Responses to the comments

Dear Reviewer,

Thank you for carefully reviewing our manuscript. The comments have helped us to improve the paper. We have classified these comments into 4 groups. The comments group 1 (includes comments 2, 3, 5, 12, 15, 16 and 39) is related with the selected study area and the matched AERONET sites in figure 3, 4, 5, 6, 8, 9 of the manuscript. The comments group 2 (comments 6 and 10) is related with the detailed information of the aerosol optical properties used in Radiative Transfer Mode (RTM) for dust aerosol Direct Radiative Effect (DRE_{dust}) estimation. The comments group 3 is related with the AERONET data using conditional. And comments group 4 is related to clear and coherent expression in the manuscript.

Following these comments and suggestions, we take a lot of efforts to optimize the structure of the manuscript, add the explanation on how to calculation the optical characteristics of the dust aerosol, analysis the cloud effect on the two AERONET sites, re-draw the most of the imaging in the article to meet the reviewer's suggestion, and modify the inaccurate information to avoid the ambiguity.

We response every comments sentence by sentence. Please find the comments in blue italics and our reply in black.

1. This paper determines the TOA direct radiative effect (DRE) and the so-called direct radiative forcing efficiency (DRFE) of dust for two dust storms by using CERES SSF data. One of the dust storms occurs near an AERONET site in Tamanrasset (Africa) and the other occurs near Kashi, India. The authors note that the mineralogy of dust is different for these two regions. The authors would like to study the impact of mineralogy on the dust radiative effect, so they constrain their analysis to a single land surface albedo (LSA, from MODIS) and a single solar zenith angle (SZA). Since the authors are looking at multiple locations with the same surface albedos, they call this the equi-albedo method. The authors also focus on DRFE instead of DRE in order to eliminate the effect of column loading. Since the authors have constrained most of the parameters that affect TOA DRFE, they attribute DRFE differences between the two storms to differences in dust minerology. Thus, the authors investigate further by analyzing the differences in microphyical dust properties inferred at the AERONET sites during the dust storms. This is an interesting idea, but the analysis is not terribly convincing.

Reply: We try our best to response the each suggestion from the reviewer. We optimize the structure of the manuscript, add the explanation on how to calculation the optical characteristics of the dust aerosol, analysis the cloud effect on the two AERONET sites, re-draw the most of the imaging in the article to meet the reviewer's suggestion, and modify the inaccurate information to avoid the ambiguity. We hope these responses could improve this article's quality and could enhance the scientific persuasion.

One information from the reviewer's comments is incorrect and I have to correct. The Kashi site we selected in this paper located in the Northwest part of China, not in India.

2. The paper is telling a pretty reasonable story until the arrival of Figure 7. Here, the data of the earlier maps is reduced to a few 1x1 deg areas. Undaunted, the authors discuss how "The high dust aerosol loading regions show significant negative radiative forcing..." (lines 267-268). I guess that the reader is supposed to scroll between Figs 5 & 7 to confirm this, but requiring a reader to scroll between two figures does not generally convince anyone of anything.

Reply: I totally agree with the reviewer's suggestion. To make the user compare the results easily, we have re-plotted the DRE_{dust} and AOD in the same image according to the reviewer's suggestion.The readers do not need to scroll between two figures anymore.

In previous study, we found that DRE_{dust} is significantly influenced by LSA and SZA (Tian et al., 2019). To avoid the influence of the LSA and SZA in estimating the $DRFE_{dust}$, we estimate $DRFE_{dust}$ using pixels with similar LSA and SZA.

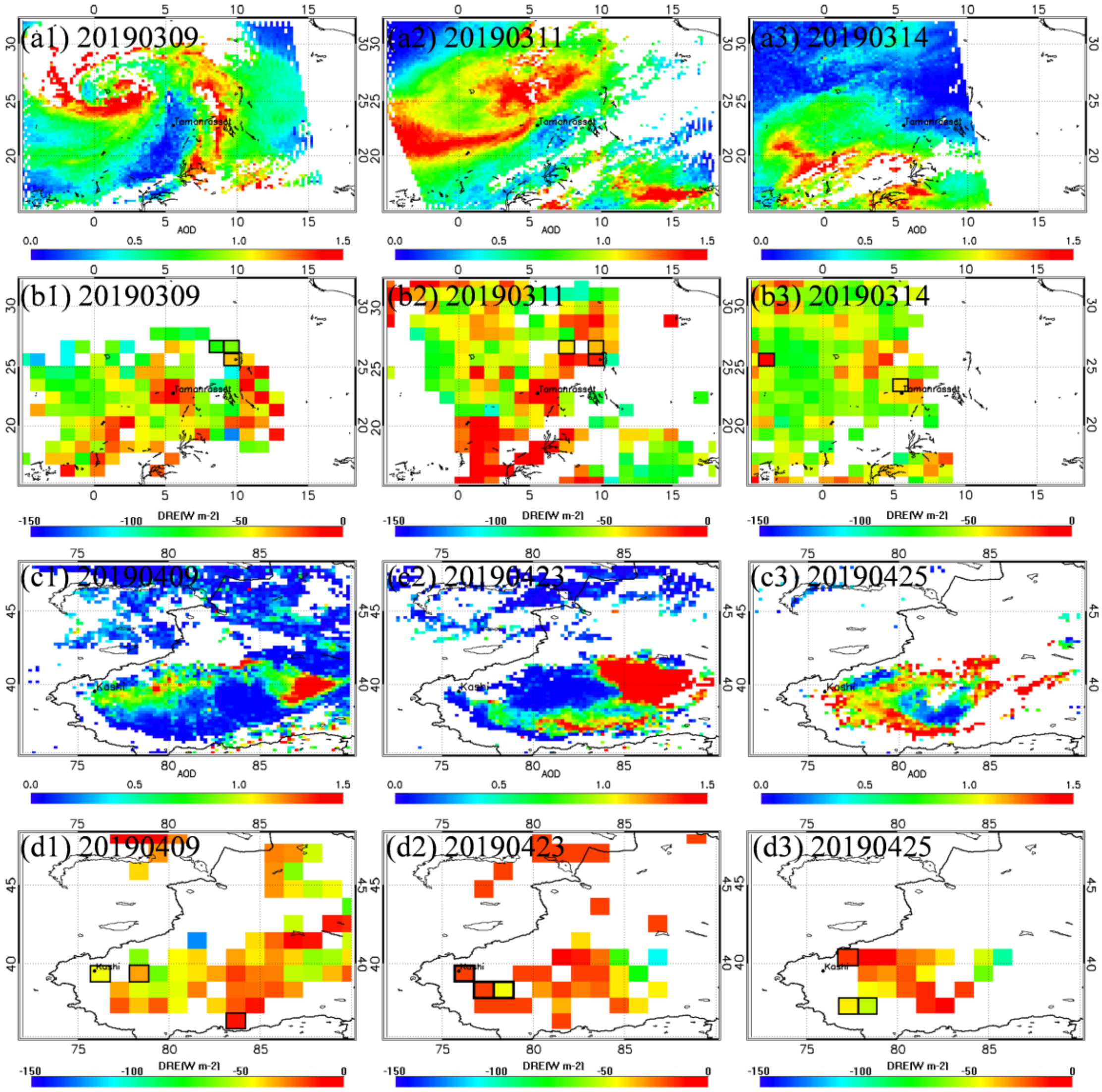

Figure 1: AOD and DRE_{dust} of dust storms over the Sahara Desert in March 2019 and over the Taklimakan Desert in April 2019.

Fig. 1 shows that AOD and DRE_{dust} plotted in the same image, the high dust aerosol loading regions show significant negative radiative forcing. It indicates that the dust aerosol loading is negatively correlated with the DRE_{dust} in these dust storm events. Thus, dust aerosols have a negative radiative effect in the SW spectrum. We also plotted all the available data of DRE_{dust} in the distribution maps, and put black borders around the chosen pixels. Please see Fig. 6 and Lines 301-324 in Page 14 -15 of the revised manuscript.

