., 2002). Following the suggestion of the referee we will include this correction in the final version of the manuscript.

As far as the receiver efficiencies for the cross and parallel polarizations are concerned we note here that in order to minimize the depolarization error caused by the receiver optics all bending mirrors of our detection are coated with the phase optimized dielectric coatings. In this way the elliptical polarization is avoided and the cross-talk

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between parallel and perpendicular polarizations is effectively reduced. The only component with an ordinary (not phase optimized) high reflection coating is the telescope's primary mirror, however, the nearly normal incidence of the incoming light together with the large curvature radius of this mirror leads to the depolarization of less than 1 per cent. To compensate the electro-optical efficiencies for parallel perpendicular detection channels the calibration routine is performed before each measurement series. First, the laser polarization is matched to the detection polarization axis and the lidar signal for the parallel polarization is measured. Then, the laser polarization is turned by 90 deg and the same lidar signal is measured with the cross polarization detection channel. The gain of the photomultiplier used for the cross polarization is next set to match the signal intensity of the parallel polarization. Because the photo-multipliers used for parallel and cross polarizations are similar (the same manufacturing series) the similar HV is applied in both cases. This allows us to assume the same gain factor for strong and weak signals. Finally, the original laser polarization (corresponding to the parallel laser polarization measured by the parallel detection channel) is retrieved and the measurements are performed. During the calibration the laser polarization is turned by the zero-order half-wavelength plate mounted at the laser beam output. A clean polarization of light after the half-wavelength plate is accomplished by the Glan Laser prism, which is located directly before the retardation plate.

6. Page 12159:

The description of the Klett method was extended on the request of the editor. In order to deal with the two layer system, the Klett algorithm was used for each layer separately, so the lidar ratio was different for each layer. The lidar ratios were adjusted on the basis of the estimated optical depths of layers, therefore the a priori information on the urban haze+mineral dust mixtures were unnecessary to run the algorithm.

7. Page 12160, 10: See point 4.

8. Page 12160, 14-16:

We checked that the algorithm is insensitive to the start value of the lidar ratio.

9. Page 12160, 16: See point 6.

10.Page 12161-12162:

The description of the T-matrix methodology itself is brief, because it is well described in the referenced paper (Mishchenko and Travis, 1998). Of course, details can be added on the parameters used in the simulations, like:

aspect ratios: 0.25 - 4.0,

mode radii: 0.01- 1.0 microns,

mode width: 0.5.

The instability of the T-matrix method for the larger particles and aspect ratios differing decidedly from 1 was observed during the simulations. However, observed values of Angstrom exponent and depolarisation are consistent with the T-matrix calculations for the size and aspect ratio ranges, for which no problems occurred.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 12155, 2006.

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