We appreciate thoughtful reading and constrictive comments provided by the reviewer. We also thank for taking time and providing all the minor comments. Below please find our point-to-point replies. The responses to the reviewer comments are given in blue text; the original reviewer comments are in black text.

Anonymous Referee #1

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This manuscript reports a systematic assessment of uncertainties in the aerosol direct radiative effect associated with assumptions and simplifications of both aerosol and surface properties, including aerosol scattering phase function, particle shape, and surface reflectance. The assessment was done with a rigorous yet computationally fast tool – GRASP and for several types of aerosol. Although the issues examined here have been touched in some previous studies (references are appropriately cited), this study has its own merit because it represents a systematic evaluation of uncertainties in the aerosol direct radiative effect associated with the assumptions and simplifications usually made in the community. Some assumptions can cause large uncertainties or even systematic errors, which the community should be aware of at least. The study also shows an application of GRASP system to calculate dust aerosol direct radiative effect in Sahara desert with POLDER/PARASOL data. I recommend the paper be published in ACP after some issues (mainly minor as listed below) are addressed.

Specific comments:

In Figure 13, I would suggest to add the domain average of each variable. It is also helpful if two additional panels are added to show the radiative efficiency (direct radiative effect per AOT at 565 nm) at TOA and BOA.

The domain average and standard deviation of each variable are presented now in Fig. 13 (Fig. 14 in new version). It will be included in the revised version of the manuscript. Thank you for this suggestion, we understand that this information can be useful. Also, two additional panels that show radiative efficiencies are added in Fig. 13 and a corresponding discussion is provided in Sect. 8.
The updated figure and related changes in the text of the manuscript are presented in the end of this document.

The paper is well written in general. But there are several places where additional attention is necessary to give a clearer presentation, including:

1. p.33446, line 9: please define radiative efficiency here.
The definition "radiative effect per unit aerosol optical thickness" is included in this sentence of the abstract. The new version is:
We use the tool to evaluate instantaneous and daily average radiative efficiencies (radiative effect per unit aerosol optical thickness) of several key atmospheric aerosol models over different surface types.

2. p.33447, line 6: add "radiative" immediately after "negative".
Corrected.

3. p.33447, line 9: "upward" is better than "backward".
Yes, indeed. Corrected.

4. P.33447, line 19: Is "contract" a right word?
Corrected to "counteract".

5. P.33448, line 7: add a reference: Yu et al., A review of measurement-based assessments of the aerosol direct radiative effect and forcing Atmos. Chem. Phys, 6, 613-666, 2006.
Of course, the reference is very important and should be included. It is done in the revised version. Thanks.

6. P.33448, line 8-11: awkward sentence.
The sentence is shortened and modified to the next:
The observation-based evaluations of aerosol radiative effect open opportunities for inter-comparison with models and leads to improvement in assessment of aerosol radiative effect on climate.

7. P.33448, line 28: using "a combination" to replace "combining".
Corrected.

8. P.33450, line 15: AOT appears first time here. Spell it out.
Corrected.

9. P.33450, line 14: "the strength of the overestimation", and "the strength of the uncertainty" throughout the paper. Is it better to just use "magnitude" instead of "strength"?
Corrected.

10. P.33458, line 3-5: I don't understand this sentence.
This part has been edited, the new version is:
Note that the computed g and ω_0 have quite strong spectral variability (Fig. 2c, d)), which illustrates strong dependence of g and also of ω_0 on the ratio of particles size to wavelength. For example, in the cases of biomass burning and urban aerosol models, the $\omega_0(\lambda)$ is changing even if imaginary part of refractive index is spectrally constant (see Table 1 and Fig. 2c)). After having a maximum at short wavelengths, $\omega_0(\lambda)$ increases again at longer wavelengths for all aerosol models where the bimodal size distribution is strongly pronounced (i.e. except for dust). It is due to increasing scattering effectiveness of fine and coarse modes at short and long wavelengths, respectively. The scattering effectiveness in case of dust aerosol model is increasing only at long wavelengths.

11. P.33461, line 10: should "then" be "than"?
Yes, corrected.

12. P.33463, line 22: "spheres are generally scatter stronger in. . ." ???
It is true, it was not clear. The phrase is rewritten as follows:
Since spheres are generally scatter stronger than spheroids at backward scattering angles, it could be expected that the upward hemispherical solar flux is also stronger for spheres.

13. P.33469, line 11: “free” should be “three”?
Corrected.

14. P.33469, line 14: “an important number of”. . . Is it better using “a significant number of”?
Corrected.

15. P.33469, line 16-17: “in the presented here theoretical calculations” what do they mean?
The intention was to climatological aerosol and surface models. The phrase is corrected to the next:
A significant amount of pixels, mostly in the northern part of Africa (e.g. central Egypt and northern part of Western Sahara), shows quite strong (up to about 10 to 20 Wm^{-2}) positive radiative effect with the corresponding radiative efficiency over 40 $Wm^{-2}\tau^{-1}$ (Fig. 14c), d)), despite that the climatological aerosol and surface models in Fig. 7 show positive radiative efficiencies of only up to 20 $Wm^{-2}\tau^{-1}$.