Moreover, reader could also confirm the “The dust aerosol loading regions show significant negative radiative forcing” from the Table 1 and Fig. 7 in the revised manuscript.

3. The frustrating part is that there is no need for the maps in Fig 7 to be so sparse -- the data is available. Now, I realize that the authors want to focus on 1x1 regions that are constrained by LSA and SZA, but there are other ways of dealing with this. For instance, one can include data for the entire maps in Fig 7, and then put a black border around the few 1x1 grids of interest. This will allow the authors to discuss the whole map (which they often do for these sparse maps) as well as the regions of

interest. Furthermore, include the same borders in Figs 3,4,5,6. This will help the reader to understand the cloud fields, AOD, and TOA SW radiative flux in the 1x1 regions of interest. Since these regions of interest are only constrained by surface albedo and SZA, they can be easily introduced in Fig 3. If you do it this way, this will allow the reader to see the patterns of DRE in Fig 7 and make the paper a whole lot more interesting. Same thing with Figs 9&10 -- show the IWV and SBDART fluxes everywhere, but outline the 1x1 regions of interest with borders. Finally, include the Tamaarasset and Kashi sites in all of the maps (including figures 4, 6, 7, 9, and 10). The authors are trying to link surface measurements at these two sites to the dust storms observed in the satellite data, and the link is very weak because they do not show the location of these sites on many of these maps.

Reply: This suggestion is pretty valuable. We have re-plotted all the available data of DRE_{dust} (please see the Fig. 1 in the reply of comments 2), integrated water vapor and SBDART derived SW fluxes in these distribution maps, and put black borders around the chosen pixels in these figures.

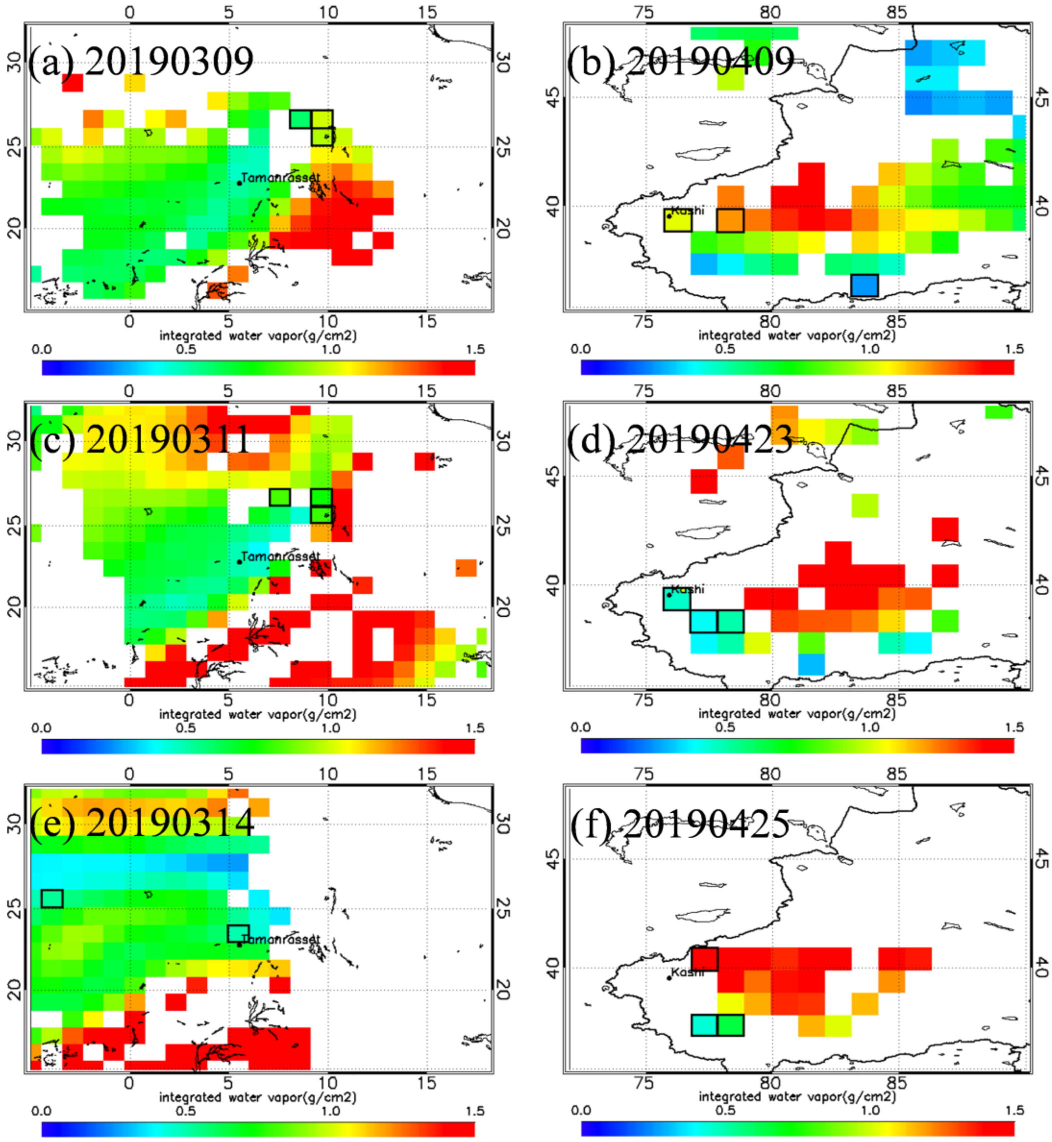

Figure 2: Integrated water vapor (g/cm^2) from European Centre for Medium-range Weather Forecasts (ECMWF) reanalysis dataset over the Sahara Desert in March 2019 and over the Taklimakan Desert in April 2019.

Fig. 2 shows the integrated water vapor from ECMWF reanalysis dataset over the Sahara Desert in March 2019 and over the Taklimakan Desert on April 2019. The grids surrounded by black border are the chosen pixels to estimate the $DRFE_{dust}$. The integrated water vapor varies little over different research areas, and the mean differences of chosen pixels are 0.51g/cm^2 and 0.18g/cm^2 over the Sahara Desert and the Taklimakan Desert, respectively.

