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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Extreme Saharan dust event over the southern Iberian Peninsula in september 2007: active and passive remote sensing from surface and satellite" *by* J. L. Guerrero-Rascado et al.

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On behalf of all authors, I would like to thank the referee #2 for the comments and suggestions, which contribute to improve the quality of our paper. In the following, the referee comments are repeated first (in italic type) and we reply to the respective statements.

More important:

Referee2: Pg 15683, first paragraph: Some of the assumptions in the CIMEL retrieval

should probably be discussed. For example, a bi-modal distribution is assumed (I think). It is not surprising that the different measurement products are consistent with one another given that they are not independent in the retrieval.

Answer: This is answered join to the next comment.

Referee2: Pg 15683, third paragraph: This is where the retrieval assumptions become more important. I doubt that the size distribution for dust is truly bimodal, but that is what is assumed here (again, I think). What are the consequences if the true distribution is not bimodal, but is forced into the bimodal assumption? Can the sub-micron particle population be an artifact of the retrieval?

Answer: To answer these questions we must be aware of the fact that the sunphotometer Cimel measures the spectral solar extinction and sky radiance due to the radiative atmospheric processes providing integrated columnar ground-based observations. From these measurements we can compute the columnar effective values of spectral aerosol optical depth and microphysical aerosol properties (i.e. AERONET-Aerosol Robotic Network papers). So, the instrument response includes the effect due to the surface aerosol layer and the lofted aerosol layer. As we showed in this work, the mineral aerosol is located mainly in the free troposphere, especially during some stages of the analysed event. Because we are working in an urban environment, the boundary layer contributes with a non-negligible load of atmospheric aerosol, including both fine and coarse. This is the reason why the final results for the whole atmospheric column evidence the bi-modal size distribution. In a previous study (Alados-Arboledas et al., 2007) we have had the opportunity to measure simultaneously with a Cimel radiometer installed in our research center at 680 m a.s.l and a second instrument located in an astronomical observatory about 3000 m a.s.l, but with a short horizontal distance between them. In this sense, we assume that both instruments were almost in the same vertical column, being the highest level station most of the time in the free troposphere. In the mentioned study we have analysed among other situations a Saharan dust outbreak, with lofted mineral aerosol layer reaching 5000 m a.s.l. The

size distributions retrieved at the low level station presented a bi-modal size distribution like those obtained in this study, while that obtained in the high level station, that "only sees" the mineral aerosol layers above 3000 m a.s.l, has a strong coarse mode and negligible presence of fine particles. So the bi-modality shown in this study only reflects the vertical integration performed by the CIMEL radiometer.

Referee2: Pg 15685: It is not clear that the Evora event is statistically significant in the MODIS measurement, but the discussion seems to imply it is.

Answer: As the Referee2 indicates, the event over Évora is not very significant considering MODIS measurements. Besides, we must remark that this event could be considered scarcely as extreme event for the other stations only taking into account MODIS measurements. However, as it is mentioned in pages 15685-15686 and it is observed for the all locations considered, MODIS shows a marked underestimation in presence of non-spherical dust particles, among other factors. The reason why we have included MODIS data for Évora station is that the main purpose of this work is analyze this extreme Saharan dust event from different points of view (active/passive and surface/ground based measurements) and this event was also significant at Évora. In fact, figure 8 indicates that the event was also relevant at Évora from the point of view of ground based passive remote sensing, with maximum values of aerosol optical depth around 0.8 at 675 nm.

Referee2: Pg 15686: Why not show inverted lidar retrievals (i.e., contours of extinction) in Figure 10? You have the capability to compute them, and they are more geophysically relevant.

Answer: This kind of plots is widely used in the Lidar communities, especially in the EARLINET community. The reason is that range corrected signal plots are the most illustrative and simply to estimate the layering in the atmospheric column without considering the application of different algorithms. Note that the Raman methodologies to derive extinction and backscatter coefficient profiles are only applied during night

time due to the low values of Raman Lidar signals (inelastic signals), whereas Klett-Fernald-Sasano is used to compute backscatter profiles at daytime. In addition, all retrieval methods require an averaging time (typically around 30 minutes), whereas range corrected signal contours allow visualizing the events with a better temporal resolution.

Referee2: Pg 15689: What is the "backscatter-related Angstrom exponent"?

Answer: The backscatter-related Angström exponent describes the spectral slope of the measured backscatter coefficients as follows:

å=-Ln[$\beta(\lambda 1)$/ $\beta(\lambda 2)$]/Ln[$\lambda 1/\lambda 2$]

A definition will be included in the paper.

