RESPONSE TO THE REVIEWER 1.

We strongly appreciate the helpful comments of the reviewer with valuable suggestions and useful remarks, patently improving this work.

Next, we will try to answer and explain, in any case, all the questions. In addition, a new Figure and two more Tables have been added in the manuscript as a consequence of responding the second reviewer's comments. Then, the Figures and Tables have been renumbered (starting from Figure 4 and Table 3). As a result the text has been accordingly modified to contain these changes, including new required calculations and results. In general, a revised manuscript containing all the necessary modifications is also available.

General Comments

A general comment to this paper is that in specific parts the text should be improved, regarding the English language.

The manuscript has been revised regarding the English language. A number of sentences have been rewritten in order to clarify and simplify the reading.

Specific Comments:

Abstract-page 27017

Replace "relatively located close" by "located relatively close". Replace "over both" by "both over" Replace "showed the Saharan origin of the dust intrusion" by "revealed the Saharan region as the dust source of the dust intrusion" Replace "Meteorological situation" by "Meteorological conditions" Replace "kept unchanged" by "kept nearly unchanged"

All these proposed replacements have been introduced in the text.

Main text

page 27018

After "Mediterranean areas" add citations (Dulac et al., 1992; Moulin et al., 1998; Papayannis et al., 2008). New references to add:
Dulac, F., P. Buat-Ménard, D. Sutton, D. Tanré, G. Bergametti, and M. Debois (1992), Assessment of the African airborne dust mass over the Western Mediterranean Sea using Meteosat data, J. Geophys. Res., 97, 2,489–2,506, doi:10.1029/91JD02427.

Moulin, C., et al. (1998), Satellite climatology of African dust transport in the Mediterranean atmosphere, J. Geophys. Res., 103, 13,137–13,144, doi:10.1029/98JD00171.

All these references suggested by the reviewer have been introduced in the text and accordingly added to the references list.

page 27019

After "for that purpose" add references from Earlinet and Aeronet studies.

In the Introduction section, a short sentence together with a few references have been added after "for that purpose" for clarification of the general scheme in that context. That is: "In general, this synergy between lidar and Cimel-photometry observations has also been widely used for mineral dust research (i.e., Ansmann et al., 2003; Müller et al., 2003, 2010a,b; Papayannis et al., 2005; Mona et al., 2006; Pérez et al., 2006; Papayannis et al., 2008) and other aerosol particles (i.e., Landulfo et al., 2003; Sicard et al., 2011)."

New references have accordingly added to the references list:

Müller, D., Weinzierl, B., Petzold, A., Kandler, K., Ansmann, A., Müller, T., Tesche, M., Freudenthaler, V., Esselborn, M., Heese, B., Althausen, D., Schladitz, A., Otto, S., and Knippertz, P.:Mineral dust observed with AERONET Sun photometer, Raman lidar, and in situ instruments during SAMUM 2006: Shape-independent particle properties, J. Geophys. Res., 115, D07202, doi:10.1029/2009JD012520, 2010a.

Sicard, M., Rocadenbosch, F., Reba, M.N.M., Comerón, A., Tomás, S., García-Vízcaino, D., Batet, O., Barrios, R., Kumar, D., and Baldasano, J.M.: Seasonal variability of aerosol optical properties observed by means of a Raman lidar at an EARLINET site over Northeastern Spain. Atmos. Chem. Phys., 11, 175–190, 2011.

Before and after "Dulac et al., 2009" add more references. Replace "Perez" by "Pérez" After "Pappalardo et al., 2010" add "Mamouri et al., 2009".

New reference to add:

Mamouri et al., Validation of CALIPSO space-borne-derived attenuated backscatter coefficient profiles using a ground-based lidar in Athens, Greece, Atmos. Meas. Tech., 2, 513–522, 2009.

After reviewer's suggestion, new references have been introduced in the text and accordingly added to the references list.

page 27024

Replace "s/n" by "SNR".

It has been replaced in the text.

page 27025

Replace "signal is registered in" by "signals are registered with" Replace "and with" by "and" Replace "the lidar ratio" by "the columnar integrated lidar ratio" Replace "the corresponding extinction" by "the guessed "extinction"" Replace "characterizing" by "characterize" "For conversion of…" This methodology adopted is not sufficiently supported. More explanations should be given by the authors, to explain why they adopt this.