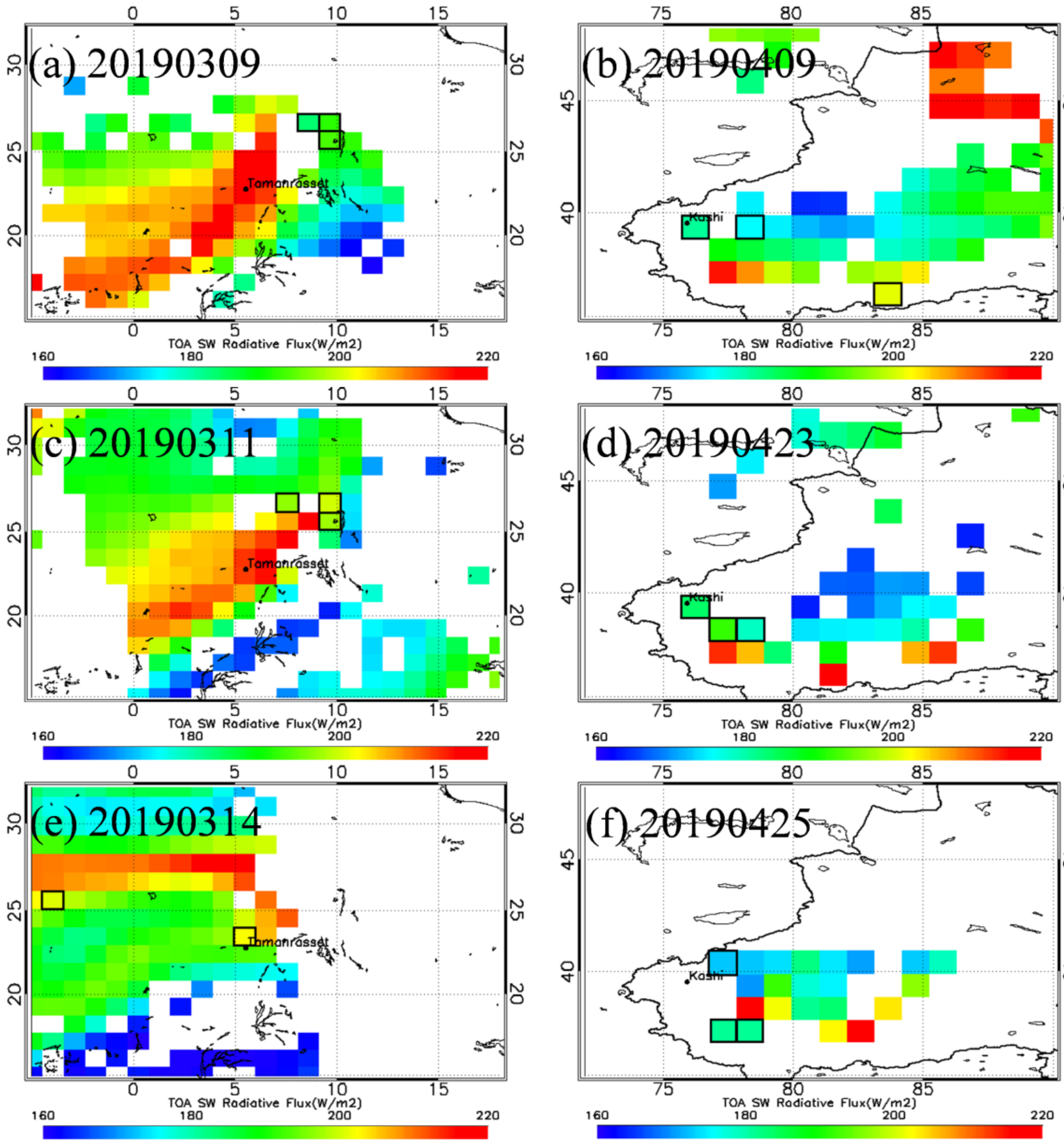

Figure 3: SBDART simulated clear-sky TOA radiative flux by using integrated water vapor (g/cm^2) from ECMWF reanalysis dataset over the Sahara Desert in March 2019 and over the Taklimakan Desert in April 2019.

Fig. 3 shows the SBDART simulated clear-sky TOA radiative flux by using the integrated water vapor from ECMWF reanalysis dataset over the Sahara Desert in March 2019 and over the Taklimakan Desert in April 2019, and the grids surrounded by black border are the chosen pixels to derive the $DRFE_{dust}$. The regional mean differences of TOA radiative flux are 2.21% and 0.85% over the Sahara Desert and the Taklimakan Desert, respectively.

Moreover, we also marked the location of Tamanrasset and Kashi sites in all of the maps. Please see Fig. 3 in Page 10, Fig. 4 in Page 11, Fig. 5 in Page 13, Fig. 6 in Page 14, Fig. 8 in Page 18 and Fig. 9 in Page 19 of the revised manuscript.

4. Is is also very odd that the 1x1 regions with data vary from day to day. Perhaps more odd, sometimes some of the boxes vary, but others do not. Since these regions are selected based upon LSA and SZA constraints, why don't the same regions show up on Mar 9, 11, and 14 at Tamanrasset and on Apr 9, 23, and 25 at Kashi? I haven't kept up on the MODIS albedo products, but it used to be produced every 2 weeks. Thus, if LSA is the same, the only parameter that will move these boxes around is the SZA. An explanation about why the SZA apparently varies so much on the different days would be helpful.

Reply: To avoid the influence of the LSA and SZA in estimating the $DRFE_{dust}$, we estimate $DRFE_{dust}$ using pixels with similar LSA and SZA. Furthermore, the values of AOD and cloud also influenced the regions we selected these chosen pixels. The deep blue algorithm retrieved AOD have large uncertaintites in the small value area (Sayer et al., 2014). Thus, the chosen pixels should have AOD great than 0.1, and in clear-sky condition.

The LSA would not have great changes in 2 weeks, and the MODIS Collection6 albedo product dataset (MCD43C3) (Schaaf et al., 2011;Schaaf et al., 2002;Schaaf et al., 2008) provide broad band land surface albedo every 2 weeks. The movements of these chosen pixels were mainly caused by the variety of SZA, the value of AOD and cloud coverage.

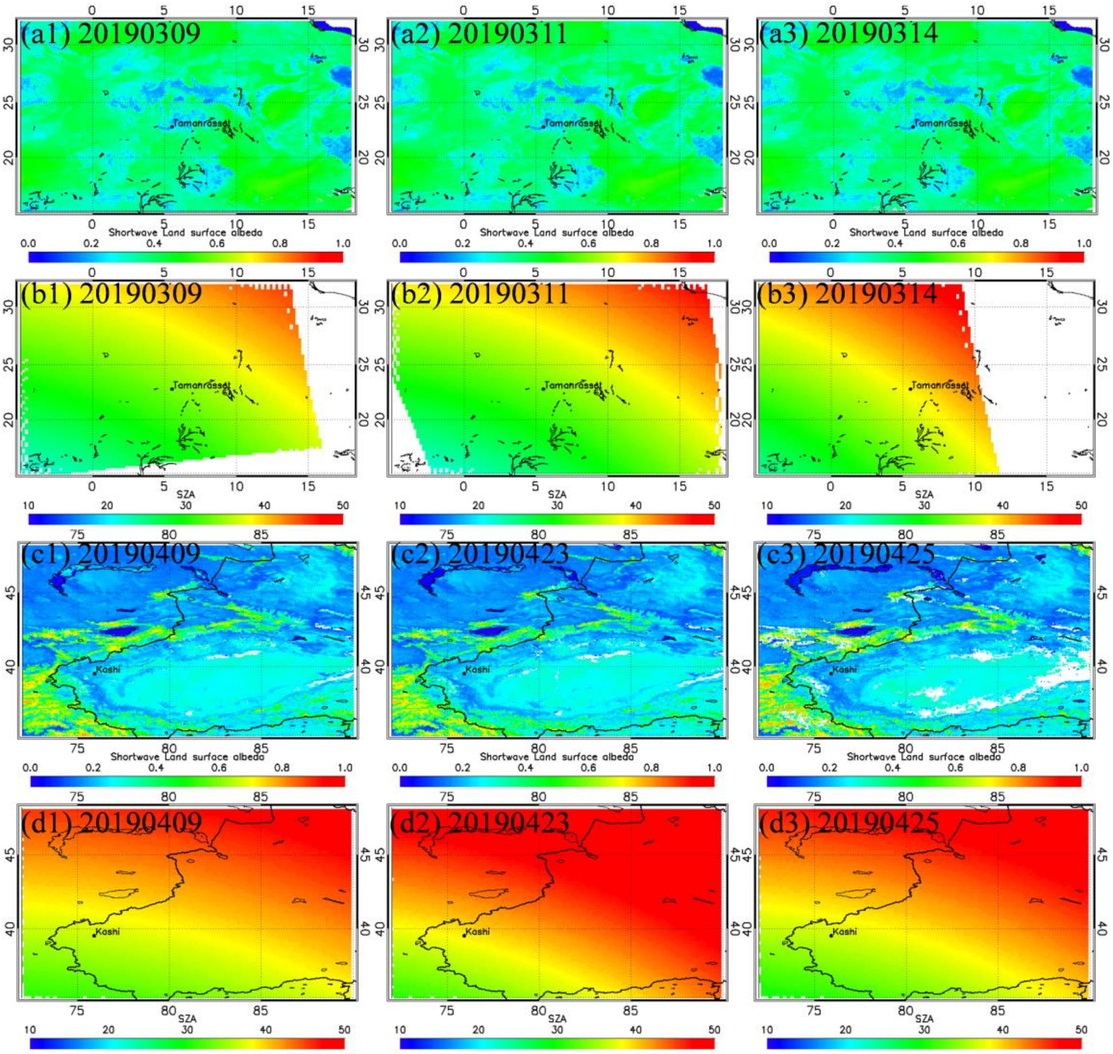

Figure 4: SW LSA and SZA over the Sahara Desert and the Taklimakan Desert derived from AQUA/MODIS.

