

Authors' response (in blue) to the Reviewer #2's comments (in black):

The authors thank Reviewer #2 for his/her comments and suggestions that definitely improved the manuscript. Required changes and modifications have been introduced in the text of the revised version of the manuscript by using the Word Track Changes tools. The manuscript has been revised and restructured in order to present more clearly the results and to implement the changes after answering the reviewer's comments. Authors think that the way they are introduced in the new version of the manuscript will improve the reading and understanding.

In addition, the following general changes have been addressed throughout the manuscript:

- The title has been slightly modified in order to highlight the main issue of the work (Part 1), i.e. the shortwave dust direct radiative effect, that is: "Aerosol radiative impact during the summer 2019 heatwave produced partly by an inter-continental Saharan dust outbreak. Part 1. Shortwave dust direct radiative effect".
- 'J' in the dates have been replaced by 'June' for avoiding confusion.
- Figure 2 has been removed (also taking into account the reviewer #3's comments) for a more fluent reading in overall, since this figure doesn't provide any crucial additional information to the current modelling analysis performed (see Fig. 1 and previous Fig. 3). The following figures have been renumbered.
- Figures 3-5 (previous 4-6), and 7-9 (previous 8-10) have been improved. In particular, error bars have been included in Fig. 3 in order to show uncertainties.
- A new Table (Table 2 now) has been added. The rest of Tables have been renumbered.
- Symbols used for the single scattering albedo (SSA), the asymmetry factor (asyF) and the surface albedo (SA) have been replaced by SSA, asyF and SA, respectively, for avoiding confusion, as in the text as in the Figures.

Next, the authors respond to the particular comments of the reviewer #2.

- Reviewer 2

General comments

In this study, the shortwave dust direct radiative effect and the contribution of coarse and fine dust components is investigated for two European cities, during a Sahara dust outbreak, using the synergy of AERONET and MPLNET measurements and the POLYPHON method. This study is a comprehensive analysis of this dust event describing the origin of dusty air masses and their trajectories, separation of coarse and fine dust components profiles and finally investigating their direct radiative effect. This is a very interesting work and the results for the shortwave direct radiative effect of dust and its coarse and fine components are of particular interest for satellite remote sensing measuring techniques. I think that the analysis is scientifically sound and the manuscript is generally well-written. I have made some suggestions for improvements below.

Specific comments

R2C1. Lines 164-165: Dust direct radiative effect maybe instead of “. . .dust radiative effect”? The acronym DRE is usually used for Direct Radiative Effect.

Authors' response: We agree. This has been revised and modified throughout the text in the revised version of the manuscript.

R2C2. Lines 357-358 (363-364): Instead of “using AE440-870” maybe better using AERONET AE440-870.

Authors' response: Replaced.

R2C3. Line 419 (425): The authors give in this line the DOD values for BCN from 24J to 27J that varies between 0.13 and .26, but I suggest to the authors to provide here and in the rest of the results section the wavelength that these values are refer to, because later in this paragraph results from other studies are provided and referred to specific wavelength.

Authors' response: This has been modified in the text (**page 18, lines 504 and 506**) and wherever needed, and also in the caption of Figure 8 (previous Fig. 9).

R2C4. Line 448 (454): Please define the acronym BOA or rephrase to SRF. The same for legend at fig 8c.

Authors' response: It has been a mistyping. At the beginning of writing the manuscript, we used BOA denoting the ‘bottom-of-atmosphere’, i.e., the surface (SRF). It has been already corrected (**page 19, line 541**).

R2C5. Lines 489-492 (495-499) & 557-561 (563-567): These positive trends of fine mode contribution to dust direct radiative effect are statistically significant?

Authors' response: There may be a misunderstanding here about the definition of these increases per hour or per day. We tried in the original version to be as accurate as possible with the wording, but such a comment is somehow not surprising. The Df/DD DRE ratio, expressed in %, increases along the event in BCN, both on SRF and at TOA. The increase is expressed in absolute value, so it represents what is gained every day. On SRF (at TOA), the increase is of an absolute +2.4% per day (+2.9% per day). It is obviously significant, since after a 7-day event (if we consider only the period of 24-30 June) the Df/DD DRE ratio has jumped from

- 28% to 44% (+16%, roughly +2.4% day⁻¹ times 7 days) on the SRF, and
- 36% to 56% (+20%, roughly +2.9% day⁻¹ times 7 days) at TOA.

