Profiling of fine and coarse particle mass: case studies of Saharan dust and Eyjafjallajökull/Grimsvötn volcanic plumes” by A. Ansmann et al., Atmos. Chem. Phys. Discuss., 12, 13363–13403, 2012.

Short comment by G. P. Gobbi (ISAC-CNR, Rome, Italy)

The manuscript addresses the retrieval of profiles of mass-specific extinction coefficients on the basis of co-located polarization-Raman Lidar profiles and sun-sky photometer inversions. The point of using sun-sky radiometers inversions to evaluate the extinction/volume relationships of fine and coarse aerosol modes is potentially good. Employing “pure” dust or “pure” ash depolarization as reference to separate fine and coarse aerosol components in the lidar trace may, however, bear some drawbacks. Here follow some relevant comments.

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Line 15-21:

The sentence is misleading and should be reconsidered: Extinction to Backscatter ratios (LR) are always needed to evaluate aerosol backscatter coefficients in aerosol-laden atmospheres. Raman lidars retrieve LR by means of minor assumptions on spectral extinction, Mie lidars require a full assumption. This latter assumption can be assisted by further knowledge about aerosol type. In this respect, depolarization or color ratios may help such a choice. In fact, the solution of the Mie-Lidar equation is commonly obtained in terms of extinction coefficients (Klett, Appl. Opt., 20, p211, 1981; Fernald, Appl. Opt., 23, p652, 1984). Some comments about the Raman technique retrievals can also be found in the Referee Comment C3792.

Furthermore, model relationships linking Backscatter to: 1) Extinction, 2) Surface area and 3) Volume for various aerosol types (Marine, Dust, Continental) have been published in 2001 (Barnaba and Gobbi, JGR-D, p.3005, 2001; correction in JGR-D, 10.1029/2002JD002340, 2002). These relationships have been validated in 2003 (Gobbi et al., ACP, p.2161, 2003) by comparing polarization lidar and in situ aerosol measurements. The model computing such aerosol optical properties is the same one that generated the Extinction/Volume relationships of Barnaba and Gobbi (2004) cited here. This to say that mineral dust volume (or mass) could be estimated from Backscatter observations with acceptable accuracy (e.g. Gobbi et al., ACP, p. 2161, 2003) before the Barnaba and Gobbi (2004) paper and that the latter originated from the two previous ones.

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Line 2: The term “Sun-Sky Photometers” should be used instead of “Photometers”.

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Line 12: Lidar depolarization measurements can be affected by a variety of uncertainties (bandpass-filter width, channels cross talk, calibration method, etc.). Lidar depolarization is, to some extent, “system dependent”. To provide the reader with a reference about the quality of the measurement, the manuscript should report both the receiver band-pass filter width and the degree of depolarization the Lidar system measures in “pure” molecular conditions (i.e., where the signal could be calibrated). These issues should also be commented in the text.

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Line 15: Depolarization of “pure” mineral dust has been observed to show a certain variability. For instance, after laboratory depolarization measurements Sakai et al. (Appl.Opt, p. 4441, 2010) report “The values obtained from Asian and Saharan mineral particles were 0.39±0.04 (mean±standard deviation) for a high number of concentrations in the supermicrometer range and 0.17±0.03 to 0.14±0.03 in the submicrometer range”. The first values are close to the ones (0.41±0.008) observed in Crete in 1999 and reported in a paper employing lidar depolarization to separate various aerosol types, including Saharan dust (Gobbi et al., Atmos. Env., p.5119, 2000). The lower depolarization values are closer to what is often measured after long-range transport. References in Sakai et al (2010) as well as in Miffre et al., (GRL, 2011) confirm such a variable behavior of depolarization. This to say that it is incorrect to expect and assume a universal “pure dust depolarization” level and that a depolarization decrease in dust clouds (as well as in volcanic plumes) can be due to both decrease in effective size or mixing with non spherical aerosols. These points and references should be addressed in the paper.

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lines 22-24: In fact, Barnaba and Gobbi(2004) show the ratio Ext/Vol to vary mostly for dust-like particles. Conversely, continental type aerosols show quite a constant behavior of such ratio.

Line 25: Coarse mode Aeronet inversions are size limited (<15um). Could this introduce errors in the presence of large volcanic/dust particles?