Fig. 4 shows the LSA and the SZA observed by the AQUA satellite over Sahara Desert (Fig. 4(a1)-(a3) and Fig. 4(b1)-(b3)) and Taklimakan Desert (Fig. 4(c1)-(c3) and Fig. 4(d1)-(d3)) during dust storms. The distribution maps shown SZA differences in these dust storms. It is because the time of satellite scanning the same place are varies in each days. And the AOD values (please see Fig. 6 in the revised manuscript) and cloud coverage (please see Fig. 4 in the revised manuscript) also changes in these dust storms.

Therefore, the selected pixels to derive the $DRFE_{dust}$ varies obviously in these dust storms. We have the pretty strict threshold to sample the data for $DRFE_{dust}$ estimation.

5. The other component of this paper is computing TOA DRE and DRFE from the microphysical properties at two AERONET sites. The purpose is to link the two techniques together (satellite and surface retrieval computaions), but the link is weak since the reader does not even know if the AERONET sites a located within any of the regions with data in Figs 7,9, and 10, or how DRFE varies across the maps. It would have been interesting to see a map of DRFE for the entire maps.

Reply: We have marked the location of Tamaarasset and Kashi sites in Fig 3, Fig 4, Fig 5, Fig 6, Fig 8 and Fig 9 in the revised manuscript.

Moreover, we also would like to explain that, the aerosols measured in Tamanrasset can represent the pure dust aerosols from the Sahara Desert (Guirado-Fuentes et al., 2014), and Kashi represents a place affected by dust aerosols transported from the Taklimakan Desert (Li et al., 2020), the dust aerosols observed in Tamanrasset and Kashi sites are typical samples of the dust aerosols from these two deserts. We supposed the microphysical properties of dust aerosols in Sahara desert and Taklimakan desert are similar with dust aerosols in Tamanrasset and Kashi, and SW $DRFE_{dust}$ are mainly determined by microphysical properties of dust aerosols, LSA and SZA. To avoid the influence of the LSA and SZA in estimating the $DRFE_{dust}$, we estimate $DRFE_{dust}$ using pixels with similar LSA and SZA. Therefore, although AERONET sites not always located within the selected pixels, it would have few influences on the estimation of $DRFE_{dust}$.

6. Putting collocation aside, the details of the microphysical calculations are missing. The authors use SBDART for broadband computations, but they only have optical properties at four wavelengths. How do they extrapolate the AERONET refractive indices throughout the SW? The methodology is sprinkled throughout the paper, and is sometimes inconsistent. For instance, the authors state that SSA and ASY are calculated using spherical and non-spherical methods -- how? Do the authors do this, or does SBDART take care of this? On lines 240-242 the authors say that AERONET computes SSA and ASY. Later (on line 153) they say that the "NASA-GISS code is used to calculate the optical properties of the spherical particles and the ellipsoidal particles." On line 375 we're back to AERONET.

Reply: In this study, we accessed aerosol microphysical properties data (include volume size distribution and the refractive index of the dust aerosol), and aerosol optical properties were calculated based on aerosol microphysical properties and T-matrix method. The T-matrix codes are accessed from the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies (GISS) group (https://www.giss.nasa.gov/staff/mmishchenko/t_matrix.html). The codes are directly applicable to spheroids and finite circular cylinders, and spheroids are formed by rotating an ellipse about its minor (oblate spheroid) or major (prolate spheroid) axis (Mishchenko and Travis, 1998):

$$r(\theta, \phi) = a\left[sin^2\theta + \frac{a^2}{b^2}cos^2\theta\right]^{-1/2}$$

where θ is the polar angle, ϕ is the azimuth angle, b is the rotational (vertical) semi-axis, and a is the horizontal semi-axis. The shape and size of a spheroid can be conveniently specified by the aspect ratio (a/b). The aspect ratio is greater than 1 for oblate spheroids, smaller than 1 for prolate spheroids, and equal to 1 for spheres. Therefore, Mie scattering method can be regarded as a special case of the T-matrix method. The dust particles are assumed to sphere (aspect ratio equal to 1) and ellipsoid (aspect ratio equal to 0.8) for dust aerosol optical properties calculating. The results shows the dust aerosol optical properties were difference in particles shape assuming, and ellipsoid (aspect ratio equal to 0.8) results is closer to those estimated by AERONET inversion aerosol optical products and the satellite observations, that is indicates most dust aerosols are non-spherical in the natural environment. We have added the description of spherical and non-spherical methods in the revised manuscript. Please see Lines 164-175 in Page 7 of the revised manuscript.

In SBDART model, user defined aerosol spectral dependence by few wavelengths points, the aerosol optical properties is extrapolated to other wavelengths using a power law (Ricchiazzi et al., 1998). Therefore, aerosol properties measured at four wavelengths are extrapolated so that flux calculations can be made in any desired wavelength across the shortwave spectrum (McComiskey et al., 2021). We have added the detailed description for the aerosol properties spectral extrapolate method.

Please see Lines 191-196 in Page 8 of the revised manuscript.

7. The authors do not discuss details of their datasets. For instance, do they use AERONET Version 2 or Version 3? Level 1.5 or Level 2? Version 2 is no longer available, but the authors may be using previously-downloaded data. Also, the Version 3 retrievals at Tamanrasset never made it to Level 2, indicating that the data did not make it through the new cloud screening process. This is important because cloud contamination could easily confound their conclusions about this part of the paper.

Reply: In this study we use AERONET Version 3 Level 1.5 data. We have made efforts to prove these data were not influenced by cloud.

In this paper, the $DRFE_{dust}$ of the Taklimakan Desert is estimated with the same dust properties referring to the works of Li et al. (Li, L., Li, Z., Chang, W., Ou, Y., Goloub, P., Li, C., Li, K., Hu, Q., Wang, J., and Wendisch, M.: Aerosol solar radiative forcing near the Taklimakan Desert based on radiative transfer and regional meteorological simulations during the Dust Aerosol Observation-Kashi campaign, Atmos. Chem. Phys., 20, 10845-10864, 10.5194/acp-20-10845-2020, 2020) (Li et al., 2020). In the paper, Li et al gives the sky conditions using full-sky visible images on 9 and 24 April, 2019 at Kashi (Fig. 5).

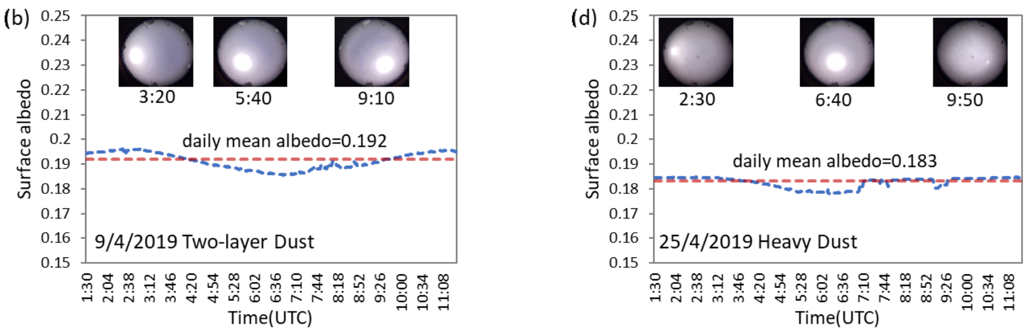

Figure 5: Full-sky visible images on 9 and 24 April, 2019 at Kashi (Li et al., 2020).