16. P.33470, line 2-3: again what do you mean by saying “from the presented here theoretically calculations”?
Corrected to “from the theoretical climatological calculations presented in this study”.

17. P.33470, line 19-21: “Especially strong ....by aerosol and underlying surface reflectance”. It is not quite clear to me what they mean here.
Yes, it was not clear. The sentence is modified to the next:
Diurnal aerosol radiative effect was found as particularly influenced by directional properties of aerosol scattering and by anisotropy of underlying surface reflectance.

We thank the reviewer again. Thanks to these comments the paper is improved now, as we believe.

Below is provided the updated version of Fig. 13 (Fig 14 in the new version) and corresponding discussion in Section 8:

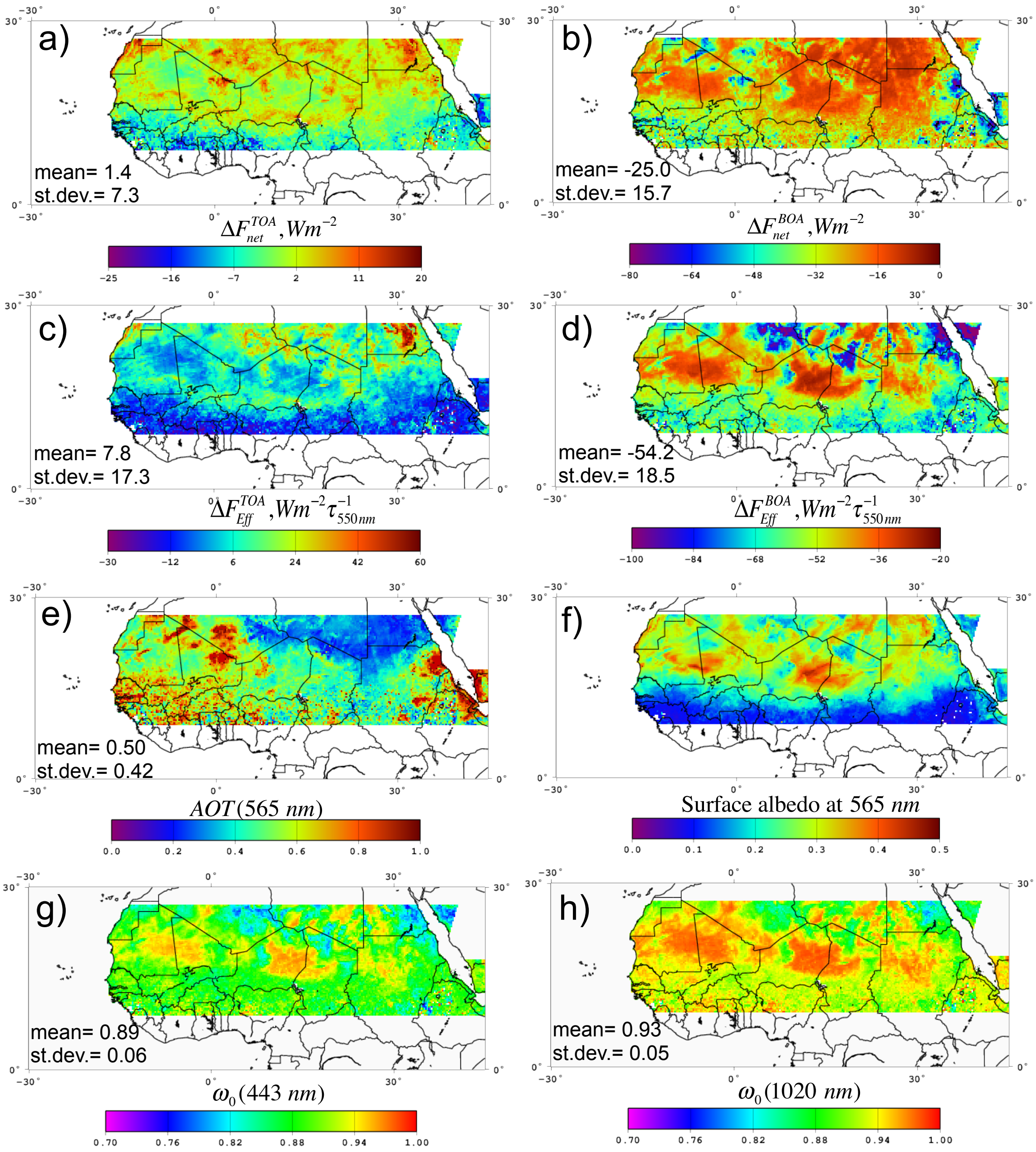

Figure 14. Three months (JJA 2008) means of a) the 24h average Top and b) 24h average Bottom Of Atmosphere (TOA and BOA) net aerosol radiative effect, c) and d) the corresponding radiative efficiencies (see Sect. 8 for the interpretation), e) AOT at 565 nm, f) underlying surface albedo at 565 nm, and g) ω_0 at 443 nm and h) at 1020 nm as retrieved and calculated by GRASP algorithm applied for POLDER/PARASOL observations. The panels also include the domain averages and corresponding standard deviations.