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Lines 24-25: The authors should address the fact that several Lidar systems are “blind” below a certain height (overlap issue). An important part of the optical depth (particularly in winter months) observed by the sun-sky photometer may then be not seen by the Lidar. Furthermore, cirrus clouds as well as aerosol inhomogeneity could also introduce biases in the sun-sky photometer inversions. To provide a “general approach” the authors should specify how to address these issues. Finally, the manuscript should indicate which Aeronet data (inversion method (1 or 2) and level (1, 1.5, 2)) is employed in each of the case studies addressed.

Sections 3.1 and 3.2

The authors should address the issue of Aeronet data quality and time coincidence between Lidar and Sun-Sky photometer observations. For instance, very few Level 1.5 and 2 measurements were available on 29-MAY-08 in Leipzig, and these ended at 17 UTC (e.g., Aeronet site). Conversely, the reported lidar observations (Fig 2) span the 21.47-23.20 time range. How to address the relevant (4-6-hours) time variability of dust properties? A similar issue could be raised for the 22-JAN-08 Capo Verde Aeronet measurements which ended at 18.30 UTC while Lidar profiles start at 20 UTC (Fig 3).

Table 2: The values reported from Barnaba and Gobbi (2004) are wrong:

In fact, Fig.13 of that paper (reported below) shows that over the extinction coefficient range (5-300 Mm^{-1}) k_{ext} varies from 3.56 to 3.44 $m^2 g^{-1}$ for continental aerosols (density=1.6 g cm^{-3}) and from 2.7 to 0.46 $m^2 g^{-1}$ for Saharan dust (density=2.6 g cm^{-3}). The maximum value of 1.35 reported in Table 2 for Saharan dust is found (in B&G2004) for Ext=20 Mm^{-1}, conversely, the reported minimum value of 0.30 is never found. Fig 13 (B&G 2004) indicates dust k_{ext} can strongly vary as a function of Ext and that at the typical extinction levels encountered in Southern Europe (20-200 Mm^{-1}, e.g. Fig 13b) k_{ext} span the range 1.5-0.54 $m^2 g^{-1}$.

As specified before, continental aerosols show a very weak variation in k_{ext} (3.44 to 3.56 $m^2 g^{-1}$, Fig.13, B&G 2004) much weaker than the range (3-4 $m^2 g^{-1}$) reported in Table 2 of this manuscript.

Table 2 should be corrected according to the previous discussion.

Figure 13 from Barnaba and Gobbi (ACP, p2367, 2004)

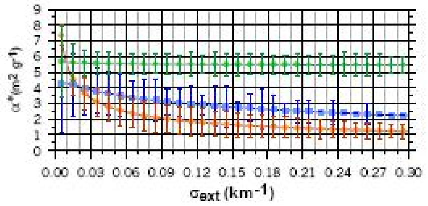
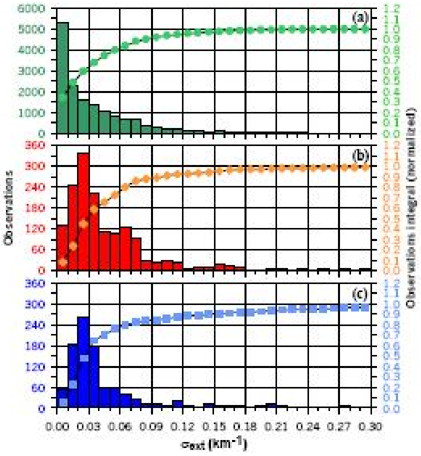


Fig. 13. Modeled behavior of the mass-to-extinction efficiency, α (m^2/g), versus the aerosol extinction coefficient, σ_{ext} (km^{-1}), computed at the lidar wavelength of 532 nm for the three different aerosol types: maritime (blue squares), continental (green bullets) and desert dust (orange diamonds). Note that the α parameter is given for unit density (i.e. $\alpha=\alpha^*=\sigma_{ext}/V\cdot\rho$, with ρ=1 g/cm^3) for each aerosol type. The σ_{ext} values reported in the plot were obtained binning 20 000 simulated σ_{ext} with a 0.01 km^{-1} step. The corresponding mean α^* value associated to each bin is reported with its variability (±1 standard deviation, error bars).



I am afraid this “short comment” is longer than the two Referee comments. That's the strength of ACP.

Gian Paolo Gobbi