Fig. 5 gives the sky conditions on 9 and 24 April, 2019 at Kashi, these images clearly shows Kashi have dust events and not covered by clouds on 9 and 24 April, 2019.

Although we did not get the full-sky visible images at Tamanrasset, we can also access the sky conditions of Tamanrasset from satellite observations.

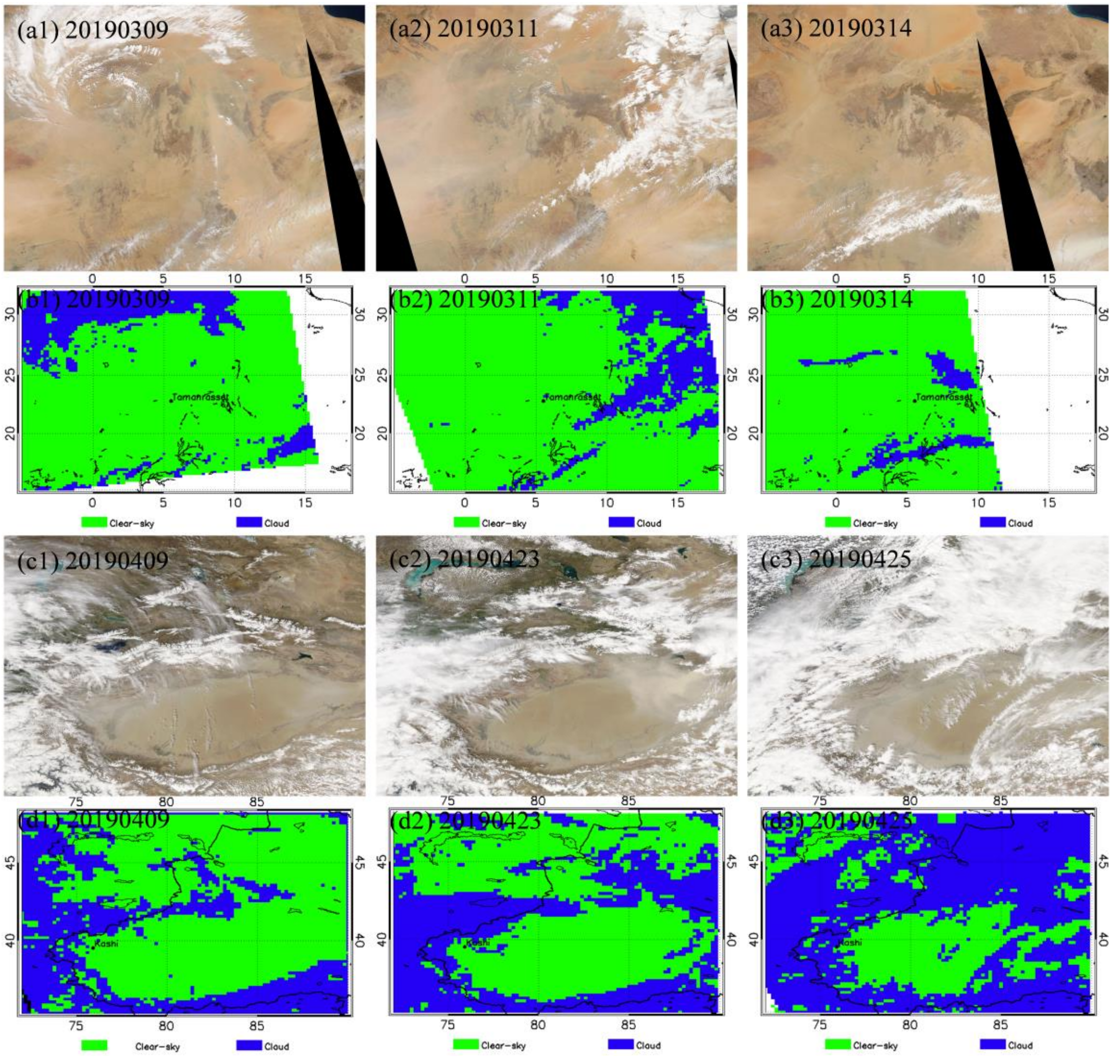

Figure 6: True color images and cloud detections from AQUA/MODIS observations.

Fig. 6 gives the true color images (Fig. 6(a1)-(a3) over Sahara Desert, and Fig. 6(c1)-(c3) over Taklimakan Desert) and cloud detections (Fig. 6(b1)-(b3) over Sahara Desert, and Fig. 6(d1)-(d3) over Taklimakan Desert) from AQUA/MODIS cloud mask products (MYD035). From the true color images and cloud detections we can see that, Tamanrasset and Kashi were not covered by clouds during these dust storm events.

Therefore, we can guarantee that these data were not polluted by cloud. We have explained in the in the manuscript. Please see Fig 4 and Lines 232-240 in Page 10-11 the revised manuscript.

8. The authors seem to have some misconceptions about SSA. On line 382, they state: "A high SSA is correlated with low real parts of the complex refractive index, while a strong absorption is correlated with a high imaginary part of the complex refractive index. Together with the size distribution, real parts of the complex refractive index can determine the magnitude of the SSA." <--- This is incorrect; the SSA is largely determined by the *imaginary* refractive index and the size distribution.

Reply: Thank you for helping us to check out the mistake. The correct meaning is "The size distribution and the complex refractive index can codetermine the magnitude of the SSA.". We have corrected this mistake in the manuscript. Please see Line 436-437 in Page 23 of the revised manuscript.

9. Story does not flow and jumps around. The writing is pretty sloppy, as evidenced by the long list of issues below.

Reply: Thank you for the criticisms, we have taken a lot of efforts to make the writing more concise and clear.

10. Line 154: Why is the particle aspect ratio set to 0.8? Is this based upon a literature value? Need to tell the reader.

Reply: In this study, the RTM results were used to theoretical verification of $DRFE_{dust}$ derived from satellite observation. The dust particles are assumed to sphere (aspect ratio equal to 1) and ellipsoid (aspect ratio equal to 0.8) for dust aerosol optical properties calculating. The results shows the dust aerosol optical properties were difference in particle shape assuming, and ellipsoid (aspect ratio equal to 0.8) results is closer to those estimated by AERONET inversion aerosol optical products and the satellite observations, that is indicates most dust aerosols are non-spherical in the natural environment. There may have better assumptions of aerosol particle shapes to calculate the aerosol optical properties closer to the real values, and that need further works on observation and research. In this study, we use sphere (aspect ratio set as 1.0) and ellipsoid (aspect ratio set as 0.8) to discuss the aerosol optical properties were difference in particles shape assuming.

We have added the detailed information about the particle aspect ratio setting in the manuscript. Please see Lines 170-175 in Page 7 of the revised manuscript.

11. Line 193: There is no Version 3 Level 2 data in March at the Tamanrasset site. So it is possible (probable?) that this data is contaminated by clouds. This could contribute significantly to the retrieval differences between the two sites. An explanation is necessary.

Reply: Thank you for the suggestion, the suggestion also made in comments 7, the full-sky visible images from Li et al. (2020) (Li et al., 2020), true color images and cloud detections from AQUA/MODIS observations clearly shows Tamanrasset and Kashi were not covered by clouds during these dust stroms. Therefore, we can guarantee that these data were not influenced by cloud.

We have added the explanation in the in the manuscript. Please see Fig. 4 and Lines 232-240 in Page 10-11 the revised manuscript.