Figure 14 presents the means for three months of: i) daily average top and bottom of atmosphere net aerosol radiative effects; ii) radiative efficiencies calculated with respect to AOT at 550 nm (interpolated from nominal wavelength of POLDER); iii) AOT at

565 nm; iv) underlying surface albedo at 565 nm; and v) spectral ω_0 (presented by means of two wavelengths, 443 nm and 1020 nm). The domain averages and standard deviations of the characteristics presented in Fig. 14 are also indicated in the panels. The domain averages and standard deviations are calculated for all observations during three months of summer 2008. As shown in Fig. 14, fine spatial feature of aerosol radiative effect (at top of atmosphere in particular) can be revealed by high spatial resolution of POLDER/PARASOL. A significant amount of pixels, mostly in the northern part of Africa (e.g. central Egypt and northern part of Western Sahara), shows quite strong (up to about 10 to 20 Wm^{-2}) positive radiative effect with the corresponding radiative efficiency over 40 $Wm^{-2}\tau^{-1}$ (Fig. 14c), d)), despite that the climatological aerosol and surface models in Fig. 7 show positive radiative efficiencies of only up to 20 $Wm^{-2}\tau^{-1}$. The relatively large positive radiative effect is due to two main factors. First, it happens when the surface reflectance is higher (around 0.4 at 565 nm) and the spectral ω_0 is lower (around 0.8) compared to the limits assumed in calculations presented in Fig. 7. Evidently, the climatological aerosol and surface models represent only an average but cannot be all-inclusive of all possible variations of the properties. Second, what is more important is the non-linearity of the aerosol radiative effect as function of AOT. In fact, the AOT varies significantly in the real data (Fig. 14e)) and strong radiative efficiencies (Fig. 14c)) appear when the AOT is low, while the AOT at 550 nm was set to one in calculations of radiative efficiency presented in Fig. 7. In an attempt to illustrate and evaluate the aforementioned reasons, the aerosol models presented in Sect. 3 have been slightly modified and some supplementary calculations have been conducted. For example, the mixture of dust and biomass burning aerosol model has been assumed to be slightly more absorbing, by changing the spectral imaginary part of refractive indices k at 440/670/870/1020 nm from 0.021/0.016/0.013/0.013 to 0.025/0.016/0.016/0.016. This modification produces aerosol properties close to those retrieved for central Egypt with the spectral ω_0(440/670/870/1020 nm) of 0.80/0.81/0.81/0.81. Radiative effect and efficiency calculated for this aerosol model and for corresponding to the central Egypt surface albedo of ~0.4 at 550 nm are presented in Fig. 15 (labeled as "Absorbing mixture"). Modification of the climatological dust aerosol model by increasing k(440/670/870/1020 nm) from 0.004/0.002/0.002/0.002 to 0.008/0.006/0.006/0.006 produces aerosol properties similar to those retrieved for northern part of Western Sahara with spectral ω_0 of 0.85/0.89/0.91/0.92, for example. Results of calculations for this aerosol model and for corresponding surface albedo of ~0.35 at 550 nm are labeled in Fig. 15 as "Absorbing dust". The radiative effect calculations presented in Fig. 15 show first of all that strongly absorbing aerosols over very bright surface produce significant positive radiative effect at top of atmosphere and reproduce range of the radiative effect values obtained over central Egypt and Western Sahara. Second, Fig. 15 illustrates that because of non-linearity of the radiative effect as function of AOT, the values of the radiative efficiency are strongly dependent on AOT with which were calculated. The presented example shows variability in radiative efficiency up to 40% at top and 25% at bottom of atmosphere due to AOT ranging from 0.2 to 1. The fact implies that one should interpret the maps of radiative efficiency in Fig. 14c), d) with caution due to the spatial variation of aerosol concentration.

Noteworthy is also the obtained spectral ω_0 (Fig. 14g), h)). Although it is generally consistent with ω_0 of mineral dust (stronger absorption at 443 nm than at 1020 nm), in some cases the ω_0 appears quite low (about 0.8) at 443 and 1020 nm, which indicates presence of probably carbonaceous particles or mixed aerosol (e.g. over central Egypt). For the daily average BOA radiative effect (Fig. 14 b)) the values show quite important spatial variability and areas with strong cooling (about –60 Wm^{-2}) that generally correspond to high AOT. Overall, it can be concluded that the values obtained from POLDER/PARASOL observations are in the range of what could be expected from the theoretical climatological calculations presented in this study. The preliminary results and spatial patterns of the aerosol radiative effect thus demonstrate potential of this high advanced product of new GRASP algorithm.