All those replacements proposed by the reviewer have been introduced in the text. In addition, according the reviewer's comments, the following sentence: "For conversion of the micrometer particle number size distribution to the volume-metric one, spherical particles with an effective particle density of 2.0 g cm^{-3} are assumed by using the algorithm as described by Sioutas et al., (1999)", has been replaced in the text, in order to explain in more detail the methodology adopted in this point, by the next one:

"Conversion of the aerodynamic into mobility diameter of the micrometer particle number distribution is performed by using the algorithm described by Sioutas et al. (1999) and assuming an effective particle density of 2.0 g cm^{-3} for spherical particles. This value was obtained at ARN site (Fernández-León et al., 2010) by comparison between the mass concentrations measured with a SMPS-APS system and a DLPI (Dekati Low Pressure Impactor). In GRA case, the estimated density was calculated from chemical composition averaging by using the GRA aerosol PM10-PM1 database (Titos-Vela et al., 2010). The density for each chemical constituent reported by Khlystov et al. (2004) was also assumed, but considering a density of 2.2 g cm^{-3} for marine and crustal components."

Besides, the following three references have been also added to the references list:

Fernández-León, M., Sorribas, M., Alados-Arboledas, L., de la Morena B: Aerosol particle microphysical properties during the 2009 summer in El Arenosillo. IV Spanish Meeting on Aerosol Science and Technology (RECTA), Granada (Spain), Extended Abstract, A3-1:-A3-6, ISBN: 978-84-693-4839-0, 2010.

Khlystov, A., Stanier, C., Pandis, S.N: An algorithm for combining electrical mobility and aerodynamic size distributions data when measuring ambient aerosol. Aerosol Sci. Tech., 38 (S1): 229-238, 2004.

Titos-Vela, G., Foyo-Moreno, I., Lyamani, H. Olmo, F.J., Alados-Arboledas, L: Estimating absorption and scattering efficiencies for particulates PM10 at urban site. IV Spanish Meeting on Aerosol Science and Technology (RECTA), Granada (Spain), Extended Abstract, A11-1:-A11-6, ISBN: 978-84-693-4839-0, 2010.

page 27026

Replace throughout the text "Angstrom" by "Ångström"

It has been replaced throughout the text.

page 27028

All heights should be given above mean sea level (amsl).

In air masses trajectories calculations by using HYSPLIT model only four options to plot vertical coordinates are possible: 1) Pressure (the vertical trajectory plot coordinate is in hPa), 2) Meters above ground level (the vertical trajectory plot coordinate is in meters above ground level, a.g.l.), 3) Isentropic (an isentropic coordinate display requires the trajectory to have been run in those coordinates), and 4) Meteo-vab., forcing the display of one of the selected meteorological variables along the trajectory rather than a trajectory vertical position coordinate.

In this work the vertical coordinate option 2 has been used. Backtrajectories calculated with similar vertical coordinates have widely been reported in the literature (i.e., see below a few references).

End of section 3. I would never trust air mass trajectories below 1 km height (Above ground level). Therefore, 500 m above ground should be omitted.

HYSPLIT model does not take into account vertical processes and therefore we agree with the referee that accuracy might be degraded inside the BL. Studies of

local pollution transport might result in errors when using low-level trajectories. Errors in HYSPLIT trajectory calculations normal to the direction of flow are 10-30% of the distance travelled after 24 h (Draxler, R.R., and Hess, G.D.: An overview of the HYSPLIT 4 modeling system for trajectories, dispersion, and deposition, Australian Meteorology Magazine, 47, 295-308, 1998).

However, most of the trajectories path takes place over ocean in the subtropical/low mid-latitude region under study where local convective processes are of minor importance. In addition, Saharan dust plumes are hundreds of km wide. Putting all this together, we still believe that trajectories at 500 m a.g.l. provide useful information of the processes we are studying. In particular, GDAS files including meteorological input data with a high spatial resolution of 1º x 1º have been used in the HYSPLIT model calculations to reproduce air masses backtrajectories for this work.

The use of HYSPLIT model for backtrajectory calculation at heights below 1 km (i.e., at 500 and 750 m) is usually found in the recent literature. See for instance following references (not included in the references list of the manuscript):

Hondula D.M., Sitka L., Davis R.E., Knight D.B., Gawtry S.D., Deaton M.L., Lee T.R., Normile C., and Stenger P.J.: A back-trajectory and air mass climatology for the Northern Shenandoah Valley, USA. Int. J. Climatology, doi: 10.1002/joc.1896, 2009.

Markou, M.T., and Kassomenos, P.: Cluster analysis of five years of back trajectories arriving in Athens, Greece. Atmos. Research, 98, 2-4, 438-457, 2010.

McGowan, H., and Clark, A.: Identification of dust transport pathways from Lake Eyre, Australia using Hysplit. Atmos. Environ., 42, 29, 6915-6925, 2008.