12. Line 254: "The TOA SW radiative flux distribution shows the highest value over cloud conditions" ...How can I tell this from Fig 6?... Tell the reader that they can find the clouds in Fig 3. Better yet, design the paper so that you can combine these flux figures with the Fig 3 images. So, one figure would contain the left panels of Figs 3 & 6 and another figure would contain the right panels of Figs 3 & 6. That way the cloud images are side by side with the flux figures.

Reply: Thank you for the suggestion, we have added the cloud detection results in Fig. 4, and we also told the reader the cloud distribution maps can be found from Fig. 4 in the revised manuscript. Please see Fig. 4 in Page 11 and Lines 291-292 in Page 13 of the revised manuscript.

13. Line 256: Sentence unclear.

Reply: We have revised this sentence in the manuscript. It has been rewritten as "Following the equi-albedo method (Tian et al., 2019), the F_{clr} and DRE_{dust} over the Sahara Desert and the Taklimakan Desert can be estimated based on the measurements from MODIS and CERES both aboard on the AQUA satellite.". Please see Lines 298-300 in Page 14 of the revised manuscript.

14. Line 257: "Thus, dust aerosols have a negative radiative effect in the SW spectrum." ...Here again -- how do I get this from Fig 6, where all numbers are positive? If you want to discuss radiative effect, why not show radiative effect in the figure? ...I see you have rad effect in Fig 7. Why not delay this discussion until then?

Reply: Dust aerosols have higher SW albedo than land surface albedo in clear-sky conditions, and dust aerosols reflect more SW radiation to TOA. DRE_{dust} was defined as the radiative fluxes difference between clear (F_{clr}) and dust loading (F_{dust}) conditions (Garrett and Zhao, 2006;Christopher et al., 2000;Ramanathan et al., 1989).

$$\mathrm{DRE}_{dust} = \mathrm{F}_{\mathrm{clr}} - \mathrm{F}_{dust}$$

Therefore dust aerosols have a negative radiative effect in the SW spectrum. It also can be founded in Fig. 6 in the revised manuscript, we delayed this discussion behind Fig. 6 in the revised manuscript. Please see Lines 312-313 in Page 15 of the revised manuscript.

15. Line 267: "The high dust aerosol loading regions show significant negative radiative forcing" ...a little difficult to conclude this with so sparse data in Fig 7.

Reply: Thank you for the suggestion, the suggestion also made in comment 3. We have re-plotted the DRE_{dust} and AOD distribution maps in the same image, and all the available data of DRE_{dust} were given in the new figure. The selected pixels to derive the $DRFE_{dust}$ were surrounded by black borders in these figures. Please see Fig.6 and Lines 304-313 in Page 14-15 of the revised manuscript.

16. Line 308: "The integrated water vapor varies little over research areas,..." -- here again, how can the reader know when you only show a few points in Fig 9? Surely ECMWF provides more H2Ov than this?

Reply: Thank you for the suggestion, the suggestion also made in comment 3. We have re-plotted all the available data of integrated water vapor and SBDART derived SW fluxes in these distribution maps, and put black borders around the chosen pixels in these figures. Please see Fig. 8 in Page 18 and Fig. 9 in Page 19 of the revised manuscript.

17. Lines 382-384: Incorrect.

Reply: Thank you for helping us to check out the mistake, we have revised in the manuscript. It has been rewritten as "The size distribution and the complex refractive index can codetermine the magnitude of the SSA.". Please see Line 436-437 in Page 23 of the revised manuscript.

18. Line 415: "As shown in Fig. 16, with higher aerosol scattering (higher SSA) and higher backward scattering coefficients (lower ASY), the negative DRFEdust from Kashi is more significant." <-- I don't see how this follows from Fig 16, as SSA is not even mentioned in the Figure.

Reply: We have revised the sentence and added the state of SSA and ASY in the manuscript. It has been rewritten as "As shown in Fig. 15, with higher aerosol scattering (higher SSA in Fig. 13) and higher backward scattering (lower ASY in Fig. 14), the negative $DRFE_{dust}$ from Kashi is more significant.". Please see Lines 466-468 in Page 25-26 the revised manuscript.

19. Throughout the paper the authors assume that all aerosols are dust, both for the satellite data set and for the surface measurements. That's ok, but it needs to be stated.

Reply: We have added the explanation of the assume that all aerosols are dust aerosol in dust storms. It has been written as “Since the Sahara Desert and the Taklimakan Desert are free of industrial activities, the major aerosol over the desert areas is dust aerosol, and the anthropogenic and marine aerosols have little contribution to the total AOD, especially during dust storm episodes. Thus, we directly use the AOD retrieved by MODIS to estimate $DRFE_{dust}$ during dust storms in this study.”. Please see Lines 256-259 in Page 12 of the revised manuscript.

20. Line 45: Anderson (2005) does seem to claim ownership of this idea, but forcing efficiency dates back to at least Satheesh (2000) papers. There are many others, but at least Satheesh (2000) needs to be added.

Reply: Thank you for the suggestion. We have revised the sentence and added the citations in the manuscript. Please see Lines 44-47 in Page 2 of the revised manuscript.

21. Line 193: This is confusing. The authors provide two dates here, but figs 3&4 provide 3 dates for each site. They have already covered Fig 2 in the previous paragraph -- why are these first two sentences even located in this paragraph?? This should really be a lead-in for the previous paragraph.

Reply: We have revised it in the in the manuscript. Please see Lines 222-228 and Fig. 3 in Page 9-10 of the revised manuscript.

22. Line 220: Retried?

Reply: Thank you for helping us to check out the mistake. This is a typing mistake, is should be “Retrieved”. We have revised it in the manuscript. Please see Line 254 in Page 11 of the revised manuscript.

23. Line 236: need to cite original AERONET paper; Holben et al, 1998.

Reply: Thank you for the suggestion, we have added the citation of Holben et al (1998). Please see Line 278 in Page 12 of the revised manuscript.

24. Line 281: "According to the definition, the DRFEdust represents the DREdust of 281 a certain AOD at per unit area..." -- not just any AOD, but at AOD = 1, right? Should state that.

Reply: The $DRFE_{dust}$ represents the DRE_{dust} of per unit aerosol optical depth (AOD), which means the efficiency of the dust aerosol that affects the net radiative flux of solar radiation. We have revised this sentence in the manuscript. It has been rewritten as “According to the definition, the $DRFE_{dust}$ represents the DRE_{dust} of per unit AOD during these storms in the dust source regions.”. Please see Lines 329-330 in Page 16 of the revised manuscript.

25. Line 285: AOD wavelength should be mentioned in caption.

Reply: We have added the describtion of the wavelength of AOD (0.55μm). Please see Line 334 in Page 16 of the revised manuscript.

26. Line 289: Two numbers, one location.

Reply: Thank you for helping us to check out the mistake. This is a typing mistake, it is should be “$DRFE_{dust}$ of the dust storms is −39.6 $Wm^{-2}\tau^{-1}$ over Tamanrasset and −48.6 $Wm^{-2}\tau^{-1}$ over Kashi”. We have corrected the mistake. Please see Lines 336-338 in Page 16 of the revised manuscript.

27. Line 285: Is the regression forced through the origin? If not, state the offset so we know. Early papers often had an offset.

Reply: The regression did not forced through the origin, the regression offset are -0.818 Wm^{-2} and -1.602 Wm^{-2} over Sahara Desert and Taklimakan Desert separately. The small offset indicates that method we used in this paper is effective, and the $DRFE_{dust}$ estimated from satellite observation has good reliability.

28. Line 311: Unclear sentence.

Reply: We have revised this sentence in the manuscript. It has been rewritten as “In order to estimate the uncertainties caused by the variation of integrated water vapor over chosen pixels, we have calculated the SW radiative flux at the TOA under different integrated water vapor based on the SBDART model.”. Please see Lines 360-362 in Page 18 of the revised manuscript.