The term absolute increase, already in the caption of Fig. 7 (previous Fig. 8), has also been added in the text in the revised manuscript. The last paragraph of Section 3.3.3 has also been partly re-written, as follows:

Page 23, lines 682-685: “Likewise, a slightly smaller positive slope of $+0.10\% \cdot \text{hr}^{-1}$ (i.e., $+2.4\% \cdot \text{day}^{-1}$, see **Sect. 3.3.2**) is found for the Df/DD DRE ratio on the surface, which is +16% higher between 24 June (28%) and 30 June (44%).”

In addition, some inconsistencies in the values of the Df/DD DRE ratio between the text and Tables 4 and 5 (previous Table 3 and 4) have also been corrected.

R2C6. Line 511 (518): Maybe instead of “in the range of values” to rephrase to close to these values?

Authors’ response: Changed. The text has been accordingly modified in the revised version of the manuscript, as follows:

Page 21, lines 613-615: “The instantaneous maximum as calculated for $DRE(TOA)$, -42.7 W m^{-2} , is, for instance, close to the values within the range $[-55.0, -50.0 \text{ W m}^{-2}]$ as found by Cachorro et al. (2008) for a dust event and AODs varying in the range $[0.82, 1.04]$.”

R2C7. Line 563 (570): Maybe apart from the day, the location may be referred too, like the day of 26J in BCN.

Authors’ response: Modified.

R2C8. Lines 627-628 (634-635): I would suggest to include here, and in the rest of the paragraph, the wavelength that DOD values are referred to, like in case of the other optical properties.

Authors’ response: The text of the paragraph has been accordingly modified in the revised version of the manuscript. In particular, the following sentence has been rephrased as:

Page 26, lines 755-756: “At BCN mean dust optical depth values at 532 nm (DOD^{532}) for Dc, Df and DD particles, respectively, of 0.116, 0.037 and 0.153, with DD DOD^{532} peaks of 0.63 (AE ~ 0.19), were found.”

R2C9. Line 670 (677): I would suggest to add inside the parenthesis: DRE peak at TOA.

Authors’ response: Added.

Technical corrections

Line 341 (347): AE440-870 instead of AE440-8

Line 413 (in the revised version of the manuscript): Done.

Line 342 (348): AE440-870 instead of AE440

Line 415: Done.

Line 410 (416): was also calculated instead of “is also calculated”

Line 494: Modified.

Line 411 (417): was calculated instead of “is calculated”, two times in this row

Line 495: Modified.

Line 429 (435): Figure 9a instead of Figure 10

Authors' response: For clarity, the corresponding paragraph has been rephrased in the revised version of the manuscript, as follows:

Page 18, lines 519-527: “**Figure 8** nicely illustrates the dust direct radiative effect on the surface, $DRE(SRF)$, and at the TOA, $DRE(TOA)$. **Figure 8a** shows the instantaneous $DRE(SRF)$ for both coarse (red) and fine (blue) modes as a function of their respective DOD^{532} . By using linear regression analysis (regarding $DRE=0$ with $DOD=0$), the $DREff$ corresponds to the slope of the linear fittings. In BCN, the total dust $DREff$ on the surface, $DREff(SRF)$, over the whole event is -75.2 and $-129.6 \text{ W m}^{-2} \tau^{-1}$ for the coarse and fine mode, respectively, producing a total dust $DREff$ of $-88.9 \pm 4.3 \text{ W m}^{-2} \tau^{-1}$. Note the small deviation of the cloud of points from the linear fitting (± 2.9 and $\pm 1.4 \text{ W m}^{-2}$ for the coarse and fine mode, respectively). It can be clearly seen that at constant DOD the dust fine mode produces a higher enhancement of DRE than the dust coarse mode. Both DRE and $DREff$ values are included in **Table 4.**”

Line 499 (506): was reached instead of “is reached”

Line 601: Done.

Line 500 (507): I suppose the authors refer to Fig. 8a

Line 602: It refers to Figure 7a (previous Fig. 8a). Changed.

In addition, also for clarity, the following paragraph has been rephrased in the revised version of the manuscript, as follows:

Page 21, lines 596-597: “The time evolution of the instantaneous dust DRE at TOA is shown in **Figures 7a** (BCN) and **7b** (LPZ) and in dependence of DOD in **Figure 8b**. Daily and maximal values are reported in **Table 5.**”

Line 514 (521): $DREdf(SRF)$ instead of $DREdfDRE(BOA)$

Line 627: Modified.

Line 526 (533): SRF instead of BOA

Line 639: Changed.

Line 560 (567): SRF instead of BOA

Line 683: Modified.

Line 584 (591): SRF instead of surface inside the parenthesis.

Line 705: Changed.