Less important:

Referee2: Pg 15674, Abstract: I am not familiar with the "Iberian Peninsula", but am familiar with Spain and Portugal. I suggest including the country names, and include the coordinates for Granada. The same information could be added to the Introduction on page 15676.

Answer: We have preferred used the term Iberian Peninsula instead of Spain and Portugal because the use of country names imply both inland and several Spanish and Portuguese islands. Our paper is devoted to the extreme Saharan dust event observed in southeastern Iberian Peninsula, excluding especially the Canarian Islands. These islands located in the Atlantic Ocean close to the western African coast, which belong to Spain, are frequently affected by strong Saharan dust outbreaks. It is possible that some outbreaks in these islands have similar strength that one presented in this paper. Thus, we consider that the term Iberian Peninsula is most accurate than Spain and Portugal. The coordinates for Granada are included in pages 15677 and 15684. This information will be also included in the Introduction.

Referee2: Pg 15674, Abstract: There is no mention of the lidar systems (ground-based

or CALIPSO), MODIS, or the use of SBDART. These should be included.

Answer: Some indications will be included in the abstract.

Referee2: Pg. 15675, line 6: Strange reference style used here.

Answer: This will be modified.

Referee2: Pg 15677: Granada is called a “medium-sized” city. What constitutes medium sized? It would be more useful to state the population.

Answer: Granada is a medium-sized city with a population of 300 000, 600 000 if the whole metropolitan area is considered. This information will be included in the paper.

Referee2: Figure 1: The subplots are much too small, and I have to zoom in quite far on the PDF to understand what is going on. That is not going to be possible in the print version. I suggest enlarging the figure, perhaps by spreading it out over multiple pages. This same comment can apply to some of the other figures.

Answer: Figures will be enlarged as the Referee 2 suggests.

Referee2: Figure 2: It would be helpful to have Granada marked on these plots.

Answer: Figure 2 will be removed, following to Referee1. Granada station will be marked on the plots in Figure 3.

Referee2: Pg 15680: You call the dust event “extraordinary”, but that has not been established yet. What makes it extraordinary? This is explained later in the paper, but seems strange to the reader at this point.

Answer: The term “extraordinary” will be removed.

Referee2: Pg 15681: More information on the MODIS analyses are needed. Are daily-average grids used? I assume that they are not the swath data.

Answer: The MODIS aerosol optical depth data used in this study correspond to data of the v005 collection with a spatial resolution $1^{\circ}\times1^{\circ}$. As indicated in the manuscript

these data have been directly downloaded through the Giovanni system from NASA (http:daac.gsfc.nasa.gov/techlab/Giovanni).

Referee2: Figure 5: Delta is used as a symbol for aerosol optical depth, but this is never explained. I suggest using “AOD” instead, as it is more commonly used.

Answer: Following the Referees2’s suggestions, delta symbol will be replaced by “AOD”.

Referee2: Pg 15681: The error in the Angstrom exponent is given as 0.2. This appears to be too large considering the random variations in the plot. Is this systematic or low-frequency error instead? A better discussion of the nature of the errors would be useful.

Answer: The uncertainty of 0.2 associated to the Angström exponent is the value proposed by AERONET considering the uncertainty associated to the aerosol optical depth computations. Because in this work we have used the retrieval of AERONET over our station we assume the mentioned value of uncertainty.

Referee2: Pg 15683: “... (the ratio between optical depth of the micrometric mode and total aerosol optical depth) ...” I think you meant “coarse mode” here.

Answer: The term micrometric mode will be replaced by coarse mode. Similarly, the term sub-micrometric mode will be replaced by fine mode

Referee2: Pg 15689: Figure 13 is introduced before Figure 12. This is probably just a LaTeX issue.

Answer: This will be modified in the final version of the paper.

Referee2: Pg 15689: Why do the Klett and Raman profiles not agree? The peak is at very different altitudes for these measurements. I assume this is due to different time intervals for the measurements, but this should be explained in the manuscript.

Answer: The differences for the altitudes of the dust layers are related to the temporal evolution of the aerosol properties along the event. Thus, figure 11 and 13 present

the aerosol optical properties at day and night time, respectively. The time for each measurement is included in the figures' captions and also in the manuscript (pages 15687 line 5 and 15689 line 21).

REFERENCES:

Alados-Arboledas, L., Guerrero-Rascado, J. L., Lyamani, H., Navas-Guzmán, F., Olmo, F. J.: Characterization of the atmospheric aerosol by combination of Lidar and sun-photometry, Proceedings of SPIE 2007, vol. 6750, 67500J-1 - 67500J-8, ISBN 0277-786X-07, 2007.

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