29. Line 324: This figure would be more intiutive if the independent variable was put on the x-axis.

Reply: Thank you for the suggestion. We have re-plotted the figure, and put the height on the x-axis.

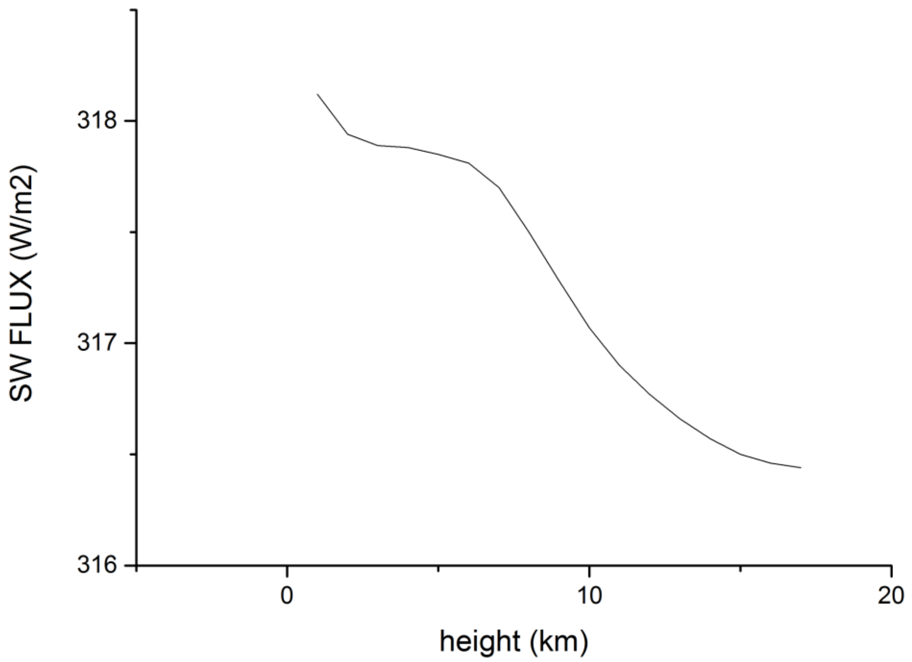

Figure 7: The sensitivity test of SW radiative flux at the TOA to various heights of dust layer.

Please see Fig. 10 in Page 20 of the revised manuscript.

30. Line 327: "...which is little than CERES observation errors." <---------- nonsensical

Reply: The radiative fluxes at TOA are derived from the CERES radiance measurements in three broad-band channel, using empirical Angular Distribution Models (ADMs). The ADMs are a function of varying scene types, such as land, ocean, cloud cover, aerosols, etc. Research shows that the uncertainty of TOA instantaneous shortwave flux is about 1.6% (4.5Wm-2) over clear-sky land, and about 2.7% (8.4Wm−2) over land under all-sky conditions (Su et al., 2015), and the overall bias in monthly regional albedos based on ADMs are < 4% (Loeb et al., 2021). Therefore, we suppose the SW fluxes in differences of 1.5Wm^{-2} (0.47%) is less than CERES observation errors.

We have added the explanation of this sentence in the manuscript. Please see Lines 378-380 in Page 20 of the revised manuscript.

31. Lines 330-332: again, nonsensical.

Reply: We had not exactly understood the meaning of “nonsensical”. The uncertainty discussions are important for evaluation of the results. In our previous articles (Tian et al., 2019), reviewers highly recommend us to add the uncertainties discussions. The each source of the uncertainties were important and can be derived from satellite observation errors (Sayer et al., 2014;Su et al., 2015;Loeb et al., 2021) and sensitive tests (Tian et al., 2019). And the estimation of the total uncertainty is following previous research (Zhang et al., 2005).

32. Line 349: why the name change from tamanrasset and kashi to Sahara and Takliman?

Reply: The aerosols measured in Tamanrasset can represent the pure dust aerosols from the Sahara Desert (Guirado-Fuentes et al., 2014), and Kashi represents a place affected by dust aerosols transported from the Taklimakan Desert (Li et al., 2020), the dust aerosols observed in Tamanrasset and Kashi sites are typical samples of the dust aerosols from these two deserts.

We have revised all the confusing sentences in the revised manuscript. Please see Lines 222-223 in Page 9, Lines 230-233 in Page 12, Lines 287-290 in Page 13, Lines 297-305 in Page 14, Lines 353-358 in Page 18 and Lines 364-369 in Page 19 of the revised manuscript.

33. Line 349: why is Kashi associated with the Sahara desert in panel d?

Reply: Thank you for helping us to check out the mistake.

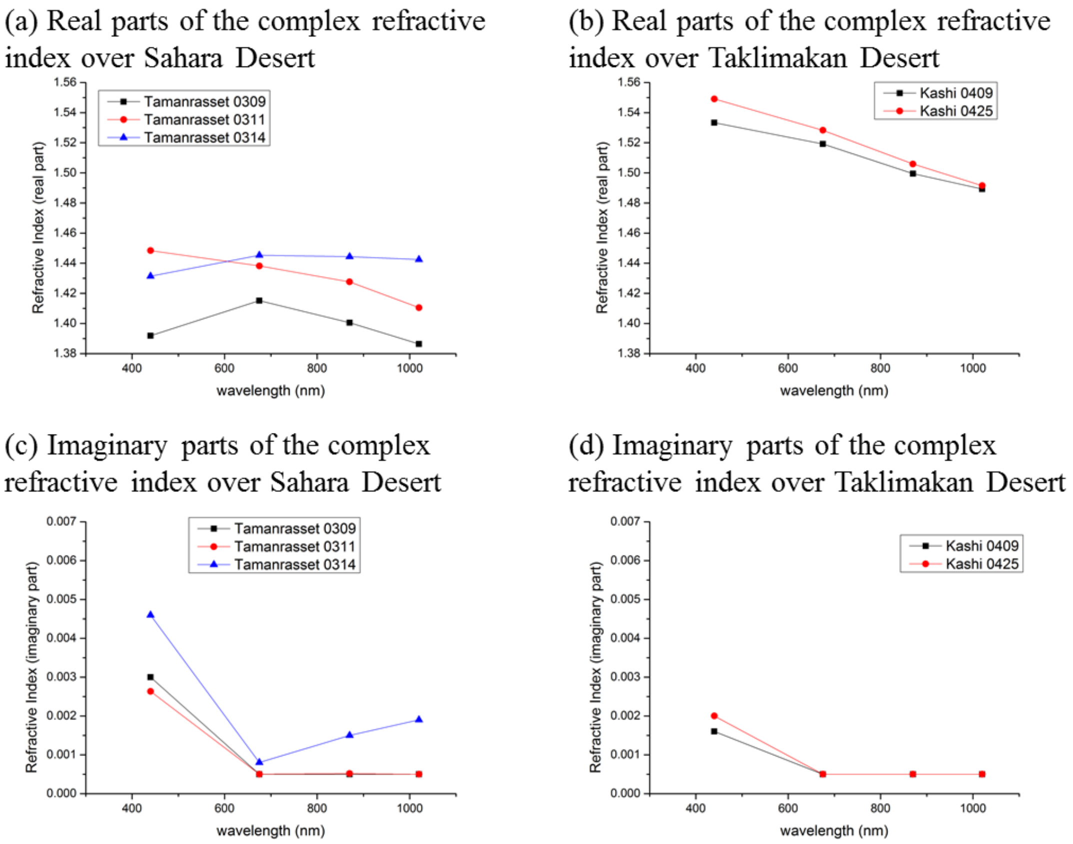

Figure 8: Real and imaginary parts of the dust complex refractive index from the Sahara Desert and the Taklimakan Desert.