Wang, P., Chen, H.Z., and Zhang, X.C.: Aerosol optical properties of regional background atmosphere in Northeast China. Atmos. Environ., 44, 35, 4404-4412, 2010.

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How the authors can support the criterion they have put (AOD500 > 0.15)?

The Sections 3.3 and 5.1.1 of the manuscript have been modified to incorporate the explanation to this reviewer's comment. A similar text to the following one has been introduced in the Section 3.3:

"In the basis of the results obtained by Dubovik et al. (2002), where high values of AOD were found to characterize turbid atmospheres affected by biomass burning, dust plumes or urban pollution as opposite to clean atmospheres dominated by oceanic aerosols (i.e., oceanic background aerosol loading was found to be related to AOD < 0.15), this threshold AOD of 0.15 is adopted in our work as a criterion to divide the aerosol loading into low and moderate/high contents.

In addition, a recent study on aerosol characterization from direct-sun AERONET observations in 39 stations (Basart et al., 2009) reports seasonal AOD and AE mean values of large aerosols fraction (corresponding to particles with AOD>0.15 and AE<0.75) for each station. In particular, AODs of 0.43, 0.35 and 0.28 and AEs of 0.37, 0.39 and 0.43 were obtained in springtime (March-May) for SCO, ARN and GRA sites, respectively.

Therefore, the final criterion adopted in our work for dust (predominance of coarse particles) evidence: non-dusty conditions with low AOD^{500} (< 0.15) and $AE^{440/675}$ > 0.5, and dusty conditions corresponding to moderate and high AOD^{500} (> 0.15) and $AE^{440/675}$ < 0.5, is supported, mainly but not only, by the AERONET data reported by those two works (Dubovik et al., 2002; Basart et al., 2009)."

The following references have been included, if not, in the references list:

Basart, S., Perez, C., Cuevas, E., Baldasano, J.M., and Gobbi, G.P.: Aerosol characterization in Northern Africa, Northeastern Atlantic, Mediterranean Basin and Middle East from direct-sun AERONET observations, Atmos. Chem. Phys., 9, 8265–8282, 2009.

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.

page 27031

Replace "no-dusty" by "non-dusty"

It has been replaced throughout the text.

I would never provide "extinction profiles" with a vertically pointing elastic scattering lidar. Therefore, extinction profiles shown (e.g. Fig. 5,6,7) should be omitted. I would provide -instead- only aerosol backscatter profiles, with error bars.

Following the reviewer's indication, Section 3.1.3 has been slightly modified in order to present more detailed lidar data retrieval information for backscatter/extinction coefficient calculation and lidar ratio estimation. The Section 3.1.3 stands now as follows:

"3.1.3 Lidar data processing for optical parameters retrieval

A Klett-Fernald-Sasano iterative inversion algorithm (Fernald et al., 1972; Klett, 1981; Fernald, 1984; Sasano and Nakane, 1984; Klett, 1985; Sasano et al., 1985) is applied to retrieve the height-resolved aerosol backscatter coefficients (molecular backscatter coefficients are obtained from local radiosoundings, if available). AERONET Aerosol Optical Depth (AOD) is used to constraint the algorithm convergence by 'tuning' the lidar ratio (LR, extinction-to-backscatter ratio) values. Once the AOD convergence is obtained (less than 10%), a height-constant LR is estimated (errors of 15% are found from AOD convergence uncertainty). Thus, the 'guessed' extinction coefficients can be retrieved, and a lidar-derived hourly-integrated AOD is calculated from day- and night-time measurements. As stated before, due to the large overlap uncertainties in the BL_{500m}, data in this range are disregarded and then a homogeneously mixed BL is assumed instead.

In the frame of SPALINET, a complete study on lidar system and data retrieval intercomparison (Sicard et al., 2009) was carried out. Indeed, both SCO and GRA lidars were involved in that study. Full-corrected data (overlap correction included) and then retrieved backscatter coefficients profiles were found to be inside the uncertainty values allowed as for the EARLINET quality control tolerances (Matthias et al., 2004) followed in that intercomparison, i.e., the mean and standard deviations between lidar systems stayed below the maximum allowed values fixed (20% and 25%, respectively, for backscatter at 532 nm). ARN system was tested against the Koldewey Aerosol Raman Lidar (KARL), managed by the Alfred-

Wegener Institute (AWI, Germany) and devoted to long-term Arctic aerosol observations. In particular, both lidars were vertically pointing under free-aerosol conditions for overlap approach in the near-range. Once overlap was estimated, full-corrected data and their uncertainties were obtained. Backscatter coefficients profiles were retrieved and compared to the KARL measurements in the near-range for polar tropospheric aerosols and in the far-range for PSC detection. Intercomparison results showed a good agreement on instrument performance and data retrieval between both datasets (Córdoba-Jabonero et al., 2008, 2009; personal communication of R. Neuber and C. Córdoba-Jabonero). "