We have corrected the mistake in the manuscript. Please see Fig. 11 in Page 21 of the revised manuscript.

34. Line 359: "The volume size distribution of dust aerosols clearly shows the particle size difference between dusty and clear-sky days." Authors need to point to a figure when making a statement like this. can not conclude this from the most recent figure (fig 12).

Reply: It can not be concluded this from Fig. 12, we deleted this sentence in the manuscript. Please see Line 416 in Page 22 of the revised manuscript.

35. Line 359-362: these first 3 sentences make no sense b/c you have not told the reader what you are talking about!

Reply: We rewrite these sentence in the manuscript. Please see Lines 416-421 in Page 22 of the revised manuscript.

36. Line 365: units

Reply: We have added units (μm) in the manuscript. It has been rewritten as “Most maximum dust aerosol size distribution peaks at the radius of 1.71μm in Tamanrasset and 2.24μm in Kashi.”. Please see Lines 417-418 in Page 22 of the revised manuscript.

37. Lines 359-367: What is the point of this paragraph?

Reply: Here describes the characteristics of Dust aerosol size distribution over the Sahara Desert and the Taklimakan Desert. We have deleted redundant statements to make the writing more concise and clear. Please see Lines 416-421 in Page 22 of the revised manuscript.

38. Figure 6: Tell us in the caption that this is CERES. Ideally, include some details about the particular CERES product. Most folks won't read more than the captions in your paper.

Reply: We have added the captions of the figure. It has been rewritten as “Figure 5: Figure 5: TOA SW radiative flux derived from AQUA/CERES over the Sahara Desert on March 2019 and over the Taklimakan Desert on April 2019.”. Please see Fig. 5 and Lines 287-288 in Page 13 of the revised manuscript.

39. Figure 10: Again -- why not the whole map?

Reply: Thank you for the suggestion, the suggestion also made in comment 3 and 16. We have re-plotted all the available data of integrated water vapor and SBDART derived SW fluxes in these distribution maps, and put black borders around the chosen pixels in these figures. Please see Fig. 8 in Page 18 and Fig. 9 in Page 19 of the revised manuscript.

40. Fig 11: independent variable should be on x-axis.

Reply: Thank you for the suggestion, the suggestion also made in comment 29. We have re-plotted the figure, and put the height on the x-axis.

Please see Fig. 10 in Page 20 of the revised manuscript.

References

Christopher, S. A., Chou, J., Zhang, J., Li, X., Berendes, T. A., and Welch, R. M.: Shortwave direct radiative forcing of biomass burning aerosols estimated using VIRS and CERES data, Geophysical Research Letters, 27, 2197-2200, 10.1029/1999gl010923, 2000.

Garrett, T. J., and Zhao, C.: Increased Arctic cloud longwave emissivity associated with pollution from mid-latitudes, Nature, 440, 787-789, 10.1038/nature04636, 2006.

Guirado-Fuentes, C., Cuevas, E., Cachorro, V., Toledano, C., Alonso-Pérez, S., Bustos, J., Basart, S., Romero, P., Camino, C., Mimouni, M., Zeudmi, L., Goloub, P., Baldasano, J., and Frutos Baraja, A.: Aerosol characterization at the Saharan AERONET site Tamanrasset, Atmospheric Chemistry and Physics, 14, 11753-11773, 10.5194/acp-14-11753-2014, 2014.

Li, L., Li, Z., Chang, W., Ou, Y., Goloub, P., Li, C., Li, K., Hu, Q., Wang, J., and Wendisch, M.: Aerosol solar radiative forcing near the Taklimakan Desert based on radiative transfer and regional meteorological simulations during the Dust Aerosol Observation-Kashi campaign, Atmos. Chem. Phys., 20, 10845-10864, 10.5194/acp-20-10845-2020, 2020.

Loeb, N., Wielicki, B., Hu, Y., Iii, J., and Stowe, L.: Clouds and the Earth's Radiant Energy System (CERES) Validation Plan CERES Inversion to Instantaneous TOA Fluxes (Subsystem 4.5), 2021.

McComiskey, A., Ricchiazzi, P., Ogren, J., and Dutton, E.: SGPGET: AN SBDART Module for Aerosol Radiative Transfer, 2021.

Mishchenko, M. I., and Travis, L. D.: Capabilities and limitations of a current FORTRAN implementation of the T-matrix method for randomly oriented, rotationally symmetric scatterers,

Journal of Quantitative Spectroscopy and Radiative Transfer, 60, 309-324, https://doi.org/10.1016/S0022-4073(98)00008-9, 1998.
Ramanathan, V., Cess, R., Harrison, E., Minnis, P., Barkstrom, B., Ahmad, E., and Hartmann, D.: Cloud-Radiative Forcing and Climate: Results from The Earth Radiation Budget Experiment, Science (New York, N.Y.), 243, 57-63, 10.1126/science.243.4887.57, 1989.
Ricchiazzi, P., Yang, S., Gautier, C., and Sowle, D.: SBDART: A Research and Teaching Software Tool for Plane-Parallel Radiative Transfer in the Earth's Atmosphere, Bulletin of the American Meteorological Society, 79, 2101, 10.1175/1520-0477(1998)079<2101:Sarats>2.0.Co;2, 1998.
Sayer, A. M., Munchak, L. A., Hsu, N. C., Levy, R. C., Bettenhausen, C., and Jeong, M.-J.: MODIS Collection 6 aerosol products: Comparison between Aqua's e-Deep Blue, Dark Target, and “merged” data sets, and usage recommendations, Journal of Geophysical Research: Atmospheres, 119, 13,965-913,989, 10.1002/2014jd022453, 2014.
Schaaf, C., Martonchik, J., Pinty, B., Govaerts, Y., Gao, F., Lattanzio, A., Liu, J., Strahler, A., and Taberner, M.: Retrieval of Surface Albedo from Satellite Sensors, in: Advances in Land Remote Sensing: System, Modeling, Inversion and Application, edited by: Liang, S., Springer Netherlands, Dordrecht, 219-243, 2008.
Schaaf, C. B., Gao, F., Strahler, A. H., Lucht, W., Li, X., Tsang, T., Strugnell, N. C., Zhang, X., Jin, Y., Muller, J.-P., Lewis, P., Barnsley, M., Hobson, P., Disney, M., Roberts, G., Dunderdale, M., Doll, C., d'Entremont, R. P., Hu, B., Liang, S., Privette, J. L., and Roy, D.: First operational BRDF, albedo nadir reflectance products from MODIS, Remote Sensing of Environment, 83, 135-148, https://doi.org/10.1016/S0034-4257(02)00091-3, 2002.
Schaaf, C. B., Liu, J., Gao, F., and Strahler, A. H.: Aqua and Terra MODIS Albedo and Reflectance Anisotropy Products, in: Land Remote Sensing and Global Environmental Change: NASA's Earth Observing System and the Science of ASTER and MODIS, edited by: Ramachandran, B., Justice, C. O., and Abrams, M. J., Springer New York, New York, NY, 549-561, 2011.
Su, W., Corbett, J., Eitzen, Z., Liang, and L.: Next-generation angular distribution models for top-of-atmosphere radiative flux calculation from the CERES instruments: validation, Atmospheric Measurement Techniques Discussions, 2015.
Tian, L., Zhang, P., and Chen, L.: Estimation of the Dust Aerosol Shortwave Direct Forcing Over Land Based on an Equi-albedo Method From Satellite Measurements, Journal of Geophysical Research: Atmospheres, 124, 8793-8807, 10.1029/2019JD030974, 2019.
Zhang, J., Christopher, S. A., Remer, L. A., and Kaufman, Y. J.: Shortwave aerosol radiative forcing over cloud-free oceans from Terra: 2. Seasonal and global distributions, Journal of Geophysical Research (Atmospheres), 110, D10S24, 2005.