At the same time, all these figures (Fig. 5-7) have been replaced by those with backscatter profiles (and error bars) instead of the previous extinction ones. They have also been renumbered and denoted as Fig. 6-8, respectively. As a result the text has been accordingly modified to contain these changes. The figures are now:
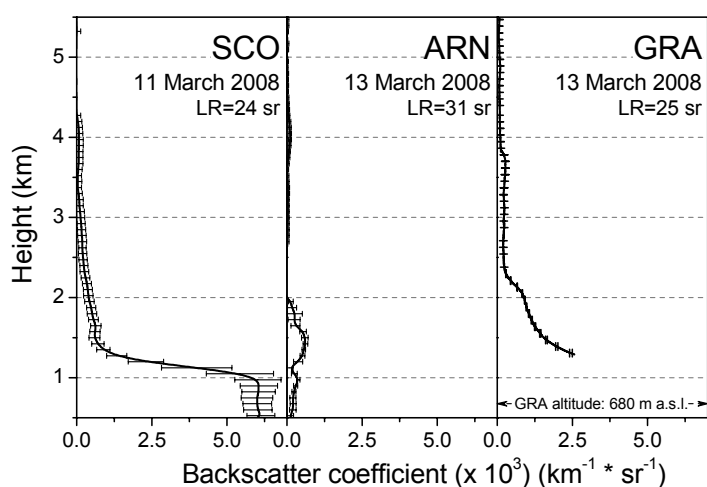

Figure 6. Height-resolved backscatter coefficients at 12:00 UTC (1-h averaged profiles) for non-dusty conditions over SCO site (left), and ARN (centre) and GRA (right) stations (GRA station altitude: 680 m a.s.l.). Both lidar-retrieved LR and date of measurements are indicated in each panel.
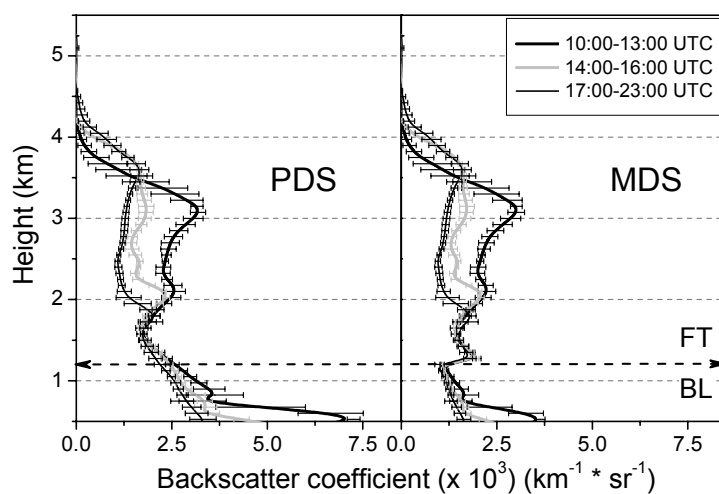

Figure 7. Height-resolved backscatter coefficients under dusty conditions over SCO site (13 March 2008) for the 'pure-dust scenario' (PDS) (left) and the 'mixed-dust scenario' (MDS) (right) at selected averaged times (see legend).
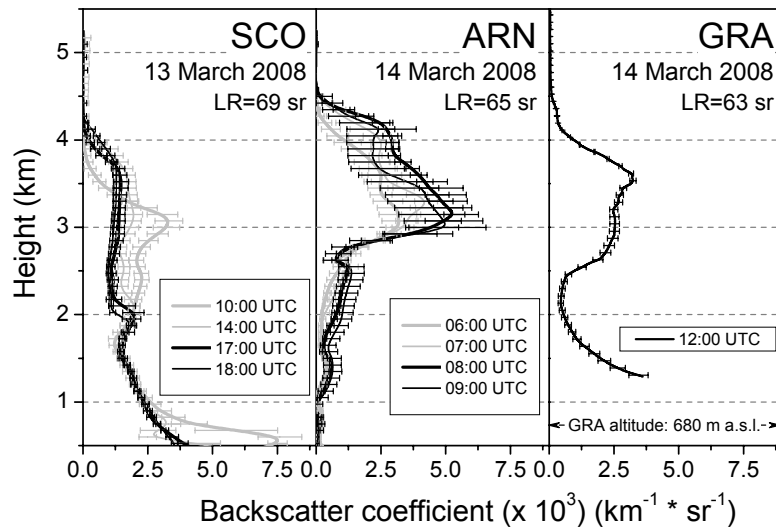
Figure 8. Height-resolved backscatter coefficients (1-h averaged profiles) at discrete times (see legend) under dusty conditions over SCO site (left), ARN (centre) and GRA (right) stations. Both lidar-retrieved LR and date of measurements are indicated in each panel.

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When CALIPSO data are referred, the authors should comment on the errors on the lidar ratio (LR) values used in the look-up Tables by CALIPSO.

This has been commented in the text (see Sect. 5.2.2), and the estimated LR errors for CALIPSO values (Omar et al., 2009) have also been included in Table 3. The text appears now as follows:

"CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation, http://www-calipso.larc.nasa.gov) LR-defined values are also included (Omar et al., 2009), showing an uncertainty of 30% as assumed (Liu et al., 2005) according to ground-based lidar measurements comparison (Voss et al., 2001; Liu et al., 2002)."

The new references have been added to the references list:

Liu, Z., N. Sugimoto, and T. Murayama: Extinction-to-backscatter ratio of Asian dust observed by high-spectral-resolution lidar and raman lidar. Appl. Opt., 41 (15), 2760-2767, 2002.

Liu, Z., Omar, A.H., Hu, Y., Vaughan, M.A., and Winker, D.M.: CALIOP Algorithm Theoretical Basis Document. Part 3: Scene Classification Algorithms. CALIPSO report, PC-SCI-202 Part 3, Release 1.0, 2005.

Voss, K.J., Welton, E.J., Quinn, P.K., Johnson, J., Thompson, A.M., and Gordon, H.R.: Lidar measurements during Aerosols99. J. Geophys. Res., 106 (D18), 20821-20831, 2001.

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The difference between the LR values (of the different stations) compared to the AERONET derived ones is higher than 100%. The authors should comment on that.

A table has been produced showing differences of the lidar-derived LR values respect to the AERONET-derived ones for each station, [(LR^{LIDAR} – LR^{AERONET})*100/LR^{AERONET}] (in %):

Day of March 2008	SCO	ARN	GRA
11	-40.0	ND	ND
12	ND	-33.3	-51.0
13	**38.0**	-31.1	-35.3
14	**10.2**	**14.0**	**31.3**
15	**-5.0 (*)**	-34.9	-73.7
16	**50.0**	ND	-47.4

Data from Fig. 9 (old Fig. 8). ND denotes 'no data available'.

Indeed, the revealed **underestimation**/overestimation of AERONET-derived LR data (**positive**/negative values in the table) under **dusty**/non-dusty conditions is clearly stated in the manuscript. There is one exception on 15 March at SCO (*), dusty day, where the difference is negative, probably due to AERONET inversion miscalculation of the optical parameters used for LR estimation. The differences found between both datasets for dust, non-spherical particles, can be addressed to an insufficient understanding of the light-scattering model (Dubovik et al., 2002, 2006), highly shape-dependent, which is used in the AERONET data inversion algorithm. Müller et al. (2010) found a good agreement of the lidar ratio at visible wavelengths derived from lidar and sun-photometry measurements when a more realistic and improved dust model (Dubovik et al., 2006) is used instead.

The references have been included, if not, in the references list:

Dubovik, O., Holben, B.N., Lapyonok, T., Sinyuk, A., Mishchenko, M.I., Yang, P., and Slutsker, I.: Non-spherical aerosol retrieval method employing light scattering by spheroids. Geophys. Res. Lett., 29 (10), 1415, doi:10.1029/2001GL014506, 2002.

Dubovik, O., Sinyuk, A., Lapyonok, T., Holben, B.N., Mishchenko, M., Yang, P., Eck, T.F., Volten, H., Muñoz, O., Veihelmann, B., van der Zande, W.J., Leon, J.-F., Sorokin, M., and Slutsker, I.: The application of spheroid models to account for aerosol particle nonsphericity in remote sensing of desert dust. J. Geophys. Res., 111, D11208, doi:10.1029/2005GL06619, 2006.

Müller, D., Ansmann, A., Freudenthaler, V., Kandler, K., Toledano, C., Hiebsch, A., Gasteiger, J., Esselborn, M., Tesche, M., Heese, B., Althausen, D., Weinzierl, B., Petzold, A., and von Hoyningen-Huene, W.: Mineral dust observed with AERONET sun photometer, Raman Lidar, and in-situ instruments during SAMUM 2006: Shape-dependent particle properties, J. Geophys. Res., 115, D11207, doi:10.1029/2009JD012523, 2010.